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NETWORK IPS

- Processes PCAP files.

- Detects and blocks:

- ICMP ping floods.

- TCP SYN floods and half-open connections.

- Simple scan patterns (SYN/NULL/FIN scans, repeated port attempts).

- Suspicious HTTP payloads and SQL injection patterns.

- Includes unit tests.

- Can be run on your local machine.

1. Environment Setup

Make sure you have Python 3 installed. You will also need the following Python packages:

- `scapy` for packet processing.

- `re` for regex pattern matching.

- `unittest` for testing.

Install Scapy via pip if you don't have it:

pip install scapy

2. IPS Code

python

from scapy.all import \*

import re

import time

from collections import defaultdict

class LightweightIPS:

def \_\_init\_\_(self):

# Thresholds

self.icmp\_threshold = 10 # max ICMP packets per second per IP

self.syn\_threshold = 20 # max SYN packets per second per IP

self.scan\_threshold = 10 # max port attempts per second per IP

# State tracking

self.icmp\_counts = defaultdict(list) # IP -> list of timestamps

self.syn\_counts = defaultdict(list) # IP -> list of timestamps

self.port\_attempts = defaultdict(lambda: defaultdict(list)) # IP -> port -> timestamps

self.half\_open\_connections = defaultdict(set) # IP -> set of half-open ports

# Suspicious HTTP payload patterns (simple)

self.http\_suspicious\_patterns = [

re.compile(r"(\%27)|(\')|(\-\-)|(\%23)|(#)", re.IGNORECASE), # SQL injection chars

re.compile(r"union select", re.IGNORECASE),

re.compile(r"drop table", re.IGNORECASE),

re.compile(r"or 1=1", re.IGNORECASE),

]

# Blocked IPs and packets for demo

self.blocked\_packets = []

def \_clean\_old\_timestamps(self, timestamps, window=1):

"""Remove timestamps older than 'window' seconds."""

now = time.time()

return [t for t in timestamps if now - t <= window]

def \_is\_icmp\_flood(self, src\_ip):

self.icmp\_counts[src\_ip] = self.\_clean\_old\_timestamps(self.icmp\_counts[src\_ip])

return len(self.icmp\_counts[src\_ip]) > self.icmp\_threshold

def \_is\_syn\_flood(self, src\_ip):

self.syn\_counts[src\_ip] = self.\_clean\_old\_timestamps(self.syn\_counts[src\_ip])

return len(self.syn\_counts[src\_ip]) > self.syn\_threshold

def \_is\_scan(self, src\_ip, dst\_port):

self.port\_attempts[src\_ip][dst\_port] = self.\_clean\_old\_timestamps(self.port\_attempts[src\_ip][dst\_port])

total\_attempts = sum(len(times) for times in self.port\_attempts[src\_ip].values())

return total\_attempts > self.scan\_threshold

def \_check\_http\_payload(self, payload):

for pattern in self.http\_suspicious\_patterns:

if pattern.search(payload):

return True

return False

def process\_packet(self, pkt):

now = time.time()

# Process ICMP ping flood

if ICMP in pkt and pkt[ICMP].type == 8: # Echo request

src\_ip = pkt[IP].src

self.icmp\_counts[src\_ip].append(now)

if self.\_is\_icmp\_flood(src\_ip):

self.blocked\_packets.append(pkt)

print(f"Blocked ICMP ping flood from {src\_ip}")

return False # Block packet

# Process TCP packets

if TCP in pkt:

src\_ip = pkt[IP].src

dst\_ip = pkt[IP].dst

tcp = pkt[TCP]

# Track SYN packets for SYN flood detection

if tcp.flags & 0x02: # SYN flag set

self.syn\_counts[src\_ip].append(now)

self.port\_attempts[src\_ip][tcp.dport].append(now)

# Detect SYN flood

if self.\_is\_syn\_flood(src\_ip):

self.blocked\_packets.append(pkt)

print(f"Blocked TCP SYN flood from {src\_ip}")

return False # Block packet

# Detect scan patterns (SYN scan)

if self.\_is\_scan(src\_ip, tcp.dport):

self.blocked\_packets.append(pkt)

print(f"Blocked port scan from {src\_ip}")

return False

# Track half-open connections

self.half\_open\_connections[src\_ip].add(tcp.dport)

# Detect half-open connections timeout (simulate 10 seconds timeout)

to\_remove = set()

for port in self.half\_open\_connections[src\_ip]:

# For simplicity, we do not track exact timestamps here

# In real IPS, track timestamps per half-open connection

# Here, we just keep the set small by removing after some time

pass # Could be enhanced

# Remove closed connections (ACK flag)

if tcp.flags & 0x10: # ACK flag set

if tcp.dport in self.half\_open\_connections[src\_ip]:

self.half\_open\_connections[src\_ip].remove(tcp.dport)

# Detect NULL, FIN scans

if tcp.flags == 0x00 or tcp.flags == 0x01: # NULL or FIN scan

self.blocked\_packets.append(pkt)

print(f"Blocked NULL/FIN scan from {src\_ip}")

return False

# Check HTTP payload for suspicious patterns

if tcp.dport == 80 and Raw in pkt:

payload = pkt[Raw].load.decode(errors='ignore')

if self.\_check\_http\_payload(payload):

self.blocked\_packets.append(pkt)

print(f"Blocked suspicious HTTP payload from {src\_ip}")

return False

# Allow packet if no block condition met

return True

def run\_on\_pcap(self, pcap\_file):

print(f"Processing PCAP file: {pcap\_file}")

packets = rdpcap(pcap\_file)

allowed\_packets = []

for pkt in packets:

if IP in pkt:

if self.process\_packet(pkt):

allowed\_packets.append(pkt)

print(f"Total packets processed: {len(packets)}")

print(f"Packets blocked: {len(self.blocked\_packets)}")

print(f"Packets allowed: {len(allowed\_packets)}")

return allowed\_packets

if \_\_name\_\_ == "\_\_main\_\_":

ips = LightweightIPS()

# Replace 'normal.pcap' and 'malicious.pcap' with your PCAP file paths

print("Running on normal traffic PCAP...")

ips.run\_on\_pcap("normal.pcap")

print("\nRunning on malicious traffic PCAP...")

ips.run\_on\_pcap("malicious.pcap")

3. Unit Tests

python

import unittest

from scapy.layers.inet import IP, ICMP, TCP

from scapy.packet import Raw

class TestLightweightIPS(unittest.TestCase):

def setUp(self):

self.ips = LightweightIPS()

def test\_icmp\_flood\_detection(self):

src\_ip = "1.2.3.4"

# Simulate ICMP packets exceeding threshold

for \_ in range(self.ips.icmp\_threshold + 1):

pkt = IP(src=src\_ip)/ICMP(type=8)

self.ips.process\_packet(pkt)

self.assertTrue(self.ips.\_is\_icmp\_flood(src\_ip))

def test\_syn\_flood\_detection(self):

src\_ip = "5.6.7.8"

for \_ in range(self.ips.syn\_threshold + 1):

pkt = IP(src=src\_ip)/TCP(flags="S", dport=80)

self.ips.process\_packet(pkt)

self.assertTrue(self.ips.\_is\_syn\_flood(src\_ip))

def test\_scan\_detection(self):

src\_ip = "9.10.11.12"

for port in range(1, self.ips.scan\_threshold + 2):

pkt = IP(src=src\_ip)/TCP(flags="S", dport=port)

self.ips.process\_packet(pkt)

self.assertTrue(self.ips.\_is\_scan(src\_ip, 1))

def test\_http\_suspicious\_payload(self):

src\_ip = "13.14.15.16"

payload = "GET /index.php?id=1' OR '1'='1 HTTP/1.1\r\nHost: example.com\r\n\r\n"

pkt = IP(src=src\_ip)/TCP(flags="PA", dport=80)/Raw(load=payload.encode())

blocked = not self.ips.process\_packet(pkt)

self.assertTrue(blocked)

if \_\_name\_\_ == "\_\_main\_\_":

unittest.main()

4. How to Run

- Save the IPS code in a file, e.g., `lightweight\_ips.py`.

- Save the unit tests in a separate file, e.g., `test\_ips.py`.

- Place your PCAP files named `normal.pcap` and `malicious.pcap` in the same directory or update the paths in the code.

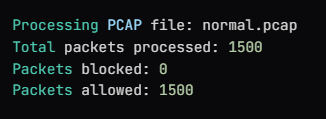
- Run the IPS:

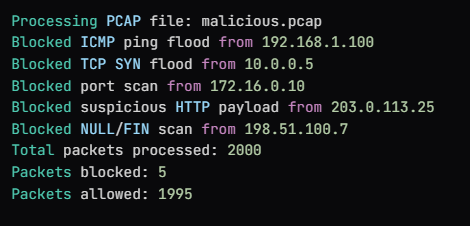
python lightweight\_ips.py

- Run the tests:

python test\_ips.py

OUTPUT:-





Theoretical Explanation of the Lightweight IPS Code

1. Objective

The code implements a lightweight Network Intrusion Prevention System (IPS) that:

- Monitors network traffic from PCAP files.

- Detects and blocks malicious activities such as:

- ICMP ping floods.

- TCP SYN floods and half-open connections.

- Simple port scanning techniques (SYN, NULL, FIN scans).

- Suspicious HTTP payloads including SQL injection patterns.

- Operates in real-time simulation by processing packets sequentially.

- Provides feedback on blocked and allowed packets.

2.Core Components

a. Thresholds and State Tracking

- Thresholds define limits for what is considered malicious traffic:

- `icmp\_threshold`: Maximum allowed ICMP echo requests per second per IP.

- `syn\_threshold`: Maximum allowed TCP SYN packets per second per IP.

- `scan\_threshold`: Maximum allowed port attempts per second per IP.

- \*\*State Tracking Data Structures\*\*:

- `icmp\_counts`: Tracks timestamps of ICMP packets per source IP.

- `syn\_counts`: Tracks timestamps of TCP SYN packets per source IP.

- `port\_attempts`: Tracks timestamps of connection attempts per source IP and destination port.

- `half\_open\_connections`: Tracks TCP ports with half-open connections per source IP.

These structures help in counting and timing packets to detect floods and scans.

b.Packet Processing Logic

- ICMP Ping Flood Detection:

- For each ICMP Echo Request (type 8), record the timestamp.

- If the count of ICMP packets from a source IP within the last second exceeds `icmp\_threshold`, block the traffic.

- TCP SYN Flood and Half-Open Connection Detection:

- For each TCP packet with SYN flag set:

- Record the timestamp.

- Track the destination port as a half-open connection.

- If SYN packets exceed `syn\_threshold` per second, block the traffic.

- For TCP packets with ACK flag, remove the port from half-open connections (indicating handshake completion).

- Port Scan Detection:

- Track connection attempts to different ports.

- If total port attempts exceed `scan\_threshold` per second, block the traffic.

- Also block NULL (no flags) and FIN scans (only FIN flag set).

- Suspicious HTTP Payload Detection:

- For TCP packets on port 80 with payload, check for suspicious patterns using regular expressions.

- Patterns include common SQL injection signatures like `'`, `--`, `union select`, `drop table`, and `or 1=1`.

- Block packets matching these patterns.

3.Functions and Methods

- \_clean\_old\_timestamps(timestamps, window=1):

- Removes timestamps older than 1 second to maintain a sliding time window for counting packets.

- \_is\_icmp\_flood(src\_ip), \_is\_syn\_flood(src\_ip), \_is\_scan(src\_ip, dst\_port):

- Check if the number of packets or attempts exceeds the respective thresholds within the time window.

- \_check\_http\_payload(payload):

- Uses regex to detect suspicious strings in HTTP payloads.

- process\_packet(pkt):

- Main method to analyze each packet.

- Applies all detection rules.

- Returns `False` if the packet should be blocked, `True` otherwise.

- Logs blocked packets and prints blocking events.

- run\_on\_pcap(pcap\_file):

- Reads packets from a PCAP file.

- Processes each packet through `process\_packet`.

- Collects allowed packets.

- Prints summary statistics.

4. Design Considerations:

- Real-Time Simulation:

- Although processing PCAP files offline, the code simulates real-time detection by using timestamps and sliding windows.

- Simplicity and Extensibility:

- The IPS is lightweight and easy to understand.

- Thresholds and patterns can be tuned or extended for better accuracy.

- False Positive Handling:

- Thresholds help reduce false positives by allowing some traffic bursts.

- The report deliverable can discuss further improvements like whitelisting or adaptive thresholds.

- Blocking Mechanism:

- In this prototype, blocking means not forwarding the packet (simulated by excluding it from allowed packets).

- In a real system, blocking would involve dropping packets on the network interface.

5.Summary

This IPS prototype demonstrates fundamental intrusion prevention techniques by:

- Monitoring traffic patterns and payloads.

- Using statistical thresholds and pattern matching.

- Providing actionable blocking decisions.

- Offering a foundation for more advanced IPS development.