

Project Report
On
Network Traffic Analysis Using
Wireshark and Zeek

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Abstract

This project demonstrates how to capture, analyze, and interpret network traffic using **Wireshark** (packet-level analysis) and **Zeek** (network security monitoring and structured logs). The report covers lab setup, ARP spoofing (MITM), capturing protocol-level plaintext leaks (HTTP, Telnet, SMTP), DHCP/DNS analysis, and how to correlate Zeek logs with Wireshark packet captures. The goal is to illustrate vulnerabilities in unencrypted protocols, compare manual packet inspection vs automated log analysis, and propose mitigation strategies.

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1. Introduction

Network traffic analysis is essential to understand how data moves across networks and to detect security weaknesses. Packet-level tools (Wireshark) let investigators inspect exact bytes on the wire, while network monitoring platforms (Zeek) convert traffic into structured logs that are easier to query and ingest into analytics systems.

This project replicates common insecure scenarios (ARP spoofing, unencrypted login, SMTP without STARTTLS, DHCP vulnerabilities) in a controlled lab and demonstrates detection and analysis using both Wireshark and Zeek.

2. Objectives

- Capture live network traffic in a controlled environment.
 - Demonstrate ARP spoofing (Man-in-the-Middle) and inspect resulting traffic.
 - Capture and identify plaintext credentials from HTTP and Telnet.
 - Observe SMTP traffic before and after STARTTLS negotiation.
 - Capture DHCP DORA process and explain its vulnerabilities.
 - Use Zeek to produce structured logs and show how it helps detect the same events.
 - Produce recommendations for securing the network.
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3. Tools and Technologies

- **Wireshark** - packet capture and GUI analysis (<https://www.wireshark.org>)
 - **Zeek** - network security monitor that produces logs (<https://zeek.org>)
 - **Linux (Ubuntu / Kali)** - attacker machine for ARP spoofing and running tools
 - **arpspoof / ettercap / Bettercap** - tools to perform ARP poisoning
 - **tcpdump** - command-line packet capture (optional for large captures)
 - **VirtualBox / VMware** - to create isolated lab VMs
 - **Optional:** ELK stack (Elasticsearch, Logstash, Kibana) or Brim/Zeek-Cluster for log visualization
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4. Lab Topology and Environment

Topology: - Victim VM (Windows or Linux) — 192.168.56.101 - Router / Gateway (Virtual or physical) — 192.168.56.1 - Attacker VM (Ubuntu/Kali) — 192.168.56.102 (runs Wireshark & Zeek)

Network: All VMs are on the same host-only or NAT network so they can communicate without affecting production networks. Use snapshots so you can revert any changes.

Precautions: - Perform experiments on an isolated test network or sandbox to avoid impacting real users. - Use intentionally vulnerable testing sites (e.g., VulnWeb, Damn Vulnerable Web Application) for HTTP tests.

5. Methodology (Step-by-step)

5.1 Prepare VMs and Tools

1. Create three VMs: Victim, Router/Internet (can be simulated by host), Attacker.
2. Install Wireshark and Zeek on the attacker VM. Install arpspoof/ettercap for MITM.

5.2 ARP Spoofing (MITM)

1. Enable IP forwarding on attacker:

```
# Enable IP forwarding (temporary)
sudo sysctl -w net.ipv4.ip_forward=1

# To persist, edit /etc/sysctl.conf and set net.ipv4.ip_forward=1
```

1. Launch arpspoof (dsniff) or bettercap:

```
# Using arpspoof (dsniff package)
sudo arpspoof -i eth0 -t <Victim_IP>
<Router_IP> sudo arpspoof -i eth0 -t
<Router_IP> <Victim_IP>

# Using bettercap (modern alternative)
sudo bettercap -iface eth0 -eval "set arp.spoof.targets <Victim_IP>;
arp.spoof on"
```

1. Start Wireshark on the attacker's interface (**eth0**) to capture traffic.

5.3 Simulate Victim Activities

- Open vulnerable test site and log in (HTTP) to capture credentials.
- Use **telnet victim-server 23** or another service on victim to generate Telnet traffic.
- Send an SMTP session via **telnet smtp.example.com 587** (observe STARTTLS negotiation).
- Run **ipconfig /release** and **ipconfig /renew** to capture DHCP exchange.

5.4 Capture and Save PCAPs

- In Wireshark: **File -> Save As** capture.pcap
- Or use **tcpdump** :

```
sudo tcpdump -i eth0 -w capture.pcap
```

6. Wireshark: Capture & Analysis

6.1 Applying Filters

- ARP: **arp**
- HTTP: **http** or **tcp.port == 80**
- Telnet: **telnet** or **tcp.port == 23**
- SMTP: **smtp** or **tcp.port == 25 || tcp.port == 587 || tcp.port == 465**
- DHCP: **bootp** (DHCP uses BOOTP dissector)

6.2 Inspecting Packets

- Select a packet and expand protocol layers (Ethernet -> IP -> TCP -> HTTP).
- For HTTP POSTs, inspect the **Hypertext Transfer** section to see form fields and credentials if unencrypted.
- For Telnet, inspect the payload bytes (Telnet is plain text).
- For SMTP on port 587, look for **STARTTLS** command; traffic before TLS handshake is plaintext.

6.3 Examples (what to look for)

- **ARP spoofing evidence:** Repeated ARP replies, wrong MAC-to-IP mapping in ARP replies.
- **Credentials:** HTTP POST body with **username** and **password** fields.
AUTH LOGIN
- **SMTP:** and base64-encoded credentials before TLS.
- **DHCP:** DORA packets: Discover, Offer, Request, Ack – check offered gateway and DNS IPs.

7. Zeek: Installation, Running, and Log Analysis

7.1 Installing Zeek (Ubuntu)

```
# Add Zeek repository (example)
sudo apt update
sudo apt install -y zeek

# Alternatively, follow official build-from-source for latest version
```

7.2 Running Zeek on Live Interface

```
sudo zeek -i eth0 local
# or simply start zeek in manager mode if installed via packages
sudo zeekctl deploy
```

7.3 Processing PCAPs with Zeek

```
zeek -r capture.pcap
```

This generates structured logs in the current directory: **conn.log**, **smtp.log**, and others. **http.log**, **dns.log**, **ssl.log**

7.4 Key Zeek Logs

- **conn.log** — connection metadata (start time, duration, protocol, bytes, state). Useful to find

suspicious flows.

- **http.log** — HTTP requests and responses, URIs, user-agent; Zeek extracts fields rather than raw bytes.
- **smtp.log** — SMTP sessions, commands observed (but may not show full message bodies if encrypted).
- **dns.log** — DNS queries and responses.
- **dhcp.log** — DHCP transactions (if the DHCP analyzer is enabled).

7.5 Using Zeek Scripts for Detection

- Zeek ships with many scripts (policy scripts) to detect anomalies (e.g., **weird.log** for unusual events).
- You can write custom Zeek scripts to flag: plaintext credential patterns, repeated ARP anomalies, or suspicious DNS lookups.

Example simple script (detect HTTP POSTs containing login keywords):

```
# save as detect-login.zeek
@load base/protocols/http

event http_request(c: connection, method: string, original_URI: string,
unescaped_URI: string)
{
    if ( method == "POST" && /password|passwd|pwd/ in unescaped_URI )
        print fmt("Possible credential POST: %s %s", c$id$orig_h,
unescaped_URI);
}
```

Run Zeek loading script:

```
zeek -r capture.pcap detect-login.zeek
```

8. Correlating Wireshark & Zeek Findings

- Use timestamps and connection tuples (src IP, dst IP, src port, dst port) to map a Wireshark packet to a Zeek log entry.
- Example: A Wireshark packet with HTTP POST at timestamp **T** from **192.168.56.101:49152 -> 10.0.0.5:80** corresponds to a **http.log** entry in Zeek with identical tuple and timestamp range.
- Zeek helps reduce investigation time by surfacing suspicious flows; Wireshark provides byte-level evidence.

9. Results (Findings with example screenshots)

Note: Replace placeholder images with your own screenshots from your captures. Filenames are suggested and referenced in captions.

9.1 ARP Spoofing / MITM

- **Observation:** Attacker successfully poisoned ARP caches; victim traffic routed via attacker.
- **Evidence (Wireshark):** `arp` packets with forged MAC mappings and repeated gratuitous ARP replies.

Figure 1: ARP Spoofing capture showing forged ARP replies

- **Zeek evidence:** Look for unusual `weird.log` entries or unexpected traffic patterns from the victim to attacker.

9.2 HTTP Credential Capture

- **Observation:** HTTP POST requests reveal form data including username/password in plaintext.

Figure 2: Wireshark HTTP POST showing credentials in packet details

- **Zeek evidence:** `http.log` will show requested URI and often referer/user-agent. Zeek does not always log POST body by default, but can if scripted or if extracted via custom analyzers.

9.3 Telnet Plaintext Commands

- **Observation:** Telnet sessions show user commands and credentials unencrypted.

Figure 3: Telnet payload captured in Wireshark

- **Zeek evidence:** Telnet traffic appears in `conn.log` and `weird.log` (if configured). Extracting telnet payloads may require custom script or using `tcpdump` /Wireshark.

9.4 SMTP before STARTTLS

- **Observation:** SMTP session initiates in plaintext; if STARTTLS is not used, credentials or email content can be captured.

Figure 4: SMTP session capture showing AUTH command before TLS

- **Zeek evidence:** `smtp.log` may capture metadata. Watch for `AUTH` commands and absence of TLS handshake.

9.5 DHCP DORA

- **Observation:** DHCP Discover/Offer/Request/Ack broadcast messages; client accepts first offer and trusts server.

Figure 5: DHCP DORA exchange captured in Wireshark

- **Zeek evidence:** If DHCP parser enabled, check `dhcp.log` for the transaction and offered/assigned IPs.

10. Mitigation and Recommendations

- **Use encryption:** Replace Telnet with SSH, HTTP with HTTPS, and SMTP with SMTPS/STARTTLS.
- **Switch-level security:** Enable DHCP snooping, Dynamic ARP Inspection (DAI), and port security on managed switches.
- **Network segmentation:** Limit broadcast domains and restrict access to critical services.
- **Harden endpoints:** Ensure clients verify certificates, disable insecure protocols, and keep software up-to-date.
- **Monitoring & Alerting:** Deploy Zeek in production to produce logs feeding into SIEM/ELK and set alerts for suspicious events.
- **User awareness:** Train users not to use unsecured public Wi-Fi for sensitive activities.

11. Conclusion

This project showed how packet captures (Wireshark) and network logs (Zeek) complement each other: Wireshark provides definitive byte-level proof, while Zeek scales analysis to long-term monitoring and ingestion into analytics systems. The experiments reproduced typical vulnerabilities in unencrypted protocols and demonstrated concrete mitigations.

12. References

- Wireshark Documentation – <https://www.wireshark.org/docs/>
- Zeek – <https://zeek.org/>
- dsniiff / arpspoof – <https://www.monkey.org/~dugsong/dsniiff/>
- Bettercap – <https://www.bettercap.org/>

13. Appendix: Commands, Scripts, and Useful Tips

A. Useful Commands

```
# Enable IP forwarding
sudo sysctl -w net.ipv4.ip_forward=1

# Run arpspoof
sudo arpspoof -i eth0 -t 192.168.56.101 192.168.56.1
```

```
sudo arpspoof -i eth0 -t 192.168.56.1 192.168.56.101
```

```
# Capture with tcpdump  
sudo tcpdump -i eth0 -w capture.pcap
```

```
# Run Zeek on capture  
zeek -r capture.pcap
```

```
# Install Zeek on Debian/Ubuntu (package may  
vary) sudo apt update && sudo apt install zeek -y
```

```
# Save Wireshark filtered view: use File -> Export Specified Packets
```

B. Example Zeek script to detect HTTP POST with password in URI

```
# detect-login.zeek  
@load base/protocols/http  
  
event http_request(c: connection, method: string, original_URI: string,  
unescaped_URI: string)  
{  
    if ( method == "POST" && /password|passwd|pwd/ in unescaped_URI )  
        print fmt("Possible credential POST: %s %s", c$id$orig_h,  
unescaped_URI);  
}
```

C. Tips for capturing clean logs

- Stop background updates and other traffic on VMs to reduce noise.
- Use capture filters (BPF) in tcpdump if you only want specific ports:
`tcp port 80 or port 23 or port`
- Use timestamps consistently and sync VM clocks (e.g., `sudo ntpdate pool.ntp.org`).



