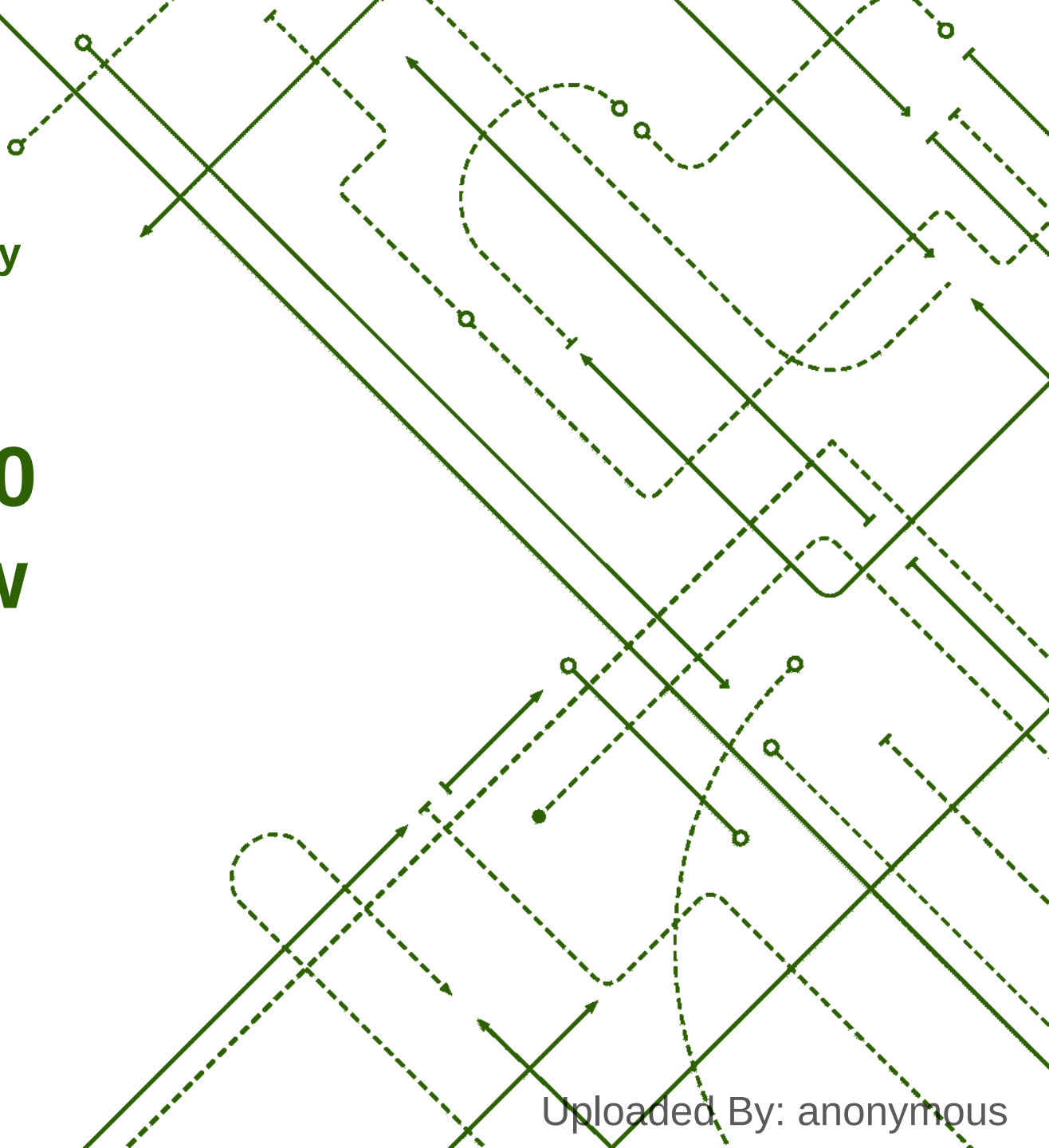
ENCS4130
Computer Networks Laboratory

EXPERIMENT #0
Network Review

Slides By: Tariq Odeh



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Objectives

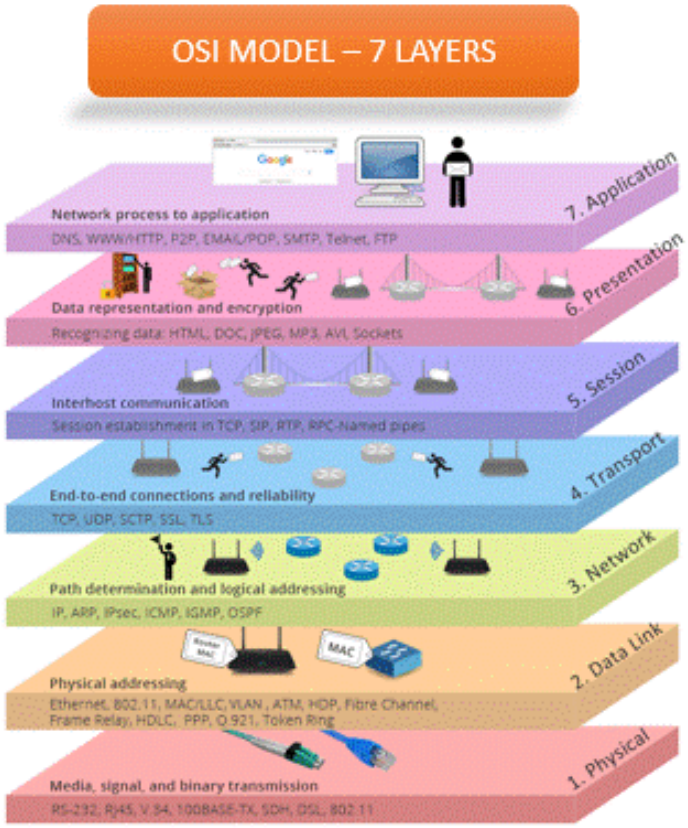
- Review network layering (OSI model).
- Introduce you to the network lab devices.
- Network Classes
- Review the network subnetting.

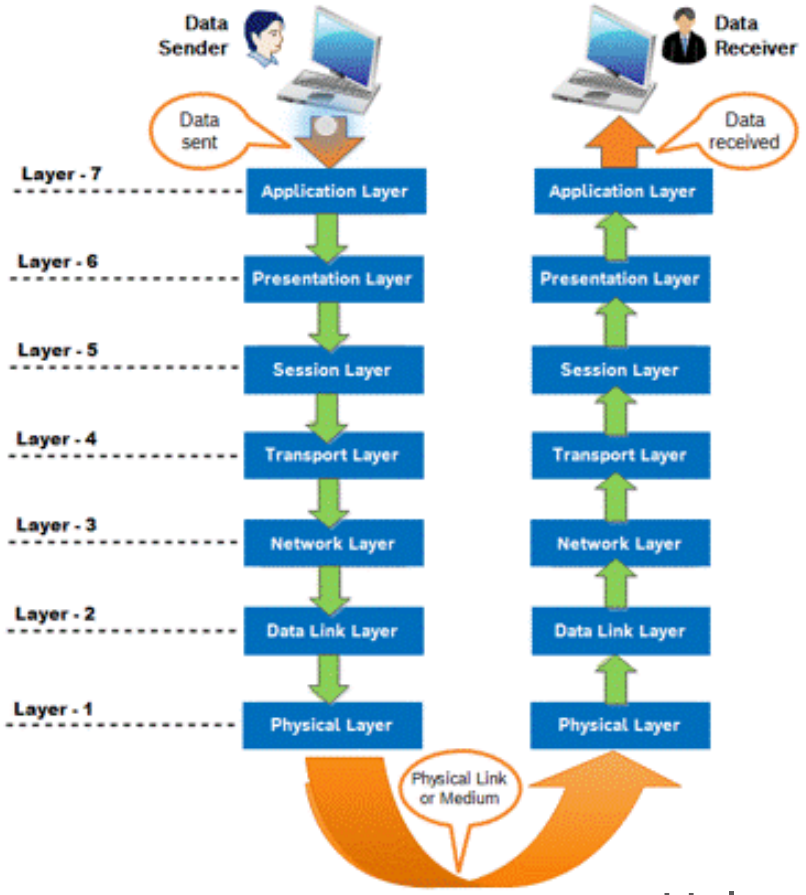
Open Systems Interconnection model (OSI model)

Open Systems Interconnection model (OSI model)

- Standardizes communication in telecom/computing systems.
- Developed by the International Organization for Standardization in 1974.
- The ISO created the OSI model, and IEEE develops standards that align with its lower layers.
- Independent of internal structure/technology.
- Divides communication into 7 layers.
- Each layer has a different but specific processing function.

Open Systems Interconnection model (OSI model)





Why layering

- **Troubleshooting:** easier.
- **Change:** change in one-layer, other layers are not affected.
- **Design:** division into layers makes the solution much simple.
- **Learning:** understanding the network communication as layers is easier

OSI model by layer

Layer	Examples	Functions	Data to be sent	
Application Layer 7	– FTP – DNS – SMTP – HTTP	Services used with end users applications	Data	Hosts Layers (between hosts)
Presentation Layer 6	– JPG, GIF – SSL (HTTPS)	Formats the data to be viewed Encryption/decryption (security)	Data	
Session Layer 5	– H322 that used for VOIP	Manage end-to-end connection between hosts	Data	
Transport Layer 4	– TCP – UDP	Ensure delivery of entire message	Segments	
Network Layer 3	IP RIP	Routing→path Forwarding→interface	Packets	Media Layers (over Network)
Data Link Layer 2	Ethernet MAC ARP	Physical addressing (MAC) Flow control	Frames	
Physical Layer 1	(Transmission media) Ethernet DSL	Signal Transmission	Bits	

Layer 7: Application Layer

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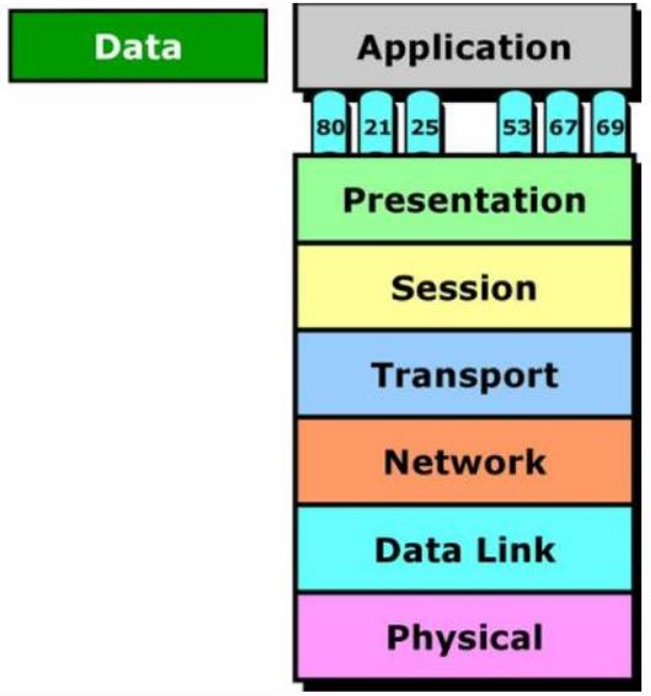
Layer 7: Application Layer

- Application Layer is responsible for providing Networking Services to the user.
- It is also known as Desktop Layer.
- Identification of Services is done using Port Numbers.
- Ports are Entry and Exit Points to the Layer
- Number of port bits = 16 bits.
- Total No. Ports – 65535 and Reserved Ports – 1023
- Open Client Ports 1024 – 65535
- **Examples:**
  - HTTP (Port 80): Web traffic (unencrypted).
  - FTP (Port 21): File transfers.
  - SMTP (Port 25): Email sending.
  - DNS (Port 53): Domain name to IP address translation.



Layer 6: Presentation Layer

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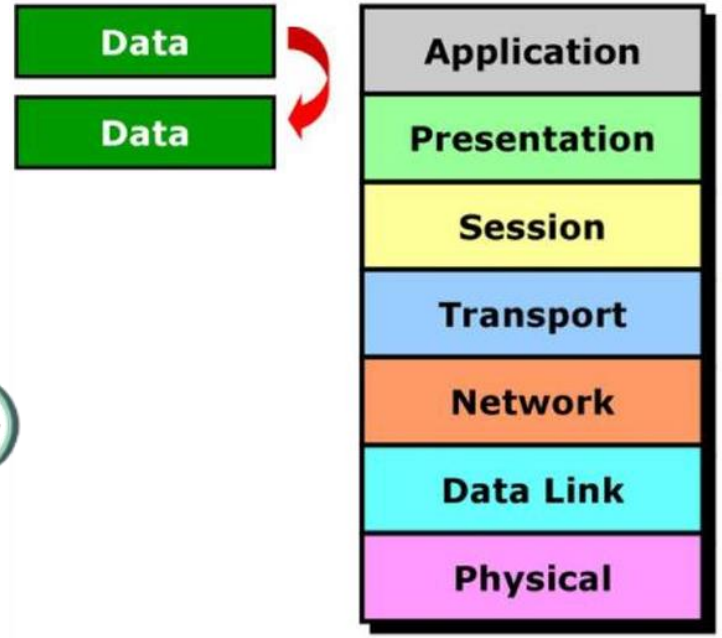
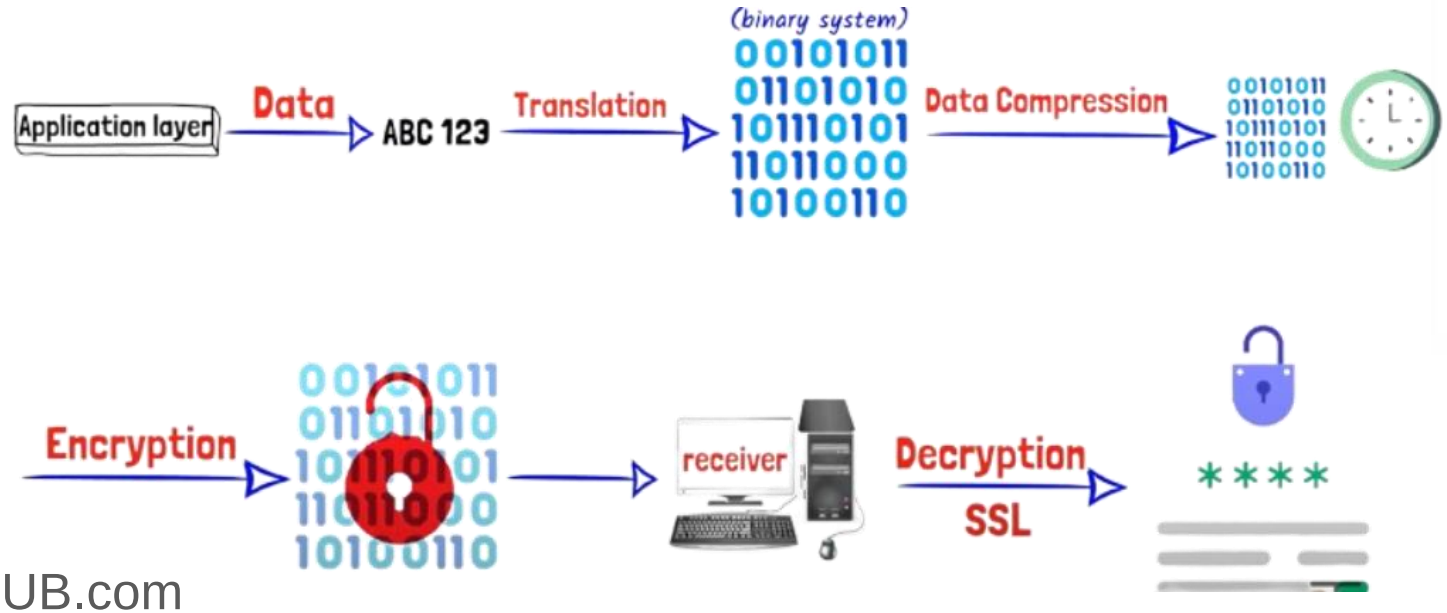
Layer 6: Presentation Layer

- Presentation Layer is responsible for converting data into standard format.
- **Examples:** ASCII, JPEG, MPEG, WAV, MP3.
- **Following tasks are perform at Presentation layer :**
  - Translation / Compression / Encoding / Encryption.





Layer 5: Session Layer

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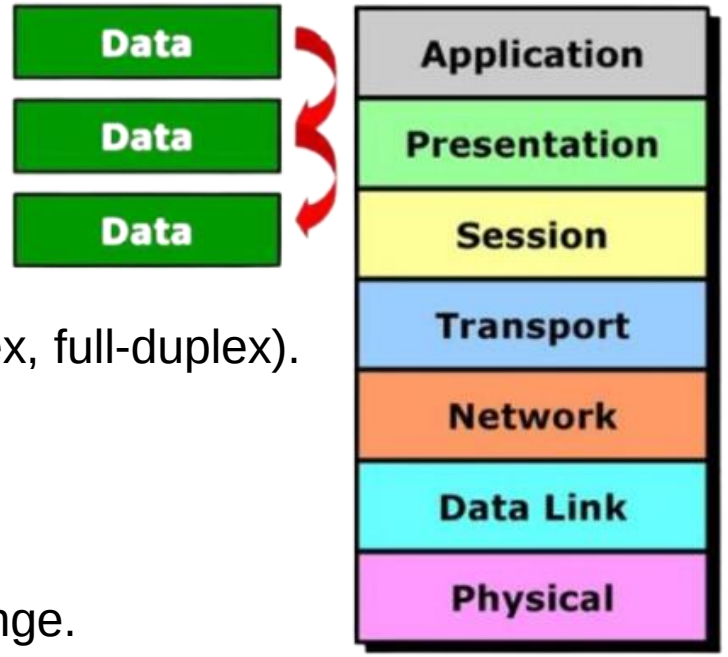
Layer 5: Session Layer



- **Function**: Establishes, maintains, and terminates sessions.
- **Session ID**: Identifies active sessions.
- **Key Features**:
  - **Transmission Modes**: Controls communication style (half-duplex, full-duplex).
  - **Authentication**: Verifies user identity.
  - **Authorization**: Grants access permissions.
  - **Session Management**: Manages session state and data exchange.
- **Examples :**
  - RPC Remote Procedure Call
  - SQL Structured Query Language
  - NFS Network File System

Layer 4: Transport Layer

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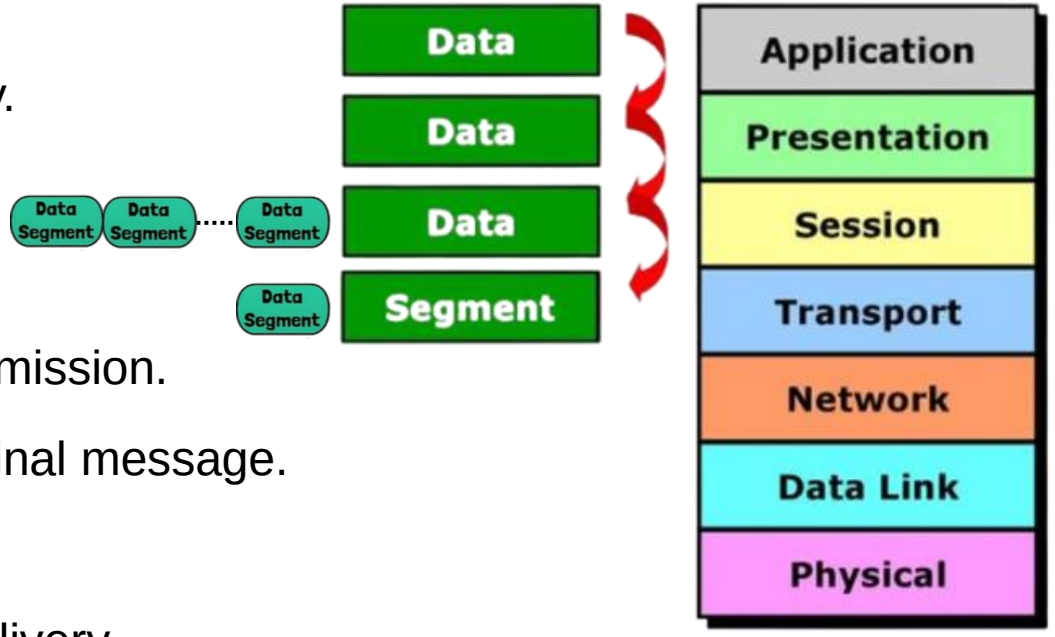

- Transport Layer is responsible for end-to-end connectivity.
- It is also known as the heart of OSI Layers.
- **Manages transmission packets:**
  - Breaks long messages into smaller packets for transmission.
  - Reassembles packets in correct order to get the original message.
- **Handles error recognition and recovery:**
  - Transport layer at receiving acknowledges packet delivery.
  - Resends missing packets.
- **Examples:**
  - TCP
  - UDP

Layer 4: Transport Layer (Cont.)

- **Identifying Service:**

TCP	UDP
Transmission Control Protocol	User Datagram Protocol
Connection Oriented	Connection Less
Acknowledgement	No Acknowledgement
Reliable	Unreliable
Slower	Faster
e.g. HTTP, FTP, SMTP	e.g. DNS, DHCP, TFTP

Layer 3: Network Layer

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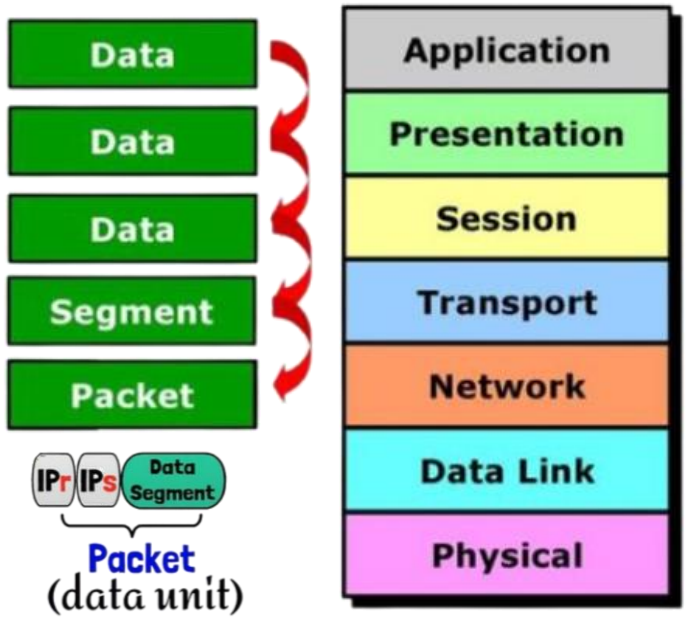

- **Function:** Manages addressing and routing of data within the subnet.
- **Key Tasks:**
  - Determines the route from the source to the destination.
  - Manages traffic issues (switching, routing, congestion control).
- **Routing Types:**
  - Static Routing: Uses fixed tables set at the start of each session.
  - Dynamic Routing: Routes are determined for each packet based on current network conditions.
- **Key Device:**
  - Routers 
- **Examples:**
  - IP, RIP, OSPF.

Layer 2: Data Link Layer

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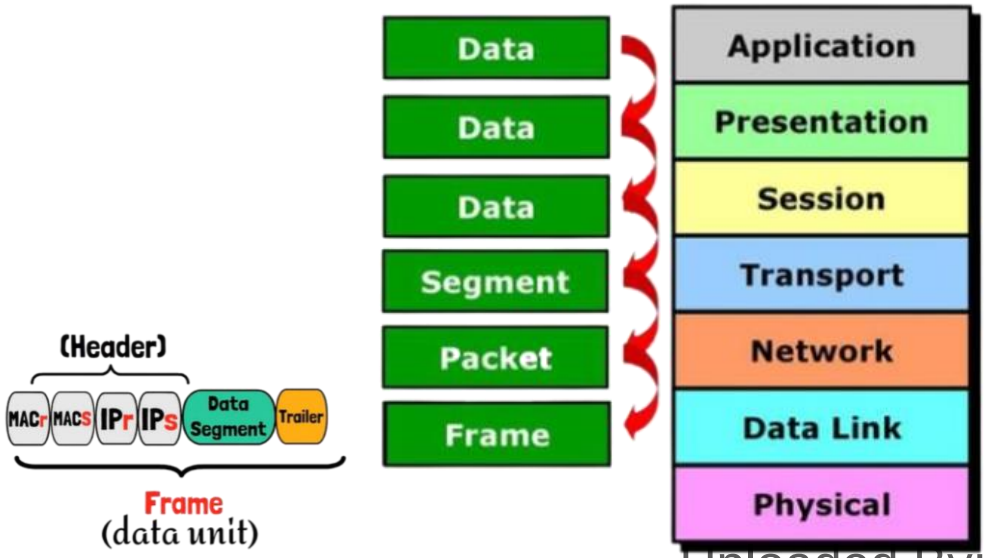
Layer 2: Data Link Layer

- **Function:** Packages raw bits from the Physical Layer into structured frames.
- **MAC (Media Access Control):**
  - Handles physical addressing with MAC addresses (48-bit, 12-digit hexadecimal).
  - 00-B0-D0-63-C2-26
  - Each MAC address is unique to a device, allowing for proper data delivery on a local network.
  - Responsible for error detection.
- **Key Devices:**
  - Switches 
  - Bridges
  - Network Interface Cards (NICs)



Layer 1: Physical Layer

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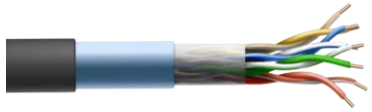
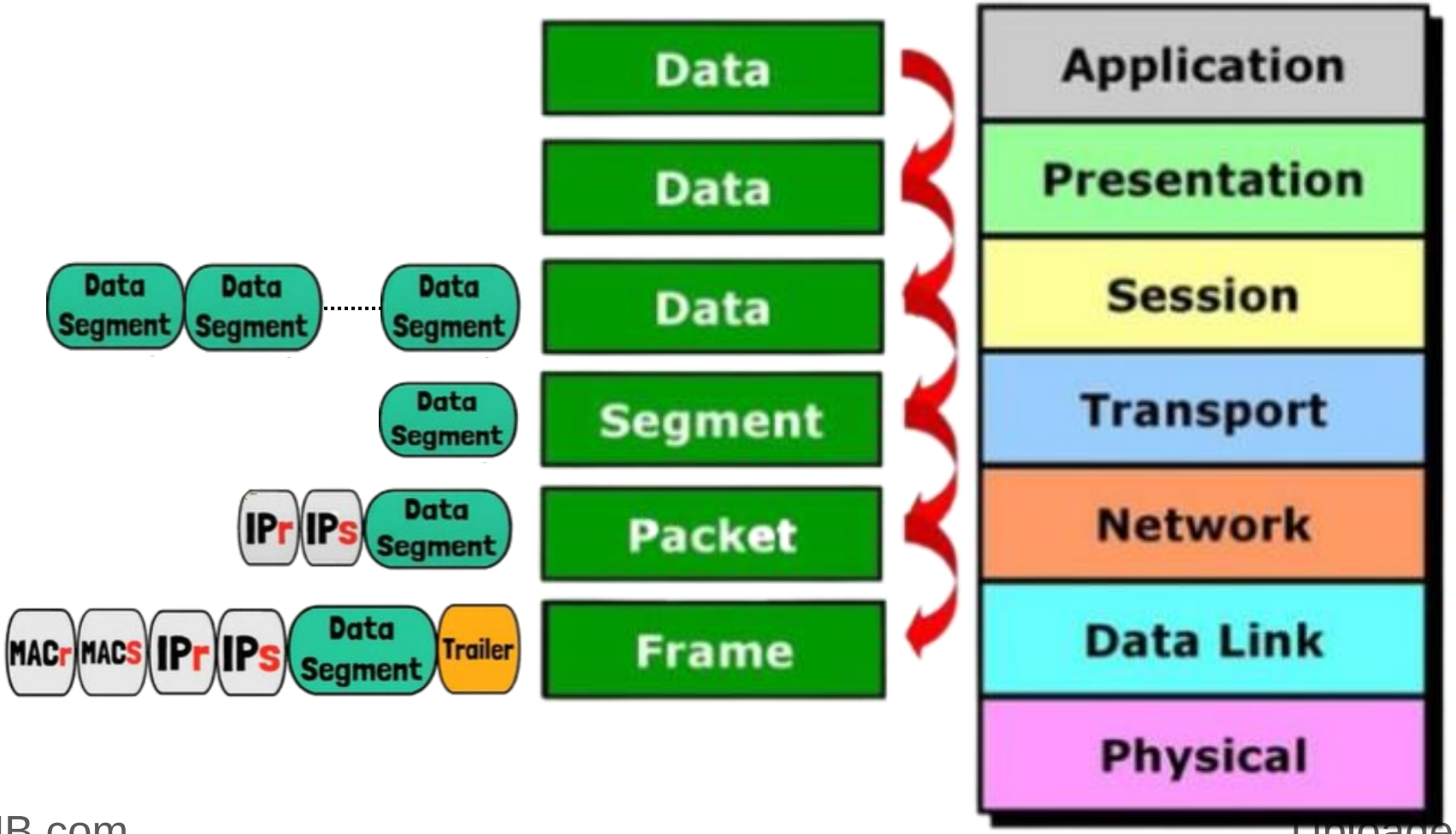
Layer 1: Physical Layer

- **Function:** Transmits bits from one computer to another.
- **Key Responsibilities:**
  - Regulates the transmission of a stream of bits over a physical medium.
  - Defines how cables connect to network adapters and the transmission techniques used.
- **Key Considerations:**
  - Signal Definitions: Defines 0 and 1 (e.g., voltage levels for signals).
  - Transmission Modes: Determines if the channel is simplex (one way) or duplex (two way).
- **Types of Signals:**
  - Copper Cable: Uses electrical signals. 
  - Fiber Optic Cable: Uses light signals. 
  - Wireless: Uses radio waves. 

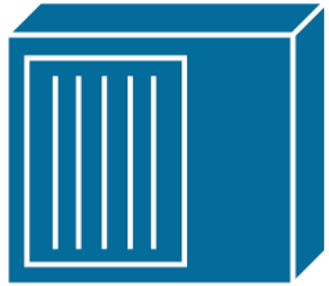
Data, Segments, Packets and Frames



Network Devices

Hub (Network Device)

- Connects multiple devices in a network.
- Broadcasts data to all connected devices.
- **Layer:** Layer 1 (Physical Layer) of the OSI model.
- **Loop Issue:** Two connected hubs can create a broadcast storm.



Hub

Bridge (Network Device)

- Connects multiple network segments.
- Filters and forwards data based on MAC addresses.
- **Layer:** Layer 2 (Data Link Layer) of the OSI model.
- Reduces collisions and improves network efficiency.

Bridge

Switch (Network Device)

- Connects multiple devices within a network.
- **Layer:** Layer 2 (Data Link Layer) of the OSI model.
- Uses MAC addresses to forward data only to the intended device, reducing unnecessary traffic.
- Supports full-duplex communication, allowing simultaneous data transmission and reception.
- **Switch = Hub + Bridge.**

Switch

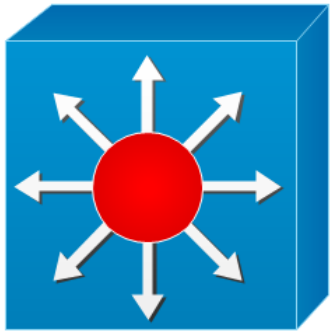
Router (Network Device)

- Connects multiple networks and routes data between them.
- **Layer:** Layer 3 (Network Layer) of the OSI model.
- Uses IP addresses to determine the best path for data packets.
- Can perform network address translation (NAT) to allow multiple devices to share a single IP address.

Router

Multilayer Switch (Network Device)

- Combines the functionality of a switch and a router.
- **Layer:** Layer 2 (Data Link Layer) and Layer 3 (Network Layer) of the OSI model.
- Can switch data based on MAC addresses and route data based on IP addresses.
- Reduces latency by performing routing at hardware speeds.
- Supports advanced features like Quality of Service (QoS) and VLANs.
- **Multilayer Switch = Router + Switch.**



Multilayer Switch

Repeater (Network Device)

- Regenerates and amplifies signals to extend the range of a network.
- **Layer:** Layer 1 (Physical Layer) of the OSI model.
- Used to connect segments of a network, overcoming distance limitations of cabling (like Ethernet).
- Helps maintain signal strength and quality over long distances.

Repeater

Splitter (Network Device)

- Divides a single network connection into multiple connections.
- Often used in Ethernet networks to allow multiple devices to share a single cable.
- **Layer:** Layer 1 (Physical Layer) of the OSI model.

Splitter

Network Classes

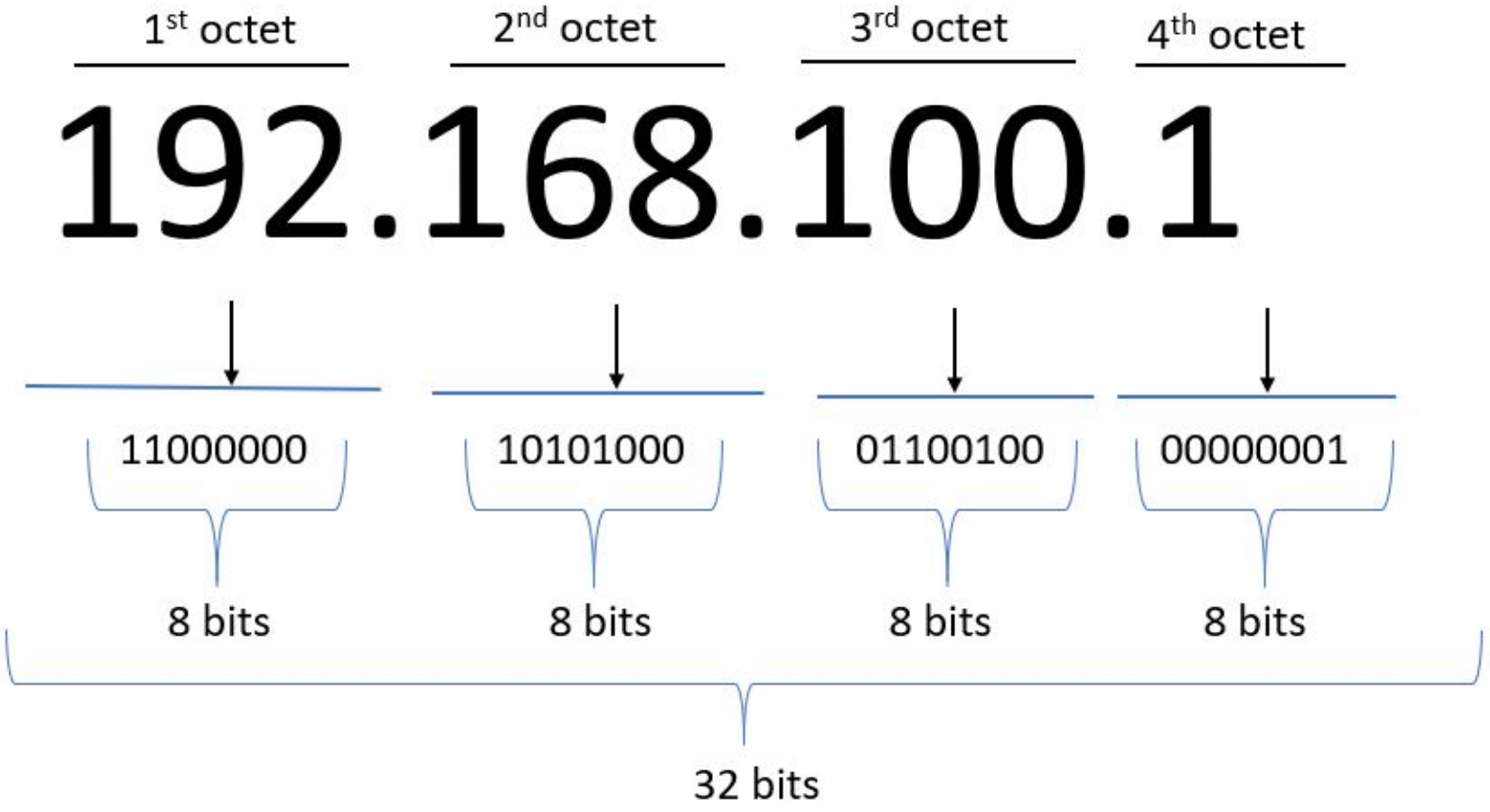
Internet Protocol (IP)

- **Definition:** A set of rules for sending and receiving data over the Internet.
- **Key Features:**
  - **Addressing:** Each device has a unique IP address for identification.
  - **Routing:** Determines the best path for data packets to travel.
  - **Packetization:** Breaks data into smaller packets for transmission, each containing source and destination addresses.
- **Versions:**
  - **IPv4:** 32-bit addresses, allowing ~4.3 billion unique addresses.
  - **IPv6:**128-bit addresses, providing virtually unlimited addresses to support the growing number of devices.
- **Importance:** Enables communication between devices on different networks.

IPv4

- **IPv4 Format:** 32-bit address written as 4 numbers (e.g., 192.168.1.1).
- **Network & Host Bits:**
  - Network Bits: Identify the network.
  - Host Bits: Identify individual devices.
- **Subnet Mask:** Divides network and host parts (e.g., 255.255.255.0 means 24 network bits, 8 host bits).
- **Network IP:** The first address in a range, used to identify the network (e.g., 192.168.1.0).
- **Broadcast IP:** The last address in a range, used to send messages to all devices (e.g., 192.168.1.255).

IPv4 (Cont.)



Slash Notation

Slash Notation	Binary (Network Bits/Host Bits)	Subnet Mask	Hosts
/24	11111111.11111111.11111111.00000000	255.255.255.0	254
/25	11111111.11111111.11111111.10000000	255.255.255.128	126
/26	11111111.11111111.11111111.11000000	255.255.255.192	62
/27	11111111.11111111.11111111.11100000	255.255.255.224	30
/28	11111111.11111111.11111111.11110000	255.255.255.240	14
/29	11111111.11111111.11111111.11111000	255.255.255.248	6
/30	11111111.11111111.11111111.11111100	255.255.255.252	2

Example:

- **For the IPv4 Address 192.168.10.50/24, find:**
  1. Subnet Mask.
  2. Network Bits.
  3. Host Bits.
  4. Network IP Address.
  5. Broadcast IP Address.
  6. Number of Hosts.

Example (Solution):

192.168.10.50/24

1. **Subnet Mask:** 255.255.255.0
   - /24 means the first 24 bits are network bits.
2. **Network Bits:** (first 3 octets) = **3*8 = 24 Bits.**
   - These identify the network.
3. **Host Bits:** (last octet) = **1*8 = 8 Bits.**
   - Identifies the device within the network.
4. **Network IP Address:** 192.168.10.0
   - First address in the subnet, used to identify the network.
5. **Broadcast IP Address:** 192.168.10.255
   - Last address in the subnet, used to broadcast messages to all devices.
6. **Number of Hosts = ($2^{\text{Host Bits}}$ – 2) = (256 – 2) = 254 Hosts**

Network IP + Broadcast IP

TCP/IP Network Classes

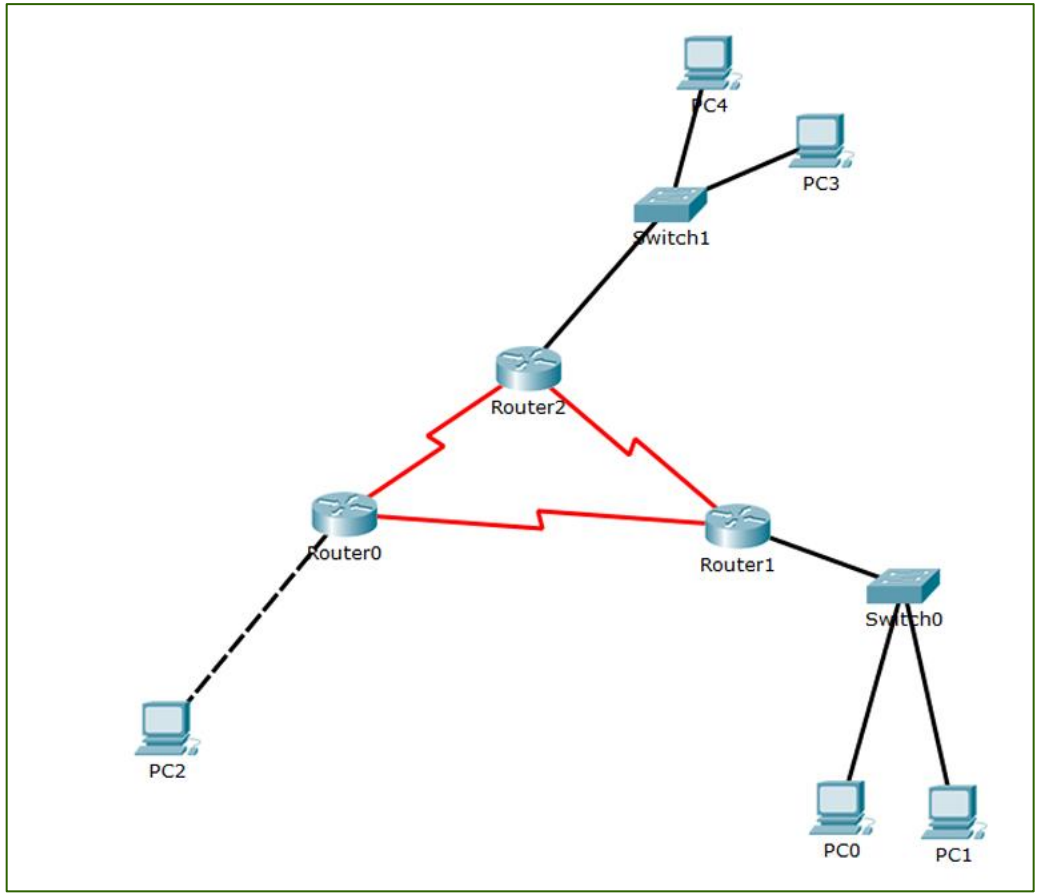
- **Classes Determine Network Size:** IP addresses are divided into classes (A, B, C) based on the number of hosts per network.
- **Class D & E:** Not used for standard networking;
  - Class D for multicast.
  - Class E for research.

Address Class	IP Range	Bits for Subnet Mask	Subnet Mask
Class A	1.0.0.1 – 126.255.255.254	Left most 8 bits	255.0.0.0
Class B	128.0.0.1 – 191.255.255.254	Left most 16 bits	255.255.0.0
Class C	192.0.0.1-223.255.255.254	Left most 24 bits	255.255.255.0

- **127.0.0.1: Loopback address**

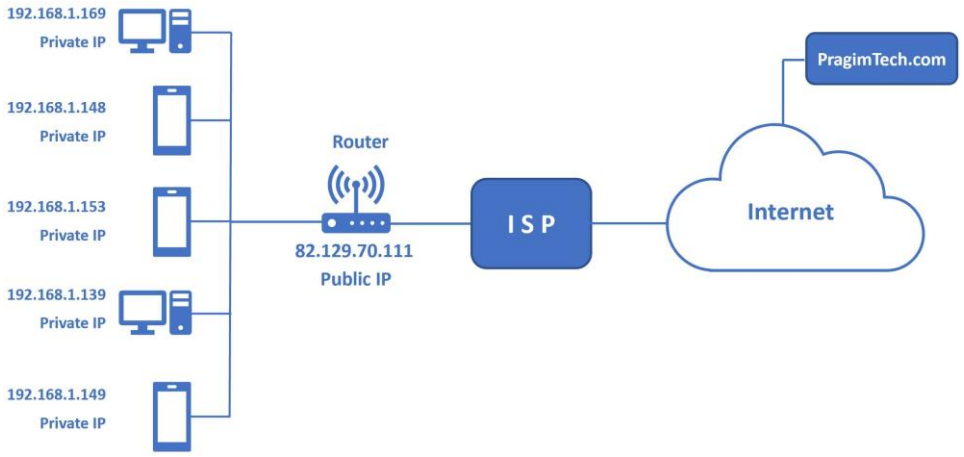
Question

- **How many networks are there in following figure?**

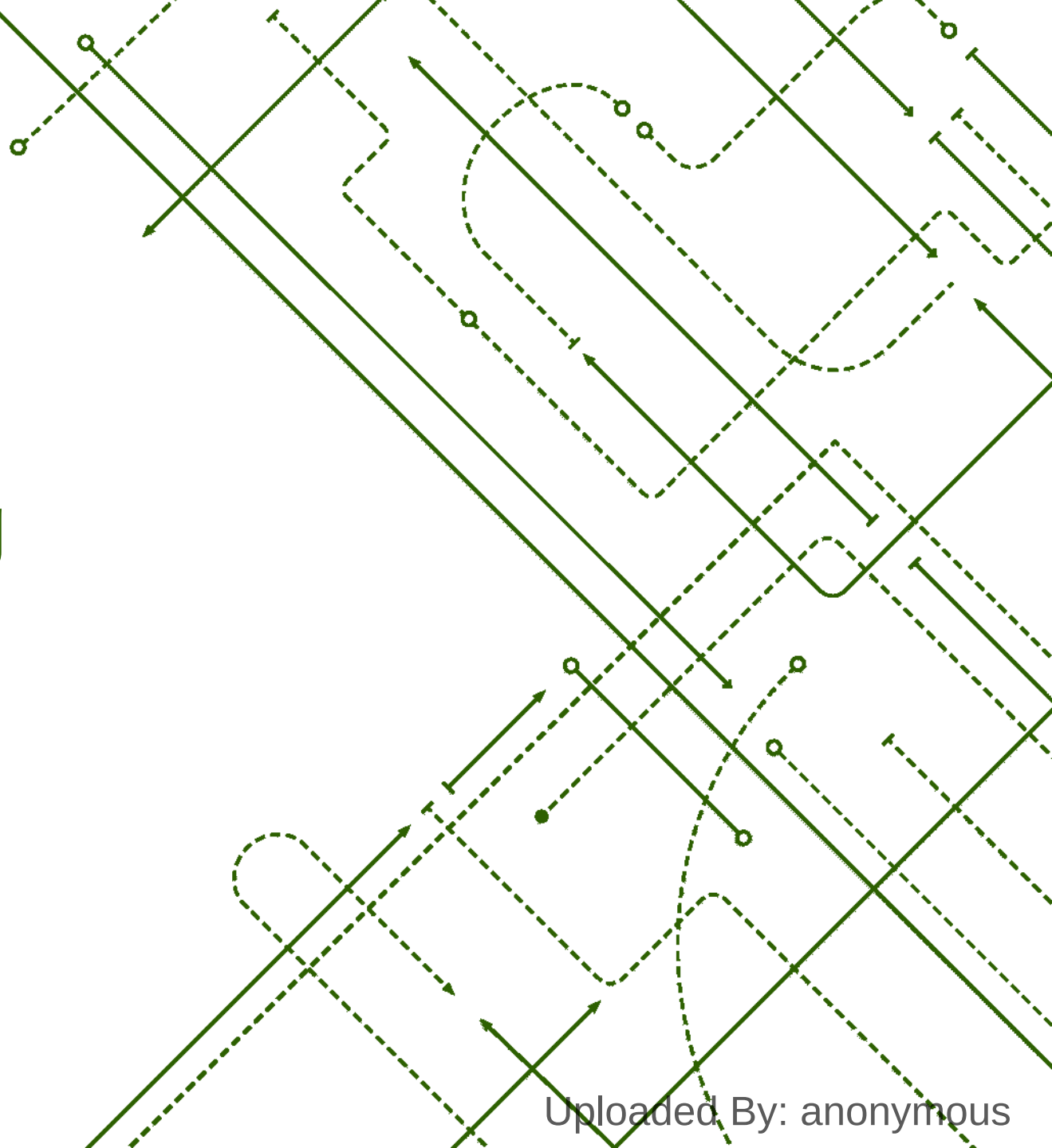


Private IP vs Public IP

- **Private IP:**
  - Used within internal networks (e.g., home, office).
  - Not accessible directly from the Internet.
- **Public IP:**
  - Used to connect to the Internet.
  - Globally unique and assigned by an Internet Service Provider (ISP).



IP Subnetting



What is Subnetting?

- **Definition:** Subnetting is the process of dividing a large network into smaller, more manageable sub-networks (subnets).

- **How It Works:**
  - **The IP address is split into three parts:**
    - Network Part
    - Host Part
    - Subnet Part (borrowed from host bits)

- **Purpose:** Helps efficiently manage network traffic and improve security by isolating different subnets.

Example:

- **Given the following topology, divide the given class C address 192.168.1.0/24 range on the Networks A, B, C, D, E using minimum number of IPs.**
- **Net A = 2 Hosts**
- **Net B = 19 Hosts**
- **Net C = 6 Hosts**
- **Net D = 99 Hosts**
- **Net E = 5 Hosts**

Example (Solution):

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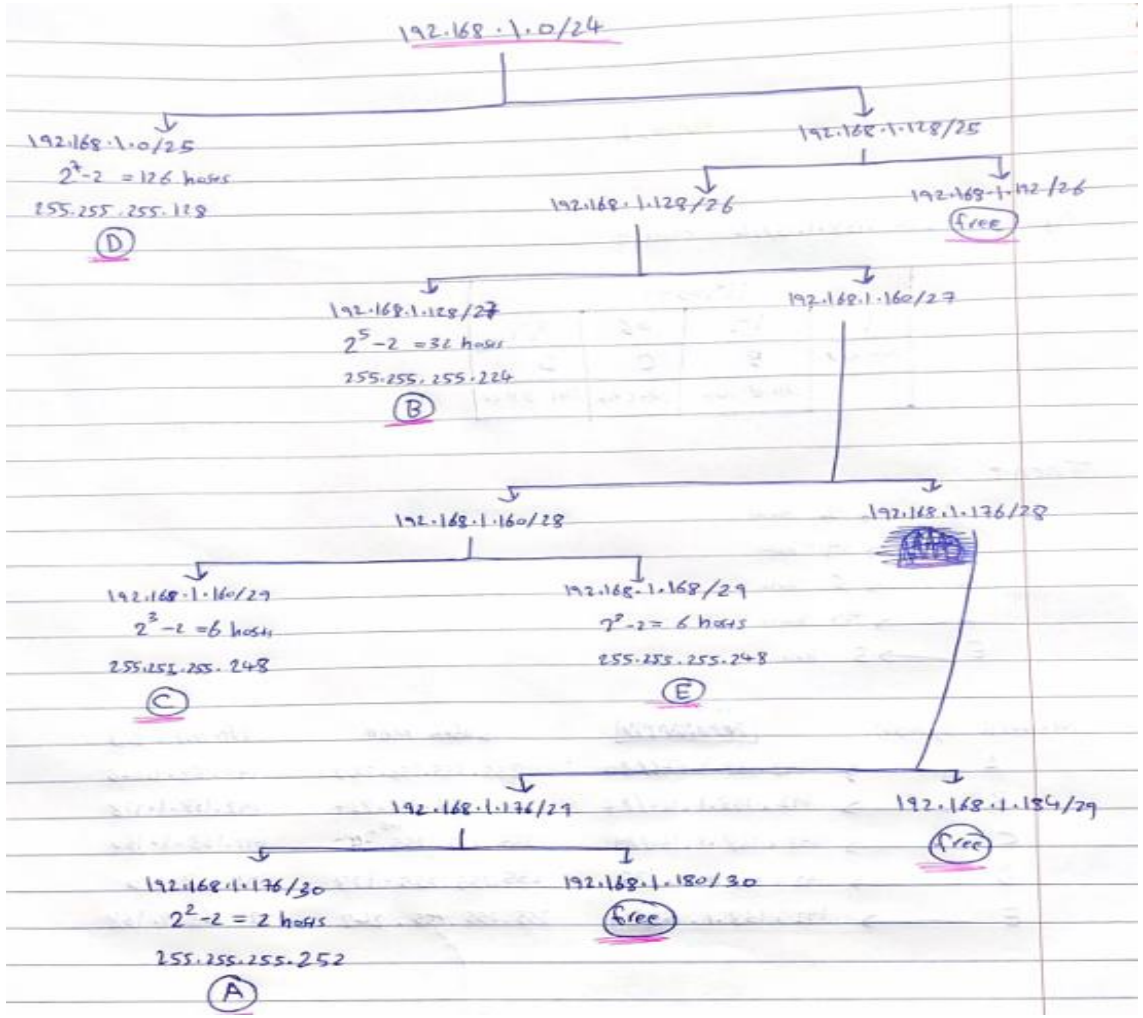

References

- **Manual for ENCS4130 Computer Networks Laboratory.**
- **Slides from Dr. Amr Slimi.**