Detection of DNS Traffic Anomalies in Large Networks

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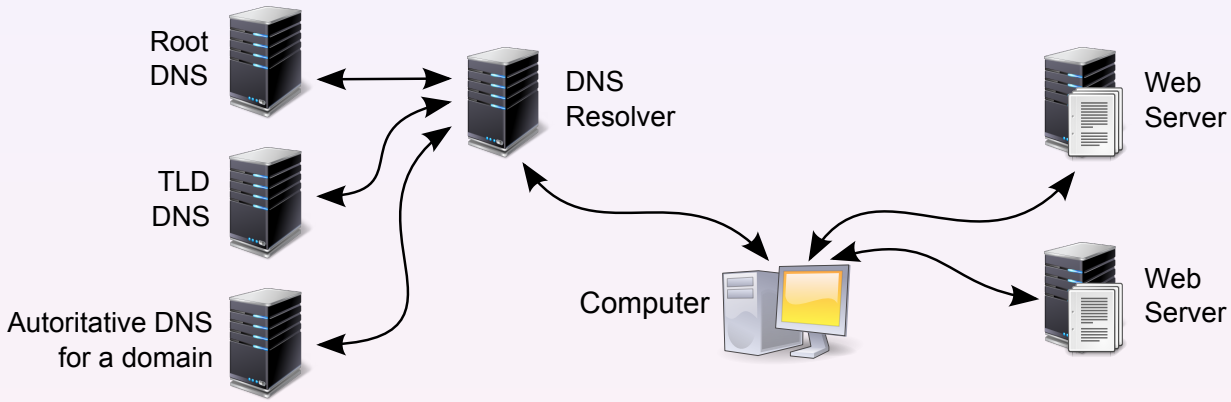
Part I

Introduction

Motivation

Almost every Internet communication is preceded by a translation of a domain name to an IP address.



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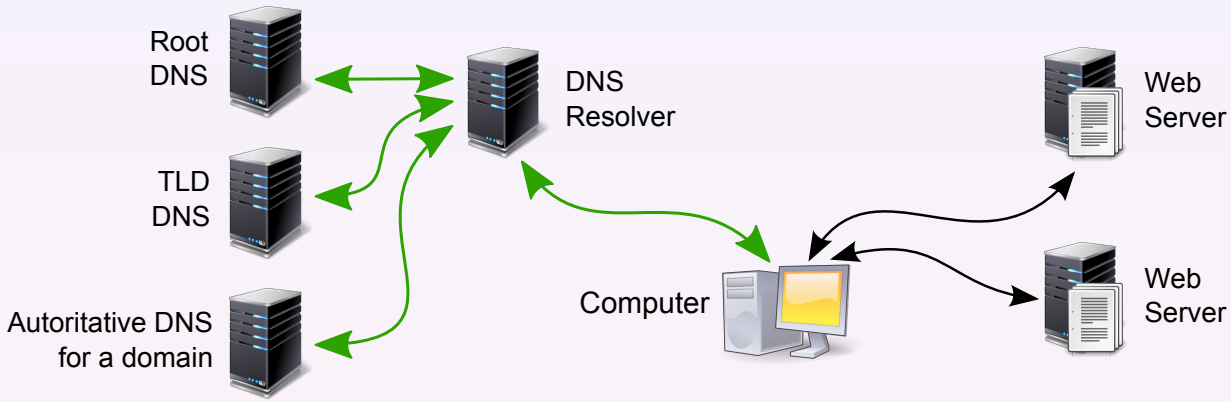

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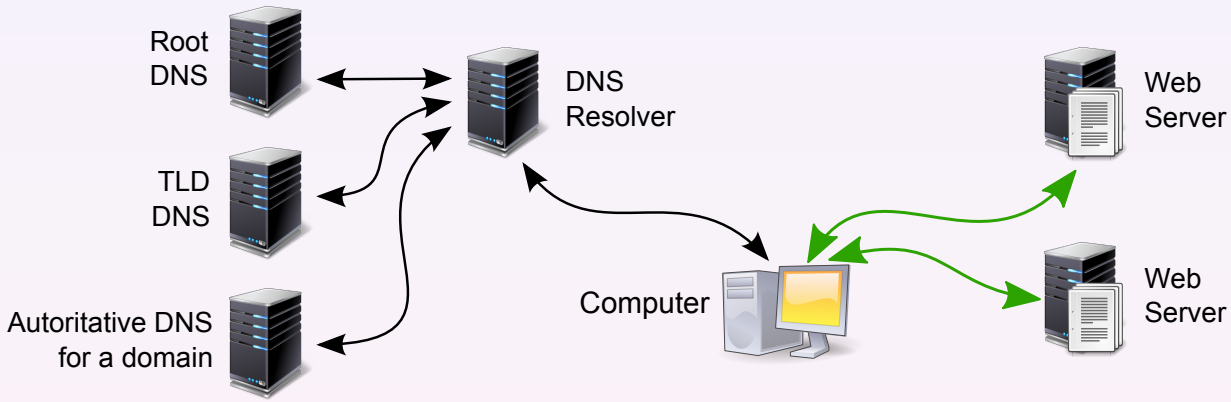

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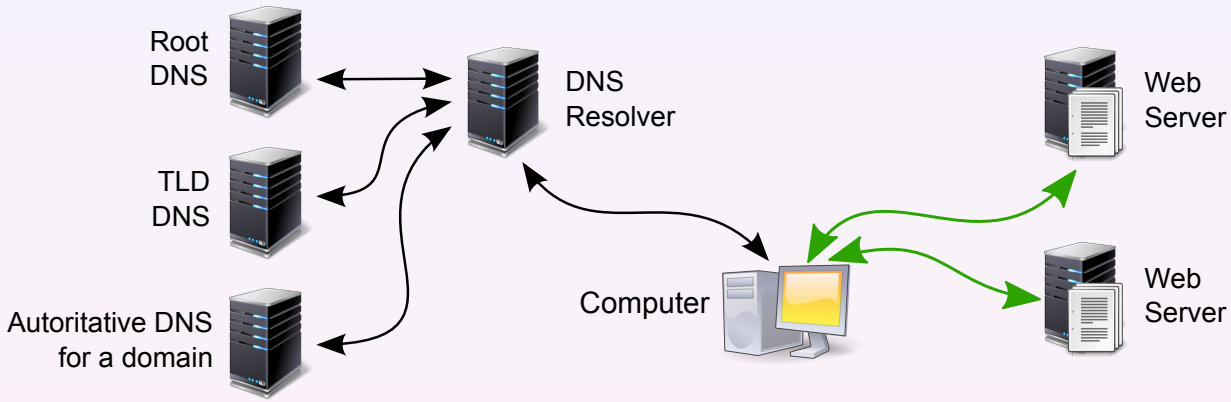

DNS Traffic Monitoring Benefits

- DNS packets are not encrypted.
- Knowledge of a queried domain can extend capabilities of current anomaly detection methods.
- Possibility to detect anomalies in a DNS traffic itself.

DNS Traffic Attacks and Anomalies

- **Malicious domains queries**
  - Botnet C&C (domain-flux and fast-flux domains),
  - Malware spread,
  - ...
- **Amplification DDoS attacks**
- **And many others ...**

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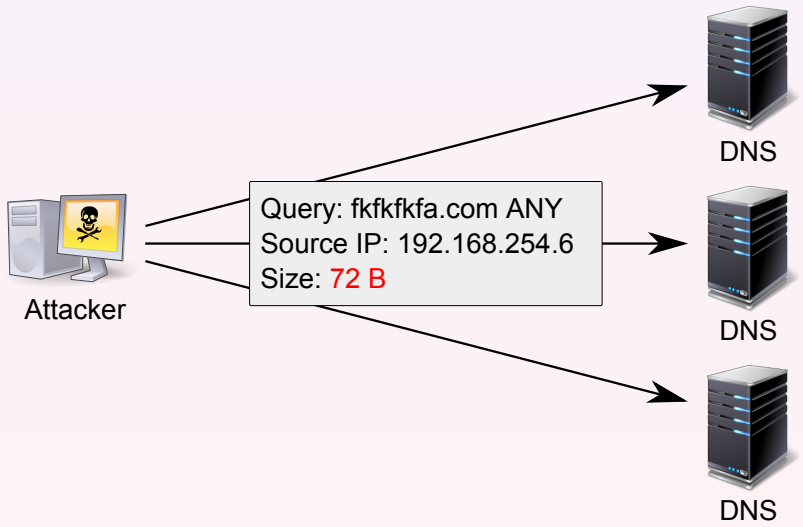

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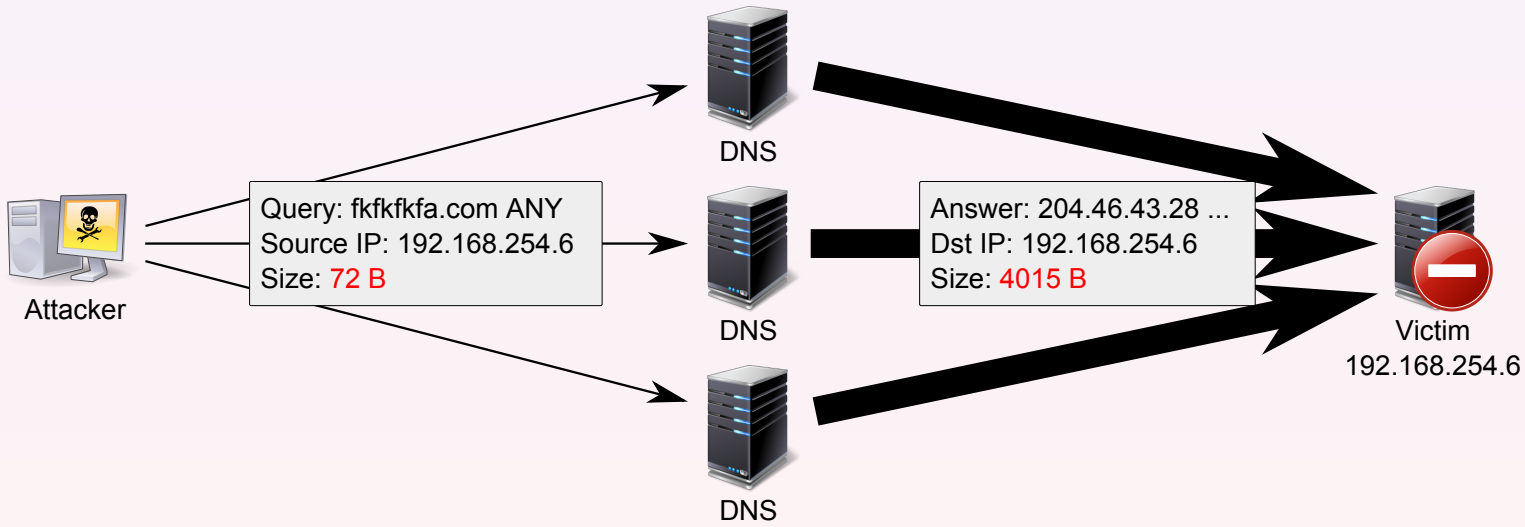

Research Questions

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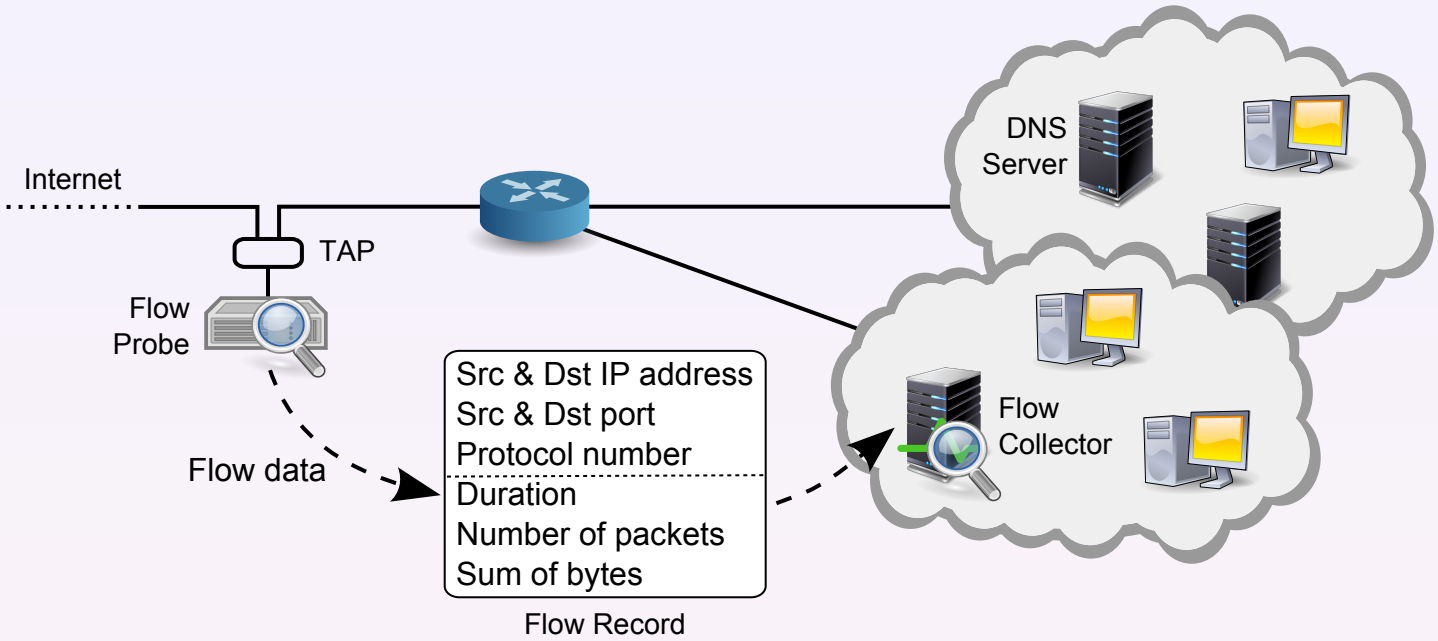
2. What are the **differences** in the analysis of DNS traffic using **standard and extended flow** records?

3. What are the advantages of **combinating DNS traffic** information **with flow** records for network anomaly detection?

Part II

DNS Traffic Monitoring

Flow Based DNS Traffic Monitoring



Standard Flow Record

$$F = (IP_{src}, IP_{dst}, P_{src}, P_{dst}, Prot, T_{start}, T_{dur}, Pckts, Octs, Flags)$$

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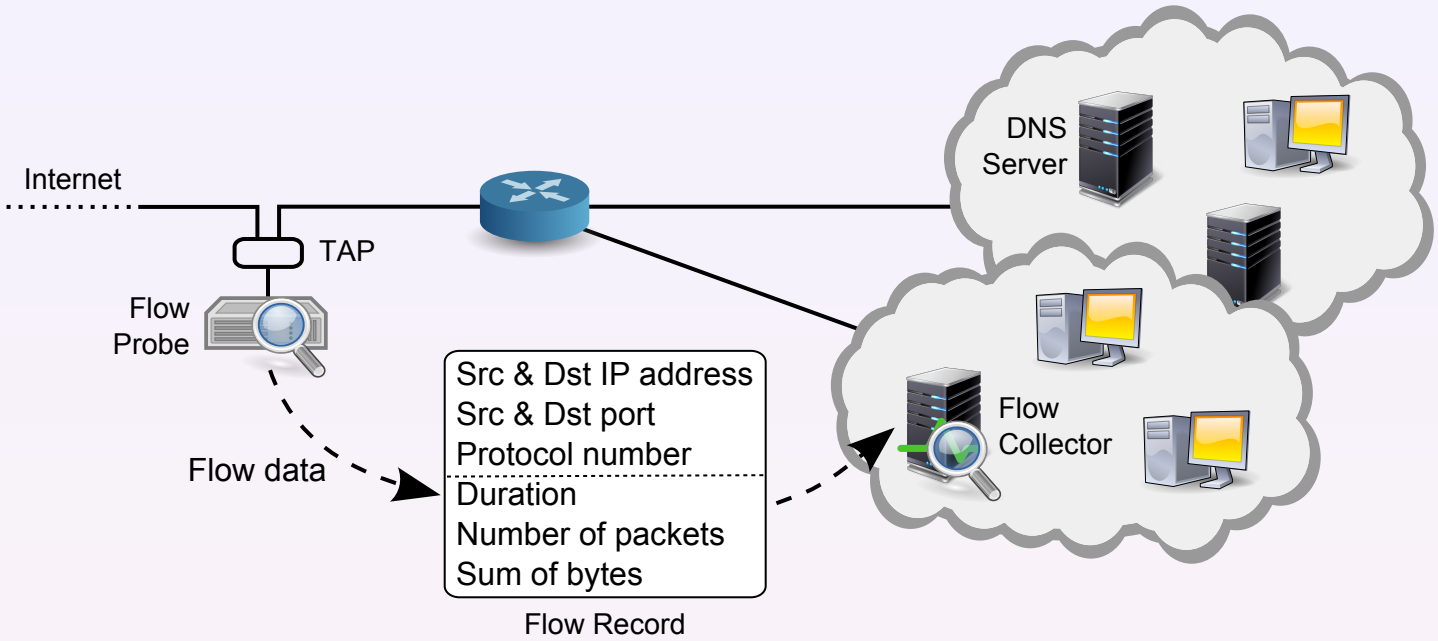

Standard Flow Record

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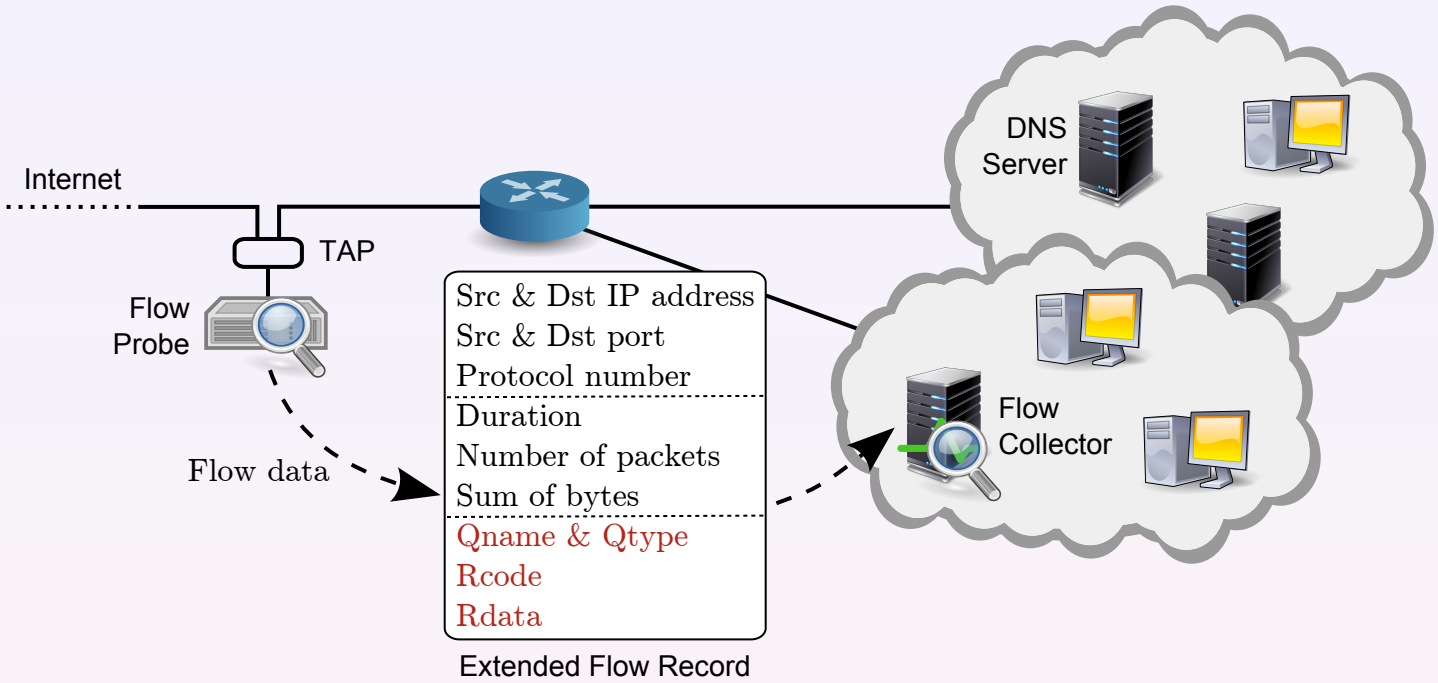
DNS Flow Record

$$F_{DNS} = (Qname, Qtype, Rcode, Rdata)$$

Flow Based DNS Traffic Monitoring

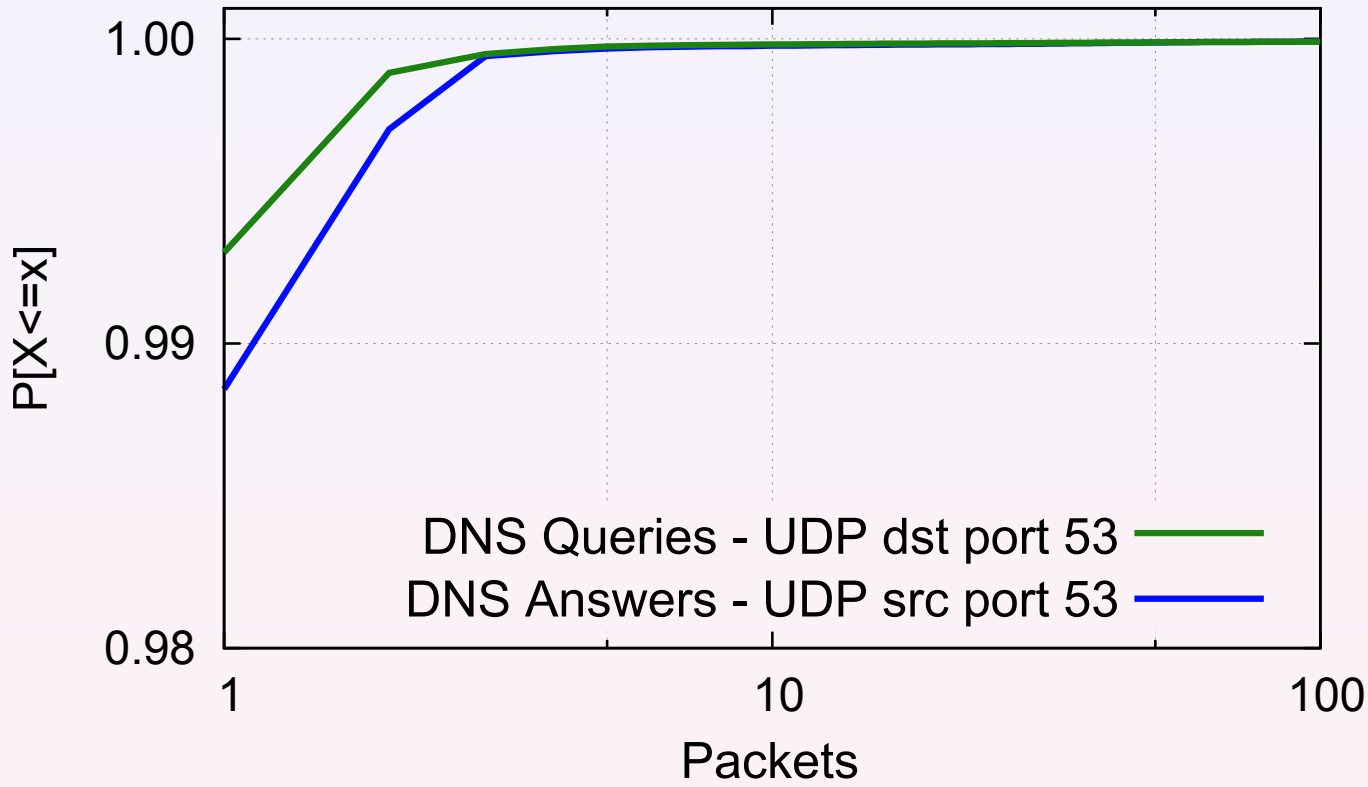


Extended Flow Record

$$F_{ext} = F \cdot F_{DNS} = (IP_{src}, IP_{dst}, P_{src}, P_{dst}, Prot, T_{start}, T_{dur}, Pckts, Octs, Flags, Qname, Qtype, Rcode, Rdata)$$

Flow Based DNS Traffic Monitoring

Cumulative Distribution Function of DNS Packets per Flow



Up to 99 % of flows with port 53 contain only one packet.

⇒ **Flow aggregation is not used.**

Extended Flow Expiration Algorithm

GenerateExtendedFlow (incoming packet)

1. Parse flow information F from incoming packet header.
2. Check if incoming packet contains a valid DNS header.
   3. Parse DNS packet and create a flow record $F_{ext} = F \cdot F_{DNS}$.
   4. Export a flow record F_{ext} without storing in a flow cache.
5. Otherwise update flow record F in a flow cache.

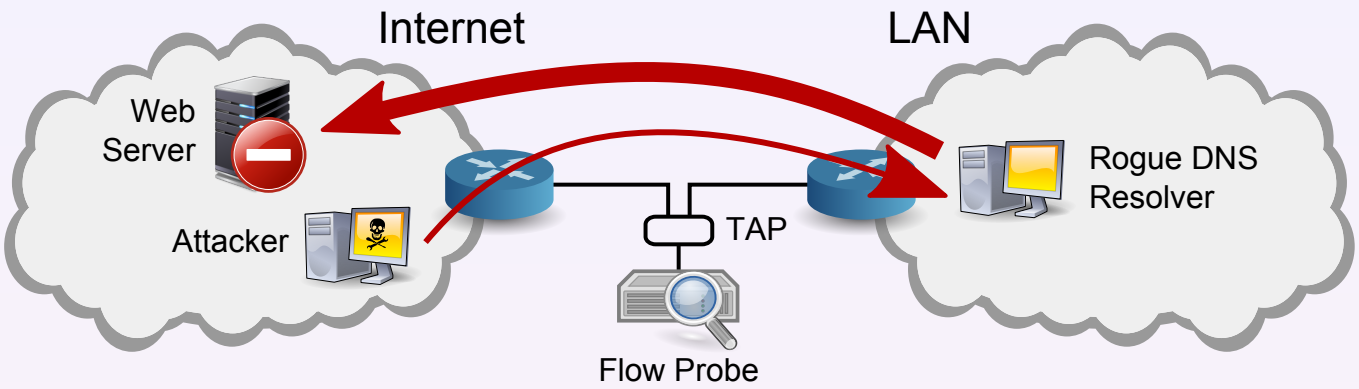
Main Contribution

- Significant **reduction of flow cache memory occupation** due to immediate export of a flow record.

Part III

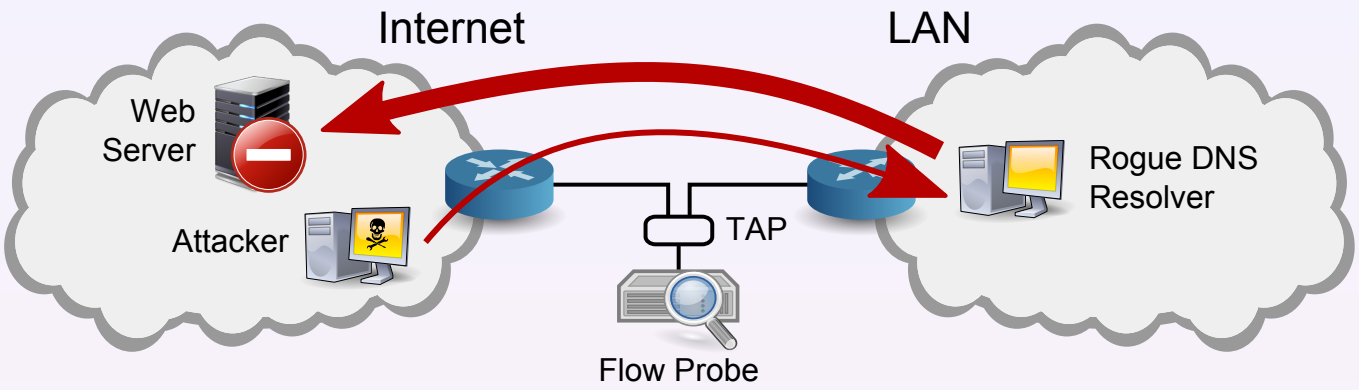
DNS Traffic Anomaly Detection Using Standard Flows

Amplification DDoS Attack



The attack is characterised by a large amount of same queries with spoofed IP address.

Amplification DDoS Attack



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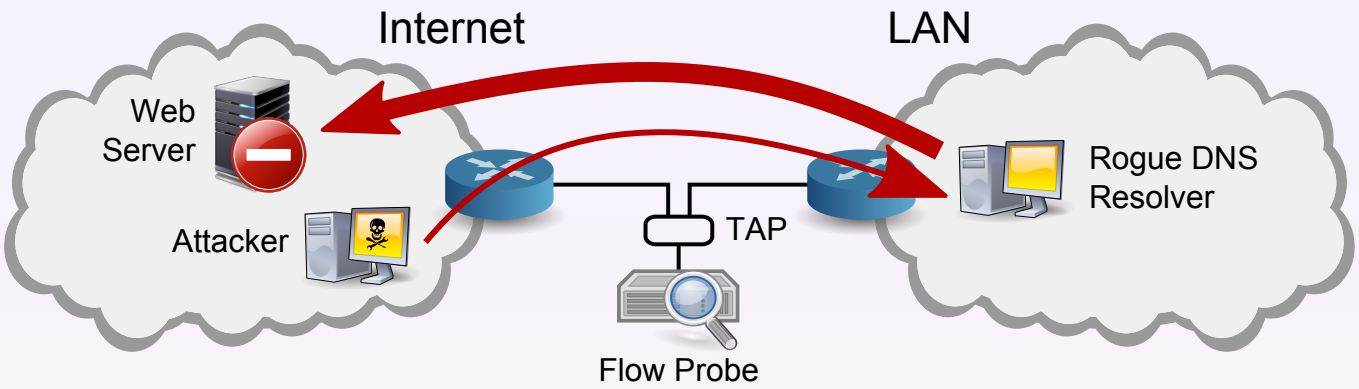
Detection Method

- Increasing count of flows, with high bytes-per-packet ratio and the source port 53.
- Access control lists reflecting network security policy.
- Usually **threshold** adjustment is **required**.

Part IV

DNS Traffic Anomaly Detection Using Extended Flows

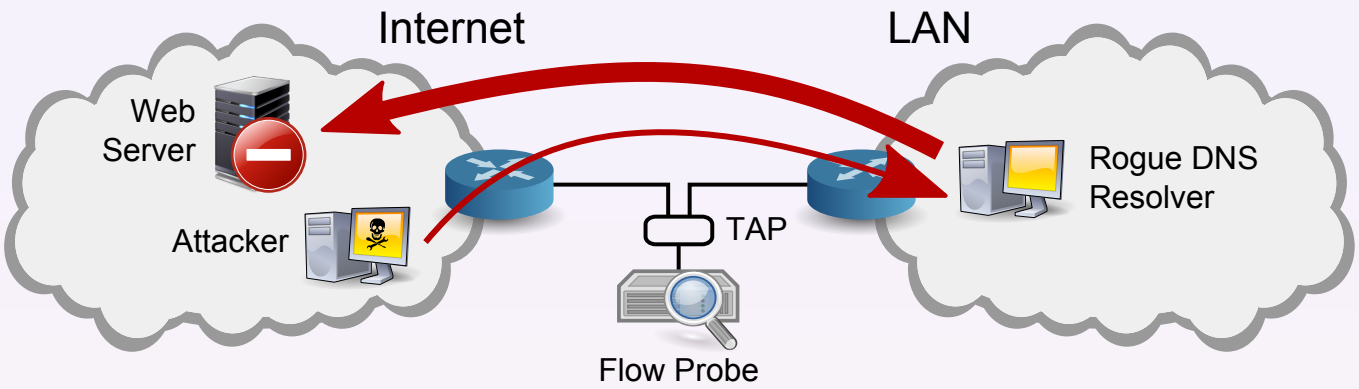
Amplification DDoS Attack



Detection Method

- Malware infected device or misconfigured DNS resolver recognition instead of using basic flow statistics.

Amplification DDoS Attack



Detection Method

- Malware infected device or misconfigured DNS resolver recognition instead of using basic flow statistics.

  $\Rightarrow$ **The problem is to distinguish a regular DNS server responding to a query containing a local domain.**

Amplification DDoS Attack

DetectOpenDNSResolver (DNS response)

1. Request all information about a domain $F_{ext}.Qname$ in the response by `ANY` query type.
2. Check if the result contains at least one IP address from a local network.
    3. If yes, then add domain to a whitelist of local domains.
    4. Otherwise report $F_{ext}.IP_{src}$ as open DNS resolver.

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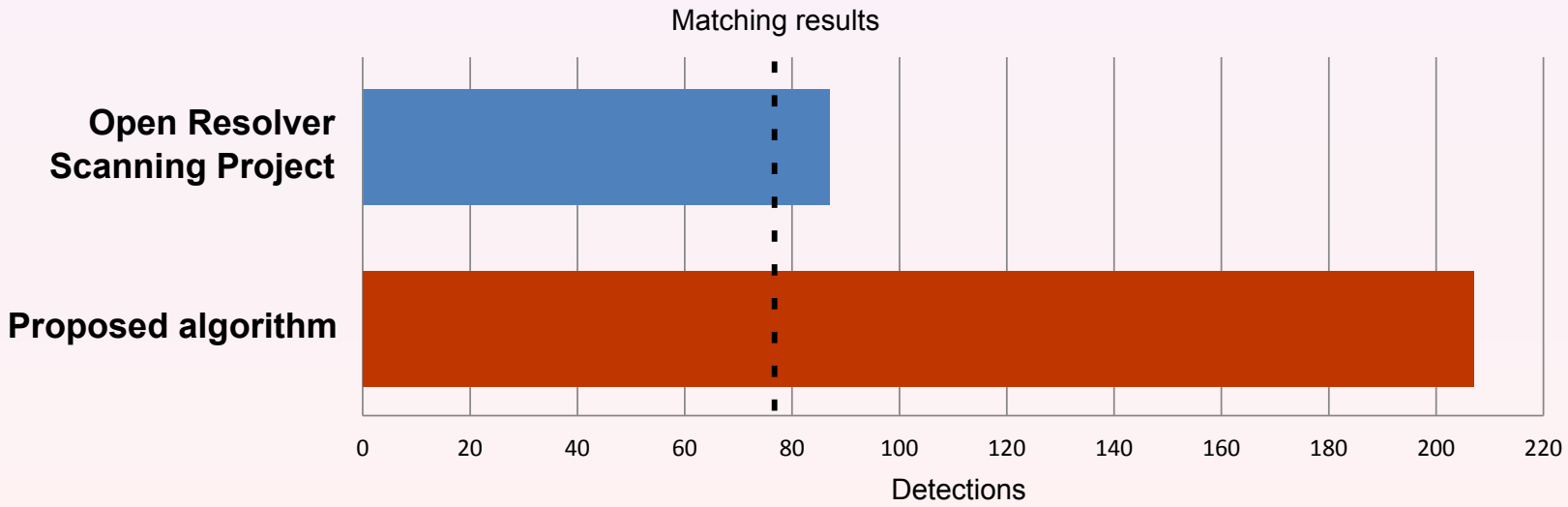
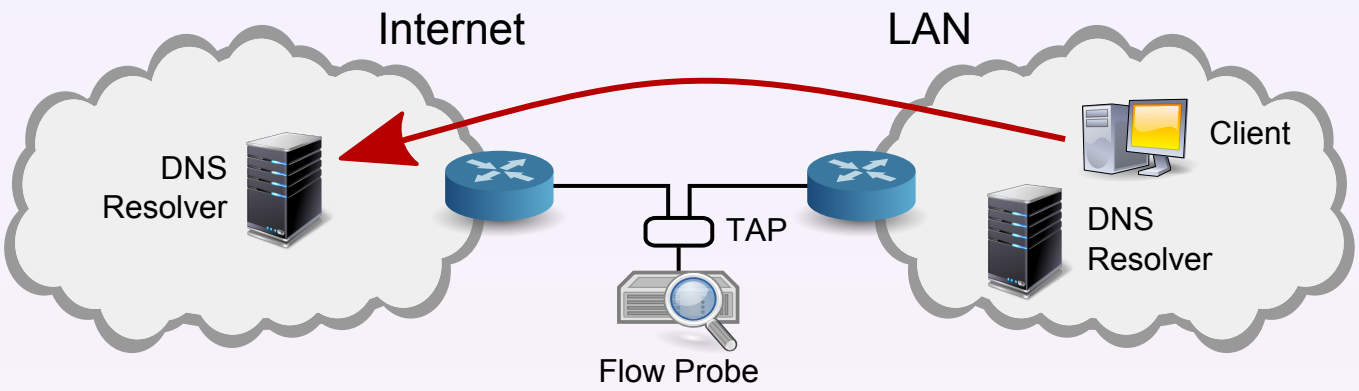


External DNS Resolver Usage Detection



Usage of an external DNS resolver may cause delay and also presents a security risk if the external DNS resolver responds with fraudulent IP addresses.

Detection Method

- In well-maintained networks is based on access control lists.
- In not well-maintained networks is a **problem to distinguish** between a **client** device and a local **DNS resolver**.

External DNS Resolver Usage Detection

DetectExternalDNS (DNS response)

1. Get time of the response $F_{ext}.T_{start}$ and IP address of queried domain $F_{ext}.Rdata$.
2. Check if client $F_{ext}.IP_{dst}$ visits queried domain during $F_{ext}.T_{start} + 2\ sec$.
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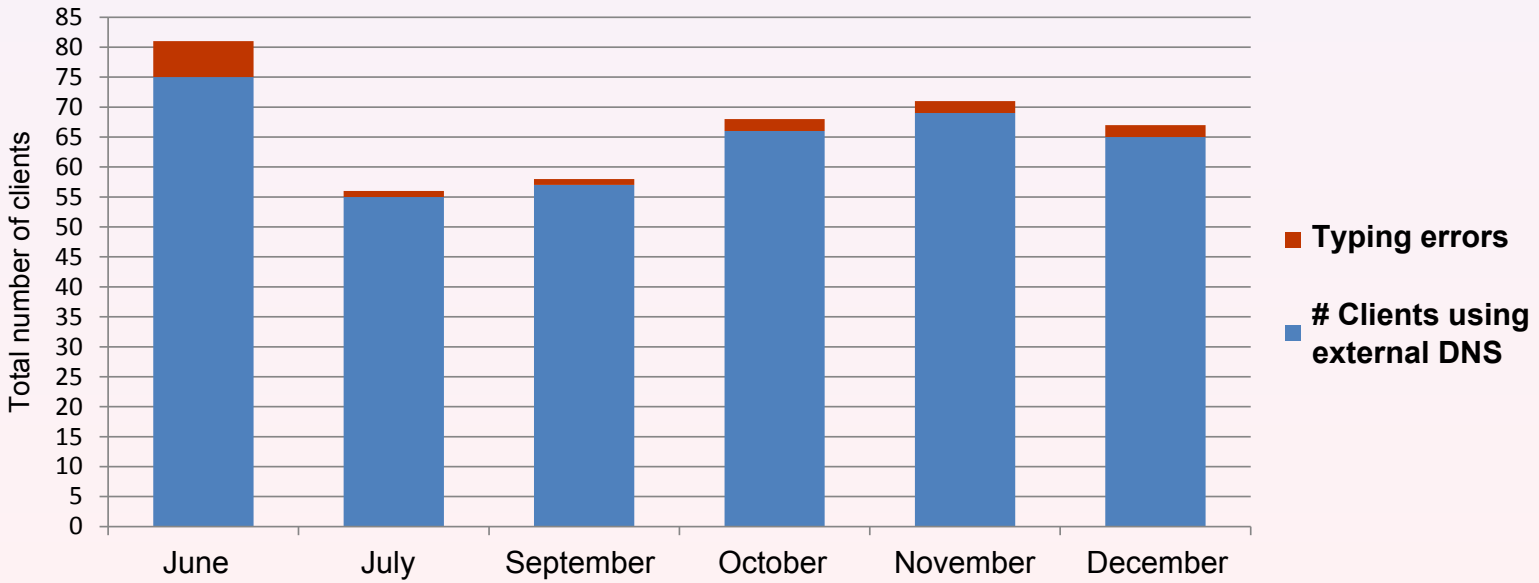
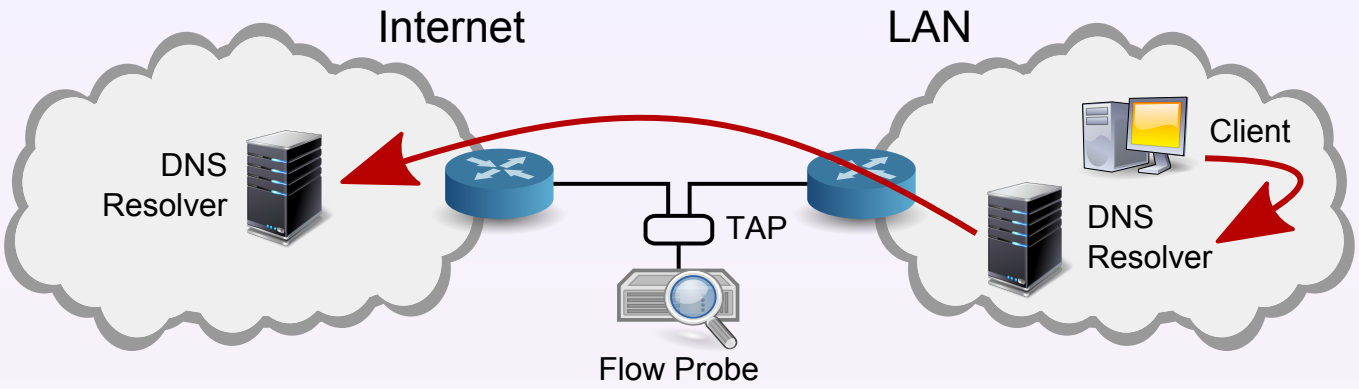


Malware Domains Query Detection



DNS queries generated by botnets (command and control center) or domains used for a malware spreading.

Detection Method

- Check all queried domains whether they are occurred in any malware domains blacklist.

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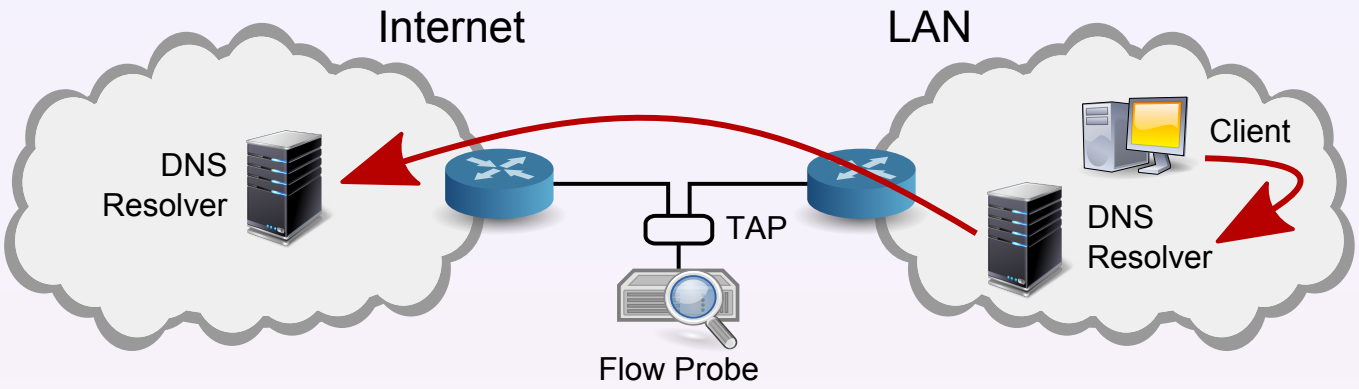

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  $\Rightarrow$ **Testing all queried domains may be very time consuming.**

Malware Domains Query Detection

GetMalwareAffectedDevices ()

1. Detect device querying the domain $F_{ext}.Qname = dns.msftncsi.com$.
2. Select next `N` queried domains.
3. Exclude domains occurring in the Alexa top domains list.
4. Check the rest of domains if they are in blacklists.

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Detection Results

Domain	Number of blacklists
habble.ru	6
www.softosystem.com	7
cybeitrapp.info	5
telemetry.tanzuki.net	5
cybermindtool.info	4

Part V

Conclusion

Conclusion

- DNS information does **not affect the privacy** of users.
- **IP flows** represents optimal choice for a **large scale network monitoring**.
- Proposed updated DNS flow **exporting algorithm saving a flow cache** and exporting only necessary DNS packet fields.
- **New** network **anomaly detection algorithms** using DNS extended flows.
  - `https://is.muni.cz/publication/1131184?lang=en`

Thank You For Your Attention!

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