Step-1:
Sandbox, Firewall & Access Control

Red Team

Jair Ramirez, David Garcia, and Zach Lay

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Section I - Introduction

1. *Background*

This project provided our team with hands-on experience creating and securing virtual network environments using a virtual machine manager, virtual machines, and a router/firewall. The primary goal of Project-1 was to simulate a real-world company network divided into two networks: Network A and Network B, each containing isolated machines connected through Router R, which enforces firewall rules between the networks. Network A consists of two internal machines: an Ubuntu server and a Windows XP workstation, while Network B has two external machines running Kali Linux and Windows 95. The scope includes setting up a virtual environment, installing operating systems and programs like Wireshark, configuring firewall rules, and analyzing network traffic using tools like ping and curl. This project allowed the team to develop valuable technical skills by working with real-world examples and industry security software.

Section II - Network Setup and Diagnostics (Tasks II & III)

1. *Screenshot of Virtual Machine Manager*

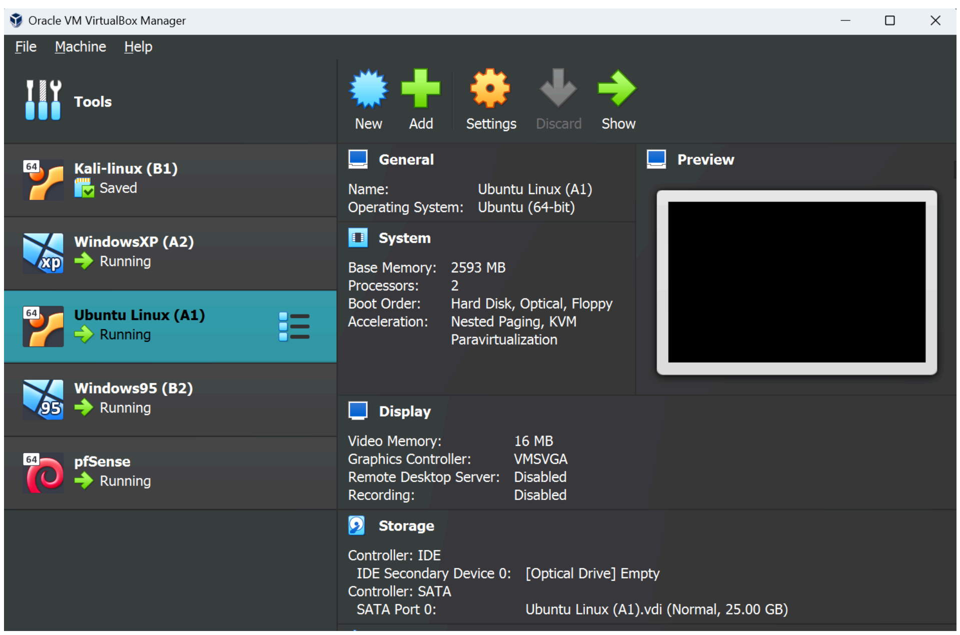


Fig 1: VM Manager with 5 virtual machines. A.1(Ubuntu), A.2(Windows XP), B.1(Kali), B.2(Windows 95) + Router (pfsense)

2. *NMap Commands for Scanning Computers and Service Ports*

Scanning Network A: To perform a regular NMap scan on Network A, we used the command ‘sudo nmap 192.168.1.0/24’, where 192.168.1.0/24 refers to the Network A subnet. When noting the service ports after the first scan, we identified the following were open from the Ubuntu Server A.1: Port 22 (SSH), Port 80 (HTTP), and Port 443 (HTTPS). Windows XP Workstation: Port 135 (MS

RPC), Port 139 (NetBIOS), and Port 445 (Microsoft-DS SMB). When scanning Network B, we used the following NMap command for a normal scan: ‘sudo nmap 192.168.2.0/24’. After this scan, we noted the open service port 22 (SSH) on the Kali machine, with no significant ports open on the Windows 95 machine.

3. *Wireshark Result Screenshots*

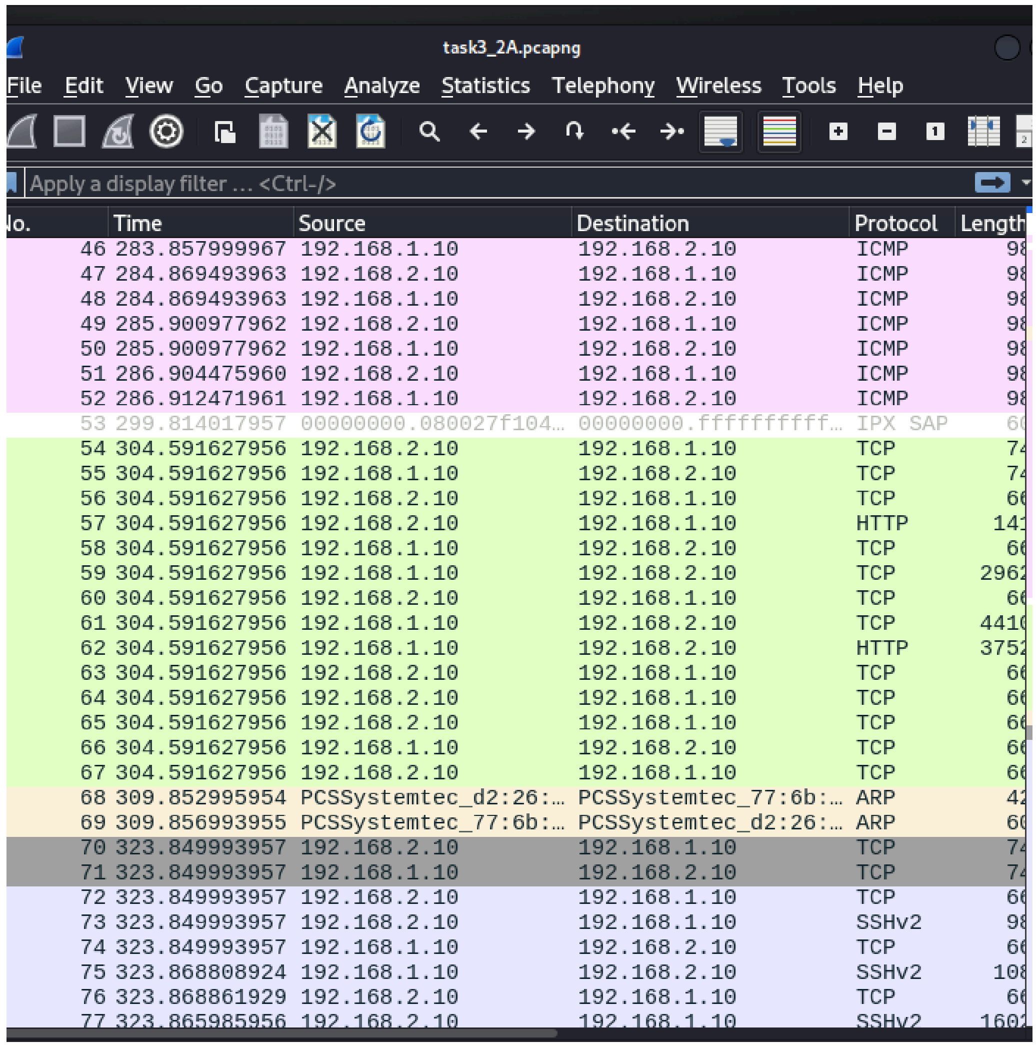


Fig 2:Wireshark Screenshot from B.1 machine monitoring requests to from B.1 to A.1. A.1’s ip is 192.168.1.10, B.1’s ip is 192.168.2.10

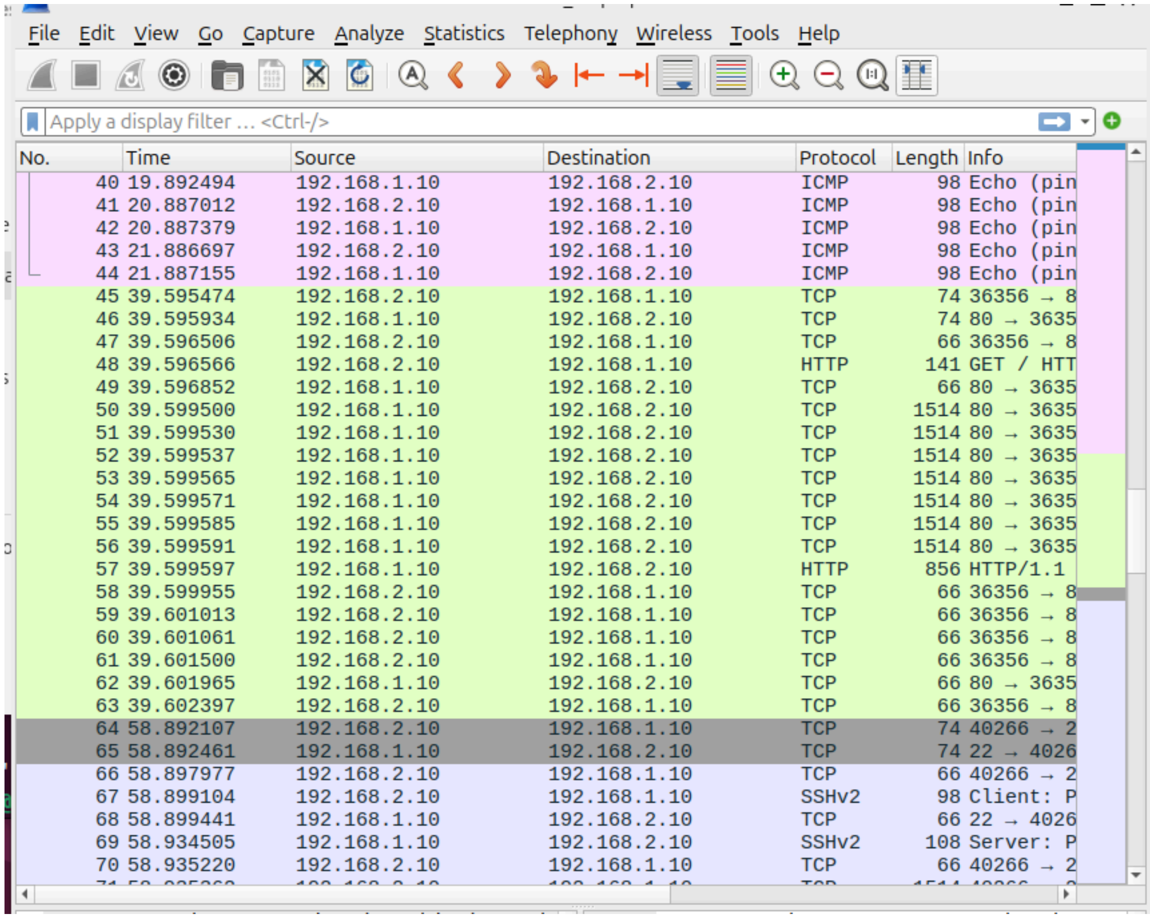


Fig 3:Wireshark Screenshot from A.1 machine monitoring requests to from B.1 to A.1. A.1's ip is 192.168.1.10, B.1's ip is 192.168.2.10

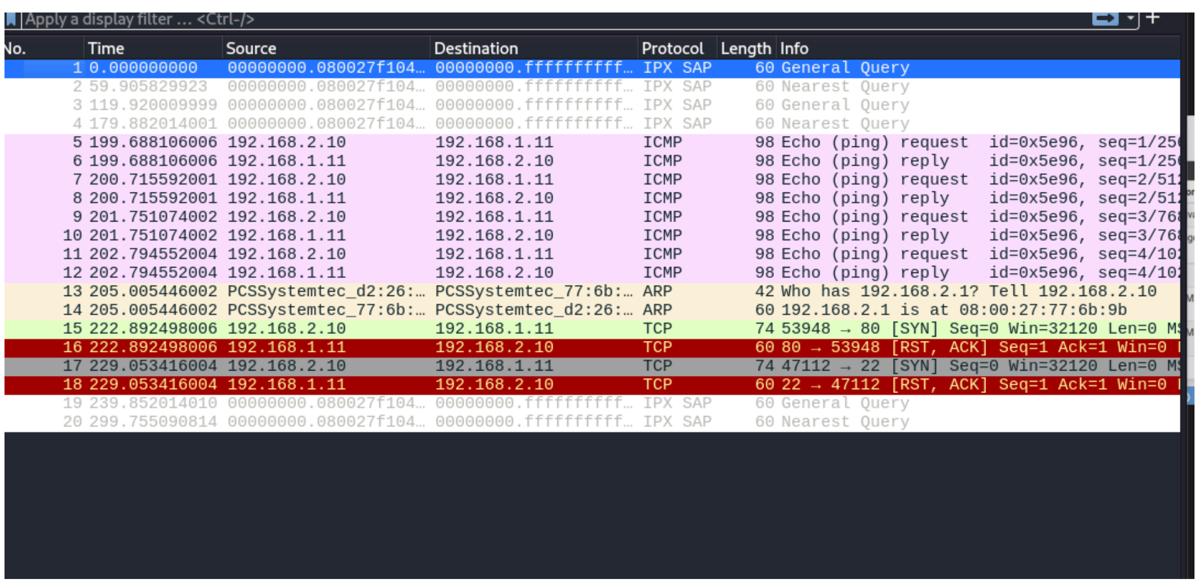


Fig 4: Wireshark Screenshot from B.1 machine monitoring requests to from B.1 to A.2. A.2's ip is 192.168.1.11, B.1's ip is 192.168.2.10

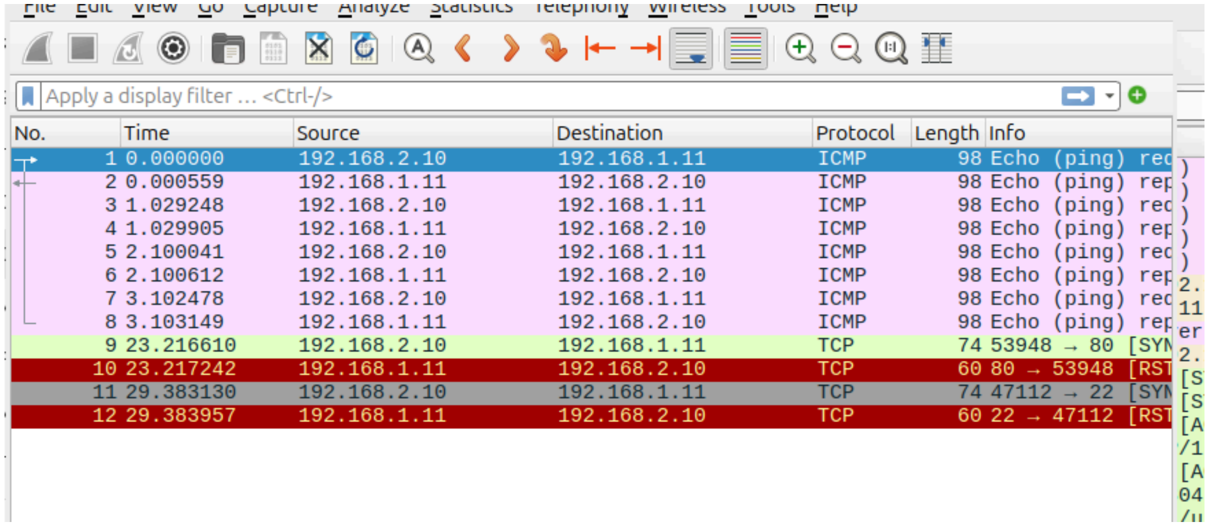


Fig 5: Wireshark Screenshot from A.1 machine monitoring requests to from B.1 to A.2.

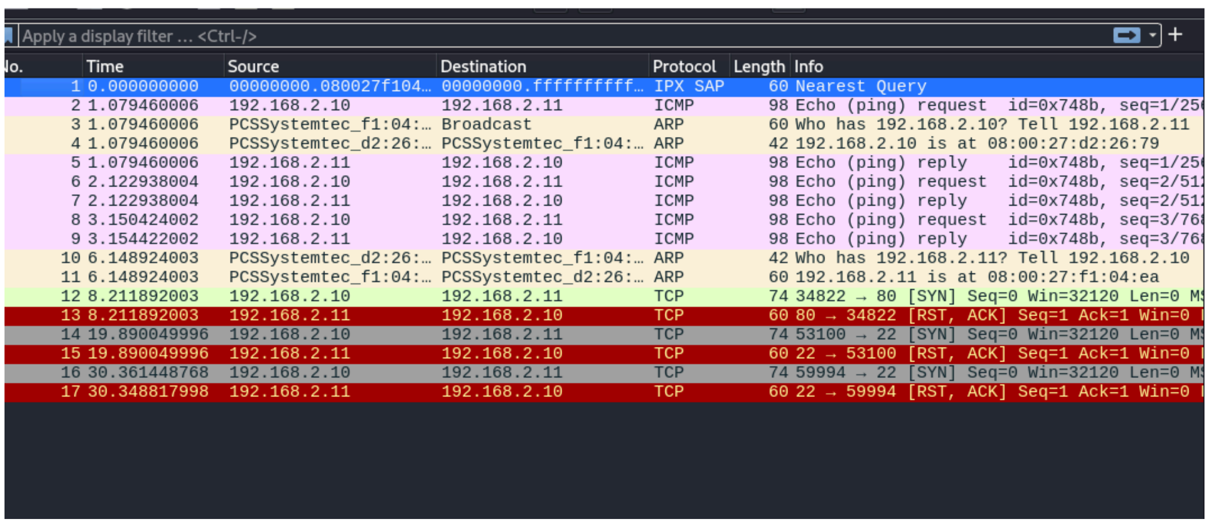


Fig 6: Wireshark Screenshot from B.1 machine monitoring requests to from B.1 to B.1. B.1's ip is 192.168.2.10. B.2's ip is 192.168.2.11

4. *What Web Services are Allowed Between Computers Before Task IV?*

Before we implemented the security rules in Task IV, Ubuntu Server A.1 provided HTTP through Port 80 and HTTPS through Port 443, allowing web services to all machines in Networks A and B. This means that A.2, B.1, and B.2 can access web services provided by Ubuntu Server A.1. No other VMs in the sandbox are configured to host web services, which is why A.1 is the only server.

Section III - Security Policy Implementation (Tasks IV & V)

1. *Access Control Matrix*

Machine	Server-Provided Web Service	Server-Provided SSH Service	External-Provided Web Service	Workstation-Provided Web Service	Ping to Company Machines	Ping to External Machines
A.1 - Company Server	N/A	N/A	Block	N/A	Allow	Block
A.2 - Company Workstation	Allow	Allow	Allow	N/A	Allow	Block
B.1 - External Machine	Allow	Block	N/A	N/A	Block	Allow
B.2 - External Machine	Allow	Block	N/A	N/A	Block	Allow

2. *Which Policies Cannot be Completely Enforced by the Router Rules of R*
    a. Due to the simplicity and limitations of the pfSense firewalls, some policies and capabilities can't be fully enforced. For example, Router R can allow and block traffic based on criteria like protocol and IP address, but it can't filter traffic based on the type of traffic content, such as specific types of websites or applications. This would require application-level filtering, which is too high on the OSI model for a firewall like pfSense to be able to affect it. Another policy that can not be completely enforced is workstations providing web services. pfSense can block common ports like HTTP and HTTPS, but it can't prevent a workstation from internally hosting a locally accessible web service through internal routing.
3. *R Router Rules Screenshot and Explanation*

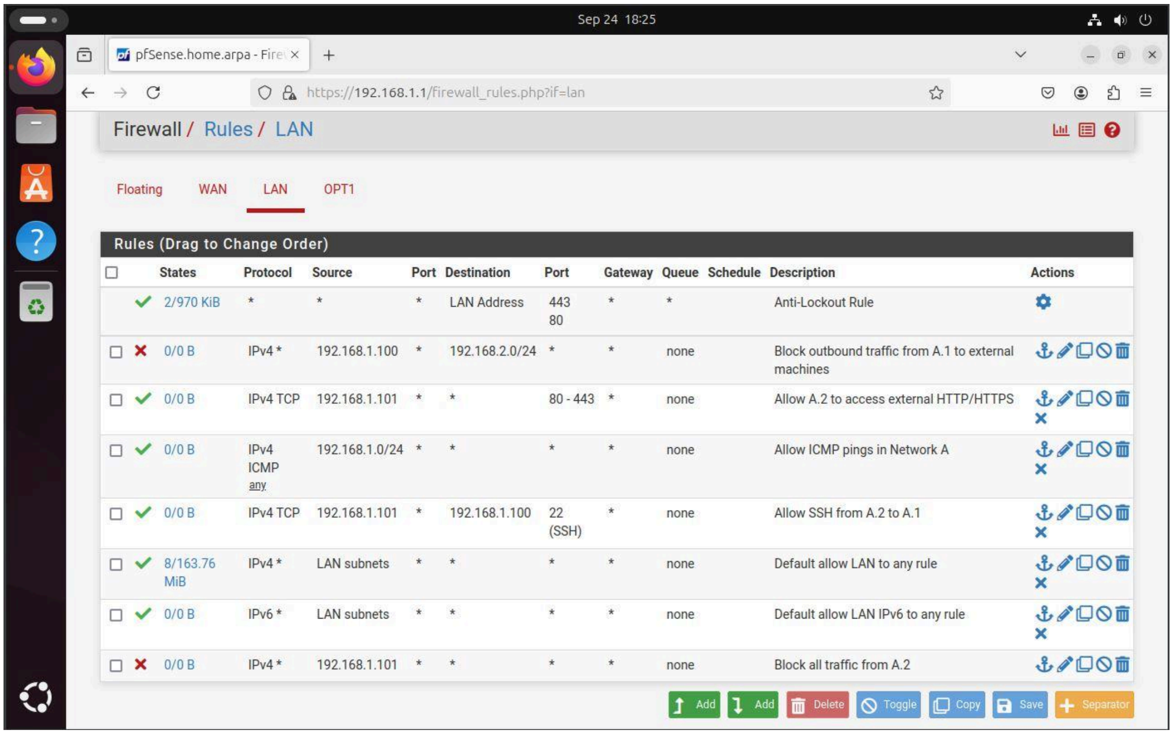
a. 

Fig 7:LAN Firewall Rules

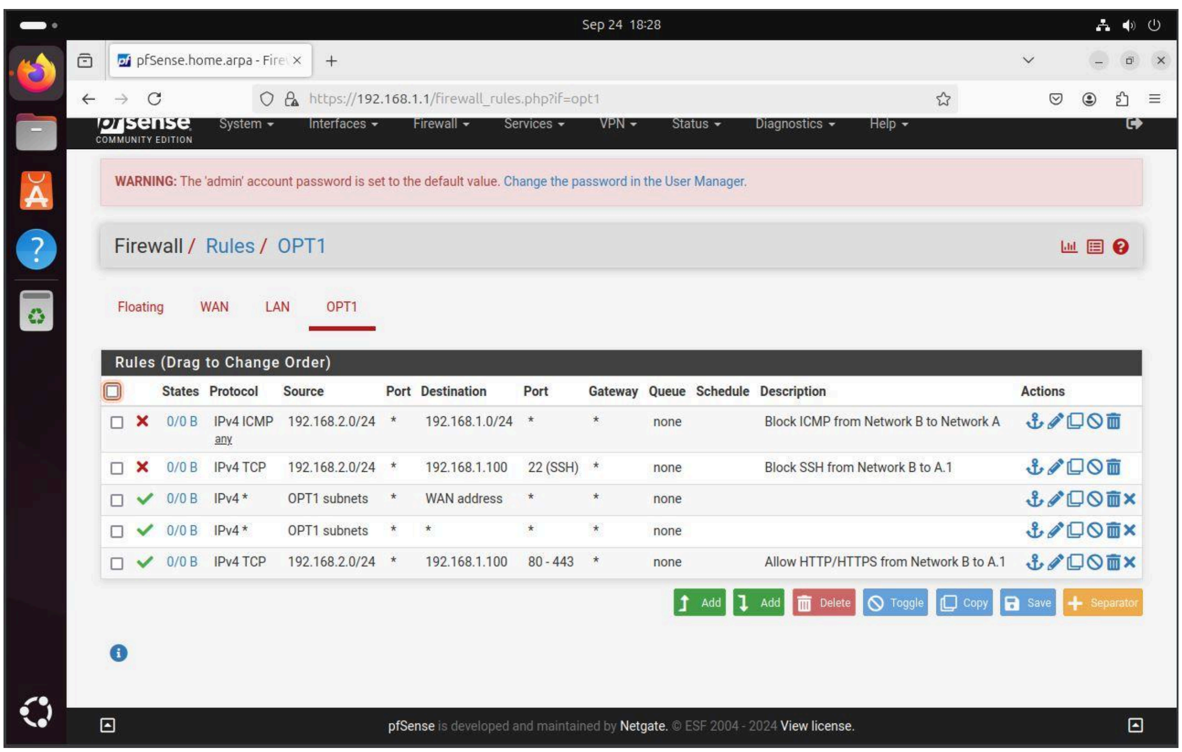
b. 

Fig 8:LAN 2 Firewall Rules

c. LAN/Network A Firewall Rules.

i. Anti-lockout rule: Automatically generated
ii. Block Outbound Traffic from A.1 to External Machines: This blocks any outbound traffic from the Ubuntu Server to the external machines on Network B, following the security policy that prohibits A.1 from accessing external machines.
iii. Allow A.2 to Access External HTTP/HTTPS: This allows the Windows XP Workstation to access HTTP/S web services on the internet by allowing traffic from 192.168.1.101 (A.2's IP address) to external destinations over ports 80 (HTTP) and 443 (HTTPS).
iv. Allow ICMP Pings in Network A: This option allows any host in the 192.168.1.0/24 Network A subnet to send pings, ensuring that everything is working correctly.
v. Allow SSH from A.2 to A.1: This rule lets A.2 establish SSH connections to A.1 by opening up TCP traffic on port 22 (SSH) from 192.168.1.101 (A.2) to 192.168.1.100 (A.1).
vi. Default Allow LAN to Any Rule: Default pass rule.
vii. Block All Traffic from A.2: This rule blocks all traffic coming from 192.168.1.101 (A.2), making sure no other hosts/machines receive traffic from the Windows XP Machine.

d. OPT1/Network B Firewall Rules.
   i. Block ICMP from Network B to Network A: This rule blocks pings, preventing Network B external machines from pinging the Network A company machines.
   ii. Block SSH from Network B to A.1: Blocks SSH traffic from Network B to A.1, which prevents the Network B external machines from accessing A.1 via port 22.
   iii. Allow OPT1 Subnets to WAN: Default rule.
   iv. Allow HTTP/HTTPS from Network B to A.1: This rule allows external machines in Network B to access A.1's HTTP(S) web services over ports 80 and 443.

4. *NMap Network-A Computers and Ports Screenshots*

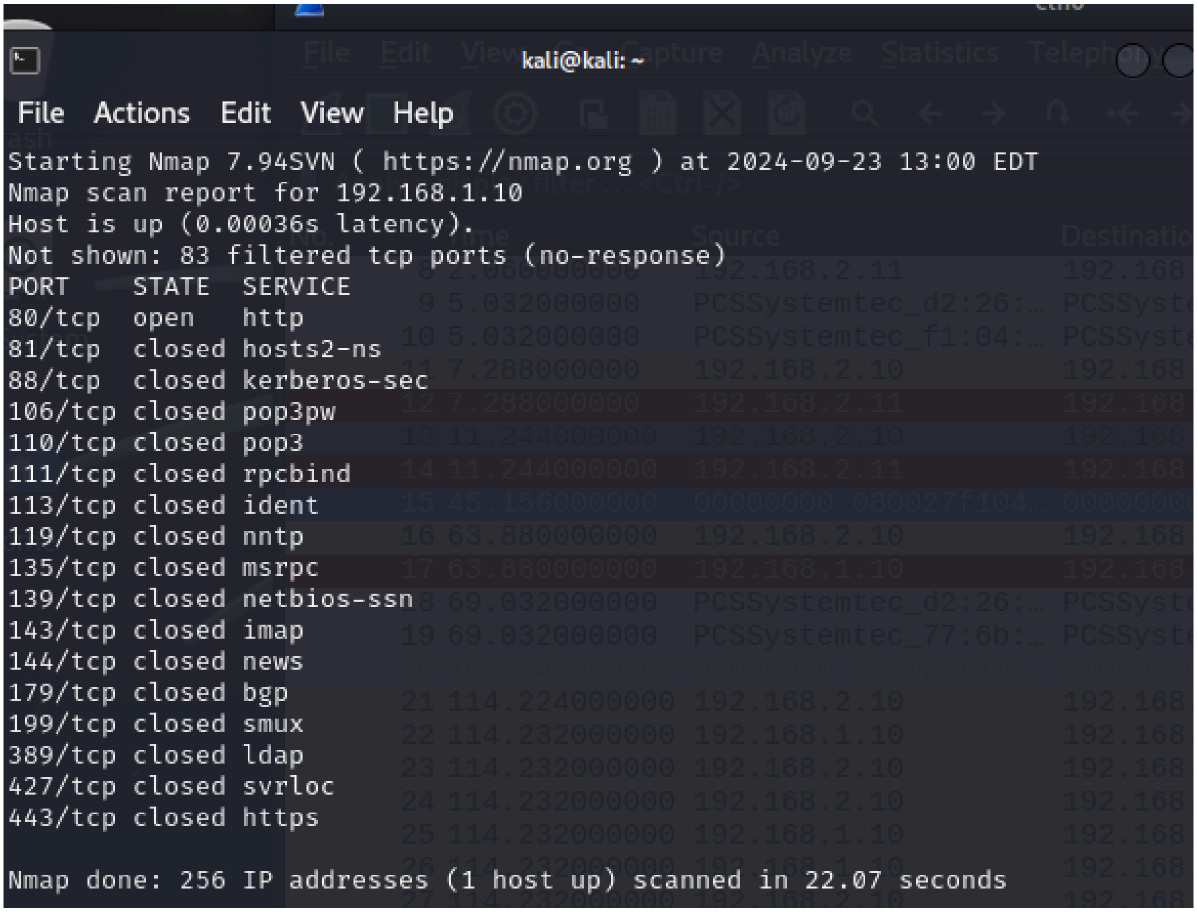
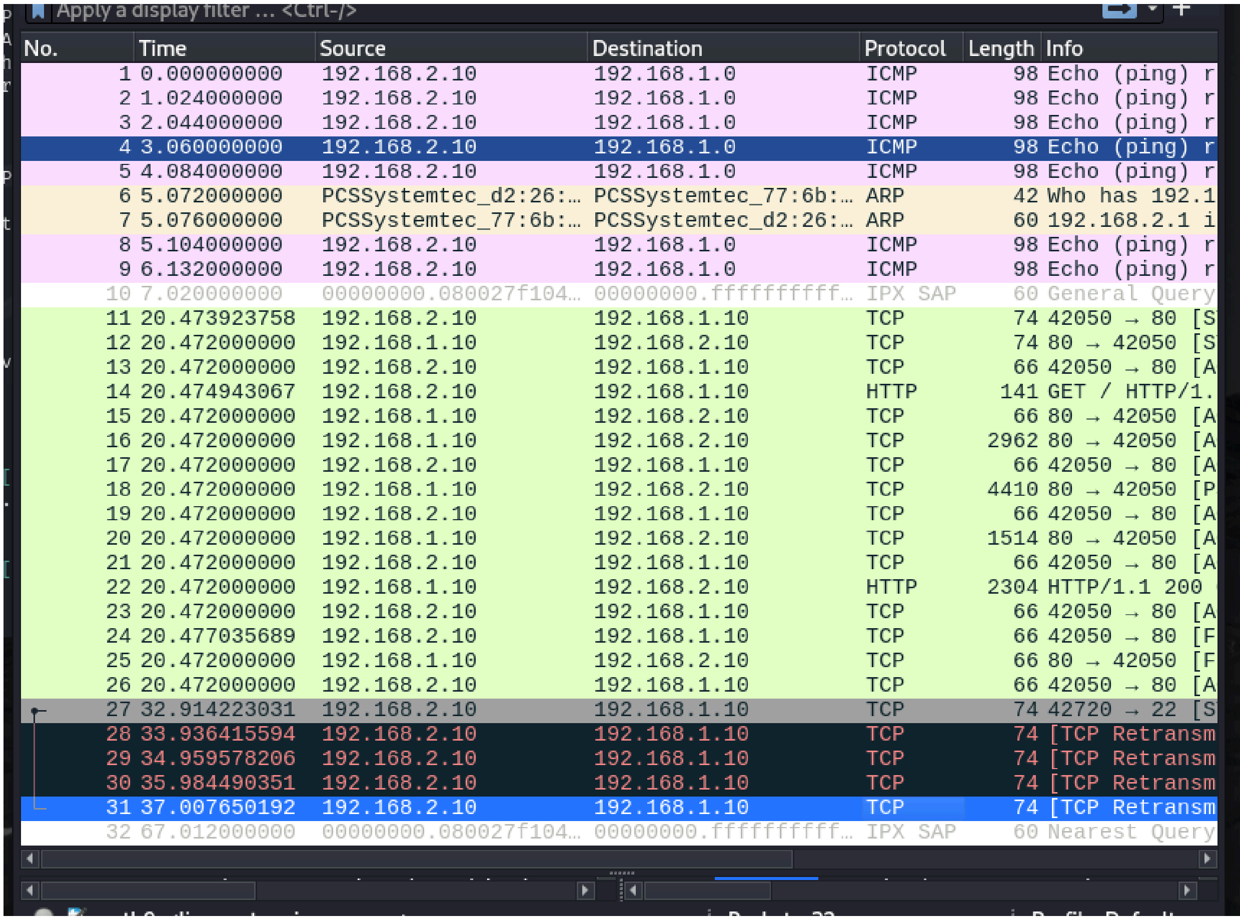
a. 

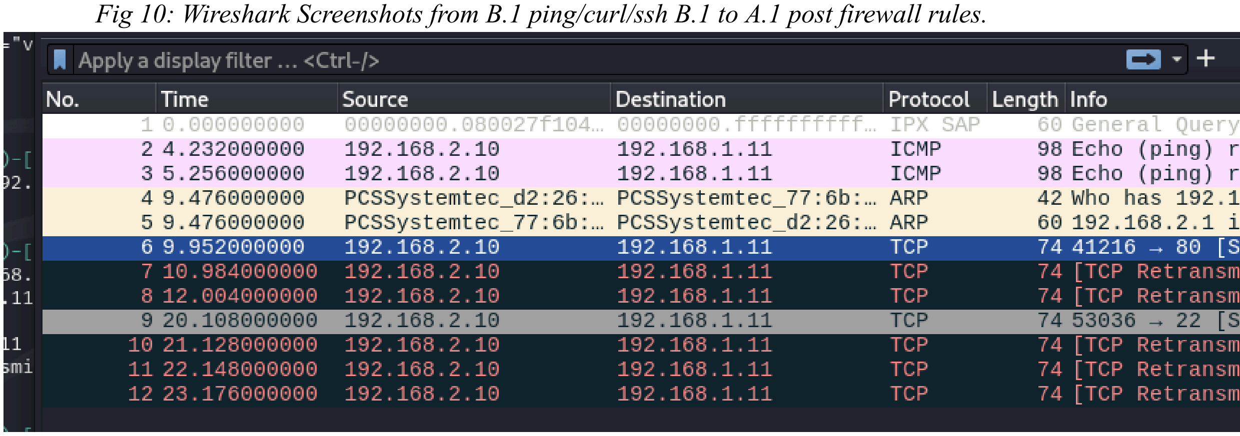
Fig 9: NMAP showing exposed Network A ports after rules

5. *Wireshark Routines Screenshots*

a. 

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	192.168.2.10	192.168.1.0	ICMP	98	Echo (ping) r
2	1.024000000	192.168.2.10	192.168.1.0	ICMP	98	Echo (ping) r
3	2.044000000	192.168.2.10	192.168.1.0	ICMP	98	Echo (ping) r
4	3.060000000	192.168.2.10	192.168.1.0	ICMP	98	Echo (ping) r
5	4.084000000	192.168.2.10	192.168.1.0	ICMP	98	Echo (ping) r
6	5.072000000	PCSSystemtec_d2:26:…	PCSSystemtec_77:6b:…	ARP	42	Who has 192.1
7	5.076000000	PCSSystemtec_77:6b:…	PCSSystemtec_d2:26:…	ARP	60	192.168.2.1 i
8	5.104000000	192.168.2.10	192.168.1.0	ICMP	98	Echo (ping) r
9	6.132000000	192.168.2.10	192.168.1.0	ICMP	98	Echo (ping) r
10	7.020000000	00000000.080027f104…	00000000.ffffffffff…	IPX SAP	60	General Query
11	20.473923758	192.168.2.10	192.168.1.10	TCP	74	42050 → 80 [S
12	20.472000000	192.168.1.10	192.168.2.10	TCP	74	80 → 42050 [S
13	20.472000000	192.168.2.10	192.168.1.10	TCP	66	42050 → 80 [A
14	20.474943067	192.168.2.10	192.168.1.10	HTTP	141	GET / HTTP/1.
15	20.472000000	192.168.1.10	192.168.2.10	TCP	66	80 → 42050 [A
16	20.472000000	192.168.1.10	192.168.2.10	TCP	2962	80 → 42050 [A
17	20.472000000	192.168.2.10	192.168.1.10	TCP	66	42050 → 80 [A
18	20.472000000	192.168.1.10	192.168.2.10	TCP	4410	80 → 42050 [P
19	20.472000000	192.168.2.10	192.168.1.10	TCP	66	42050 → 80 [A
20	20.472000000	192.168.1.10	192.168.2.10	TCP	1514	80 → 42050 [A
21	20.472000000	192.168.2.10	192.168.1.10	TCP	66	42050 → 80 [A
22	20.472000000	192.168.1.10	192.168.2.10	HTTP	2304	HTTP/1.1 200
23	20.472000000	192.168.2.10	192.168.1.10	TCP	66	42050 → 80 [A
24	20.477035689	192.168.2.10	192.168.1.10	TCP	66	42050 → 80 [F
25	20.472000000	192.168.1.10	192.168.2.10	TCP	66	80 → 42050 [F
26	20.472000000	192.168.2.10	192.168.1.10	TCP	66	42050 → 80 [A
27	32.914223031	192.168.2.10	192.168.1.10	TCP	74	42720 → 22 [S
28	33.936415594	192.168.2.10	192.168.1.10	TCP	74	[TCP Retransm
29	34.959578206	192.168.2.10	192.168.1.10	TCP	74	[TCP Retransm
30	35.984490351	192.168.2.10	192.168.1.10	TCP	74	[TCP Retransm
31	37.007650192	192.168.2.10	192.168.1.10	TCP	74	[TCP Retransm
32	67.012000000	00000000.080027f104…	00000000.ffffffffff…	IPX SAP	60	Nearest Query

Fig 10: Wireshark Screenshots from B.1 ping/curl/ssh B.1 to A.1 post firewall rules.

b. 

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	00000000.080027f104…	00000000.ffffffffff…	IPX SAP	60	General Query
2	4.232000000	192.168.2.10	192.168.1.11	ICMP	98	Echo (ping) r
3	5.256000000	192.168.2.10	192.168.1.11	ICMP	98	Echo (ping) r
4	9.476000000	PCSSystemtec_d2:26:…	PCSSystemtec_77:6b:…	ARP	42	Who has 192.1
5	9.476000000	PCSSystemtec_77:6b:…	PCSSystemtec_d2:26:…	ARP	60	192.168.2.1 i
6	9.952000000	192.168.2.10	192.168.1.11	TCP	74	41216 → 80 [S
7	10.984000000	192.168.2.10	192.168.1.11	TCP	74	[TCP Retransm
8	12.004000000	192.168.2.10	192.168.1.11	TCP	74	[TCP Retransm
9	20.108000000	192.168.2.10	192.168.1.11	TCP	74	53036 → 22 [S
10	21.128000000	192.168.2.10	192.168.1.11	TCP	74	[TCP Retransm
11	22.148000000	192.168.2.10	192.168.1.11	TCP	74	[TCP Retransm
12	23.176000000	192.168.2.10	192.168.1.11	TCP	74	[TCP Retransm

Fig 11: *Screenshot from B.1 machine monitoring B.1 ping/curl/ssh to A.1*

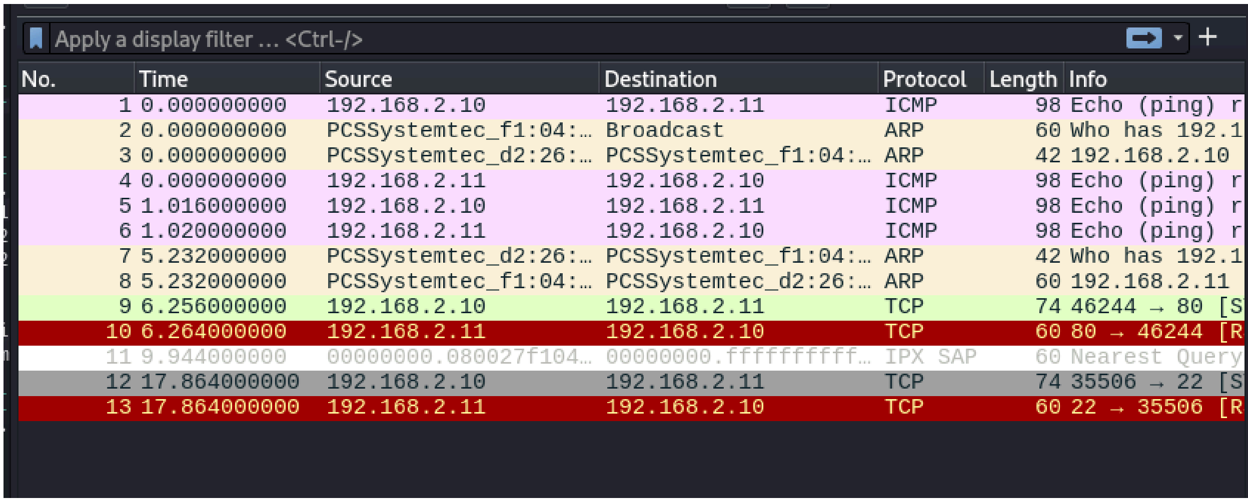
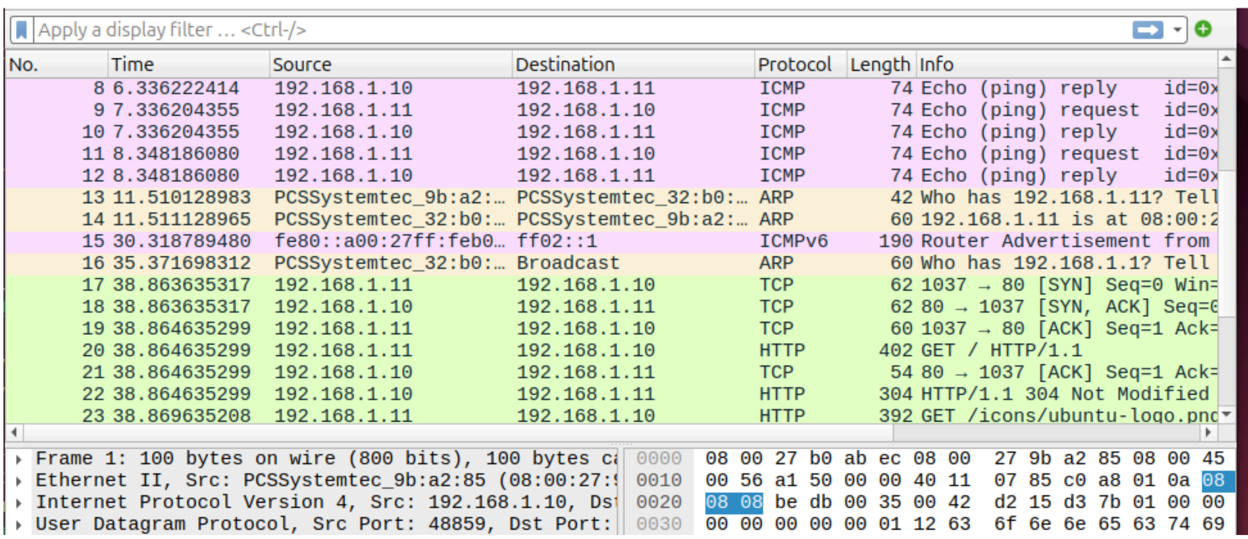


Fig 12: Screenshot from B.1 ping/curl/ssh B.1 to B.2 post firewall



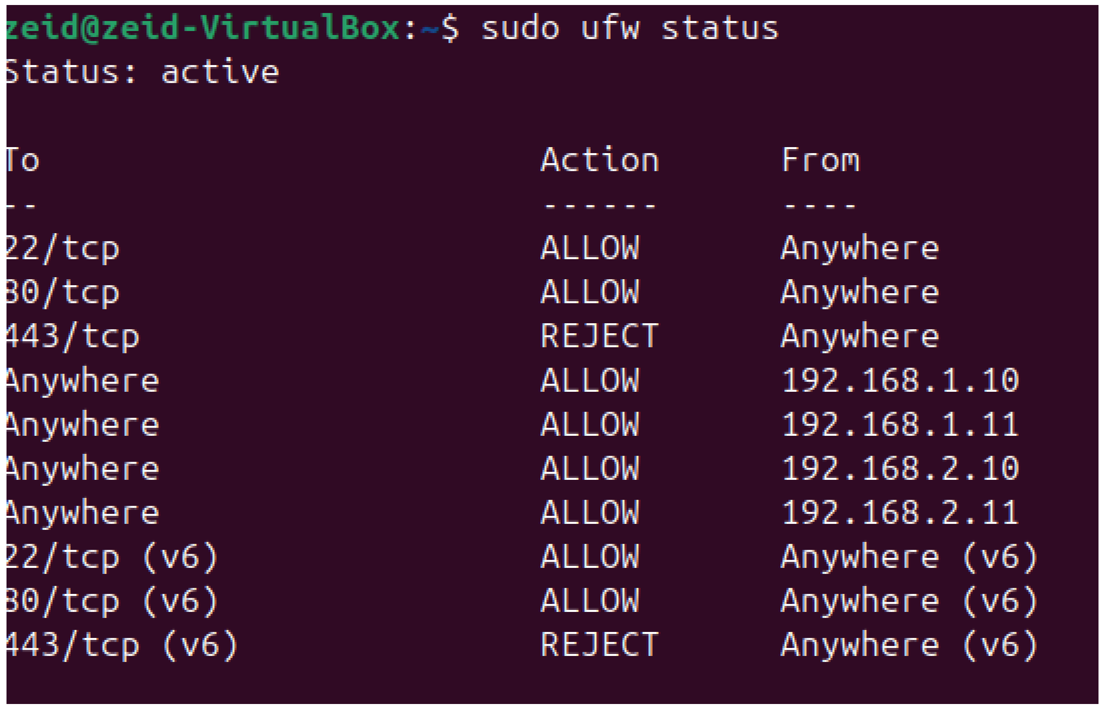
c. Fig 13: Ping/Curl/SSH A.1 monitoring A.1 to A.2

6. *What Web Services are Allowed Between Computers?*
    a. After implementing the security policies in Task IV to the configuration of the Access Control Matrix, many web services were restricted. The Ubuntu Server now can not access any external web services and only provides HTTP(S) services to the machines in Network B. The XP Workstation can access web services internally and externally, but the Network B machines can not provide access or host their services, same with the XP Workstation.. A.1 continues to to serve web services through port 80 and 443.
7. *Share the Differences Between the Scans from Task III and V*
    a. The main difference between Task III and V scans is the blocking of pings. Before the security policies, the Kali machine could ping on A.1 and A.2. After the security policies were enforced, all pings from the Kali machine to A.1 and

A.2 are now blocked, with the firewall restricting ICMP traffic between the two networks.

Section IV - Additional Security (Task VI)

1. *Local A.1 Router Configuration Rules Screenshots and Explanations*
    a.



```
zeid@zeid-VirtualBox:~$ sudo ufw status
Status: active

To                         Action      From
--                         ------      ----
22/tcp                     ALLOW       Anywhere
80/tcp                     ALLOW       Anywhere
443/tcp                    REJECT      Anywhere
Anywhere                   ALLOW       192.168.1.10
Anywhere                   ALLOW       192.168.1.11
Anywhere                   ALLOW       192.168.2.10
Anywhere                   ALLOW       192.168.2.11
22/tcp (v6)                ALLOW       Anywhere (v6)
80/tcp (v6)                ALLOW       Anywhere (v6)
443/tcp (v6)               REJECT      Anywhere (v6)
```

Fig 14:Internal Firewall Config

    b. Allow TCP Port 22: allows SSH connections on port 22, giving remote access to the server from any machine.
    c. Allow TCP Port 80: allows HTTP traffic web services on port 80, permitting web access from any external machine.
    d. Reject TCP Port 443: blocks port 443 (HTTPS traffic), making web services inaccessible from any external source.
    e. Allow Access from Specific IPs (192.168.x.x). These rules allow access to the server from specific IP addresses of machines in Networks A and B, ensuring specific machines are accessing their own certain services or resources on the server.
    f. Allow/Reject IPv6 Rules: Allows SSH and HTTP over IPv6 while HTTPS is blocked.
2. *Wireshark Routines Screenshots*

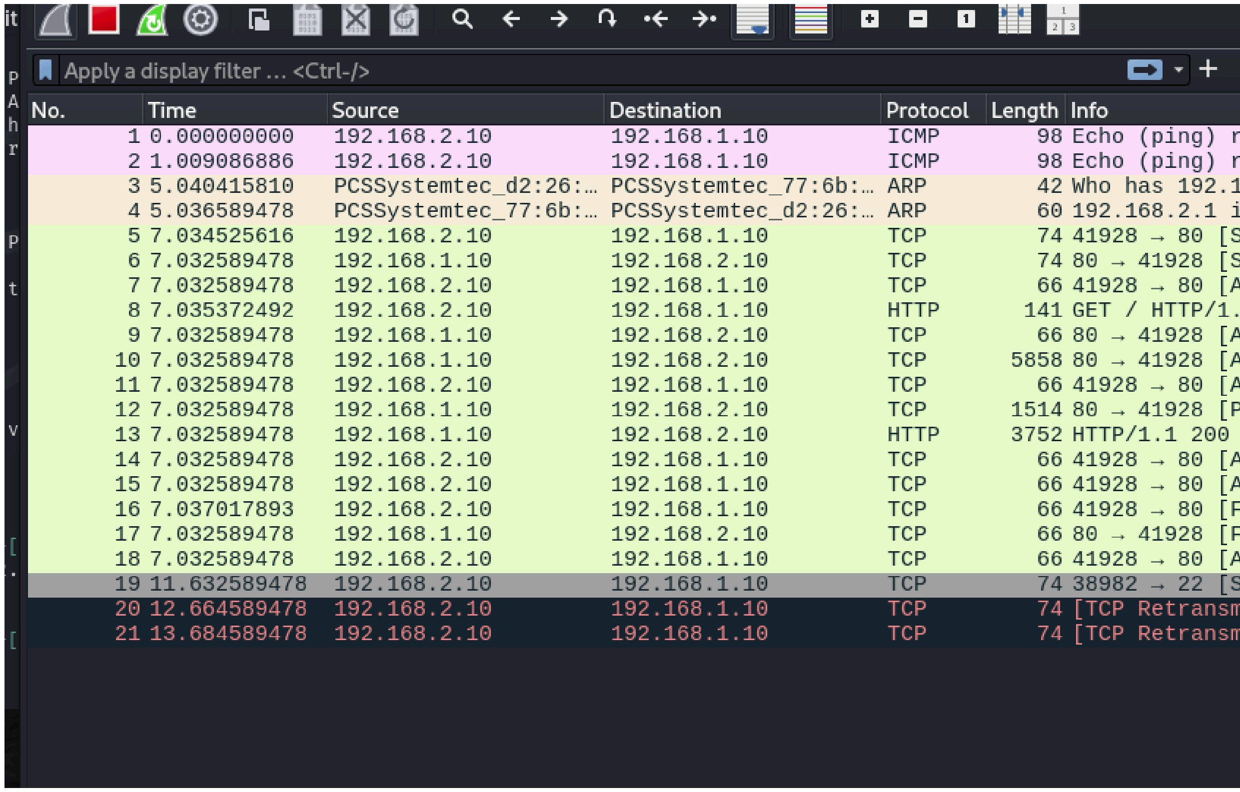
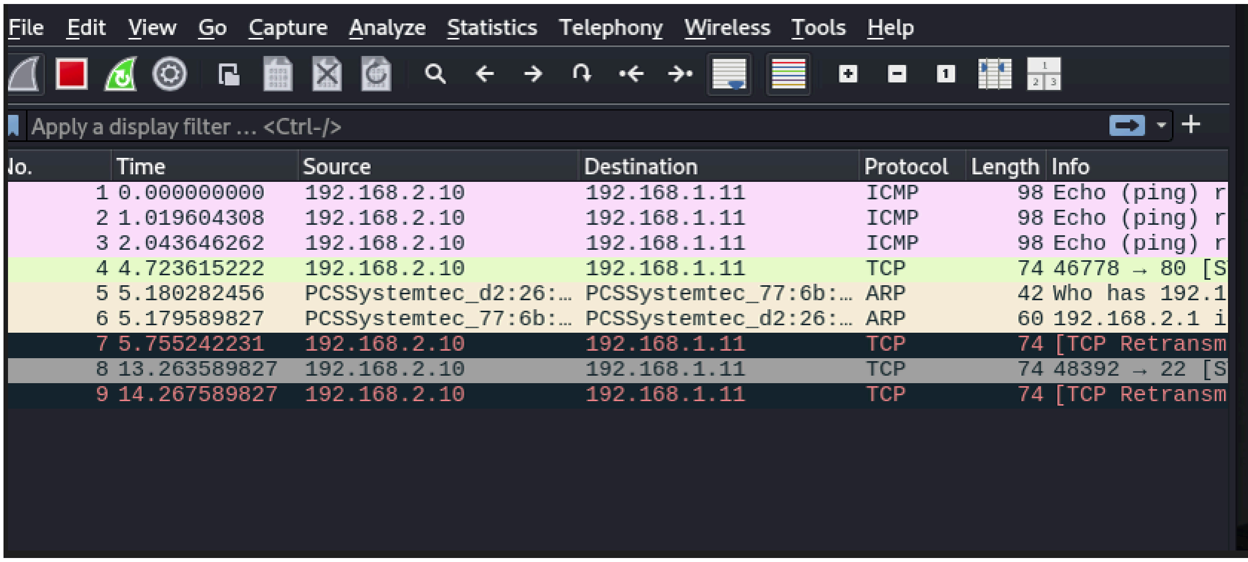
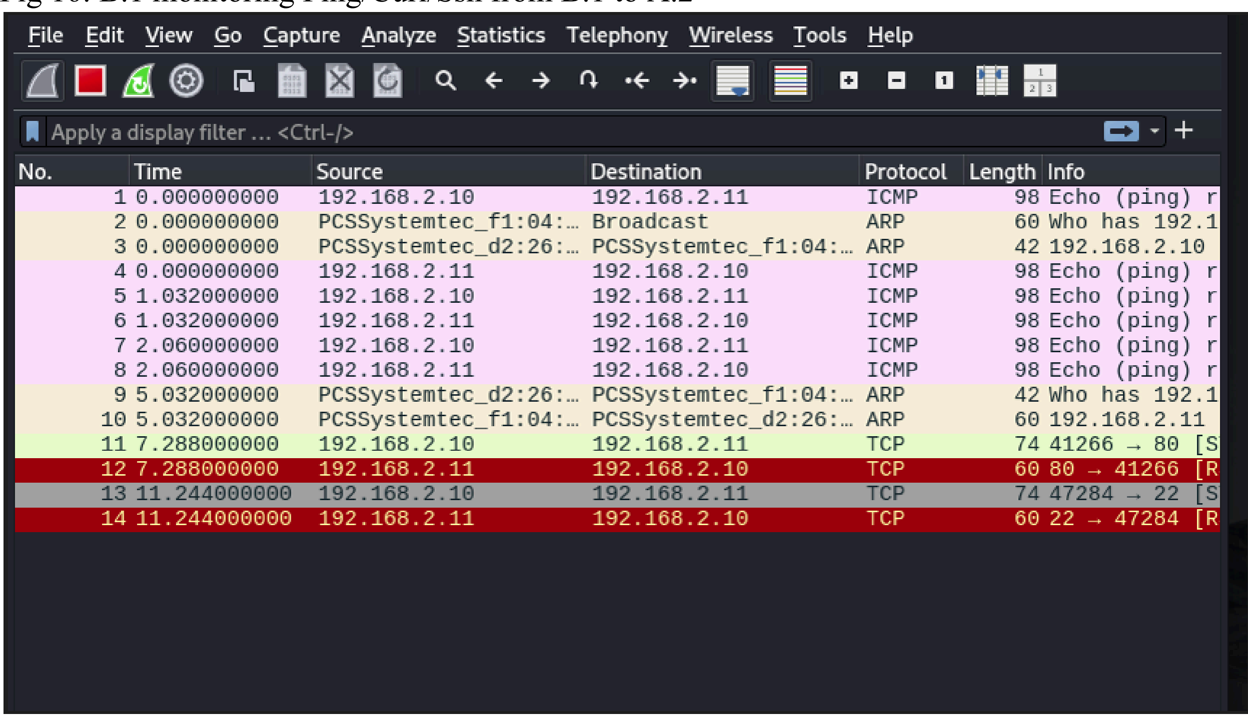
a. 

Fig 15: B.1 Monitoring B.1 ping/curl/ssh to A.1 post internal firewall update

b. 

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	192.168.2.10	192.168.1.11	ICMP	98	Echo (ping) r
2	1.019604308	192.168.2.10	192.168.1.11	ICMP	98	Echo (ping) r
3	2.043646262	192.168.2.10	192.168.1.11	ICMP	98	Echo (ping) r
4	4.723615222	192.168.2.10	192.168.1.11	TCP	74	46778 → 80 [S
5	5.180282456	PCSSystemtec_d2:26:…	PCSSystemtec_77:6b:…	ARP	42	Who has 192.1
6	5.179589827	PCSSystemtec_77:6b:…	PCSSystemtec_d2:26:…	ARP	60	192.168.2.1 i
7	5.755242231	192.168.2.10	192.168.1.11	TCP	74	[TCP Retransm
8	13.263589827	192.168.2.10	192.168.1.11	TCP	74	48392 → 22 [S
9	14.267589827	192.168.2.10	192.168.1.11	TCP	74	[TCP Retransm

Fig 16: B.1 monitoring Ping/Curl/Ssh from B.1 to A.2



No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	192.168.2.10	192.168.2.11	ICMP	98	Echo (ping) r
2	0.000000000	PCSSystemtec_f1:04:…	Broadcast	ARP	60	Who has 192.1
3	0.000000000	PCSSystemtec_d2:26:…	PCSSystemtec_f1:04:…	ARP	42	192.168.2.10
4	0.000000000	192.168.2.11	192.168.2.10	ICMP	98	Echo (ping) r
5	1.032000000	192.168.2.10	192.168.2.11	ICMP	98	Echo (ping) r
6	1.032000000	192.168.2.11	192.168.2.10	ICMP	98	Echo (ping) r
7	2.060000000	192.168.2.10	192.168.2.11	ICMP	98	Echo (ping) r
8	2.060000000	192.168.2.11	192.168.2.10	ICMP	98	Echo (ping) r
9	5.032000000	PCSSystemtec_d2:26:…	PCSSystemtec_f1:04:…	ARP	42	Who has 192.1
10	5.032000000	PCSSystemtec_f1:04:…	PCSSystemtec_d2:26:…	ARP	60	192.168.2.11
11	7.288000000	192.168.2.10	192.168.2.11	TCP	74	41266 → 80 [S
12	7.288000000	192.168.2.11	192.168.2.10	TCP	60	80 → 41266 [R
13	11.244000000	192.168.2.10	192.168.2.11	TCP	74	47284 → 22 [S
14	11.244000000	192.168.2.11	192.168.2.10	TCP	60	22 → 47284 [R

Fig 17: B.1 monitoring ping/curl/ssh from B.1 to B.2

3. *What Web Services are Allowed Between Computers?*
    a. After implementing all of the security policies in the project, including Task VI, the web services between the machines continue to follow the Access Control Matrix, with Ubuntu Server A.1 being the only machine providing web services through ports 80 and 443 for HTTP and HTTPS, respectively. Those web services are only accessible to machines in Network B as per the security guidelines. The XP workstation can still access internal and external web services while still being restricted from hosting its own, the same as the Network B machines.

4. *Share the Differences Between the Scans from Task V and VI*
    a. We did not find any significant differences between the scans from Task V and Task VI
5. *A.1 Security Policy Discussion*
    a. Assuming that the company only stores classified business data in A.1, our team agreed that it is reasonably secure but can still be improved. There is a potential vulnerability with the XP Workstation A.2 machine that could become a possible weak link in the system. Since A.2 has access to internal and external web services, it can act as a bridge between the sensitive information on machine A.1 in Network A and the open internet with the external machines in Network B. A malicious actor could exfiltrate data, taking sensitive information from the internal network and funneling it to the external networking, sharing secrets from a private machine to the World Wide Web. Staying with the idea of a malicious actor using A.2 as a "bridge", an attacker who gains access to A.1 has the ability to explore it and compromise the other machine on the network, A.1, which can be used to bypass the firewall rules set up between Networks A and B.

Section V - Conclusion

1. *What We Learned*

    The project went smoothly and taught us a great deal about working with different operating systems in VMware and setting up a virtual sandbox for practice. Learning to manage the specific requirements of various machines, such as not assigning too much memory or CPU cores to older Windows operating systems, was an important lesson that will help us configure machines more efficiently in the future. The pfSense router tool proved to be extremely useful, allowing us to create a network setup that mimics the behavior of real-world separate networks. This provided an ideal environment to test and apply different firewall rules, as well as simulate attacks to observe their effects. By experimenting with firewall rules, we were able to see how they impacted connectivity in real time. Our main goal was to complete the project efficiently and correctly, while gaining a full understanding of the benefits of creating a virtual environment like this. It was a great refresher on using different operating systems and a fun introduction to deeper concepts in computer security.

2. *Obstacles We Overcame*

    Although there were only a few obstacles, we did encounter some challenges when setting up the machines and router. For the Windows machines, both required a specific amount of RAM and CPU cores to function correctly, which took a combination of internet research and trial-and-error to solve. We also had significant trouble getting Windows 95 to install correctly until we were able to properly install the patch. Once all the machines were up and running, the rest of the process went smoothly until after we applied the first round of firewall rules on pfSense. The external network, for some reason, was unable to access A.1's web service, despite A.1 being able to ping both machines on the external network. We eventually discovered that the issue was caused by the incorrect order of the firewall rules. After rearranging the rules to ensure they applied in the correct sequence, the web service began functioning properly, everything worked as expected, and we were able to finish up with the rest of the tasks of Project-1.