SCIENCE
PASSION
TECHNOLOGY

Real-time Network Traffic Analysis and Feature Extraction

Riccardo Baljak, Ismar Nurdinović, Javier Nieto Castaño

January, 2025

Network traffic analysis

Capturing, inspecting, and interpreting data packets transmitted over a network. [Bar+20]

Network traffic analysis

Network traffic analysis

- Flow Analysis

Network traffic analysis

- Flow Analysis
- Performance Monitoring

Network traffic analysis

- Flow Analysis
- Performance Monitoring
- ...

Network traffic analysis

- Flow Analysis
- Performance Monitoring
- ...
- Packet Capture and Inspection

What are we doing?

Explaining the importance, and showing real-world examples of Network Traffic Analysis and feature extraction

Why are we doing it?

Show and explain the importance of real-time security in today's increasing network usage

Importance

- Increasing complexity: Cloud, IoT, and 5G.
- Cyber threats like DDoS [DM04] and APTs [TJ03] require real-time response.
- Real-time analysis reduces risks [Som+17].

Key Concepts

- **Packet Capture:**
  - Involves capturing and inspecting data packets transmitted over a network.
  - Packets contain headers and payloads with information about source, destination, and protocol.

Key Concepts

- **Anomaly Detection:**
  - Identifies unusual patterns in network traffic that may indicate security threats.
  - Utilizes machine learning and statistical techniques to detect anomalies in real-time.

Pseudo-Code

This pseudo-code is a very simplified representation of the Python source code provided (without anomaly detection):

Pseudo-Code

This pseudo-code is a very simplified representation of the Python source code provided (without anomaly detection):

```
Input: interface, packet_count
Output: Formatted packet data
pcap_reader ← LiveCapture(interface)
while not KeyboardInterrupt do
    foreach packet from pcap_reader.sniff_continuously(packet_count) do
        print packet number and timestamp
        if 'eth' ∈ packet then
            print source and destination MAC address
        end
        if 'ip' ∈ packet then
            print IP version number, protocol type, protocol number, source and
              destination IP address
        end
        if 'tcp' ∈ packet then
            print source and destination port, flags, window size and checksum
        end
        if 'udp' ∈ packet then
            print source and destination port, length and checksum
        end
    end
end
```

Explanation

Explanation

1. Initialize the `pcap (= packet capture) reader` to be a `LiveCapture` of the desired `interface`.

Explanation

1. Initialize the `pcap (= packet capture) reader` to be a `LiveCapture` of the desired `interface`.
2. Go though every sniffed packet (until the threshold is reached).

Explanation

1. Initialize the `pcap (= packet capture) reader` to be a `LiveCapture` of the desired `interface`.
2. Go though every sniffed packet (until the threshold is reached).
3. Print the basic information (packet number and timestamp).

Explanation

4. Check for distinct metrics of the packet and print different information:

Explanation

4. Check for distinct metrics of the packet and print different information:
   a. Ethernet: source and destination `MAC` address

Explanation

4. Check for distinct metrics of the packet and print different information:
    a. Ethernet: source and destination `MAC` address
    b. IP: IP version number, protocol type, protocol number, source and destination IP address

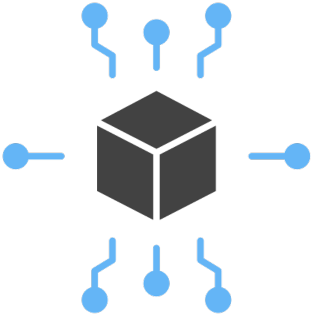
Explanation

4. Check for distinct metrics of the packet and print different information:
   a. Ethernet: source and destination `MAC` address
   b. IP: IP version number, protocol type, protocol number, source and destination IP address
   c. TCP: source and destination port, flags, window size and checksum

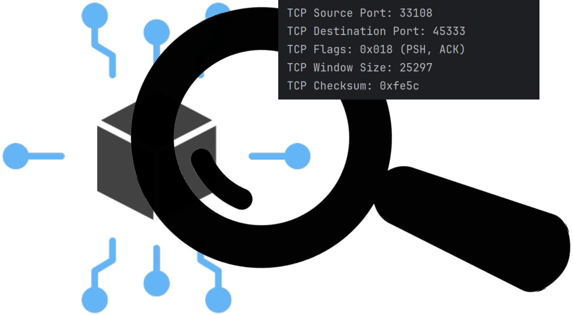
Explanation

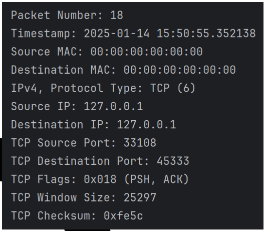
4. Check for distinct metrics of the packet and print different information:
   a. Ethernet: source and destination `MAC` address
   b. IP: IP version number, protocol type, protocol number, source and destination IP address
   c. TCP: source and destination port, flags, window size and checksum
   d. UDP: source and destination port, length and checksum

Example



Example





```
Packet Number: 18
Timestamp: 2025-01-14 15:50:55.352138
Source MAC: 00:00:00:00:00:00
Destination MAC: 00:00:00:00:00:00
IPv4, Protocol Type: TCP (6)
Source IP: 127.0.0.1
Destination IP: 127.0.0.1
TCP Source Port: 33108
TCP Destination Port: 45333
TCP Flags: 0x018 (PSH, ACK)
TCP Window Size: 25297
TCP Checksum: 0xfe5c
```

Getting the Malicious IPs

The next code simplifies the filters that we have applied.

Getting the Malicious IPs

The next code simplifies the filters that we have applied.

```
Input: IP address ip
Output: True if ip is malicious, False otherwise
Initialize headers ← {'Accept': 'application/json', 'Key': API_KEY};
Initialize params ← {'ipAddress': ip, 'maxAgeInDays': 90};
Send HTTP GET request to ABUSEIPDB_URL with headers and params;
if response is successful then
    abuse_score ← response.json()['data']['abuseConfidenceScore'];
    if abuse_score > 50 then
        Print: "Malicious IP: ip (Score: abuse_score)";
        return True;
    end
end
else
    Print: "Error querying ip";
end
return False;
```

Explanation

Explanation

1. Connect to the API of a webpage called AbuseIPDB

Explanation

1. Connect to the API of a webpage called AbuseIPDB
2. For every IP we get from the packets we check it

Explanation

1. Connect to the API of a webpage called AbuseIPDB
2. For every IP we get from the packets we check it
3. Is it is flag as malicious we send a message

Explanation

1. Connect to the API of a webpage called AbuseIPDB
2. For every IP we get from the packets we check it
3. Is it is flag as malicious we send a message
4. Otherwise we check the next IP

Filters

Filters

```
Input: Packet $p$
Output: True if $p$ is anomalous, False otherwise
Check Packet Size;
Extract $length$ from $p$;
if $length > 1500 \vee length < 50$ then
    Log: "Unusual packet size";
    return True;
end
```

```
Input: Packet $p$
Output: True if suspicious DNS, False otherwise
if $'dns' \in p$ then
    foreach $part$ in $p.dns.qry\_name.split('.')$ do
        if $Length(part) \geq 10 \wedge Vowels(part) \leq 2$ then
            return True (Suspicious domain);
        end
    end
    if $EndsWith(qry\_name, ".xyz") \vee Length(qry\_name) > 20$ then
        return True (Unusual domain);
    end
end
```

```
Input: Packet $p$, Threat API $T$
Output: True if $p$ contains malicious IP, False otherwise
Extract $src\_ip$, $dst\_ip$ from $p$;
$abuse\_score \leftarrow T.query(src\_ip)$;
if $abuse\_score > 50$ then
    Log: "Dynamic Malicious Source IP";
    return True;
end
$abuse\_score \leftarrow T.query(dst\_ip)$;
if $abuse\_score > 50$ then
    Log: "Dynamic Malicious Destination IP";
    return True;
end
```

```
Input: Packet $p$, Threshold $T_p$
Output: True if $p$ is anomalous, False otherwise
Track $src\_ip \rightarrow dst\_port$;
if $Unique\ dst\_port\ for\ src\_ip > T_p$ then
    Log: "Potential Port Scan";
    return True;
end
```

Explanation

Explanation

We created some basic example filters

Explanation

We created some basic example filters

1. Check if the packet size is too high or too low

Explanation

We created some basic example filters

1. Check if the packet size is too high or too low
2. Check if the DNS has a strange pattern

Explanation

We created some basic example filters

1. Check if the packet size is too high or too low
2. Check if the DNS has a strange pattern
3. Check if an IP could be malicious using the function from before

Explanation

We created some basic example filters

1. Check if the packet size is too high or too low
2. Check if the DNS has a strange pattern
3. Check if an IP could be malicious using the function from before
4. Check if the packet IP tries to connect to many ports

Conclusion

- Real-time network traffic analysis is crucial for addressing modern cybersecurity challenges.
- Combining advanced techniques ensures efficient and timely threat detection.
- Continuous technology advancements means we need to continuously advance in security measures as well.

Questions?

Thanks for the attention!

Bibliography

[Bar+20]	M. Barabas et al. **Real-time network traffic monitoring and analysis: A survey.** *Journal of Network and Computer Applications* (2020).
[DM04]	C. Douligeris and A. Mitrokotsa. **DDoS attacks and defense mechanisms: classification and state-of-the-art.** *Computer Networks* (2004).
[Som+17]	G. Somani et al. **DDoS mitigation techniques in cloud computing: Challenges and opportunities.** *IEEE Communications Surveys & Tutorials* (2017).
[TJ03]	M. Thottan and C. Ji. **Anomaly detection in IP networks.** *IEEE Transactions on Signal Processing* (2003).

All icons used are from https://thenounproject.com/ and are licensed under the *Creative Commons* license.