Lab 04: Network Reconnaissance & Firewall Evasion

Course: Cyber Defense
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1. Lab Overview & Objectives

In this lab, students explored the Reconnaissance and Evasion phases of the cyber kill chain from the perspective of an external attacker on the WAN. After executing offensive operations, students switched roles to the Blue Team to detect and analyze these activities using firewall logs and Snort IDS.

Lab Goals

1. **Preparation:** Configure the open-source firewall to simulate a realistic, semi-restricted DMZ environment.
2. **Reconnaissance:** Perform port scanning and banner grabbing to identify entry points and service versions.
3. **Evasion:** Execute SSH tunneling (port forwarding) to bypass firewall rules and access blocked internal services via a compromised DMZ host as a pivot.
4. **Defense:** Analyze firewall logs and configure Snort on the IAM server to detect intrusive traffic.

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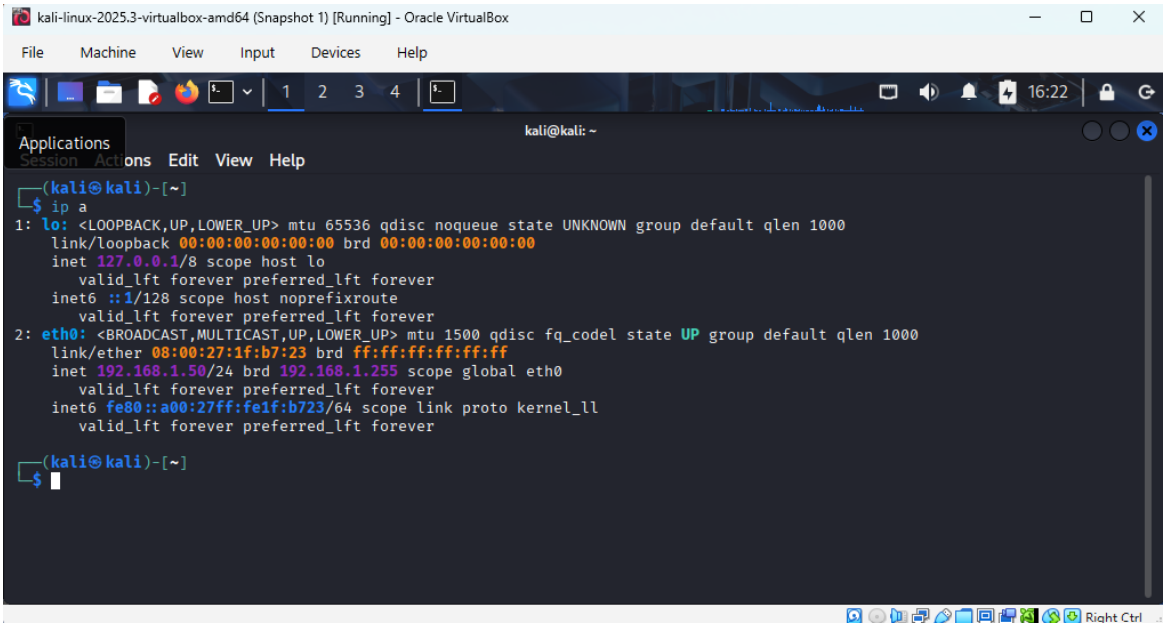
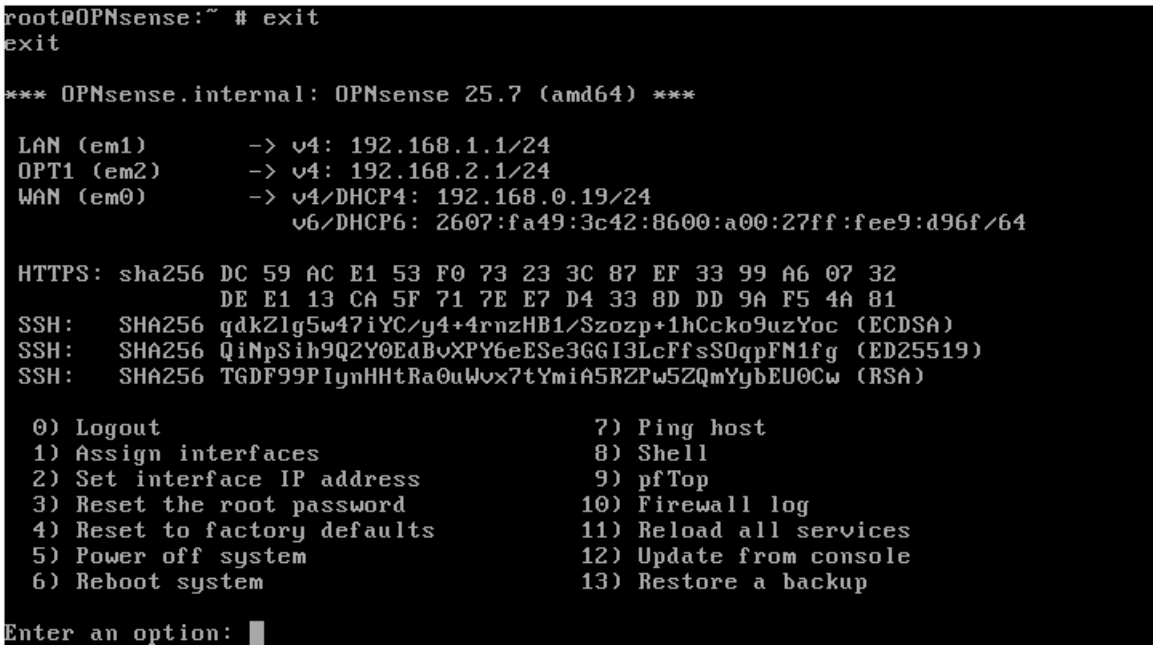
2. Infrastructure Overview

The lab environment consisted of the following topology:

- **Attacker (WAN):** Kali Linux, bridged to student home network, acting as external attacker.



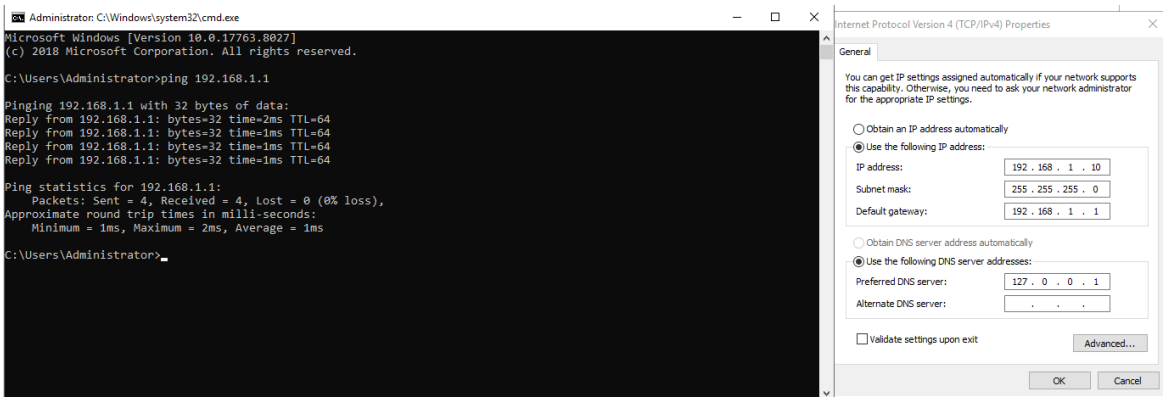
- **Firewall:** Open-source firewall (OPNsense) with WAN, LAN, and DMZ interfaces.



- **DMZ Target:** Metasploitable / Web Server at IP `192.168.2.10`.

```
msfadmin@metasploitable:~$ ip a
1: lo: <LOOPBACK> mtu 16436 qdisc noop
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast qlen 1000
    link/ether 08:00:27:4e:5e:07 brd ff:ff:ff:ff:ff:ff
    inet 192.168.2.10/24 brd 192.168.2.255 scope global eth0
    inet6 fe80::a00:27ff:fe4e:5e07/64 scope link
       valid_lft forever preferred_lft forever
msfadmin@metasploitable:~$
```

- **LAN Target:** IAM Server (Windows Server 2019 / Active Directory DC) at IP `192.168.1.10`, with RDP (TCP 3389) enabled.



This architecture simulates a typical enterprise network where external traffic can only reach selected DMZ services, and direct WAN→LAN access is blocked by firewall policy.

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3. Phase 0: Firewall Configuration & Baseline

3.1 DMZ Ingress Rules (WAN → DMZ)

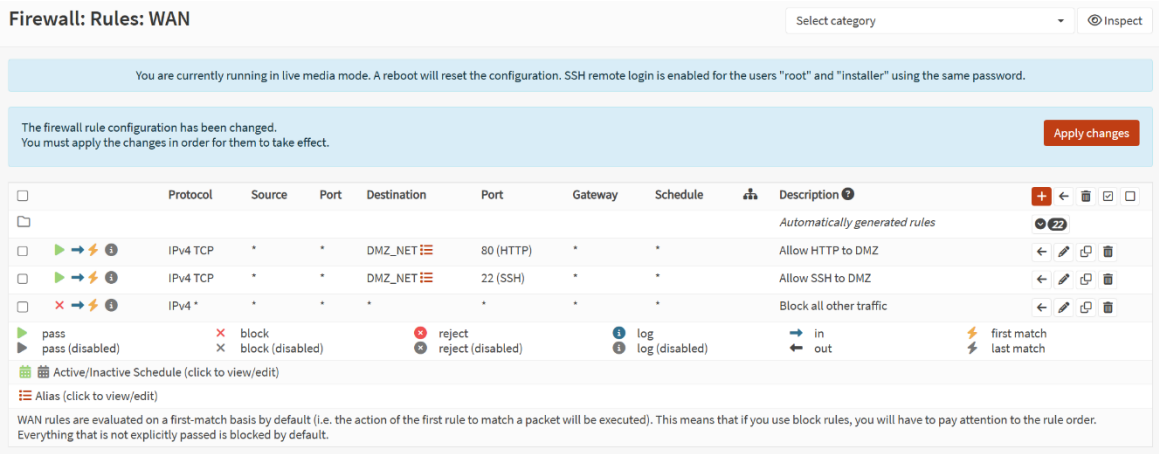
Objective: Allow public access to web and SSH services on the DMZ while blocking all other traffic.

Configuration Steps:

1. Logged into firewall WebGUI.
2. Navigated to: `Firewall → Rules → WAN`.
3. Created and verified the following rules:

Rule	Action	Protocol	Source	Destination	Port	Purpose
A	Pass	IPv4 TCP	Any	DMZ Net	80	Allow HTTP
B	Pass	IPv4 TCP	Any	DMZ Net	22	Allow SSH
C	Block	IPv4 TCP	Any	DMZ Net	All	Default deny

4. Applied changes and verified active rules in the WebGUI.



3.2 LAN Isolation (WAN → LAN Blocked)

Objective: Ensure no direct traffic from WAN reaches the internal LAN.

Verification Steps:

1. Confirmed under `Firewall → Rules → WAN` that **no** rules permit traffic from WAN to LAN network (192.168.1.0/24).
2. From the Attacker machine (Kali), executed tests:

ping 192.168.1.10
nmap -sS -Pn 192.168.1.10

3. Both ICMP echo and TCP SYN scan timed out or were silently dropped, confirming firewall enforcement.

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4. Phase A: Port Scanning (Reconnaissance)

4.1 TCP SYN Scan for Open Ports

Objective: Identify which TCP ports are reachable on the DMZ server (192.168.2.10).

Command (on Kali):

nmap -sS -Pn 192.168.2.10

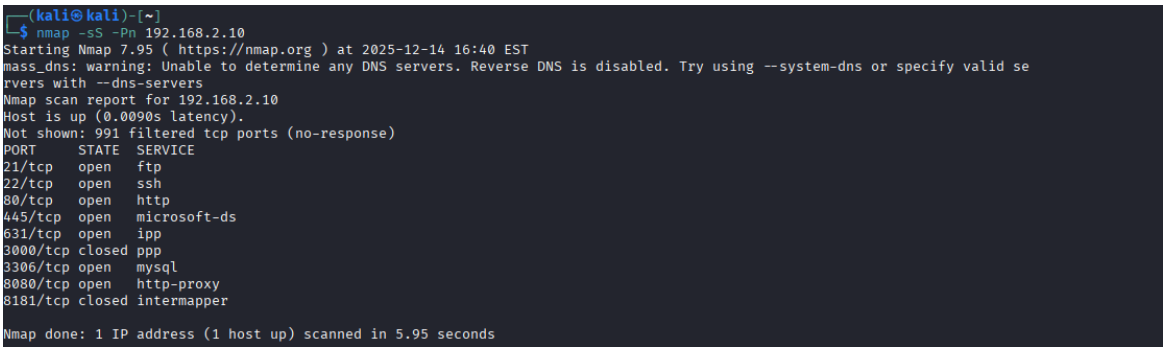
Parameter Explanation:

- `-sS`: TCP SYN (stealth) scan – does not complete three-way handshake.
- `-Pn`: Assume host is online, skip ICMP ping.

Results Observed:

Port	State	Service
21/tcp	open	ftp
22/tcp	open	ssh
80/tcp	open	http
445/tcp	open	microsoft-ds
631/tcp	open	ipp
3306/tcp	open	mysql
8080/tcp	open	http-proxy
3000/tcp	closed	ppp
8181/tcp	closed	intermapper

This scan revealed that SSH (port 22) is publicly accessible, making it a viable entry point for tunneling.



4.2 Service Version Detection

Objective: Determine exact service versions to identify potential vulnerabilities.

Command:

nmap -sV -p 22,80 192.168.2.10

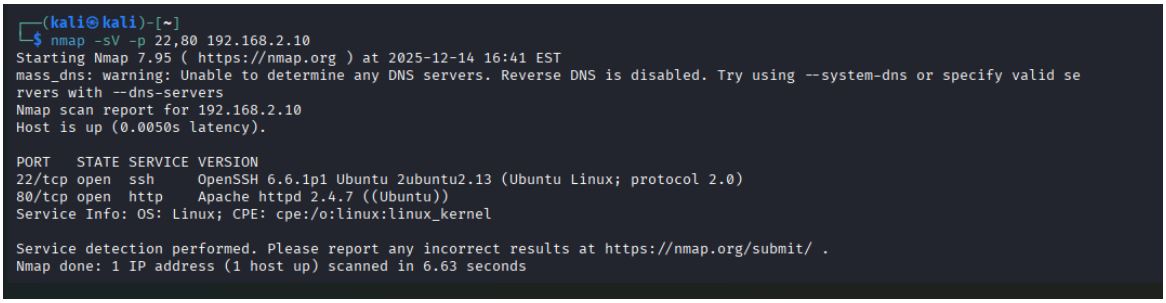
Parameter Explanation:

- `-sV`: Probe open ports to determine service and version information.
- `-p 22,80`: Limit scanning to SSH and HTTP ports for clarity.

Results Observed:

Port	State	Service	Version
22/tcp	open	ssh	OpenSSH 6.6.1p1 Ubuntu 2ubuntu2.13
80/tcp	open	http	Apache httpd 2.4.7 (Ubuntu)

Analysis: The service versions disclosed indicate Ubuntu Linux as the underlying OS. This information helps an attacker select appropriate exploits or brute-force techniques specific to OpenSSH 6.6.1p1 or Apache 2.4.7.



4.3 Optional: UDP Port Scan

Command:

nmap -sU --top-ports 20 192.168.2.10

Rationale: UDP services are sometimes less strictly filtered. This scan probes the 20 most common UDP ports.

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5. Phase B: Banner Grabbing (Service Fingerprinting)

5.1 SSH Banner via Netcat

Objective: Manually retrieve the SSH service banner to confirm version and gather additional system information.

Command (Kali):

nc -v 192.168.2.10 22

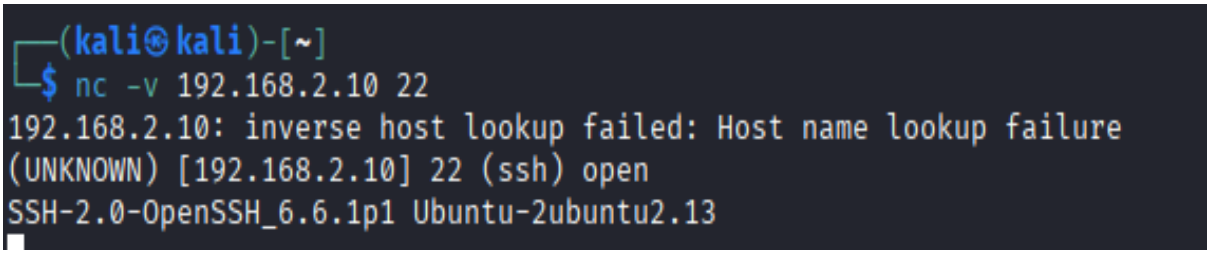
Expected Output (example):

Connection to 192.168.2.10 22 port [tcp/ssh] succeeded!
SSH-2.0-OpenSSH_6.6.1p1 Ubuntu-2ubuntu2.13

Analysis: The banner string reveals:

- SSH protocol version 2.0
- OpenSSH version 6.6.1p1
- Operating system: Ubuntu (2ubuntu2.13 patch level)

This precise information is valuable for exploit selection and vulnerability assessment.

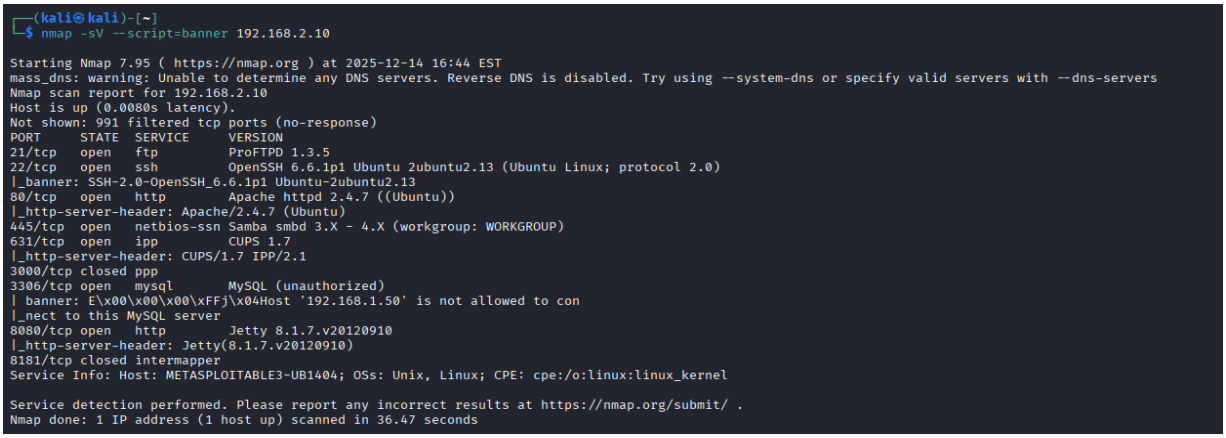


5.2 Automated Banner Grabbing via Nmap NSE

Command:

nmap -sV --script=banner 192.168.2.10

Purpose: Nmap's NSE (Nmap Scripting Engine) automates banner retrieval across multiple services and ports simultaneously.



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6. Phase C: SSH Tunneling (Firewall Evasion)

6.1 Scenario & Goal

Scenario:

- Firewall allows WAN → DMZ SSH (port 22).
- Firewall blocks WAN → LAN entirely.
- Intelligence (from scanning) confirms an RDP service on LAN at 192.168.1.10:3389.

Goal: Use SSH access to DMZ as a jumping-off point (pivot) to tunnel RDP traffic to the internal server.

6.2 Establish Local Port Forwarding

Command (Kali – Terminal 1):

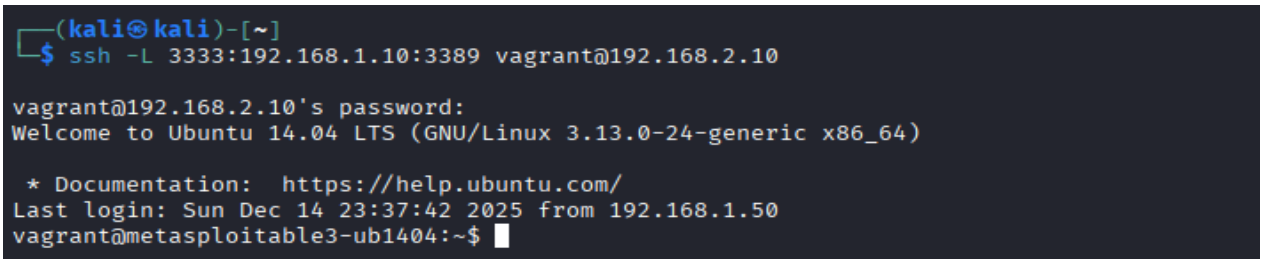
ssh -L 3333:192.168.1.10:3389 vagrant@192.168.2.10

Parameter Breakdown:

- `-L 3333:192.168.1.10:3389`: Local port forwarding.
  - `3333`: Listen port on attacker's Kali machine.
  - `192.168.1.10:3389`: Target destination (IAM Server LAN IP : RDP port).
  - vagrant`@192.168.2.10`: SSH user and DMZ jump host.

Execution Flow:

1. SSH connection established to DMZ server.
2. Prompted for password (default for Metasploitable3: vagrant).
3. After authentication, the terminal receives a shell prompt on the DMZ server.
4. The SSH tunnel remains active in the foreground; data sent to `127.0.0.1:3333` on Kali is tunneled through this session to `192.168.1.10:3389` on the LAN.



6.3 Verify Tunnel Establishment

Command (Kali – Terminal 2):

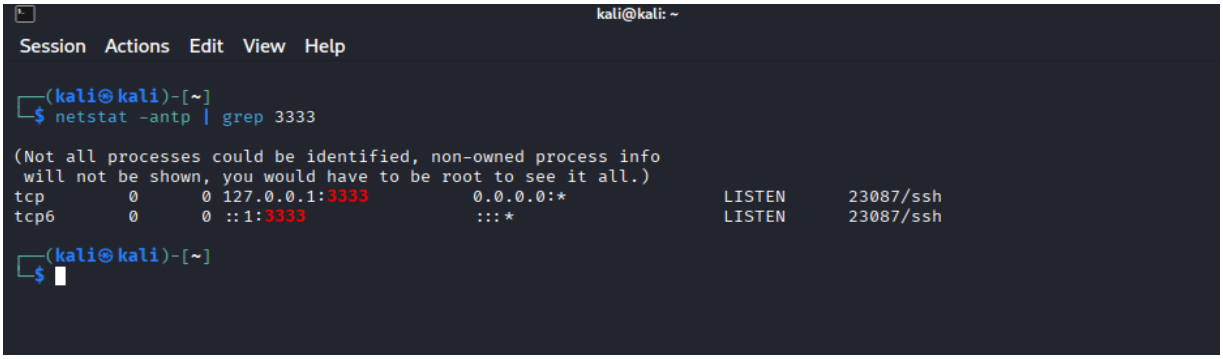
netstat -antp | grep 3333

Expected Output:

tcp 0 0 127.0.0.1:3333 0.0.0.0:* LISTEN 1234/ssh

Interpretation:

- Confirms that Kali is listening on port 3333.
- Process owner is `ssh`, indicating the tunnel is active.
- Traffic on 3333 is bound to 127.0.0.1 (localhost only) and will be forwarded to 192.168.1.10:3389 via the SSH tunnel.



6.4 RDP Connection Over Tunnel

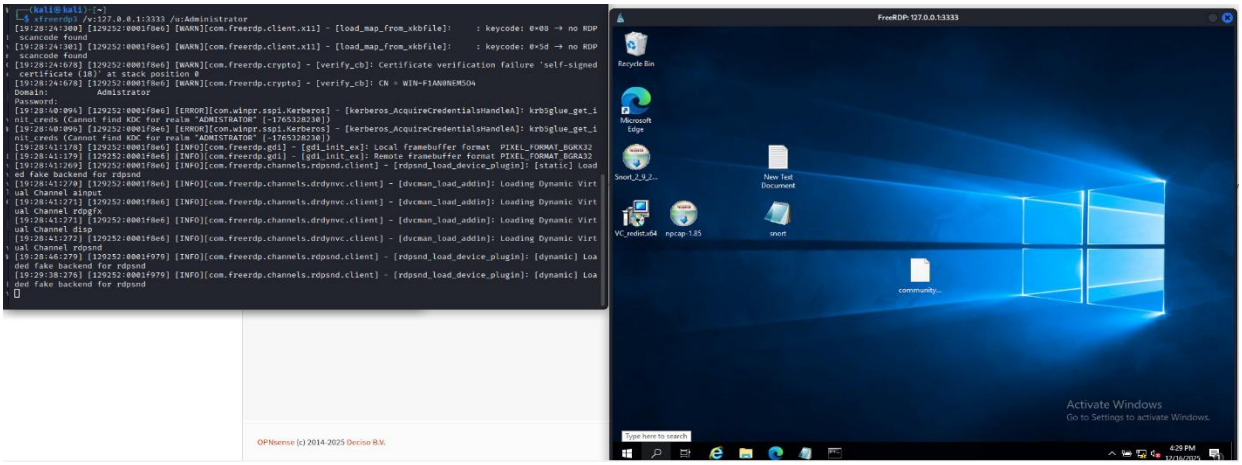
Command (Kali):

xfreerdp3 /v:127.0.0.1:3333 /u:Administrator

Execution:

1. RDP client connects to localhost on port 3333.
2. Kali forwards the RDP traffic through the SSH tunnel.
3. DMZ server (192.168.2.10) receives the tunneled RDP traffic and forwards it to IAM Server (192.168.1.10:3389).
4. The firewall observes SSH traffic from WAN to DMZ (allowed).
5. RDP traffic to LAN is encapsulated within SSH and therefore bypasses the WAN→LAN block.

Result: The RDP login window appears, showing the IAM Server desktop despite the firewall's WAN→LAN restriction.



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7. Phase D: Defense (Blue Team)

7.1 Detecting Port Scanning via Firewall Logs

Objective: Identify scanning activities in firewall logs.

Steps:

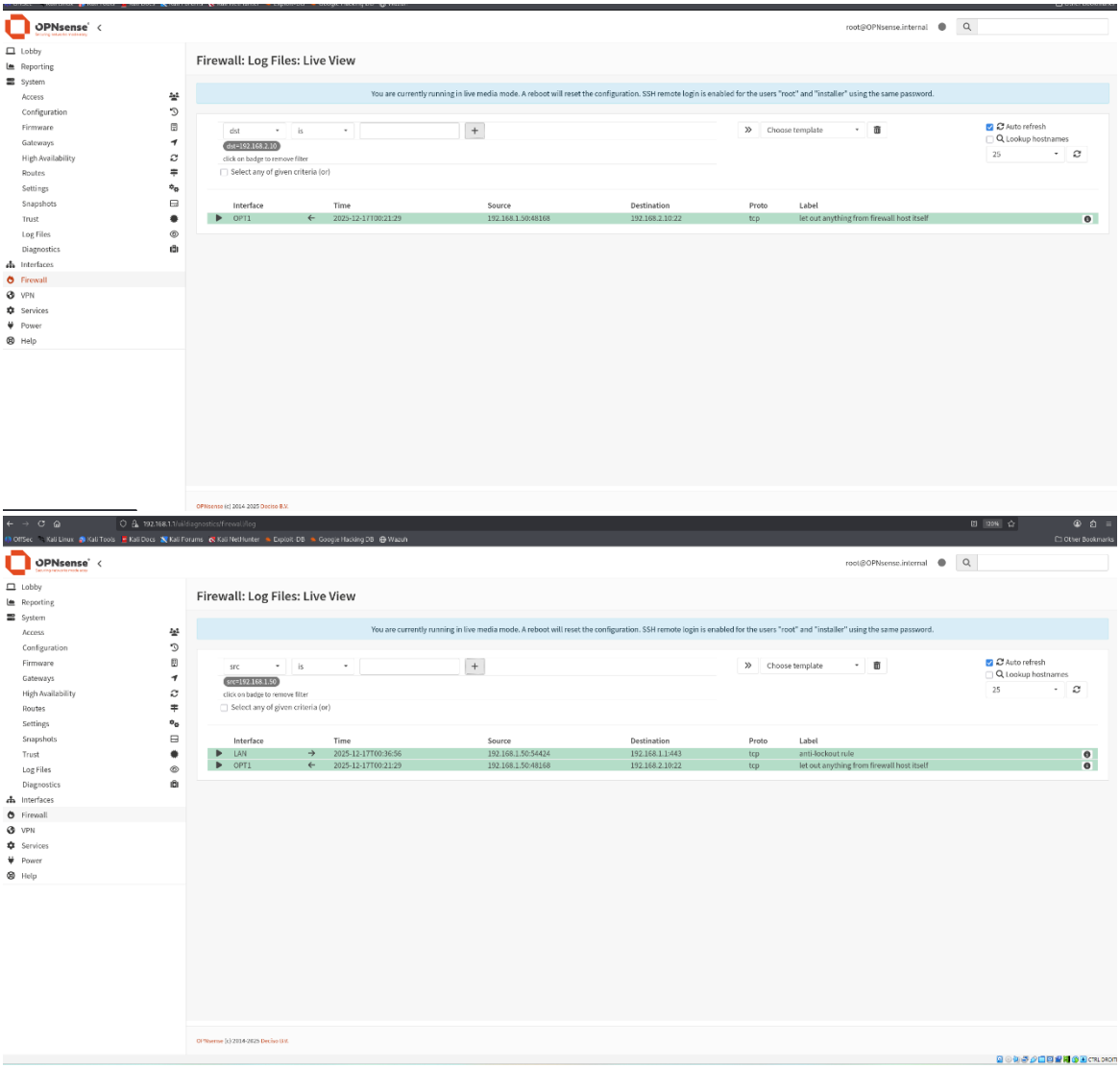
1. Logged into firewall WebGUI.
2. Navigated to: `Status → System Logs → Firewall → Normal View`.
3. Filtered logs by attacker IP address (Kali's WAN IP).
4. Analyzed the log entries.

Observations:

During the Nmap SYN scan, the firewall logged numerous **Blocked (Deny)** entries (often displayed as red X symbols) for ports that were not explicitly allowed (i.e., not 80 or 22). These entries correspond to:

- Nmap probing random/sequential ports.
- The firewall silently dropping packets for ports without an allow rule.
- A characteristic "noise signature" of a port scan.

Interpretation: Multiple denied attempts from a single source targeting various ports is a classic indicator of reconnaissance activity.



7.2 Configuring Snort on IAM Server

Objective: Deploy Snort IDS to detect suspicious RDP access from the DMZ.

7.2.1 Snort Installation Verification

Confirmed that Snort is installed in `C:\Snort` on the IAM Server (192.168.1.10).

7.2.2 Network Variable Configuration

File: `C:\Snort\etc\snort.conf`

Configuration Added:

Setup the network addresses you are protecting

ipvar HOME_NET 192.168.1.10

Set up the external network addresses

ipvar EXTERNAL_NET any

Rationale:

- `HOME_NET`: Defined as the IAM Server itself (192.168.1.10).
- `EXTERNAL_NET`: Set to "any" to monitor traffic from all sources.

7.2.3 Rule Paths Verification

Verified that rule include paths in `snort.conf` point to `C:\Snort\rules` for proper rule loading.

7.3 Creating a Detection Rule

Objective: Write a Snort rule to alert on RDP traffic originating from the DMZ network.

File: `C:\Snort\rules\local.rules`

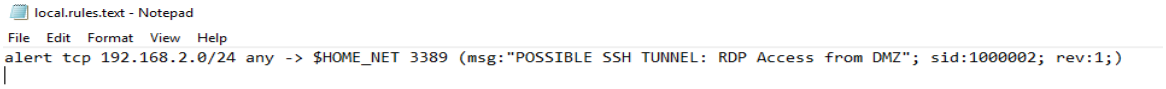
Rule Added:

alert tcp 192.168.2.0/24 any -> $HOME_NET 3389
(msg:"POSSIBLE SSH TUNNEL: RDP Access from DMZ"; sid:1000002; rev:1;)

Rule Explanation:

Component	Value	Purpose
`alert`	–	Generate alert when rule matches
`tcp`	–	Match TCP protocol
`192.168.2.0/24`	Source	DMZ network (CIDR notation)
`any`	Source Port	Any source port
`->`	Direction	Unidirectional (source → destination)
$HOME_NET	Destination	IAM Server (192.168.1.10)
`3389`	Dest Port	RDP protocol port
`msg:`	–	Human-readable alert message
`sid:`	1000002	Unique signature ID
`rev:`	1	Rule revision number

Security Rationale: In a secure environment, RDP should only originate from trusted admin subnets, not from a public-facing DMZ server. Any RDP traffic from DMZ to IAM is highly suspicious and likely indicates a compromised pivot point or tunnel.



7.4 Running Snort and Triggering the Alert

Snort Execution (on IAM Server – Run as Administrator):

1. Opened Command Prompt as Administrator.
2. Navigated to Snort binary directory:

cd C:\Snort\bin

3. Determined the correct interface number:

snort -W

(Example output: Interface 1 = Ethernet, etc.)

4. Started Snort in IDS mode with console alerting:

snort -i 1 -A console -c C:\Snort\etc\snort.conf -l C:\Snort\log -K ascii

Parameter Explanation:

- `-i 1`: Listen on interface 1 (LAN adapter).
- `-A console`: Output alerts to console in real-time.
- `-c C:\Snort\etc\snort.conf`: Use the configuration file with our custom rule.
- `-l C:\Snort\log`: Log packets and alerts to this directory.
- `-K ascii`: Log in ASCII format (human-readable).

Snort Status: Snort initialized successfully, displayed rules loaded count, and entered packet processing mode.

7.5 Triggering and Observing the Alert

Procedure:

1. While Snort was running on the IAM Server, returned to the Kali attacker machine.
2. Re-established the SSH tunnel (Terminal 1):

ssh -L 3333:192.168.1.10:3389 vagrant@192.168.2.10

3. Initiated RDP connection over the tunnel (Terminal 2):

xfreerdp /v:127.0.0.1:3333 /u:Administrator

4. Once RDP session established, observed the Snort console on the IAM Server.

Alert Triggered:

[] [1:1000002:1] POSSIBLE SSH TUNNEL: RDP Access from DMZ []
{TCP} 192.168.2.10:XXXXX -> 192.168.1.10:3389

Interpretation:

- Snort matched the rule condition: TCP traffic from DMZ subnet (192.168.2.10) to HOME_NET (192.168.1.10) on port 3389.
- Alert flagged the suspicious RDP connection as a potential SSH tunnel attack.
- This demonstrates successful detection of evasion tactics.

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8. Key Findings & Analysis

8.1 Reconnaissance Effectiveness

Port scanning and banner grabbing successfully mapped the target environment:

- Identified open services (SSH, HTTP, etc.).
- Determined exact service versions and OS type.
- Provided sufficient intelligence to select SSH as an entry point.

8.2 Evasion Success

SSH local port forwarding proved effective in bypassing firewall restrictions:

- Firewall allowed SSH to DMZ (policy-compliant).
- RDP traffic was encapsulated within SSH (transparent to firewall rules).
- Direct WAN→LAN access remained blocked, but was circumvented via pivot.

8.3 Defense Detection

Layered defense mechanisms successfully identified attack activities:

- **Firewall Logs:** Detected reconnaissance noise from port scanning.
- **Snort IDS:** Detected suspicious RDP access pattern inconsistent with normal operations.
- **Combined Analysis:** Traces of attacker activity visible at multiple layers.

8.4 Security Lessons

1. **Defense in Depth:** A single firewall rule cannot stop sophisticated attackers; IDS complements perimeter controls.
2. **Pivot Risk:** Compromised DMZ hosts can become pathways to internal networks via tunneling.
3. **Suspicious Pattern Recognition:** RDP from a DMZ web server is inherently anomalous and should trigger alerts.
4. **Monitoring & Logging:** Without logs and IDS rules, the attack would have succeeded silently.

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9. Recommendations

1. **Network Segmentation:** Implement more granular firewall rules; restrict SSH to specific admin IPs if possible.
2. **Host-Based Security:** Deploy endpoint detection and response (EDR) on DMZ servers to monitor outbound SSH tunnel activity.
3. **IDS Tuning:** Expand Snort rules to detect SSH tunneling signatures (anomalous SSH session patterns).
4. **Access Controls:** Use multi-factor authentication (MFA) on RDP and limit RDP accessibility to VPN or jump servers.
5. **Incident Response:** Establish procedures to respond to alerts (e.g., disconnect suspicious sessions, isolate hosts).

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10. Conclusion

This lab demonstrated the complete attack-defense lifecycle:

- **Offensive Phase:** Reconnaissance and evasion techniques enabled an external attacker to achieve unauthorized internal access despite firewall restrictions.
- **Defensive Phase:** Logs and IDS rules provided visibility into attack stages and enabled detection of suspicious activity.

The success of this lab illustrates that security is not achieved through a single control but through **defense in depth**, combining network perimeter security, intrusion detection, log analysis, and incident response procedures. Organizations must continuously monitor for indicators of compromise and maintain updated security rules to defend against evolving threats.

Appendix A: Command Reference

Phase	Command	Purpose
Scanning	`nmap -sS -Pn 192.168.2.10`	Identify open TCP ports
Scanning	`nmap -sV -p 22,80 192.168.2.10`	Detect service versions
Banner Grab	`nc -v 192.168.2.10 22`	Retrieve SSH banner
Evasion	ssh -L 3333:192.168.1.10:3389 vagrant@192.168.2.10	Establish SSH tunnel
Verification	`netstat -antp | grep 3333`	Confirm tunnel listening
Evasion	`xfreerdp /v:127.0.0.1:3333 /u:Administrator`	Access RDP over tunnel
Detection	Firewall: Status → System Logs → Firewall	Review firewall logs
Detection	`snort -i 1 -A console -c C:\Snort\etc\snort.conf -l C:\Snort\log -K ascii`	Run Snort IDS

Appendix B: Screenshot Checklist

- [ ] Screenshot 1: Network Topology Diagram
- [ ] Screenshot 2: Firewall WAN Rules (A, B, C)
- [ ] Screenshot 3: Failed ping/Nmap to 192.168.1.10
- [ ] Screenshot 4: `nmap -sS -Pn 192.168.2.10` output
- [ ] Screenshot 5: `nmap -sV -p 22,80 192.168.2.10` output
- [ ] Screenshot 6: UDP scan output (if performed)
- [ ] Screenshot 7: Netcat SSH banner output
- [ ] Screenshot 8: `nmap -sV --script=banner` output
- [ ] Screenshot 9: SSH tunnel established (Terminal 1)
- [ ] Screenshot 10: netstat LISTEN on port 3333
- [ ] Screenshot 11: RDP window/Desktop via tunnel
- [ ] Screenshot 12: Firewall logs showing port scan blocks
- [ ] Screenshot 13: snort.conf network variable configuration
- [ ] Screenshot 14: local.rules with RDP detection rule
- [ ] Screenshot 15: Snort startup and running
