# White House Confirms Chinese Cyberattack

Posted by **samzenpus** on Monday October 01, @02:34PM
from the testing-the-waters dept.

First time accepted submitter clam666 writes

> "White House sources partly confirmed that U.S. government computers — reportedly including systems used by the military for nuclear commands — were breached by Chinese hackers. From the article: 'The attempted hack used "spear phishing," in which an attacker sends an email to a specific target that uses familiar phrases in hopes that the recipient will follow links or download attachments that unleash the hacker's malware. None of the White House's secure, classified computer systems were affected, said the official, who reached out to POLITICO after the Free Beacon story appeared — without having been asked for comment. Nor had there been any attempted breach of a classified system, according to the official.'"

# Announcements

- "You must therefore hard-code target stack locations in your exploits. You should not use a function such as get sp() in the exploits you hand in."
- Some confusion about this.
  - Read about semantics of execve (man page good start)
  - Calling get_sp in sploit1.c does not necessarily give appropriate stack addresses of target1

# TCP/IP security

# CS642: Computer Security


Professor Ristenpart

http://www.cs.wisc.edu/~rist/

rist at cs dot wisc dot edu

# Moving up the network stack

Internet protocol and ICMP

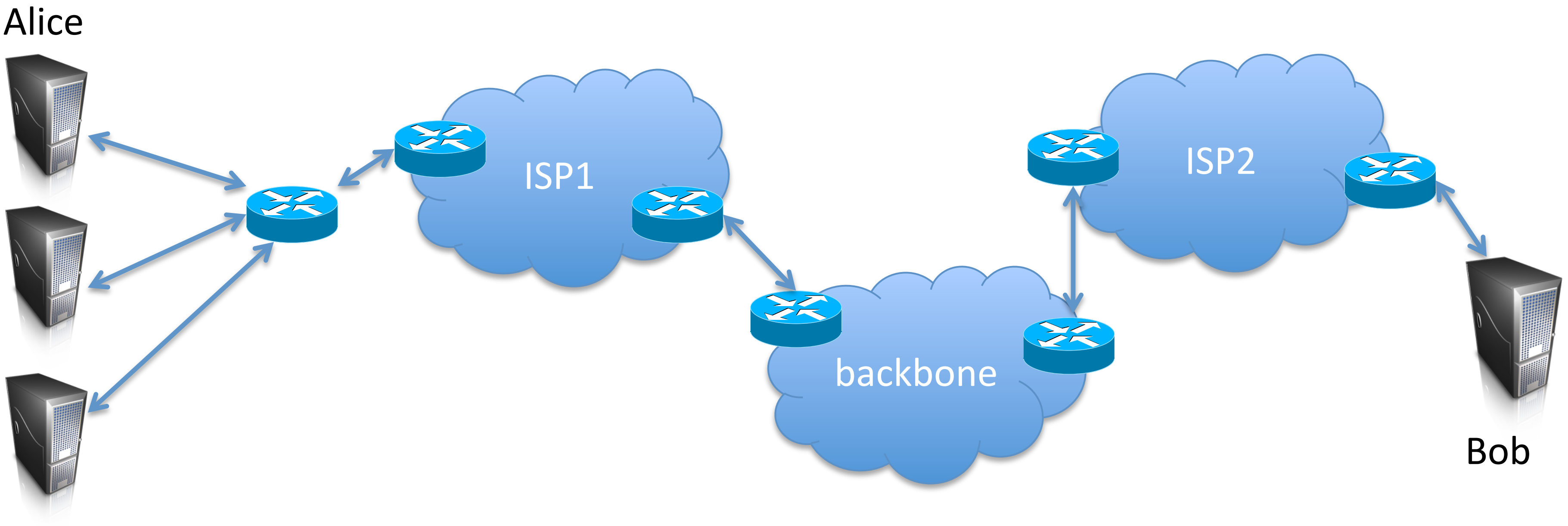
IP spoofing, fragmentation

UDP and TCP

Denial of Service

IP traceback, filtering

# Internet




Local area network (LAN)

Ethernet

802.11

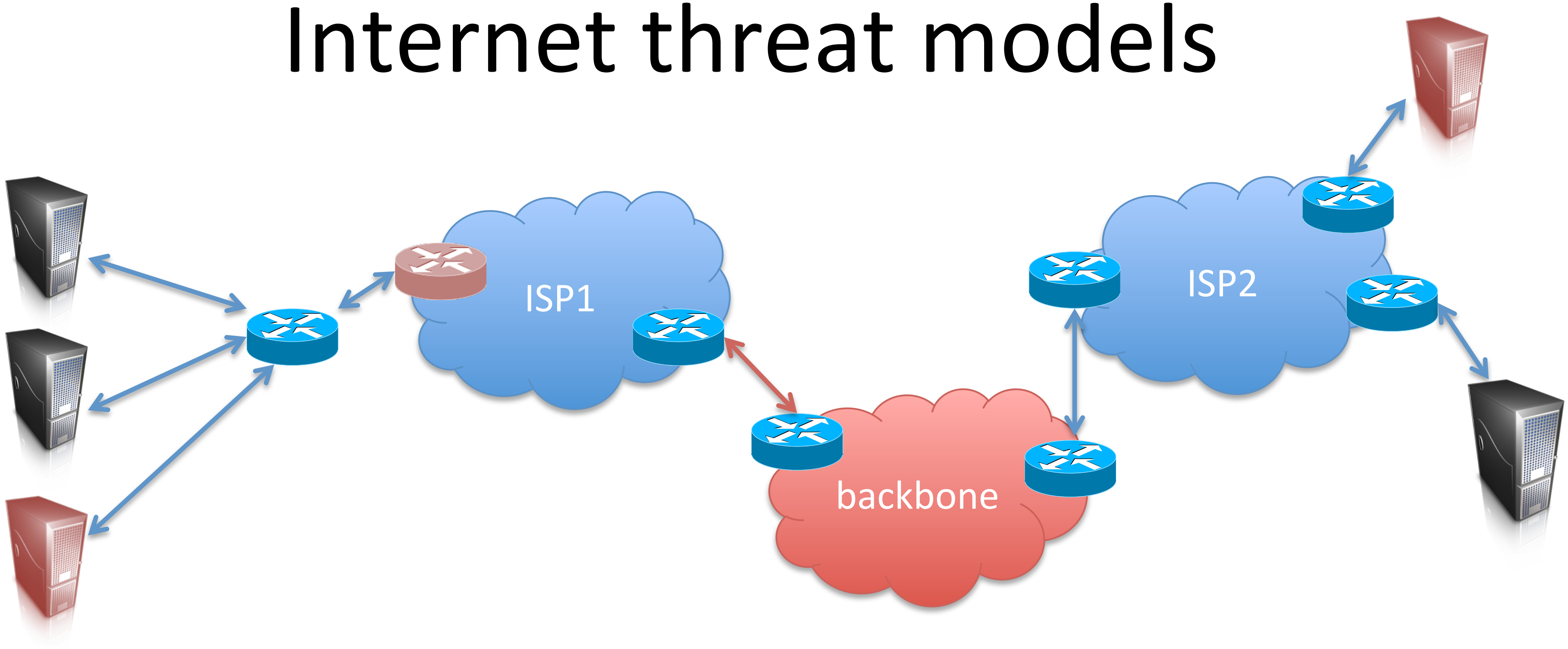
Internet

TCP/IP

BGP (border gateway protocol)

DNS (domain name system)

# Internet threat models



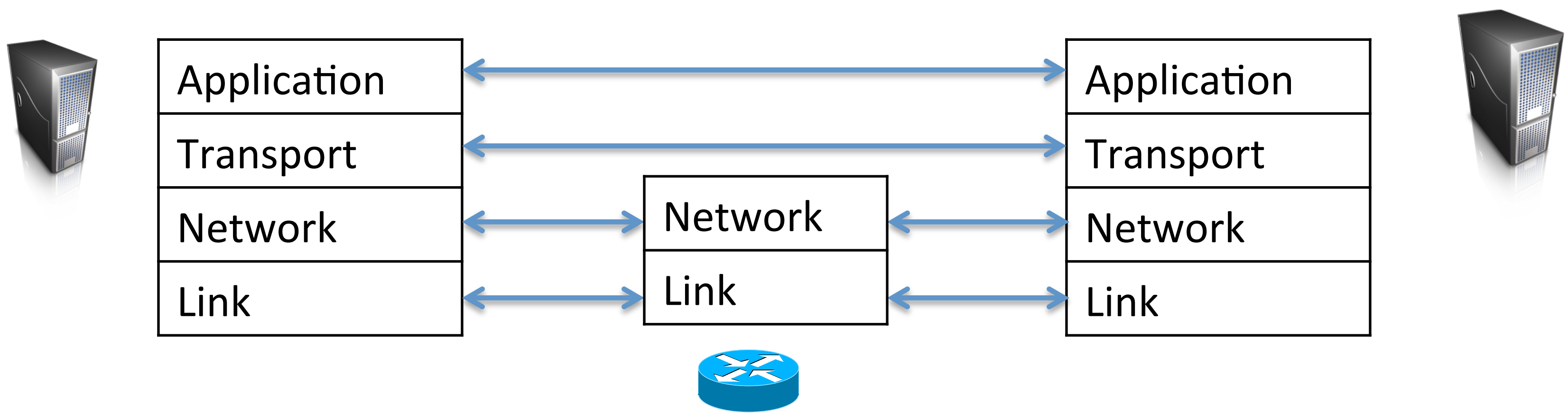

(1) Malicious hosts

(2) Subverted routers or links

(3) Malicious ISPs or backbone

# Internet protocol stack

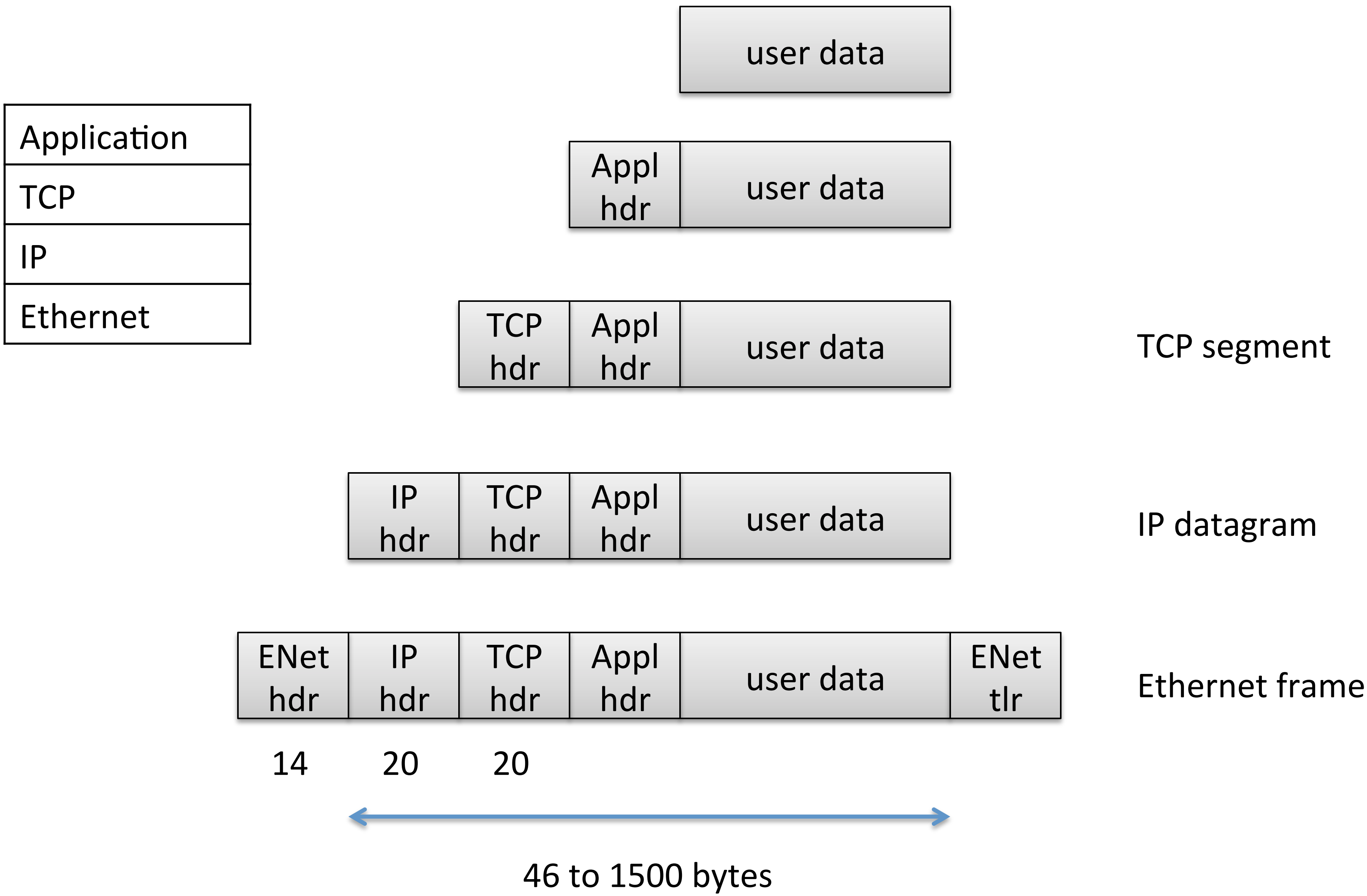
| | |
|---|---|
| Application | HTTP, FTP, SMTP, SSH, etc. |
| Transport | TCP, UDP |
| Network | IP, ICMP, IGMP |
| Link | 802x (802.11, Ethernet) |



# IP protocol (IPv4)

- Connectionless
  - no state
- Unreliable
  - no guarantees
- ICMP (Internet Control Message Protocol)
  - error messages, etc.
  - often used by tools such as ping, traceroute

# Internet protocol stack



# IPv4

| ENet hdr | IP hdr | data | ENet tlr |
|---|---|---|---|

Ethernet frame containing IP datagram

<table>
<tr><td colspan="1">4-bit<br>version</td><td colspan="1">4-bit<br>hdr len</td><td colspan="2">8-bit<br>type of service</td><td colspan="4">16-bit<br>total length (in bytes)</td></tr>
<tr><td colspan="4">16-bit<br>identification</td><td colspan="1">3-bit<br>flags</td><td colspan="3">13-bit<br>fragmentation offset</td></tr>
<tr><td colspan="2">8-bit<br>time to live (TTL)</td><td colspan="2">8-bit<br>protocol</td><td colspan="4">16-bit<br>header checksum</td></tr>
<tr><td colspan="8">32-bit<br>source IP address</td></tr>
<tr><td colspan="8">32-bit<br>destination IP address</td></tr>
<tr><td colspan="8">options (optional)</td></tr>
</table>

# Classless Inter-Domain routing (CIDR)

128.168.0.0/16

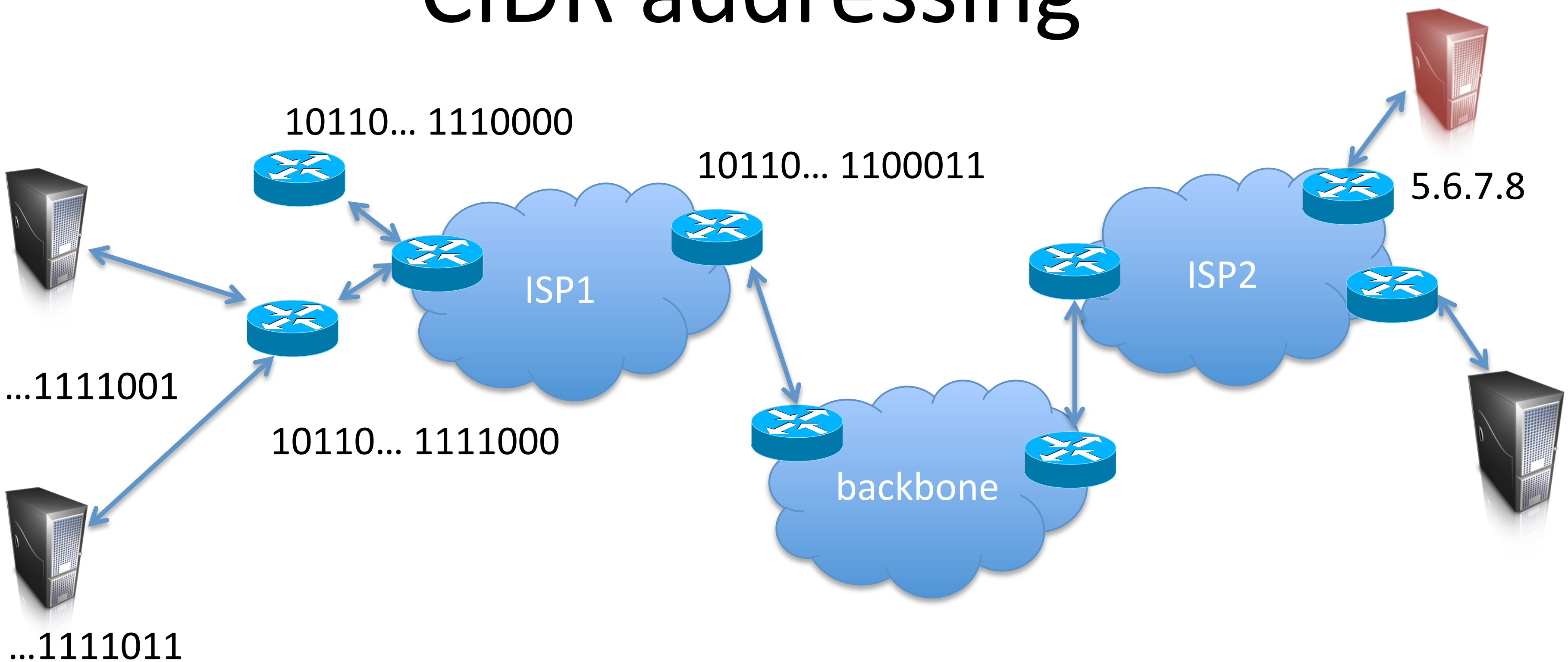
a.b.c.d / x

x indicates number of bits used for a routing prefix
IP addresses with same /x prefix share some portion of route

| CIDR address block | Description | Reference |
|---|---|---|
| 0.0.0.0/8 | Current network (only valid as source address) | RFC 1700 |
| 10.0.0.0/8 | Private network | RFC 1918 |
| 127.0.0.0/8 | Loopback | RFC 5735 |
| 169.254.0.0/16 | Link-Local | RFC 3927 |
| 172.16.0.0/12 | Private network | RFC 1918 |
| 192.0.0.0/24 | Reserved (IANA) | RFC 5735 |
| 192.0.2.0/24 | TEST-NET-1, Documentation and example code | RFC 5735 |
| 192.88.99.0/24 | IPv6 to IPv4 relay | RFC 3068 |
| 192.168.0.0/16 | Private network | RFC 1918 |
| 198.18.0.0/15 | Network benchmark tests | RFC 2544 |
| 198.51.100.0/24 | TEST-NET-2, Documentation and examples | RFC 5737 |
| 203.0.113.0/24 | TEST-NET-3, Documentation and examples | RFC 5737 |
| 224.0.0.0/4 | Multicasts (former Class D network) | RFC 3171 |
| 240.0.0.0/4 | Reserved (former Class E network) | RFC 1700 |
| 255.255.255.255 | Broadcast | RFC 919 |

From http://en.wikipedia.org/wiki/IPv4

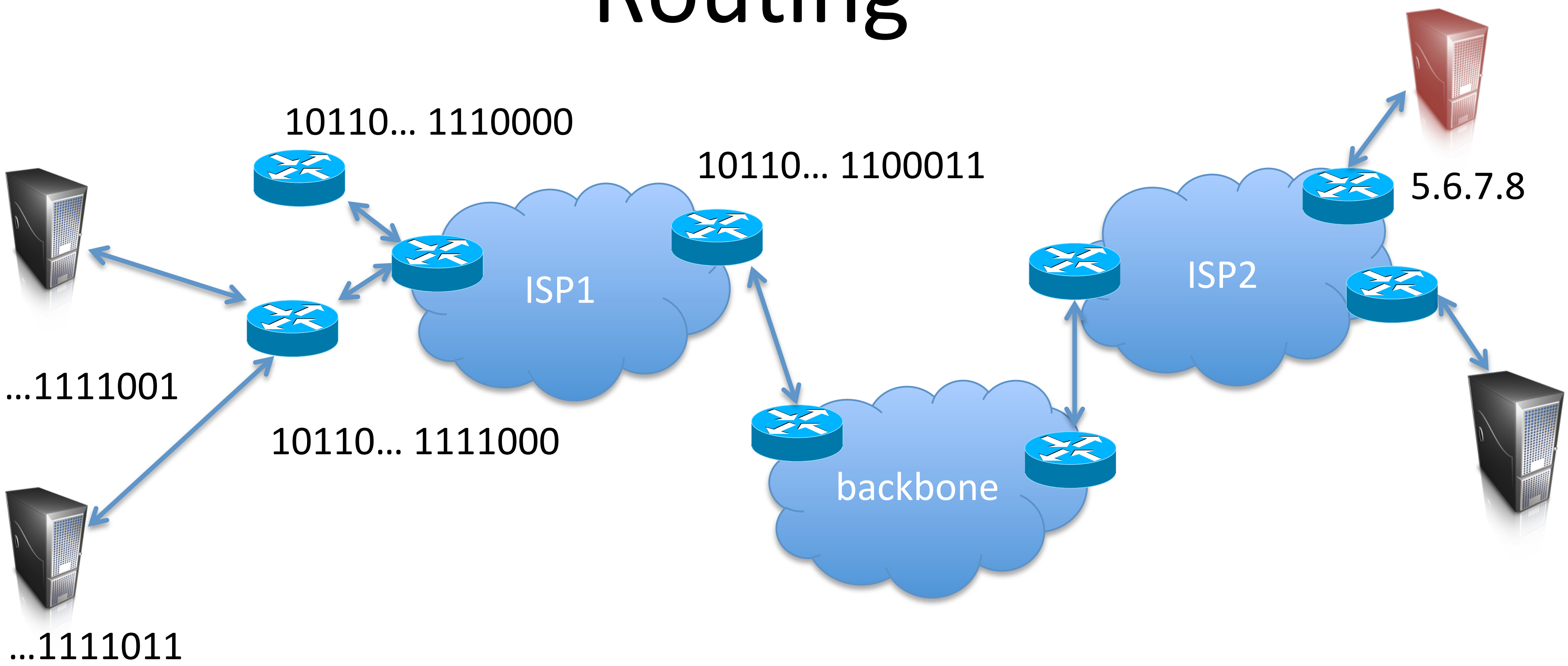
# CIDR addressing




Prefixes used to setup hierarchical routing:

- An organization assigned a.b.c.d/x
- It manages addresses prefixed by a.b.c.d/x

# Routing



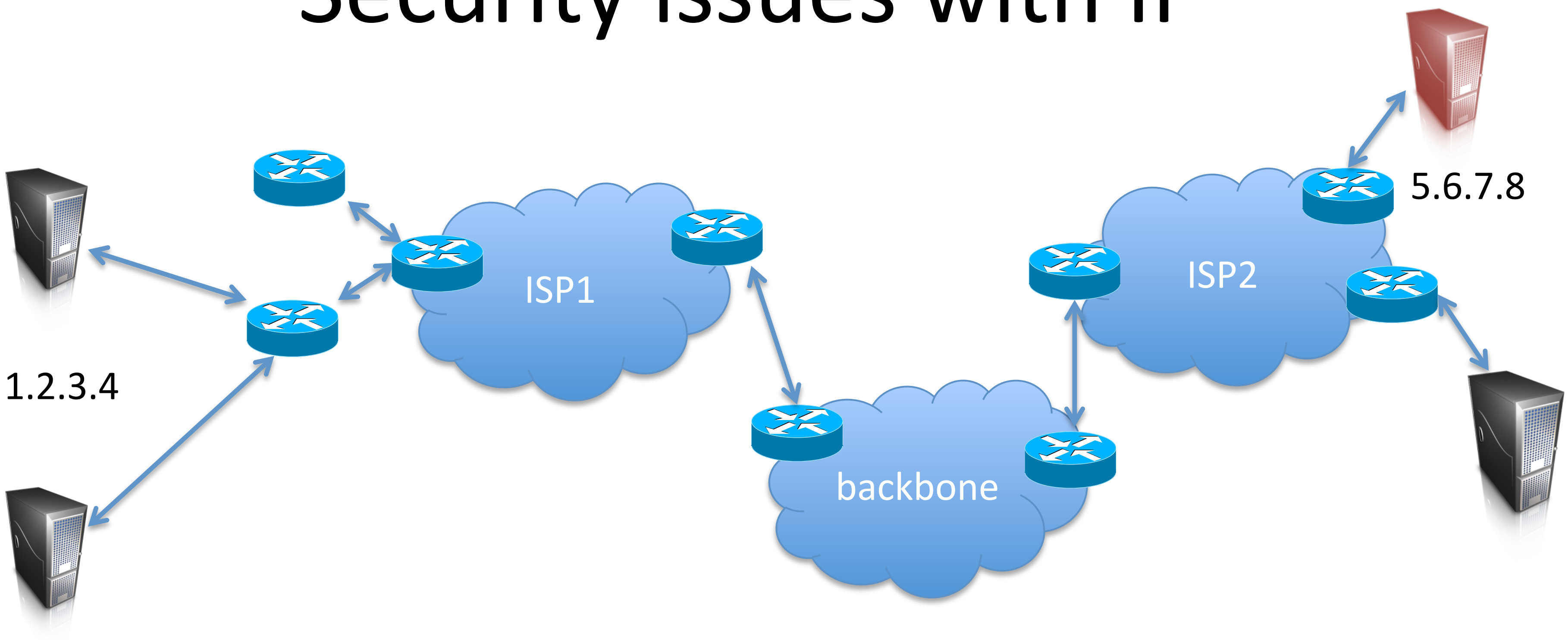

Autonomous systems (AS) are organizational building blocks

- Collection of IP prefixes under single routing policy
- wisc.edu

Within AS, might use RIP (Routing Information Protocol)

Between AS, use BGP (Border Gateway Protocol)

# Security issues with IP

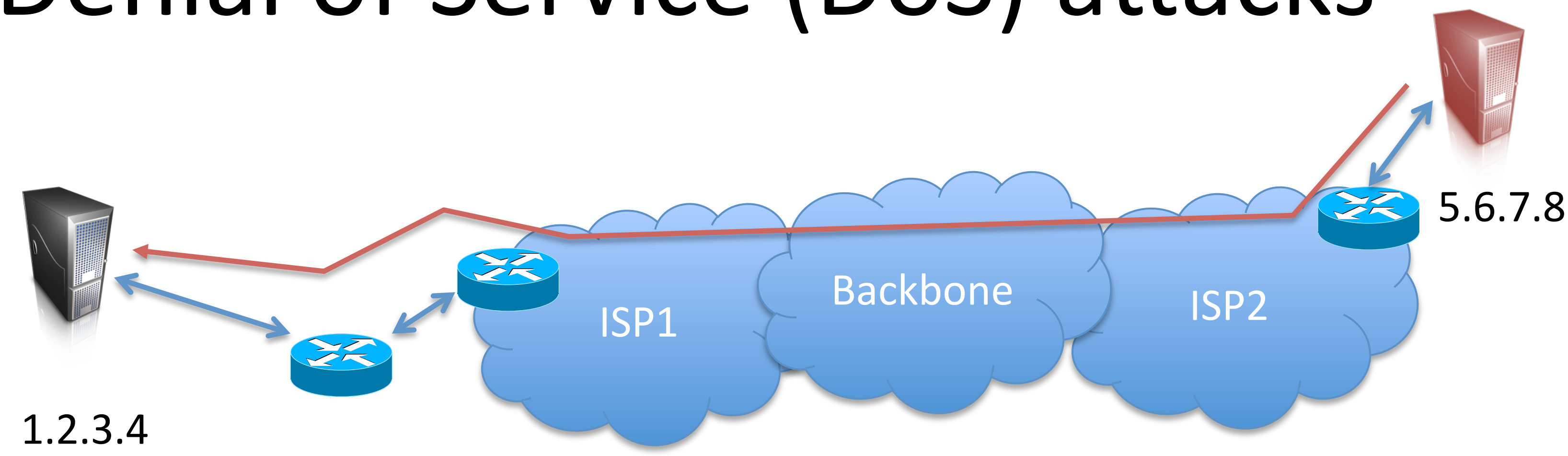



Routing has issues, we'll get to that later

What else?

- Anyone can talk to anyone
- No source address authentication in general

# Denial of Service (DoS) attacks




Goal is to prevent legitimate users from accessing victim (1.2.3.4)

ICMP ping flood

# ICMP
# (Internet Control Message Protocol)

| | | |
|---|---|---|
| IP hdr | ICMP hdr | ICMP message |

| | | |
|---|---|---|
| 8-bit type | 8-bit code | 16-bit checksum |
| 4-byte more of header (depends on type) | | |
| message … | | |

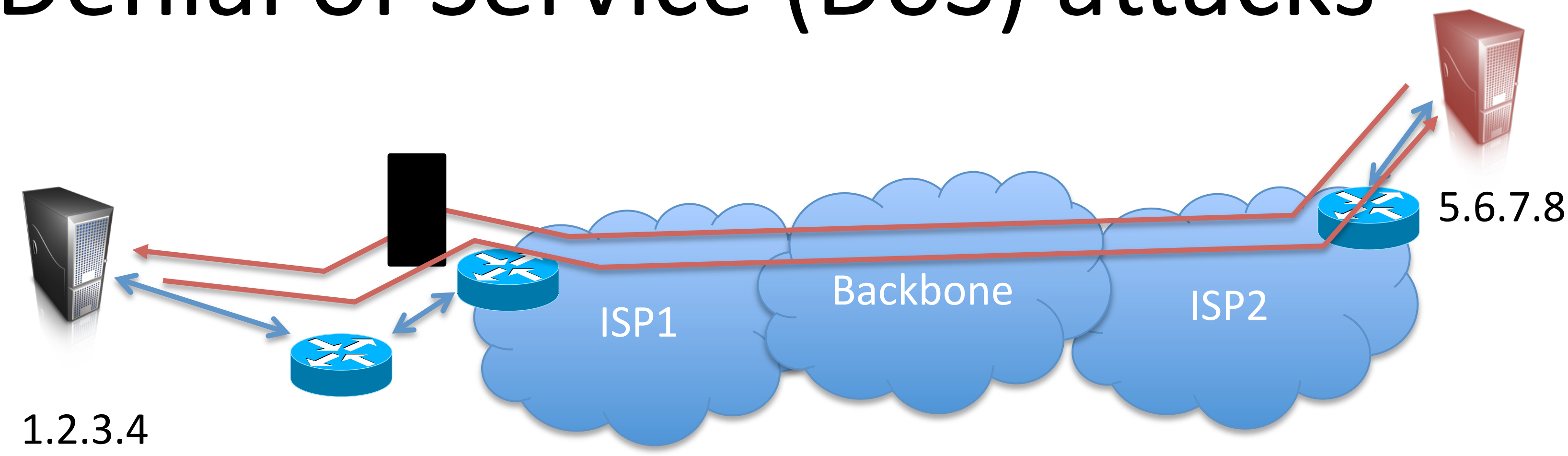
# ICMP
# (Internet Control Message Protocol)

| | | |
|---|---|---|
| IP hdr | ICMP hdr | ICMP message |

| | | |
|---|---|---|
| 8-bit type (0 or 8) | 8-bit code = 0 | 16-bit checksum |
| 16-bit identifier | | 16-bit sequence number |
| optional data | | |

Echo request (used by ping)

# Denial of Service (DoS) attacks

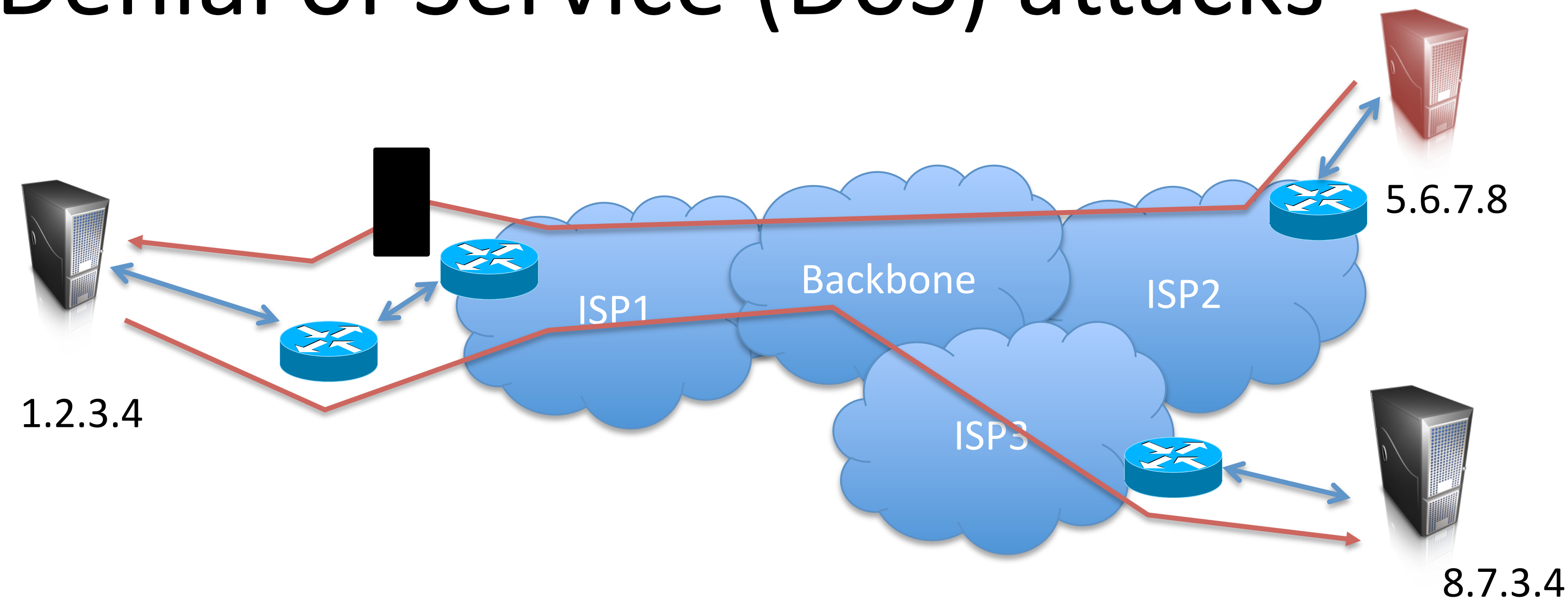



Goal is to prevent legitimate users from accessing victim (1.2.3.4)

ICMP ping flood

- Attacker sends ICMP pings as fast as possible to victim
- When will this work as a DoS? Attacker resources > victim's
- How can this be prevented? Ingress filtering near victim

# Denial of Service (DoS) attacks

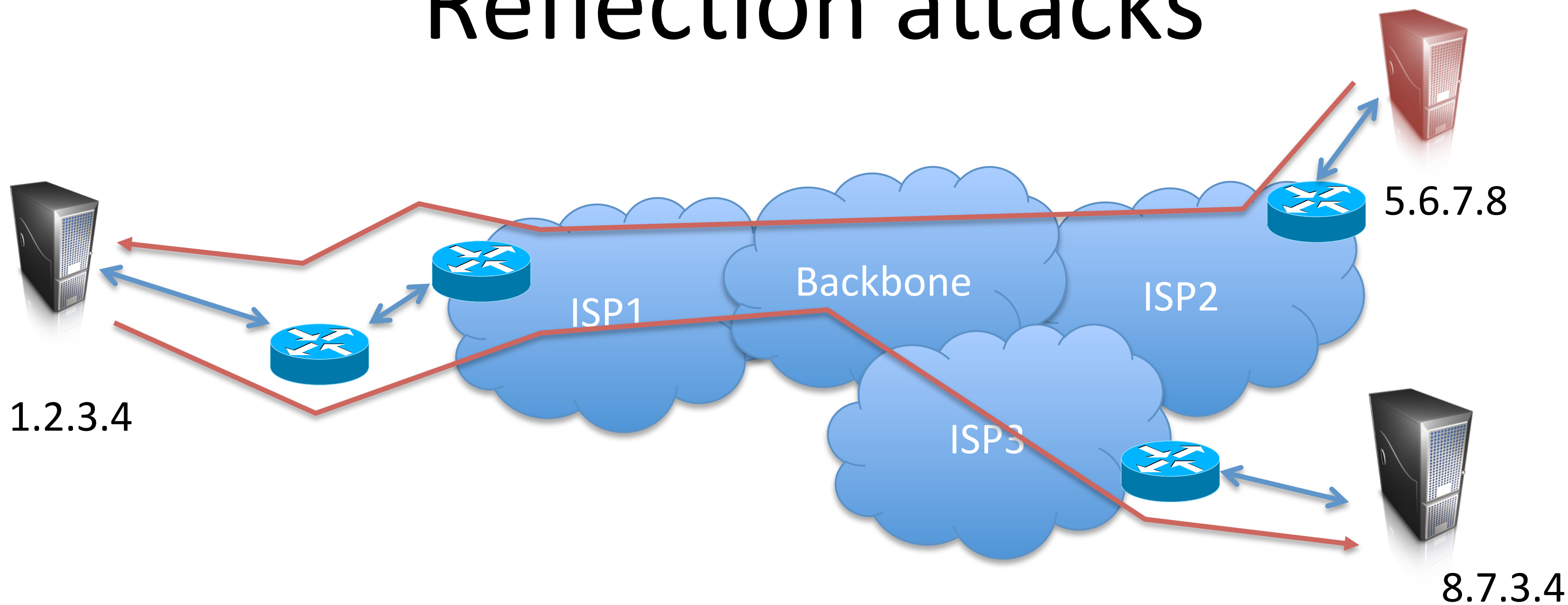



How can attacker avoiding ingress filtering?

Attacker can send packet with fake source IP "spoofed" packet
Packet will get routed correctly
Replies will not

Send IP packet with source: 8.7.3.4 dest: 1.2.3.4 from 5.6.7.8

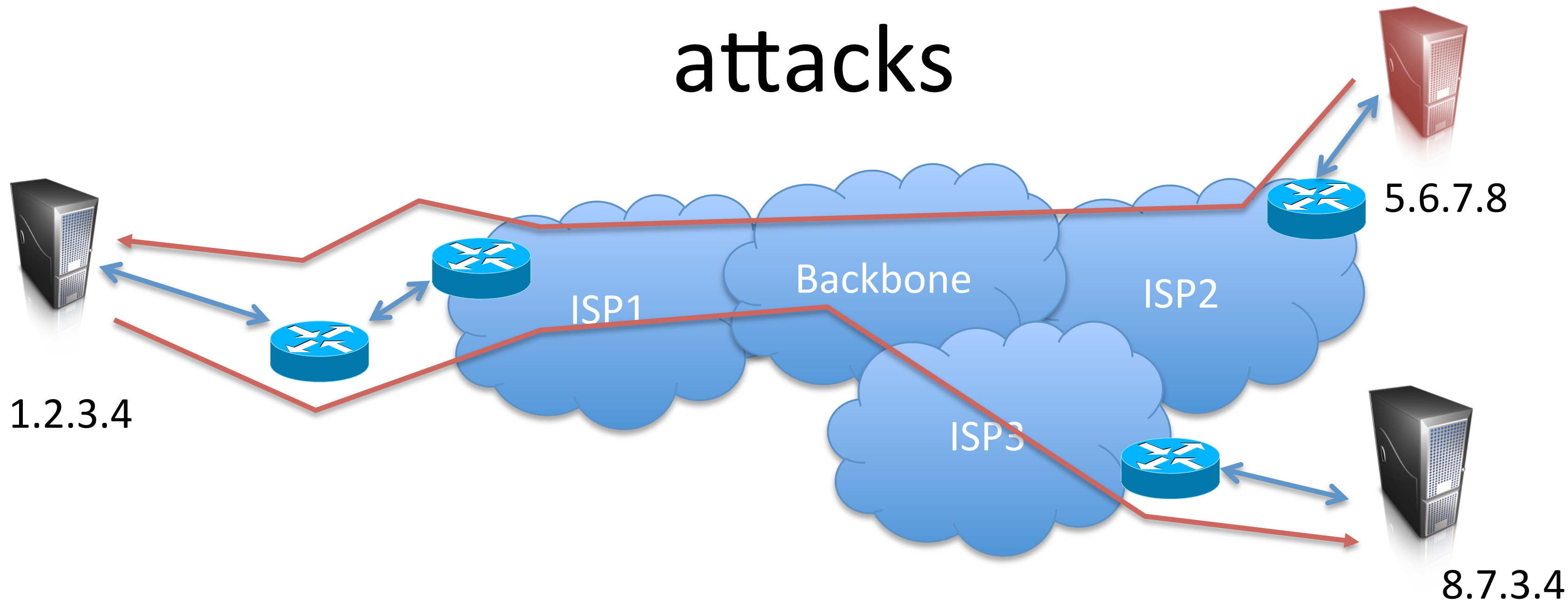
# Reflection attacks




Note a valid packet sends a reply to 8.7.3.4

- Attacker can bounce an attack against 8.7.3.4 off 1.2.3.4
- Frame 1.2.3.4
- Hides a single-packet exploit even better
  (1.2.3.4 in foreign country)

# Anonymous single-packet attacks




1.2.3.4 contains a buffer overflow in web server

src: 8.7.3.4
dst: 1.2.3.4

HTTP/1.1 GET
AAAAAAAAAAA….

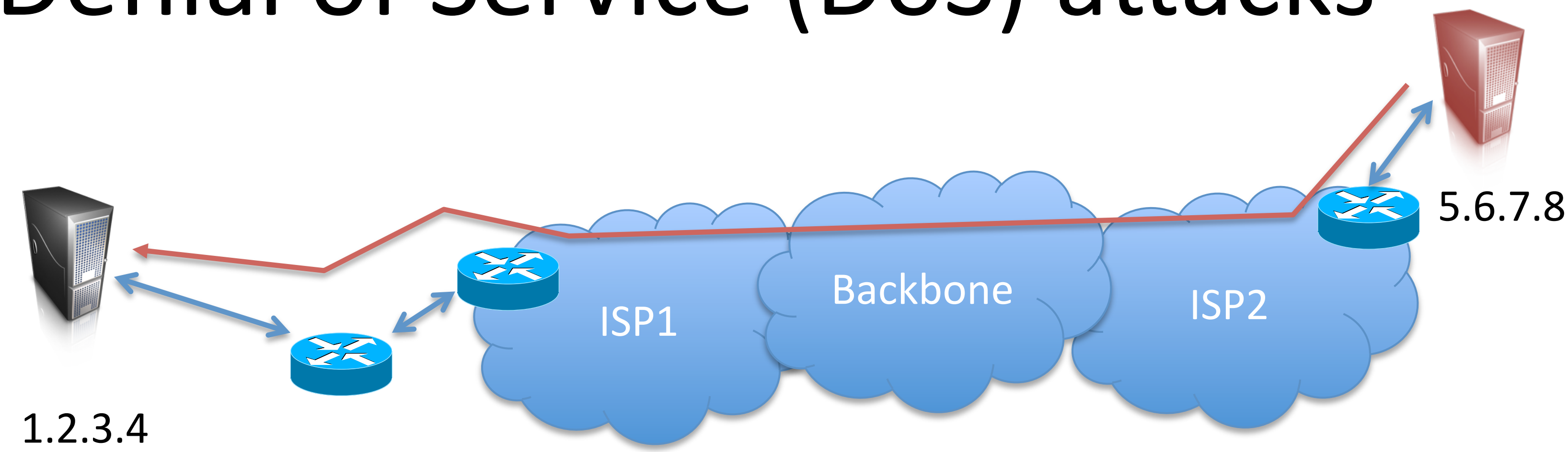
Untraceable packet of death

src: 8.7.3.4
dst: 1.2.3.4

HTTP/1.1 GET
exploit buffer

Untraceable single-packet exploit + payload

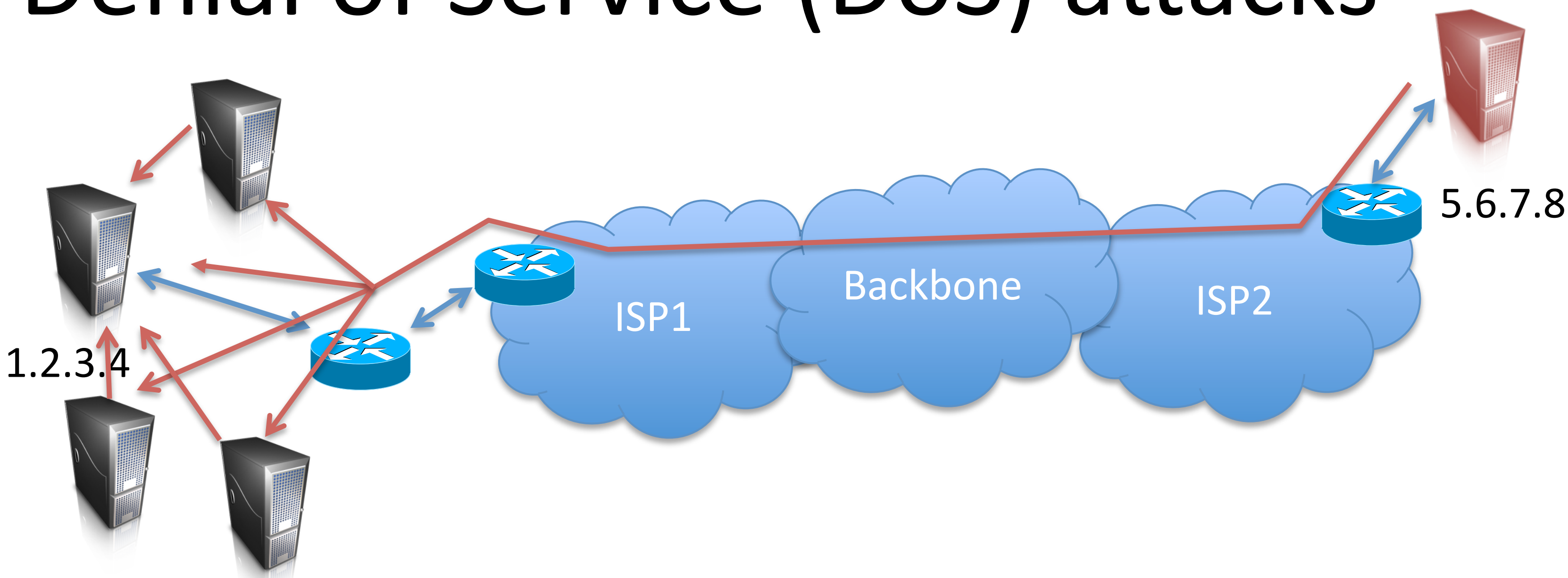
# Denial of Service (DoS) attacks




DoS works better when there is ***asymmetry*** between victim and attacker

- Attacker uses few resources to cause
- Victim to consume lots of resources

# Denial of Service (DoS) attacks

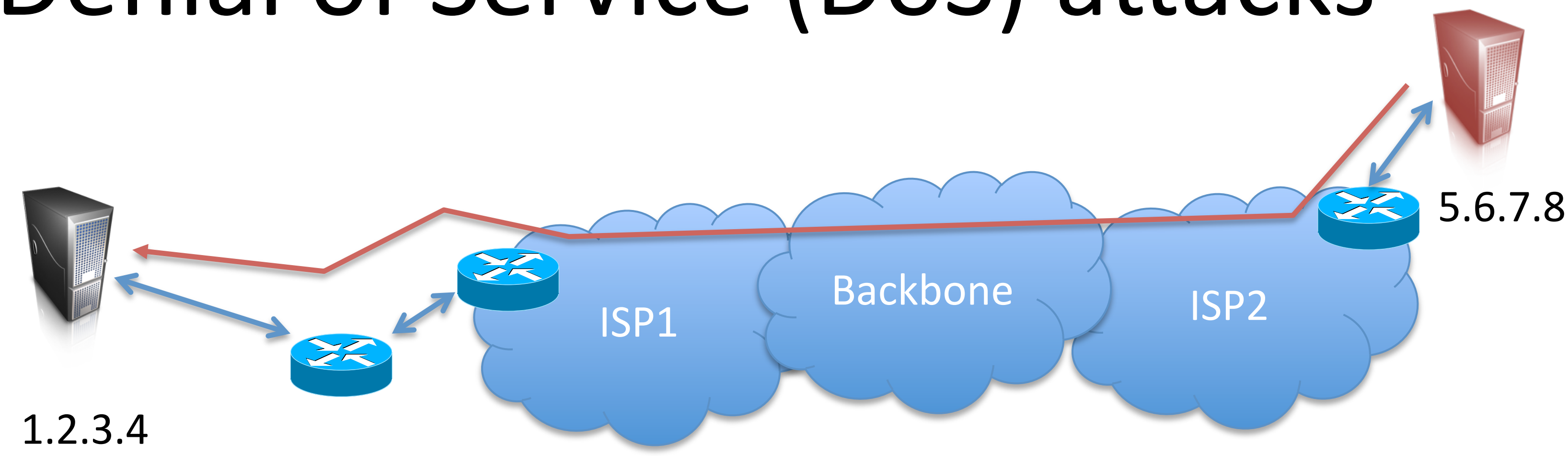



DoS works better when there is ***asymmetry*** between victim and attacker

- Attacker uses few resources to cause
- Victim to consume lots of resources

Old example: Smurf attack
Router allows attacker to send broadcast ICMP ping on network. Attacker spoofs SRC address to be 1.2.3.4

# Denial of Service (DoS) attacks




DoS works better when there is ***asymmetry*** between victim and attacker

- Attacker uses few resources to cause
- Victim to consume lots of resources

Better yet: ping of death

A single packet that causes crash on remote system

Early on: ping packet with size > 65,535

# IPv4 fragmenting


Ethernet frame containing IP datagram

IP allows datagrams of size from
20 bytes up to 65535 bytes

Some link layers only allow MTU of 1500 bytes

IP figures out MTU of next link, and fragments packet if necessary into smaller chunk

# IPv4 fragmenting

| ENet hdr | IP hdr | data | ENet tlr |
|---|---|---|---|

Ethernet frame containing IP datagram

<table>
<tr><td>4-bit<br>version</td><td>4-bit<br>hdr len</td><td>8-bit<br>type of service</td><td colspan="2">16-bit<br>total length (in bytes)</td></tr>
<tr><td colspan="3">16-bit<br>identification</td><td>3-bit<br>flags</td><td>13-bit<br>fragmentation offset</td></tr>
<tr><td colspan="2">8-bit<br>time to live (TTL)</td><td>8-bit<br>protocol</td><td colspan="2">16-bit<br>header checksum</td></tr>
<tr><td colspan="5">32-bit<br>source IP address</td></tr>
<tr><td colspan="5">32-bit<br>destination IP address</td></tr>
<tr><td colspan="5">options (optional)</td></tr>
</table>

# IPv4 fragmenting


Ethernet frame containing IP datagram

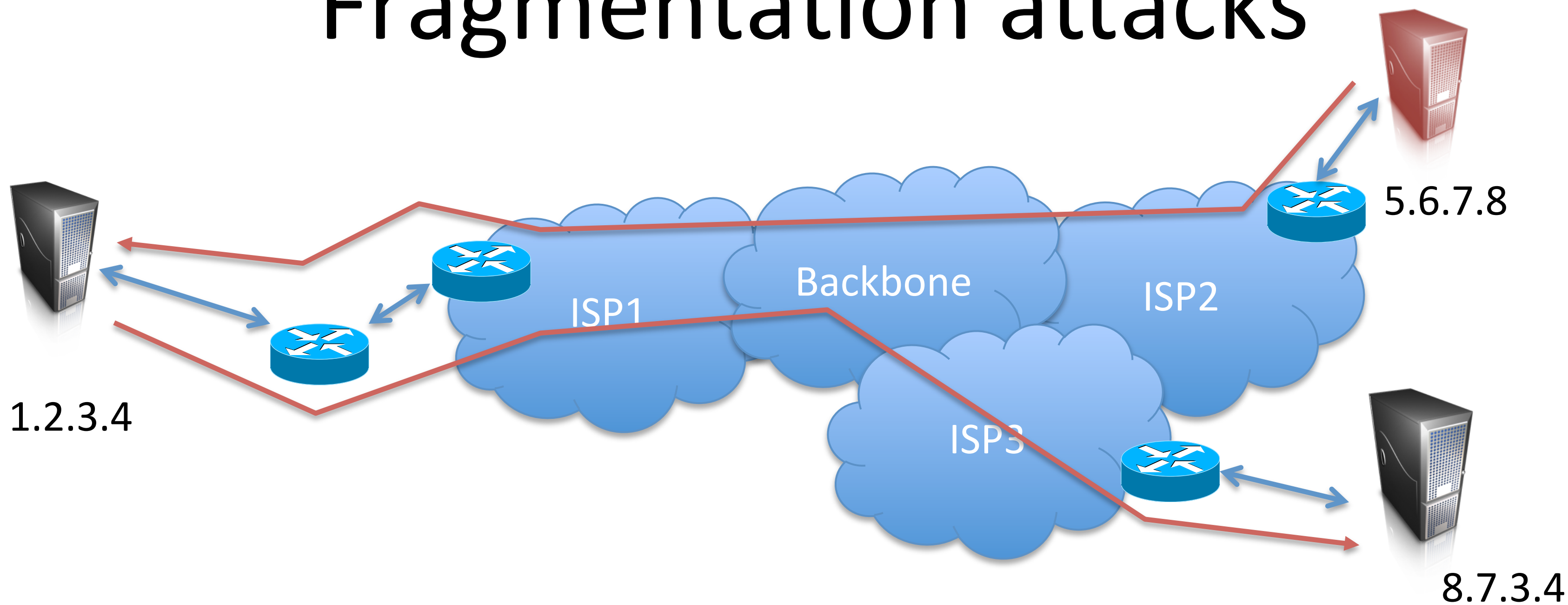

Source-specified “unique” number identifying datagram

Fragment offset in 8-byte units

Flags:
0 b1 b2

where b1 = May Fragment (0) / Don’t Fragment (1)
where b1 = Last Fragment (0) / More Fragments (1)

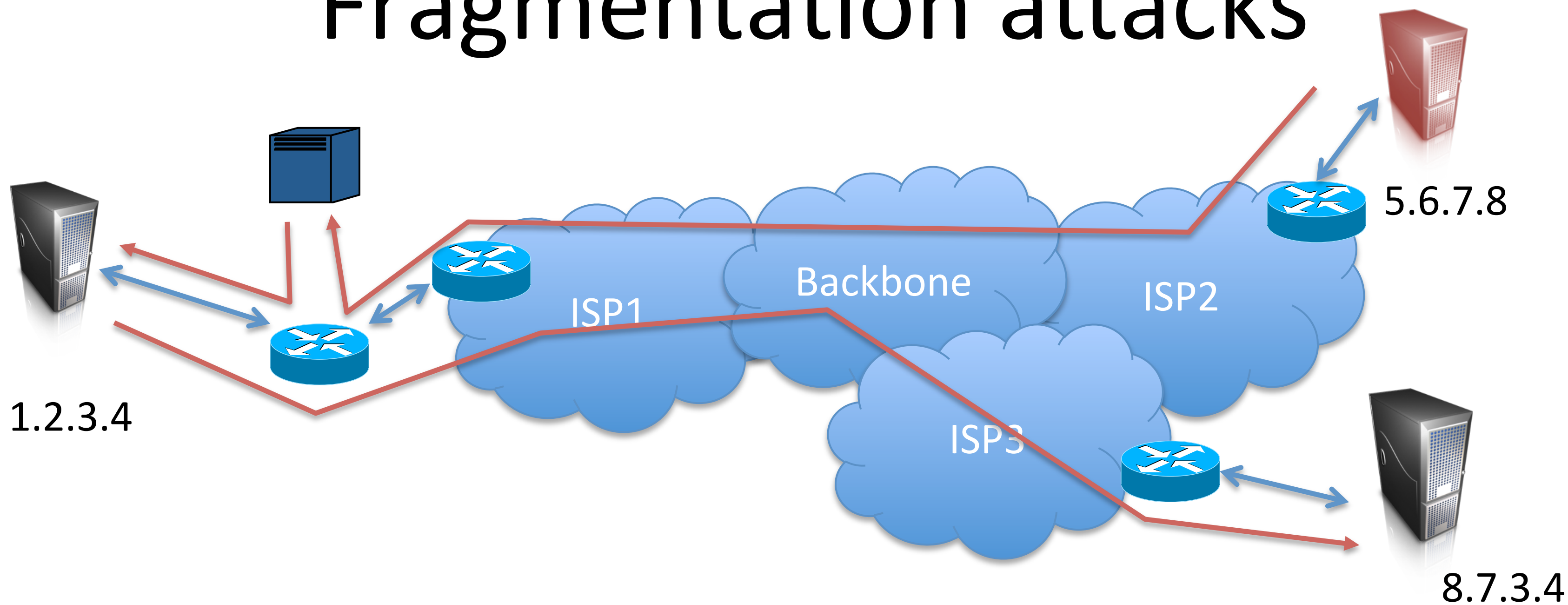
# Fragmentation attacks




Fragmentation abused in lots of vulnerabilities:

- Ping of death: allows sending 65,536 byte packet, overflows buffer.
- Teardrop DoS: mangled fragmentation crashes reconstruction code (Set offsets so that two packets have overlapping data)

# Fragmentation attacks



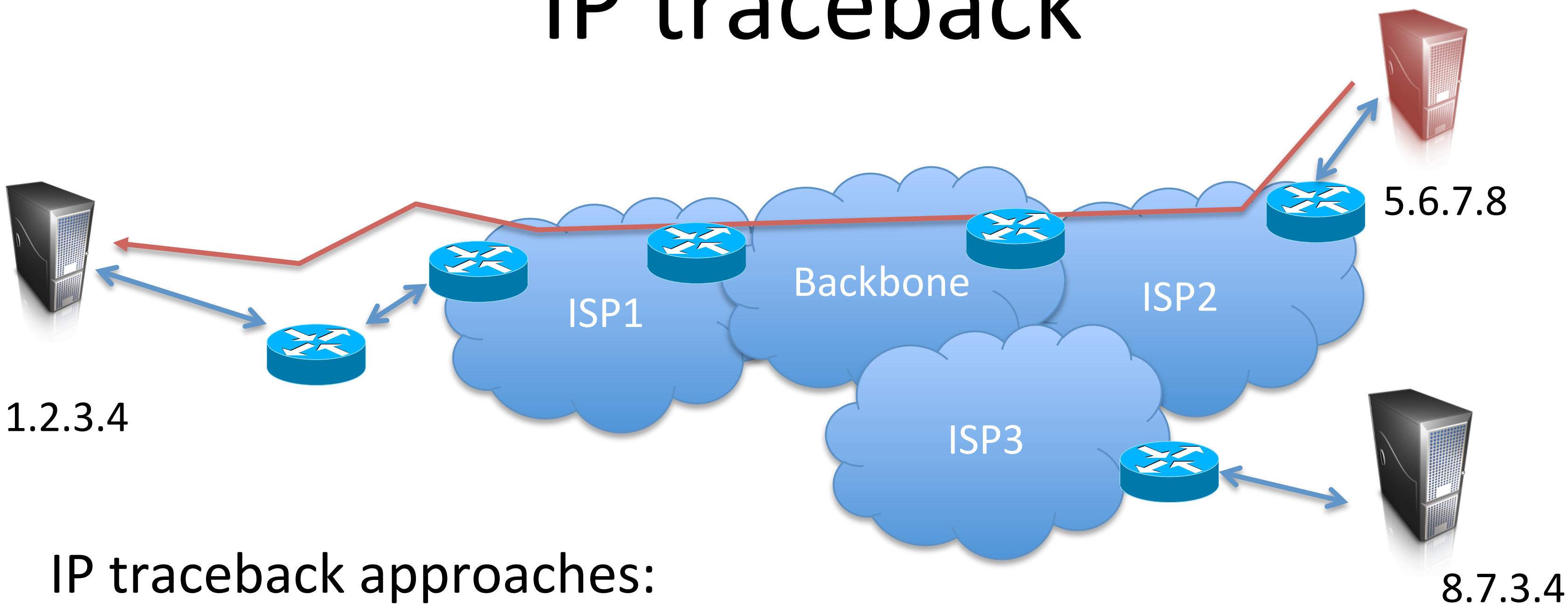

Fragmentation abused in lots of vulnerabilities:

- Ping of death: allows sending 65,536 byte packet, overflows buffer.
- Teardrop DoS: mangled fragmentation crashes reconstruction code (Set offsets so that two packets have overlapping data)
- Avoiding IDS systems: IDS scans packets for exploit strings; add random data into packets, overwrite later during reconstruction due to overlapping fragments

# IP traceback

- Spoofed IPs means we cannot know where packets came from
- IP traceback is problem of determining the origination of one or more packets

# IP traceback




IP traceback approaches:

- Logging – each router keeps logs of packets going by
- Input debugging – feature of routers allowing filtering egress port traffic based on ingress port. Associate egress with ingress
- Controlled flooding – mount your own DoS on links selectively to see how it affects malicious flood
- Marking – router probabilistically marks packets with info
- ICMP traceback – router probabilistically sends ICMP packet with info to destination

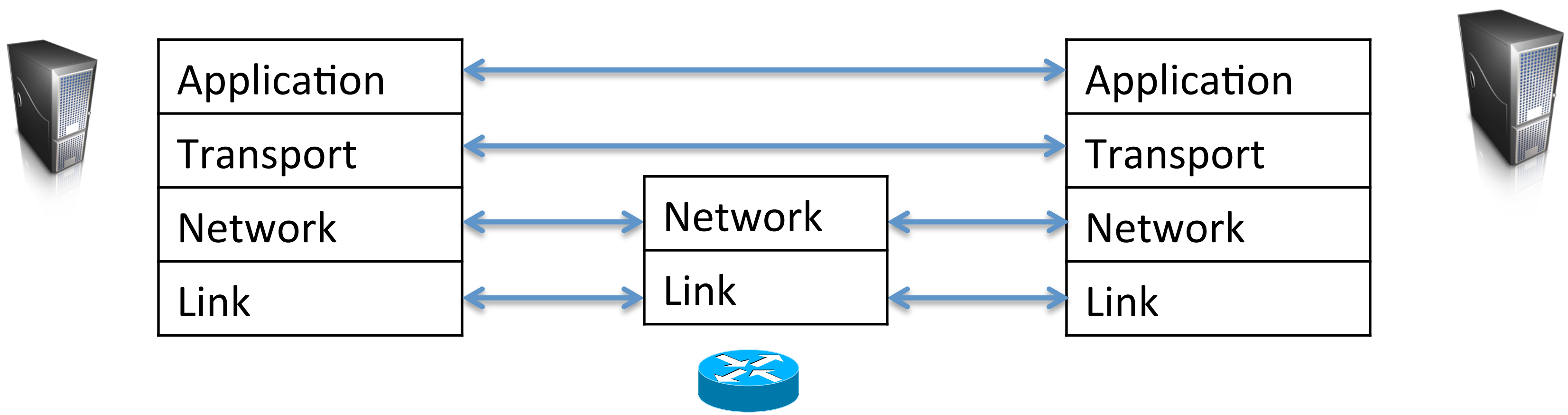
# IP traceback

| | Management overhead | Network overhead | Router overhead | Distributed capability | Post-mortem capability | Preventative/ reactive |
|---|---|---|---|---|---|---|
| Ingress filtering | Moderate | Low | Moderate | N/A | N/A | Preventative |
| Link testing | | | | | | |
| Input debugging | High | Low | High | Good | Poor | Reactive |
| Controlled flooding | Low | High | Low | Poor | Poor | Reactive |
| Logging | High | Low | High | Excellent | Excellent | Reactive |
| ICMP Traceback | Low | Low | Low | Good | Excellent | Reactive |
| Marking | Low | Low | Low | Good | Excellent | Reactive |

From Savage et al., “Practical Network Support for IP Traceback”

# Internet protocol stack

| | |
|---|---|
| Application | HTTP, FTP, SMTP, SSH, etc. |
| Transport | TCP, UDP |
| Network | IP, ICMP, IGMP |
| Link | 802x (802.11, Ethernet) |



# UDP (user datagram protocol)

| IP hdr | UDP hdr | data |
|---|---|---|

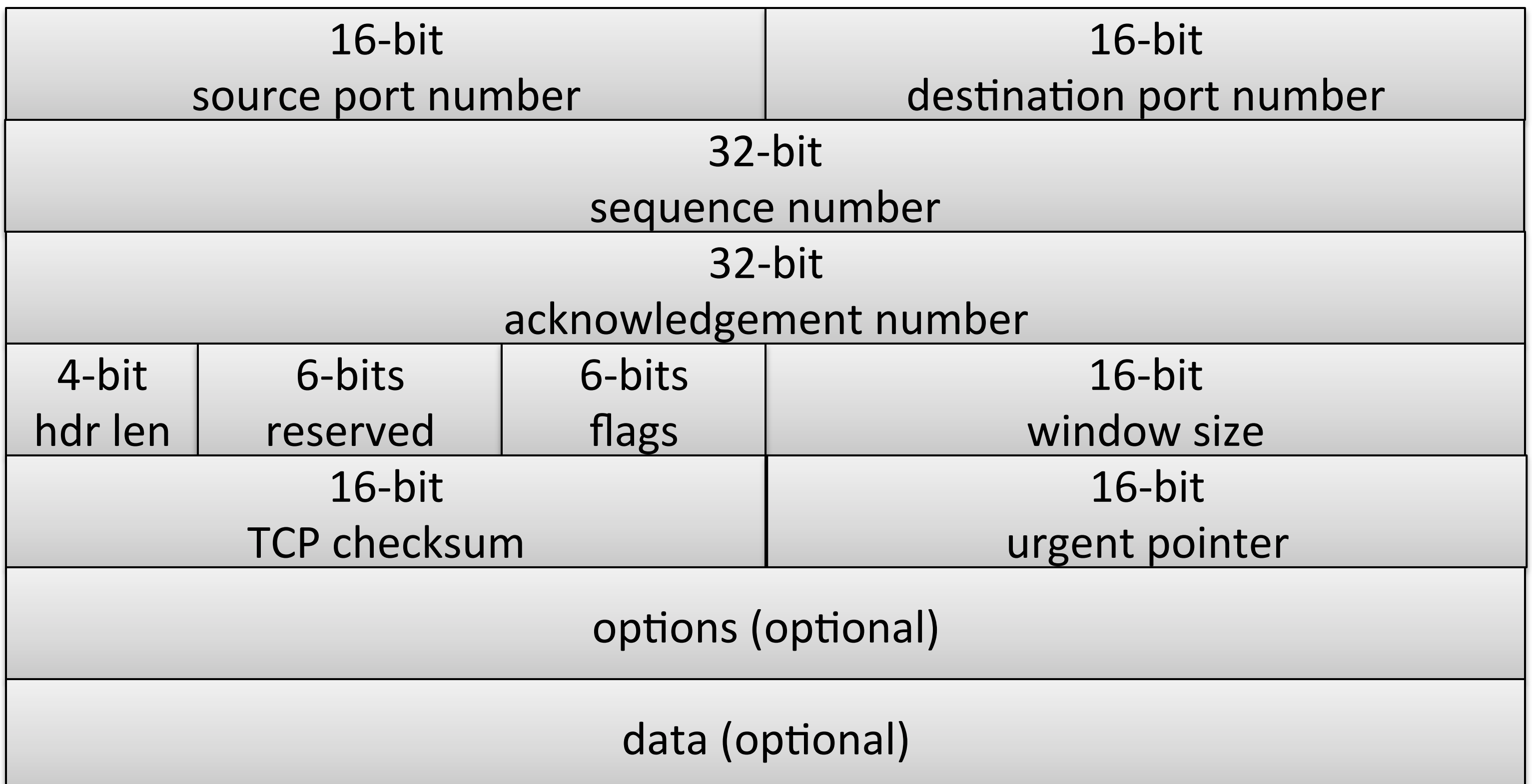
| | |
|---|---|
| 16-bit source port number | 16-bit destination port number |
| 16-bit UDP length | 16-bit UDP checksum |

length = header len + data len

# TCP (transport control protocol)

- Connection-oriented
  - state initialized during handshake and maintained
- Reliability is a goal
  - generates segments
  - timeouts segments that aren't ack'd
  - checksums headers,
  - reorders received segments if necessary
  - flow control

# TCP (transport control protocol)

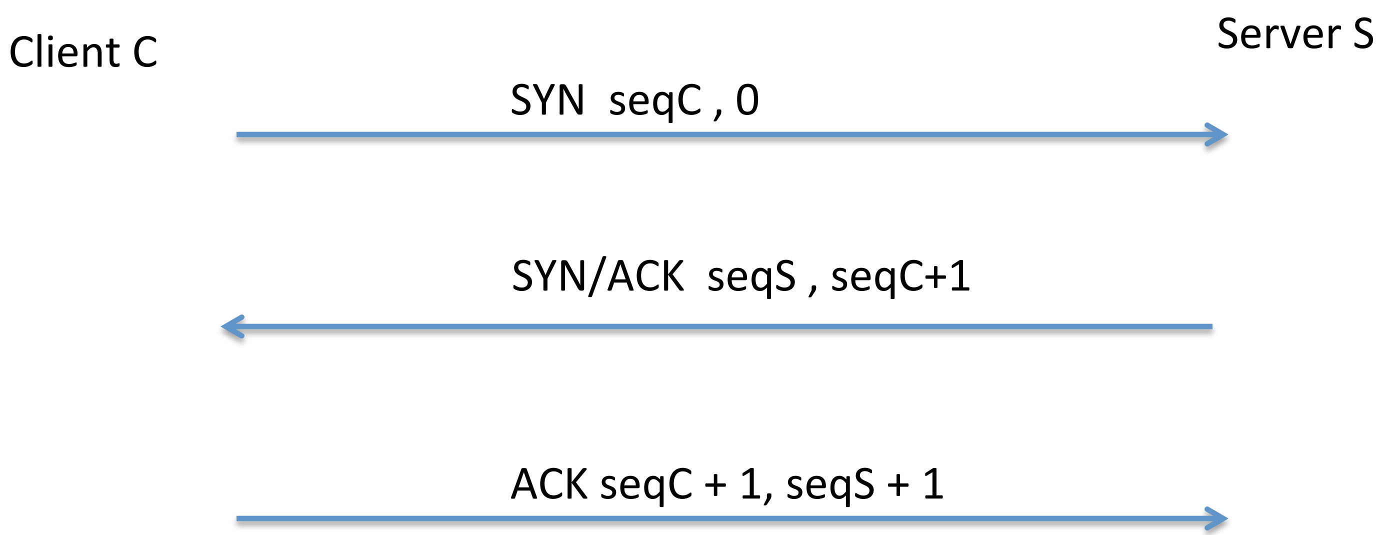



# TCP (transport control protocol)


TCP flags:

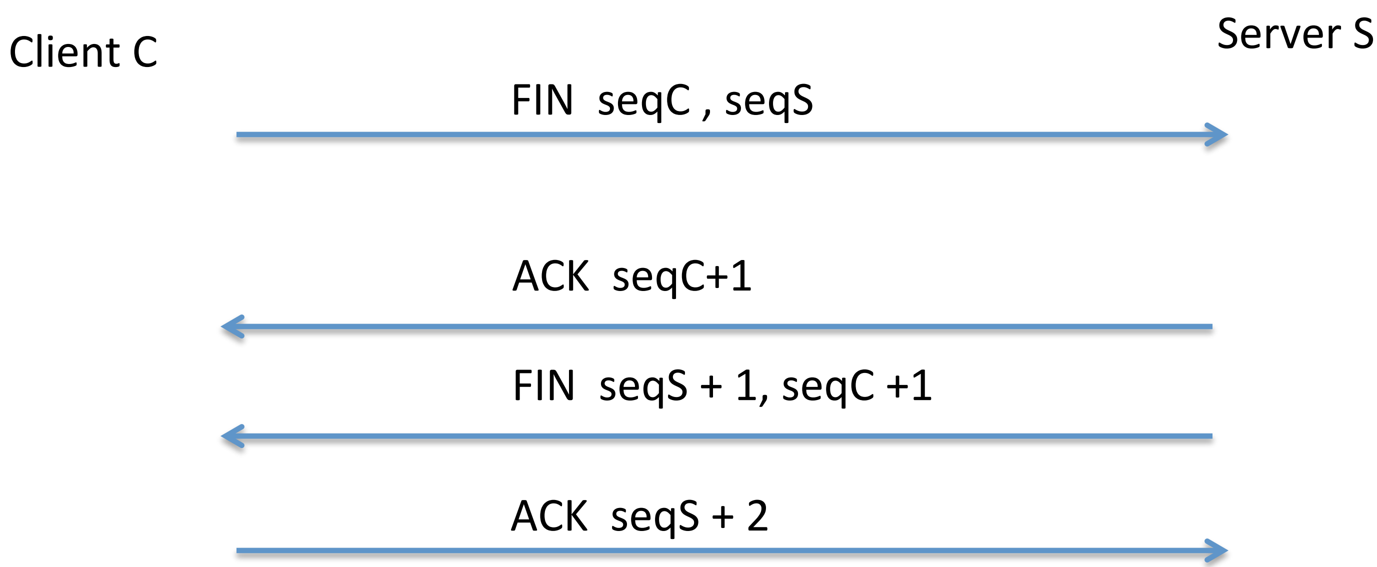
| | |
|---|---|
| URG | urgent pointer valid |
| ACK | acknowledgement number valid |
| PSH | pass data to app ASAP |
| RST | reset connection |
| SYN | synchronize sequence #'s |
| FIN | finished sending data |

# TCP handshake



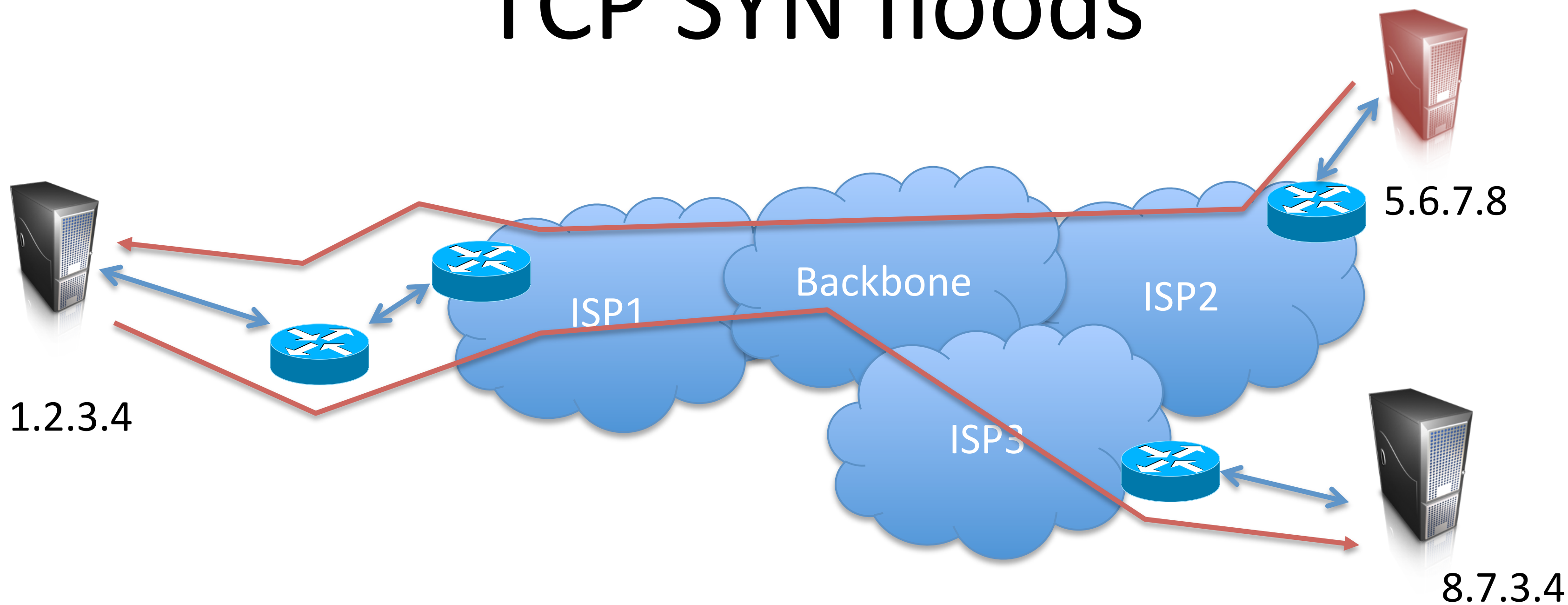

SYN = syn flag set
ACK = ack flag set
x,y  = x is sequence #, y is acknowledge #

# TCP teardown




SYN = syn flag set
ACK = ack flag set
x,y = x is sequence #, y is acknowledge #

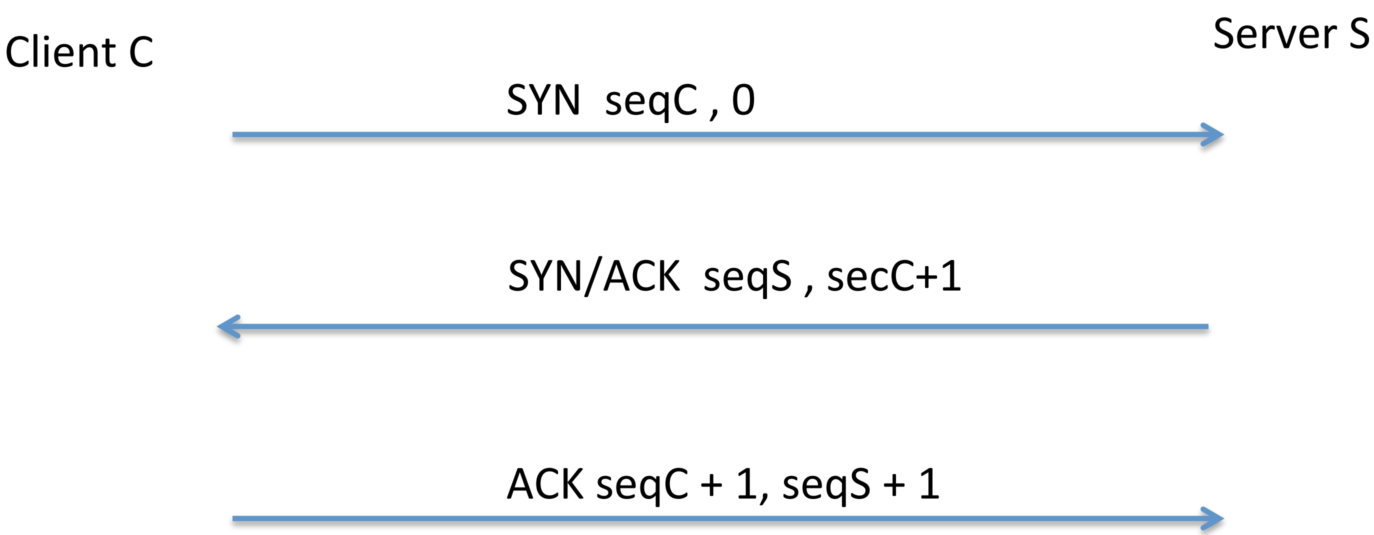
# TCP SYN floods




Send lots of TCP SYN packets to 1.2.3.4

- 1.2.3.4 maintains state for each SYN packet for some amount window of time
- If 5.6.7.8 sets SRC IP to be 8.7.3.4, what does 8.7.3.4 receive?

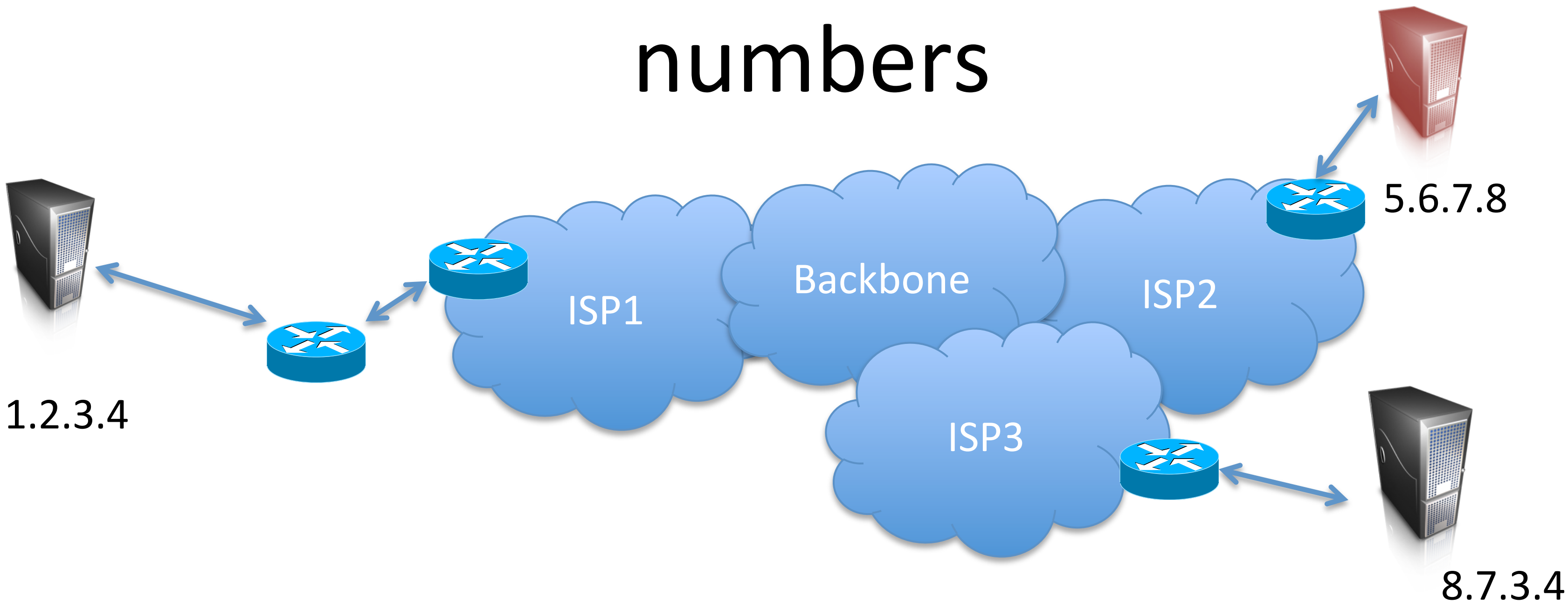
# TCP handshake




How are secC and seqS selected?

Initial sequence numbers must vary over time so that different connections don't get confused

# Predictable sequence numbers

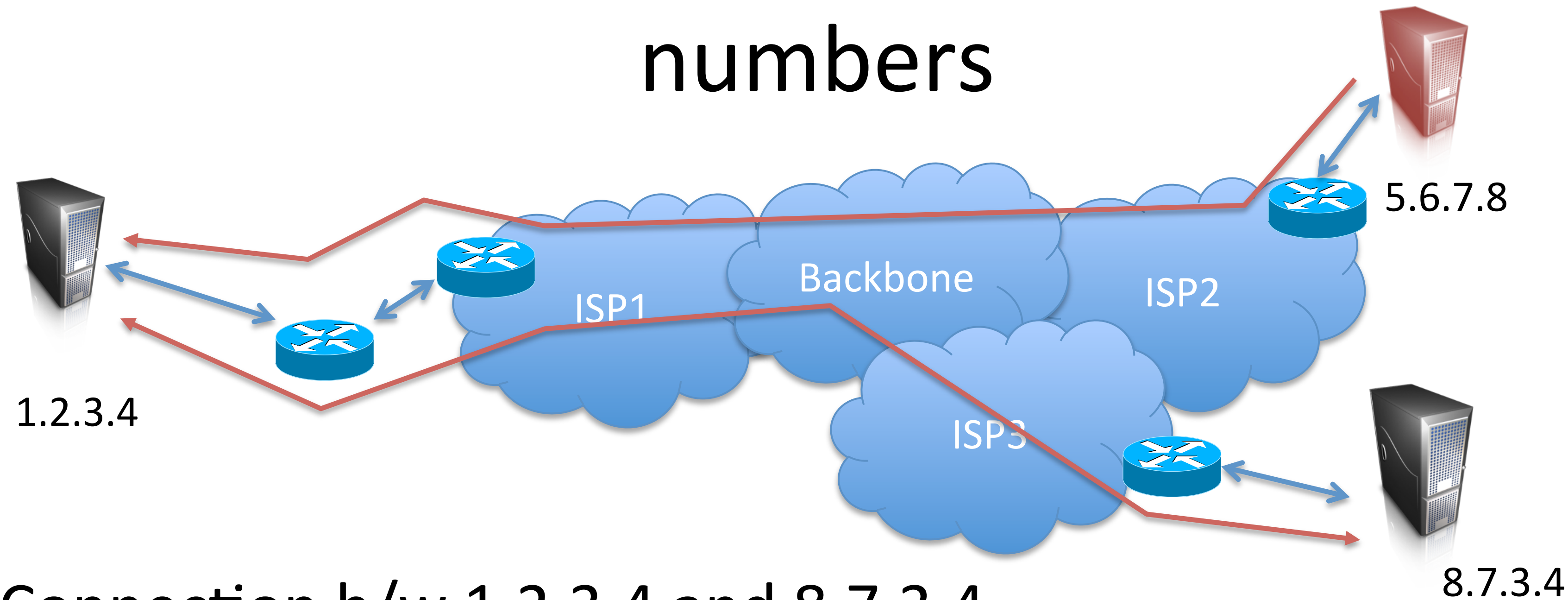



4.4BSD used predictable initial sequence numbers (ISNs)

- At system initialization, set ISN to 1
- Increment ISN by 64,000 every half-second

What can a clever attacker do?

# Predictable sequence numbers




Connection b/w 1.2.3.4 and 8.7.3.4

Forge a FIN packet from 8.7.3.4 to 1.2.3.4

src: 8.7.3.4
dst: 1.2.3.4

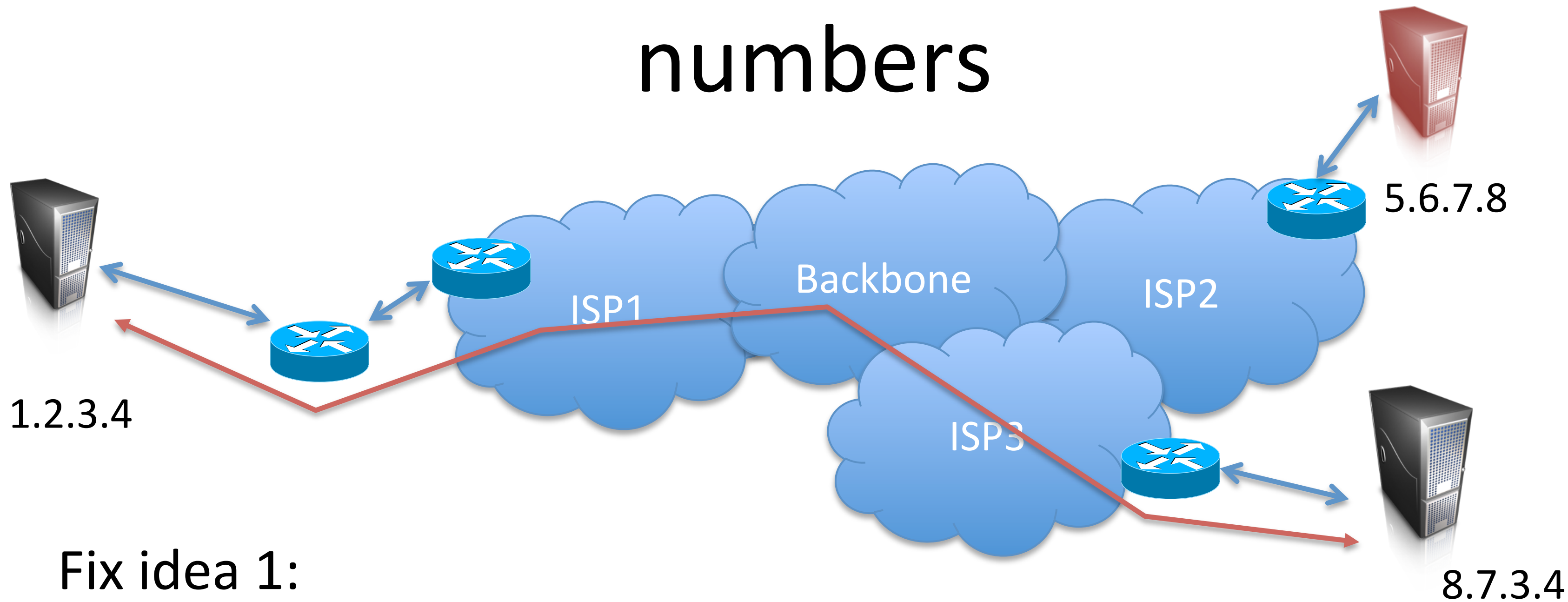
seq#(8.7.3.4)
FIN

Forge some application-layer packet from 8.7.3.4 to 1.2.3.4

src: 8.7.3.4
dst: 1.2.3.4

seq#(8.7.3.4)
“rsh rm –rf /”

# Predictable sequence numbers




Fix idea 1:

- Random ISN at system startup
- Increment by 64,000 each half second

Better fix:

- Random ISN for every connection

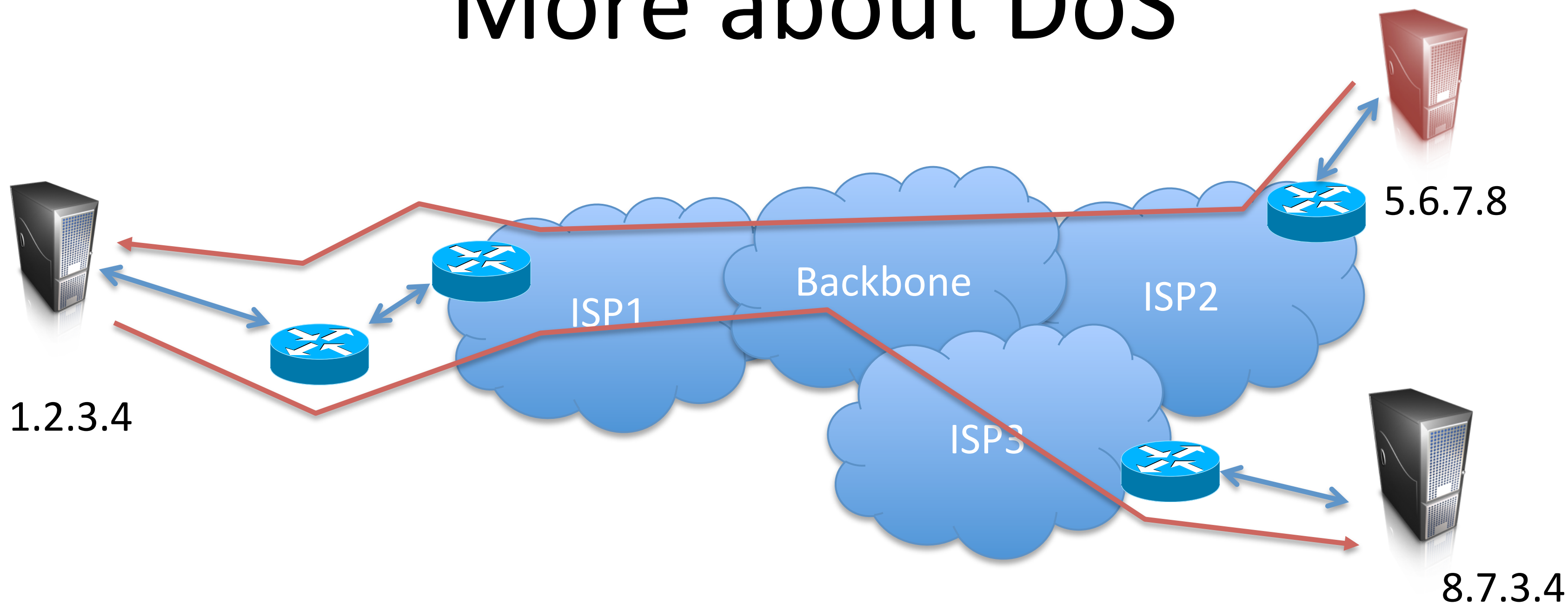
Still issues:

- Any FIN accepted with seq# in receive window: $2^{17}$ attempts

# TCP/IP security: other issues

- Congestion control abuse
  - can allow cheaper DoS
- No crypto
  - We'll talk about IPsec and TLS later
- BGP routing
  - we'll talk about later
- DNS (mapping from IP to domain names)
  - We'll talk about later

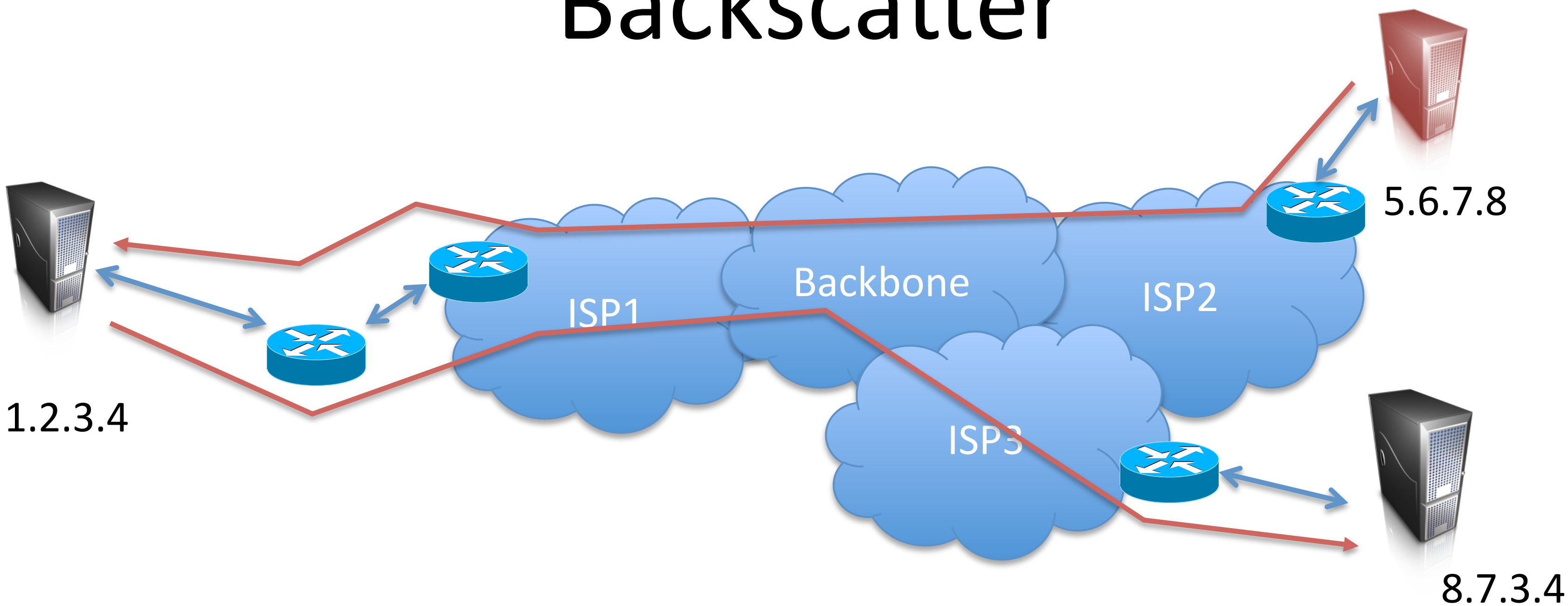
# More about DoS




DoS is still a big problem

How big?

# Backscatter




Can we measure the level of DoS attacks on Internet?

- If we can measure spurious packets at 8.7.3.4, we might infer something about DoS at 1.2.3.4

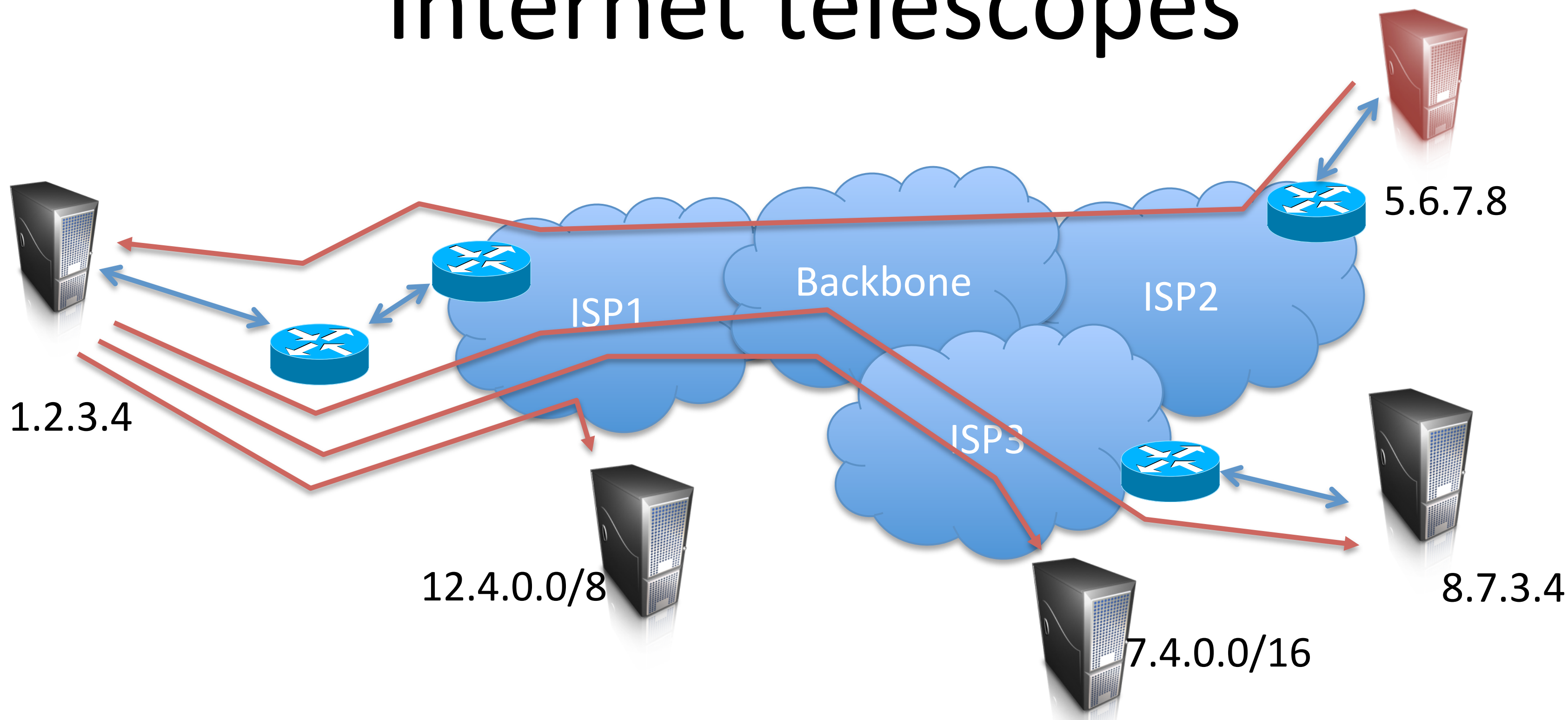
# Types of responses to floods

| Packet sent | Response from victim |
|---|---|
| TCP SYN (to open port) | TCP SYN/ACK |
| TCP SYN (to closed port) | TCP RST (ACK) |
| TCP ACK | TCP RST (ACK) |
| TCP DATA | TCP RST (ACK) |
| TCP RST | no response |
| TCP NULL | TCP RST (ACK) |
| ICMP ECHO Request | ICMP Echo Reply |
| ICMP TS Request | ICMP TS Reply |
| UDP pkt (to open port) | protocol dependent |
| UDP pkt (to closed port) | ICMP Port Unreach |
| ... | ... |

Table 1: A sample of victim responses to typical attacks.

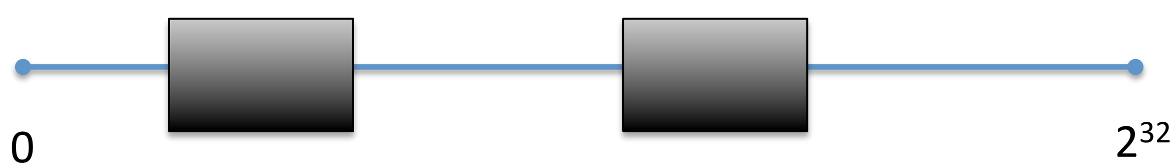
From Moore et al., "Inferring Internet Denial-of-Service Activity"

# Internet telescopes




Setup some computers to watch traffic sent to darknets

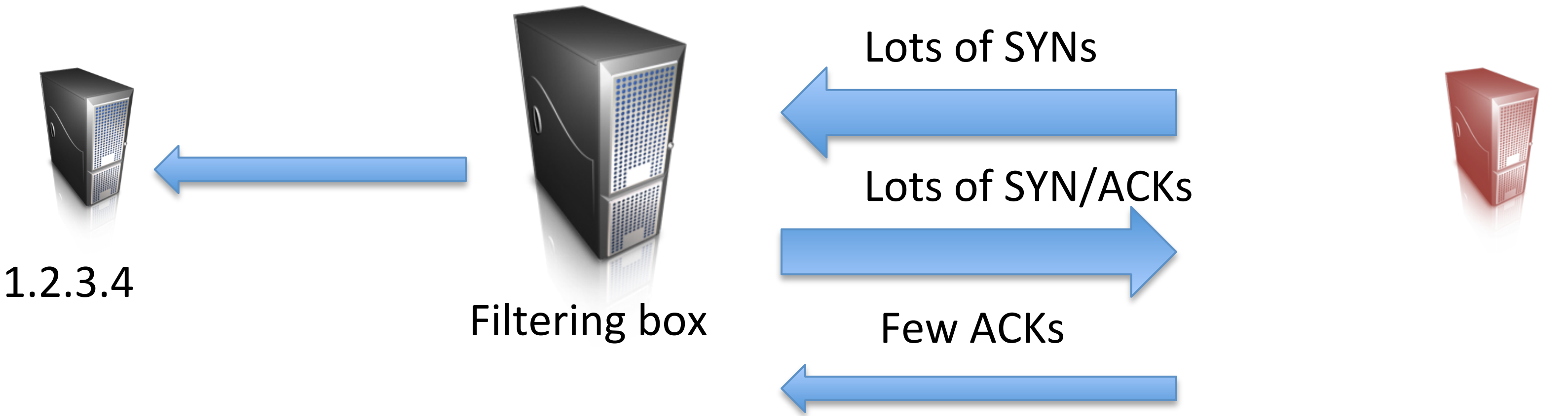
- Darknet = unused routable space




2001: 400 SYN attacks per week

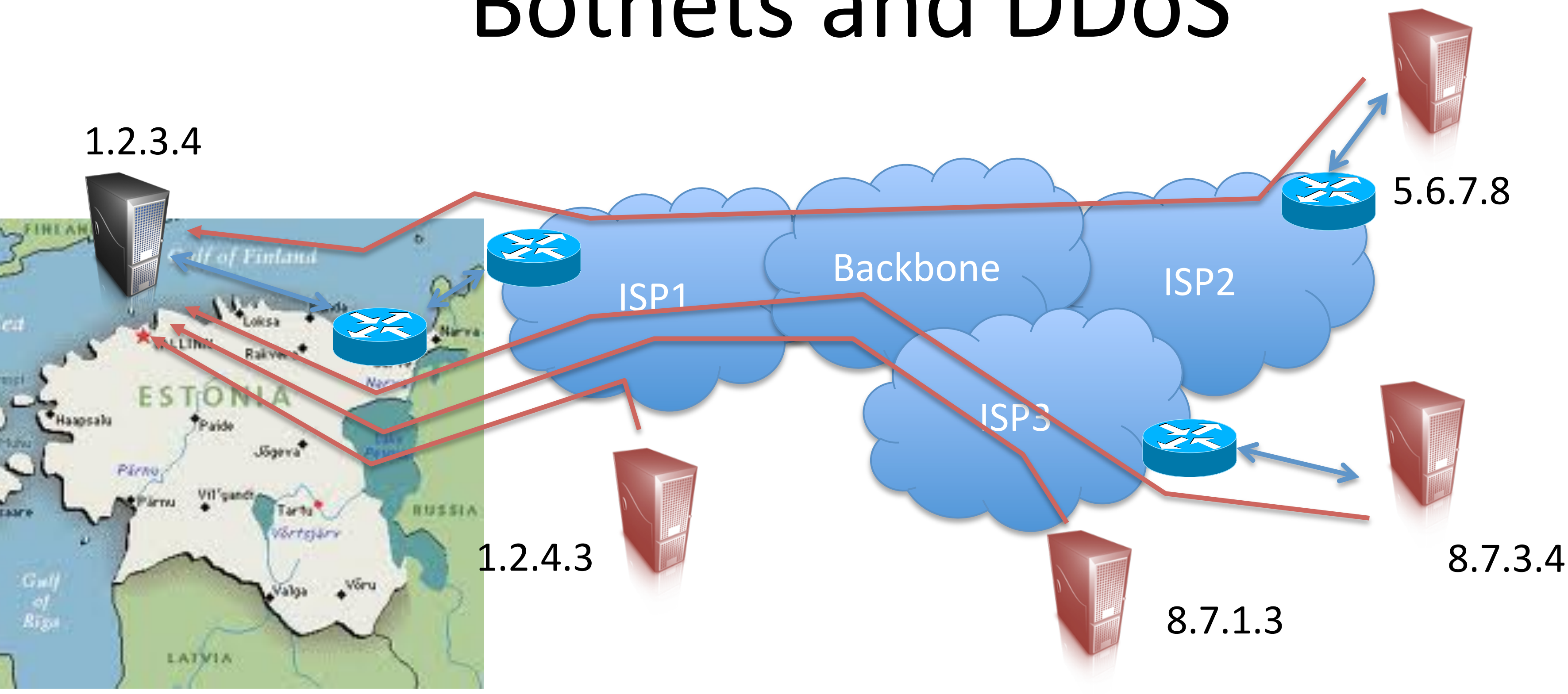
2008: 4425 SYN attacks per 24 hours

# Preventing DoS: Prolexic approach




Just need a beefy box to help with filtering.
Companies pay Prolexic to do it for them

# Botnets and DDoS




April 27, 2007

Continued for weeks, with varying levels of intensity

Government, banking, news, university websites

Government shut down international Internet connections

# Hierarchical addressing

128.168.3.4

| | | | | | |
|---|---|---|---|---|---|
| Class A | 0 | 7 bits<br>netid | 24 bit<br>hostid | | |
| Class B | 1 | 0 | 14 bits<br>netid | 16 bits<br>hostid | |
| Class C | 1 | 1 | 0 | 21 bits<br>netid | 8 bits<br>hostid |
| Class D | 1 | 1 | 1 | 0 | 28 bits<br>multicast group ID |
| Class E | 1 | 1 | 1 | 1 | 28 bits<br>reserved for future use |