CSE 484 / CSE M 584 (Autumn 2011)

Security and Networks

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Thanks to Dan Boneh, Dieter Gollmann, John Manferdelli, John Mitchell, Vitaly Shmatikov, Bennet Yee, and many others for sample slides and materials ...

Class updates

- (Short) Homework 3
  - Due Wednesday
  - Individual assignment
- My office hours this week:
  - **CSE 210:** M,W,F after class. T,Th afternoons
  - others by appointment
  - come pick up graded Homework #2

Lab 3

- **Posted on website and on Catalyst.**
    - https://catalyst.uw.edu/collectit/assignment/dhalperi/17513/72548
    - Hack my privacy!

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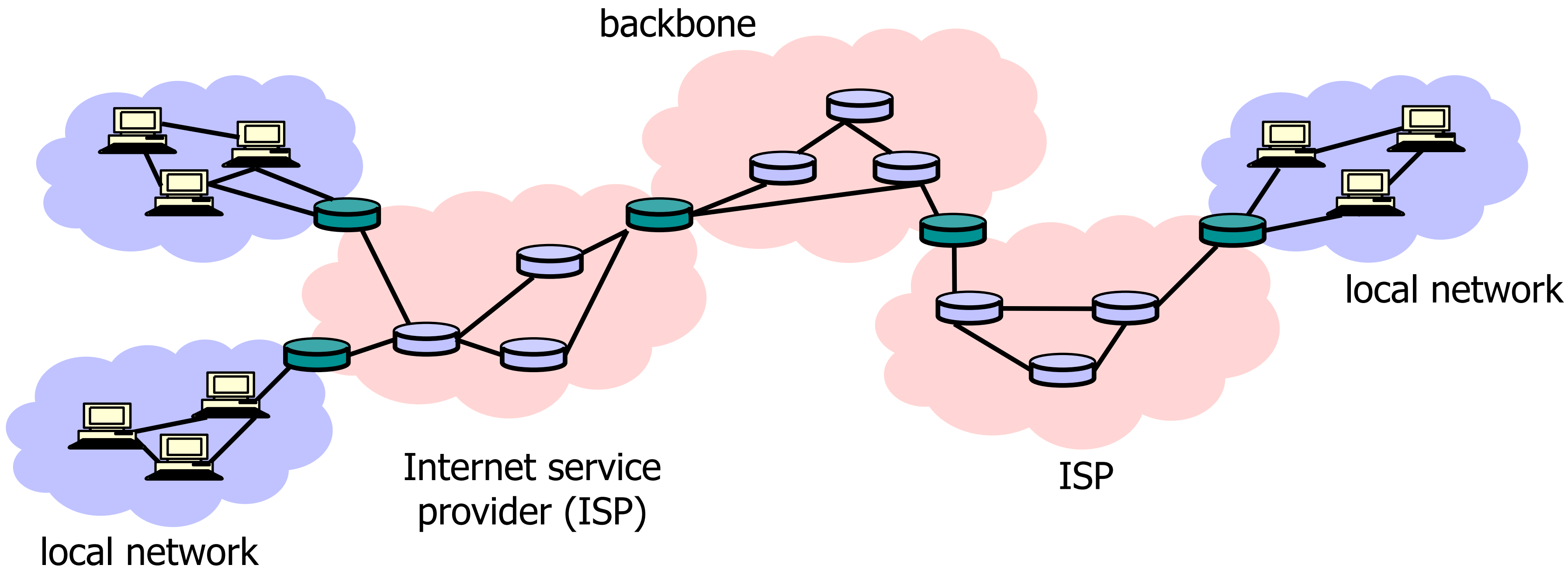
  - https://catalyst.uw.edu/collectit/assignment/dhalperi/17513/72548
  - Hack my privacy!
- ***This lab is optional***
  - Can only help your grade.
  - Lots of opportunity for extra credit.
  - I really think this lab is fun, and encourage you to do it, but we're not going to require it.

This week

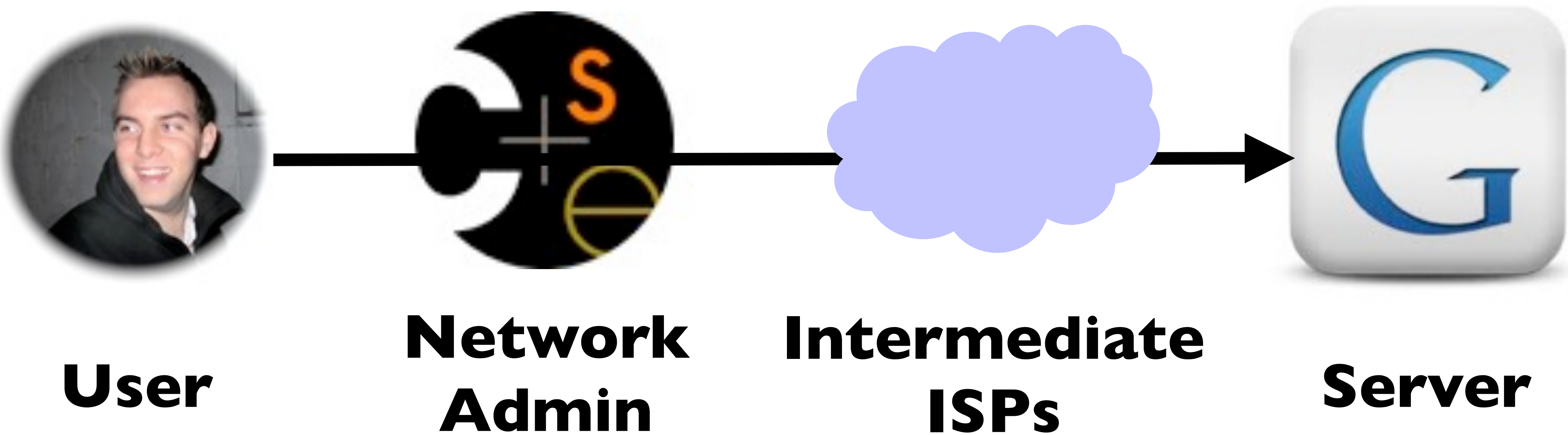
- **Today:** Network security
- **Wednesday:** Potpourri
- **Friday:** Any questions you have
  - Submit to my email, cse484-tas
  - Submit anonymously via the feedback form on the website

Internet Infrastructure



- TCP/IP for packet routing and connections
- Border Gateway Protocol (BGP) for route discovery
- Domain Name System (DNS) for IP address discovery

(Some) Entities



(Some) Goals

User

(Some) Goals

User

- Service (can get to Internet)
- Privacy (middle-entities shouldn't know what communicating or with whom)
- Fairness (e.g., get service I paid for)
- Integrity (can't impersonate me)
- Safety (network shouldn't attack me)

(Some) Goals

Network Admin

(Some) Goals

Network Admin

- Service (clients can get to Internet)
- Performance (network works well)
- Identity (know what's on network)
- Safety (no one launching attacks)
- Accountability (can find bad users)

(Some) Goals

Intermediate ISPs

(Some) Goals

Intermediate ISPs

- Service (deliver traffic -> earn $$)
- Reliability & Performance (network works well)
- Integrity of delivered traffic (can bill customers properly, you're not over-charged by providers)

(Some) Goals

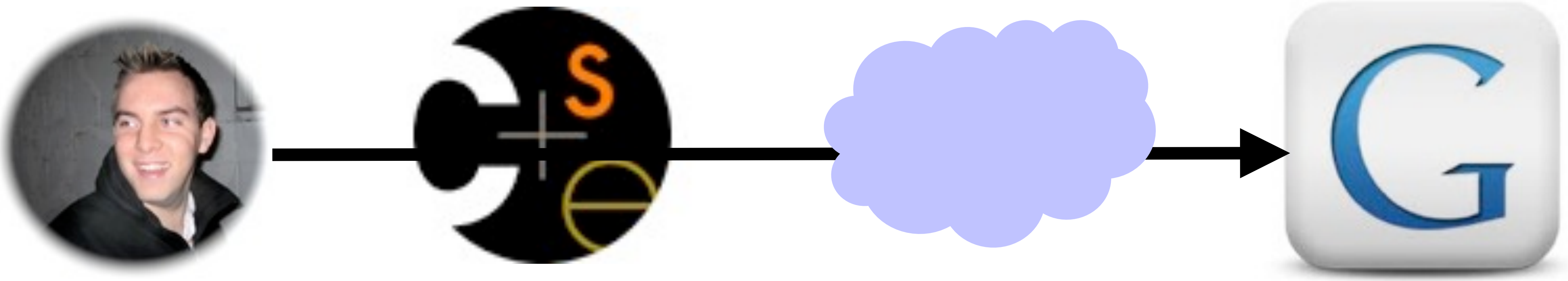
Server

(Some) Goals

Server

- Service (deliver traffic -> earn $$)
- Reliability & Performance (network works well)
- Analytics (better delivery)
- Accounting (can bill customers properly)
- Safety (not being attacked)

(Some) Malicious Goals



User

Network Admin

Intermediate ISPs

Server

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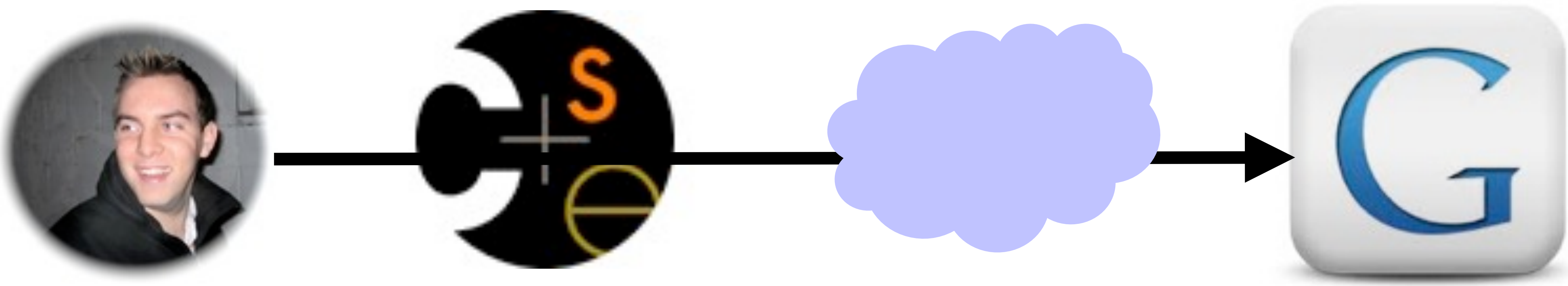
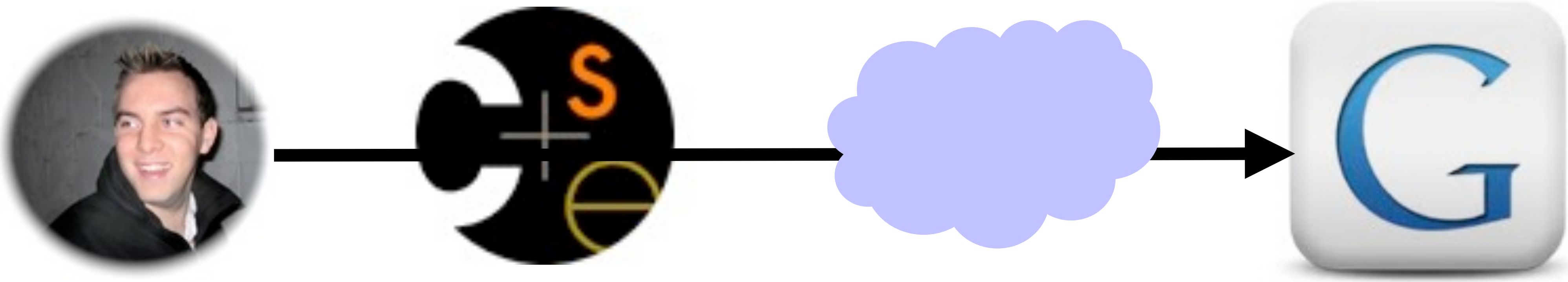


User | **Network Admin** | **Intermediate ISPs** | **Server**

Launch undetectable attacks

Probe for vulnerabilities

(Some) Malicious Goals



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Spy on/tamper with traffic

Impersonate servers

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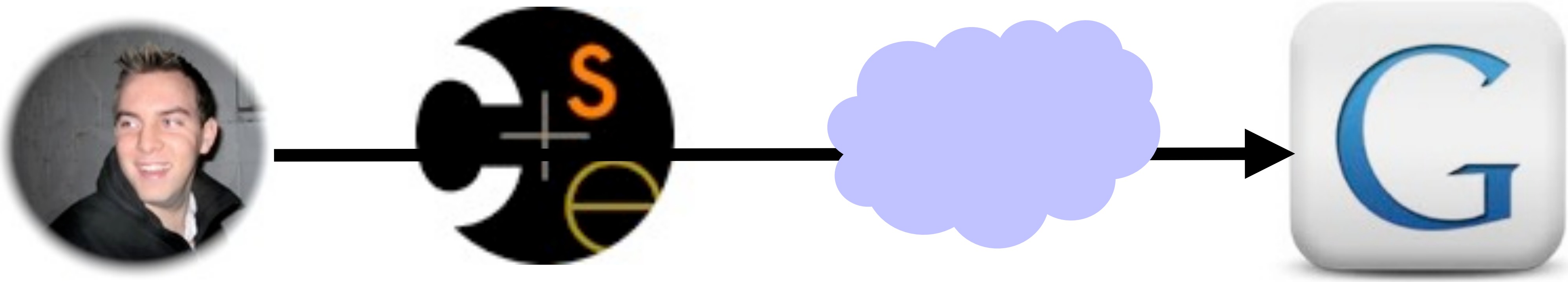

User

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Network Admin / **Intermediate ISPs**

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Impersonate servers

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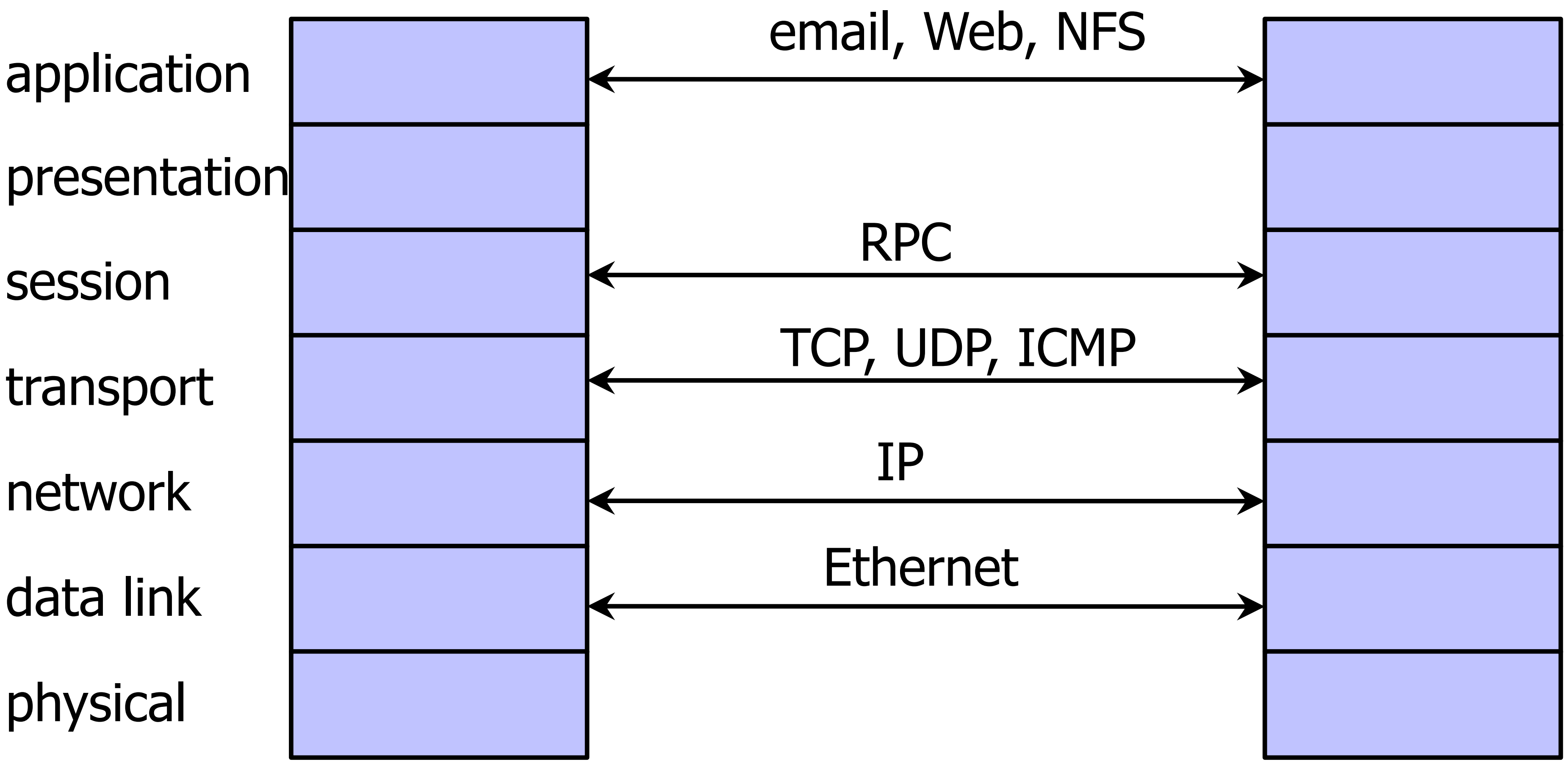
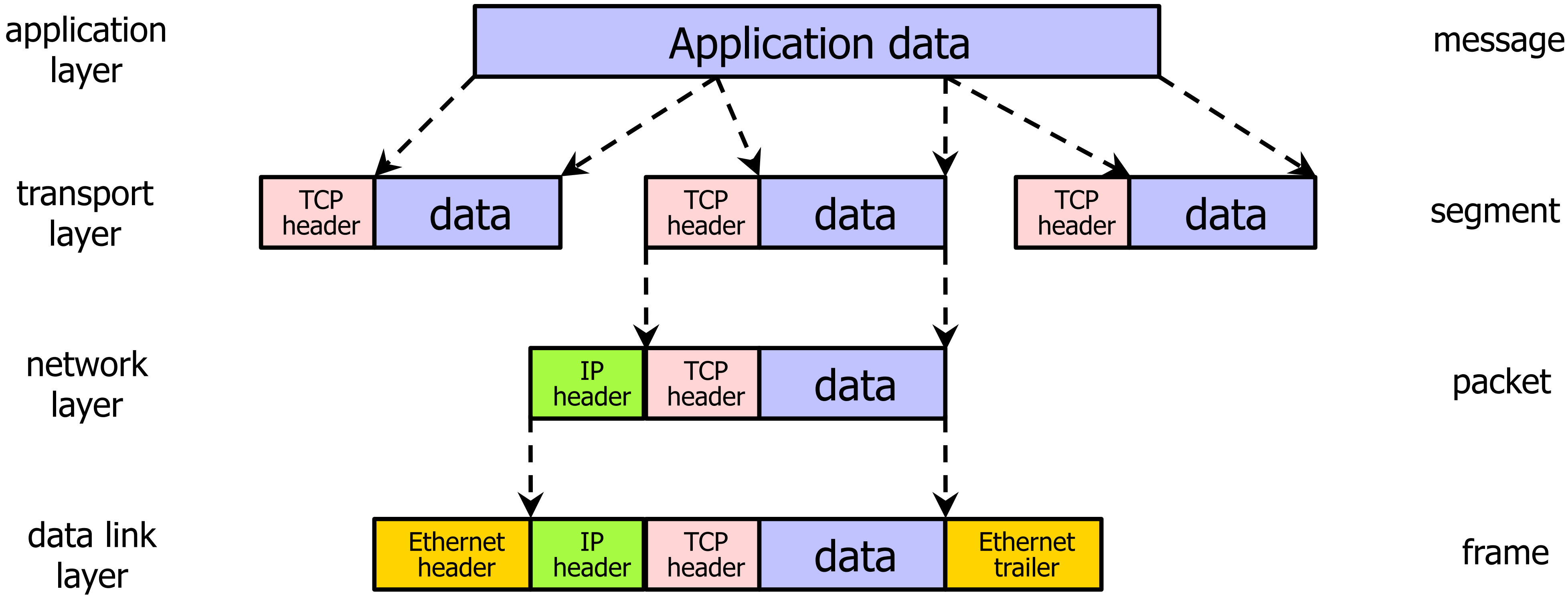
Spy on users

Identify anonymous users

OSI Protocol Stack

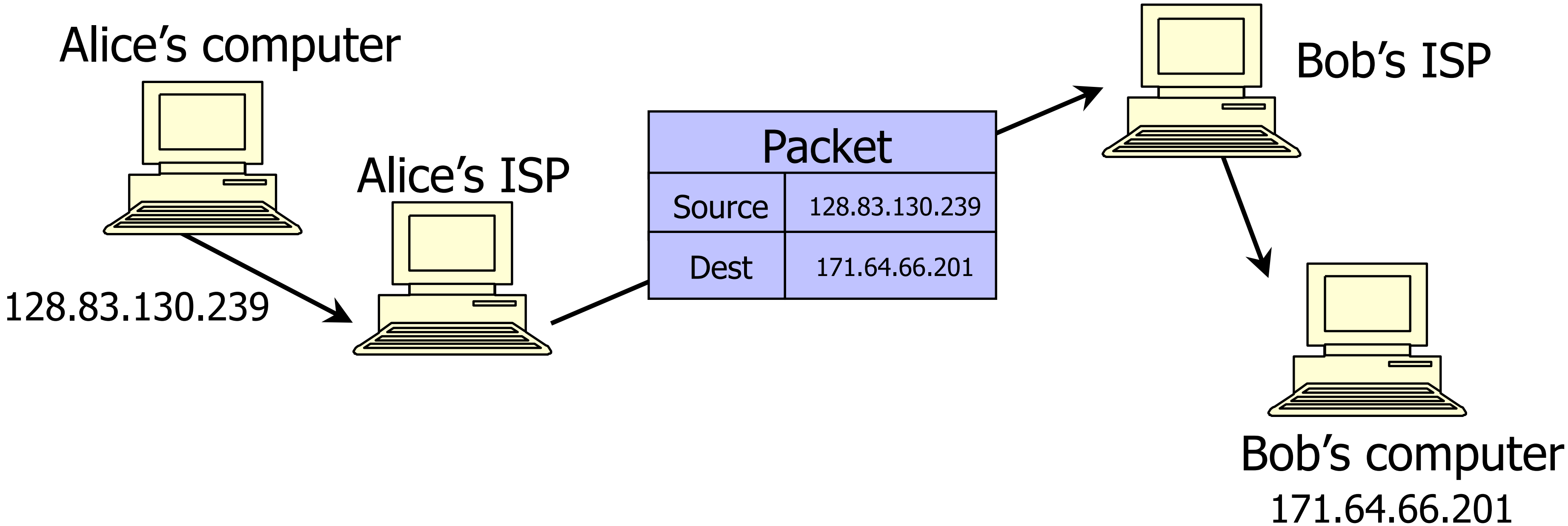


Data Formats



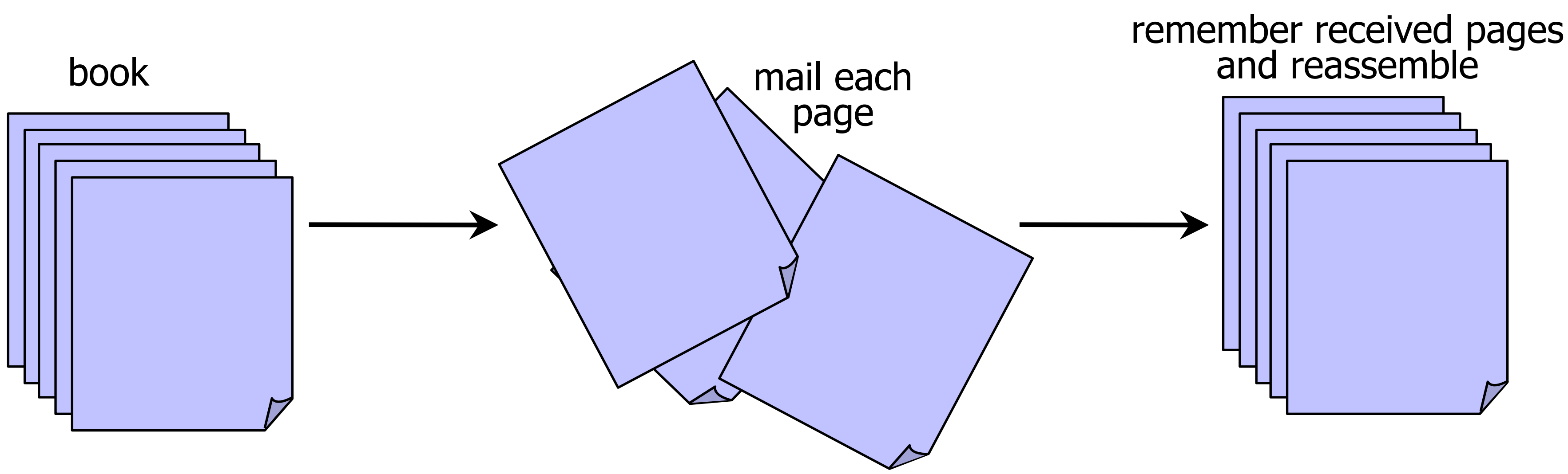
IP (Internet Protocol)

- Connectionless
  - Unreliable, "best-effort" protocol
- Uses numeric addresses for routing
  - Typically several hops in the route



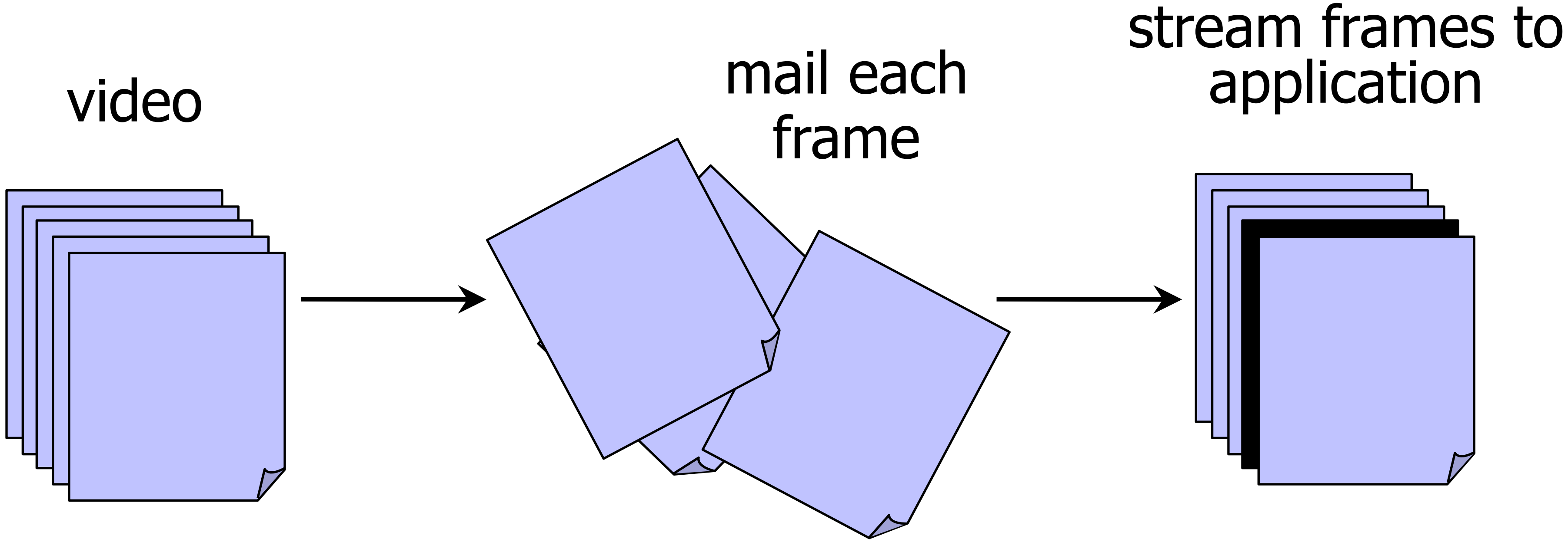
TCP (Transmission Control Protocol)

- Sender: break data into packets
  - Sequence number is attached to every packet
- Receiver: reassemble packets in correct order
  - Acknowledge receipt; lost packets are re-sent
- Connection state maintained on both sides



UDP (User Datagram Protocol)

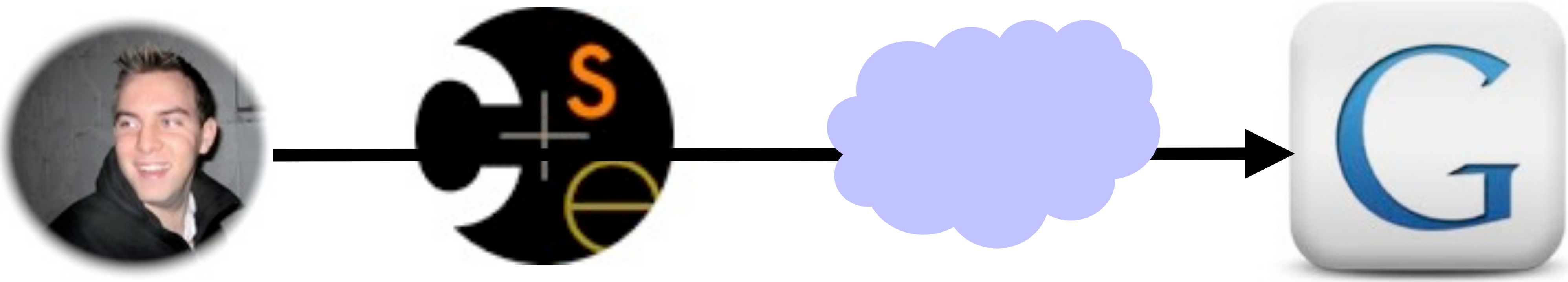
- Sender: break data into packets
  - Sequence number - maybe? If Application wants them
- Receiver: receive packets
  - No acknowledgement
  - Dropped packets are skipped - no retransmission



ICMP (Control Message Protocol)

- Provides feedback about network operation
  - "Out-of-band" messages carried in IP packets
  - Error reporting, congestion control, reachability, etc.
- Example messages:
  - Destination unreachable
  - Time exceeded
  - Parameter problem
  - Redirect to better gateway
  - Reachability test (echo / echo reply)
  - Message transit delay (timestamp request / reply)

(Some) Malicious Goals



User

Network Admin

Intermediate ISPs

Server

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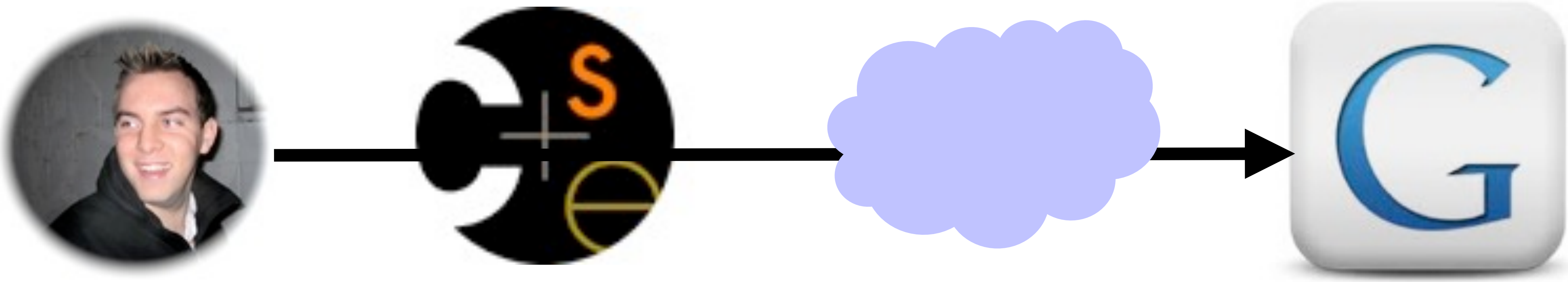

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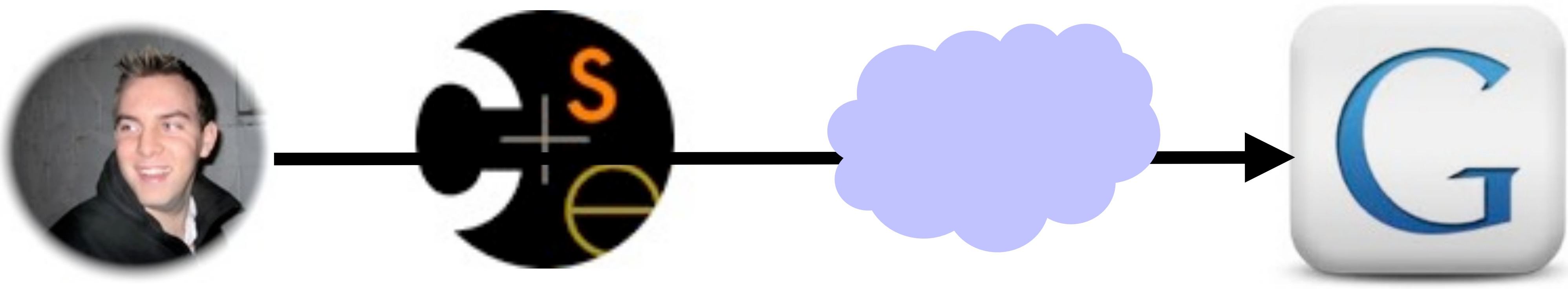

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Spy on/tamper with traffic

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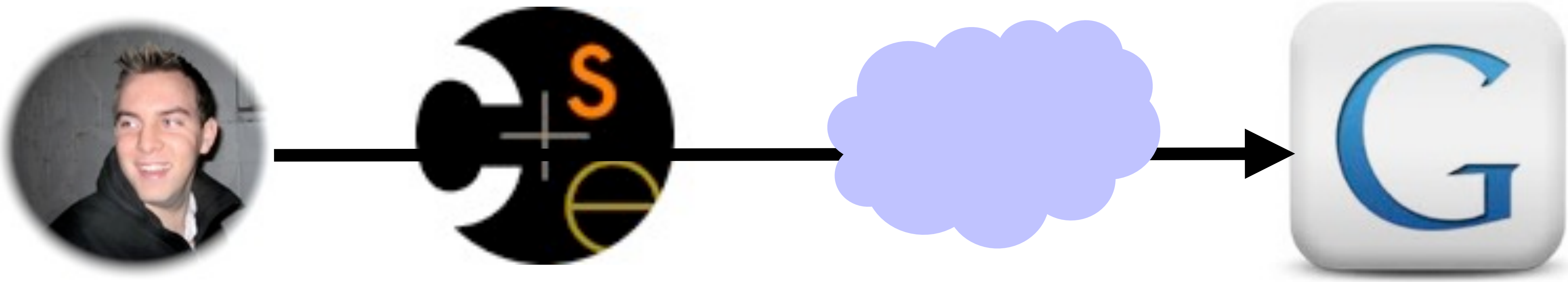

User	**Network Admin**	**Intermediate ISPs**	**Server**

Launch undetectable attacks

Probe for vulnerabilities

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Identify anonymous users

Detecting attacks

User

Launch undetectable attacks

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- **Problem:** IP packets contain source IP address

Detecting attacks

User

Launch undetectable attacks

- **Problem:** IP packets contain source IP address

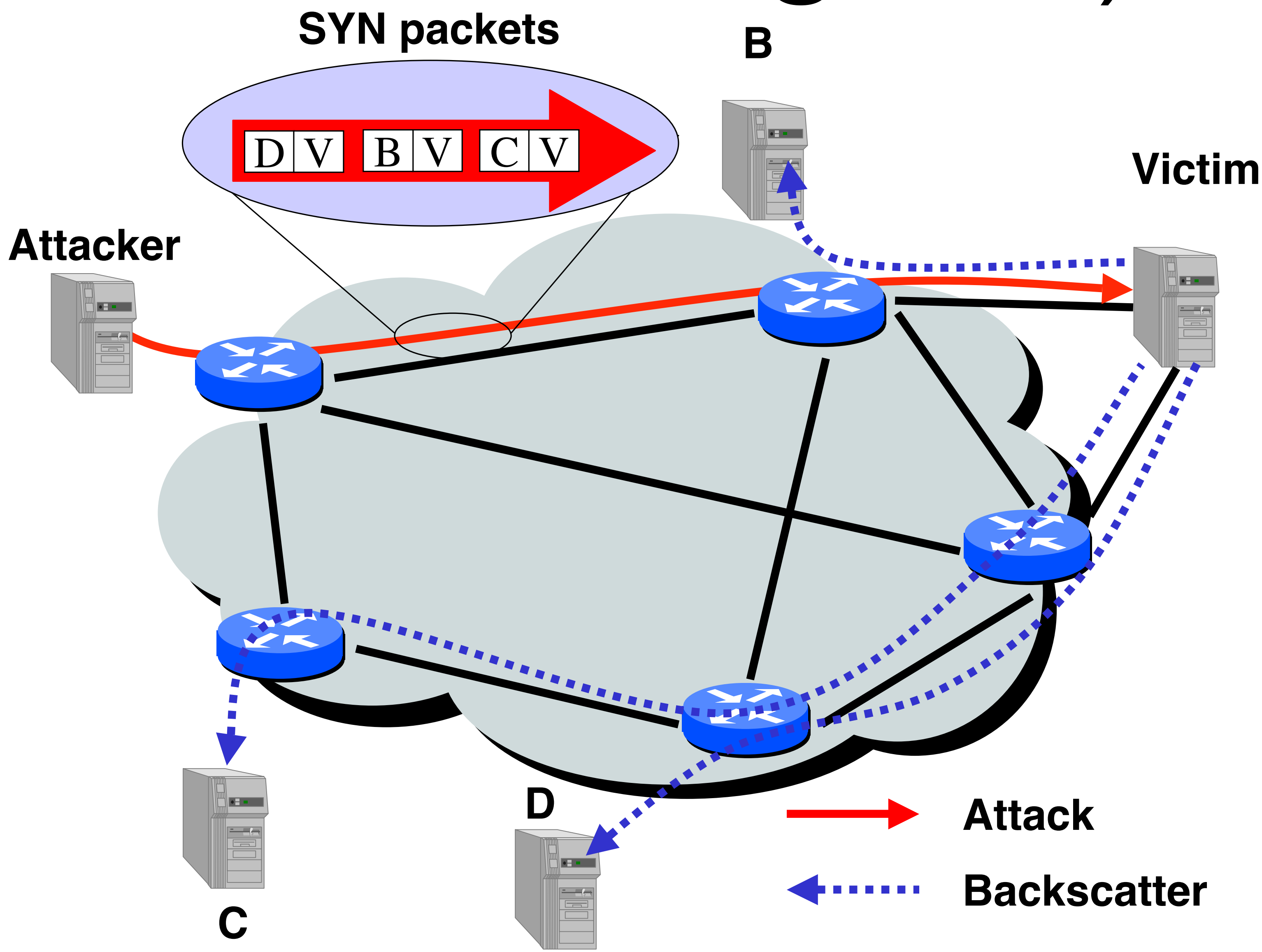
Detecting attacks

User

Launch undetectable attacks

- **Problem:** IP packets contain source IP address
- **Solution:** Spoof IP address

Inferring DDOS (Moore, Voelker, Savage '01)



Finding vulnerabilities

User

Probe for vulnerabilities

Finding vulnerabilities

User

Probe for vulnerabilities

- **Many, many tools**

Finding vulnerabilities

User

Probe for vulnerabilities

- **Many, many tools**
- One example: **Nmap**
  - Many services have known TCP/UDP ports
  - These give away what services you're running

Nmap example (me)

dhalperi@dhm cse484 % **nmap dsp.cs.washington.edu**

Starting Nmap 5.51 (http://nmap.org) at 2011-12-05 14:05 PST
Nmap scan report for dsp.cs.washington.edu (128.208.4.246)
Host is up (0.0062s latency).
Not shown: 996 closed ports
PORT STATE SERVICE
22/tcp open ssh
139/tcp open netbios-ssn
443/tcp open https
445/tcp open microsoft-ds

Nmap done: 1 IP address (1 host up) scanned in 1.36 seconds

Nmap example (aqua)

dhalperi@dhm cse484 % nmap aqua.cs.washington.edu

Starting Nmap 5.51 (http://nmap.org) at 2011-12-05 14:06 PST
Nmap scan report for aqua.cs.washington.edu (128.208.4.187)
Host is up (0.0022s latency).
Not shown: 990 filtered ports
PORT STATE SERVICE
80/tcp open http
135/tcp open msrpc
139/tcp open netbios-ssn
445/tcp open microsoft-ds
1025/tcp open NFS-or-IIS
1026/tcp open LSA-or-nterm
1027/tcp open IIS
1028/tcp open unknown
1048/tcp open neod2
3389/tcp open ms-term-serv

Nmap done: 1 IP address (1 host up) scanned in 5.29 seconds

telnet example

Fingerprinting users

Server

Identify anonymous users

Fingerprinting users

Server

Identify anonymous users

- **Browser**

Fingerprinting users

Server

Identify anonymous users

- **Browser**
- **Clocks**

Fingerprinting users

Server

Identify anonymous users

- **Browser**
- **Clocks**
- More

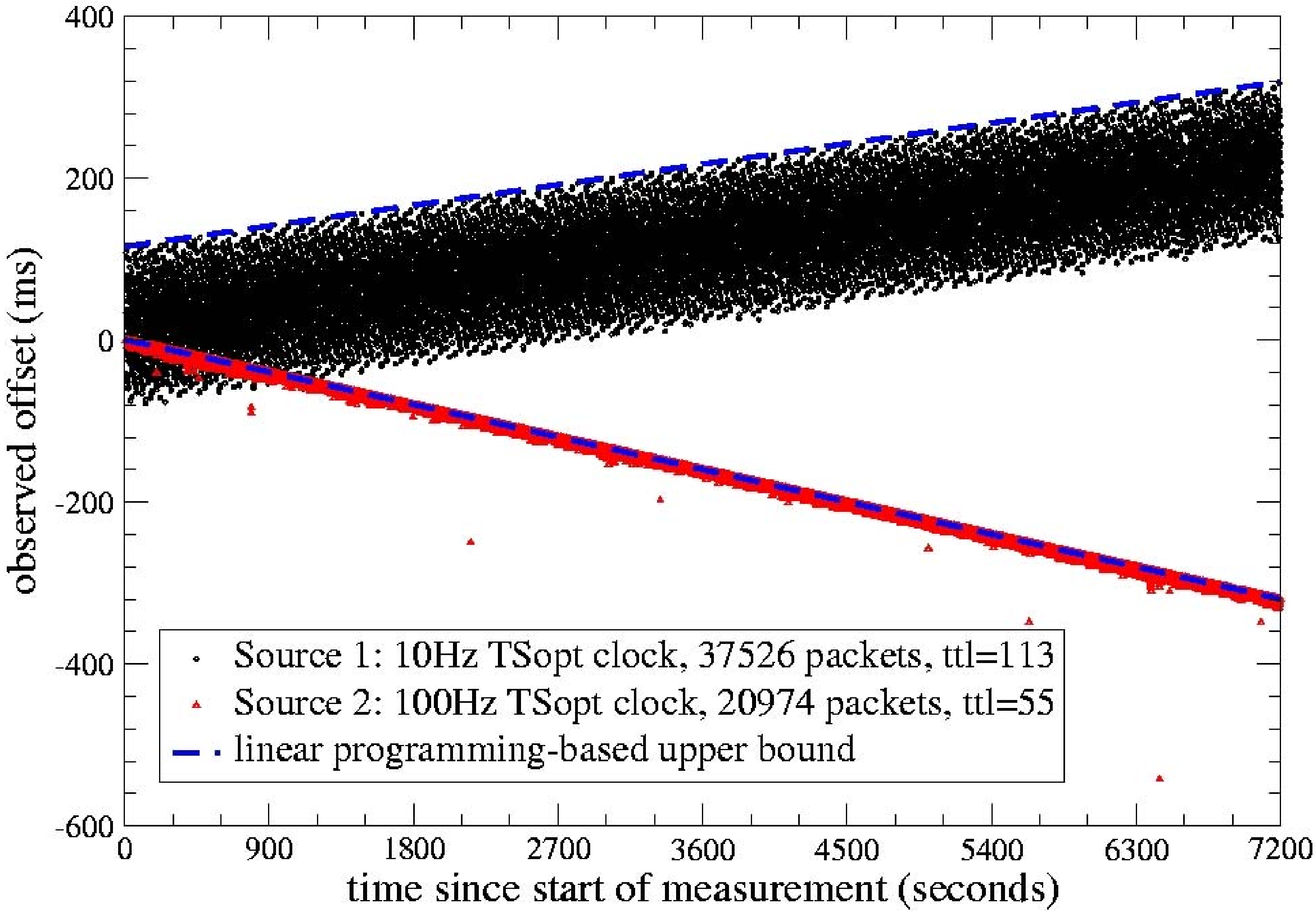
Browser example

http://panopticlick.eff.org/

Clocks

Kohno, et al. 2004

Clocks

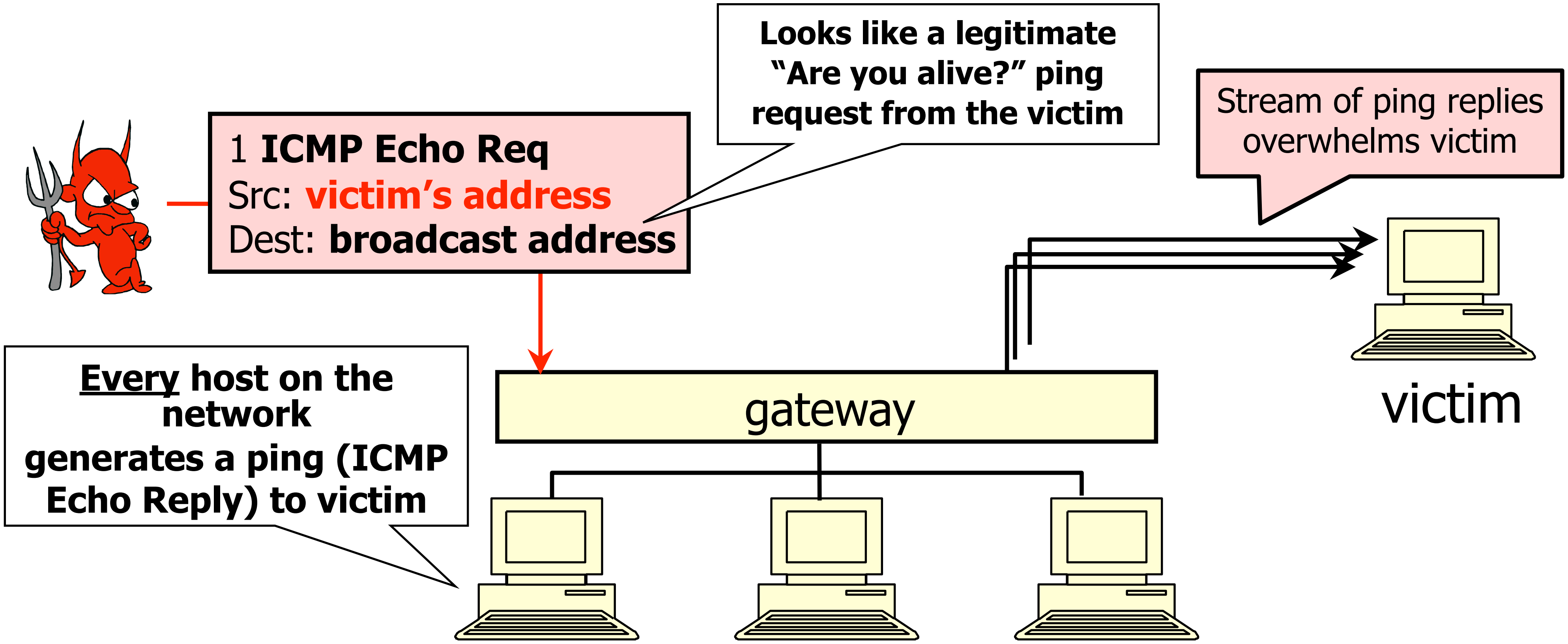


Kohno, et al. 2004

Security Issues in TCP/UDP

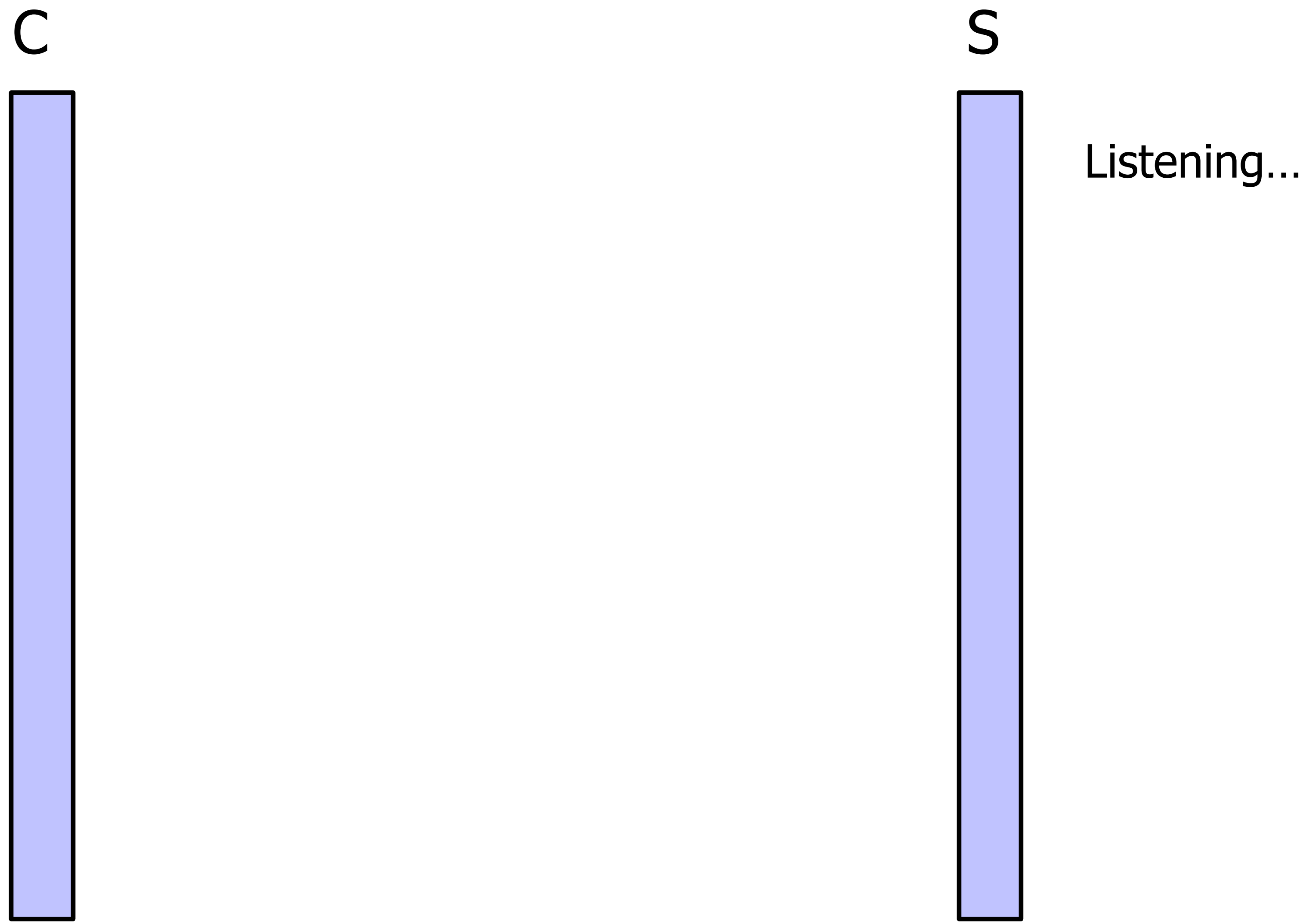
- Network packets pass through/by untrusted hosts
  - Eavesdropping (packet sniffing)
  - Modifications
- IP addresses are public
  - Smurf attacks
  - Anonymity?
- TCP connection requires state
  - SYN flooding
- TCP state is easy to guess
  - TCP spoofing and connection hijacking

Smurf Attack

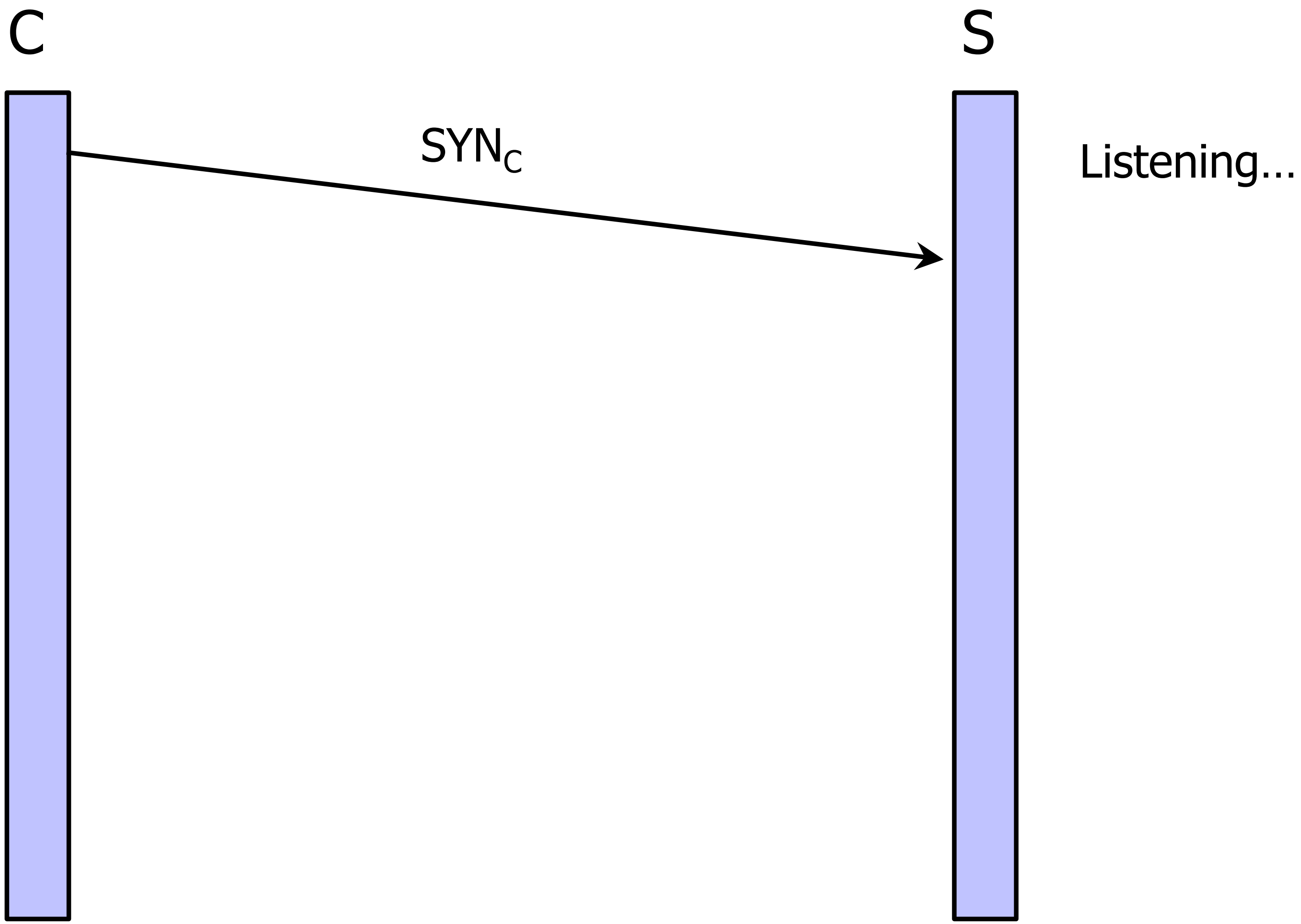


Solution: reject external packets to broadcast addresses

TCP Handshake



TCP Handshake



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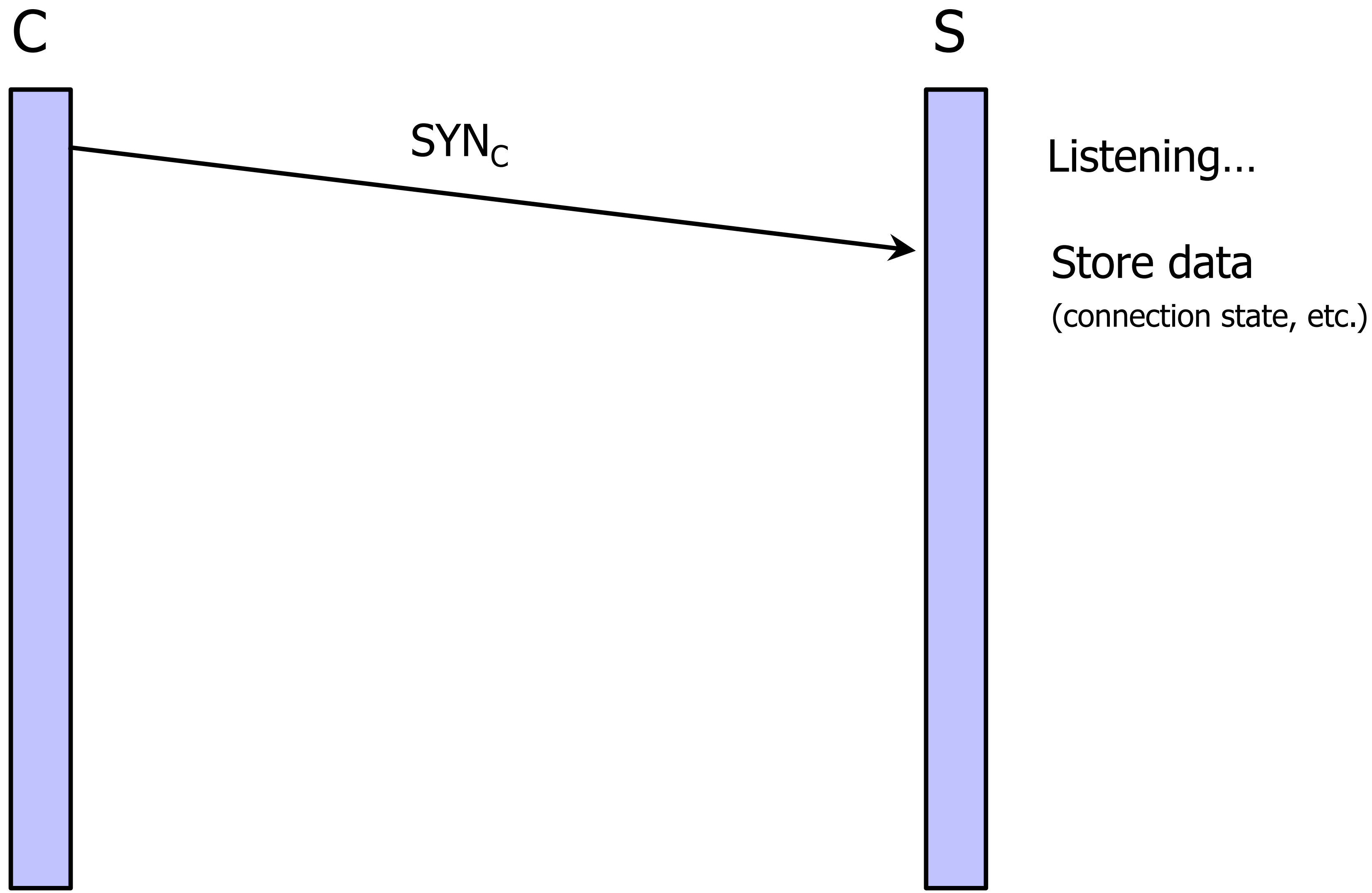

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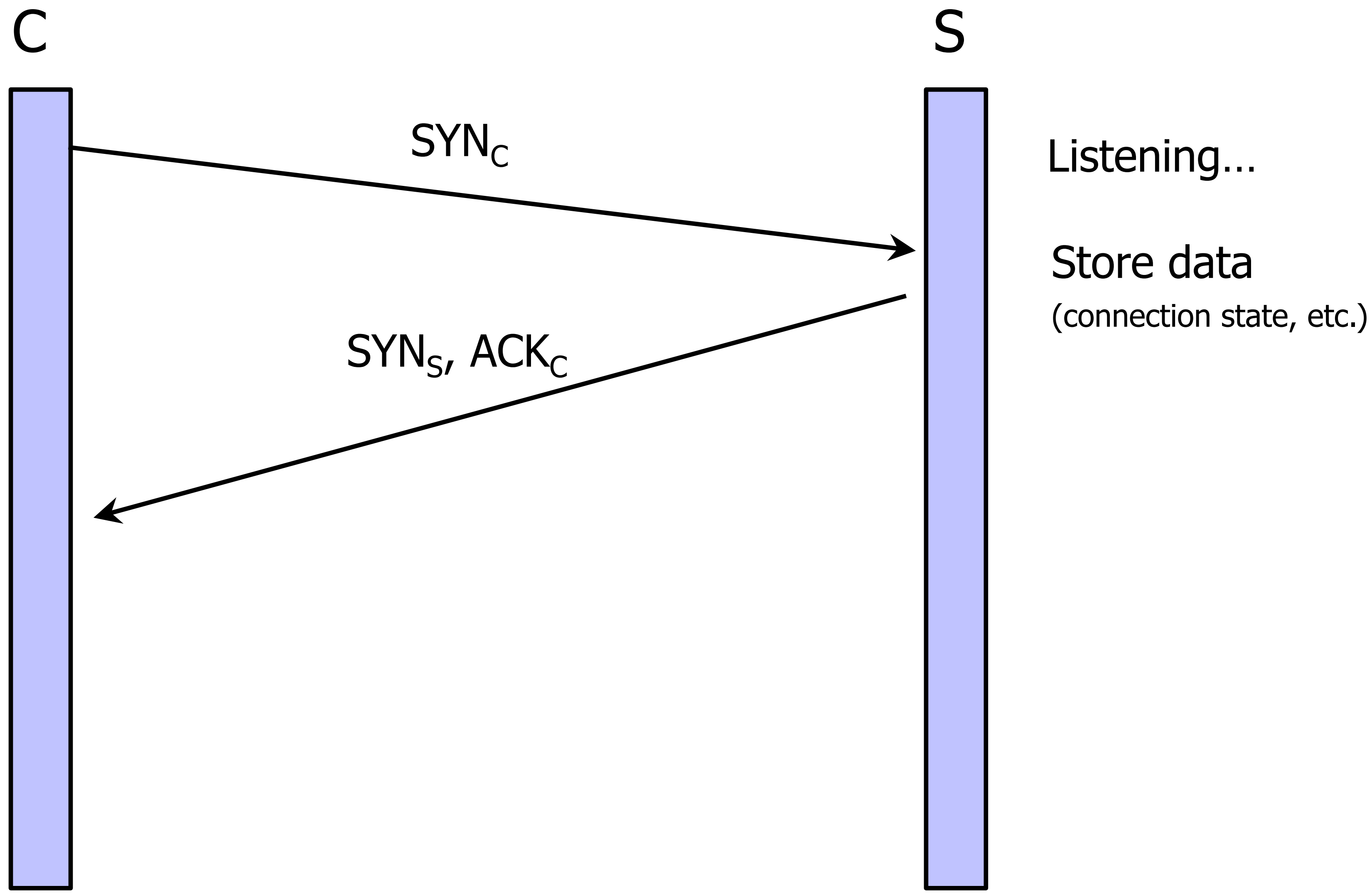

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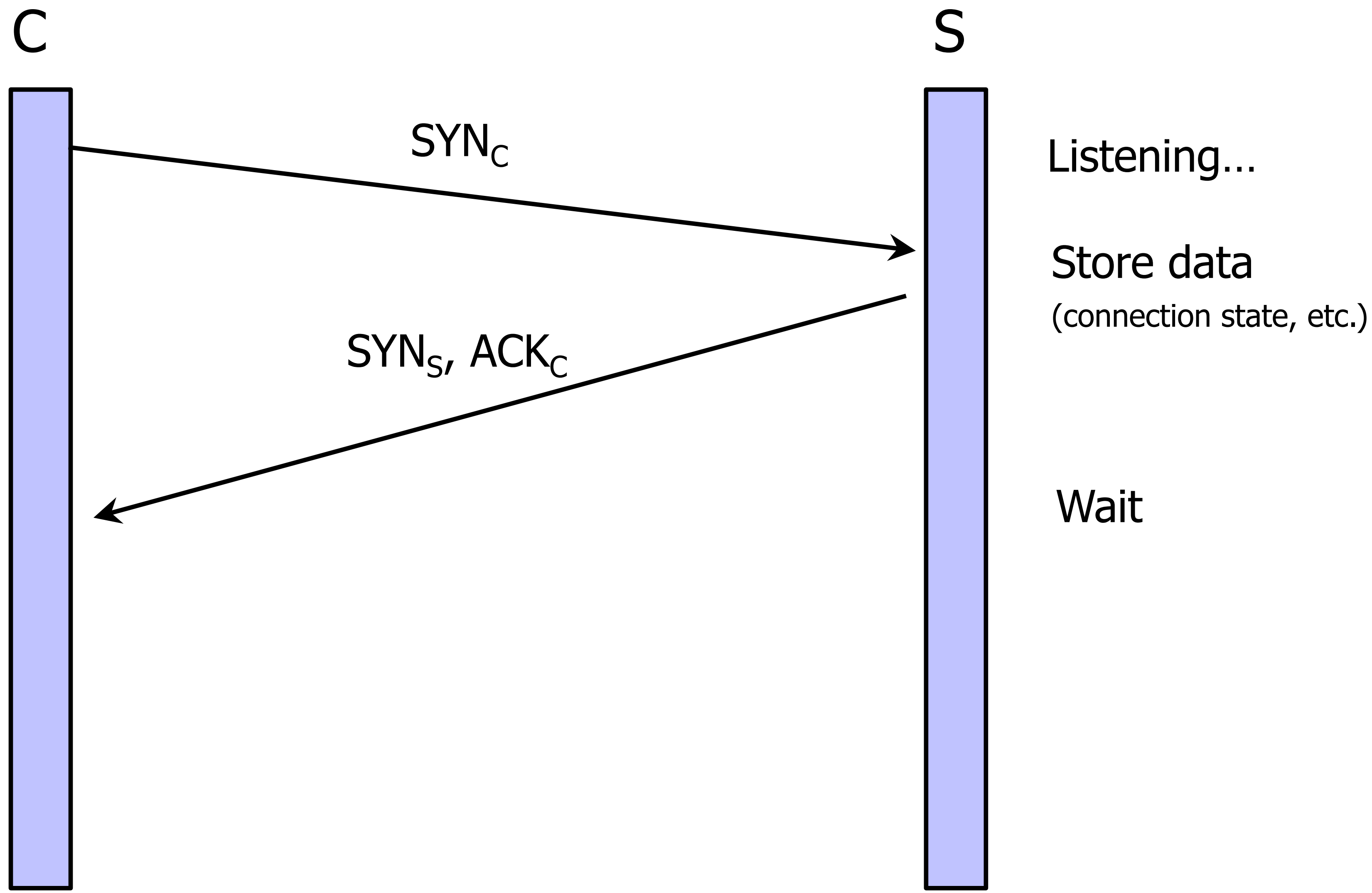

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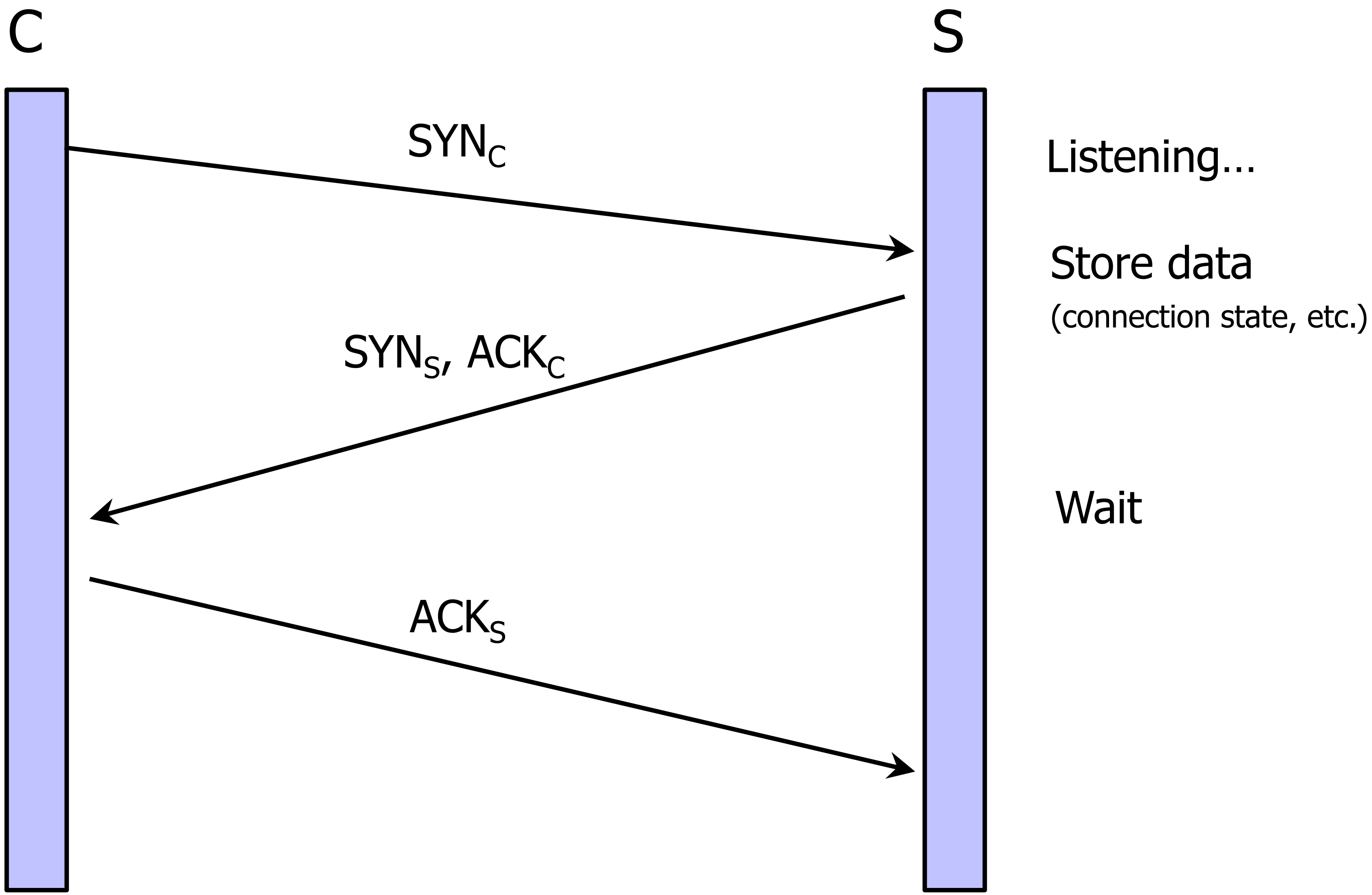

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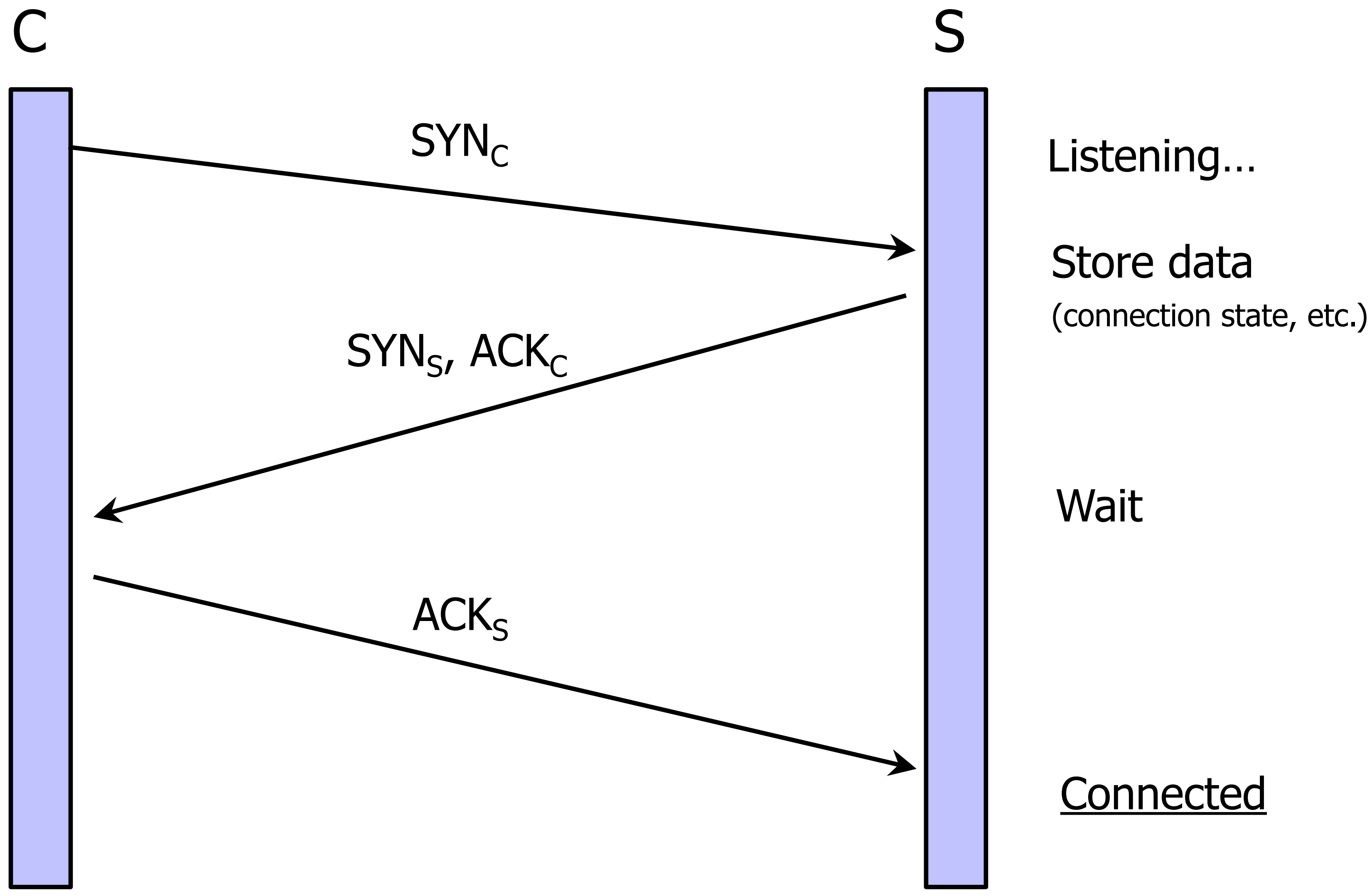
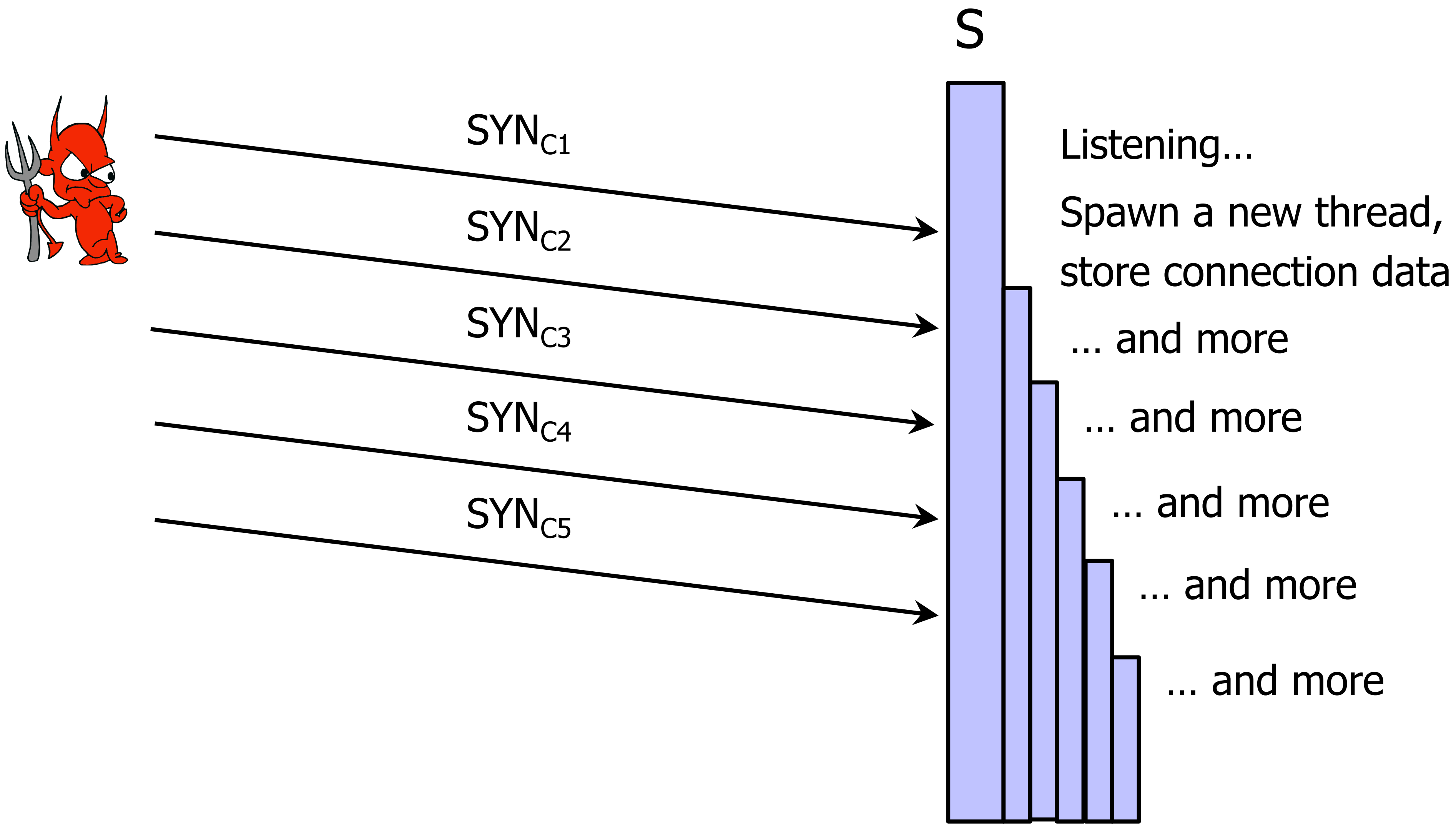


SYN Flooding Attack



SYN Flooding Explained

- Attacker sends many connection requests with spoofed source addresses
- Victim allocates resources for each request
  - Connection state maintained until timeout
  - Fixed bound on half-open connections
- Once resources exhausted, requests from legitimate clients are denied
- This is a classic denial of service (DoS) attack
  - Common pattern: it costs nothing to TCP initiator to send a connection request, but TCP responder must allocate state for each request (asymmetry!)