

NETWORKS LAYERS

Computer Networking

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UNIVERSIDAD DISTRITAL
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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!



OSI Layers & Protocols

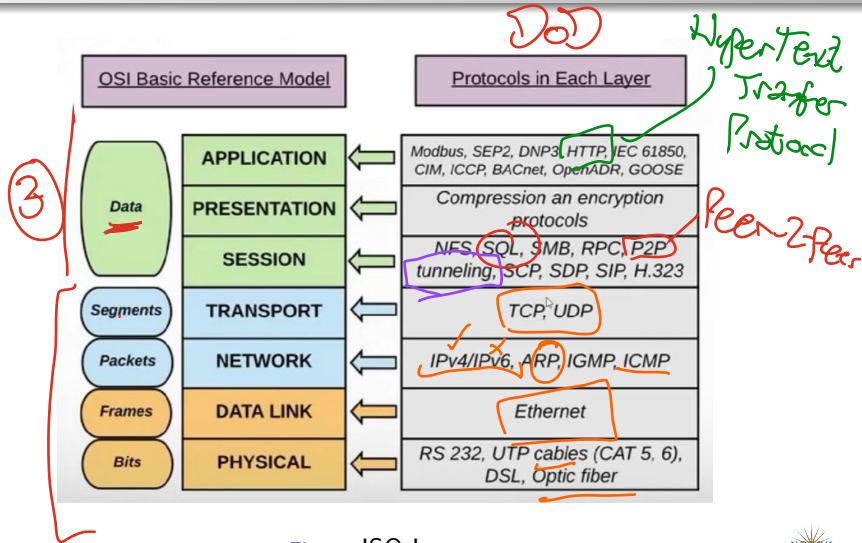


Figure: ISO Layers



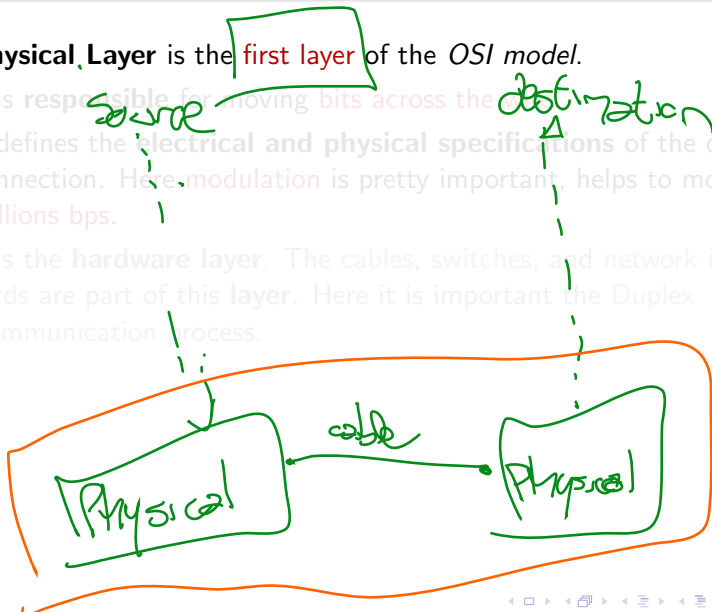
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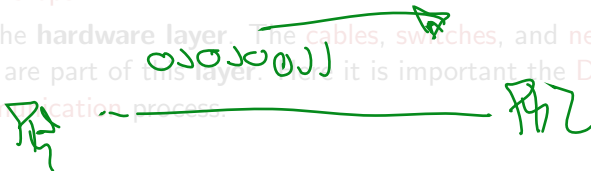
Moving Bits Across the Wire

- **Physical Layer** is the **first layer** of the *OSI model*.
- It is **responsible for moving bits across the wire**.
- 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**.

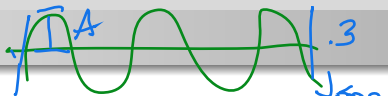


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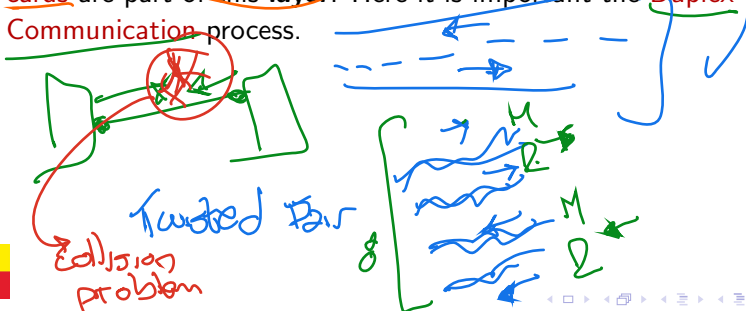


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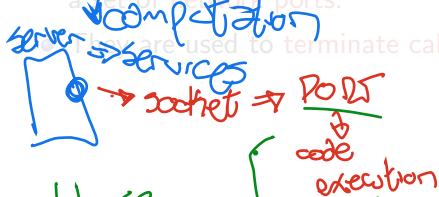
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- **Network Ports** are the **physical connection points** for devices to connect to a network, commonly using **RJ45 connectors**. Sometimes called as **endpoints**. → *electronic MAC*

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

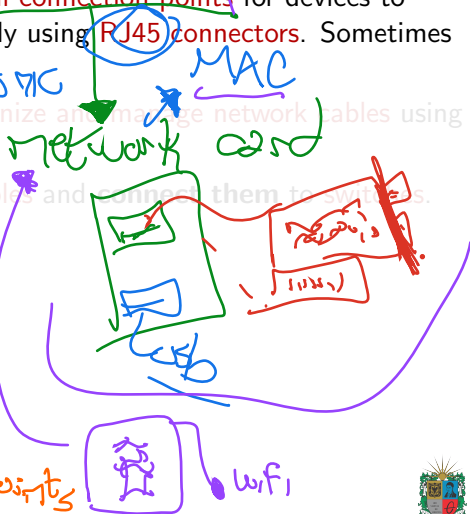
They are used to terminate cables and connect them to switches.



url base

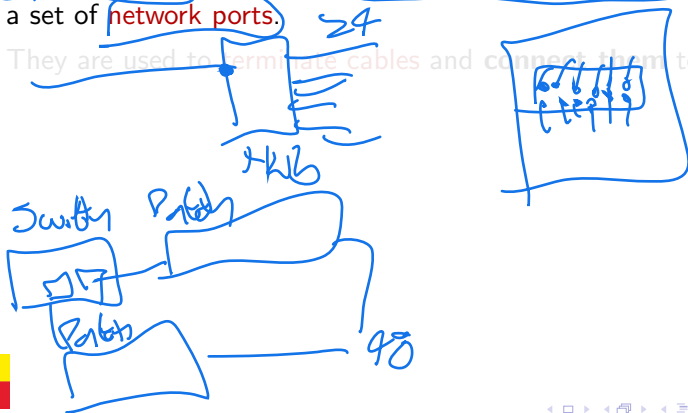
IP: port / molecular
free_hospital
/ ingresos

Endpoints



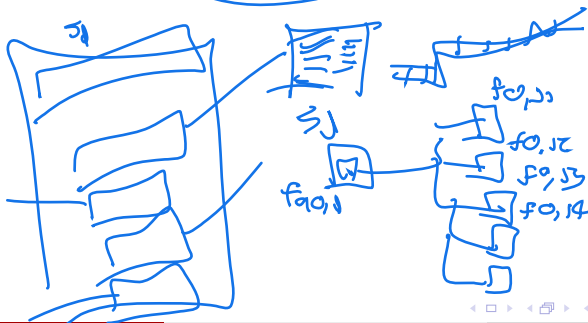
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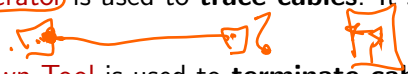
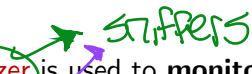
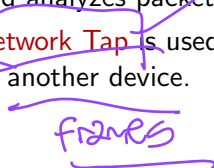


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Cabling Tools

- **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. 

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.



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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:BB:CC:DD:EE:FF

16 16 16 16

$16^{12} \sim \text{combinations}$
 8^{24}
 4^{48}
 2^{96}



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↳ depends on IP



MAC Address Structure

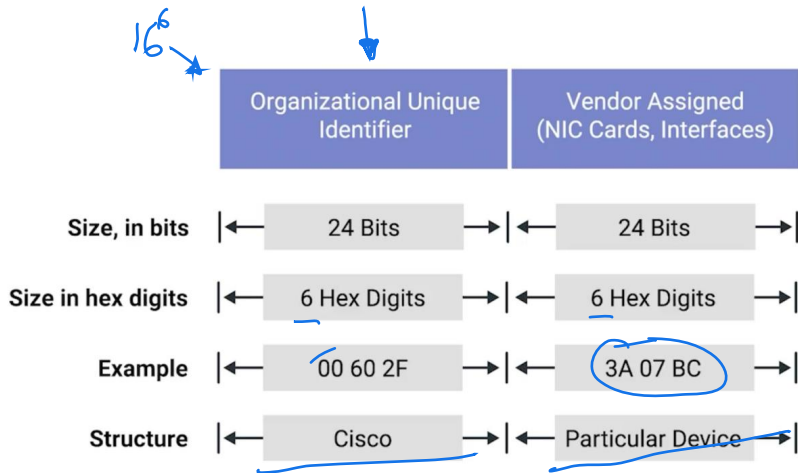


Figure: MAC Address Structure



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 \Rightarrow P2P

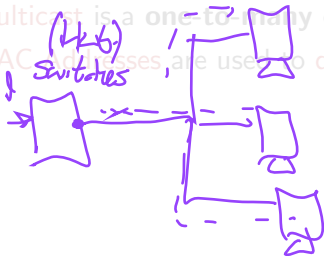


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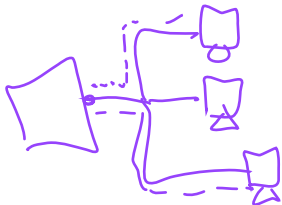
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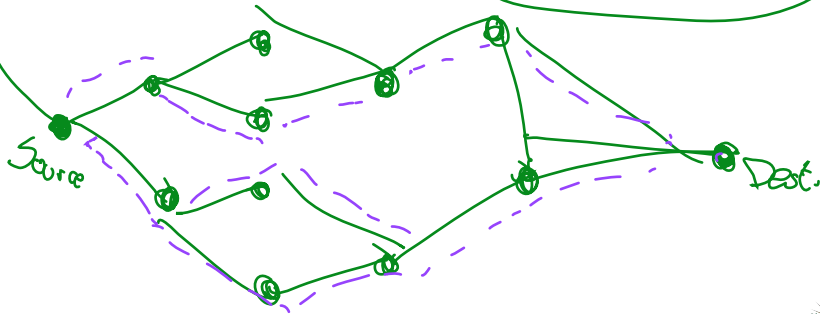
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Ethernet Frames

- **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** *network* between **devices** on a network.

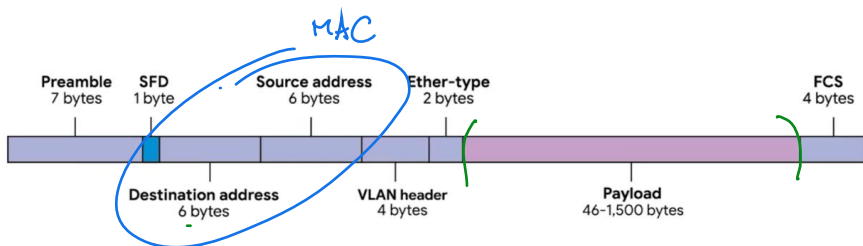


Figure: Ethernet Frame



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.

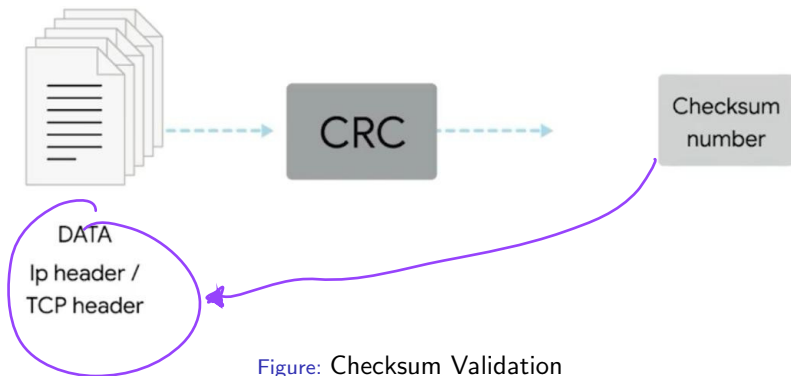


Figure: Checksum Validation



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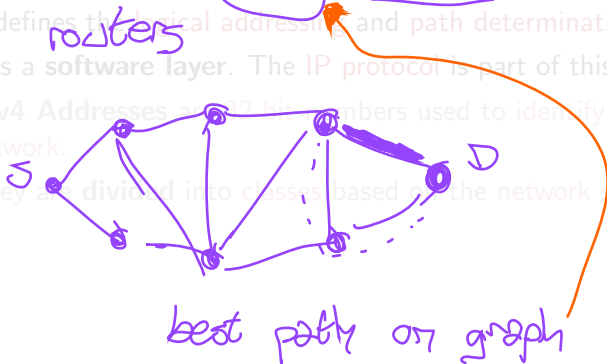
IPv4 Addresses and Addresses Classes

- **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**.
- It is a **software layer**. The **IP protocol** is part of this **layer**.
- **IPv4 Addresses** are **32-bit numbers** used to **identify devices** on a **network**.
- They are **divided** into **classes** based on the **network size**.



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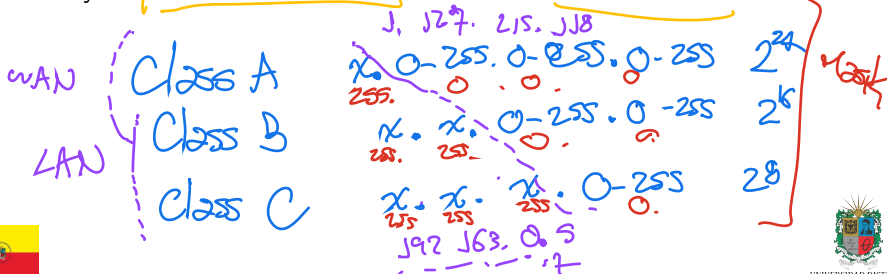
• They are **divided into classes** based on the **network size**.

$0-255 \cdot 0-255 \cdot 0-255 \cdot 0-255$
 $2^8 \quad 2^8 \quad 2^8 \quad 2^8 = 2^{32}$



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IPv4 Datagram

L2 → Ethernet Frame

- **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**.

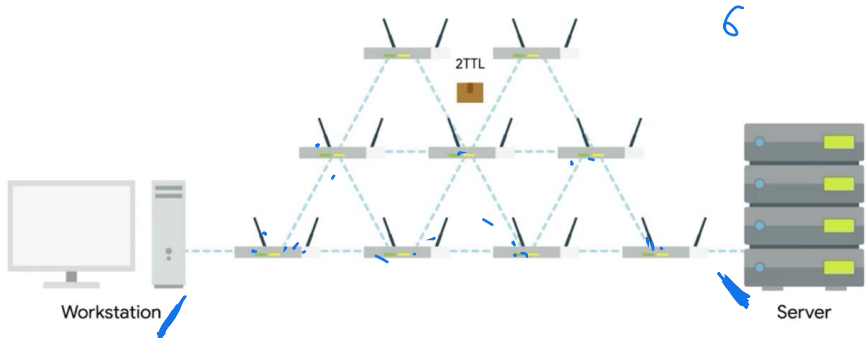
IP Datagram Header

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

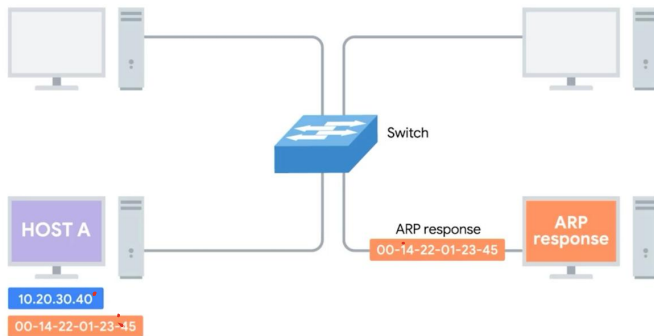


Time To Live is a counter used to limit the lifespan of a data packet.



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.

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

$256 - 2 = 254$

$254 + 254 = 508$

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

$512 - 2 = 510$



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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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**.
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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**.
- It is **used** when **speed** is more important than **reliability**.



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TCP Socket States

- **TCP Socket States** are used to **track the state** of a **TCP connection**.
- 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**.
- It is used to **hide internal network addresses** from the myemphpublic Internet.



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Application Layer Protocols

- **Application Layer** is the **seventh layer** 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**. The **HTTP** protocol is part of this layer.



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Encapsulation

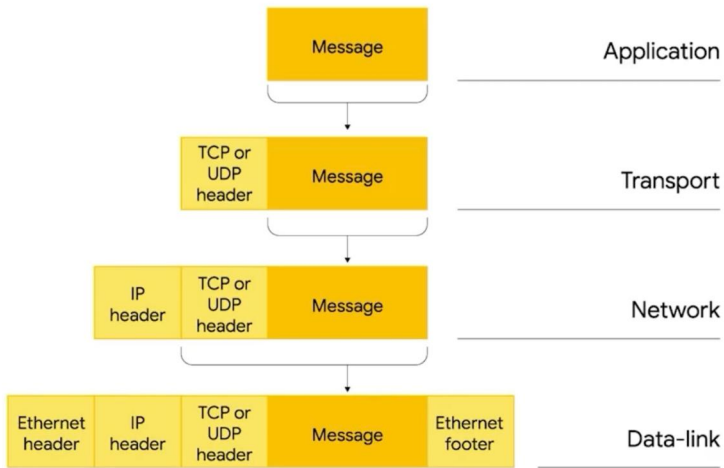


Figure: Payload Encapsulation



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!**



All the Layers Together

#	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



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Thanks!

Questions?



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

