Security Apps with P4 Programmable Switches

Mitigating DNS amplification attack in P4

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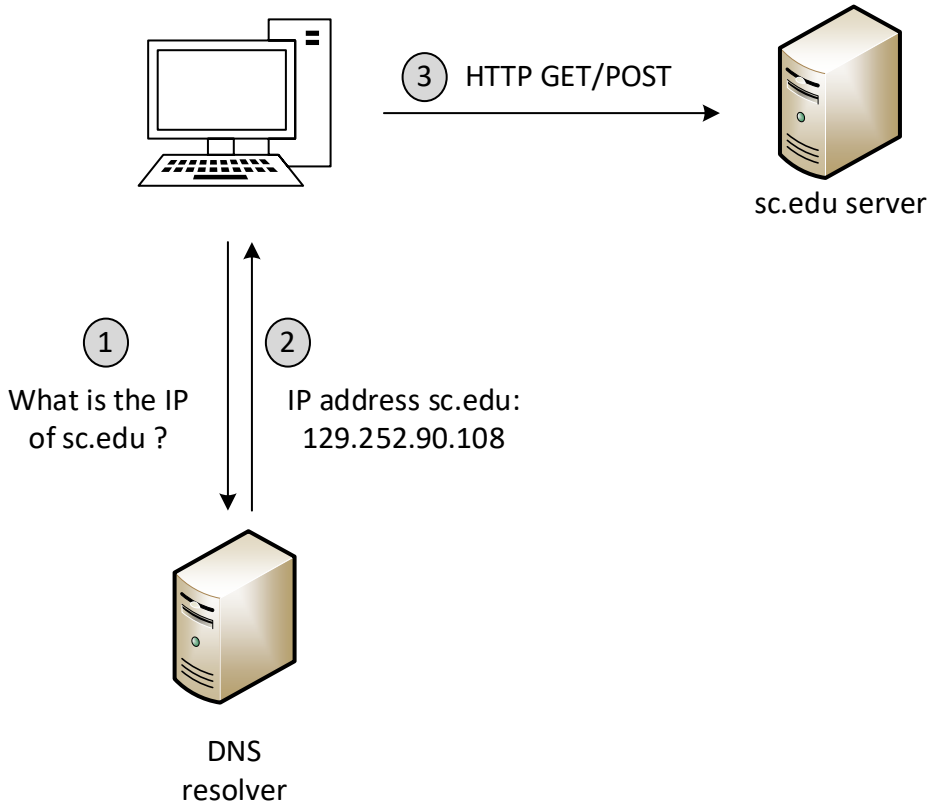
Lab 8: Detecting and Mitigating the DNS Amplification Attack

Domain Name System (DNS)

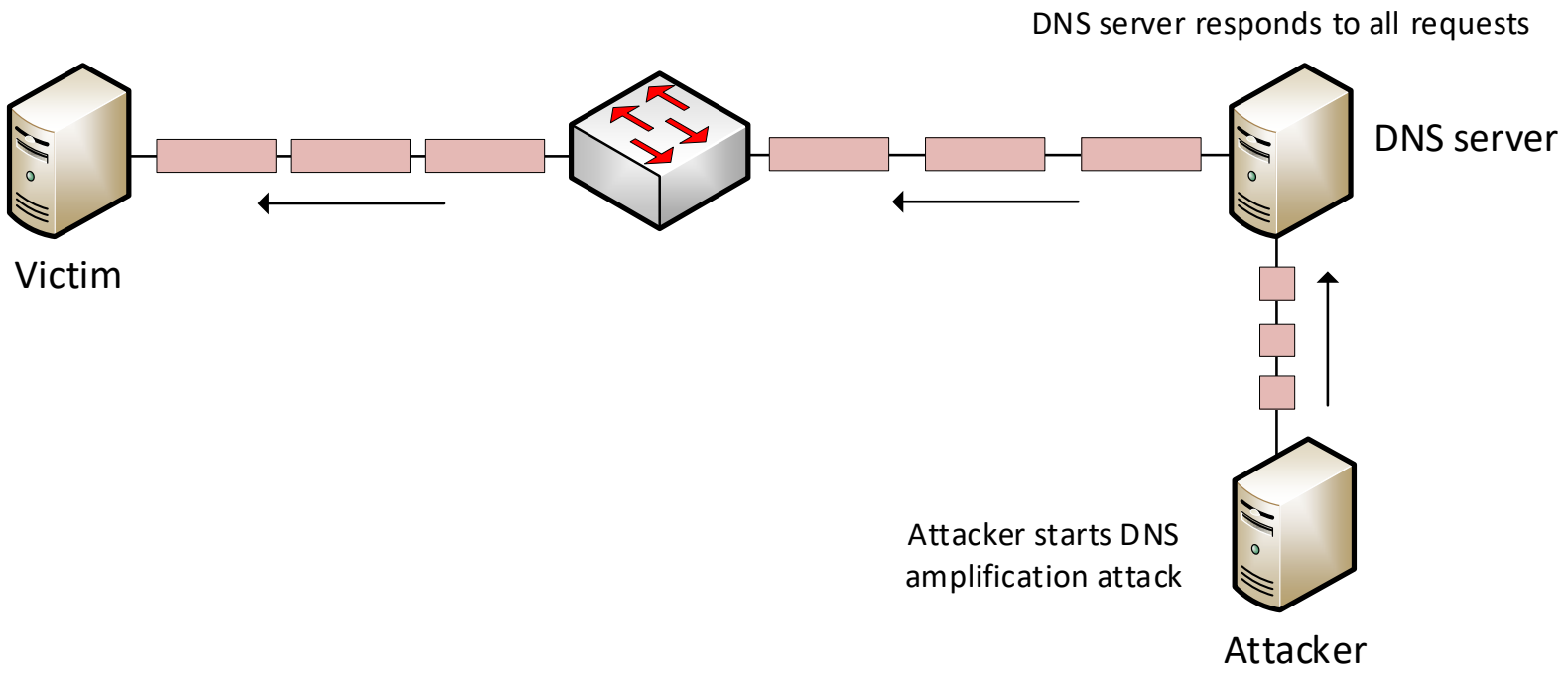
- The Domain Name System (DNS) is an essential component of the internet
- It is responsible for translating human-readable domain names into IP addresses that can be understood by devices connected to the internet[1]



[1] Amazon, “What is DNS?” [Online]. Available: https://tinyurl.com/ynb9esn6

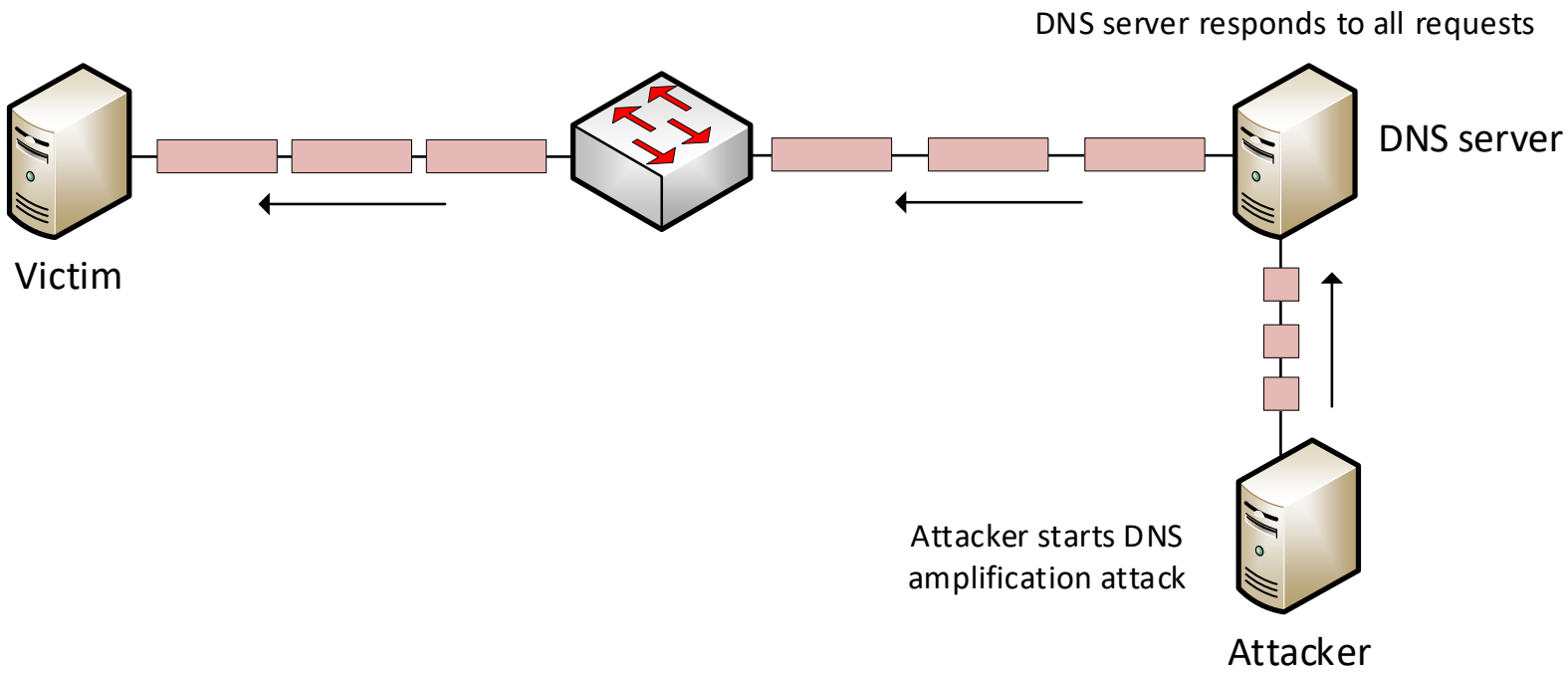
DNS Amplification

- Due its frequent use on the Internet, the DNS is susceptible to many attacks
- DNS amplification is an attack that exploits the infrastructure of the DNS to create a Distributed Denial of Service (DDoS) on a target victim
  - Thus, rendering the victim unresponsive due to the large amount of traffic received



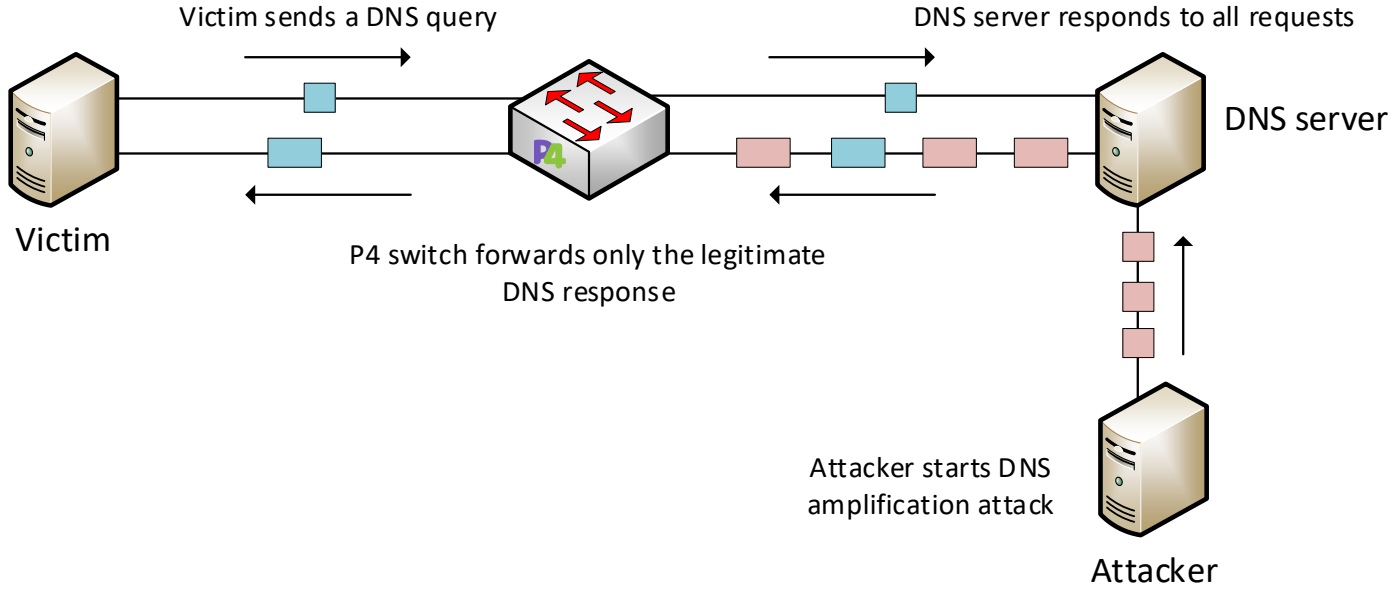
DNS Amplification

- In a DNS amplification attach, the attacker sends DNS requests with spoofed source IP address of the target victim
- The DNS server responds to all the requests and send them to the target victim
- Typically, a valid response is much larger than the request



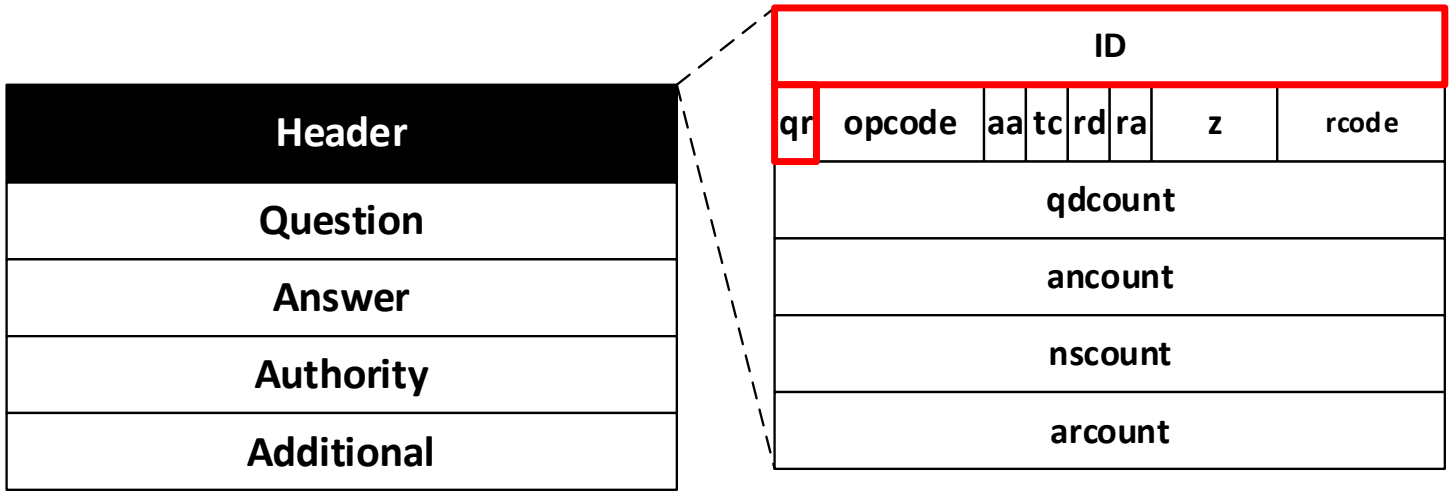
Attack Scenario

- The attacker performs a DNS amplification attack using the source IP address of the victim
- The DNS server responds to the DNS requests and sends them to the victim
- The P4 switch drops all the DNS replies that do not associate with DNS requests issued by the victim
- The P4 switch forwards legitimate DNS replies requested by the victim



DNS Header Fields

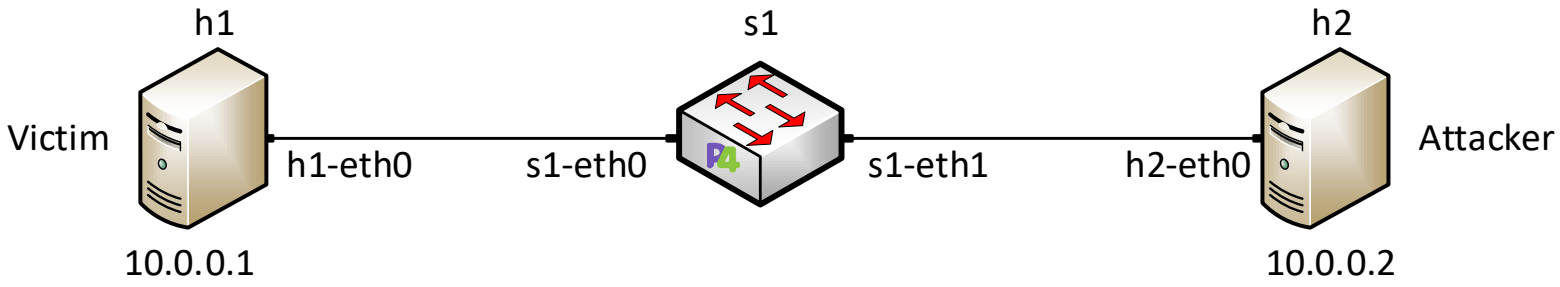
- UDP packets with source or destination port 53 are DNS packets
- The transaction ID is generated by the client upon sending a DNS request
- The DNS *qr* flag indicates that the DNS packet is request (*qr*=0) or response (*qr*=1)



Lab Topology

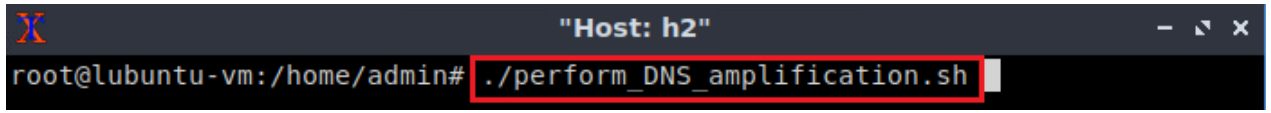
The topology consists of:

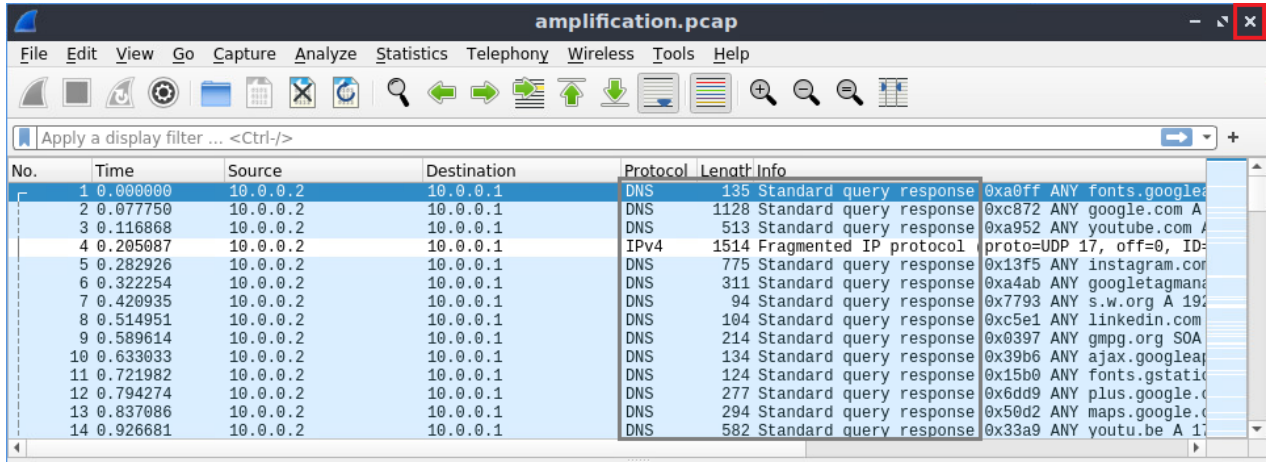
- Host h1 representing the victim of the DNS amplification attack
- Host h2 representing the attacker and the DNS resolver
- Programmable switch s1 that forwards traffic and protects against DNS amplification attack



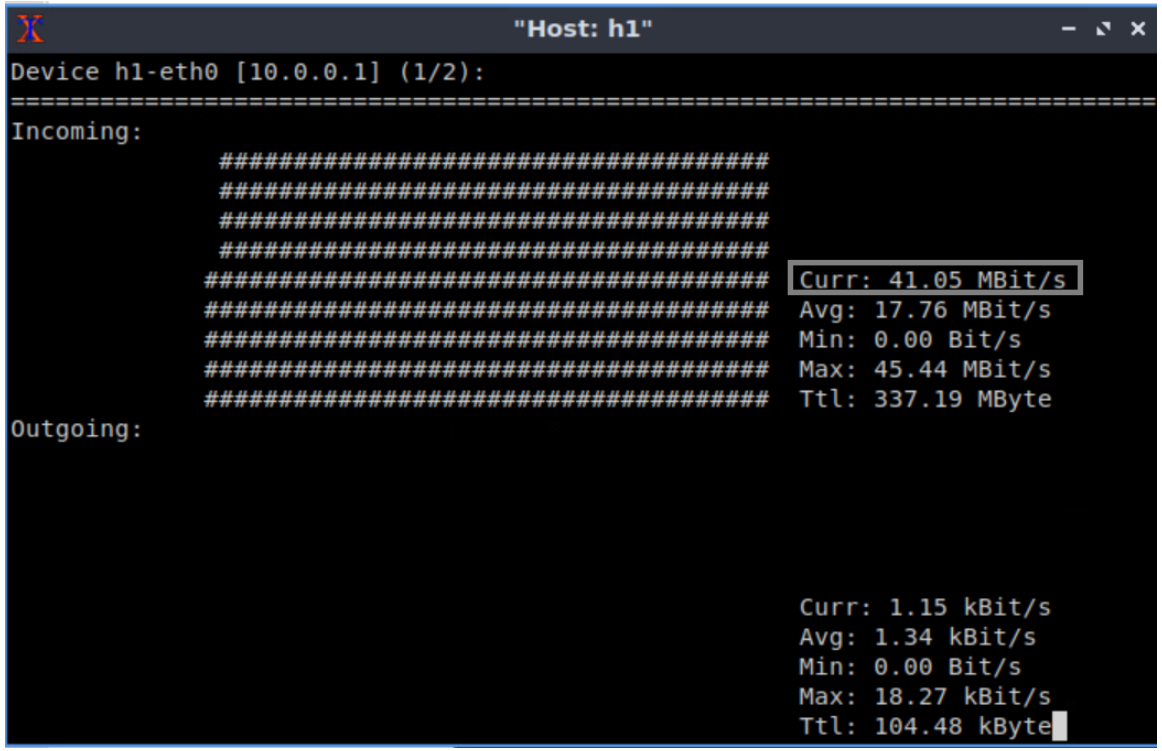
DNS Amplification without Mitigation

Performing DNS amplification



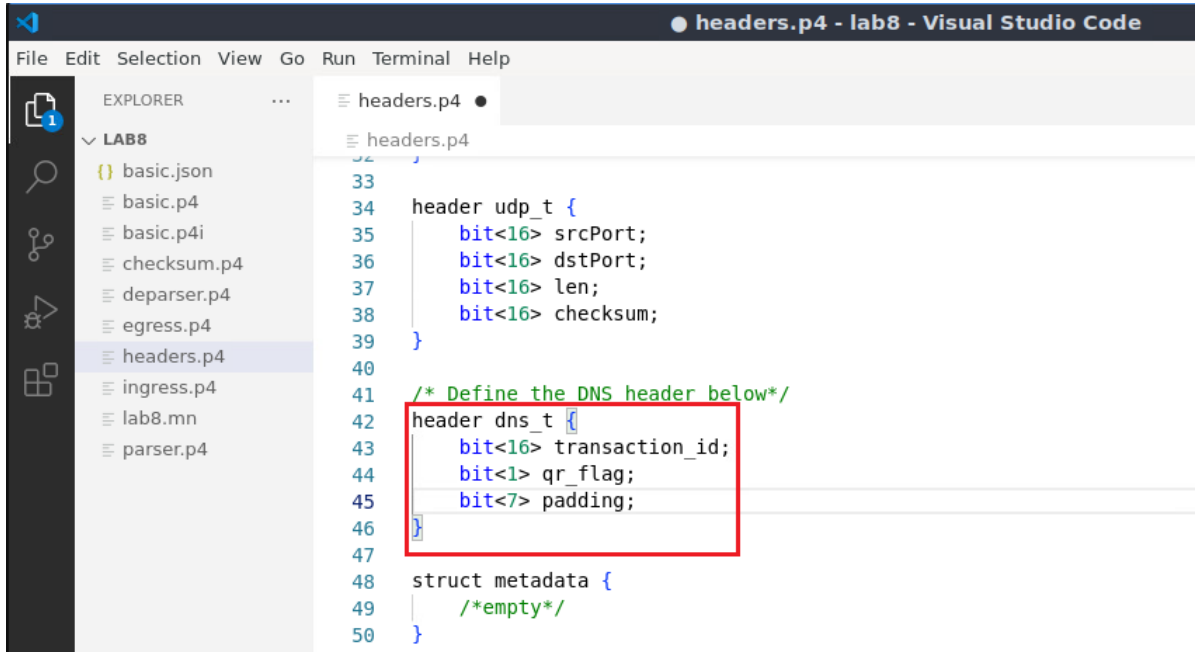


Inspecting resource usage at the victim

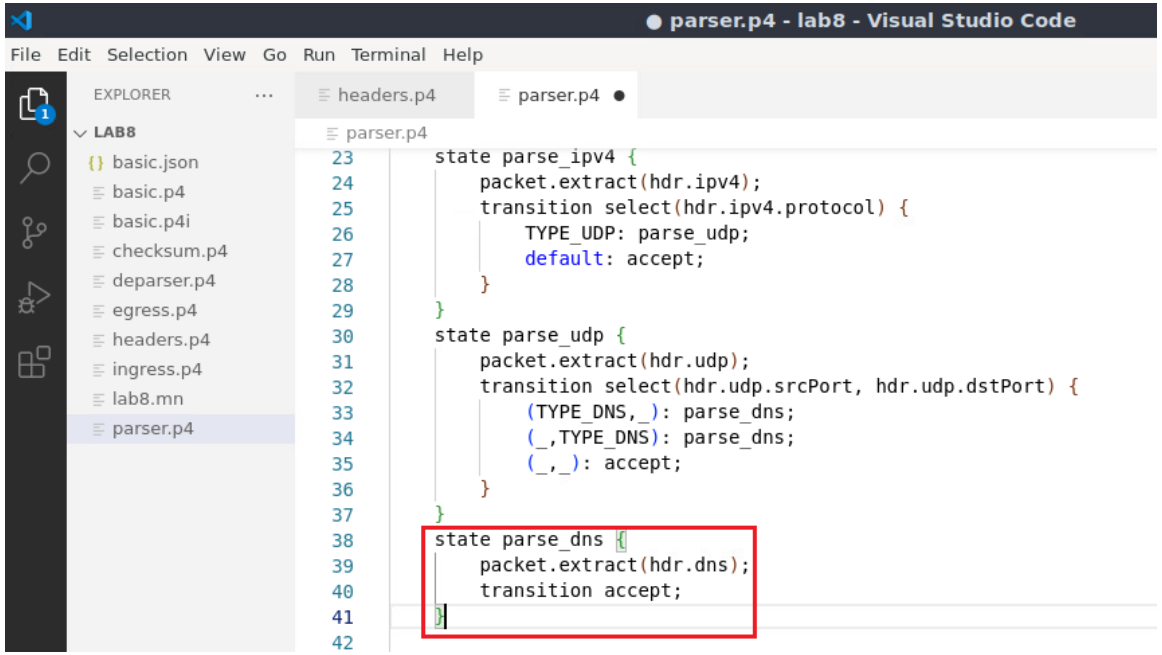


DNS Amplification Mitigation with P4

Defining DNS header

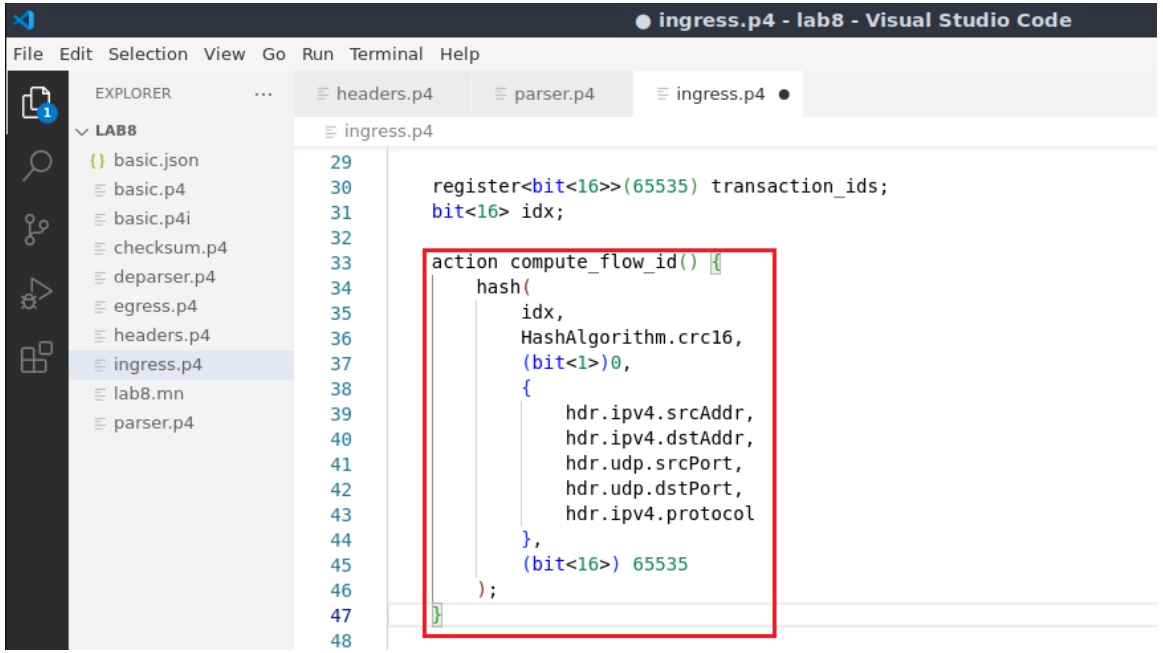


Transitioning and extracting DNS header



DNS Amplification Mitigation with P4

Defining a function that computes a unique flow ID based on the 5-tuple (used for DNS requests)



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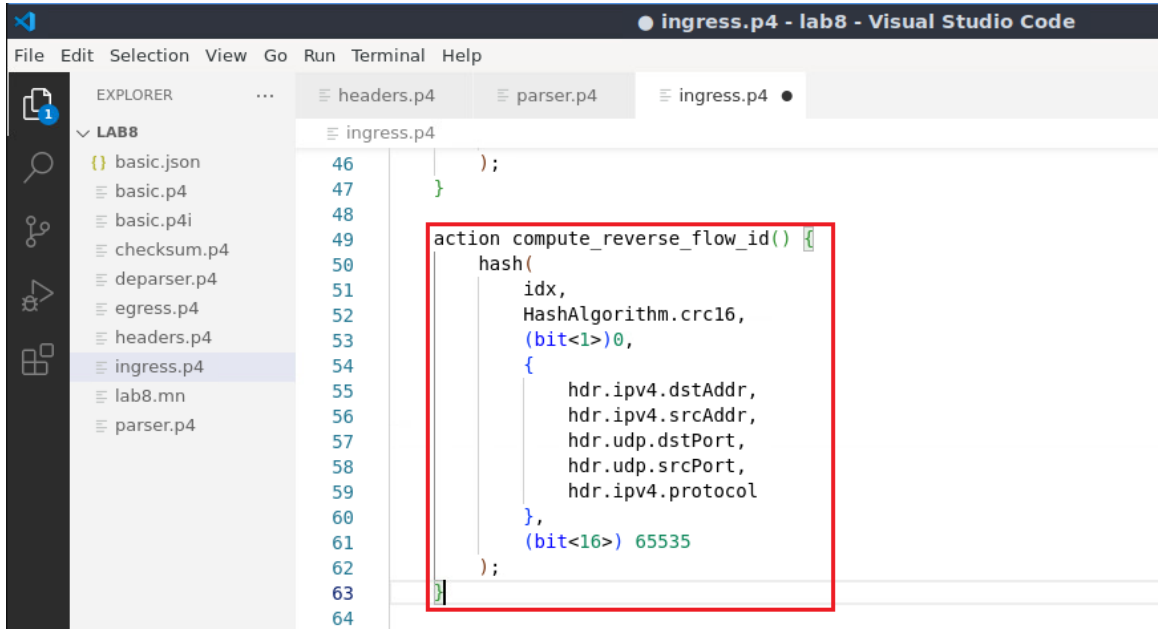
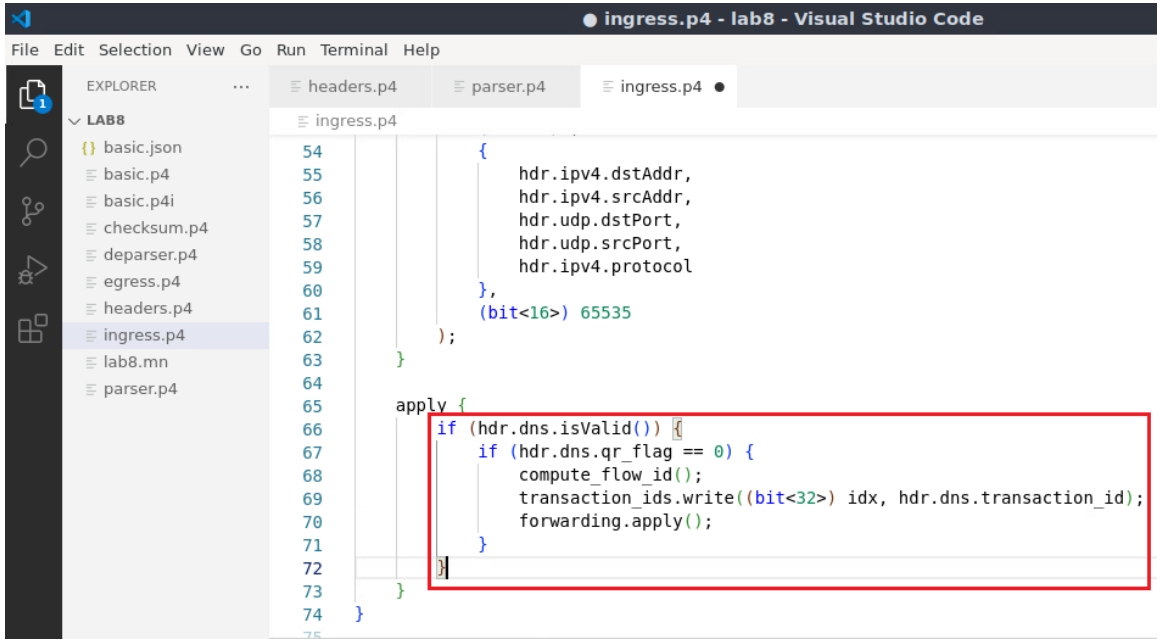
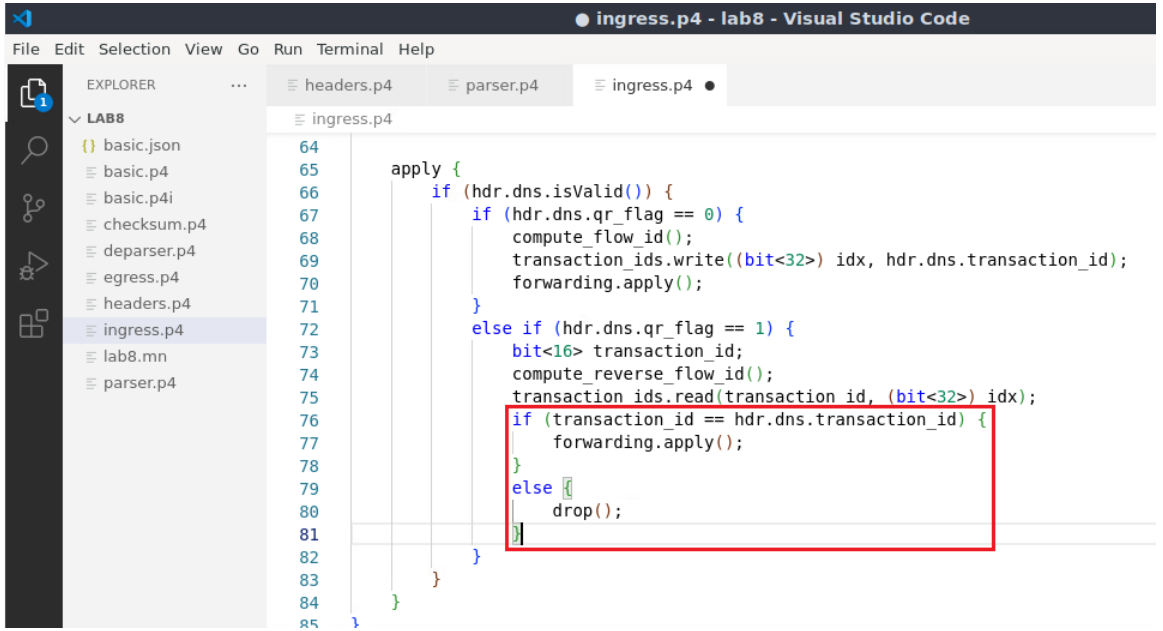


DNS Amplification Mitigation with P4

Using the flow ID to save the transaction ID of DNS request in a P4 register

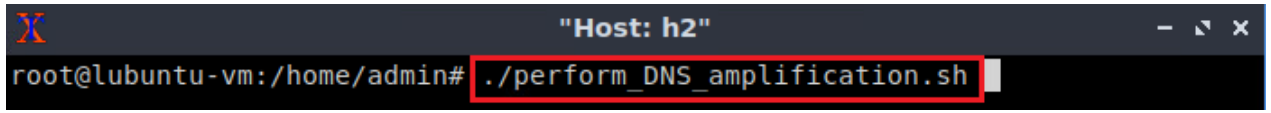


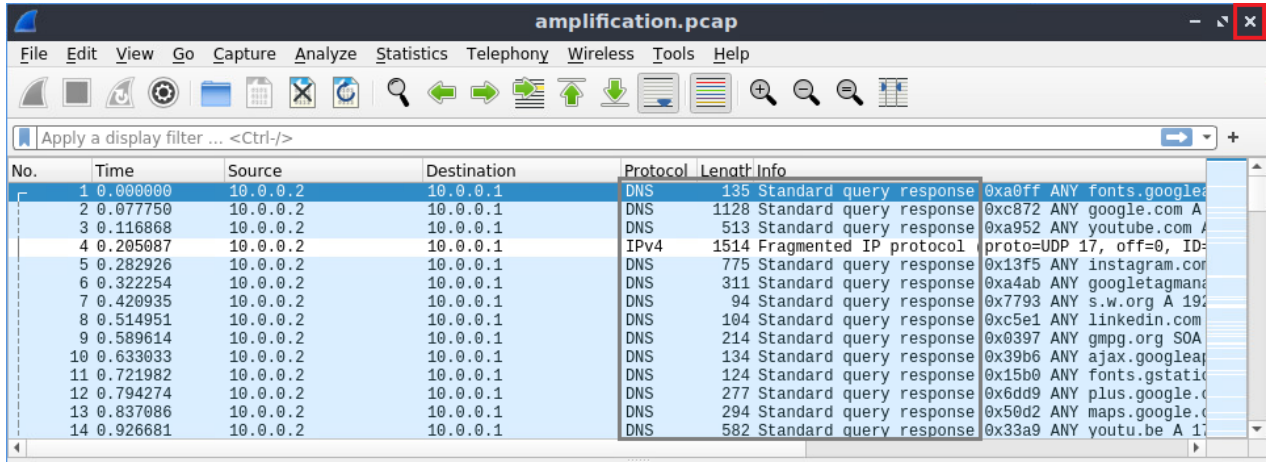
Using the flow ID to retrieve the transaction ID of DNS request saved in a P4 register and comparing it with the transaction ID of the received DNS reply



DNS Amplification with Mitigation

Performing DNS amplification





Inspecting resource usage at the victim