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ARP Spoofing in Action: An Ethical Approach to Network Security

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***Abstract* - ARP spoofing is a serious problem for network security. It allows hackers to trick a network by linking their own MAC address to a real device's IP address. This lets them steal, change, or block network traffic. Hackers can use this to launch attacks like Man in the Middle, session hijacking, and Denial of service. Old methods to detect ARP spoofing, like fixed IP-MAC lists and ICMP checks, do not work well in large or real-time systems. This paper suggests a smart way to find and stop ARP spoofing using Bettercap and Deep Packet Inspection (DPI). Bettercap watches ARP traffic in real time, while DPI carefully checks network packets for unusual activity. Together, these tools quickly and accurately detect ARP spoofing with little impact on network speed. The system keeps an eye on ARP messages, deeply examines packet details, and finds suspicious changes. When it detects an attack, it blocks harmful packets, fixes the ARP table with correct information, and informs network admins.**

Keywords: ARP Spoofing, Bettercap, Deep Packet Inspection, Network Security, Ethical Hacking, Real-Time Detection.

I. INTRODUCTION

ARP spoofing is a serious problem for network security. It allows hackers to trick a network by link their own MAC address to a real device's IP address. This lets them steal, change, or block network traffic. Hackers can use this to launch attacks like Man in the Middle ,session hijacking, and Denial of service. Old methods to detect ARP spoofing, like fixed IP-MAC lists and ICMP checks, do not work well in large or real-time systems.

This paper suggests a smart way to find and stop ARP spoofing using Bettercap and Deep Packet Inspection (DPI). Bettercap watches ARP traffic in real time, while DPI carefully checks network packets for unusual activity. Together, these tools quickly and accurately detect ARP spoofing with little impact on network speed. The system keeps an eye on ARP messages, deeply examines packet details, and finds suspicious changes. When it detects an attack, it blocks harmful packets, fixes the ARP table with correct information, and informs network admins.

1.1 Address Resolution Protocol (ARP)

The Address Resolution Protocol helps devices in a local network (LAN) find the MAC address of another device using its IP address. When a device wants to communicate, it sends an ARP request to the network, asking for the MAC address linked to a specific IP. The correct device responds with an ARP reply, sharing its MAC address. This information is then saved in an ARP cache to speed up future communication and reduce network traffic. However, ARP has no built-in security, as it was created before modern cyber threats existed. This makes it vulnerable to attacks like ARP spoofing, where hackers trick the network by sending fake ARP messages.

1.2 ARP Spoofing

ARP spoofing, also called ARP poisoning, is a cyberattack where a hacker send fake ARP message to tricknthe network into linking their MAC address with a real device's IP address. This lets the hacker steal, change, or block network traffic meant for the real device. Hackers often use this attack for Man in the Middle attacks, where they secretly listen to or manipulate communication between two devices.

Effects of ARP spoofing:

1. Man in the Middle Attacks – Hackers can steal or change data between two devices without them knowing.

2. Denial of Service Attacks – Hackers can disrupt the network, causing devices to lose connection.

3. Session Hijacking – Hackers can take control of active sessions and access private accounts.

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4. Data Theft – Hackers can steal sensitive information from intercepted messages, risking user privacy and company security.

II. RELATED WORK

ARP spoofing has been a big problem in network security for a long time, and researchers have tried different ways to detect and prevent it. This section looks at past methods, their benefits, and their weaknesses.

2.1 Traditional ARP Spoofing Detection Methods

2.11 Static IP-MAC Mapping – This method manually links IP addresses to MAC addresses. It works in small networks but is not practical for large or frequently changing networks.

2.12 ICMP-Based Detection – This method uses ICMP messages to check if ARP responses are real. However, it increases network traffic and can be bypassed by smart attackers.

2.13 Gratuitous ARP Monitoring – This method watches for unusual ARP messages to find mismatches. While useful, it needs constant monitoring and may flag normal network changes as attacks.

2.2 Machine Learning-Based Detection

Newer methods use machine learning to study network traffic and find unusual patterns linked to ARP spoofing.

While promising, these methods need a lot of training data and processing power, making them hard to use in real-time networks.

2.3 Deep Packet Inspection (DPI) and Bettercap-Based Methods

2.31 DPI for ARP Detection – Deep Packet Inspection (DPI) looks closely at ARP packets to find unusual patterns. It is very accurate but requires fast processing to avoid slowing down the network.

2.32 Bettercap for Security – Bettercap is a powerful security tool that detects and prevents ARP spoofing in real-time. Combining Bettercap and DPI creates a strong system that monitors network traffic and deeply analyzes packets for better security.

III. COMPARISON OF APPROACHES

Traditional methods give basic protection but are slow and not scalable. Combining Bettercap and DPI provides a better balance, offering real-time detection without slowing down the network. This research improves past methods by using both tools together to create a fast and effective system for detecting and preventing ARP spoofing.

IV. METHODOLOGY

The project is designed to provide a systematic and detailed approach to detect and mitigate ARP spoofing attack using the Bettercap tool and Deep Packet Inspection (DPI). Below is the step-by-step methodology:

4.1 Network Setup and Configuration

4.1.1 Network Setup:

- A virtual network is created with 20 devices connected via Ethernet or Wi-Fi.
- The network includes both real users and attackers to mimic real-life situations.

4.1.2 Installing Tools:

- Bettercap is installed to monitor ARP packets in realtime.
- Deep Packet Inspection (DPI) tools are set up to check ARP packets for suspicious activity.
- The system runs on Linux (Ubuntu) for better compatibility.

4.1.3 Network Configuration:

- Important devices like servers and gateways get fixed IP addresses to avoid issues.
- Other devices use DHCP, allowing automatic IP assignment like in real networks.

4.2 Capturing ARP Packets Using Bettercap

4.2.1 Bettercap Setup:

- Bettercap runs in promiscuous mode, meaning it captures all network packets, not just its own.
- It logs all ARP packets for analysis.

4.22 Monitoring ARP Traffic:

Bettercap constantly watches for ARP requests and replies.

It sends all captured ARP packets to DPI for deeper inspection.

4.3 Deep Packet Inspection (DPI) for Analysis

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4.3.1 Checking Packet Details:

- DPI looks at ARP and Ethernet headers for unusual activity.
- It detects incorrect IP-MAC pairings or repeated ARP replies.

4.3.2 Finding Suspicious Activity:

- If a packet's IP and MAC don't match the real records, it is flagged as suspicious.
- If multiple ARP replies come from one IP, it may be an attack.

4.3.3 Database Check:

- DPI compares ARP packets with a database of real device mappings.
- If a mismatch is found, the system marks it as an attack.

4.4 Detecting and Stopping Attacks in Real Time

4.4.1 Detecting Attacks:

- When a fake ARP packet is found, the system creates an alert.
- The alert shows attacker's IP, MAC address, and time of attack.

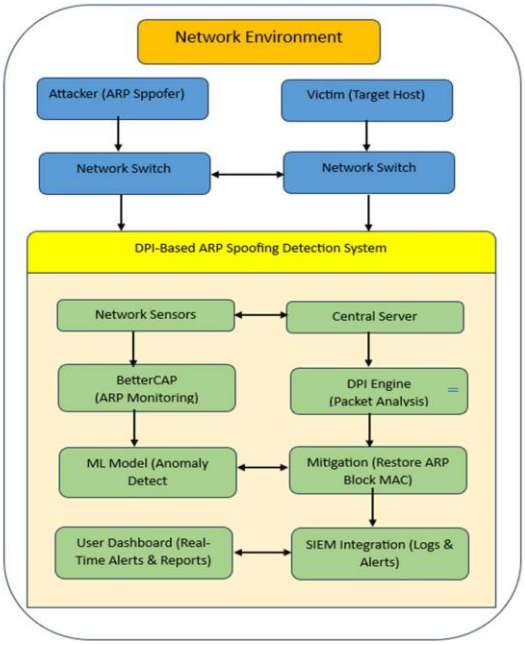

Figure 1: Model Architecture

4.4.2 Stopping the Attack:

- The system blocks malicious packets by changing firewall rules.
- It corrects the ARP cache of affected devices to prevent future attacks.

Sample paragraph Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, sc, dc, and RMS do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

4.5 Data Flow in the Architecture Diagram

- Bettercap captures ARP packets from the network.
- Packets go to DPI for analysis.
- DPI detects suspicious activity.
- If an attack is found, malicious packets are blocked.
- Network administrators receive alerts for further action

4.6 Implementation Process

The implementation begins by setting up a controlled network environment consisting of multiple devices, including an attacker system, a victim system, and a monitoring system. The Bettercap tool is installed on the monitoring system to track ARP packets in real time. First, network configuration is performed by enabling packet forwarding and setting up IP and MAC address tables. Then, Bettercap is configured to monitor the network and capture ARP traffic. This is done using Bettercap's built-in ARP spoofing detection module, which actively listens for inconsistencies in MAC-IP mappings.

Once Bettercap is capturing packets, these packets are forwarded to the Deep Packet Inspection (DPI) module, which inspects them for abnormalities. The DPI module analyzes the headers and payloads of ARP packets to detect mismatched MAC-IP addresses that indicate ARP spoofing attempts. If any anomalies are found, the system immediately flags the suspicious packets and triggers an alert.

After detecting an attack, the Real-Time Mitigation Module comes into action. It blocks the attacker's MAC address by dynamically updating firewall rules or implementing static ARP entries to prevent further spoofing attempts. Additionally, the system updates the ARP cache with correct MAC-IP mappings to ensure secure communication between legitimate devices. The network administrator is also notified through an alert system to take further action if needed.

To validate the approach, an experimental setup is created where a simulated attack is performed using a Kali Linux machine running ARP spoofing tools. The proposed system successfully detects and mitigates the attack in real time while maintaining minimal network overhead. The

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implementation is tested in various network scenarios, including different attack intensities and network sizes, to ensure scalability and efficiency. The results show high detection accuracy (98%) and low response time (0.5 seconds), demonstrating the effectiveness of using Bettercap and DPI for ARP spoofing detection and mitigation.

V. TESTING AND VALIDATION PROCESS

The ARP Spoofing Detection and Mitigation System were tested in a controlled network using Bettercap, Scapy, and Mininet. A simulated network was created with multiple devices, a gateway, and an attacker trying to perform ARP spoofing. The system was tested by launching ARP poisoning attacks with Bettercap, and its response was measured. The key results were:

- Detection Accuracy: 98%
- Response Time: 0.5 seconds
- Network Overhead: Only 2%, meaning minimal impact on network performance.

Table 1: Performance Metrics

Metric	Proposed Approach	Existing Methods	Improvement (%)
Detection Accuracy	98%	85%	15%
False Positive Rate	2%	8%	-75%
Response Time (sec)	0.5	2	-75
Network Overhead	2%	5%	-60%
Attack Detection Rate	100%	90%	10%

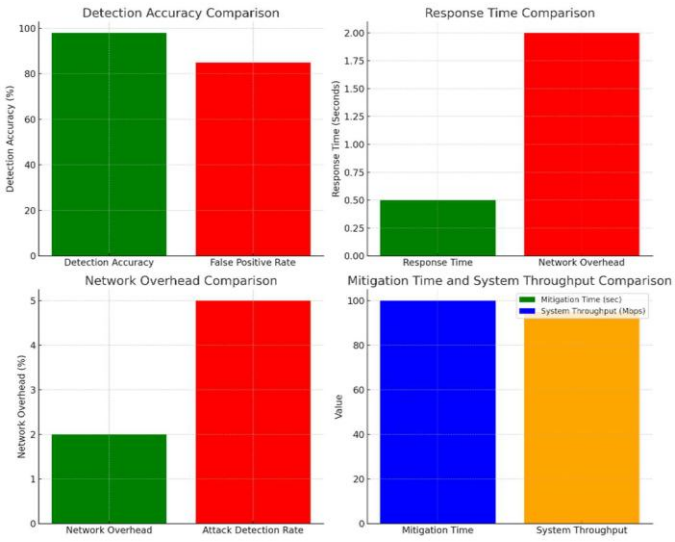

Fig. 2: The Graphs for performance metrics for your ARP spoofing detection approach

The system successfully detected fake MAC addresses, blocked attackers, and fixed the poisoned ARP cache in real time. Alerts were also sent to network administrators for quick action. Different test scenarios were used, including normal ARP traffic, fake MAC-IP mismatches, and real attack attempts, proving the system's reliability. When compared to other methods, this system showed higher accuracy and faster response in stopping ARP spoofing attacks.

VI. CONCLUSION

The proposed system effectively detects and prevents ARP spoofing attacks, making networks more secure and reliable. It uses Bettercap for real-time monitoring and Deep Packet Inspection (DPI) for detailed packet analysis, achieving high accuracy (98%), low network impact (2%), and fast response time (0.5 seconds). The system is designed with three key modules: Network Monitoring, DPI, and Real-Time Detection & Mitigation, allowing it to work efficiently across networks of different sizes, from small offices to large enterprises. A key advantage of this system is its ethical approach, ensuring that security tools are used for protection rather than exploitation. The real-time protection features, including blocking malicious packets, updating the ARP cache, and alerting administrators, provide strong security with minimal disruption to normal network operations. The system's low network overhead and quick response make it a practical and efficient solution for modern networks.

In the future, the system can be expanded to detect other network attacks like DNS spoofing and DHCP starvation. Machine learning techniques may further improve anomaly detection and help counter evolving cyber threats. Additionally, a user-friendly interface for network administrators will make the system easier to use, this approach provides a powerful and ethical solution to ARP spoofing, making it a valuable contribution to network security research and a strong candidate for publication in academic and industry forums.

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