Networks Layers

Computer Networking

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2024-III
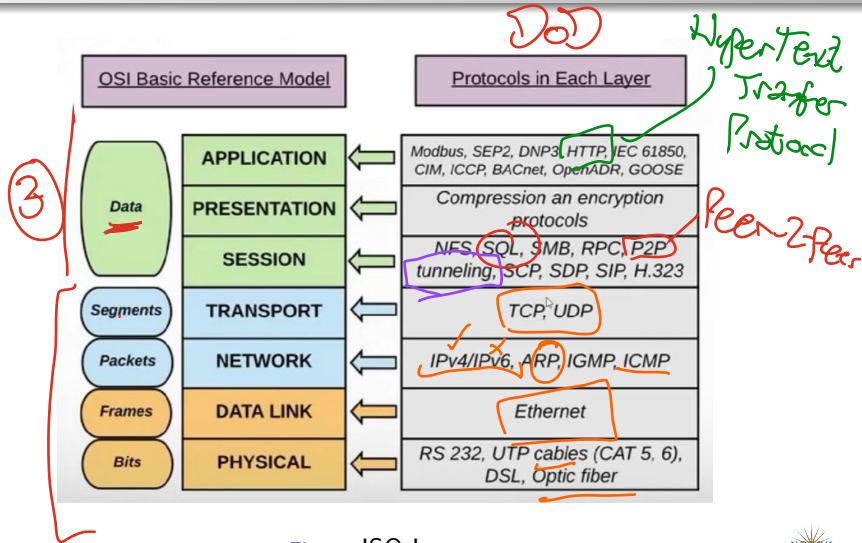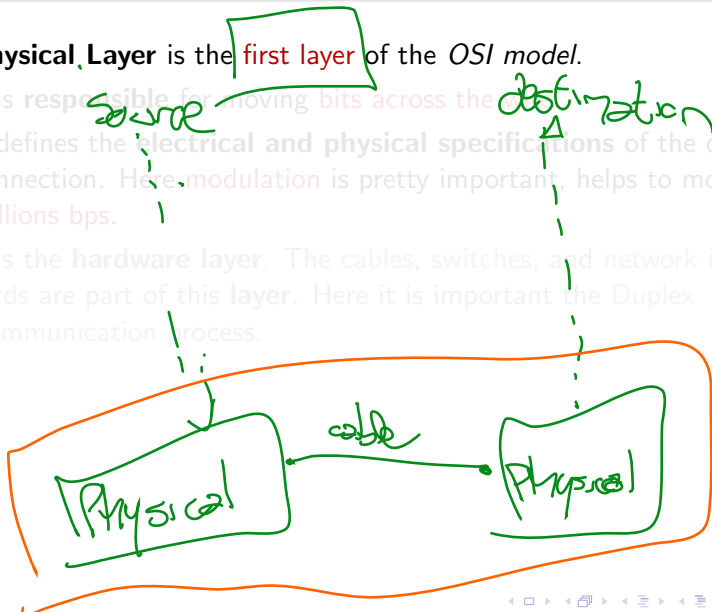
Outline

1. The Physical Layer

2. The Data Link Layer

3. The Network Layer

4. The Transport Layer

5. The Application Layer

6. Working Together!

Figure: ISO Layers

Outline

Moving Bits Across the Wire

- **Physical Layer** is the first layer of the *OSI model*.

- It is **responsible** for moving bits across the

- It defines the **electrical and physical specifications** of the data connection. Here, modulation is pretty important, helps to move 10 millions bps.

- It is the **hardware layer**. The cables, switches, and network interface cards are part of this **layer**. Here it is important the Duplex Communication process.
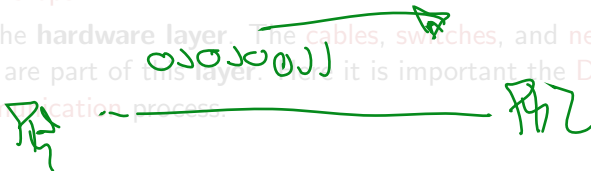
source

destination

cable

Physical

Physical

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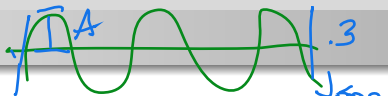
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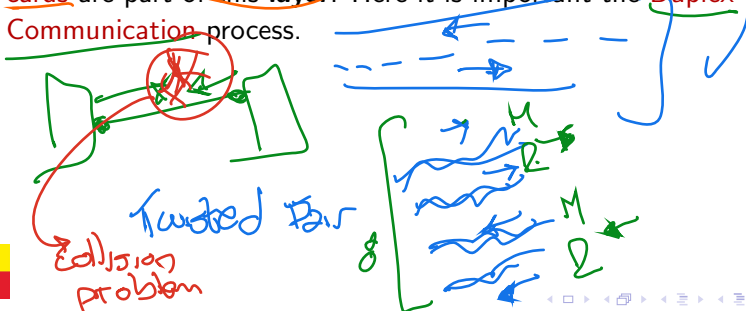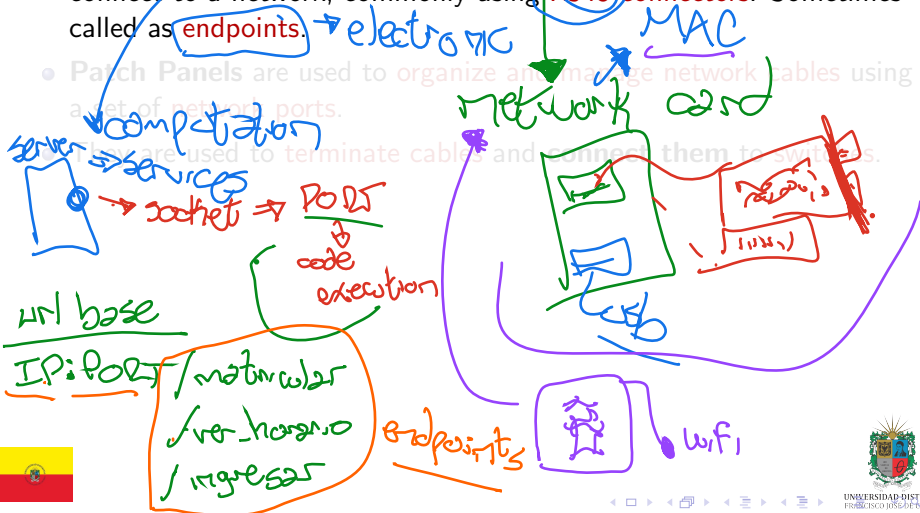- **Physical Layer** is the first layer of the *OSI model*.

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Networks Ports and Patch Panels

- **Network Ports** are the physical connection points for devices to connect to a network, commonly using RJ45 connectors. Sometimes called as endpoints.

- Patch Panels are used to organize and manage network cables using a set of network ports.

- Patch Panels are used to terminate cables and connect them to switches.

Handwritten annotations:

ethernet — fiber

electronic

MAC

network card

endpoints

server => services

computation

socket => PORT

code execution

url base

IP: PORT / matricular

✓ ver_horario

✓ ingresar

endpoints

wifi

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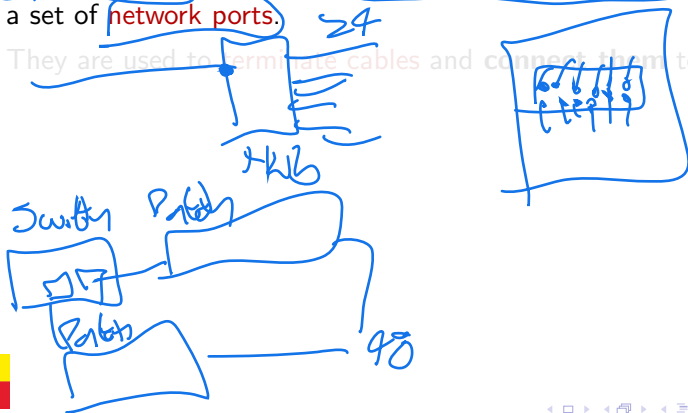
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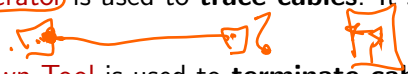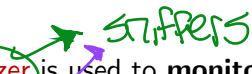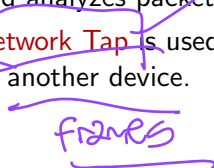- They are used to terminate cables and connect them to switches.

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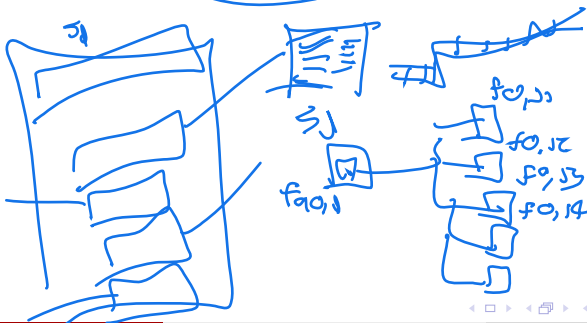
Cabling Tools

- **Crimping Tool** is used to **attach connectors to the end of a cable**.
- **Cable Tester** is used to **verify that the cable is properly connected**.
- **Tone Generator** is used to **trace cables**. It sends a signal through the cable.
- **Punch Down Tool** is used to **terminate cables on patch panels**.
- **Loopback Plug** is used to **test network ports**. It sends a signal back to the device.
- **Network Analyzer** is used to **monitor network traffic**. It captures and analyzes packets.
- **Network Tap** is used to **capture network traffic**. It copies the data to another device.

sniffers

frames

Example of a Professional Networking ToolKit

Package Contents

- **1x** Crimp tool for 6P/8P plugs
- **1x** Cable cutter
- **1x** Punch-down tool for 110 type terminal blocks
- **1x** UTP/STP, flat cable stripper/cutter
- **6x** 8P8C plugs
- **6x** 6P6C plugs
- **1x** Cable tester
  for RJ45 (EIA/TIA 568A/568B), 10BaseT,
  Token Ring, RJ11/12 USOC, and Coaxial BNC cables

Here is an example of a professional networking toolkit usage.

Outline

Ethernet and MAC Addresses

- **Data Link Layer** is the second layer of the *OSI model*.
- It is **responsible** for framing and error detection.
- It defines the logical link control and media access control.
- It is a **software layer**. The Ethernet protocol (1980s) is part of this layer.
- **MAC Addresses** are unique identifiers assigned to network interfaces. It is a 48-bit (*six groups of two hexadecimal*) number.
- They are used to **identify devices** on a network.

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AA:B3: -

16 16   16 16

16^{12} ~ combinations

8^{24}

4^{48}

2^{96}

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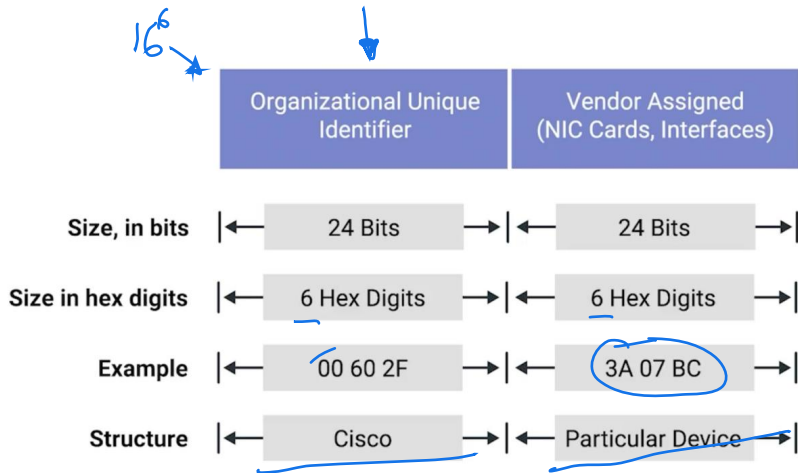
MAC Address Structure

Figure: MAC Address Structure

Unicast, Broadcast, and Multicast

- Unicast is a **one-to-one** communication.
- Broadcast is a **one-to-all** communication.
- Multicast is a **one-to-many** communication.
- MAC Addresses are used to determine the type of communication.

Peer 2 Peer ⇒ P2P

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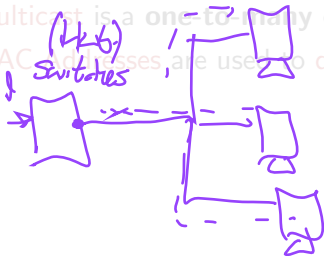- MAC addresses are used to determine the type of communication.

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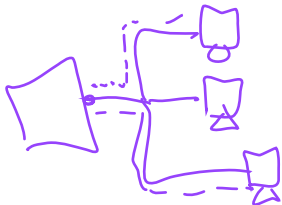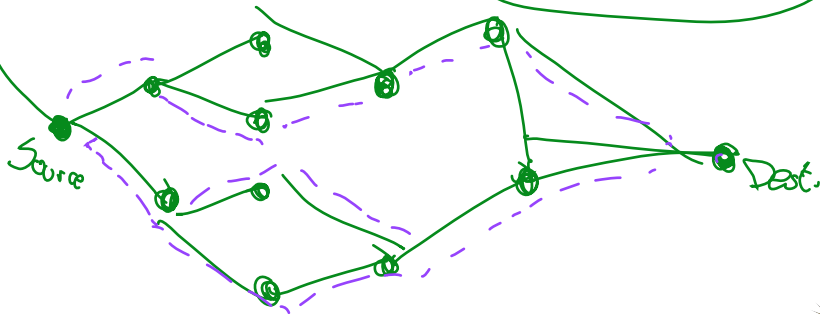- **Broadcast** is a **one-to-all** communication.
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Ethernet Frames

- **Ethernet Frames** are the data packets used in Ethernet networks.
- They **contain** the source and destination MAC addresses.
- They also **contain** the type of data and the data payload

  → data
- They are used to **transfer data** between devices on a network.

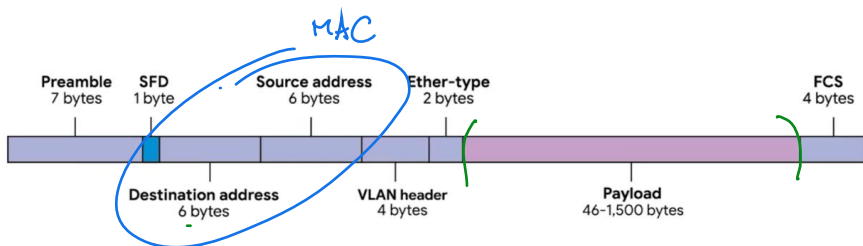Figure: Ethernet Frame

Avoiding Data Corruption

To **avoid data corruption**, error detection is used. The Cyclic Redundancy Check (*CRC*) is a common error detection technique. It is used to detect errors in the data payload.
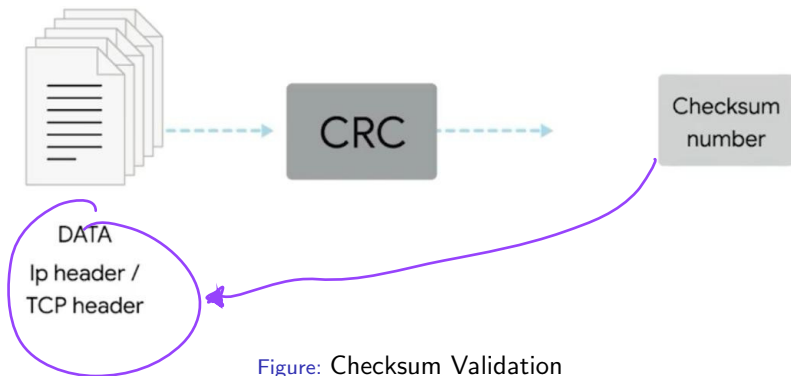

Figure: Checksum Validation

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IPv4 Addresses and Addresses Classes

- **Network Layer** is the third layer of the *OSI model*.
- It is **responsible** for routing and addressing.
- It defines the logical addressing and path determination.
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- **IPv4 Addresses** are 32-bit numbers used to identify devices on a network.
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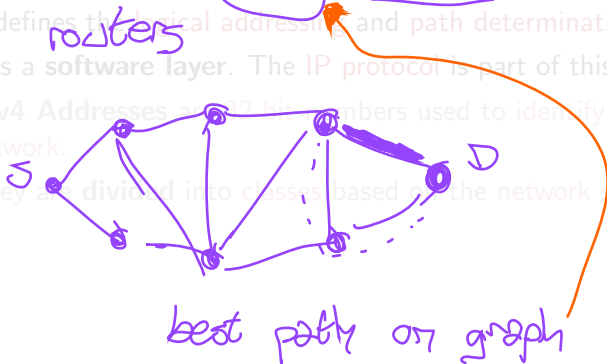- They are **divided** into classes based on the network size.

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$$0-255 . 0-255 . 0-255 . 0-255$$

$$2^8 \qquad 2^9 \qquad 2^8 \qquad 2^8 = 2^{32}$$

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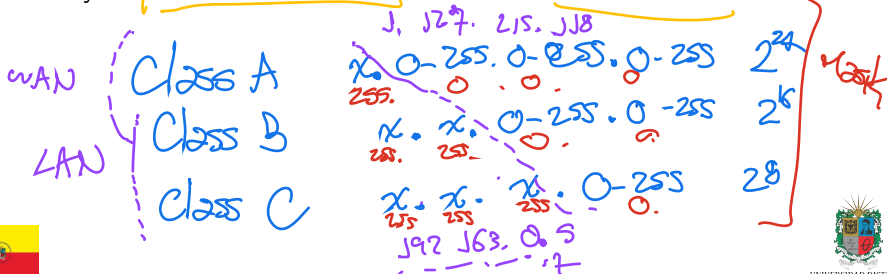- They are **divided** into classes based on the network size.

IPv4 Datagram

- **IPv4 Datagram** is the data packet used in IP networks.
- It **contains** the source and destination IP addresses.
- It also **contains** the type of data and the data payload.
- It is used to **transfer data** between devices on a network.

IP Datagram Header

0	4	8	16	19	31*
Version	Header Length	Service Type		Total Length	
Identification			Flags	Fragment Offset	
TTL		Protocol		Header Checksum	
Source IP Address					
Destination IP Address					
Options				Padding	

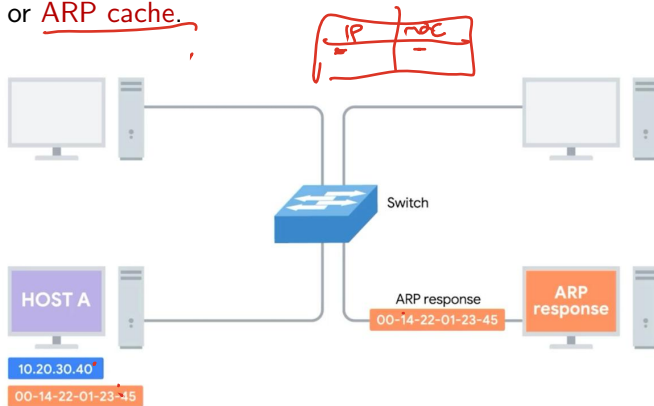# Time To Live

Time To Live is a counter used to limit the lifespan of a data packet.
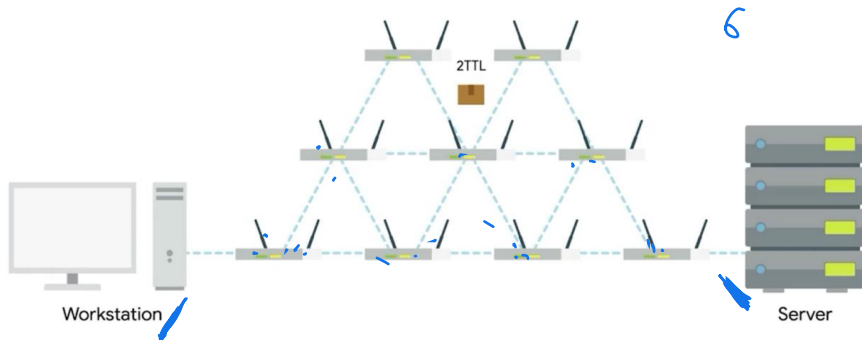
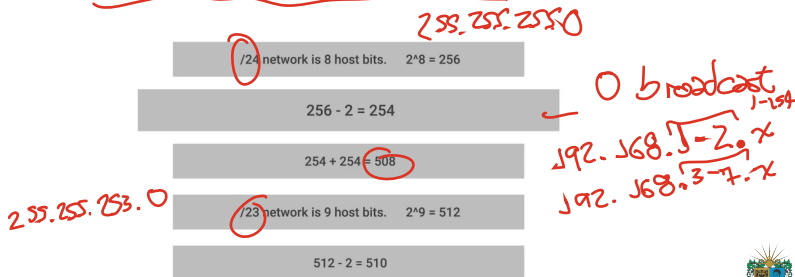# Address Resolution Protocol (ARP)

- **Address Resolution Protocol (ARP)** is used to map IP addresses to MAC addresses.

- It is used to **resolve IP addresses** to physical addresses, using ARP table or ARP cache.

Subnetting and CIDR

- **Subnetting** is the process of dividing a network into smaller subnets.
- It is used to reduce network congestion and improve network performance.
- **CIDR** (stands for *ClassLess InterDomain Routing*) is a subnetting technique that uses a prefix length to define the subnet.
- It is used to reduce the number of IP addresses required for a network.

255.255.255.0

/24 network is 8 host bits.   2^8 = 256

256 - 2 = 254

0 broadcast 1-254

254 + 254 = 508

192.168.1-2.x

255.255.253.0

/23 network is 9 host bits.   2^9 = 512

192.168.3-7.x

512 - 2 = 510

Routing and Routers

- **Routing** is the process of determining the best path for data to travel on a network.
- **Routing** is used to forward data packets between devices on a network.
- Routers are devices that are used to route data between networks.
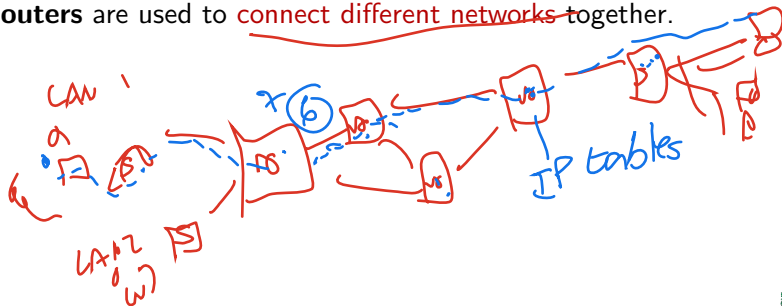- Routers are used to connect different networks together.

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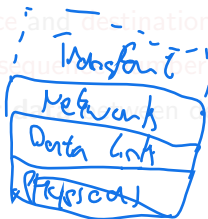- **Routers** are used to connect different networks together.

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TCP Segment

- **Transport Layer** is the fourth layer of the *OSI model*.
- It is **responsible** for end-to-end communication and error recovery.
- It defines the connection-oriented and reliable **data transfer**.
- It is a **software layer**. The TCP protocol is part of this **layer**.
- **TCP Segment** is the data packet used in TCP networks.
- It **contains** the source and destination port numbers.
- It also **contains** the sequence number and the data payload.
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  metadata   *data (payload)*
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TCP Control Flags

- **TCP Control Flags** are used to control the flow of data in a TCP connection.

- They are **used** to establish and terminate connections.

- They are **used** to acknowledge data and control the flow of data.

TCP & UDP Packets

- **TCP** (*Transmission Control Protocol*) is a connection-oriented protocol.
- It is **used** to establish a connection between devices.
- It is **used** to guarantee the delivery of data.
- **UDP** (*User Datagram Protocol*) is a connectionless protocol.
- It is **used** to send data without establishing a connection.
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TCP Socket States

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- They are used to **manage the connection** between devices.
- They are used to establish, maintain, and terminate **connections**.
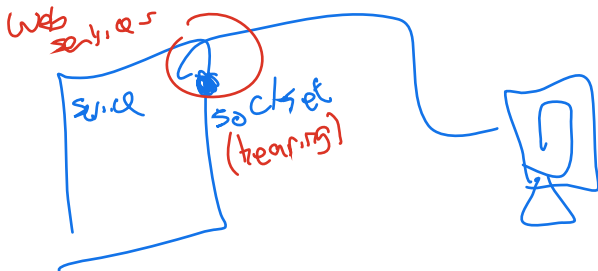
Firewalls and NAT

- **Firewalls** are used to protect networks from unauthorized access.
- They are used to **filter traffic** based on rules and policies.
- **NAT** (*Network Address Translation*) is used to map private IP addresses to public IP addresses.
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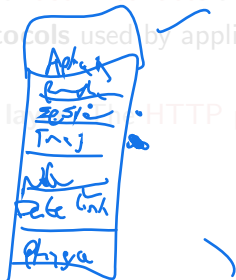
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Application Layer Protocols

- **Application Layer** is the <u>seventh layer</u> of the *OSI model*.

- It is responsible for user interfaces and application services.

- It defines the **protocols** used by applications to communicate over the network.

- It is the **software layer** HTTP protocol is part of this layer.

Application Layer Protocols

- **Application Layer** is the seventh layer of the *OSI model*
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Encapsulation

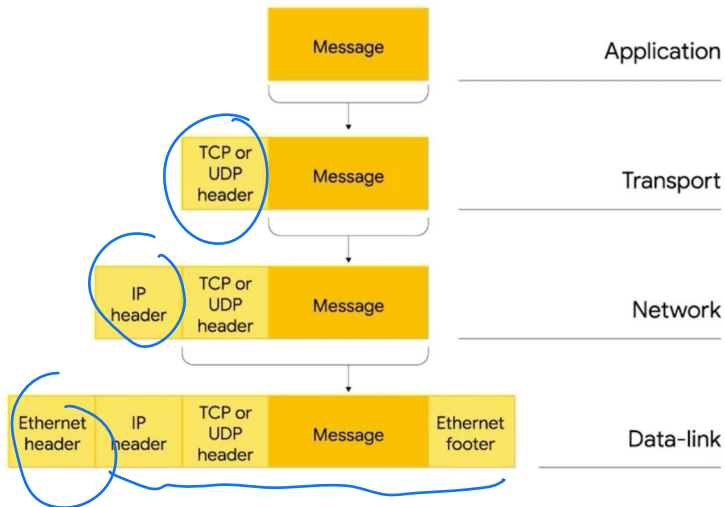Figure: Payload Encapsulation

Outline

All the Layers Together

source

Destination

#	Layer Name	Protocol	Protocol Data Unit	Addressing
5	Application	HTTP, SMTP, etc...	Messages	n/a
4	Transport	TCP/UDP	Segment	Port #'s
3	Network	IP	Packet / Datagram	IP Address
2	Data Link	Ethernet, Wi-Fi	Frames	MAC Address
1	Physical	n/a	Bits	n/a
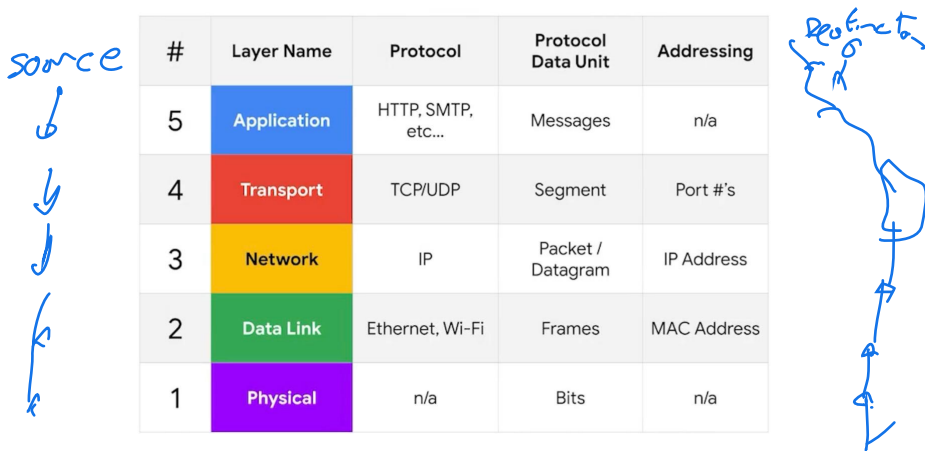
Figure: All the Layers working in Unison

Outline

Thanks!

Questions?

Repo: *https://github.com/EngAndres/ud-public/tree/main/courses/computer-networking*