CSCI 476: Computer Security

Network Security: TCP/IP Stack Packet Sniffing and Spoofing

Reese Pearsall

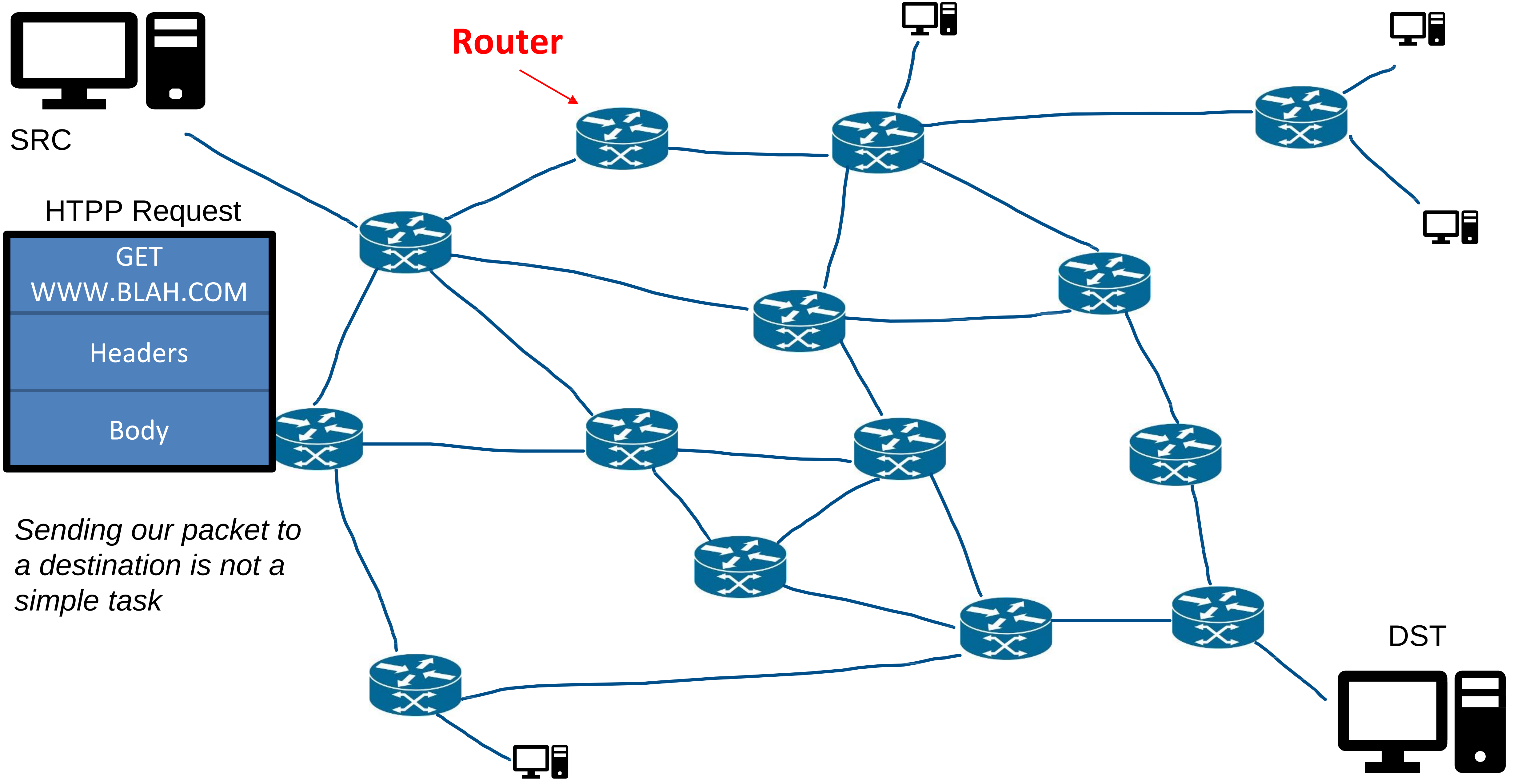
Spring 2023

Announcement

Lab 5 (XSS) Due **Tuesday** 10/31 @ 11:59 PM

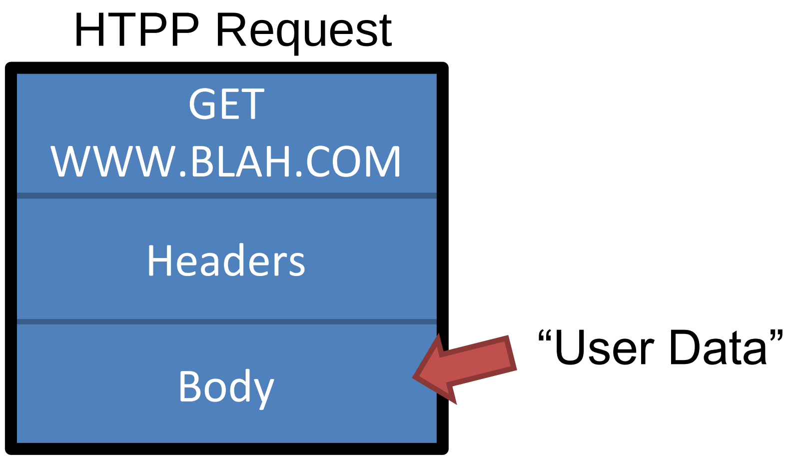
Research Project due on 11/16

Asynchronous class on Thursday



Sending our packet to a destination is not a simple task

There is a lot of stuff that gets added onto our data being send



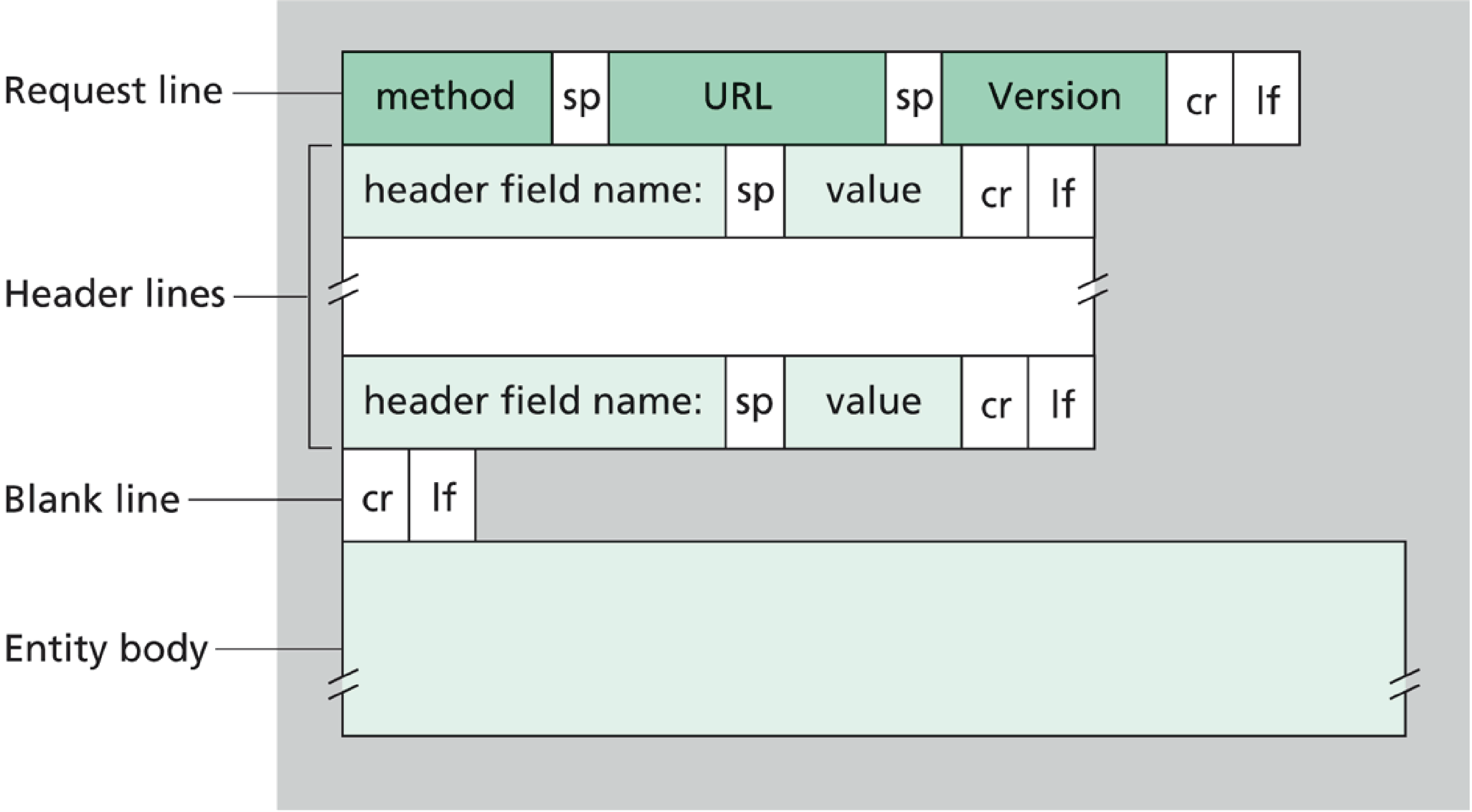
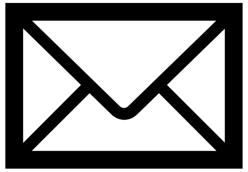


Figure 2.8 ♦ General format of a request message

There are a few pieces of information a packet needs in order to arrive to its destination



HTPP Request

GET WWW.BLAH.COM
Headers
Body

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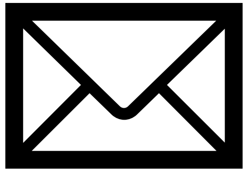

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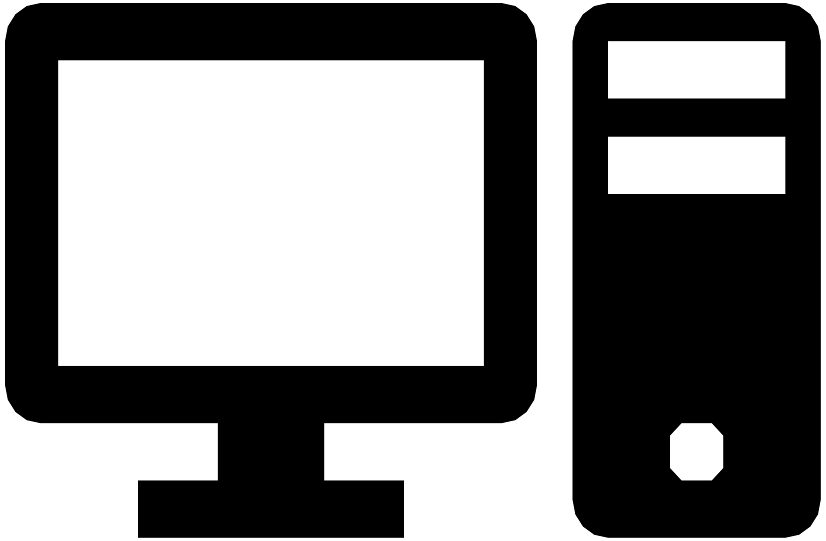
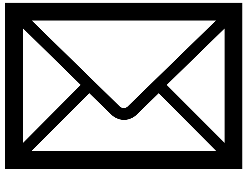


A packet arriving to a machine needs to know which **process**/application to go to

There are a few pieces of information a packet needs in order to arrive to its destination



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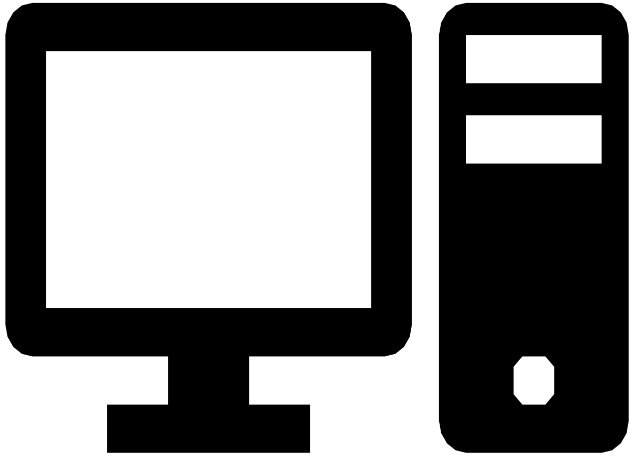
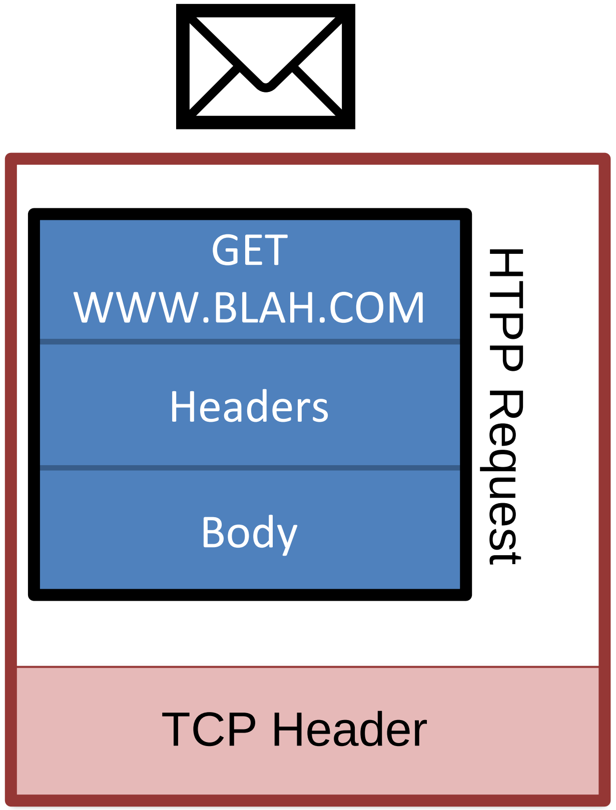
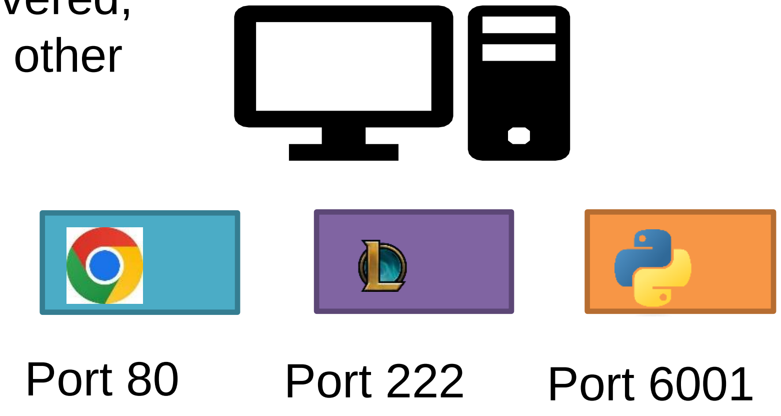


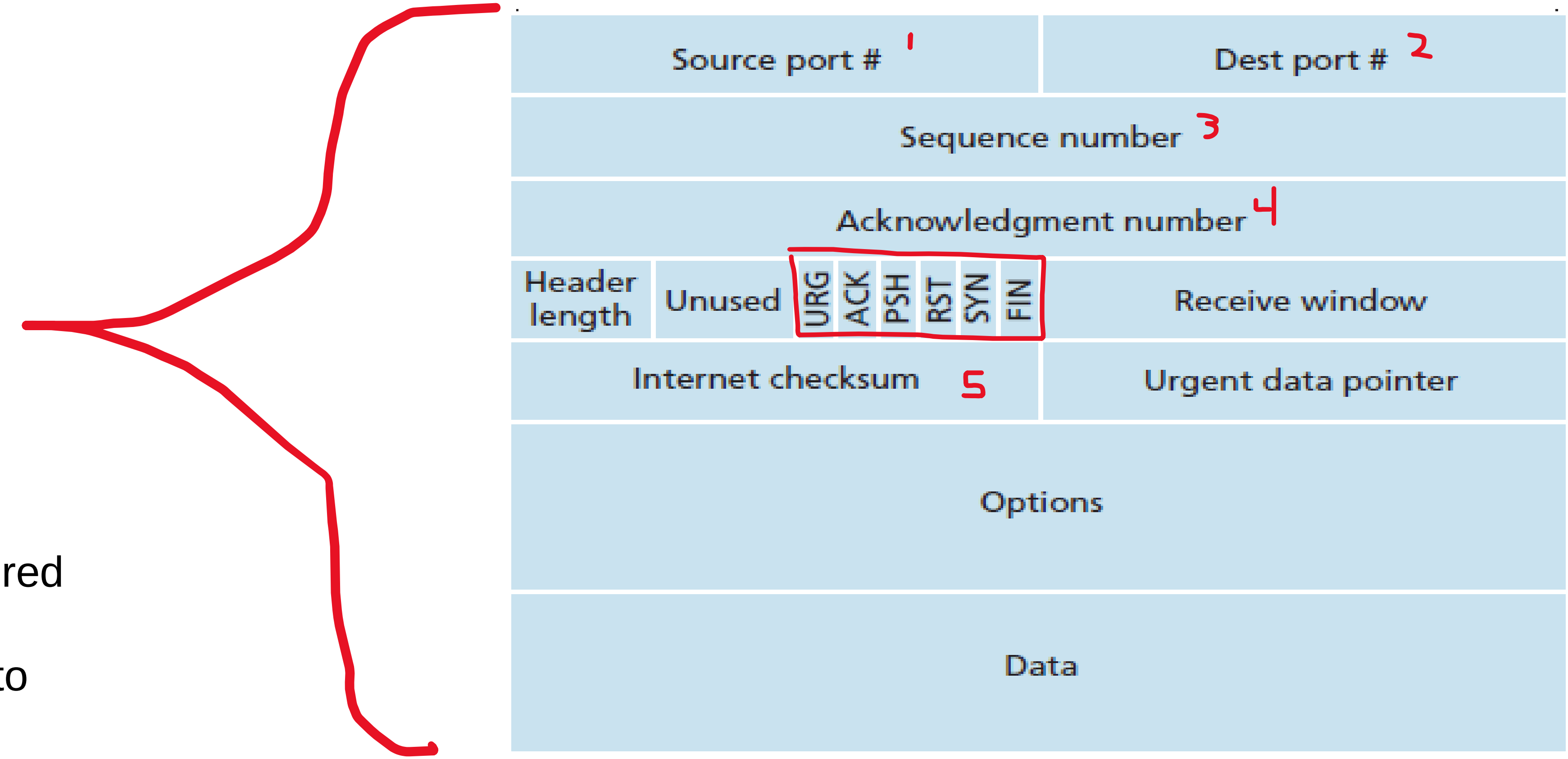
Port 802 | Port 222 | Port 6001

Each application is bound to a **port**, so each packet will need to know what port they need to go to

TCP is a transport-layer protocol that ensures data gets delivered, and controls how the two endpoints communicate with each other



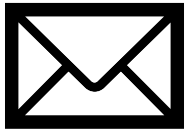




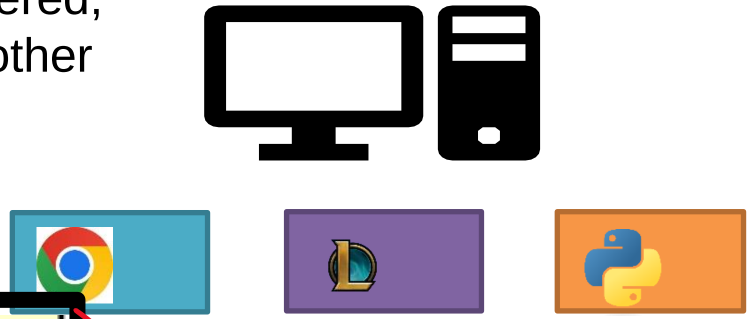
Our packet of information gets wrapped in a **TCP Header**

- Ensures that data gets delivered reliably (Seq/Ack #s)
- Ensures data gets delivered to the correct process (Port #s)

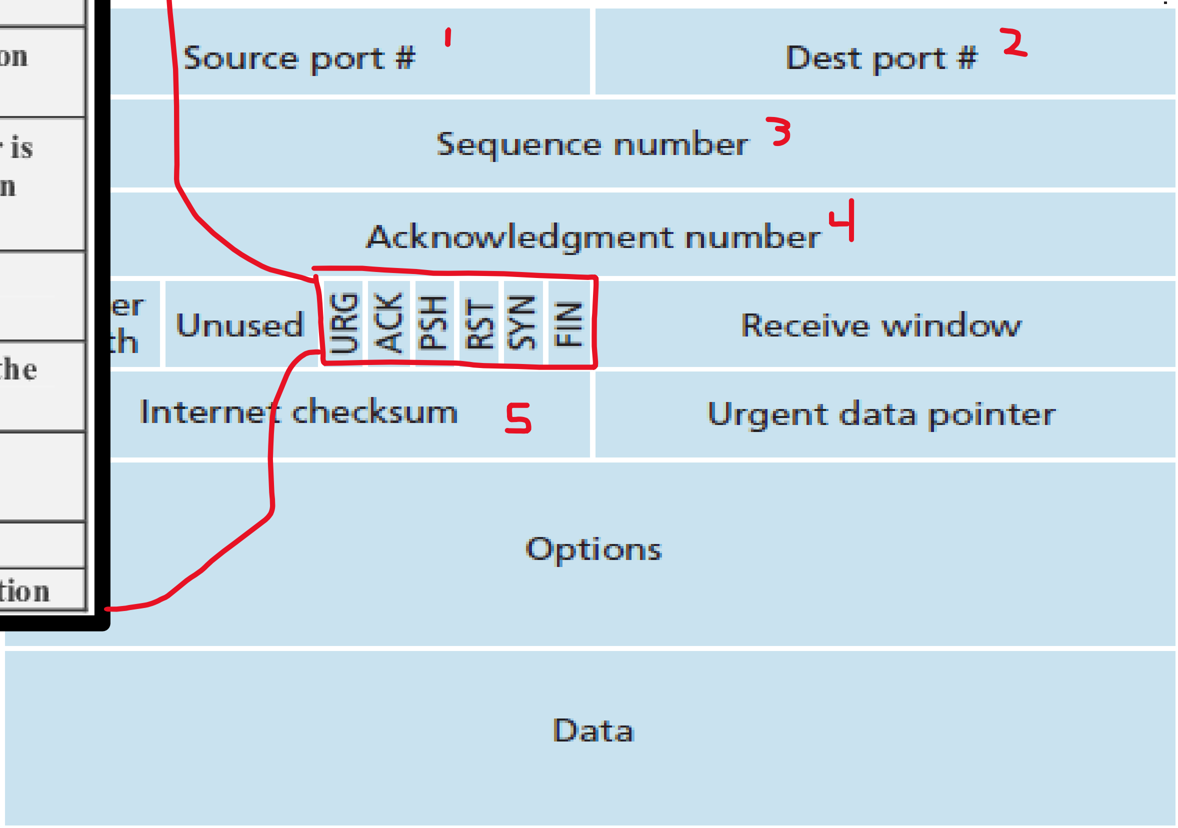
TCP is a transport-layer protocol that ensures data gets delivered, and controls how the two endpoints communicate with each other



TCP Flags Bit	Control Sections	Corresponding Decimal	Description
8	CWR	128	Indicate that the congestion window has been reduced
7	ECE	64	Indicate that a CE notification was received
6	URG	32	Indicates that urgent pointer is valid that often caused by an interrupt
5	ACK	16	Indicates the value in acknowledgement is valid
4	PSH	8	Tells the receiver to pass on the data as soon as possible
3	RST	4	Immediately end a TCP connection
2	SYN	2	Initiate a TCP connection
1	FIN	1	Gracefully end a TCP connection



80 Port 222 Port 6001



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- Ensures that data gets delivered reliably (Seq/Ack #s)
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Our packet currently has

- Some application-level message (HTTP Request)
- Port number of that application process (TCP header)
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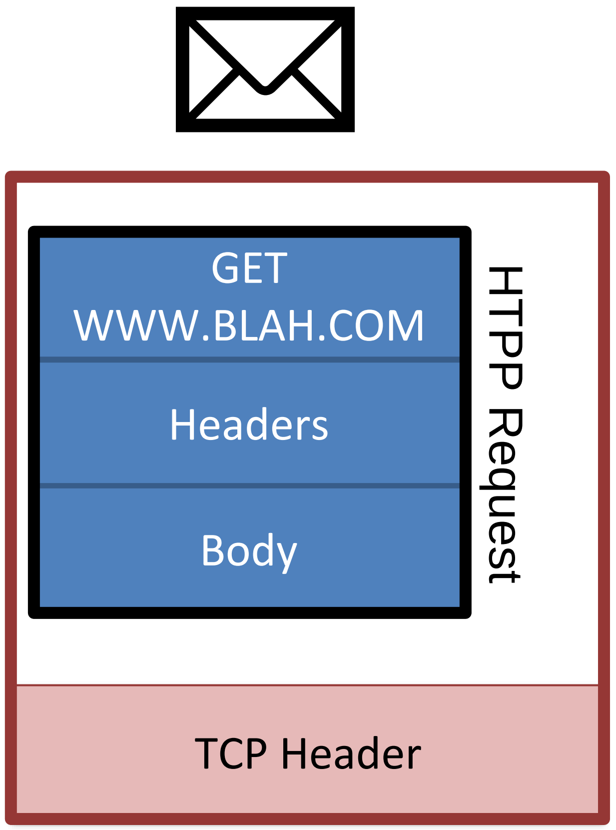

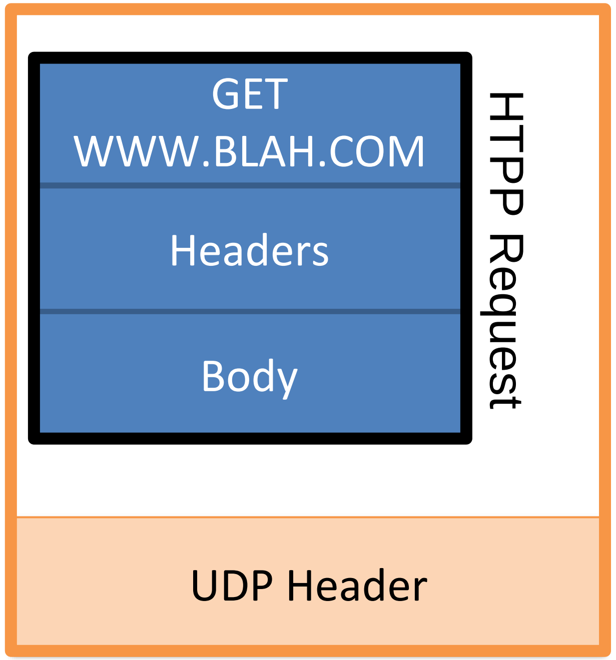

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Applications will either user **TCP** or **UDP** to send their data. UDP adds on port #s just like TCP, but does not ensure reliable delivery

HTTP/HTTPS uses TCP,   DNS protocol uses UDP

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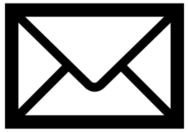
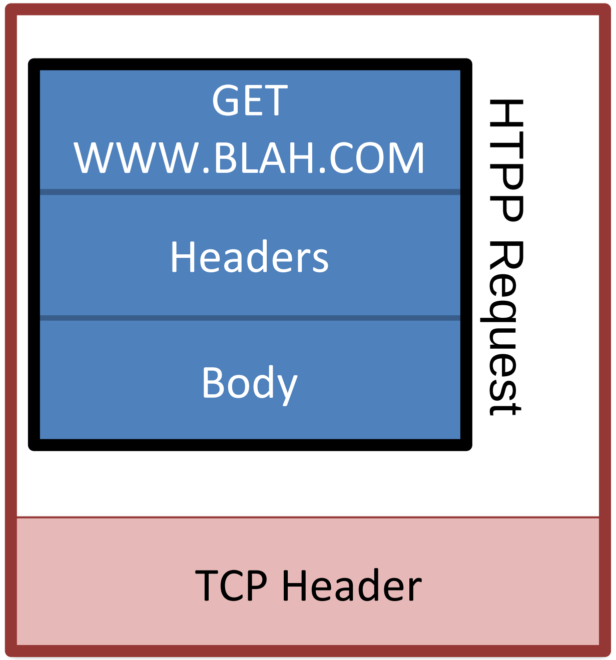
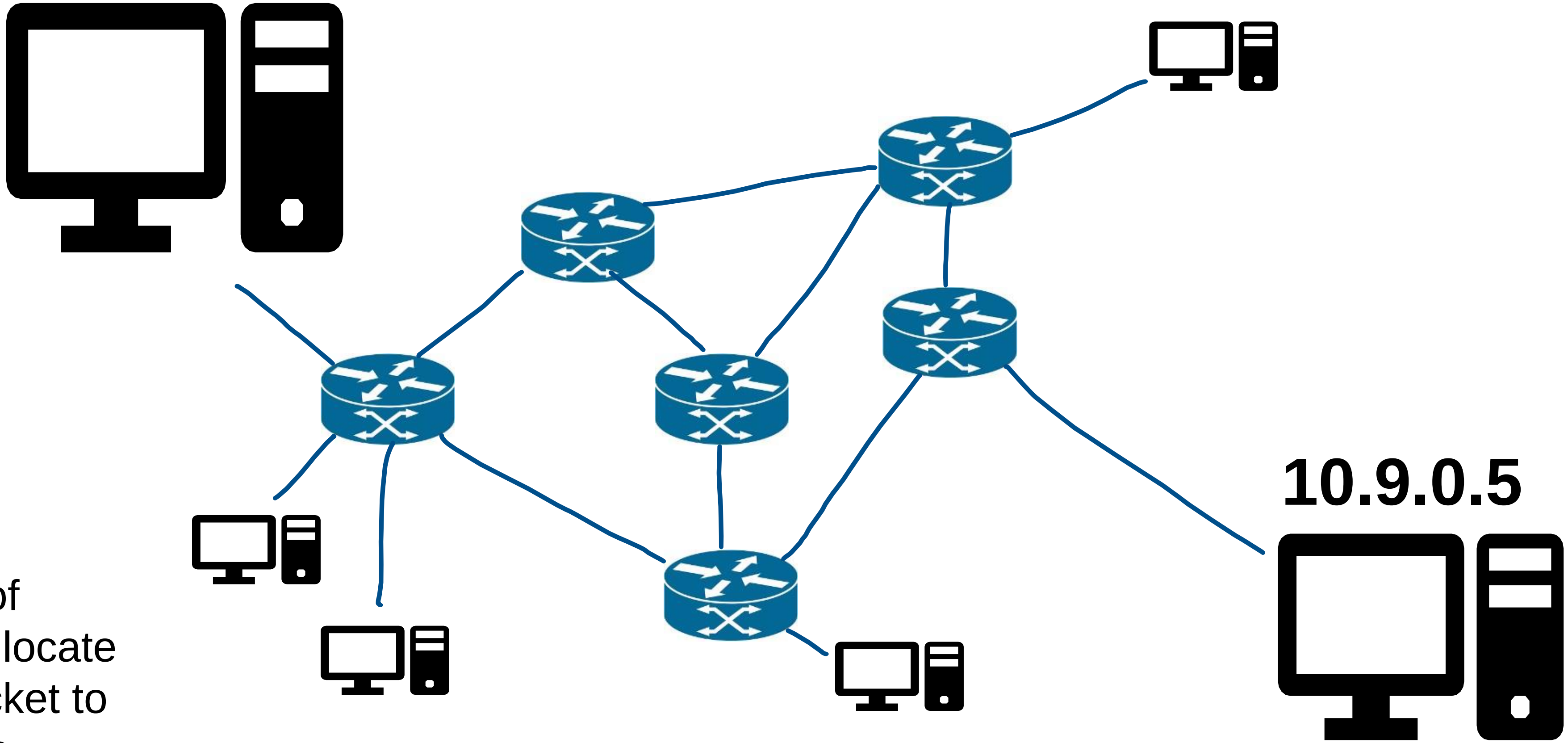




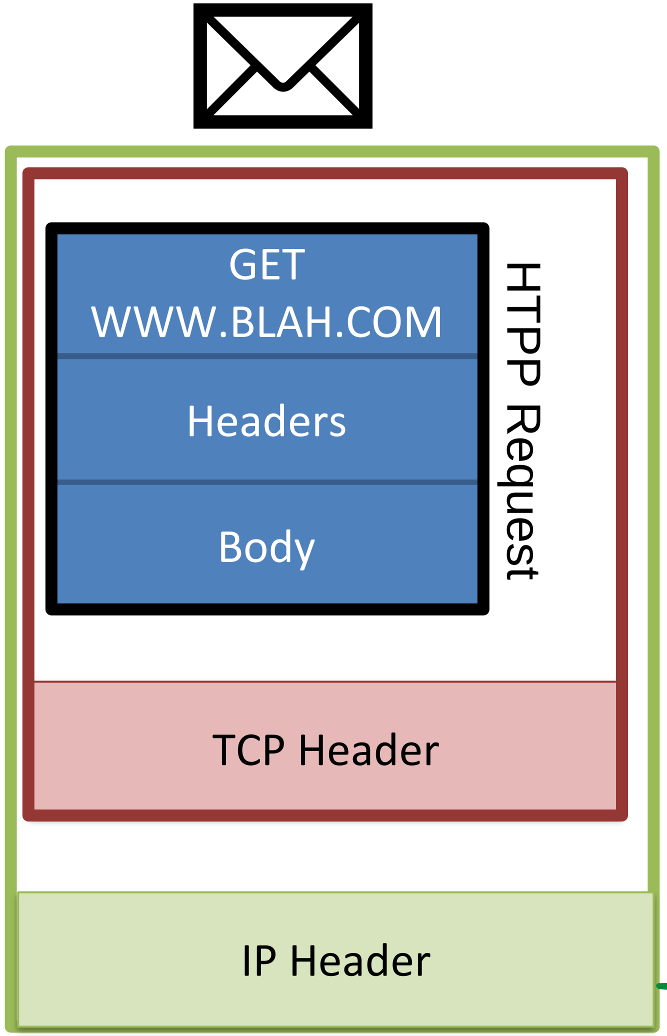
We also need to know which device to send to → IP Address



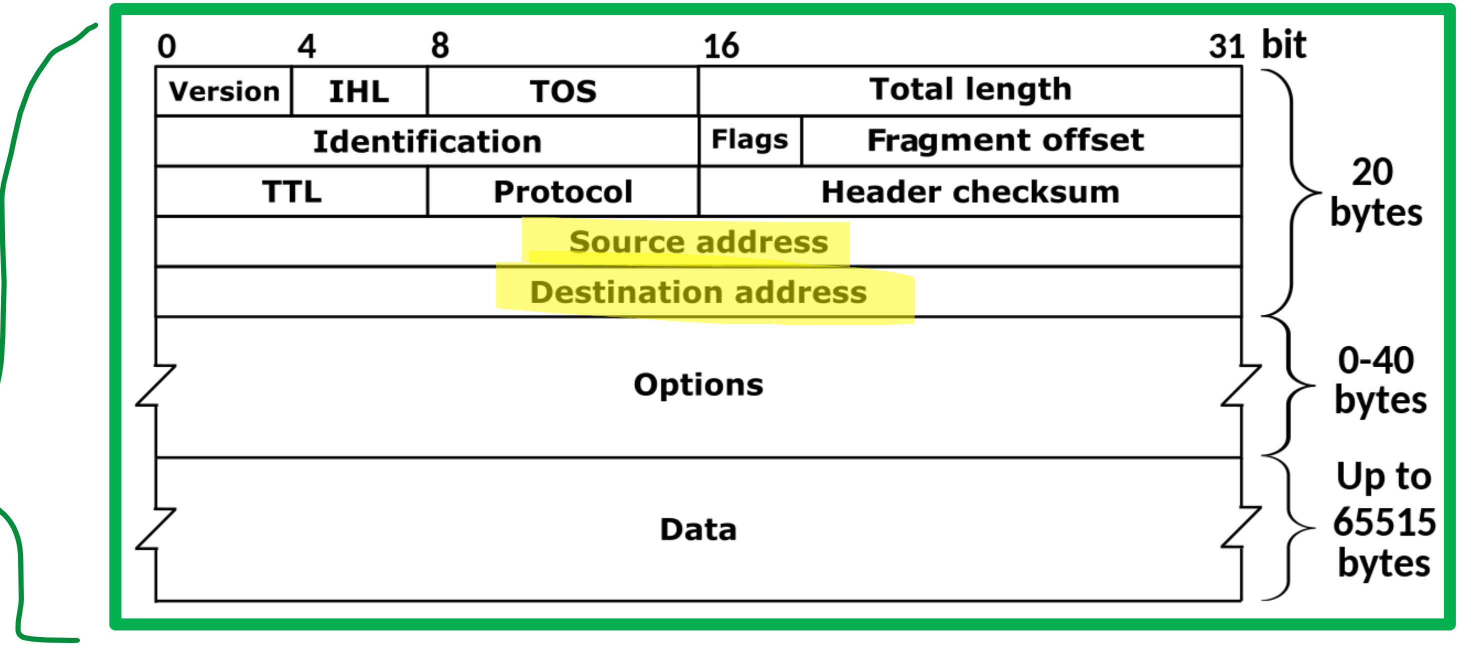
Think of the internet as a bunch of islands. The IP address helps us locate the correct island to send the packet to (Routers look at the IP address to determine where to forward the packet to)

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)



To add an IP address to our packet, we add another header, called the **IP Header**



There are two types of IP addresses: IPv4 (32 bits) and IPv6 (128 bits), we use IPv4 in this class ☺

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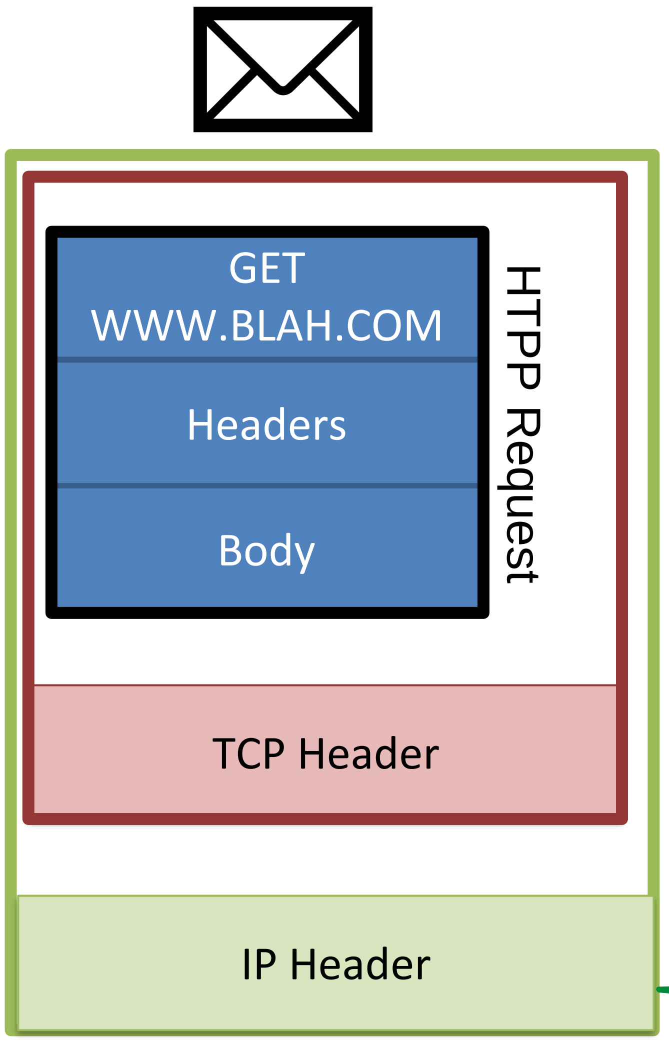

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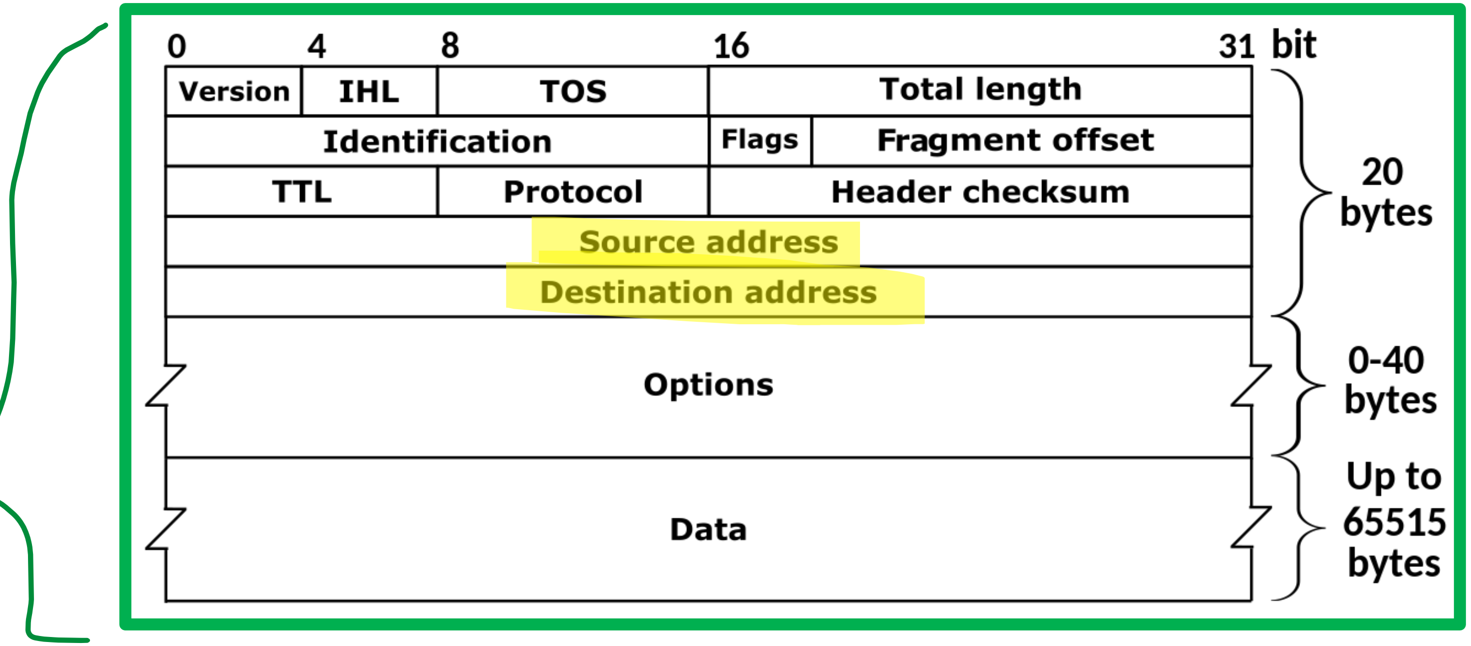
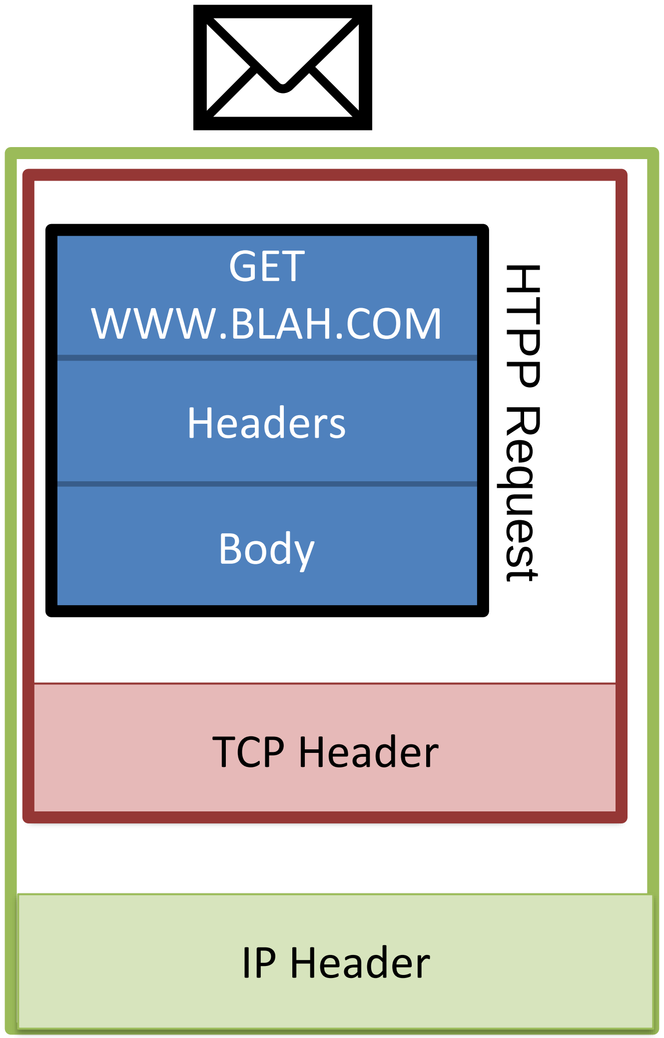


IP Addresses are dynamic (generally), can be public/private, and can sometimes be shared between multiple devices



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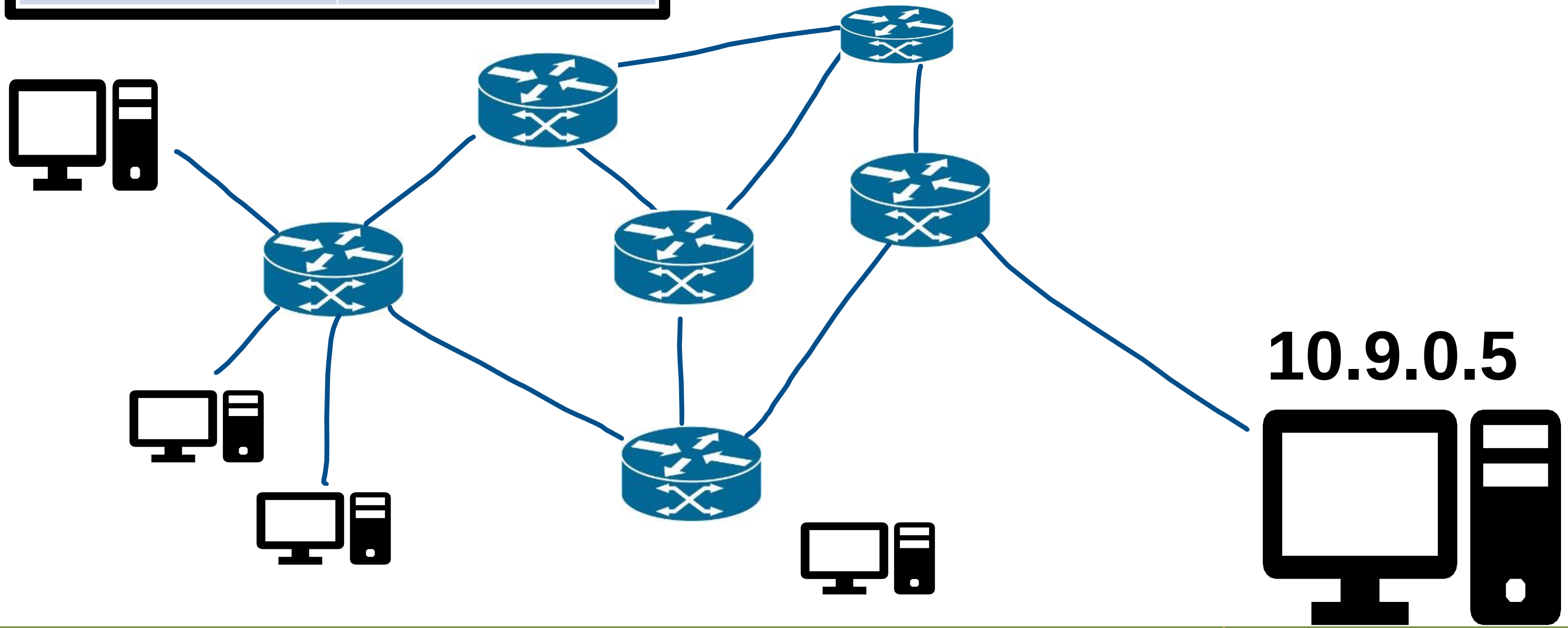
Address range	Interface (output link)
128.11.52.0 – 128.11.52.255	1
153.90.2.0 – 153.90.2.255	2
153.90.2.87 – 153.90.2.89	3

Routers maintain a table that will forward a packet to the next router based on the packet's destination IP address*



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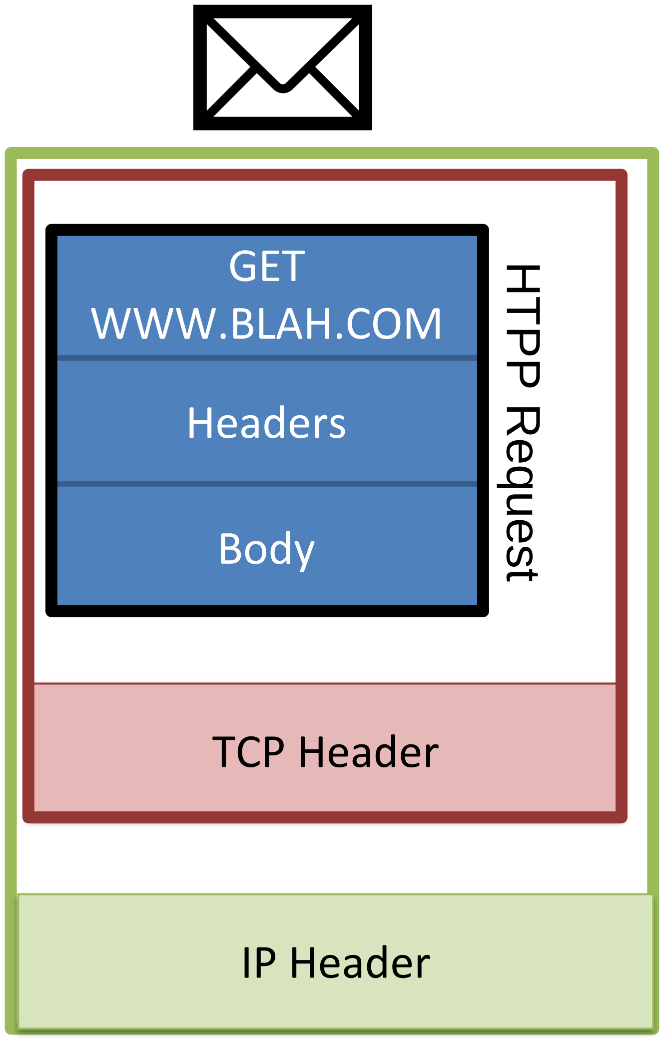
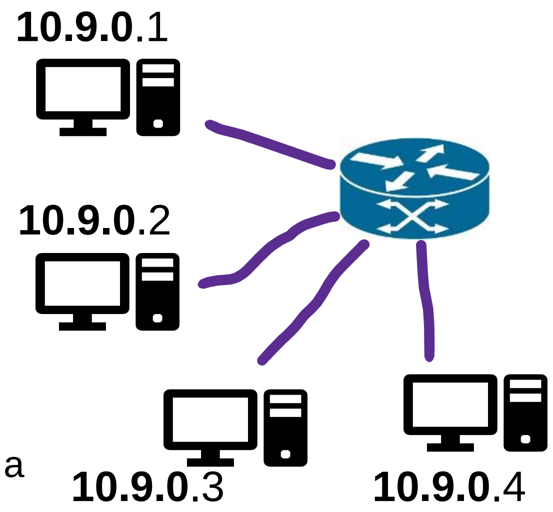


A packet may arrive to a network, but there is likely many devices under one network

We now need a unique identifier to find the destination device on this local network



Devices in a **subnet** share a common prefix for their IP addresses

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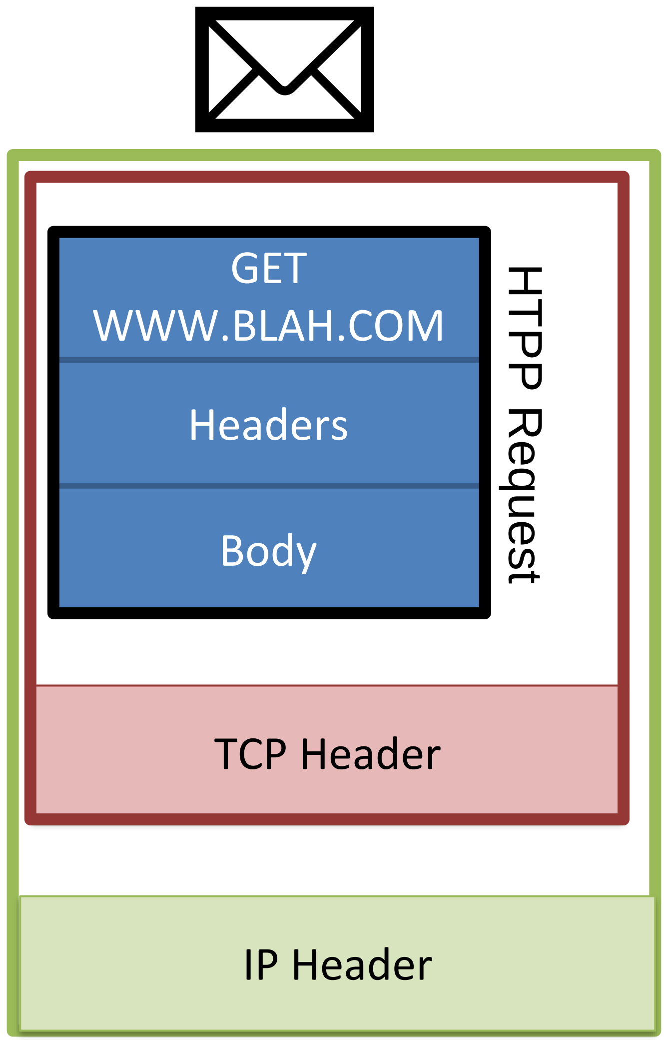

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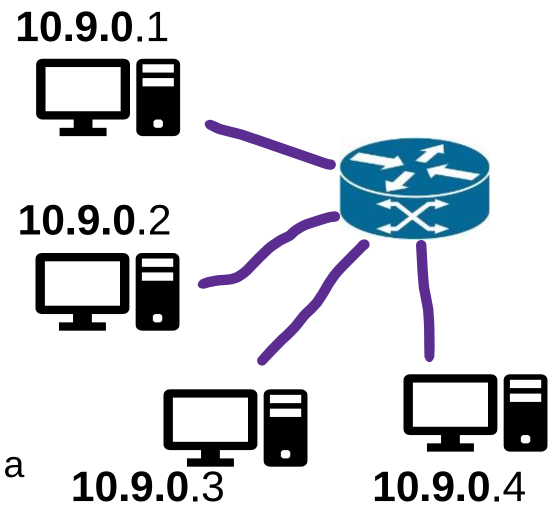


We now need a unique identifier to find the destination device on this local network

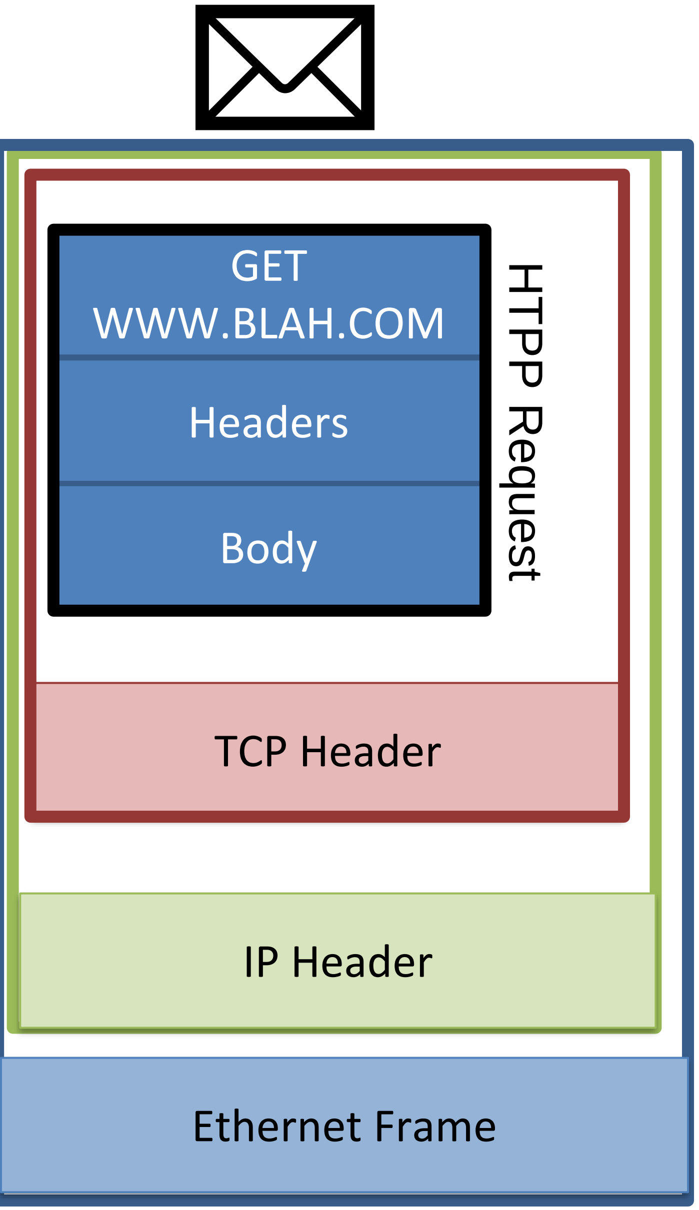
A **MAC address** is a unique, hard-coded value given to each device connected to a network

Devices in a **subnet** share a common prefix for their IP addresses

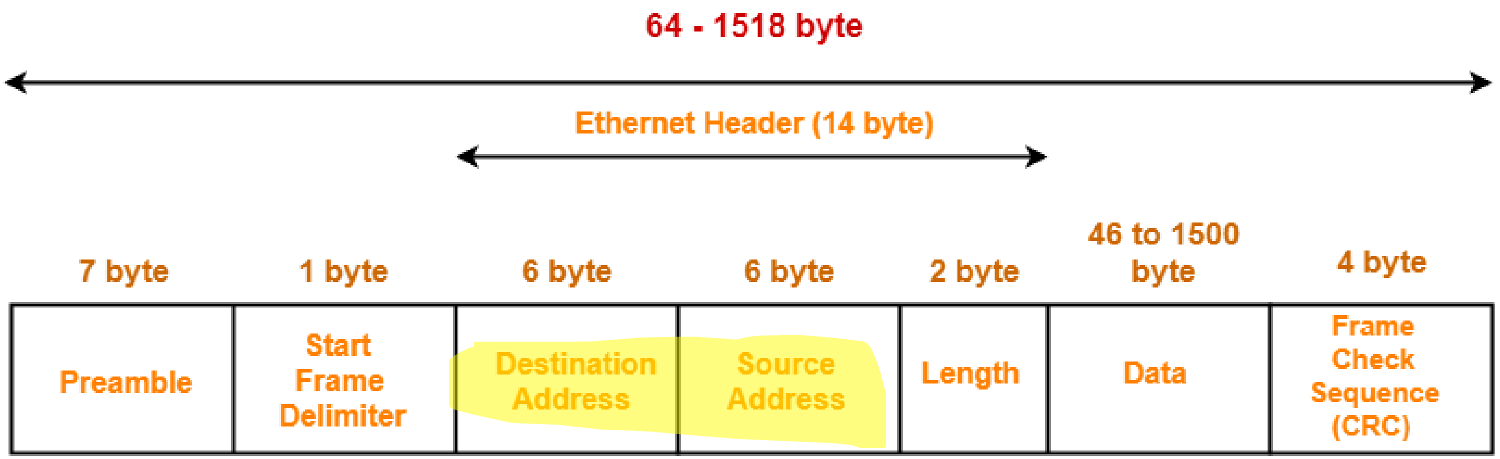
(Additionally, there might be times computers communicate without IP address)

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)

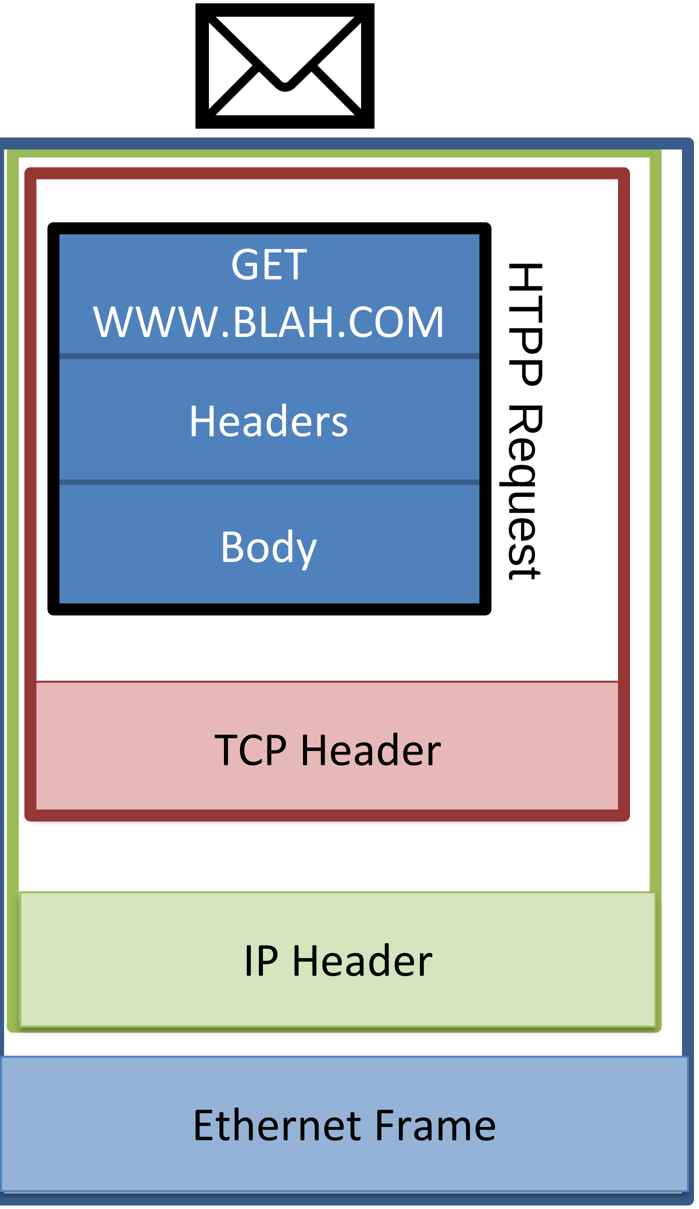


To add the MAC Address to our packet, we wrap our packet in an **ethernet frame** (usually)



IEEE 802.3 Ethernet Frame Format

(We have protocols that can map IP Address → Mac Address)



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)

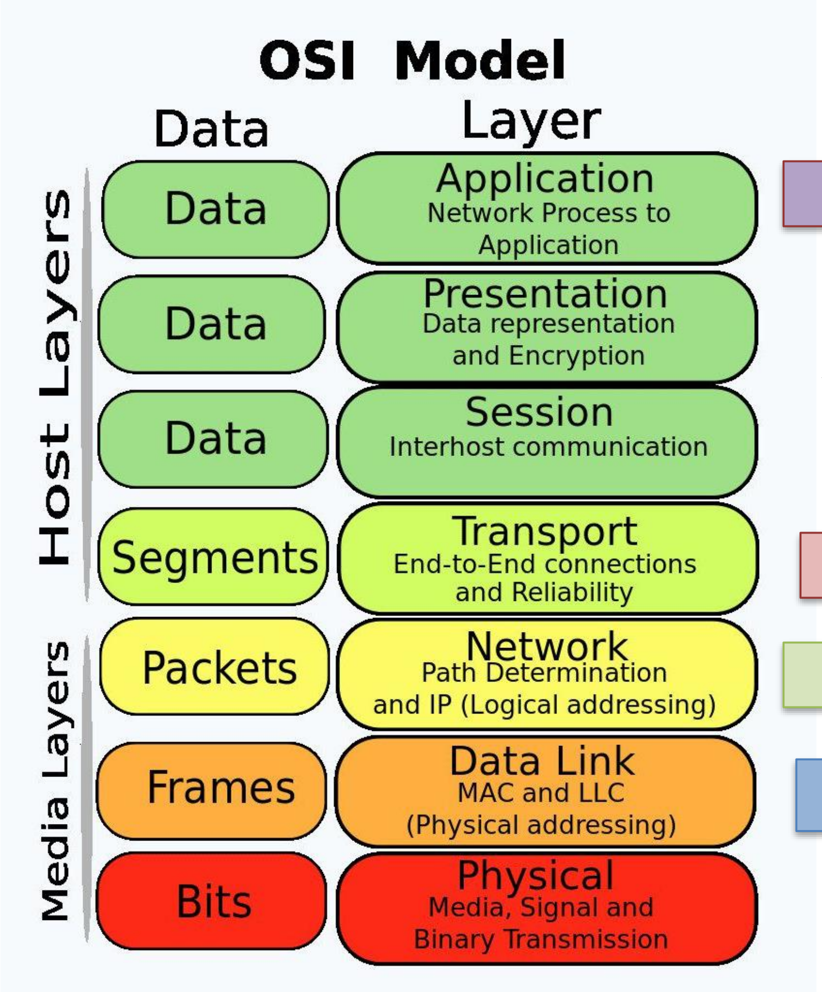
Our final packet!

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

(Jump scare warning for CSCI 466 people)

The Journey of a packet

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



HTTP Request

(Encryption, Authentication, Management, HTTPS)

TCP Header

IP Header

Ethernet Frame

The **OSI Model** is a very popular internet stack model that describes the layers of the internet, and the different responsibilities of each layer

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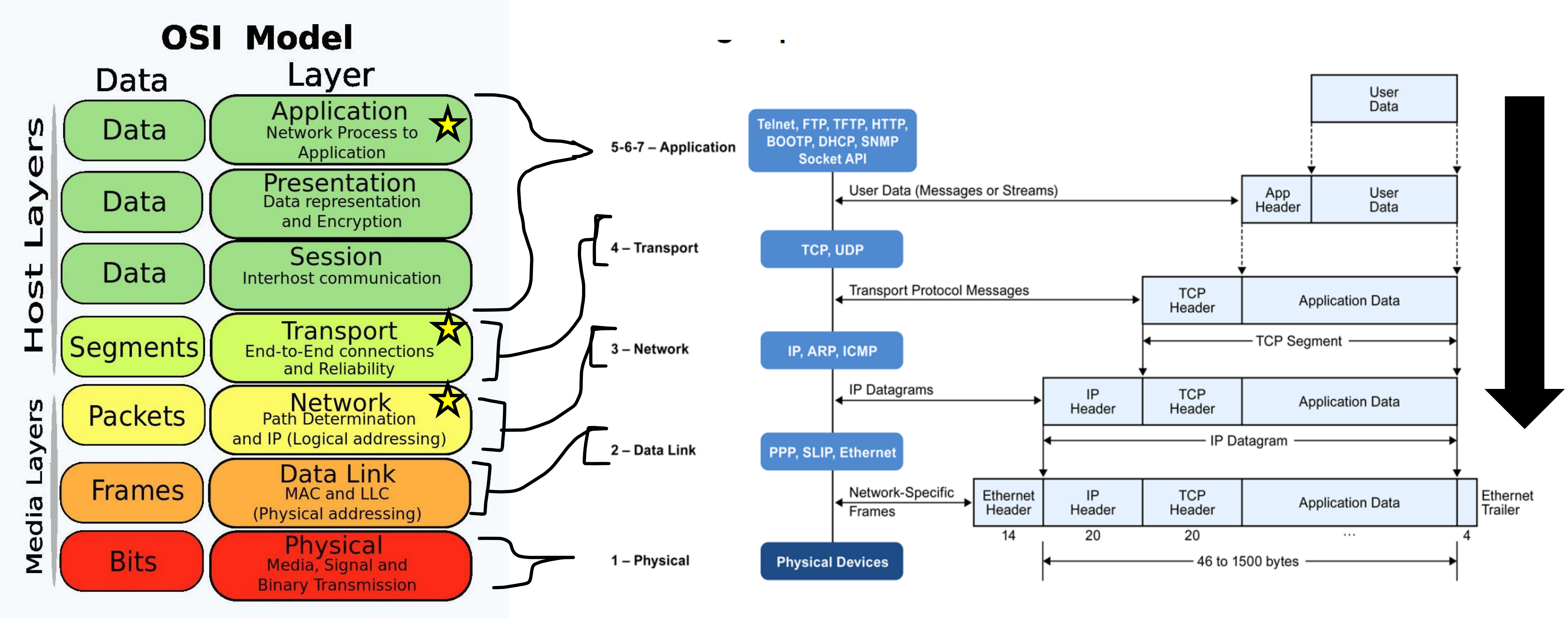
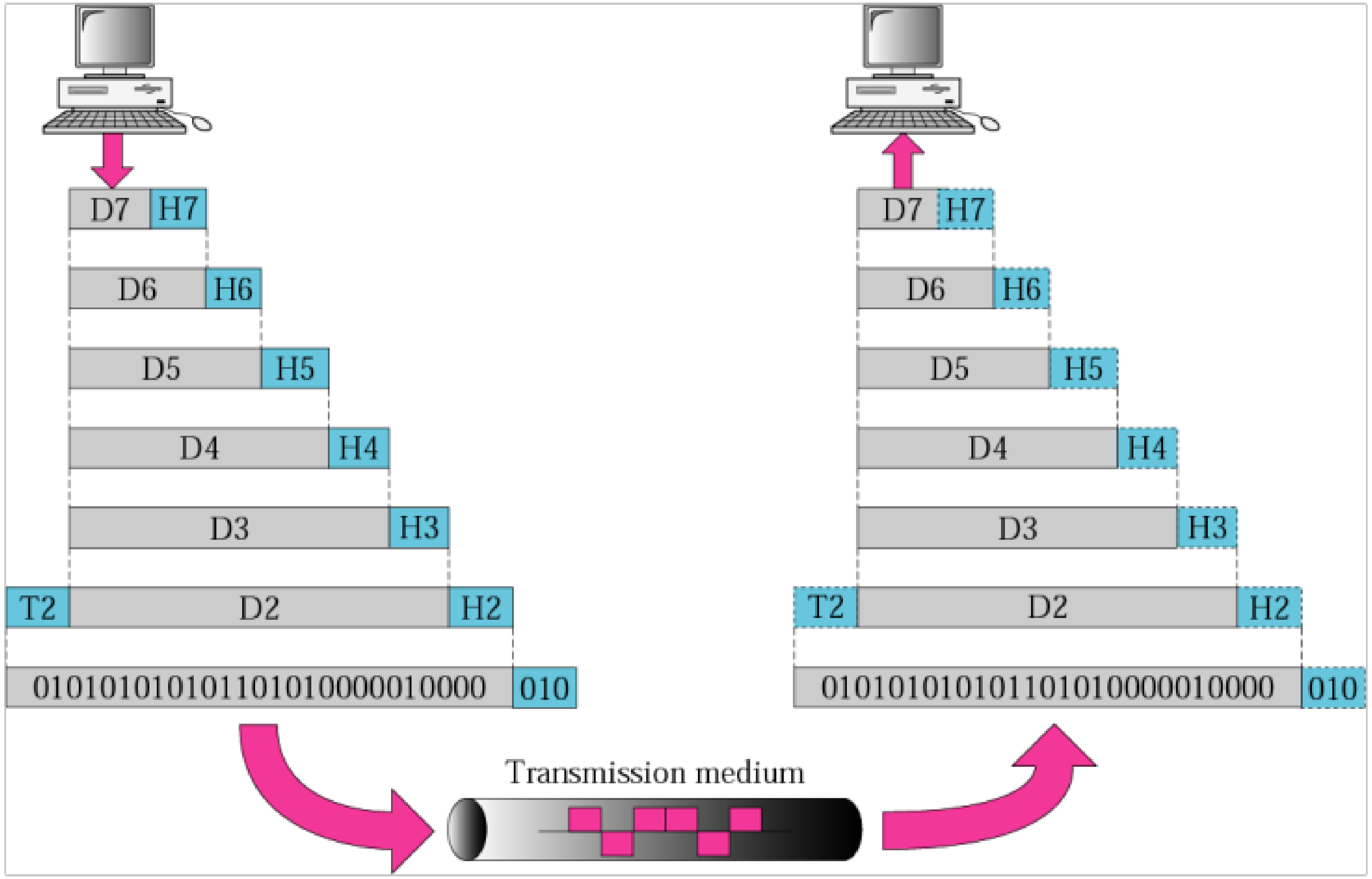


Our focus in the next few weeks will be on the transport layer (**TCP/UDP**), network layer (**IP**), and application layer



WIFI, Fiber optic, Copper
Wire, Birds

*** Many devices are sharing this medium*

Devices connect to a network via a **Network Interface Card** (NIC)

25-6B-78-1D-A0-57

Each NIC as a **Medium Access Control** (MAC) address

Every NIC “hears” all the frames “on the wire” (or “in the air”)

NIC checks destination (dst) address of the packet’s link layer header

Ethernet Header	IP Header	TCP Header	Application Data		Ethernet Trailer
14	20	20	...	4	

Accept packets that match the NIC’s MAC address, “**drop**” other packets

25-6B-78-1D-A0-57 ✓ **41-91-31-CB-F0-BD** ✗

How do we get *all* the network traffic?

Promiscuous Mode

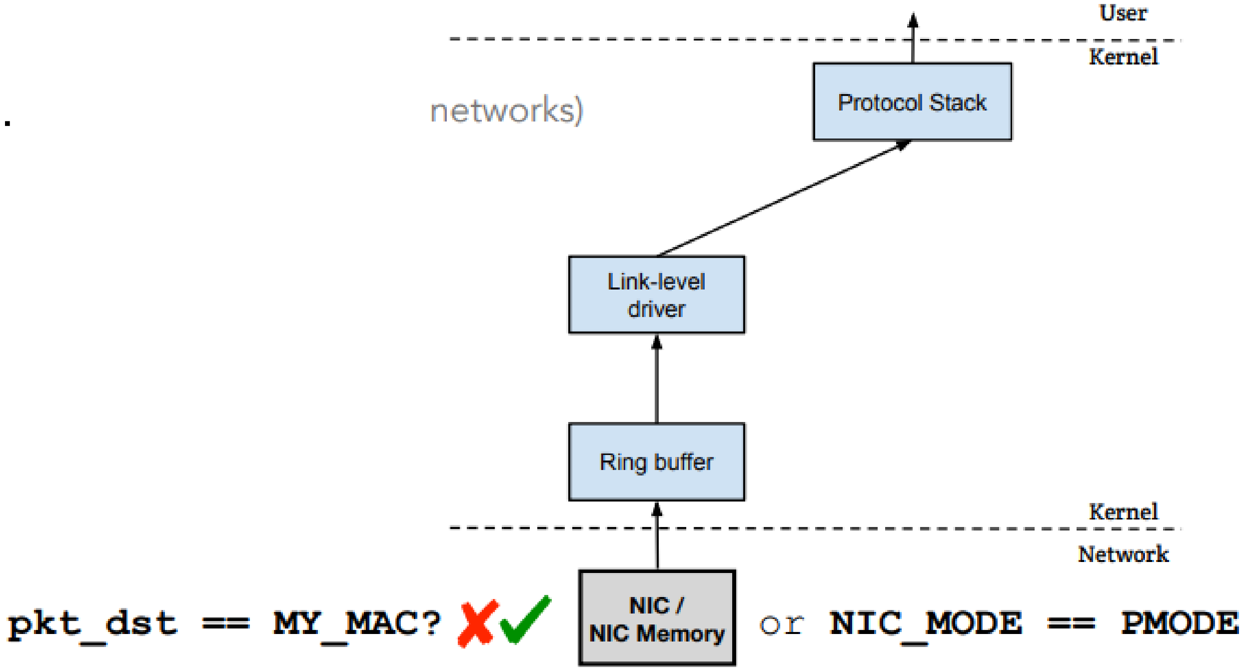
- Frames that are not destined to a given NIC are normally discarded
- When operating in promiscuous mode, the NIC passes every frame received from the network to the kernel
- If a **sniffer** program is registered with the kernel, it will be able to see all the packets

There are **tons** of packets. We don't need all of them…

The interesting ones are **TCP**, **UDP**, **DNS**, ~~HTTPS~~

Lets start "sniffing" for packets!

We can write a python program that will sniff packets for us!



Packet Sniffing (Python)

scapy is a python module designed for packet sniffing and spoofing

sniffer.py

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

def print_pkt(pkt):
    print(pkt.summary())

pkt = sniff(filter ='icmp', prn=print_pkt)
```

Sniff only `icmp` packets

When a matching packet is caught, run the `print_pkt` function

Scapy uses **Berkeley Packet Filter** (**BPF**) syntax to filter packets

Packet Sniffing (Python)

1. Start the sniffer program

```
[03/20/23]seed@VM:~/.../sniff_spoof$ vi sniffer.py
[03/20/23]seed@VM:~/.../sniff_spoof$ sudo python3 sniffer.py
Ether / IP / ICMP 10.0.2.5 > 142.251.33.110 echo-request 0 / Raw
Ether / IP / ICMP 142.251.33.110 > 10.0.2.5 echo-reply 0 / Raw
Ether / IP / ICMP 10.0.2.5 > 142.251.33.110 echo-request 0 / Raw
Ether / IP / ICMP 142.251.33.110 > 10.0.2.5 echo-reply 0 / Raw
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Ether / IP / ICMP 10.0.2.5 > 142.251.33.110 echo-request 0 / Raw
```

2. In another terminal, start generating ICMP packets

```
seed@VM: ~
[03/20/23]seed@VM:~$ ping google.com
PING google.com (142.251.33.110) 56(84) bytes of data.
64 bytes from sea30s10-in-f14.1e100.net (142.251.33.110): icmp_seq=1 ttl=55 tim
=15.8 ms
64 bytes from sea30s10-in-f14.1e100.net (142.251.33.110): icmp_seq=2 ttl=55 tim
=16.8 ms
64 bytes from sea30s10-in-f14.1e100.net (142.251.33.110): icmp_seq=3 ttl=55 tim
=16.6 ms
64 bytes from sea30s10-in-f14.1e100.net (142.251.33.110): icmp_seq=4 ttl=55 tim
=16.5 ms
64 bytes from sea30s10-in-f14.1e100.net (142.251.33.110): icmp_seq=5 ttl=55 tim
=15.6 ms
64 bytes from sea30s10-in-f14.1e100.net (142.251.33.110): icmp_seq=6 ttl=55 tim
=19.1 ms
```

We can see all the packets being sent in the `ping` request

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

print("SENDING SPOOFED UDP PACKET.........")
ip = IP(src="1.2.3.4", dst="10.0.2.69") # IP Layer
udp = UDP(sport=8888, dport=9090)       # UDP Layer
data = "Hello UDP!\n"                   # Payload
pkt = ip/udp/data      # Construct the complete packet
pkt.show()
send(pkt,verbose=0)
```

1 We can set the packets source IP and destination IP

Source IP: 1.2.3.4 (bogus)

Destination IP: 10.0.2.69 (also bogus)

2 We can set the packets source port and destination port (udp)

Source port: 8888 (bogus)

Destination port: 9090 (also bogus)

We can write a program that will craft and send out packets that we create

We can modify

- Src/dst IP address
- Port #s
- TCP Header information

```
^C[03/20/23]seed@VM:~/.../sniff_spoof$ sudo python3 sniffer.py
Ether / IP / UDP 1.2.3.4:8888 > 10.0.2.69:9090 / Raw
Ether / IP / UDP / DNS Qry "b'connectivity-check.ubuntu.com.'"
Ether / IP / UDP / DNS Ans "2620:2d:4000:1::2a"
```

```
[03/20/23]seed@VM:~/.../sniff_spoof$ vi udp_spoof.py
[03/20/23]seed@VM:~/.../sniff_spoof$ sudo python3 udp_spoof.py
SENDING SPOOFED UDP PACKET.........
###[ IP ]###
  version   = 4
  ihl       = None
  tos       = 0x0
  len       = None
  id        = 1
  flags     =
  frag      = 0
  ttl       = 64
  proto     = udp
  chksum    = None
  src       = 1.2.3.4
  dst       = 10.0.2.69
  \options   \
###[ UDP ]###
```

1 Sniff/listen for ICMP packets coming from `10.0.2.4`

2 When we intercept an ICMP packet, extract the packets source IP, and then create a spoofed packet

- `44.22.11.33` will receive a packet from `10.0.2.4`

`icmp_sniff_spoof.py`

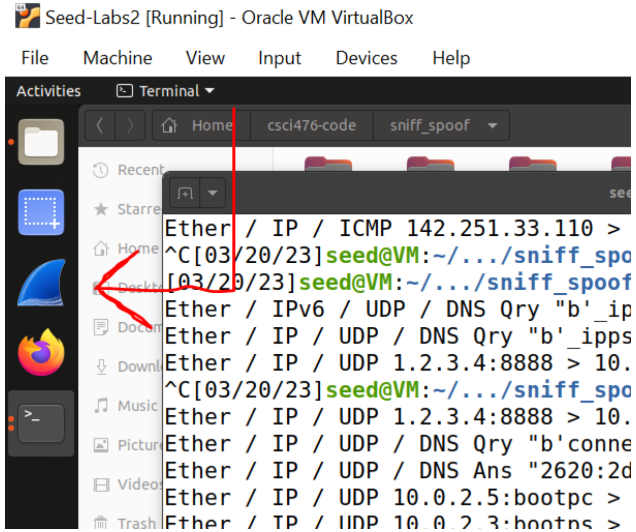
```
#!/usr/bin/python3
from scapy.all import *

def spoof_pkt(pkt):
  if ICMP in pkt and pkt[ICMP].type == 8:
     print("Original Packet.........")
     print("Source IP : ", pkt[IP].src)
     print("Destination IP :", pkt[IP].dst)

     ip = IP(src=pkt[IP].src, dst="44.22.11.33", ihl=pkt[IP].ihl)
     icmp = ICMP(type=0, id=pkt[ICMP].id, seq=pkt[ICMP].seq)
     data = pkt[Raw].load
     newpkt = ip/icmp/data

     print("Spoofed Packet.........")
     print("Source IP : ", newpkt[IP].src)
     print("Destination IP :", newpkt[IP].dst)
     print("")
     send(newpkt,verbose=0)

pkt = sniff(filter='icmp and src host 10.0.2.4',prn=spoof_pkt)
```

We can sniff for packets, and then spoof packets using the sniffed information!

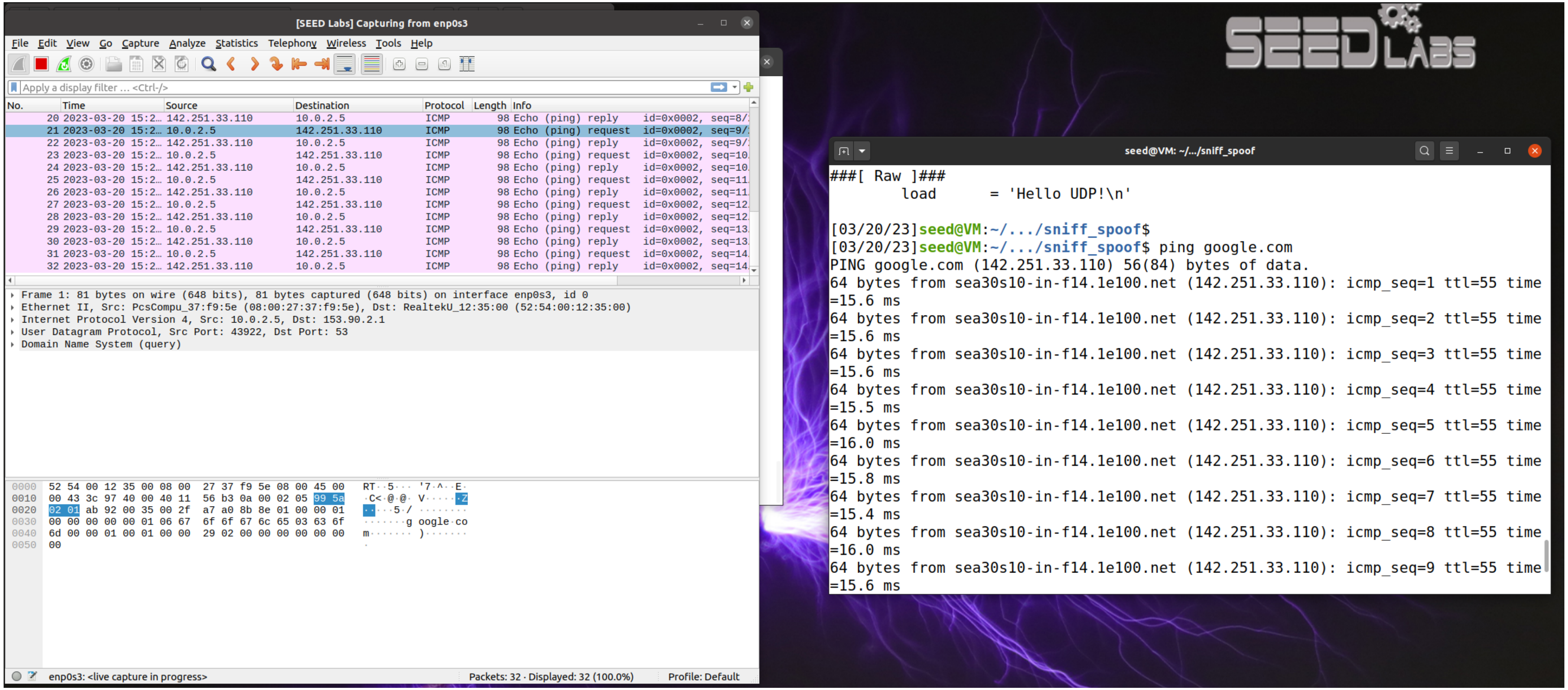
Wireshark is a very popular network analysis tool that allows you to analyze and view network traffic

We will use Wireshark to sniff packets instead of Python ☺

And it's installed on your VM!!

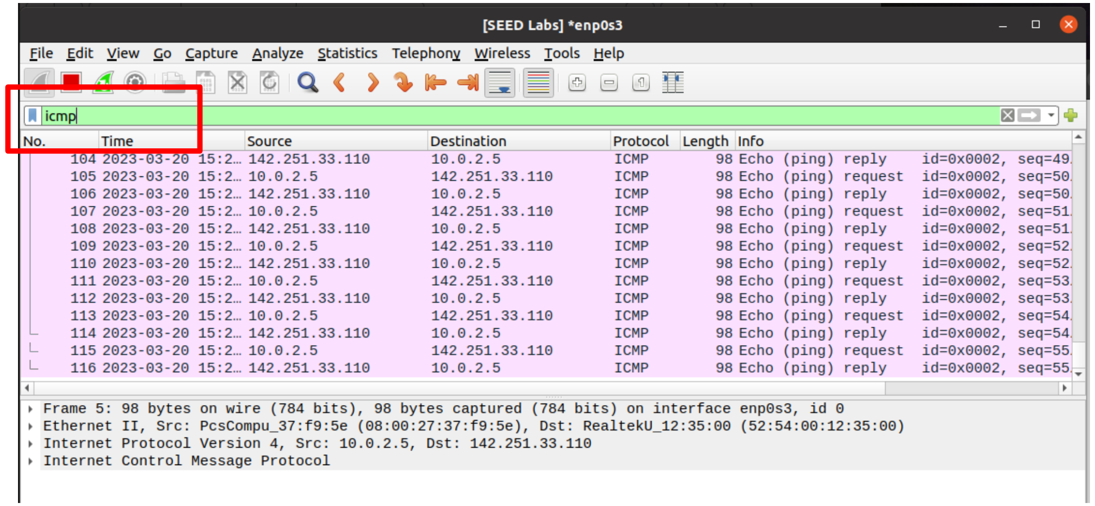


Sniffing packets using Wireshark

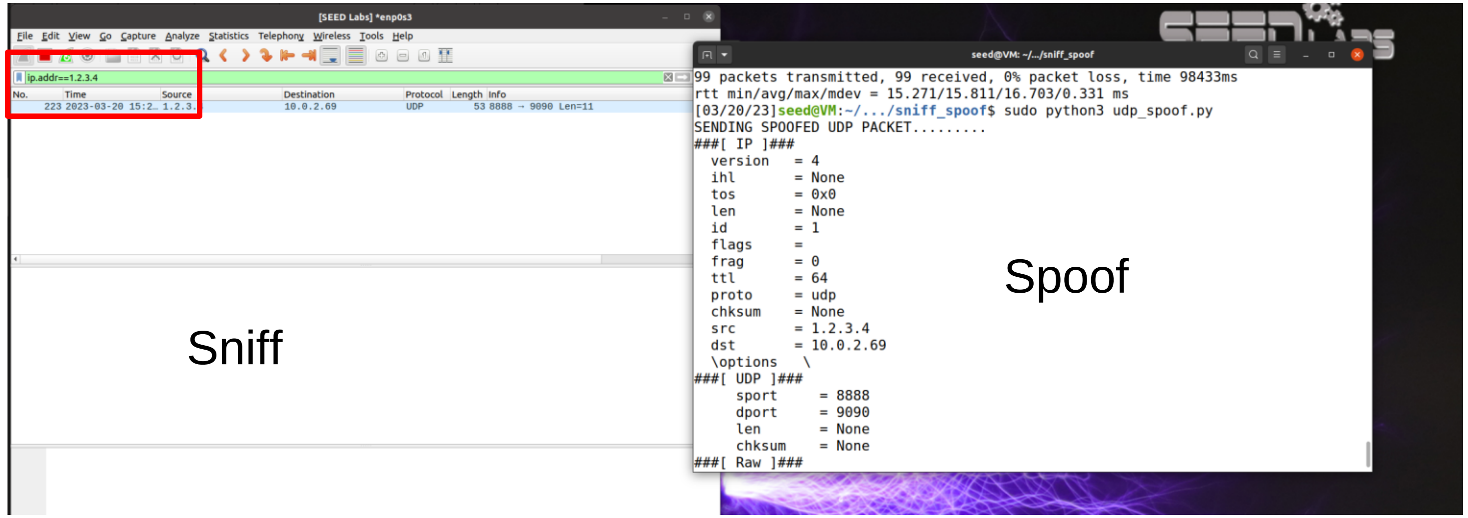


Sniffing packets using Wireshark

We can apply filters in Wireshark to sniff for certain packers



Show only ICMP packets



Show packets going to/coming from a certain IP address