

NETWORKS LAYERS

Computer Networking

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2024-III



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

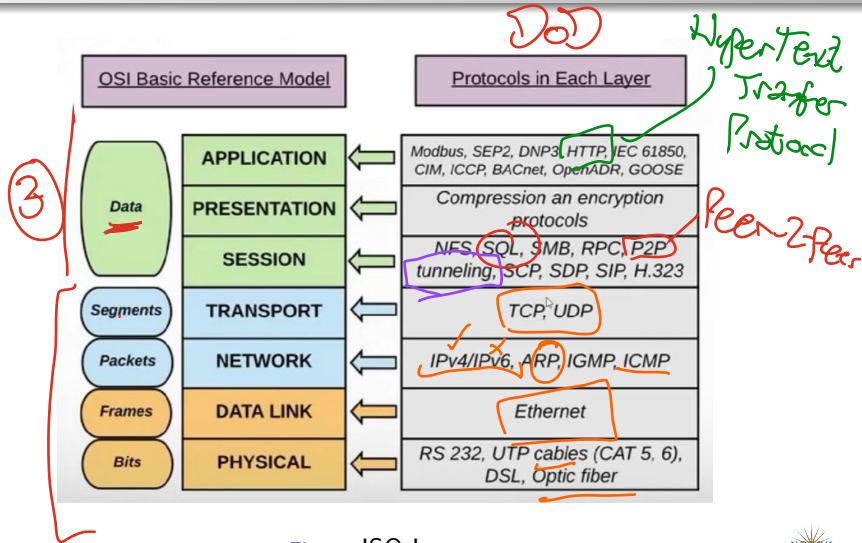


Figure: ISO Layers



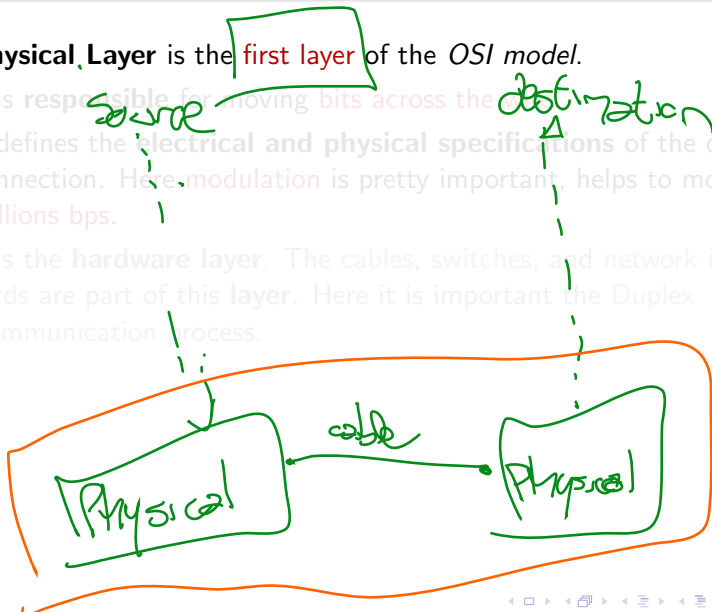
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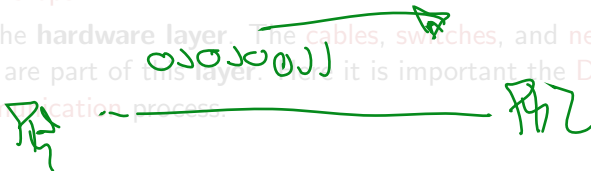
Moving Bits Across the Wire

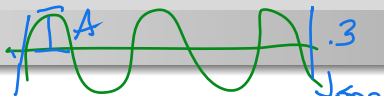
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- It is **responsible for moving bits across the wire**.
- It defines the **electrical and physical specifications** of the data connection. Here, **modulation** is pretty important, helps to move 10 millions bps.
- It is the **hardware layer**. The **cables, switches, and network interface cards** are part of this layer. Here it is important the **Duplex Communication process**.



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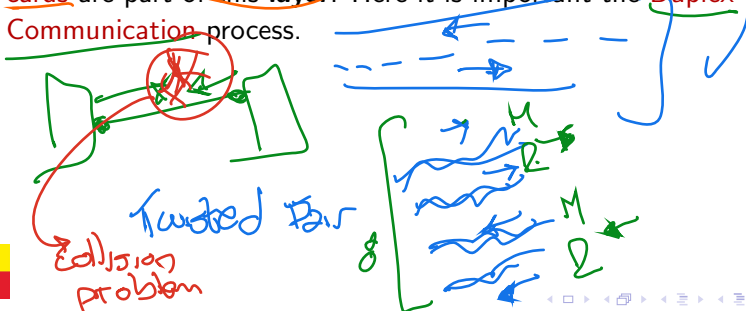
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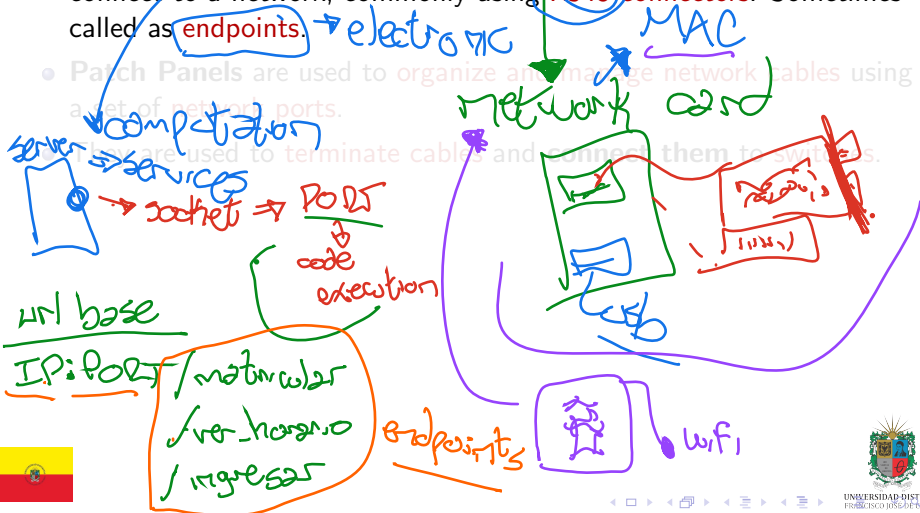
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- **Network Ports** are the **physical connection points** for devices to connect to a network, commonly using **RJ45 connectors**. Sometimes called as **endpoints**. → *electronic MAC*

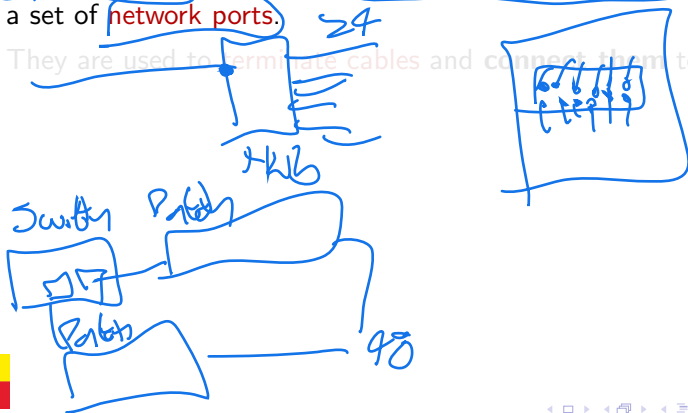
- Patch Panels are used to organize and manage network cables using a set of network ports.

They are used to terminate cables and connect them to switches



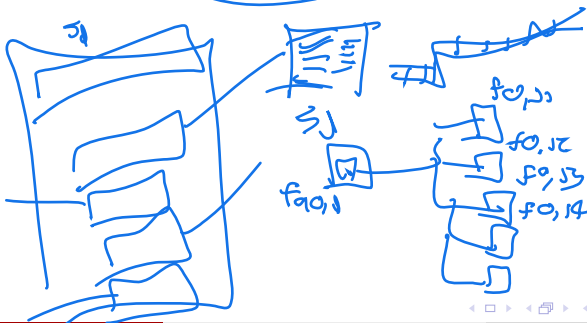
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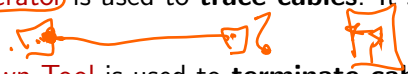
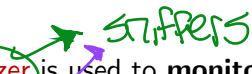
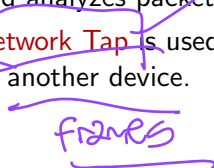


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Cabling Tools

- **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.
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MAC Address Structure

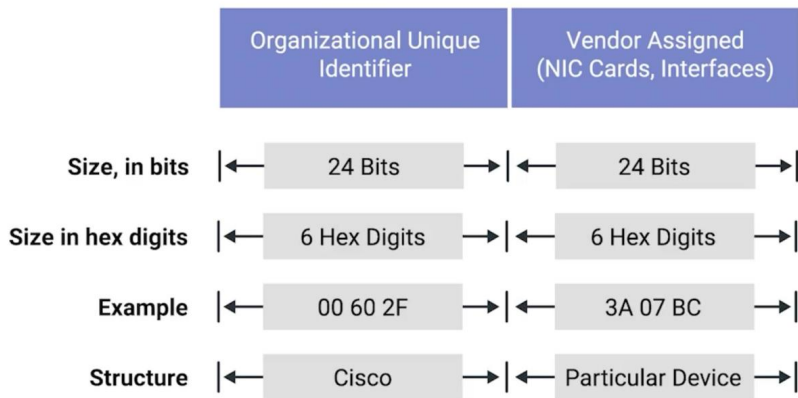


Figure: MAC Address Structure



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

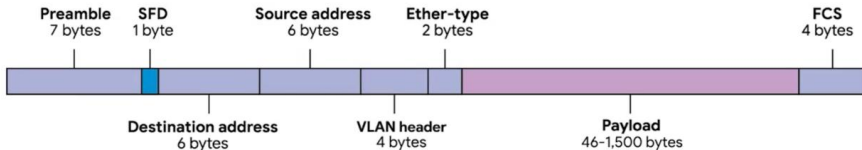


Figure: Ethernet Frame



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.

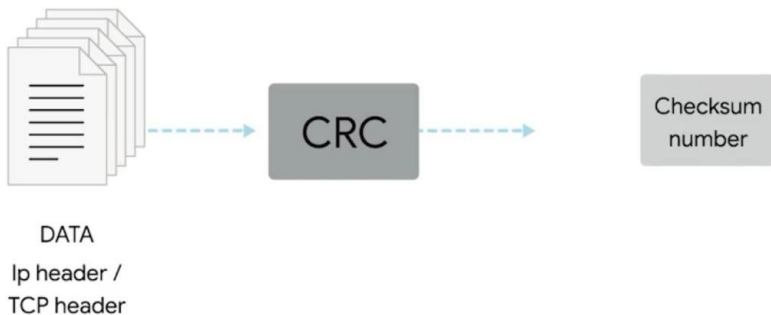


Figure: Checksum Validation



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IPv4 Addresses and Addresses Classes

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- It is **responsible** for **routing** and **addressing**.
- It defines the **logical addressing** and **path determination**.
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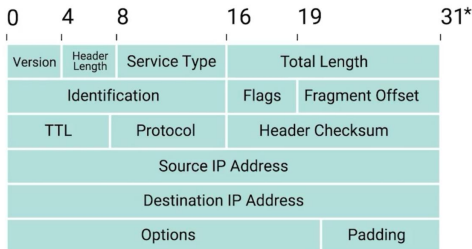
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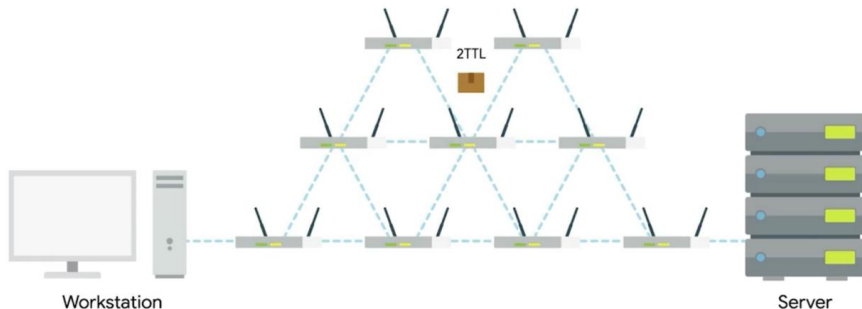
- **IPv4 Datagram** is the **data packet** used in **IP networks**.
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IP Datagram Header



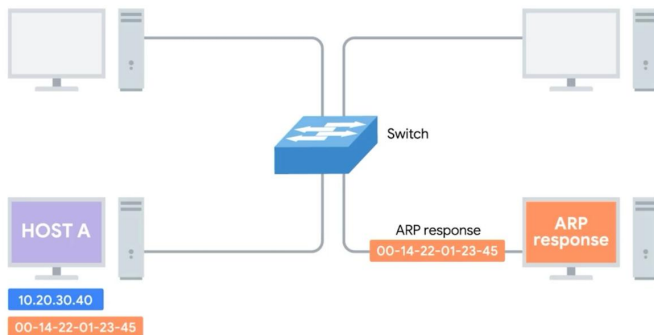
Time To Live

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*.
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- It defines the **connection-oriented** and **reliable data transfer**.
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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.
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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

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

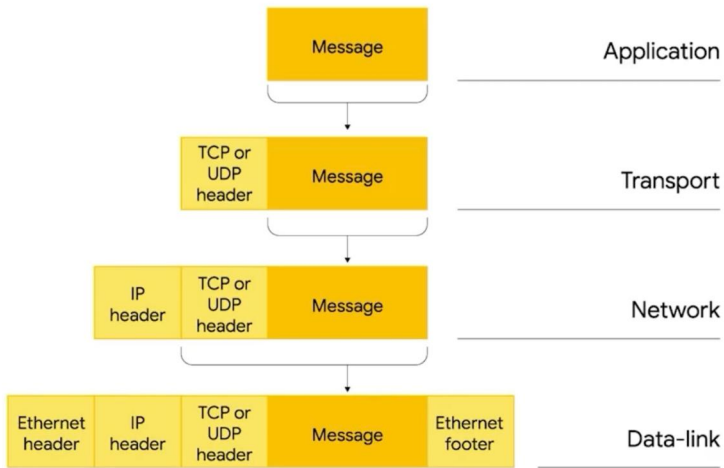


Figure: Payload Encapsulation



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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>

