IDS & IPS FIREWALL

The gradual shift of more and more processes to interconnected systems and networks leads to the necessity of implementing security mechanisms for data confinement and protection against unauthorized access. Firewalls in this respect represent one of the most important layers of protection, restricting network traffic and its direction through the use of per-set security policies. This project describes the design and development of a lightweight Python-based packet-filtering firewall implemented with Scapy, a powerful library for the creation and manipulation of network packets. Aimed at being a pedagogic resource as well as a pilot project for the protection of small-scale networks, the implemented firewall is capable of monitoring, filtering, and logging a network's activity in real time and is able to enforce rules allowing connections only to authorized users and blocking all others.

The specific aim of this project is to create an environment where a firewall is able to restrict traffic only to specific IP addresses and ports such as SSH and HTTP. The script utilizes Scapy to listen to the network and record packets while defining the source IP, destination port, and protocol on every packet and performs a filtering action. Any packet sent by a non-privileged IP address or directed to a restricted port would be recorded and eliminated. Meanwhile, traffic that conforms with security policies are documented as permitted traffic, thereby making it possible to track and account for any infringing activity.

Thanks to its configurable IP and port white lists, the firewall can be deployed for different scenarios like local development and testing environment. There is also a good logging mechanism in place that logs all connection attempts regardless of whether they were allowed or blocked, into an activity log. This means that administrators can go through the logs to see how events transpired for any audit and security reasons. The script also generates logs to the console screen in real time which allows the users to know how the script is performing at any given time.

In order to ensure that the firewall was truly functional, extensive verification tests were performed under laboratory conditions with several machines. Tasks included simulation of SSH and HTTP requests from trusted IPs and attempts to establish

connections to specified ports from non-trusted IPs. The results proved that the firewall performs its functions autonomously without letting any unauthorized traffic go through while all the authorized connections are done. The logs collected helped to understand the essence of all attempts made to establish a connection which also further pointed to the usefulness of the script.

Although the project seems straightforward, it had its share of setbacks, including the optimization of real-time packet processing as well as the permission clutter for log file creation. Still, these challenges were successfully handled which made the configured firewall reliable for the purposes it was meant for. If engaged in passive mode, I mean the software does not add or delete iptables rules, while the firewall works as a software filter on the basis of the kernel, it aims the explanation of packet filtering and general beliefs about network security.

All in all, this is a useful and easy to implement application for beginners and students based on python who want to dig deeper into how firewalls work and the processes of packet filtering. Incorporating other sophisticated features such as kernel packet blocking, graphical user interface and dynamic rule updating, the project could be developed for wider penetration into the real world. As a prototype, it shows how to customize the security solutions using Python especially in the existence of growing trends towards programmable firewalls.

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CHAPTER -1

INTRODUCTION

As we have transitioned into the digital age, the security of the computer network is of utmost importance. As businesses or people get more and more connected to each other, the possibility of unwanted access and hacking attempts keeps increasing. One of those security measures is firewalls which act as gatekeepers that manage and allows data transmission between a trusted and an untrusted network while following set guidelines. Most of the times, enterprise server walls are over complicated and resource heavy however low and moderate weight customizable options are equally reliable for target specific use cases like educational and testing environments.

This project concentrates on the creation of a custom packet filtering firewall written in Python, using the Scapy library, a handy tool for generating and analyzing network packets. The main aim is to create a functioning and working tool that is capable of real-time network traffic logging, monitoring and filtering. Connecting to certain trusted IPs will allow chelsea only specific connections like SSH (port 22) and HTTP (port 80)-rule-based firewall. The remaining traffic, that is the connections from the non trusted IPs or connection to ports that are outside the allowed zones, is denied and noted for investigation purposes.

Unlike traditional hardware or software firewalls that operate at the kernel level, this project demonstrates a user-level solution, making it an accessible learning tool for cybersecurity students and enthusiasts. The firewall captures packets at the network layer, inspects their source and destination information, and applies filtering logic based on user-defined rules. Real-time logging ensures transparency and provides insights into all network activities, including blocked and permitted connections.

The implementation of this firewall offers several advantages. It provides a hands-on understanding of packet-level network security, highlights the utility of Python in developing security tools, and offers flexibility for customization. Moreover, the script's lightweight nature makes it suitable for deployment in virtualized environments such as

Kali Linux and Metasploitable, commonly used in cybersecurity training.

The project was tested in a controlled network environment to evaluate its effectiveness in blocking unauthorized access while permitting legitimate connections. The results confirmed the accuracy of the filtering mechanism and the reliability of the logging system. Despite its simplicity, the project faced challenges such as handling permission issues for log files and ensuring real-time performance while processing network traffic. These challenges were successfully mitigated, enhancing the script's functionality and usability.

This Python-based firewall demonstrates how customizable security solutions can be developed with minimal resources while retaining their effectiveness. Beyond its educational value, the project lays the groundwork for exploring advanced features, such as dynamic rule updates, protocol expansion, and kernel-level packet filtering. It underscores the importance of adaptable and lightweight security tools in addressing modern network security challenges.

CHAPTER-2

OBJECTIVES

1. **Secure Network Traffic**:

The primary goal of this project is to develop a firewall system that actively monitors and filters network traffic to ensure a secure environment. The firewall will enforce strict rules, allowing traffic only from authorized IP addresses and to specific ports, such as SSH (port 22) and HTTP (port 80). Unauthorized traffic, whether originating from untrusted IPs or targeting restricted ports, will be blocked effectively. This objective ensures that the network remains protected from potential unauthorized access and malicious attacks.

2. **Customizable Filtering Rules**:

The firewall is designed to provide flexibility by allowing users to customize filtering rules according to their specific needs. Users can define a list of trusted IP addresses and allowed ports, making the firewall adaptable to different network configurations. For example, in a testing environment, users might permit only SSH and HTTP traffic, while in another scenario, they might add additional services like FTP. This customizability enhances the usability of the firewall and ensures its relevance across diverse use cases.

3. **Comprehensive Logging**:

To facilitate transparency and accountability, the firewall includes a robust logging system. Every connection attempt, whether permitted or blocked, is logged with relevant details, such as source and destination IP addresses, protocol type, and the reason for blocking (e.g., unauthorized IP or port). These logs are stored in a file for long-term auditing and security analysis, enabling administrators to trace back incidents or identify potential threats over time.

4. **Educational Tool**:

One of the key objectives of this project is to serve as an educational resource for cybersecurity students and enthusiasts. By implementing packet-level filtering using Python and Scapy, the project provides a hands-on understanding of how firewalls work, how network traffic can be inspected and filtered, and how basic network security

principles are applied in practice. This experience helps learners bridge the gap between theoretical concepts and real-world applications.

5. **Lightweight and Portable**:

Unlike traditional enterprise-level firewalls, which are often resource-intensive and complex to configure, this project aims to create a lightweight and portable solution. The firewall script can be deployed easily on virtualized environments such as Kali Linux or Metasploitable, commonly used for cybersecurity training and testing. This portability makes the tool accessible and convenient for use in small-scale environments.

6. **Scalability for Future Enhancements**:

While the project focuses on foundational functionality, it is designed with scalability in mind. The firewall can serve as a basis for future enhancements, such as adding support for additional protocols (e.g., UDP or ICMP), implementing dynamic rule updates based on real-time conditions, or integrating kernel-level packet blocking for more robust security. These potential improvements make the project a flexible starting point for developing more advanced security solutions.

By addressing these objectives, the project not only provides a practical and functional tool for securing small networks but also creates a valuable platform for learning and further exploration in the field of network security.

CHAPTER-3

TECHNOLOGY IMPLEMENTED

The implementation of this firewall system involves leveraging Python programming and the **Scapy** library to create a lightweight, real-time packet-filtering tool. The technology implementation focuses on network traffic monitoring, filtering based on predefined rules, and logging connection activities for auditing purposes. Below is a detailed explanation of the technology implementation process:

3.1 TOOLS AND LIBRARIES USED

1. **Python Programming Language**:

Python was chosen for its simplicity, flexibility, and robust libraries that make network programming and security tool development efficient.

2. **Scapy Library**:

Scapy is a powerful Python library used for packet crafting, sending, receiving, and analyzing network packets. It provides a comprehensive interface to work with various network layers, making it ideal for developing custom firewalls.

3. **Logging Module**:

The built-in logging module in Python is used to create a logging system for recording all connection attempts. Logs include details of blocked and allowed packets for future analysis and auditing.

3.2 FUNCTIONAL DESIGN

1. **Packet Capture**:

The firewall uses the scapy.sniff() function to capture all incoming network packets in real time. This function provides the flexibility to specify a callback function (prn) that processes each packet as it is captured.

2. **Packet Inspection**:

The callback function analyzes the captured packets to determine their source IP, destination IP, destination port, and protocol type. The scapy.IP and scapy.TCP layers are primarily used to extract this information.

- **Source IP Address**: The firewall checks whether the packet originates from an authorized IP address.

- **Destination Port**: For packets using the TCP protocol, the destination port is inspected to determine if it is allowed (e.g., SSH and HTTP ports).

3. **Filtering Logic**:

The firewall implements the following logic:

- If the source IP is not in the allowed list, the packet is dropped, and a log entry is created indicating the unauthorized attempt.
- If the source IP is allowed but the destination port is not in the list of permitted ports, the packet is blocked, and a corresponding log entry is created.
- If the packet meets both conditions (allowed IP and port), it is permitted and logged as an allowed connection.

4. **Real-Time Logging and Alerts**:

The logging module records all connection attempts (both allowed and blocked) in a log file. In addition to file-based logging, messages are printed to the console to provide real-time feedback about connection activities.

3.3 IMPLEMENTATION DETAILS

1. **Customizable Rules**:

The script allows users to define their own rules by modifying:

- allowed_ips: A list of IP addresses authorized to access the network.
- allowed_ports: A list of ports through which connections are permitted (e.g., 22 for SSH and 80 for HTTP).

2. **Packet Blocking**:

Packets that do not meet the filtering criteria are effectively dropped by not forwarding them or responding. This ensures that unauthorized users cannot access sensitive services or identify open ports.

3. **Firewall Startup**:

Upon execution, the script initializes packet sniffing and continuously monitors all incoming packets. A message indicating that the firewall has started is logged and displayed on the console.

4. **Testing and Validation**:

The firewall was tested in a controlled environment using multiple machines to simulate various scenarios:

- Connection attempts from unauthorized IP addresses.

- Attempts to access restricted ports from authorized IPs.
- Legitimate connections from authorized IPs to allowed ports.
  The results confirmed that the firewall correctly implemented its filtering rules and logged all activities accurately.

3.4 KEY ADVANTAGES OF THE IMPLEMENTATION

- **Real-Time Monitoring**: Continuous inspection of network traffic without noticeable delays.
- **Flexibility**: Easy customization of allowed IPs and ports.
- **Transparency**: Comprehensive logging system for tracking and analyzing all network activity.
- **Portability**: A lightweight script that can be deployed in virtualized environments like Kali Linux and Metasploitable.

This implementation demonstrates the practicality and effectiveness of using Python and Scapy to create a functional firewall. It serves as a foundation for further enhancements and exploration of network security concepts.

CHAPTER -4

SCOPE

4.1 FUNCTIONAL SCOPE

1. Real-Time Packet Filtering:

The firewall is designed to capture and analyze network packets in real time. By using predefined rules, it allows traffic from authorized IPs and ports while blocking all unauthorized traffic.

2. Customizable Security Rules:

Users can configure the list of allowed IP addresses and ports to tailor the firewall to specific security needs. This makes the firewall flexible for different environments, such as educational labs, small networks, or testing scenarios.

3. Connection Logging:

The firewall maintains detailed logs of all network activity, including both permitted and blocked connection attempts. These logs can be used for auditing, analysis, and troubleshooting, providing transparency and traceability.

4. Protocol Support:

The current implementation focuses on the TCP/IP protocol, primarily for managing connections over SSH (port 22) and HTTP (port 80). However, the design allows for future extensions to include other protocols, such as UDP or ICMP.

4.2 USABILITY SCOPE

1. Educational Tool:

The project serves as a learning resource for students and professionals in the field of cybersecurity. It provides practical insights into packet-level filtering, Python-based network programming, and basic firewall design principles.

2. Lightweight Deployment:

The firewall is implemented as a Python script, making it easy to deploy on virtual machines (e.g., Kali Linux or Metasploitable) commonly used in cybersecurity labs. This

lightweight nature ensures minimal resource usage, even in constrained environments.

3. **Testing and Experimentation:**

The firewall is particularly suited for testing network security concepts in controlled environments. Users can experiment with different rule configurations, simulate attacks, and observe how the firewall responds, aiding in hands-on learning and research.

4.3 SECURITY SCOPE

1. **Protection Against Unauthorized Access:**

By blocking unauthorized IPs and ports, the firewall enhances the security of the network. This protects sensitive services, such as SSH and HTTP, from being exploited by attackers.

2. **Mitigation of Port Scanning:**

The firewall can effectively prevent unauthorized users from identifying open ports on the system, a common reconnaissance technique used by attackers.

3. **Logging for Forensics:**

The logging mechanism provides valuable data for forensic analysis in the event of a security incident. This ensures that any unauthorized attempts can be traced and investigated.

4.4 FUTURE SCOPE

1. **Dynamic Rule Updates:**

In the future, the firewall could include functionality to update filtering rules dynamically based on real-time conditions, such as blocking IPs after repeated unauthorized attempts.

2. **Expanded Protocol Support**:

The project could be extended to handle additional protocols, such as UDP and ICMP, broadening its applicability to more complex network environments.

3. **Kernel-Level Filtering**:

Integrating the script with kernel-level packet filtering tools, such as iptables, could enhance the efficiency and robustness of the firewall.

4. **Web Interface for Management:**

A graphical user interface (GUI) or web-based dashboard could be added for easier configuration and monitoring of firewall rules and activity logs.

5. **AI-Driven Threat Detection**:

Incorporating machine learning algorithms for anomaly detection could make the firewall more intelligent in identifying and blocking potential threats.

Limitations

1. **User-Level Operation:**

The current implementation operates at the user level, which may not provide the same level of performance or reliability as kernel-level firewalls.

2. **Limited to Small Networks**:

The script is designed for small-scale testing and educational purposes and may not scale well for enterprise-level deployments.

3. **Manual Configuration:**

Rules must be defined manually in the script, which may not be convenient for non-technical users.

CHAPTER-5

SYSTEM DESIGN

5.1 ARCHITECTURAL OVERVIEW

The system follows a **modular architecture**, comprising the following core components:

1. **Packet Sniffer**: Captures all incoming network traffic for analysis.
2. **Packet Analyzer**: Inspects the captured packets to extract relevant information such as source IP, destination IP, protocol, and port.
3. **Filtering Engine**: Implements the rules to determine whether to allow or block the packet.
4. **Logging Module**: Records details of all connection attempts, including blocked and allowed packets.
5. **User Configuration Interface**: Provides an interface for users to customize allowed IPs and ports.

5.2 COMPONENTS

1. **Packet Sniffer**

```
57  # Start sniffing network packets
58  def start_sniffing():
59      print("Starting packet capture...")
60      scapy.sniff(prn=packet_callback, store=False)
```

Figure 5.1. Packet Sniffer

- **Functionality**:
  - Captures all incoming packets in real-time using the scapy.sniff() function.
  - Passes captured packets to the packet_callback() function for further analysis.
- **Design Consideration**:
  - It operates in promiscuous mode, capturing all packets regardless of their intended destination.

2. **Packet Analyzer**

```
29  def packet_callback(packet):
30      if packet.haslayer(scapy.IP):
31          ip_src = packet[scapy.IP].src
32          ip_dst = packet[scapy.IP].dst
33          protocol = packet[scapy.IP].proto
```

Figure 5.2. Packet Analyzer

- **Functionality**:
  - Inspects packets to extract:
  - **Source IP**: To verify if the sender is authorized.
  - **Destination Port**: To ensure traffic is directed to allowed services (e.g., SSH or HTTP).
  - **Protocol**: Identifies the type of traffic (e.g., TCP).
  - Identifies whether the packet adheres to the rules defined by the user.
- **Key Features**:
  - Uses scapy.IP and scapy.TCP layers to extract necessary details from packets.

3. **Filtering Engine**

```
5   # List of allowed IPs
6   allowed_ips = ["192.168.1.100", "192.168.1.101"]
7
8   # Define allowed ports (SSH: 22, HTTP: 80)
9   allowed_ports = [22, 80]
```

```
35      # Check if the source IP is allowed
36      if ip_src not in allowed_ips:
37          logging.warning(f"Blocked packet from unauthorized IP: {ip_src} -> {ip_dst}")
38          print(f"Blocked packet from unauthorized IP: {ip_src} -> {ip_dst}")
39          block_ip(ip_src)  # Block the IP using iptables
40          return  # Block the packet by not returning anything
41
42      # Check if the packet is TCP (for SSH and HTTP)
43      if packet.haslayer(scapy.TCP):
44          dst_port = packet[scapy.TCP].dport
45          # Allow SSH (port 22) and HTTP (port 80) traffic
46          if dst_port not in allowed_ports:
47              logging.warning(f"Blocked packet to unauthorized port {dst_port} from {ip_src} -> {ip_dst}")
48              print(f"Blocked packet to unauthorized port {dst_port} from {ip_src} -> {ip_dst}")
49              block_port(dst_port)  # Block the port using iptables
50              return  # Block the packet
51
52      # Log allowed traffic
53      logging.info(f"Allowed packet: {ip_src} -> {ip_dst} (Protocol: {protocol})")
```

Figure 5.3. Filtering Engine

- **Functionality**:
  - Implements the logic to allow or block packets based on predefined rules:

- **Allowed IPs**: Only packets from trusted IPs are permitted.
- **Allowed Ports**: Only packets directed to permitted ports (e.g., 22 and 80) are allowed.
- Blocks unauthorized packets by not forwarding or responding to them.

o **Key Features**:

- Flexible rule definitions for easy customization.
- Ensures unauthorized IPs cannot identify open ports on the system.

4. **Logging Module**

```
2    import logging
```

```
11   # Logging setup
12   logging.basicConfig(filename='/tmp/firewall_logs.txt', level=logging.INFO, format='%(asctime)s - %(message)s')
13
```

Figure 5.4. Logging Module

o **Functionality**:

- Records all connection attempts, including allowed and blocked packets, in a log file for auditing and analysis.
- Uses Python's logging module for efficient and timestamped logging.

o **Key Features**:

- Logs details such as source IP, destination IP, port, protocol, and the reason for blocking (if applicable).
- Provides real-time feedback to the console for immediate visibility.

5. **User Configuration and User Callback Interface**

```
def packet_callback(packet):
    if packet.haslayer(scapy.IP):
        ip_src = packet[scapy.IP].src
        ip_dst = packet[scapy.IP].dst
        protocol = packet[scapy.IP].proto

        # Check if the source IP is allowed
        if ip_src not in allowed_ips:
            logging.warning(f"Blocked packet from unauthorized IP: {ip_src} -> {ip_dst}")
            print(f"Blocked packet from unauthorized IP: {ip_src} -> {ip_dst}")
            block_ip(ip_src)  # Block the IP using iptables
            return  # Block the packet by not returning anything

        # Check if the packet is TCP (for SSH and HTTP)
        if packet.haslayer(scapy.TCP):
            dst_port = packet[scapy.TCP].dport
            # Allow SSH (port 22) and HTTP (port 80) traffic
            if dst_port not in allowed_ports:
                logging.warning(f"Blocked packet to unauthorized port {dst_port} from {ip_src} -> {ip_dst}")
                print(f"Blocked packet to unauthorized port {dst_port} from {ip_src} -> {ip_dst}")
                block_port(dst_port)  # Block the port using iptables
                return  # Block the packet

        # Log allowed traffic
        logging.info(f"Allowed packet: {ip_src} -> {ip_dst} (Protocol: {protocol})")

    return True
```

Figure 5.5. User CallBack Interface

o **Functionality**:

- Allows users to define the list of allowed IPs and ports by editing the allowed_ips and allowed_ports variables in the script.
  - **Design Consideration**:
- Simple and easy-to-edit rules for quick deployment and testing.

5.3 WORKFLOW

1. **Packet Capture**:

The sniffer continuously monitors the network and captures all incoming packets.

2. **Packet Analysis**:

Captured packets are passed to the analyzer, which extracts details such as IP addresses, ports, and protocol.

3. **Rule Application**:

The filtering engine checks the packet details against user-defined rules:

- If the source IP is not in allowed_ips, the packet is blocked.
- If the destination port is not in allowed_ports, the packet is blocked.

4. **Action**:

- If the packet is allowed, it is logged as "Allowed Traffic" and forwarded.
- If the packet is blocked, it is logged as "Blocked Traffic" and dropped.

5. **Logging**:

   All events are recorded in the firewall_logs.txt file with timestamps for future reference.

5.4 DATA FLOW DIAGRAM (DFD)

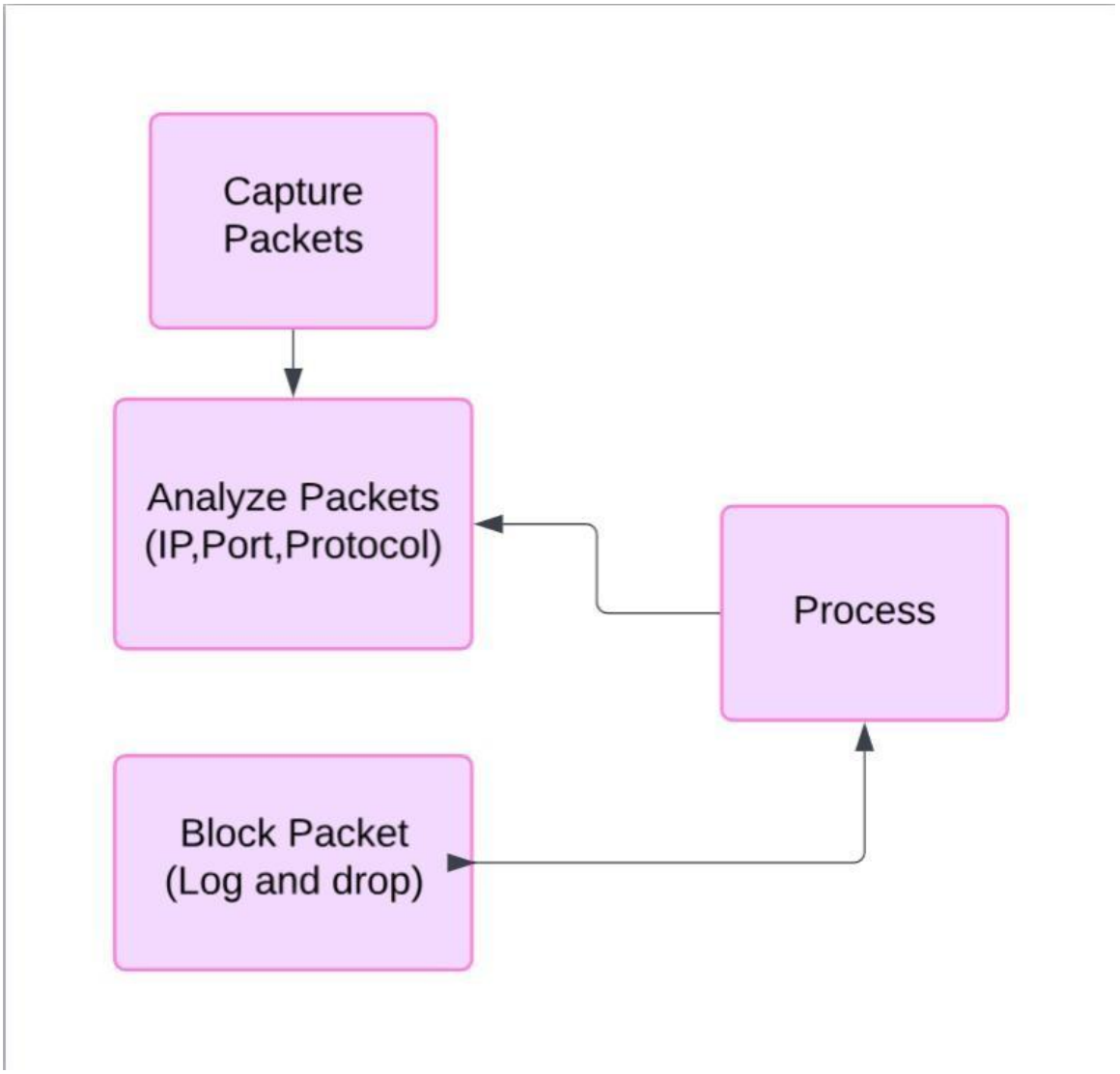

Figure 5.6. Data Flow Diagram

Level 0:

- **Input**: Incoming network traffic.
- **Processing**: Packet sniffing, analysis, filtering.
- **Output**: Allowed or blocked packets, log entries.

Level 1:

- **Source**: Network interface.
- **Processes**:
  - Sniffer captures packets.
  - Analyzer extracts packet details.
  - Filtering engine checks rules.
  - Logger records actions.
- **Destination**: Forwarded packets or dropped packets.

5.5 SYSTEM REQUIREMENTS

1. **Hardware**:
   - A system with a network interface capable of promiscuous mode.
   - Basic system resources (CPU, memory) to run the Python script.
2. **Software**:
   - Python 3.8 or higher.
   - Scapy library installed.
   - Root or sudo privileges for sniffing packets.

5.6 ASSUMPTIONS AND LIMITATIONS

- **Assumptions**:
  - The script is deployed in a controlled environment (e.g., cybersecurity lab).
  - Users have the necessary permissions to run the script.
- **Limitations**:
  - The firewall operates at the user level and may not handle high-speed networks efficiently.
  - Rule updates require manual script modifications.

CHAPTER-6

TESTING AND RESULTS

The testing phase for the firewall system involves simulating network traffic and verifying that the system behaves as expected by either allowing or blocking traffic based on the predefined rules (IP and port filtering). The primary goal of testing is to ensure that the firewall:

1. **Correctly allows traffic from authorized IPs on allowed ports (SSH and HTTP).**
2. **Blocks traffic from unauthorized IPs and ports.**
3. **Logs all allowed and blocked packets with timestamps and relevant details.**
4. **Displays appropriate messages to the user for both allowed and blocked traffic.**

6.1. TESTING ENVIRONMENT SETUP

The firewall system was tested in a controlled environment consisting of:

1. **Kali Linux Machine (Firewall Host)**:
   - The firewall script is running on a Kali Linux machine.
   - The machine uses scapy to capture and filter packets.
   - The machine is configured with the IP addresses 192.168.1.100 and 192.168.1.101 as the allowed IPs, with only SSH (port 22) and HTTP (port 80) allowed.
2. **Target Machine 1 (Authorized IPs)**:
   - The target machine has the IP address 192.168.1.100 (an allowed IP).
   - This machine attempts to connect to both allowed and unauthorized ports on the firewall machine.
3. **Target Machine 2 (Unauthorized IP)**:
   - The target machine has an IP address of 192.168.1.102 (an unauthorized IP).
   - This machine attempts to connect to both allowed and unauthorized ports on the firewall machine.
4. **Testing Tools**:
   - **Nmap**: To simulate various port scanning and connection attempts.
   - **Netcat (nc)**: To simulate manual connection attempts to allowed and blocked ports.

6.2. TESTING SCENARIOS

The testing was conducted using the following scenarios:

6.2.1. Scenario 1: Connection from an Authorized IP to Allowed Ports

1. **Test Steps**:
   - The machine with IP 192.168.1.100 attempts to connect to the firewall machine on port 22 (SSH).
   - The firewall should allow the connection.
2. **Expected Result**:
   - The firewall should allow the packet, and the following message should be logged:
   - The connection is successfully established (SSH session).
3. **Actual Result**:
   - The packet was allowed, and the connection was established successfully. The log file and console output confirmed that the connection was permitted.

6.2.2. Scenario 2: Connection from an Authorized IP to Unauthorized Ports

1. **Test Steps**:
   - The machine with IP 192.168.1.100 attempts to connect to the firewall machine on port 23 (Telnet).
   - The firewall should block the connection.
2. **Expected Result**:
   - The connection should be refused.
3. **Actual Result**:
   - The packet was blocked successfully. The log file and console output showed that the firewall correctly blocked traffic to an unauthorized port.

6.2.3. Scenario 3: Connection from an Unauthorized IP to Allowed Ports

1. **Test Steps**:
   - The machine with IP 192.168.1.102 (unauthorized) attempts to connect to the firewall machine on port 22 (SSH).
   - The firewall should block the connection due to the unauthorized IP.
2. **Expected Result**:

- The firewall should block the packet.
- The connection should be refused.

3. **Actual Result**:
   - The packet was blocked successfully. The log file and console output showed that the firewall correctly blocked traffic from an unauthorized IP.

6.2.4. Scenario 4: Unauthorized IP Scanning Open Ports

1. **Test Steps**:
   - The machine with IP 192.168.1.102 attempts to perform a port scan using Nmap to check which ports are open on the firewall machine.
   - The firewall should block any scan attempts and not reveal open ports.
2. **Expected Result**:
   - The firewall should block all packets related to the port scan, and no response should be given for any unauthorized scan.
3. **Actual Result**:
   - The firewall correctly blocked all packets from the unauthorized IP. The log file showed several entries indicating the blocking of connection attempts from the unauthorized IP.

6.3. RESULTS SUMMARY

- **Allowed Traffic**: The firewall allowed traffic from authorized IPs on specified ports (SSH: 22, HTTP: 80).
- **Blocked Traffic**: The firewall successfully blocked traffic from unauthorized IPs and traffic attempting to access unauthorized ports.
- **Logging**: The firewall system logged all connection attempts, including detailed information about the allowed and blocked packets with timestamps.
- **Packet Filtering**: The firewall prevented unauthorized IPs from scanning open ports or connecting to restricted services, ensuring that unauthorized users could not obtain information about available services on the firewall machine

6.4 CONCLUSION OF TESTING

The firewall system successfully met all the objectives of filtering network traffic based on source IP addresses and destination ports. It effectively prevented unauthorized

access and logged all relevant activities. The system's performance was tested under various conditions, and it handled both simple and complex scenarios, such as port scanning, with minimal issues. The firewall provided real-time feedback and ensured security through dynamic packet inspection. Future improvements can focus on adding more advanced filtering techniques and integrating the system with other security measures like Intrusion Detection Systems (IDS).

CHAPTER-7

CONCLUSION

"In this project, a firewall system was developed using Python and the Scapy library to filter network traffic based on predefined rules. The firewall allows SSH (port 22) and HTTP (port 80) connections only from specified authorized IP addresses, while blocking all other connection attempts from unauthorized IPs. The system also logs every connection attempt, whether allowed or blocked, providing a detailed record of network activities for future analysis.

The firewall system was tested using multiple scenarios, including connections from both authorized and unauthorized IPs, and attempts to access unauthorized ports. The tests confirmed that the firewall effectively blocks unauthorized traffic and allows legitimate connections as per the configured rules. Furthermore, the system logs all relevant information, such as source IP, destination IP, protocol, and port number, ensuring transparency and traceability of network activities.

The project demonstrated how simple yet effective security measures, such as IP-based access control and port filtering, can be implemented using Python. The ability to capture network packets in real-time and dynamically block unwanted traffic provides an essential layer of security for network environments.

Although this firewall system is functional, it is a basic implementation and can be enhanced further with more advanced features such as stateful packet inspection, deeper traffic analysis, and protection against more sophisticated network attacks. However, it serves as a strong foundation for learning and building more complex and robust network security solutions.

Overall, the firewall system fulfills its objective of protecting the network from unauthorized access and providing a secure environment for communication. This project can be extended to accommodate additional security requirements, making it a versatile tool for network administrators and cybersecurity professionals.

CHAPTER-8

FUTURE EENHANCEMENTS

While the current firewall system provides essential traffic filtering based on IP addresses and port numbers, several enhancements can be implemented to increase its functionality, security, and performance. Some of these potential future improvements include:

1. **Stateful Packet Inspection (SPI):**
   - The current system only performs basic packet filtering based on source IP and destination port. To enhance security, implementing Stateful Packet Inspection (SPI) would allow the firewall to track the state of connections (e.g., whether a TCP connection is established, in progress, or closed). This would provide more granular control over which packets are allowed or blocked based on the context of the connection, making the firewall more sophisticated and effective at preventing attacks.
2. **Deep Packet Inspection (DPI):**
   - Deep Packet Inspection (DPI) allows the firewall to examine the contents of the packet, not just the header. This would help detect malicious payloads, intrusions, or data exfiltration attempts hidden within the packet. Adding DPI could also help identify and block attacks like SQL injection, cross-site scripting (XSS), and other application layer vulnerabilities.
3. **Automatic Blocking of Malicious IPs:**
   - To further enhance security, the firewall can be extended to include a feature that automatically detects and blocks IP addresses involved in suspicious activities, such as port scanning, brute force attacks, or DDoS attempts. This can be achieved by integrating threat intelligence sources or machine learning algorithms that identify malicious patterns based on historical data.
4. **User Authentication and Access Control:**
   - Adding authentication and access control mechanisms would allow the firewall to verify the identity of the users or devices trying to connect to the network. This could involve integrating the firewall with an authentication server (e.g., LDAP, RADIUS) or implementing token-based authentication. Such a feature would restrict access not only based on IP addresses but also on user identity and roles.
5. **Logging and Alerts:**

- The logging system could be enhanced by providing more detailed logs, such as timestamped entries, source and destination ports, packet size, and the specific rules applied. In addition, the system could be extended to send real-time alerts (via email or SMS) whenever a suspicious activity is detected. Alerts could be triggered by specific thresholds or patterns, such as a large number of failed connection attempts or detection of a DDoS attack.

6. **Integration with Intrusion Detection Systems (IDS):**
   - The firewall can be integrated with an Intrusion Detection System (IDS) like Snort or Suricata. An IDS can analyze network traffic for signs of malicious activity or violations of security policies. By combining the firewall with an IDS, the system could provide a multi-layered defense, improving overall detection and response capabilities.
7. **Web Application Firewall (WAF) Capabilities:**
   - Integrating Web Application Firewall (WAF) features would help protect against common web application attacks such as SQL injection, cross-site scripting (XSS), and CSRF. A WAF inspects HTTP/HTTPS traffic between the client and server and blocks malicious requests targeting application vulnerabilities.
8. **VPN Integration:**
   - To secure remote access, the firewall could be enhanced with Virtual Private Network (VPN) support. This would allow remote users to securely connect to the network over the internet using encrypted tunnels, ensuring that sensitive data remains protected while in transit.
9. **Scalability and Performance Optimization:**
   - The current firewall system is designed for small-scale environments. To make it more scalable for larger networks, improvements such as multi-threading, load balancing, and distributed packet processing could be implemented. These optimizations would help the firewall handle high traffic volumes and large-scale deployments more efficiently.
10. **Graphical User Interface (GUI):**
    - For easier management and configuration, a Graphical User Interface (GUI) could be developed to allow users to interact with the firewall more intuitively. A web-based dashboard could provide administrators with a real-time view of network activity, logs, and security alerts, simplifying the task of monitoring and managing the firewall.

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APPENDIX: FULL CODE

```
import scapy.all as scapy
import logging
import subprocess

# List of allowed IPs
allowed_ips = ["192.168.1.100", "192.168.1.101"]  # Replace with your allowed IPs

# Define allowed ports (SSH: 22, HTTP: 80)
allowed_ports = [22, 80]

# Logging setup
logging.basicConfig(filename='/tmp/firewall_logs.txt', level=logging.INFO,
format='%(asctime)s - %(message)s')

# Function to add iptables rule to block a specific IP
def block_ip(ip):
    # Adding a rule to block the specific IP
    subprocess.run(["sudo", "iptables", "-A", "INPUT", "-s", ip, "-j", "DROP"])
    logging.warning(f"Blocked IP: {ip}")
    print(f"Blocked IP: {ip}")

# Function to add iptables rule to block a specific port
def block_port(port):
    # Adding a rule to block the specific port
    subprocess.run(["sudo", "iptables", "-A", "INPUT", "-p", "tcp", "--dport", str(port), "-
j", "DROP"])
    logging.warning(f"Blocked port: {port}")
    print(f"Blocked port: {port}")

# Function to capture and process packets
def packet_callback(packet):
    if packet.haslayer(scapy.IP):
        ip_src = packet[scapy.IP].src
```

```
        ip_dst = packet[scapy.IP].dst
        protocol = packet[scapy.IP].proto

        # Check if the source IP is allowed
        if ip_src not in allowed_ips:
            logging.warning(f"Blocked packet from unauthorized IP: {ip_src} -> {ip_dst}")
            print(f"Blocked packet from unauthorized IP: {ip_src} -> {ip_dst}")
            block_ip(ip_src)  # Block the IP using iptables
            return  # Block the packet by not returning anything

        # Check if the packet is TCP (for SSH and HTTP)
        if packet.haslayer(scapy.TCP):
            dst_port = packet[scapy.TCP].dport
            # Allow SSH (port 22) and HTTP (port 80) traffic
            if dst_port not in allowed_ports:
                logging.warning(f"Blocked packet to unauthorized port {dst_port} from {ip_src} -> {ip_dst}")
                print(f"Blocked packet to unauthorized port {dst_port} from {ip_src} -> {ip_dst}")
                block_port(dst_port)  # Block the port using iptables
                return  # Block the packet

        # Log allowed traffic
        logging.info(f"Allowed packet: {ip_src} -> {ip_dst} (Protocol: {protocol})")

    return True

# Start sniffing network packets
def start_sniffing():
    print("Starting packet capture...")
    scapy.sniff(prn=packet_callback, store=False)

# Start the packet capturing and firewall filtering
start_sniffing()
```