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(Distributed) Denial of Service Attacks

aka

(D)DoS Attacks

Panos Papadimitatos

Networked Systems Security Group

www.kth.se/nss

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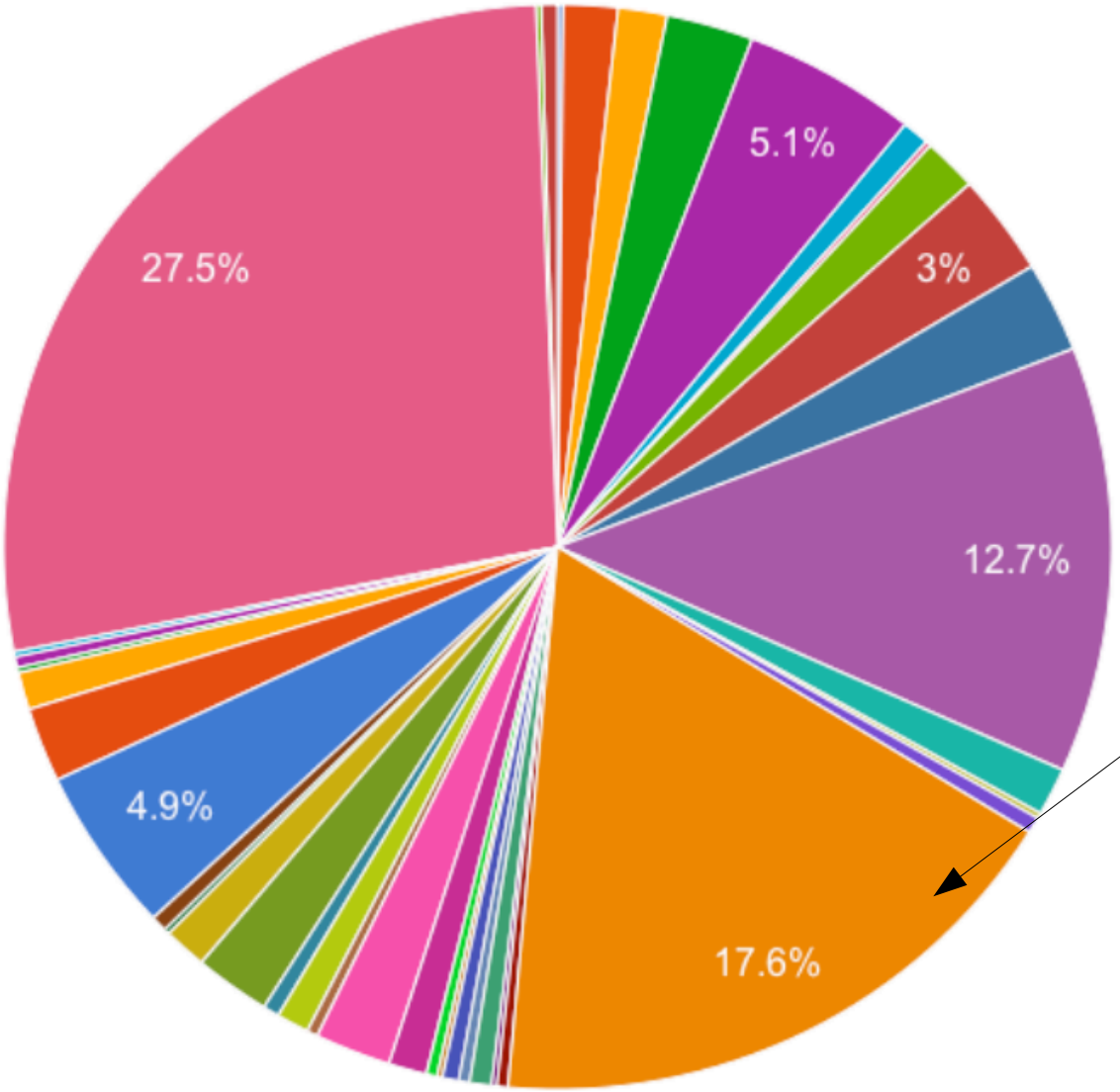
Outline

- Introduction
    - A Denial of Service Attack?
    - A Distributed Denial of Service Attack?
- BotNets, BotNet Architectures, Bot Recruitment
- Transport Layer DoS Attacks
    - TCP attacks
- Network Layer and Overlay Attacks
    - Smurf Attacks, P2P based DDoS
- Operation #PayBack
- Research on DoS and DDoS
    - Tracing back the source of DDoS traffic

Introduction



- Approximately 20% of attacks targeting web sites are DoS based
- Things get worse in case of DDoS attacks

Web Hacking Incident Database

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Introduction (cont'd)

(Recall: Introduction lecture - revise)

DoS and DDoS are common attack methods targeting:

Introduction (cont'd)

Companies

Introduction (cont'd)

Authorities

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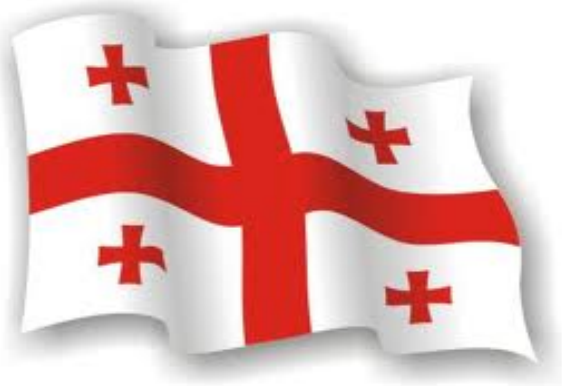
Introduction (cont'd)

Or even Nations...



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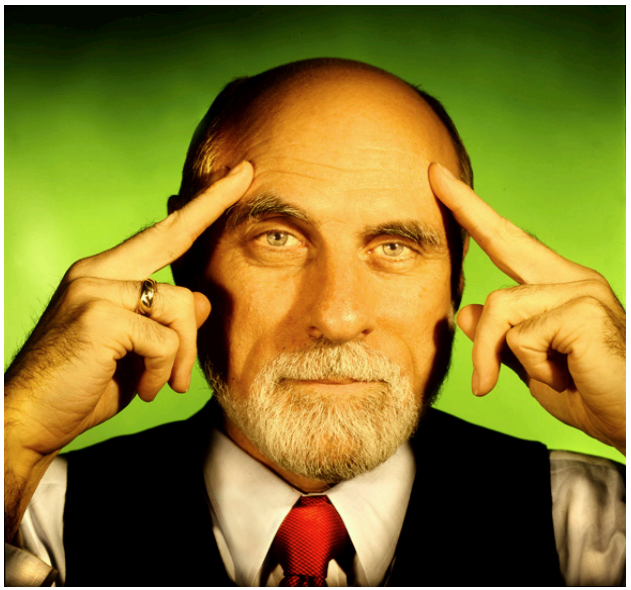
Introduction (cont'd)

Defending against them is really hard...

Because when these DDoS attacks swamp access lines, then filtering at the other end does not help

Vinton Cerf



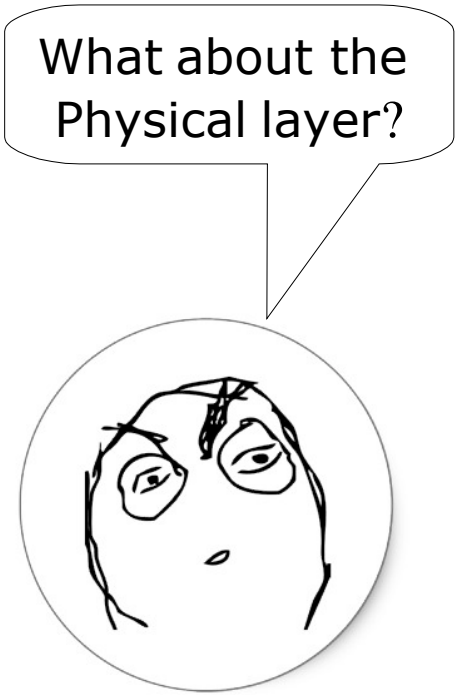
DoS Attacks

- Denial of Service (DoS) Attacks target system availability
- They do not require a lot of computing work and resources
- They take advantage of
  - Security-agnostic design
  - Design problems
  - System defects, bugs

DoS attacks (cont'd)

- Can be launched on all OSI layers:
  - 802.11b bug: Link Layer DoS
  - Apache Killer: Application Layer DoS

Jamming is a DoS attack too
- *Recall previous lecture*



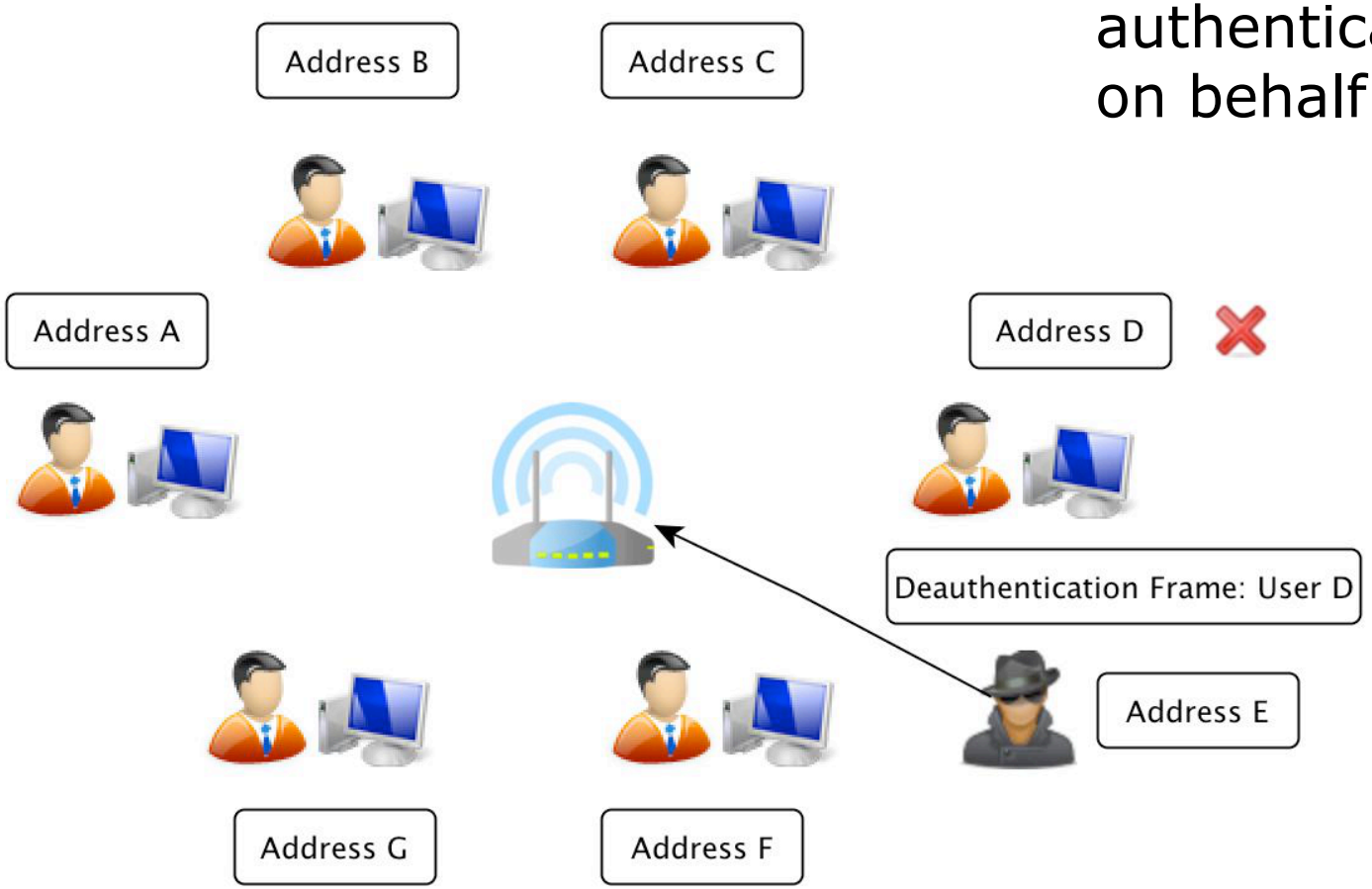
DoS attacks: 802.11b De-authentication

- All users are connected to the AP in a 802.11b network

DoS attacks: 802.11b De-authentication (cont'd)

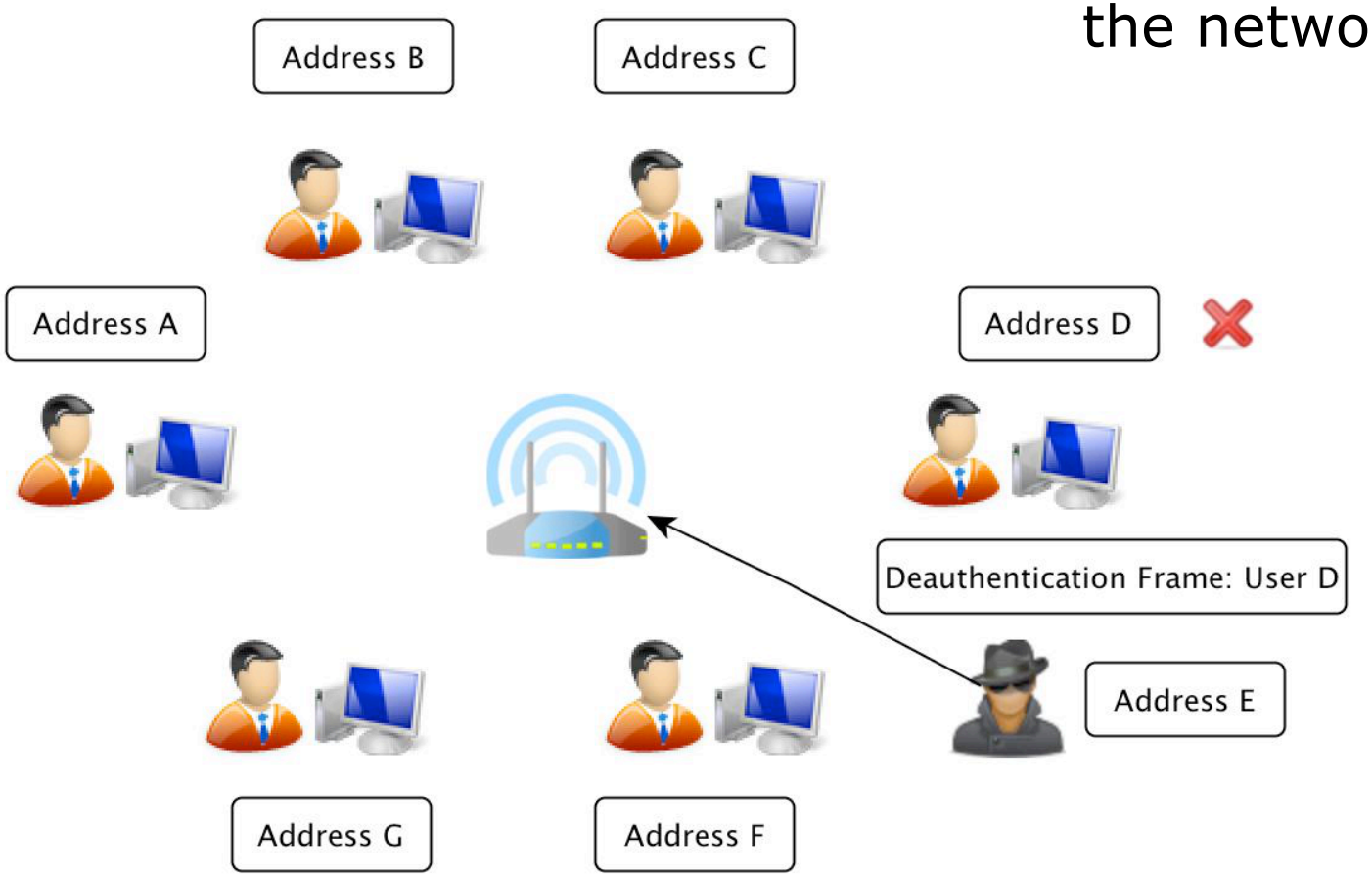
The 802.11b De-authentication:

- The attacker sends a de-authentication frame to the AP on behalf of user D

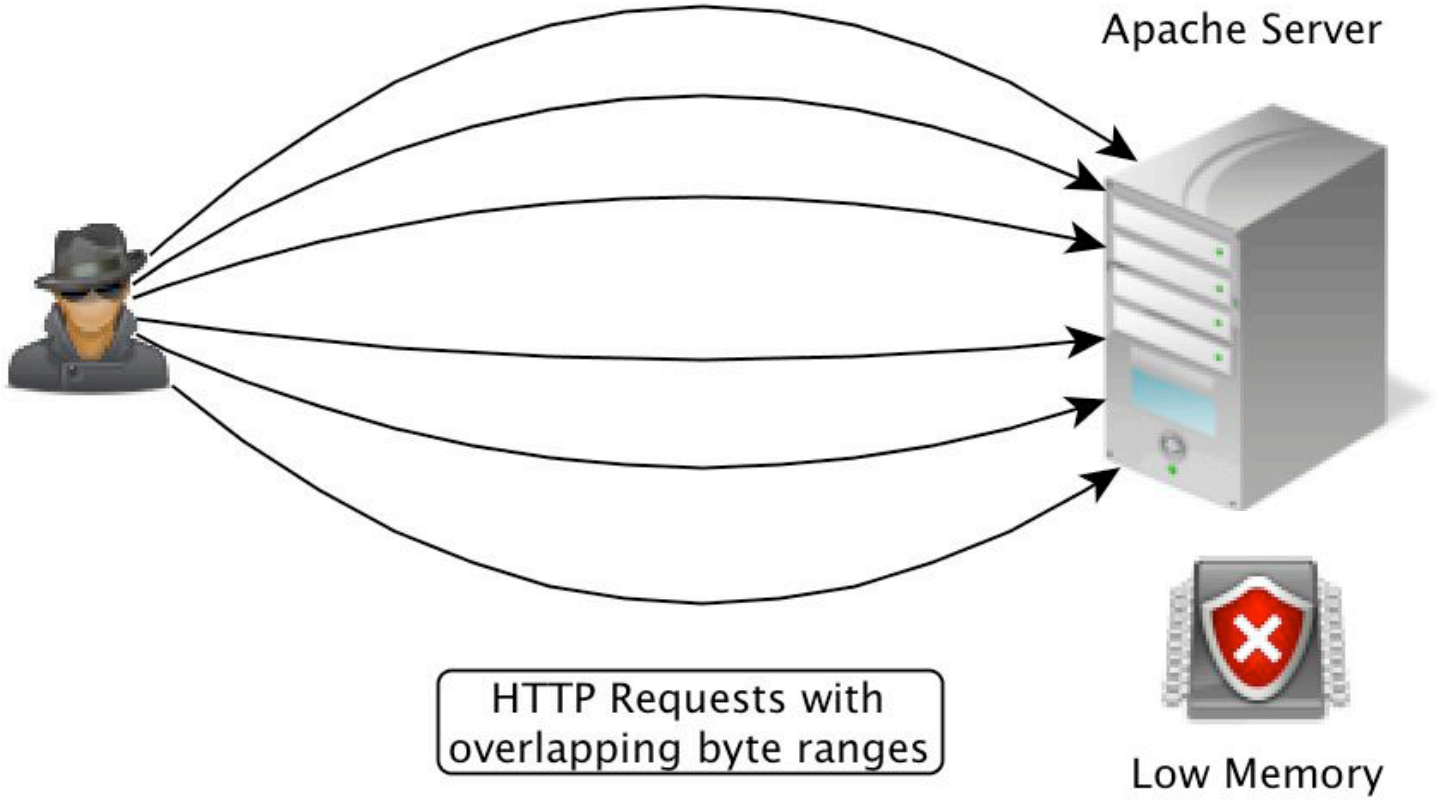


DoS attacks: 802.11b De-authentication (cont'd)

- User D gets disconnected from the network



DoS attacks: The Apache Killer Bug



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DoS attacks (cont'd)

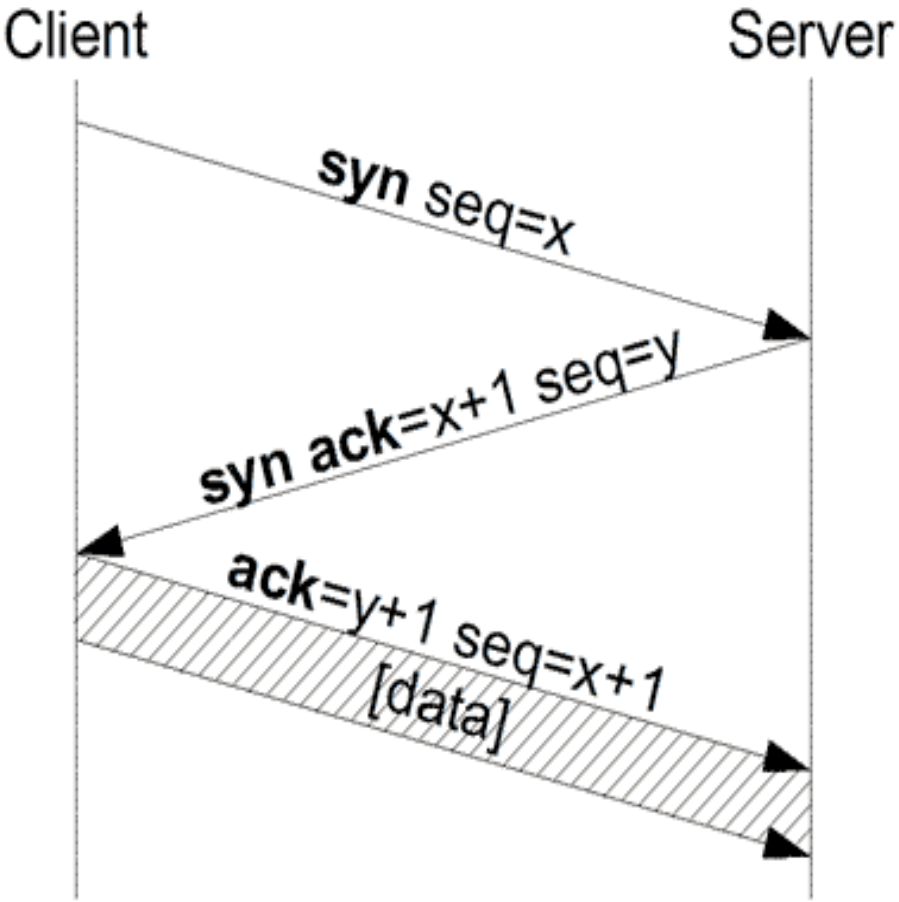
- Feasible when there is a **mismatch** between
  - Client resources to issue a request
  - Server resources respond to the request

  E.g.,
  - SSL/TLS Handshake RSA verification
  - HTTP request of large files

* Flash forward: **Every** technique used to launch a DoS attack can be used as part of a Distributed DoS (DDoS) attack...

SYN Flooding (1)

Transport Layer Attacks (SYN Flooding)

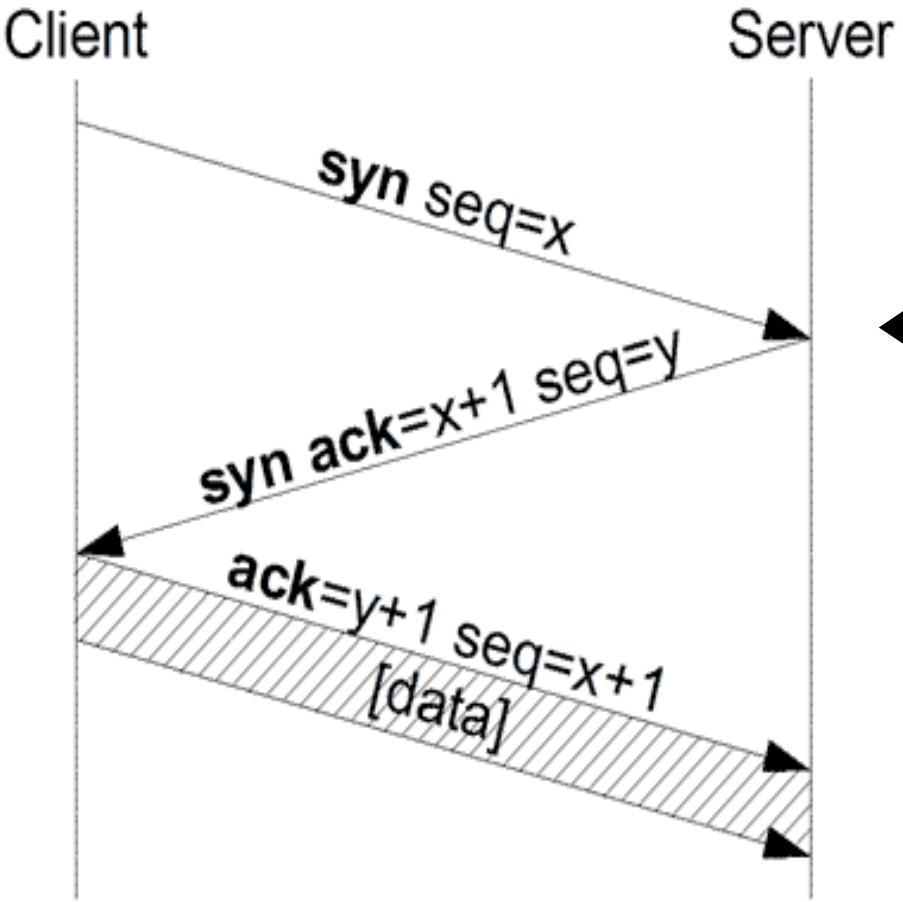


A TCP connection is established with a 3-way handshake

- SYN message
- SYN-ACK message
- ACK message

SYN Flooding (2)

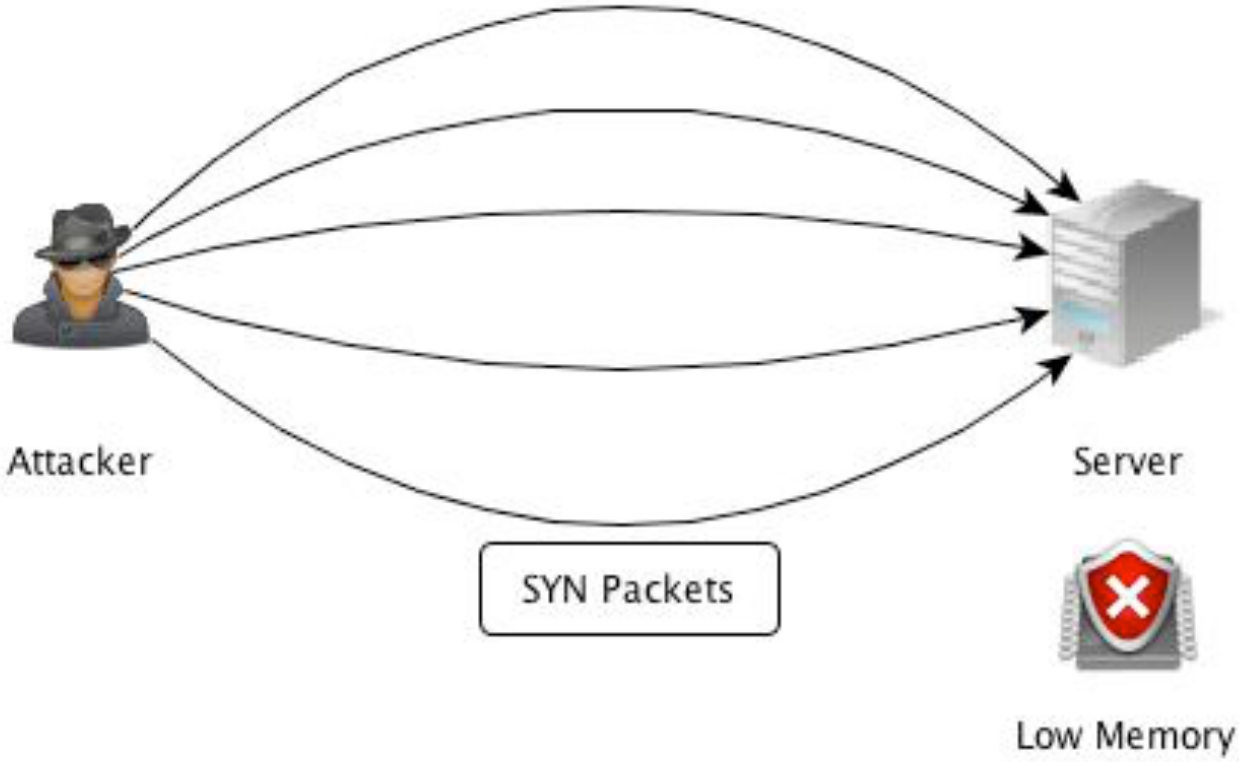
Transport Layer Attacks (SYN Flooding)



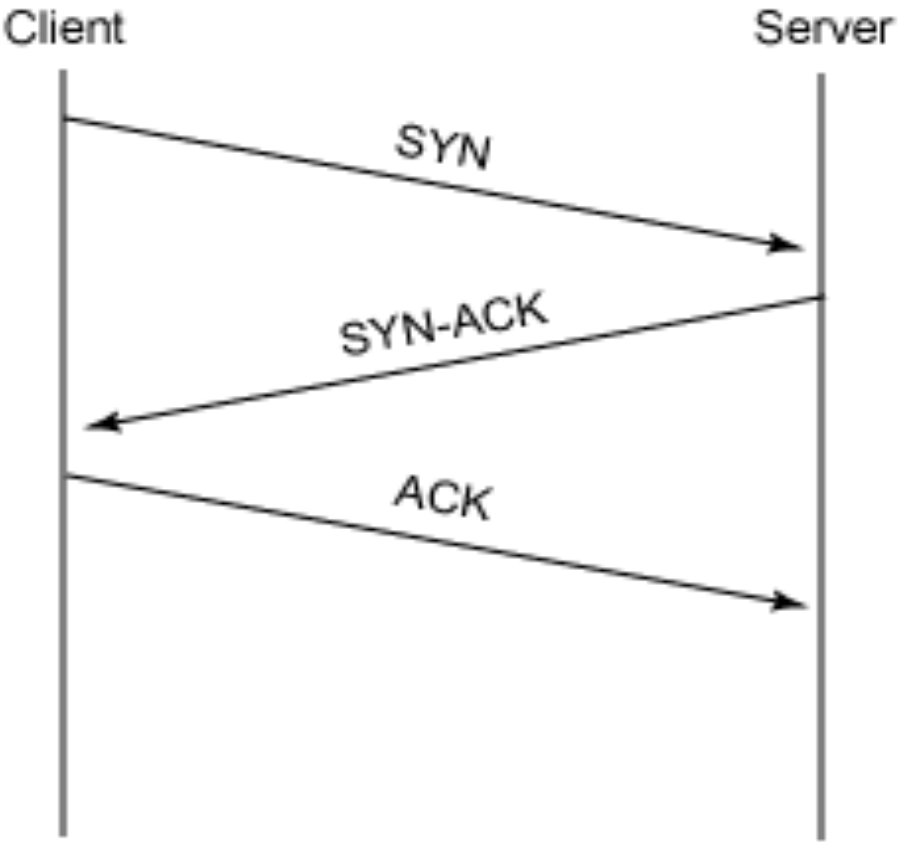
At this point the server keeps state and as a result consumes resources

SYN Flooding (3)

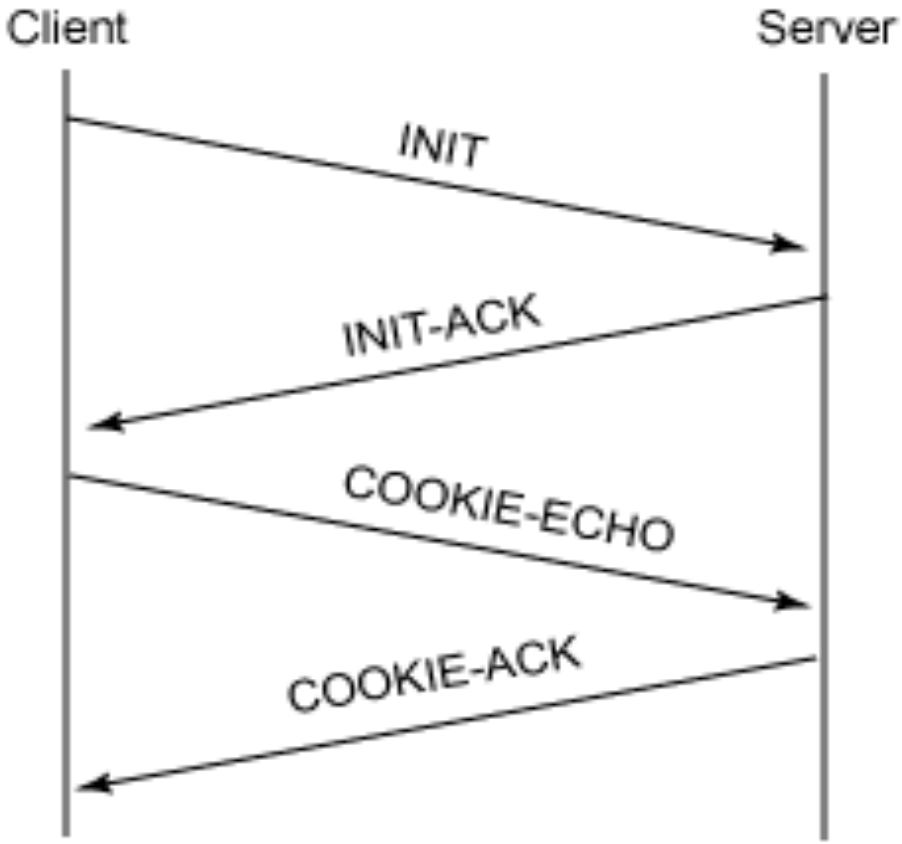
Transport Layer Attacks (SYN Flooding)



Protecting Against SYN-Flooding: The SCTP Protocol



TCP 3-way handshake



SCTP 4-way handshake

Protecting Against SYN-Flooding: The SCTP Protocol

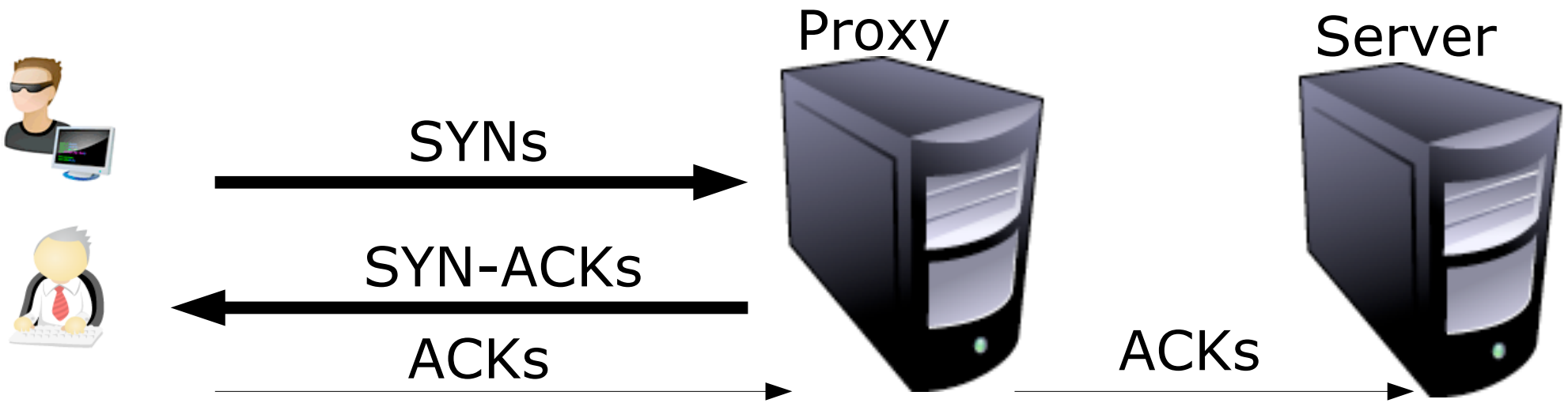
- Use of SCTP transport protocol:

  - The server sends a **cookie** to the initiator of the SCTP connection **(INIT- ACK)**
  - If the client did not use a spoofed IP address, then she receives the cookie and replays it back to the server
  - The server calculates the cookie in the **INIT-ACK** message and does not save it (no state kept)
  - Rather, it expects the **COOKIE-ECHO** within a (short) "validity" period. If so, it saves the state and proceeds

Protecting Against SYN-Flooding: Proxies

Preventing SYN Flooding:

- Use of Proxies

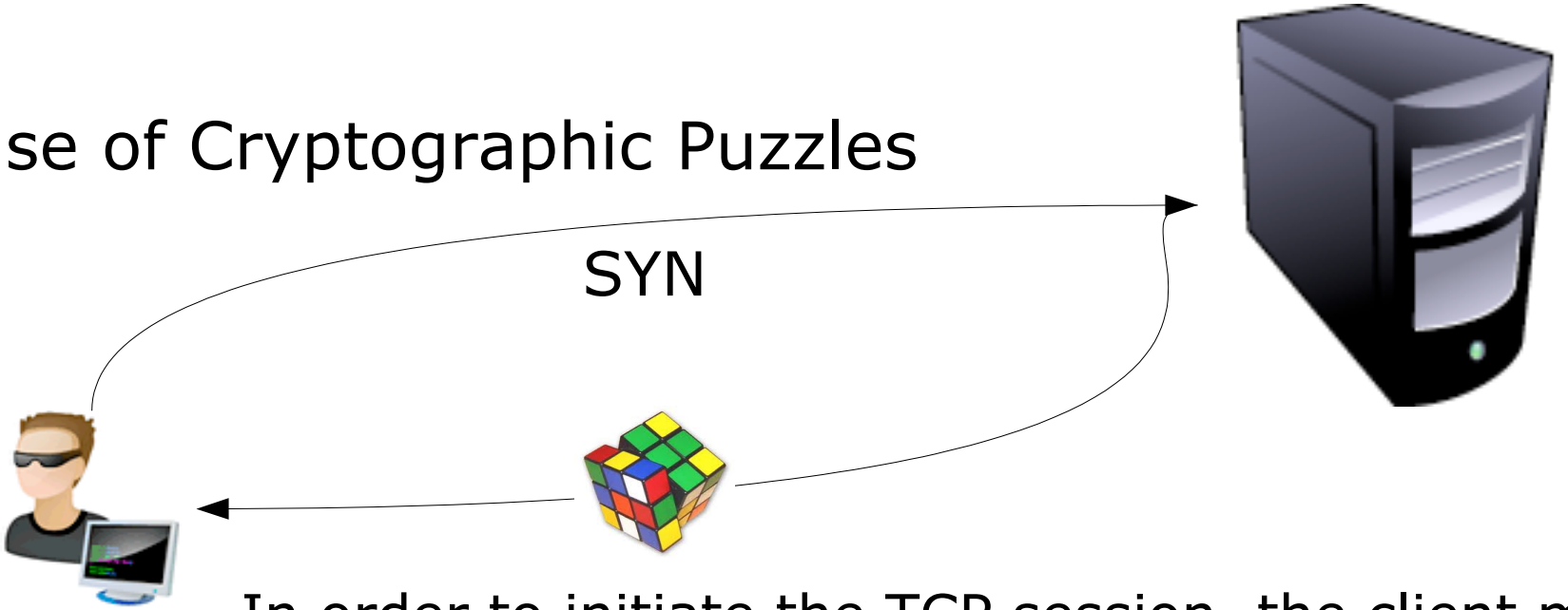


Protecting Against SYN-Flooding: Cryptographic Puzzles

Transport Layer Attacks (SYN Flooding)

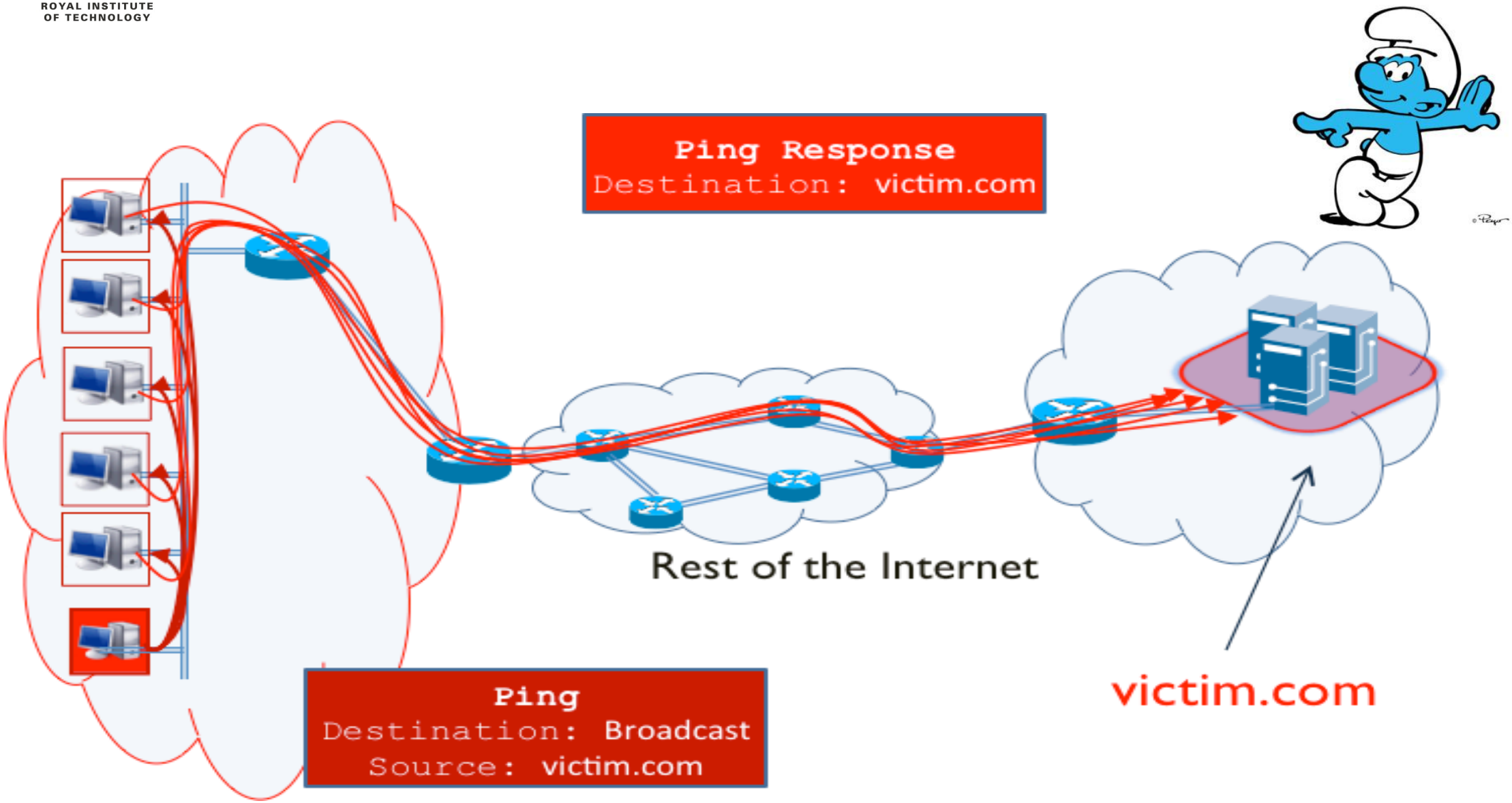
Preventing SYN Flooding:

- Use of Cryptographic Puzzles



In order to initiate the TCP session, the client must solve a (cryptographic) puzzle.

Smurf Attacks



Preventing Smurf Attacks

- Ingress Filtering must prevent the forwarding of Directed Broadcast Traffic

- Use Access Control to define which hosts (subnets) can trigger directed Broadcast traffic (CISCO Guide)

Distributed Denial of Service (DDoS) Attacks

DoS vs DDoS

Hollywood version of a **BotNet**

Vs

[Agent Smith, aka Hugo Weaving; "The Matrix" (motion picture)]

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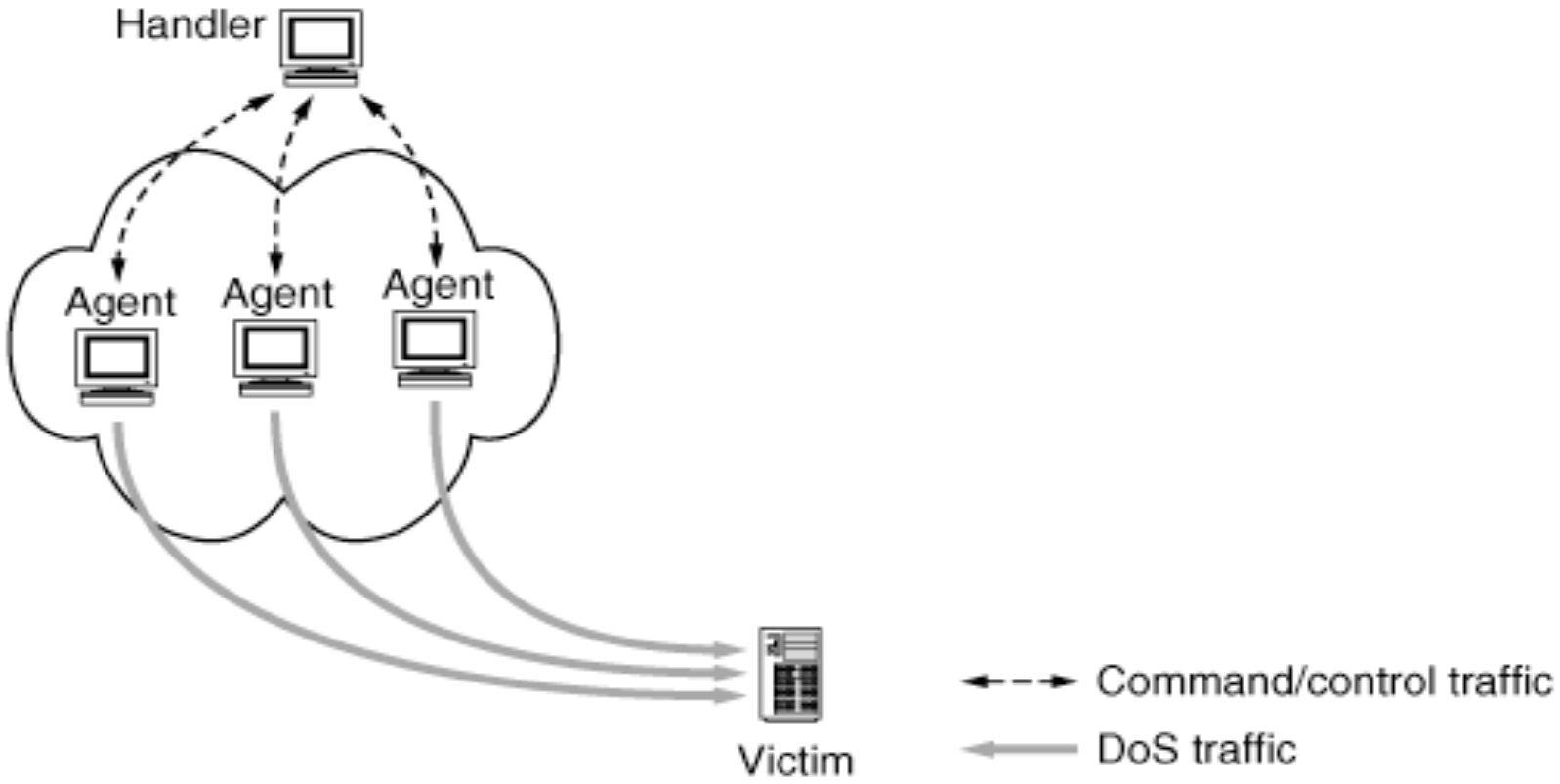
Basic BotNet Architectures

BotNet: A large number of compromised computers

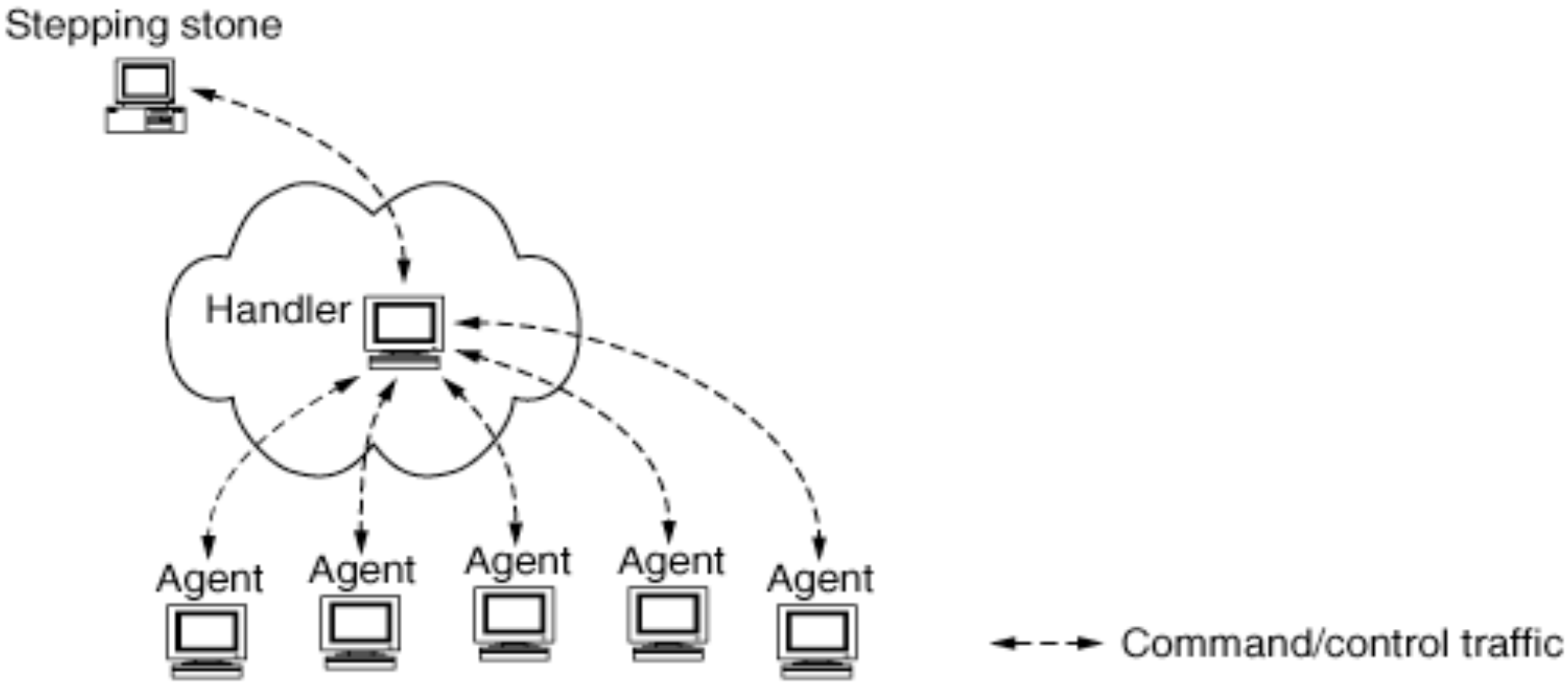
- Controlled by one or more Bot-Masters
- Computers are 'recruited' with the use of Malicious Code (Trojan, viruses, backdoors ...)
- BotNets are used for various malicious purposes:
  - DDoS
  - Spam
  - Attacking on-line communities
  - ...

Basic BotNet Architectures (1)



Internet Denial of Service: Attack and Defense Mechanisms

Basic BotNet Architectures (2)



Internet Denial of Service: Attack and Defense Mechanisms

Basic BotNet Architectures (3)

- Stepping Stone machines
  - Bot-Masters communicate with Handlers going through Stepping Stones
  - Stepping Stones are, in essence, an additional layer of hierarchy in the BotNet architecture
  - Their purpose: to prevent tracing of the Bot-Masters

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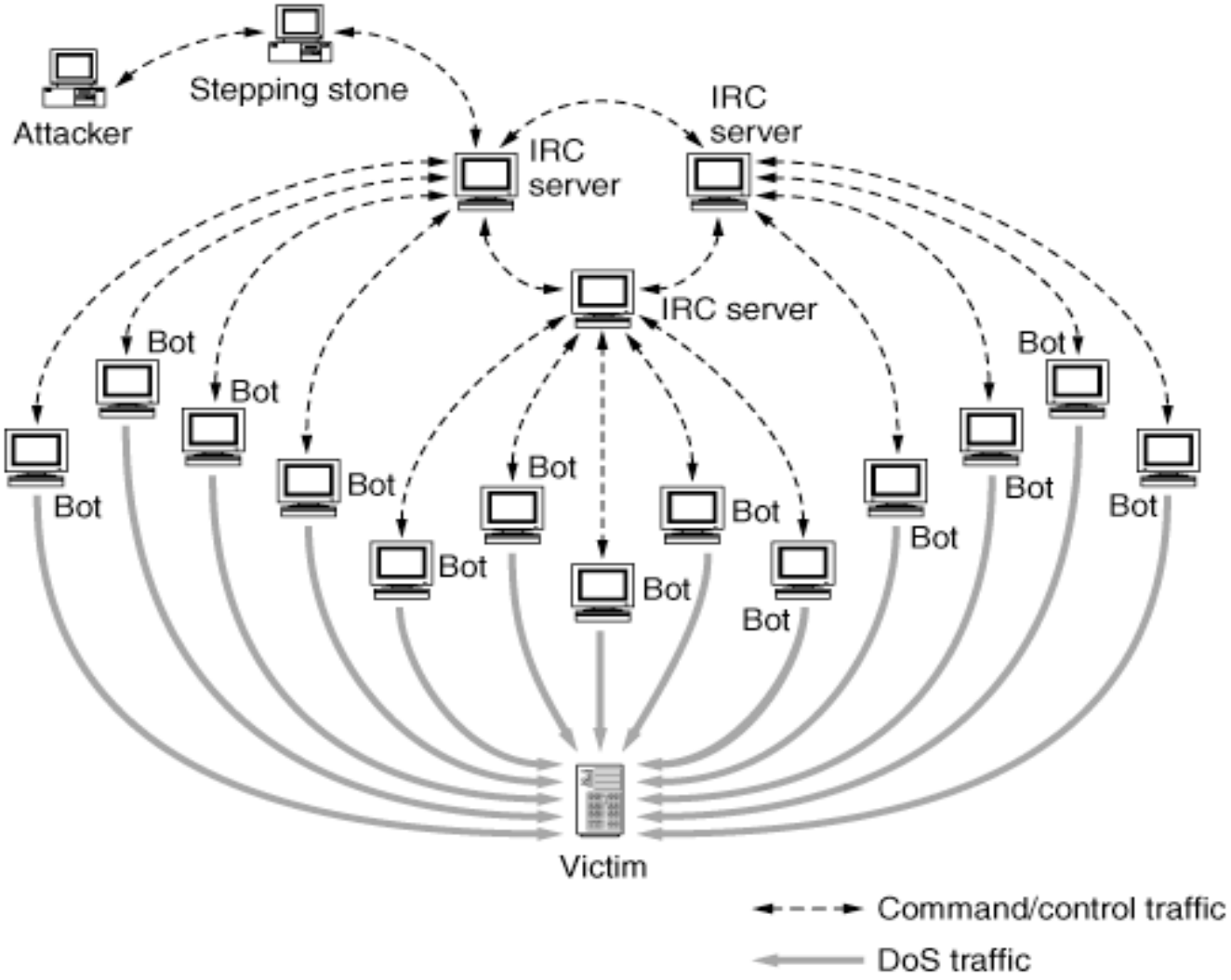
Basic BotNet Architectures (4)

- A Handler machine controls the bots of the BotNet
- Control Traffic between the Handler and the Bots
- Attack DDoS Traffic: sent by the bots to the targeted victim server

Basic BotNet Architectures (5)

- But, still, direct communication between the Handler and the Bot-Master is easily traceable
- Further obscurity is required so that Bot-Masters are not traceable

IRC controlled BotNets



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IRC controlled BotNets (2)

The most common DDoS Architecture

- For historical reasons
- For obscurity (thousands of channels)
- Maintainability (IRC Channels are maintained by IRC communities)

BotNet Recruitment

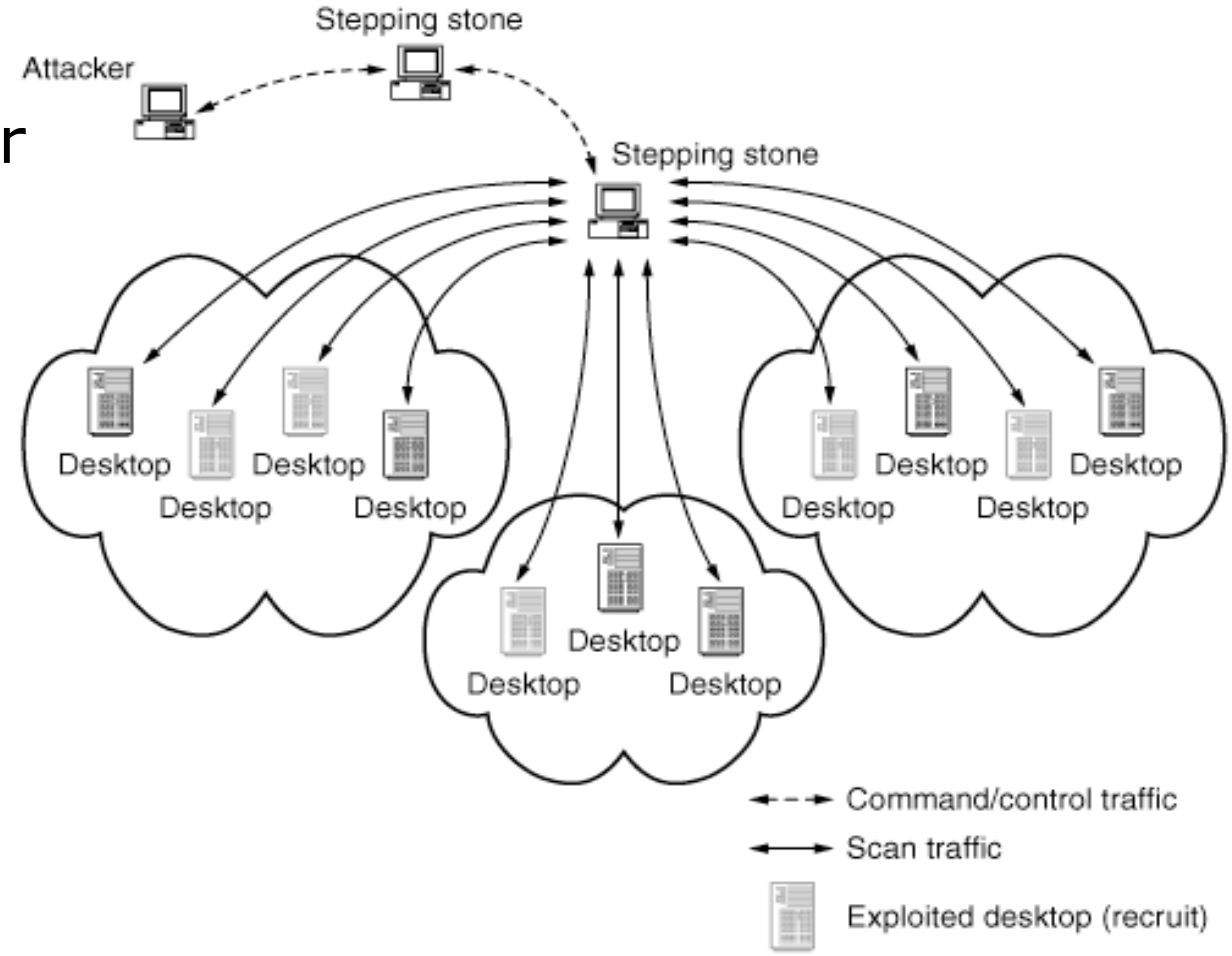
BotNet Recruitment (1)

Scanning for vulnerable machines to 'recruit' for a BotNet:

- Random: Brute-force the IP address space
- Random IP range: Scan randomly, a specific range of the IP space
- Intelligent scan: Look for specific type of machines like Windows boxes
- Step-by-step scanning: Once a machine is compromised, check for other machines it is associated with

BotNet Recruitment (2)

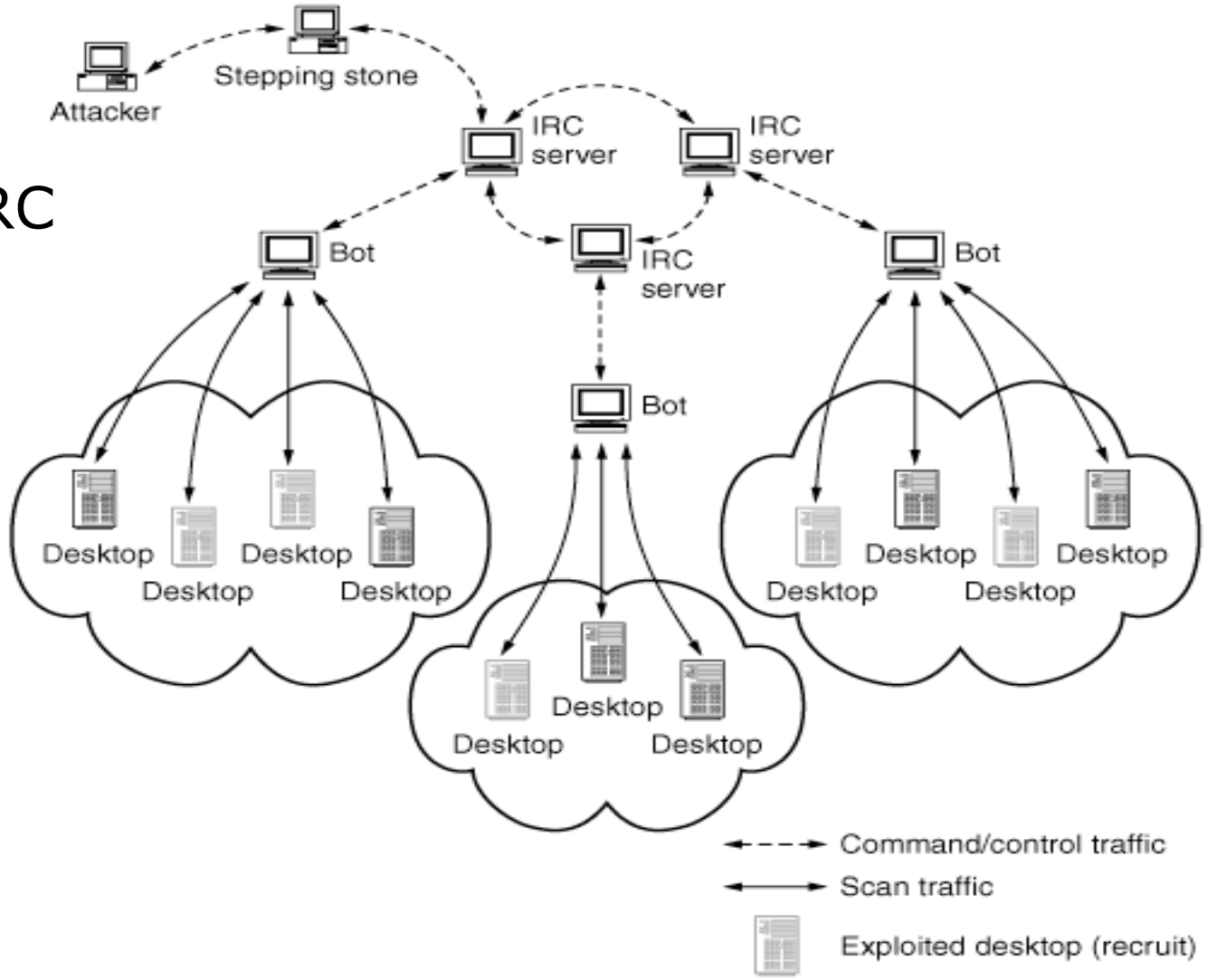
Stepping Stones looking for vulnerable machines



Internet Denial of Service: Attack and Defense Mechanisms

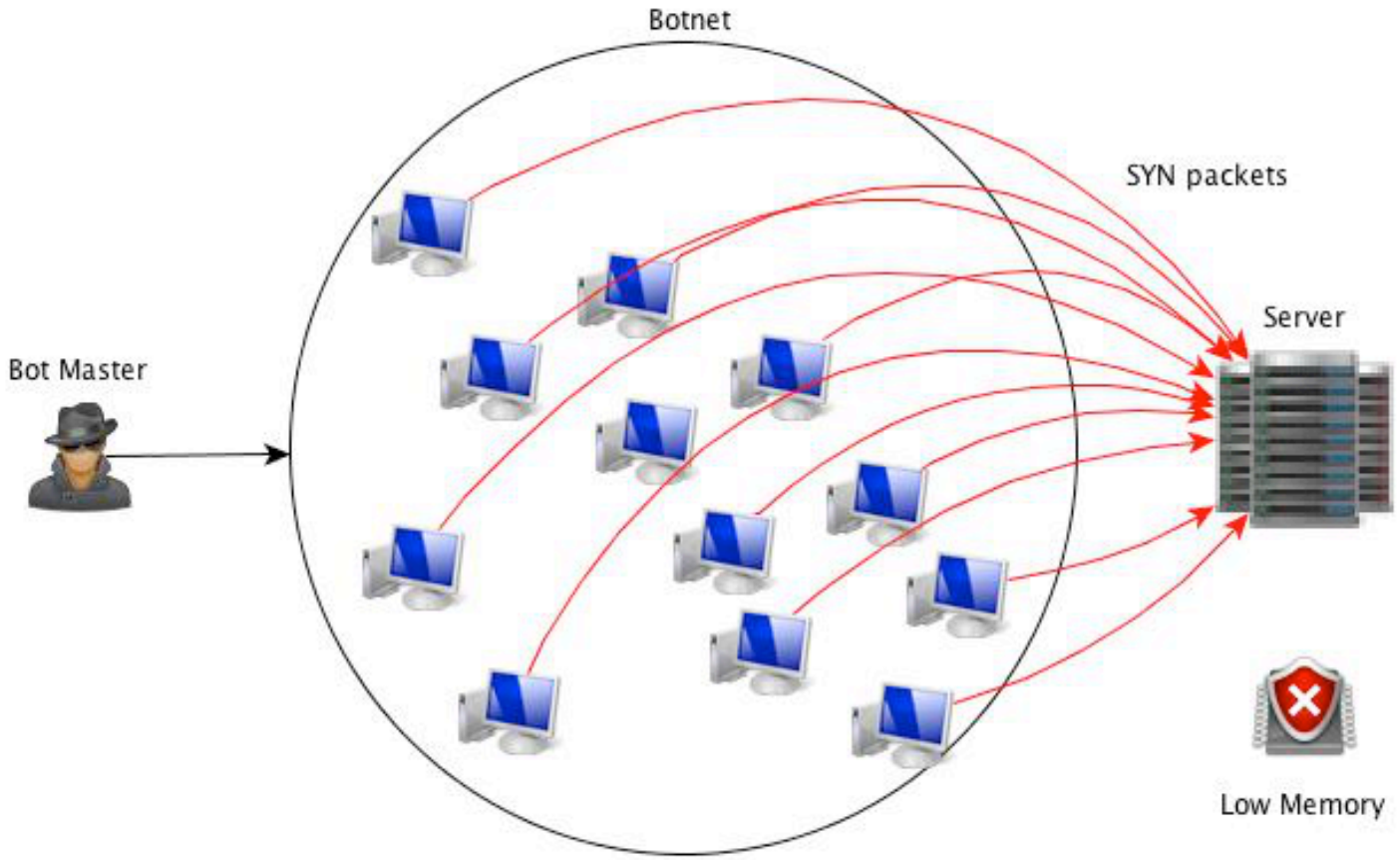
BotNet Recruitment (3)

Looking for vulnerable machines within the IRC network



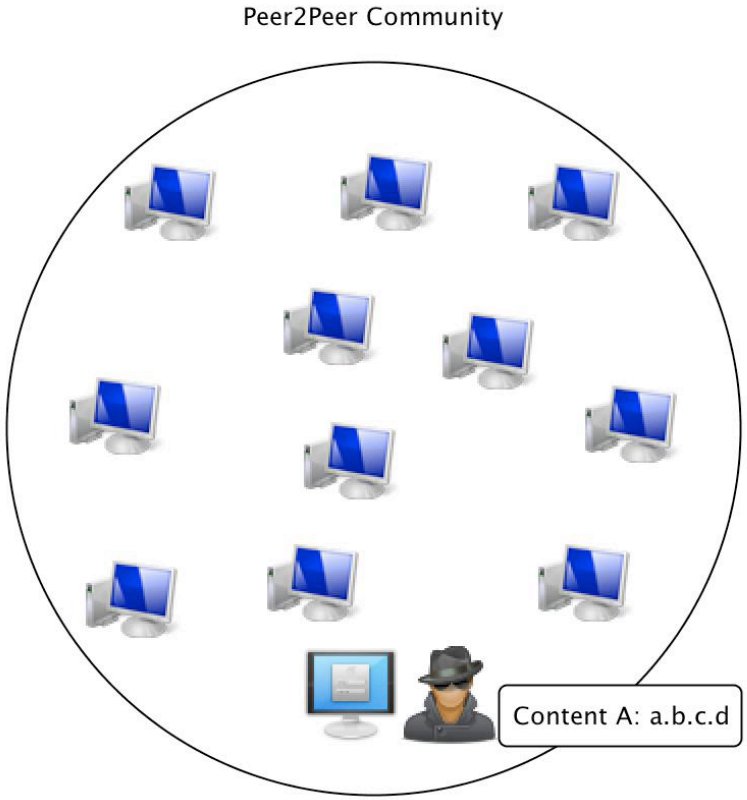
Internet Denial of Service: Attack and Defense Mechanisms

Distributed SYN flooding



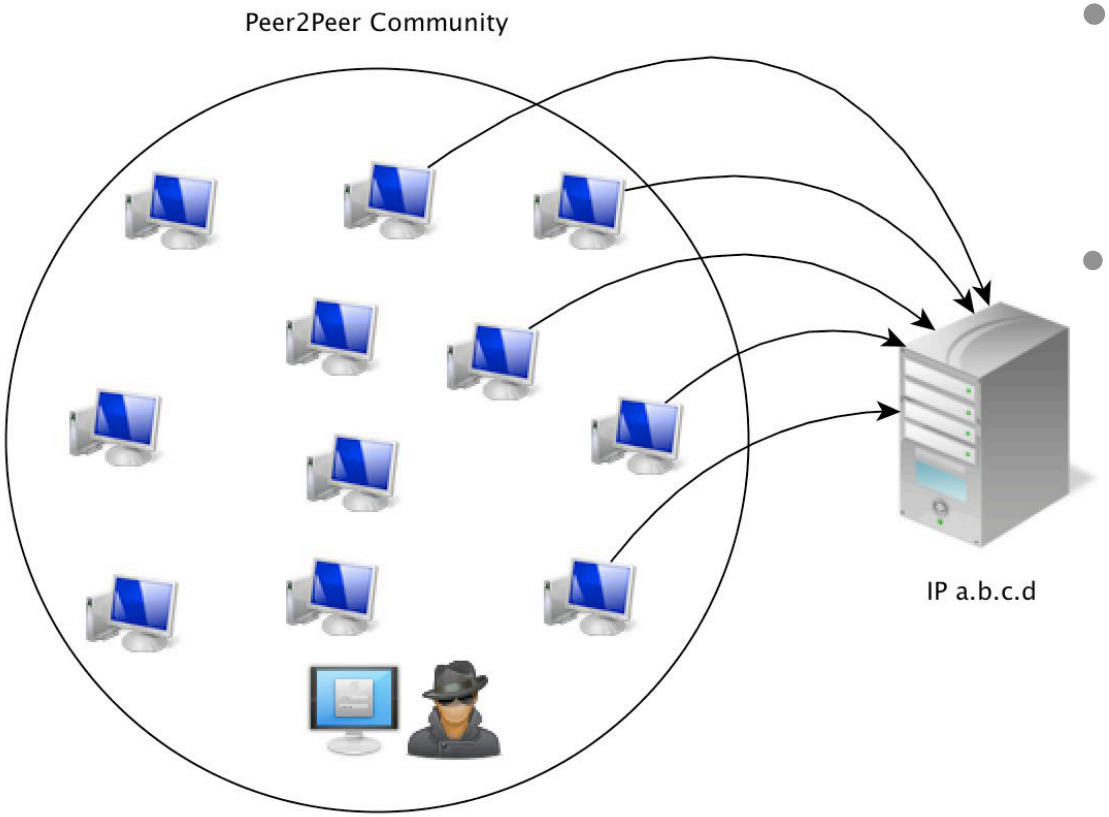
- The same idea like the simple DoS version of TCP flooding
- Much more effective due to the use of a BotNet
- Server has to keep state for thousands semi-open TCP sessions.

P2P based DDoS Attacks



- A large number of hosts have joined a P2P Community for content exchange purposes

P2P based DDoS Attacks (2)



- The server is overwhelmed with requests for content it does not possess
- Most of the time, the connections that the hosts try to establish to the server are TCP connections

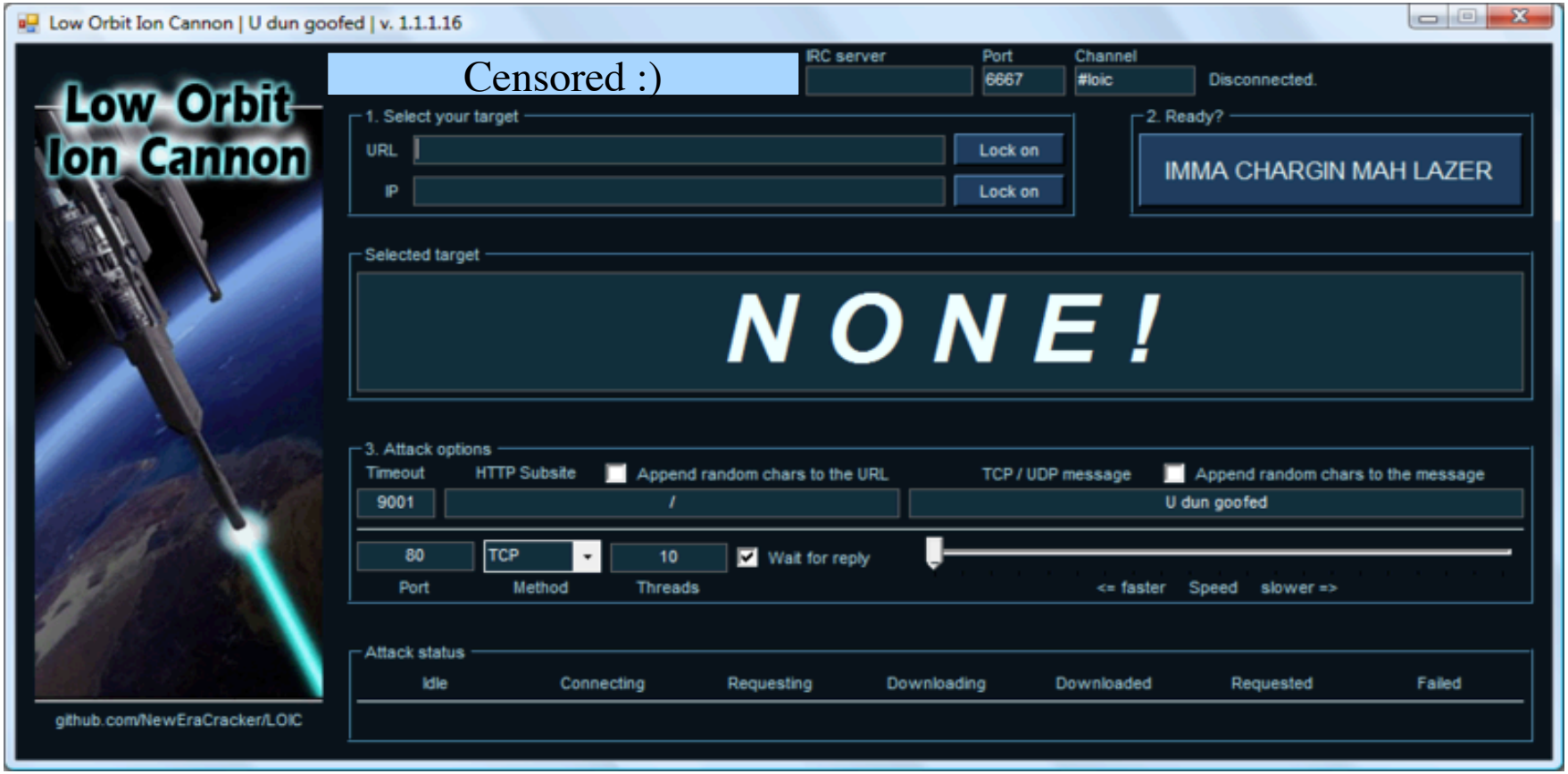
Operation #PayBack

Social DDoS

- Social BotNets
- Normal users joining willingly a DDoS attack against major websites (paypal, mastercard, visa, ...)

Operation #PayBack (2)

Social DDoS



http://en.wikipedia.org/wiki/LOIC

Operation #PayBack (3)

Social DDoS

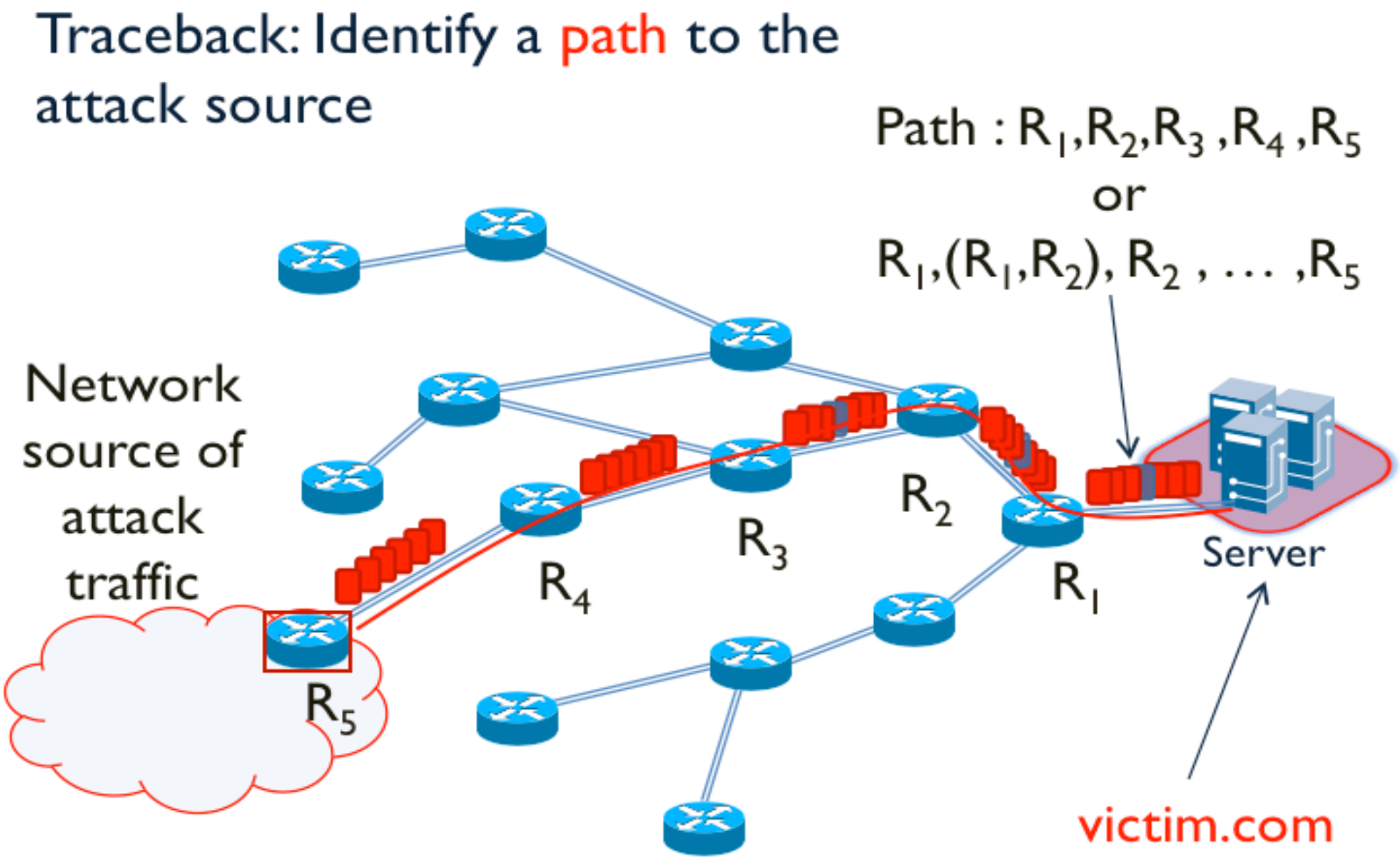
Operation Payback @Anon_payback 8 Dec 10

CURRENT TARGET: WWW.VISA.COM :: WEAPONS

http://bit.ly/e6iR3X ::: SET YOUR LOIC TO --> irc.anonops.net &

FIRE FIRE FIRE!!! #WIKILEAKS #DDOS

Research on DoS and DDoS



[S. Savage, D. Wetherall, A. Karlin and T. Anderson, "Practical Network Support for IP Traceback," ACM SIGCOMM 2000]

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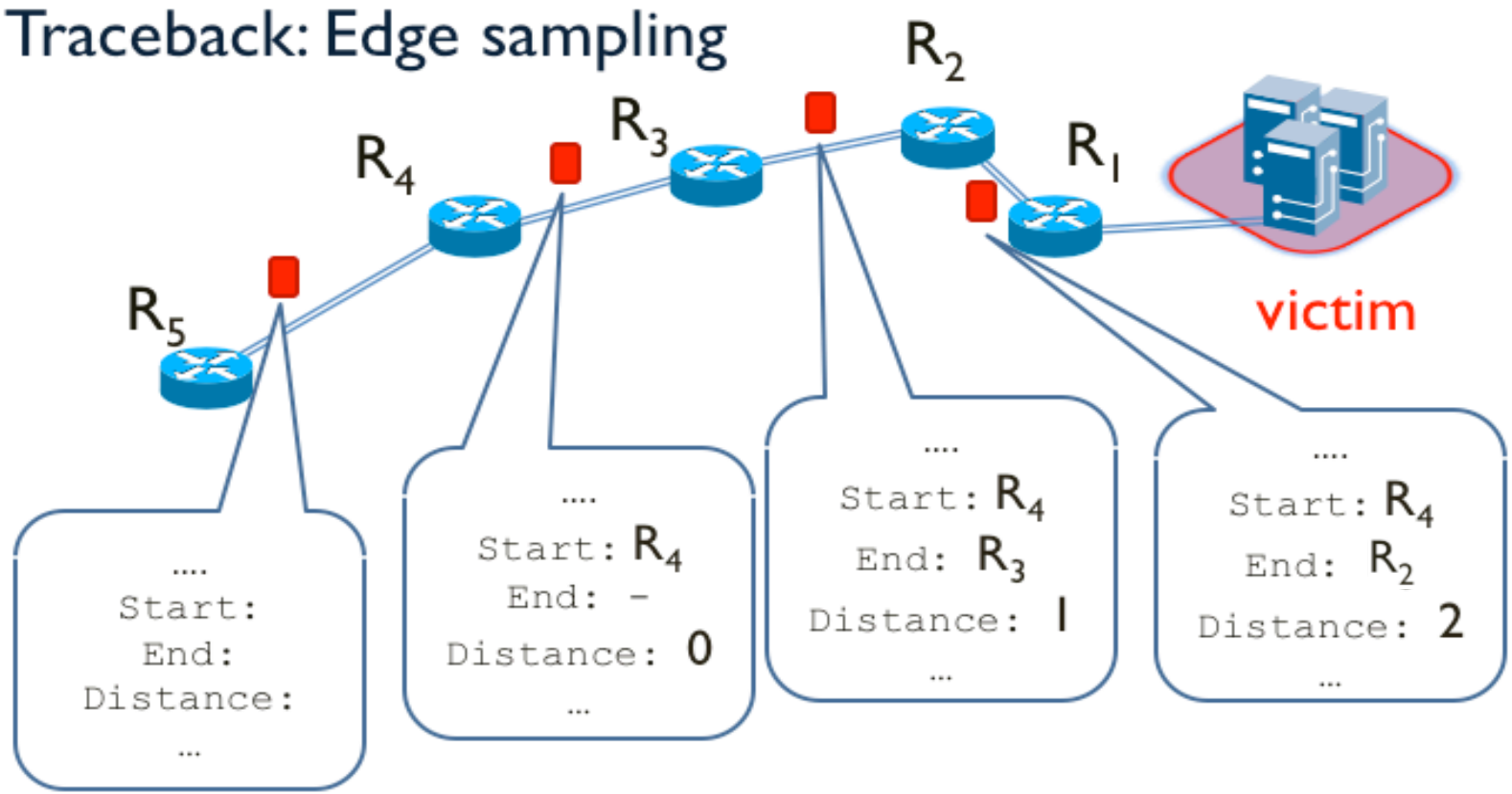
Research on DoS and DDoS



- Victim:
  - Gets (R_i,R_j,d) from each *attack* packet
  - Adds it to the 'picture' if it fits in

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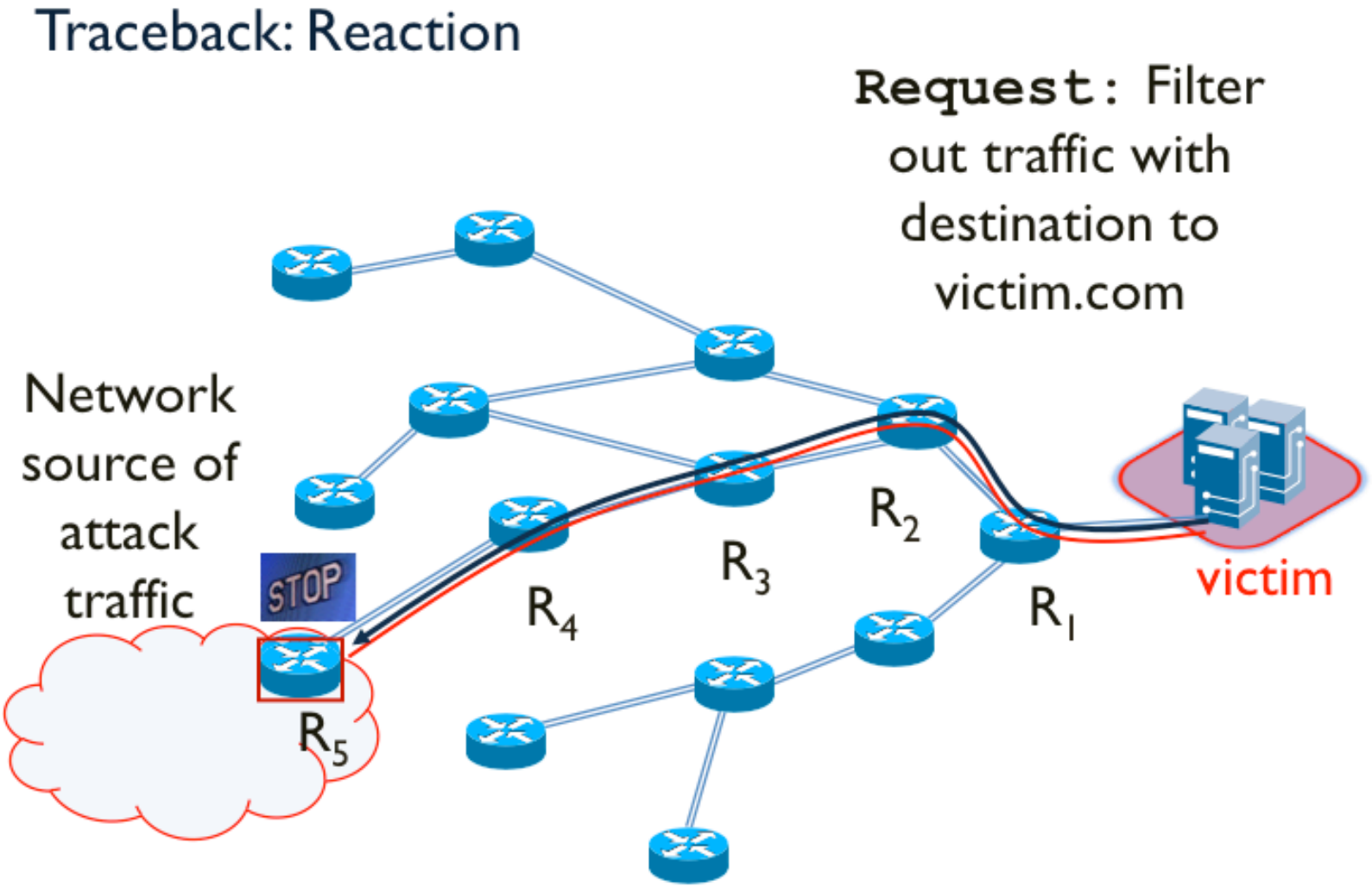
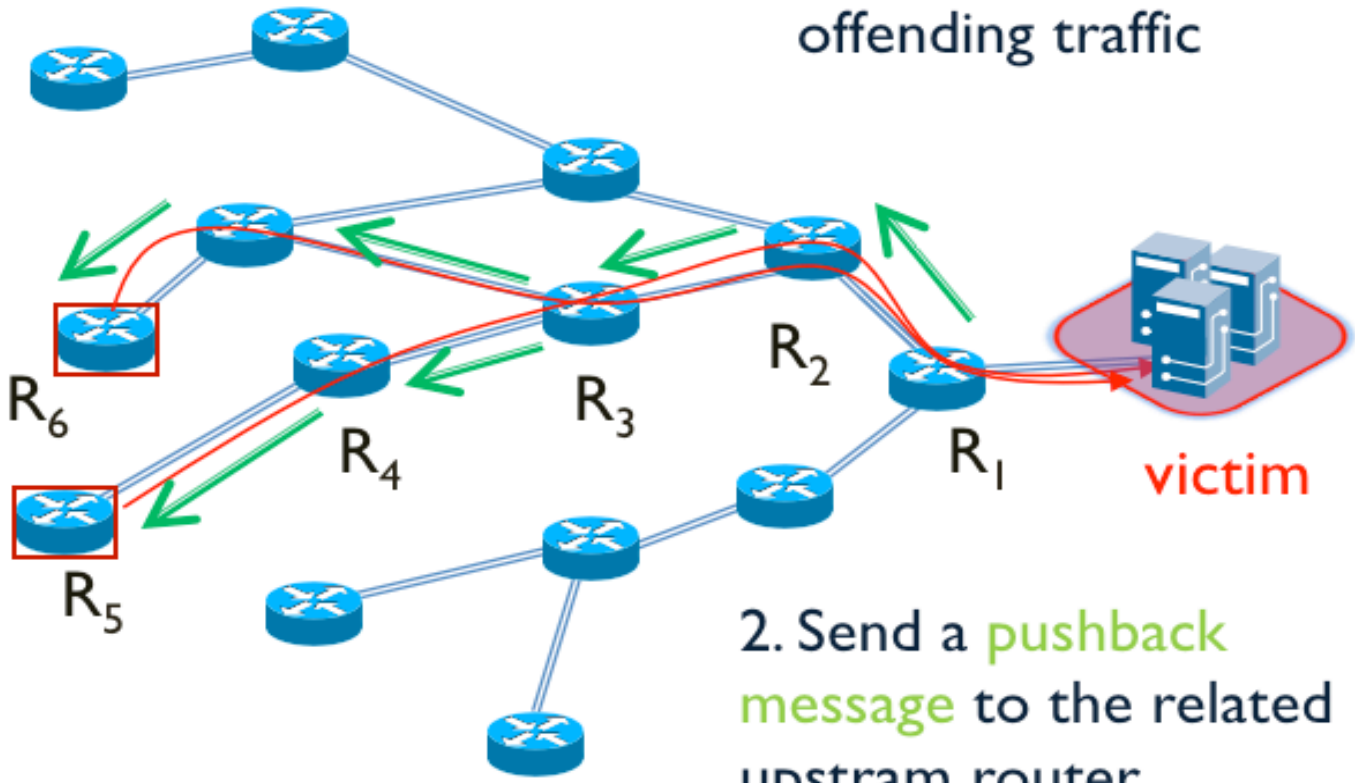
Research on DoS and DDoS (2)



Research on DoS and DDoS (3)

Pushback: Deal with congestion one hop at a time

1. Detect an aggregate of offending traffic



2. Send a pushback message to the related upstram router

[R. Mahajan, S. Bellovin, S. Floyd, J. Ioannidis, V. Paxson, and S. Shenker, "Controlling High Bandwidth Aggregates in the Network," ACM CCR 2002]

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Conclusions

- DoS and DDoS target the availability of a system/service
- Attackers can take advantage of system defects to launch a DoS/DDoS attack
- DoS attacks do not require many resources from the attacker.
- Any DDoS attack can be launched as a Distributed attack
- These attacks require the use of large collections of infected computers (Botnets)
  - Botnets need to be created, organized and managed
- Different attack traffic can be used by the Botnets to overwhelm a targeted server.
- The countermeasures available depend on the type of the attack
- But still it is and probably will remain a hard problem to solve...
  - Many vulnerable machines out there are willing to join a Botnet