Denial of Service

Recall: Goals of communications sec.

- Confidentiality
- Integrity
- Availability

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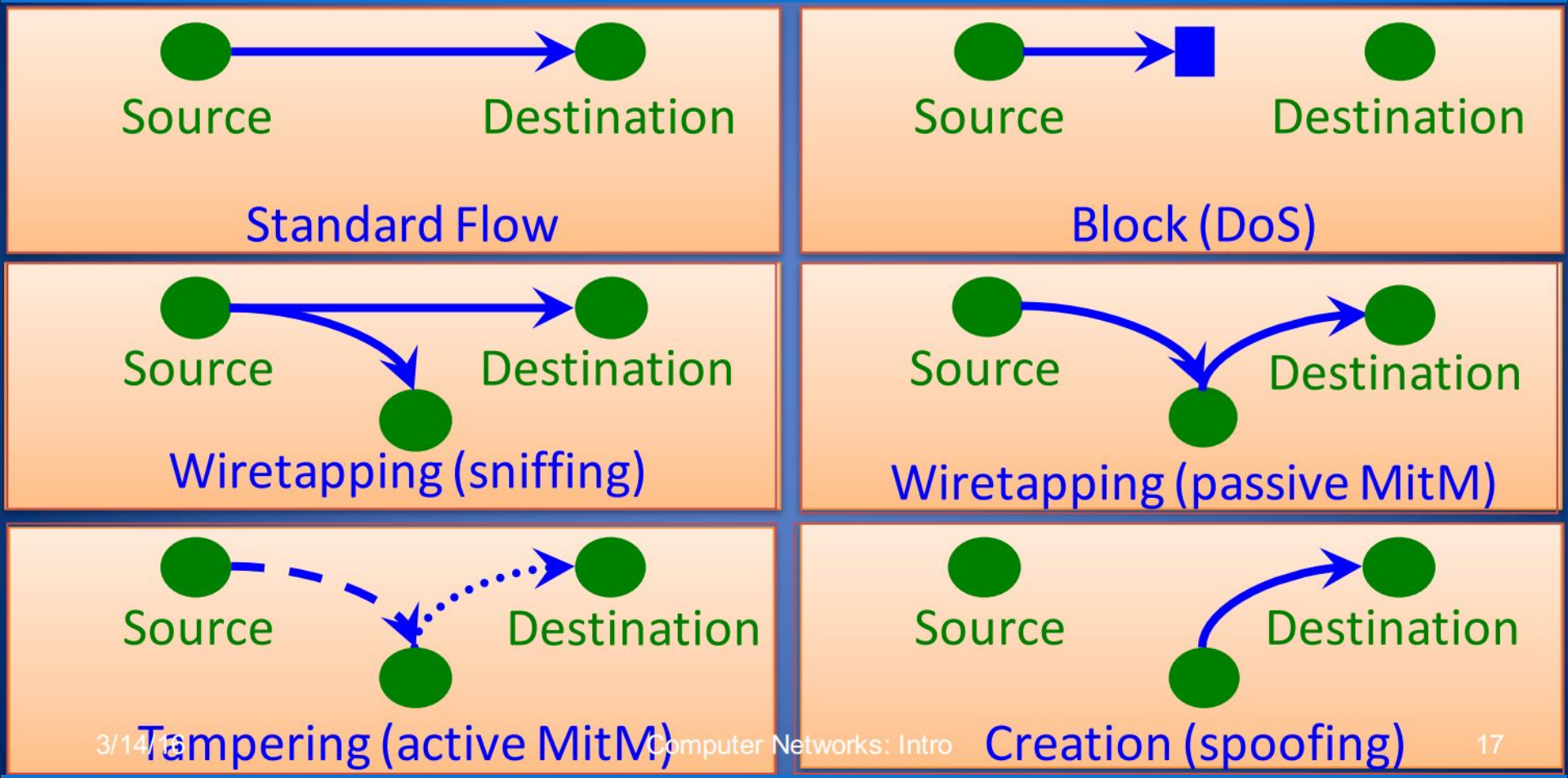
Source
Destination
Standard Flow
Source
Destination
Block (DoS)
Source
Destination
Wiretapping (sniffing)
Source
Destination
Wiretapping (passive MitM)
Source
Destination
Tampering (active MitM)
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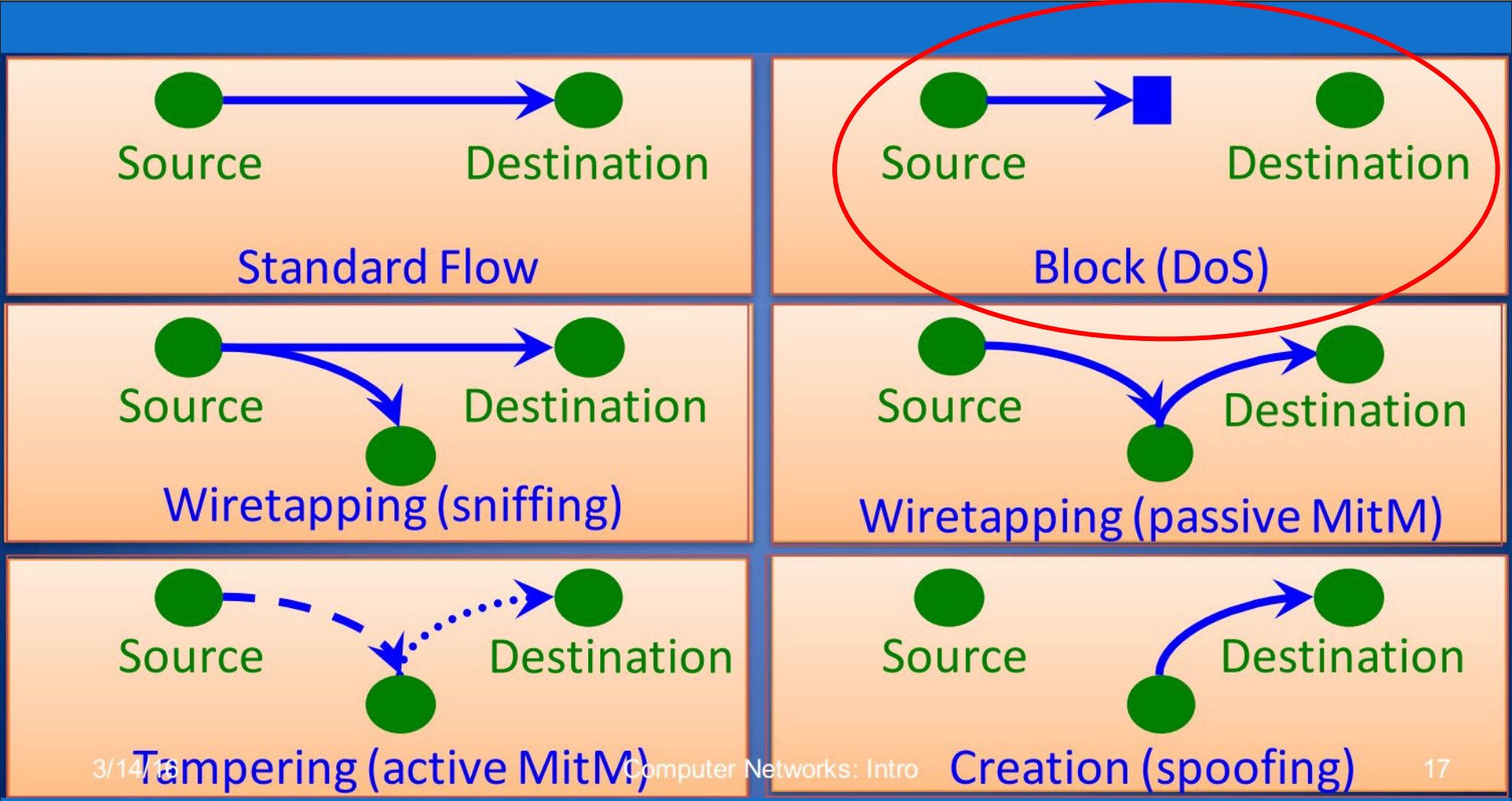
Creation (spoofing)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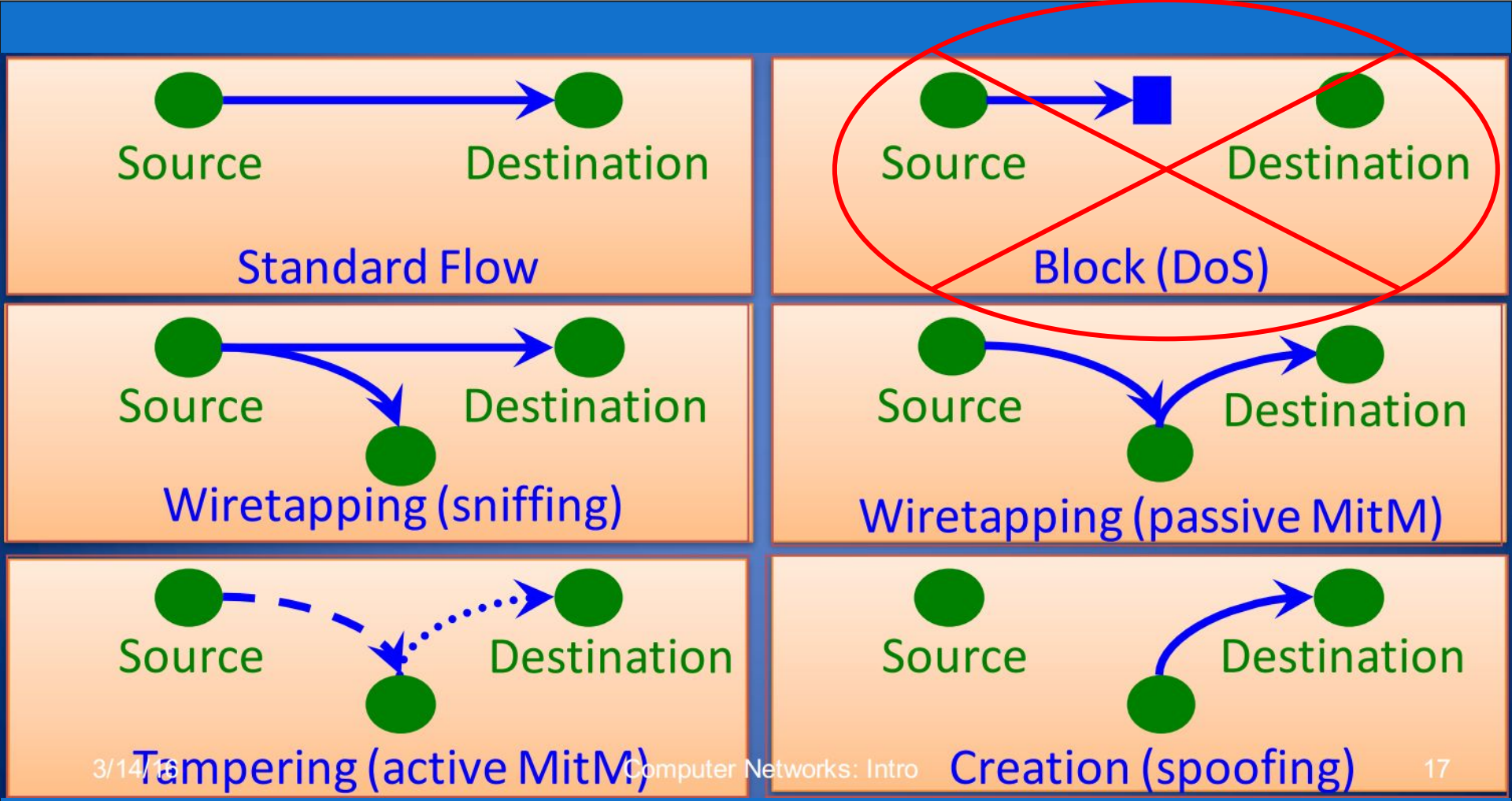
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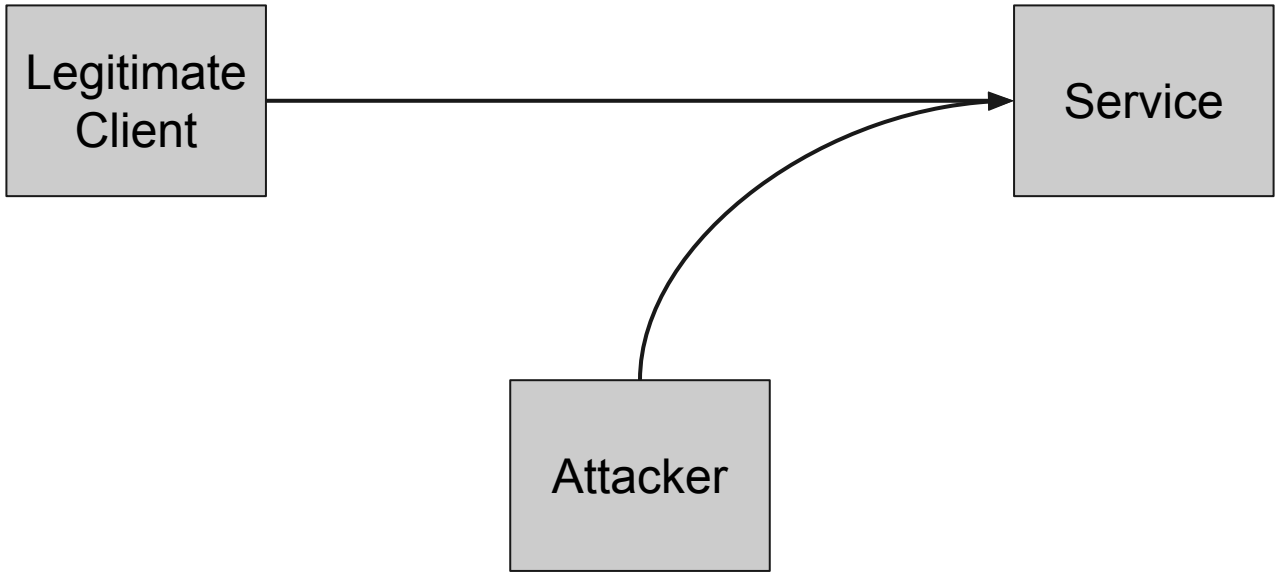
Overview of Non-MitM DoS Attack

- Players
  - Service
  - Clients of the service
  - Attacker
- Goal: consume service's resources so they aren't available for legitimate clients


Legitimate Client
Service
Attacker

Classic Denial of Service

- Idea: find requests that are expensive for the service to perform
- Example: PHP's hash tables
  - Non-cryptographically secure hash function
  - "Chaining" to handle hash collisions
  - Attackers can engineer "multicollisions"
    - Turn hash table into one linked list
    - O(n) insertion and lookup
    - $O(n^2)$ for n elements

Classic Denial of Service: PHP

- Estimates from the bug report
  - POST requests can have key/value pairs
  - PHP stores these in `$_POST` (a hash table)
  - Maximum POST request size: 8MB
  - Estimated time to construct table on an Intel Core i7:

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4 hours of CPU time

Classic Denial of Service

- Other examples of DoS attacks:
  - Billion laughs
  - Zip bomb
  - Ping of death
  - Pentium `F00F` bug

Distributed Denial of Service (DDoS)

- DoS like that is *very* powerful, but…
- Uncommon to find in the wild
- What to do?

Distributed Denial of Service (DDoS)

- What to do?
  - You've found the most expensive request
  - What's left?
  - Send as many of them as you can

Distributed Denial of Service (DDoS)

- **Distributed** Denial of Service
  - Distribute your attack across many machines
- In practice, usually PCs infected with malware
  - Each PC is called a “zombie” or “bot”
  - The entire collection of bots is a “botnet”

Distributed Denial of Service (DDoS)

- PC security is bad, so lots of machines can get infected
- Botnets can get **big**
  - Conficker (late 2000s): 3-4 million bots
  - Mariposa (late 2000s): 1 million bots
  - ZeroAccess (early 2010s): 2 million bots
- With millions of bots, you can do **lots** of computation and send **lots** of network traffic

Amplification Attacks

- You've found an expensive request
- You've acquired lots of computers
- Can you still do better?

Amplification Attacks

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- You've acquired lots of computers
- Can you still do better?
- Yes: amplification attacks

Amplification Attacks

- Idea: trick third-party service into attacking for you
- Usually the goal is to send lots of network traffic
  - The resource is network bandwidth itself
  - “Layer 3” attacks - consume bandwidth of IP packets
- Best explained by example...

Spamhaus Attack

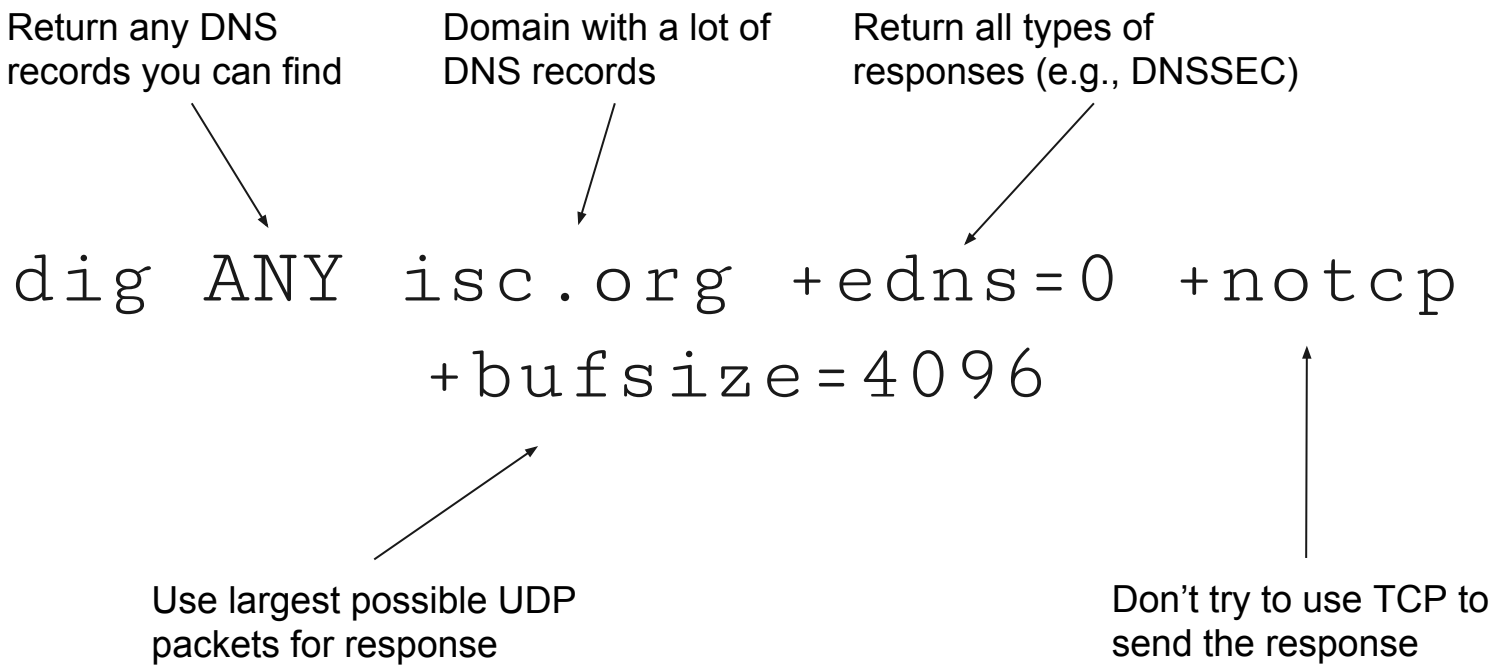
- March 2013
- 5-7 servers
- 3 networks
- ~300 Gbps traffic to Spamhaus
  - Most don’t get above 100 Gbps
  - Largest DDoS attack ever at the time
- How?

Spamhaus Attack

- Two ingredients:
  - Open DNS resolvers - accept queries from any IP
  - Networks that allow source IP spoofing
- Spoof victim's IP as the source IP
- Send DNS requests to these resolvers:

```
dig ANY isc.org +edns=0 +notcp
    +bufsize=4096
```

Spamhaus Attack



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3,363-byte response…

~50x amplification factor

Spamhaus Attack

- “DNS Amplification”
- 300 Gbps
- 30,956 open DNS resolvers
- 50x amplification factor
- 6 Gbps of input traffic
- 5-7 compromised servers
- 1 Gbps traffic from each server