SCIENCE
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Real-time Network Traffic Analysis and Feature Extraction

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Network traffic analysis

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

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- Flow Analysis

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- Performance Monitoring

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- 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 [DM04] 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

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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

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2. Go though every sniffed packet (until the threshold is reached).
3. Print the basic information (packet number and timestamp).

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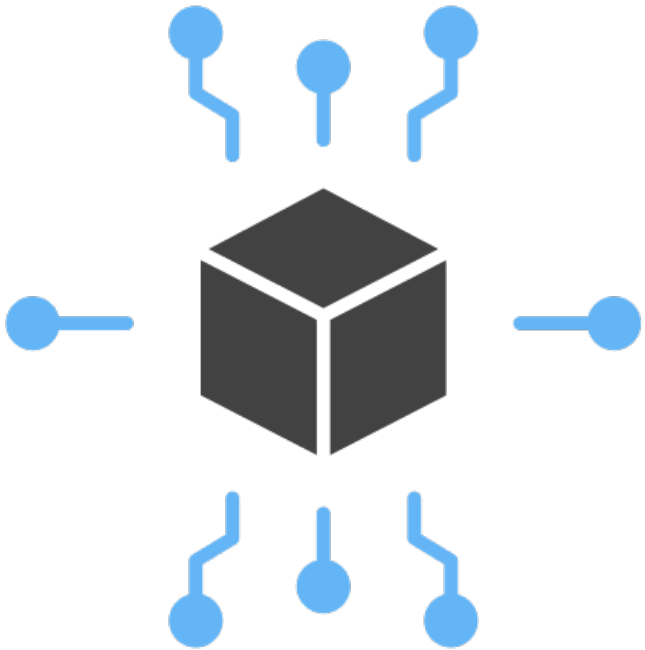
   a. Ethernet: source and destination `MAC` address
   b. IP: IP version number, protocol type, protocol number, source and destination IP address
   c. TCP: source and destination port, flags, window size and checksum
   d. UDP: source and destination port, length and checksum

Example



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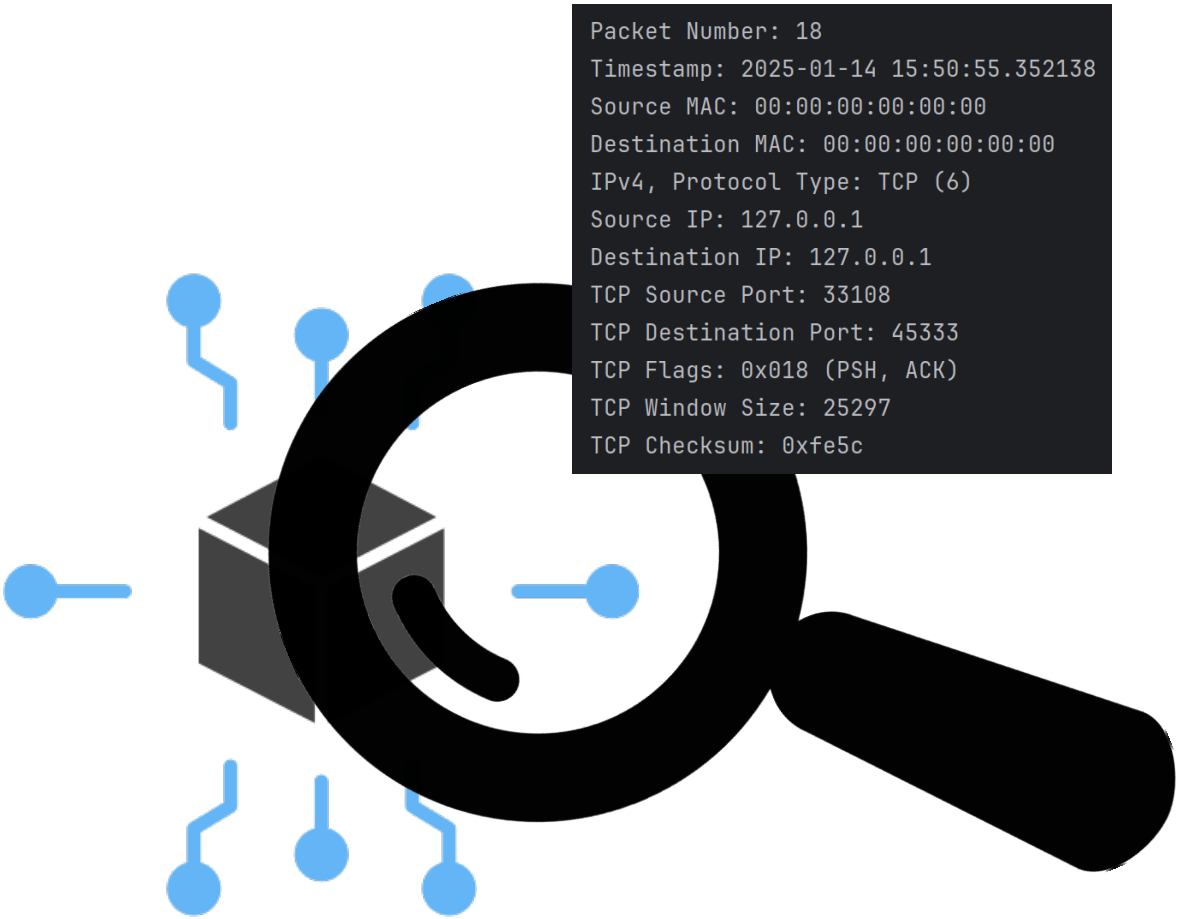
Packet Number: 18
Timestamp: 2025-01-14 15:50:55.352138
Source MAC: 00:00:00:00:00:00
Destination MAC: 00:00:00:00:00:00
IPv4, Protocol Type: TCP (6)
Source IP: 127.0.0.1
Destination IP: 127.0.0.1
TCP Source Port: 33108
TCP Destination Port: 45333
TCP Flags: 0x018 (PSH, ACK)
TCP Window Size: 25297
TCP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

Getting the Malicious IPs

The next code simplifies the filters that we have applied.

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Input: IP address *ip*
Output: **True** if *ip* is malicious, **False** otherwise
Initialize *headers* $\leftarrow$ {'Accept': 'application/json', 'Key': API_KEY};
Initialize *params* $\leftarrow$ {'ipAddress': ip, 'maxAgeInDays': 90};
Send HTTP GET request to *ABUSEIPDB_URL* with *headers* and *params*;
if *response is successful* **then**
    abuse_score $\leftarrow$ *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;

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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

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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)* ≤ 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

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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!

[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).

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