QUIZ

1. Bluetooth is an example of _____
a) personal area network
b) local area network
c) virtual private network
d) wide area network

2. Which of the following networks extends a private network across public networks?
a) local area network
b) virtual private network
c) enterprise private network
d) storage area network

private → public → private.
private area N/w.
Virtual private N/w (VPN)

QUIZ

3) In which of the following switching methods, the message is divided into small packets?

1. Message switching
2. Packet switching
3. Virtual Switching
4. None of these

4) Which of the following switch methods creates a point-to-point physical connection between two or more computers?

1. Message switching
2. Packet switching
3. Circuit switching
4. None of these

QUIZ

5) POTS network works on the principle of _____

A) Telephone Switching
B) Proxy server
C) File system
D) Circuit system

6) Which of the following addresses is 32-bit?

a) MAC address
b) Virtual address / logical address.
c) Source address
d) Destination address

QUIZ

7) Which one of the following is not a network topology?

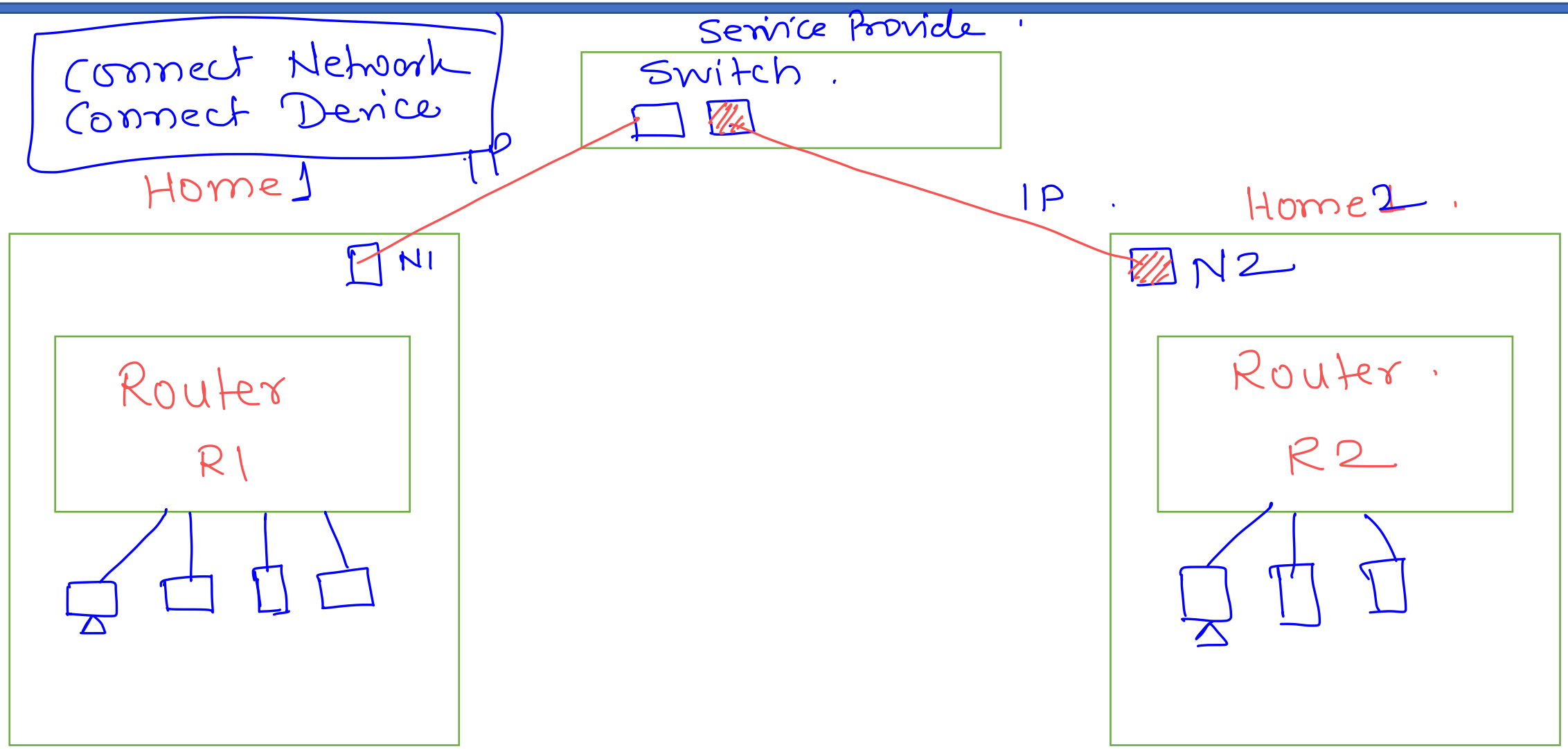
1. Star
2. Ring
3. Bus
4. Peer to Peer

8) The term FTP stands for?

1. File transfer program
2. File transmission protocol
3. File transfer protocol
4. File transfer protection

Network Devices / Internetworking Devices

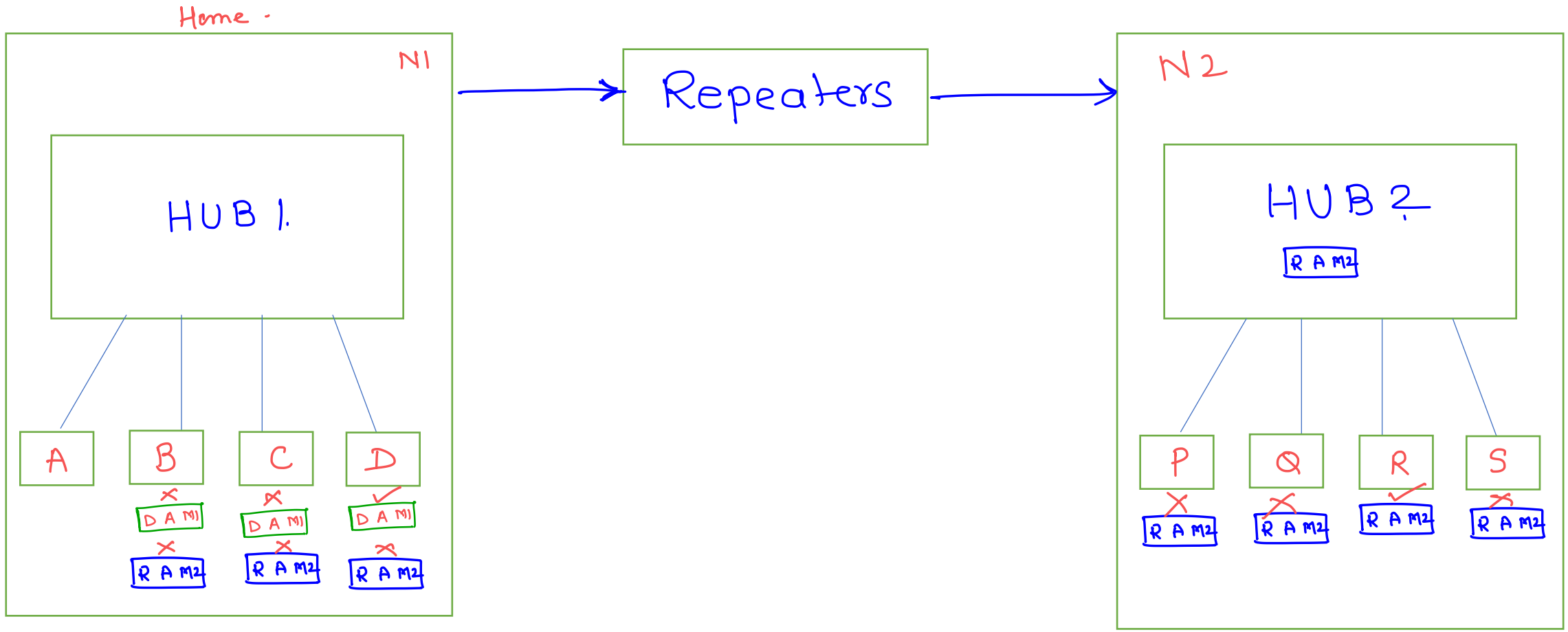
Network Device



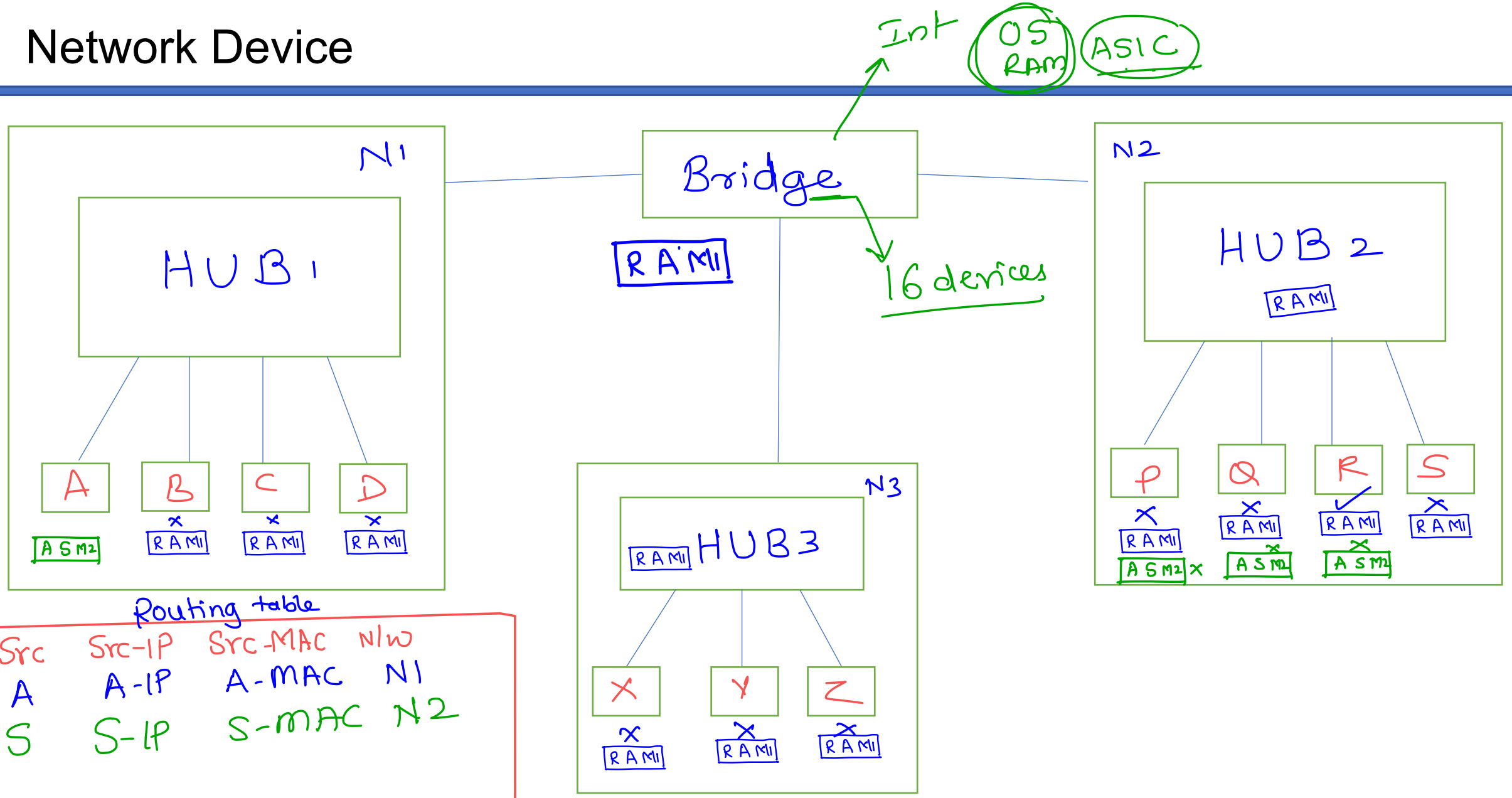
Internetworking Devices

- Internetworking devices are products used to connect networks.
- As computer networks grow in size and complexity, so the internetworking devices used to connect them.
  - Hubs
  - Repeaters
  - Bridges
  - Switches
  - Routers
  - Gateways

Network Device



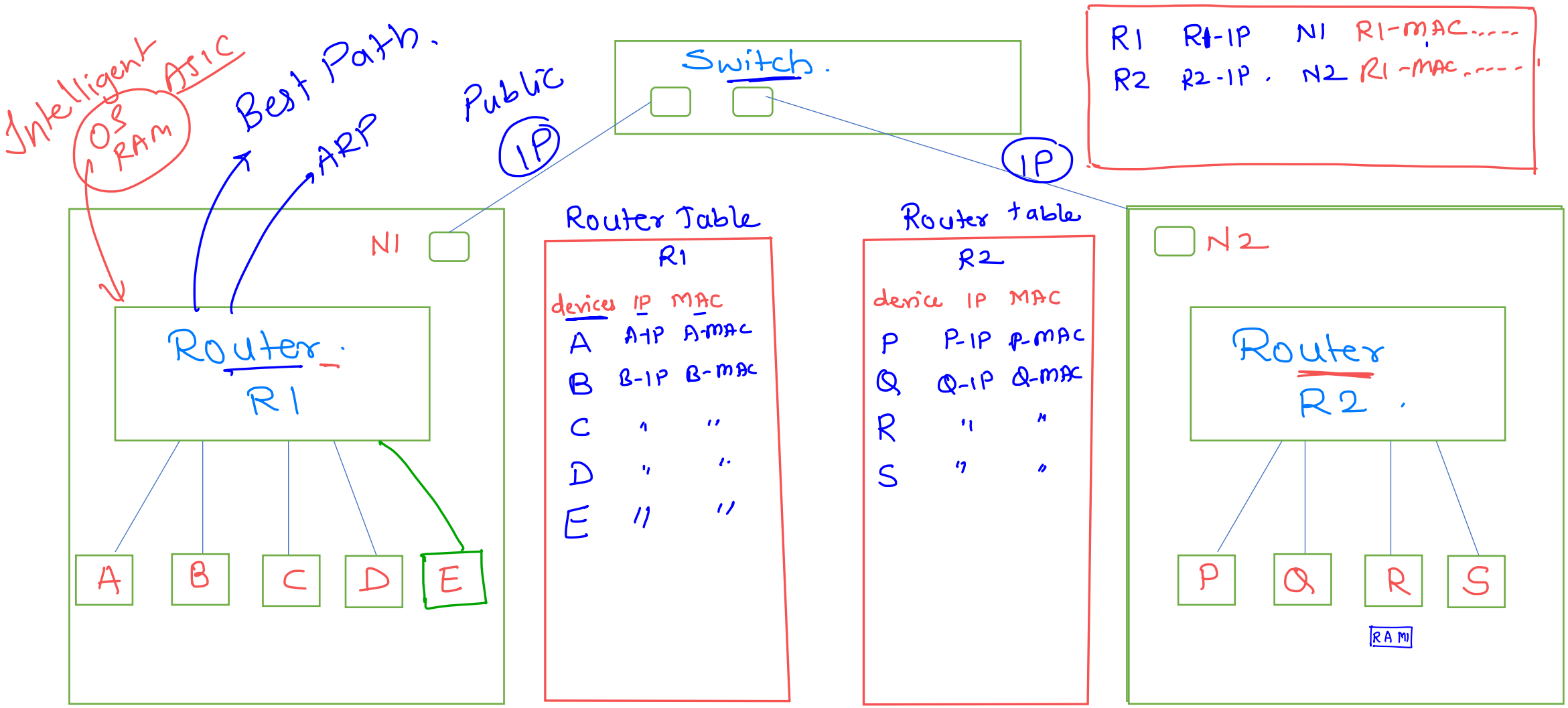
Network Device



Routing table

Src	Src-IP	Src-MAC	N/w
A	A-IP	A-MAC	N1
S	S-IP	S-MAC	N2

Network Device



Hubs

- Hub is used to build a LAN.
- Common connection point for devices in a network.
- It is non intelligent device.
- It does not understand the addressing.
- Hub is Multiport repeater containing multiple ports to interconnect multiple devices
- Hubs regenerate and retime network signals (increases traffic and collision)
- They cannot filter network traffic and they cannot determine best path
- The hub contains multiple ports.
- When a packet arrives at one port, it is copied to the other ports so that all segments of the LAN can see all packets.
  - does not concern about the address
  - concerns with only electrical signals
  - increases the traffic, as they broadcast data to all
  - increases the collision

Repeaters

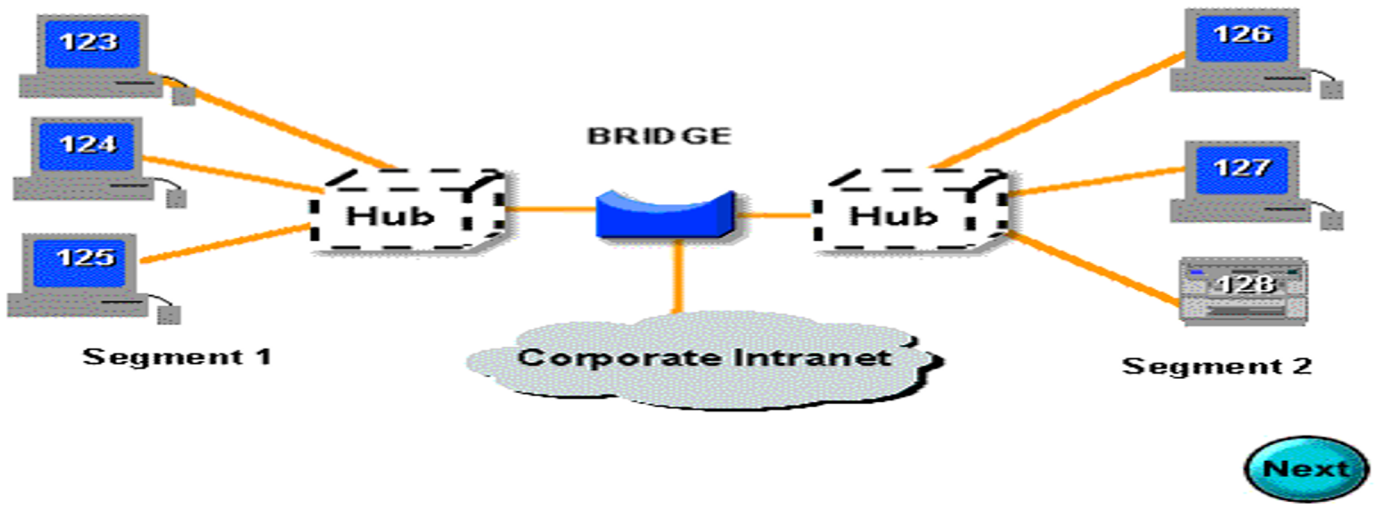
- Repeaters or hubs work at the OSI physical layer to regenerate the network's signal and resend them to other segments.
- Its job is to regenerate the signal over the same network before the signal becomes too weak or corrupted so as to extend the length to which the signal can be transmitted over the same network.
- The longer the cable length, the weaker and more deteriorated the signals become as they pass along the networking media.
- Repeaters can be installed along the way to ensure that data packets reach destination.

One way to solve the problems of too much traffic on a network and too many collisions is to use an internetworking device **called a bridge.**

Bridges : Operates at Data Link Layer

- A bridge eliminates unnecessary traffic and minimizes the chances of collisions occurring on a network by dividing it into segments .
- Device that connects and passes packets between two network segments.
- More intelligent than hub-As they analyze incoming packets and forwards (or drops) based on addressing
- Bridges work best where traffic from one segment information.(Routing Table is Build to record segment number of address)
- If a network to other segments is not too great.

Bridge Example



However, when traffic between network segments becomes too heavy, the bridge can become a bottleneck and actually slow down communication.

Switches (Multiport Bridges)

- **Switches operate at the Data Link layer (layer 2) of the OSI model**
- A switch is a device that is used to segment networks into sub networks called subnets. (Used to build LAN)
- **Can interpret address information**
- Uses Addressing Scheme knows as MAC Addressing.
- Switches are capable of inspecting data packets as they are received, determining the source and destination device of that
  packet, and forwarding it appropriately

- Switches have
  - ASIC (Application Specific IC)
  - OS is hardcoded in microprocessor
  - So switches are hardware based.
  - Ports are unlimited

- Bridges have
  - OS is separated
  - So bridges are not used
  - Bridges are software based.
  - Limited Ports (16)

Routers

- Used to build WAN
- The router connects multiple networks and routes the packets.
- Uses an IP Address to identify every machine uniquely.
- Routers are used to connect two or more networks. For routing to be successful, each network must have a unique network number
- Routers can make intelligent decisions as to the best path for delivery of data on the network.
- They use the “logical address” of packets and routing tables to determine the best path.

Gateways

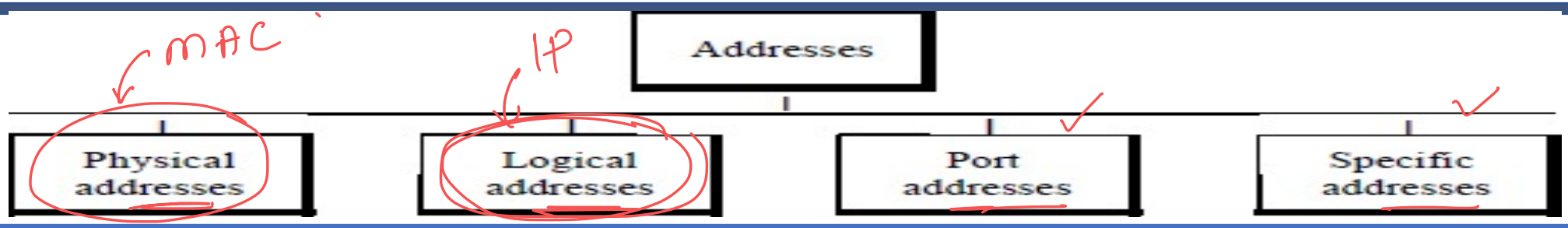
- Device that connects dissimilar networks.
- Operates at the highest level of abstraction.
- Expands the functionality of routers by performing data translation and protocol conversion.
- Establishes an intelligent connection between a local network and external networks with completely different structures.
- Gateways serve as an entry and exit point for a network as all data must pass through or communicate with the gateway prior to being routed.
- If a network wants to communicate with devices, nodes or networks outside of that boundary, they require the functionality of a gateway.
- A gateway is often characterized as being the combination of a router and a modem.

http → https .

Gateways → Software .

Addressing

Addressing



Physical Address/ Link Address

- For example, Ethernet uses a 6-byte (48-bit) physical address that is imprinted on the network interface card (NIC).

Logical Address

- logical address in the Internet is currently a 32-bit address that can uniquely define a host connected to the Internet.

Port Address

- computer A can communicate with computer C by using TELNET. At the same time, computer A communicates with computer B by using the File Transfer Protocol (FTP).

Specific Addresses

- Examples include the e-mail address and Uniform Resource Locator (URL)

Port Address.

port address.

http. → hyper text transfer protocol → Unique addr. → 80

http://google.co.in

https →

Emails { SMTP → , POP3 → }

ftp → 20

ssh →

Specific Address.

Website develop.

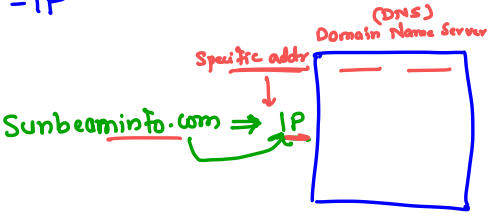
↓

Upload. (hosting) . IP.

sunbeaminfo.com .

↓

132.12.9.6 - IP



IPV4 → 32bit ✓
IPV6 → 128-bit

Logical Address - Internet Protocol (IP)

1 Byte	2 Byte	3 Byte	4 Byte
8-bit	8-bit	8-bit	8-bit
(0-255)	(0-255)	(0-255)	(0-255)

IPV4 → 32 bit
2^0
2^1
2^2
⋮
2^{32}
IP — 4 octets.

1 Byte = 8 bit
$2^8 = 256$
(0-255)

dotted decimal Notation
- Min IP addr. ⟹ 0.0.0.0
- Max IP addr ⟹ 255.255.255.255

172.2.1.65 → Valid
255.254.254.255 → Valid

Binary Notation
- Min IP addr ⟹ 00000000 00000000 00000000 00000000
- Max IPaddr ⟹ 11111111 11111111 11111111 11111111

172.2.1.1.65 → invalid.
255.256.216.176 → invali

8.12.5.3
00001000 00001100 00000101 00000011 → Binary IP

00000001 00000110 00000111 00001101 → valid

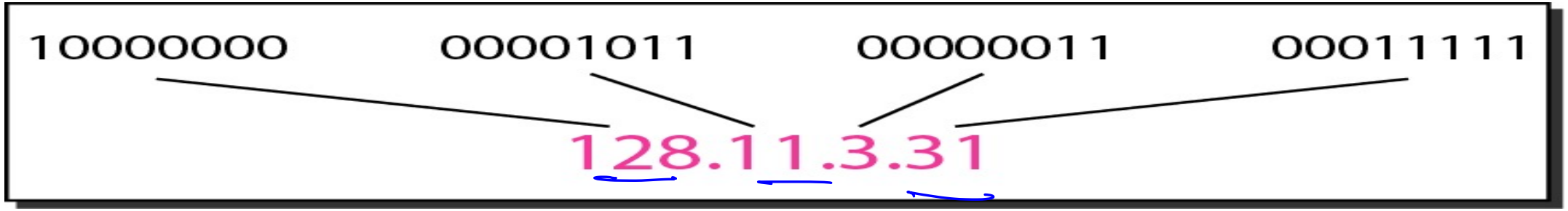
IP Address / Logical Address

- IP address to mean a logical address in the network layer of the TCP/IP protocol suite.
- Identify a machine / device uniquely.
- Size = 4 bytes = 32 bits
- to find the IP address of Machine
  - windows: ipconfig
  - linux/macOS: ifconfig
- IP Versions:
  - IPV4 (32 bits address length)
  - IPV6 (128 bits address length)
- IP addresses are made up of four sets of numbers called **“Octets”.**
- Types
  - Private : used to identify a machine on the LAN and can not be used to connect to internet
  - Public : used to connect to the internet
- e.g.
  - decimal: 192.168.1.6
  - binary : 11000000 10101000 00000001 00000110

IP Addressing Types

- Classful : IP Address is split into 5 classes
- Classless

  - IPv4 uses 32-bit addresses, which means that the address space is 2^{32} or4,294,967,296 (more than 4 billion)
  - **There are two prevalent notations to show an IPv4 address:**
    - binary notation
    - dotted decimal notation



Example

- *Find the error, if any, in the following IPv4 addresses.*

a. 111.56.045.78 → Invalid (octal).

b. 221.34.7.8.20 → Invalid.

c. 75.45.301.14 → Invalid.

d. 11100010.23.14.67 → Invalid.

Example

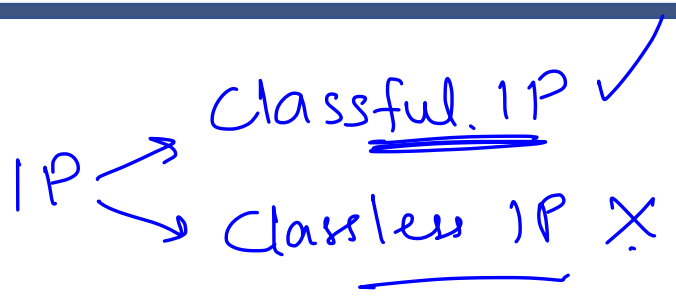
- *Find the error, if any, in the following IPv4 addresses.*

a. 111.56.045.78

b. 221.34.7.8.20

c. 75.45.301.14

d. 11100010.23.14.67



Solution

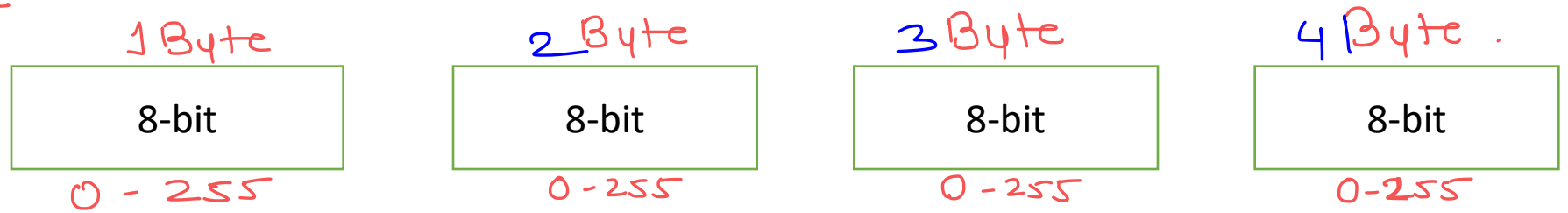
a. There must be no leading zero (045).

b. There can be no more than four numbers.

c. Each number needs to be less than or equal to 255.

d. A mixture of binary notation and dotted-decimal notation is not allowed.

Classful IP Address → 32 bit



1st byte tells you which class it belong to.

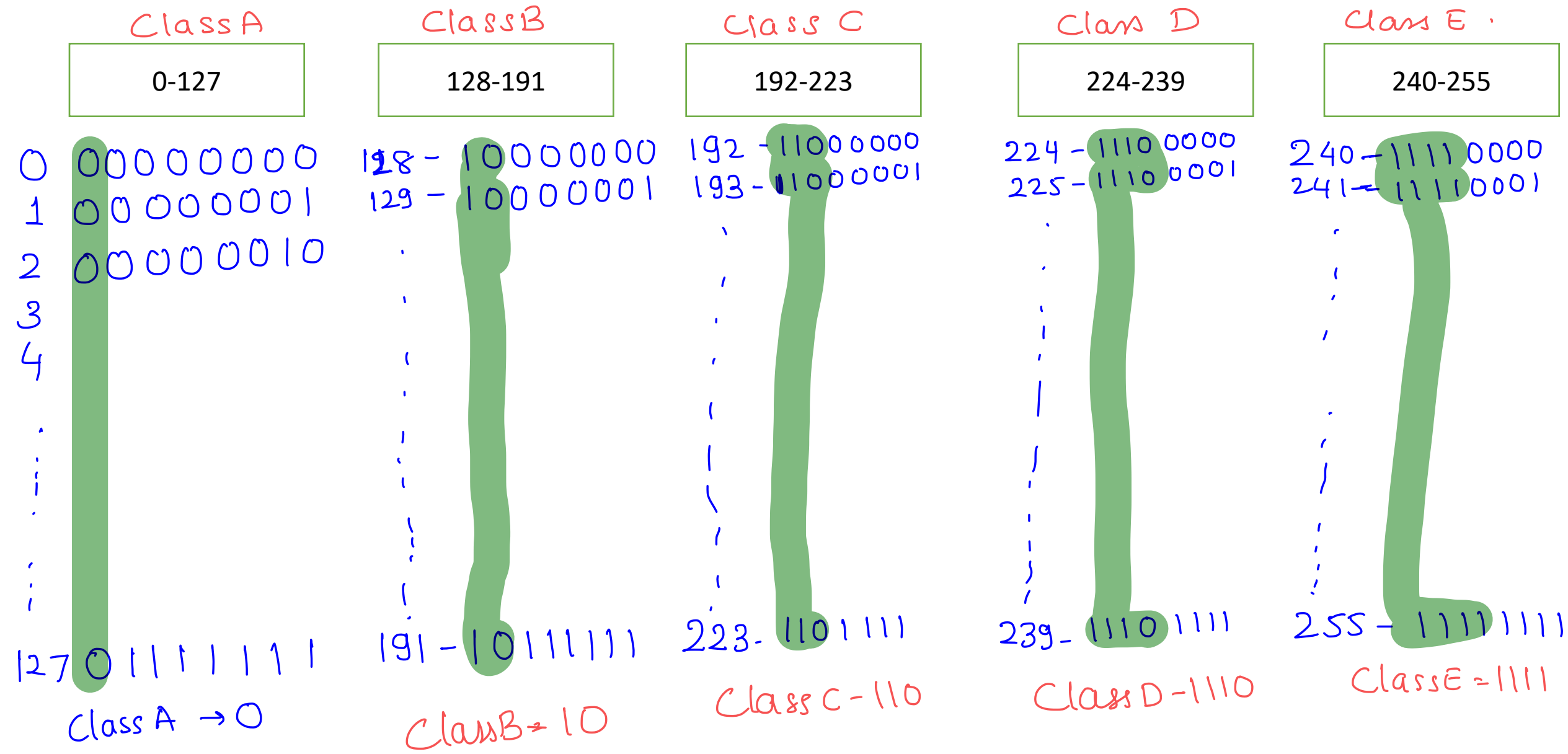
Class A	0 - 127	0.0.0.0 → 127.255.255.255
Class B	128 - 191	128.0.0.0 → 191.255.255.255
Class C	192 - 223	192.0.0.0 → 223.255.255.255
Class D	224 - 239	224.0.0.0 → 239.255.255.255
Class E	240 - 255	240.0.0.0 → 255.255.255.255

172.0.1.21 → valid → Class B.

10.0.1.2 → Class A.

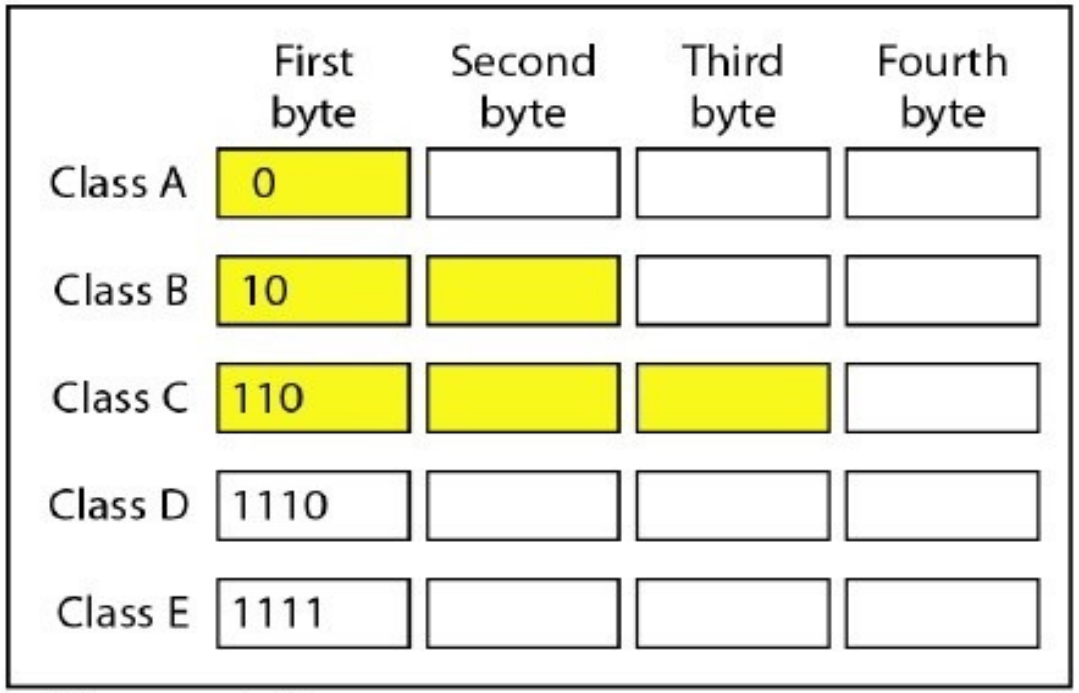
254.1.2.12 → Class E.

255.255.12.256 → invalid

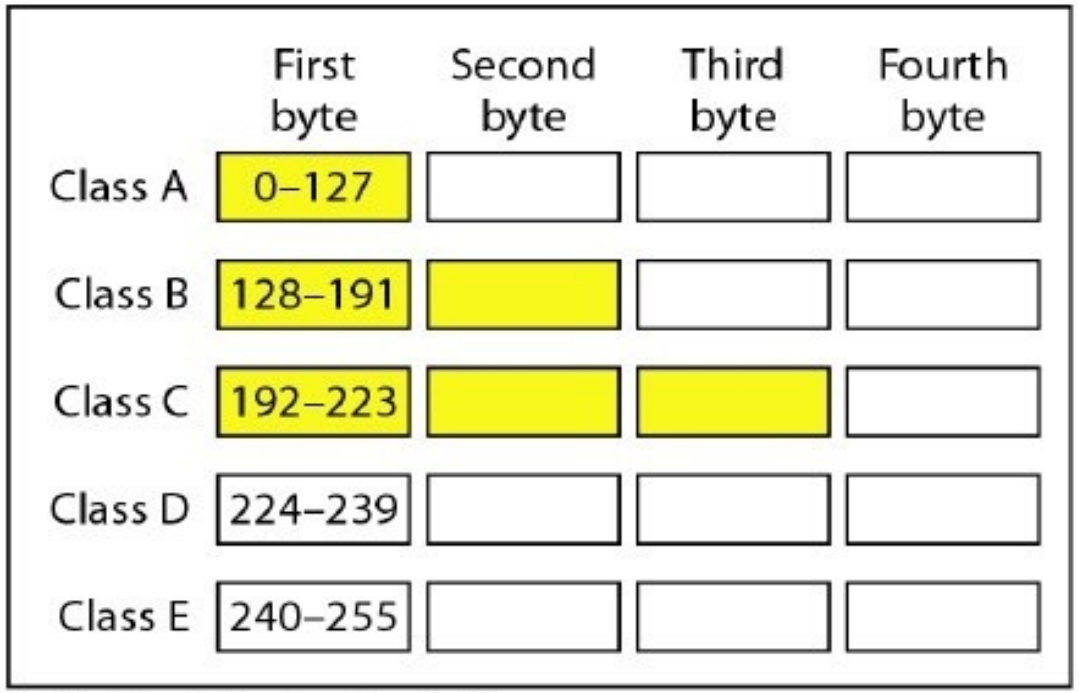

Class A
0-127
0 00000000
1 00000001
2 00000010
3
4
127 01111111
Class A → 0
Class B
128-191
128 - 10000000
129 - 10000001
191 - 10111111
Class B = 10
Class C
192-223
192 - 11000000
193 - 11000001
223 - 11011111
Class C - 110
Class D
224-239
224 - 11100000
225 - 11100001
239 - 11101111
Class D - 1110
Class E
240-255
240 - 11110000
241 - 11110001
255 - 11111111
Class E = 1111

Classful Addressing

- IP is 32 bit means 2^{32} IP Addresses. (more than 4 billion , so many IP Addresses)
- We need to distribute those that's why we have classes.
- In classful addressing, the address space is divided into five classes: A, B, C, D, and E.



a. Binary notation



b. Dotted-decimal notation

Example

- Find the class of each address.

1. 00000001 00001011 00001011 11101111 → Class A.
2. 11000001 10000011 00011011 11111111 → Class C.
3. 14.23.120.8 → Class A.
4. 252.5.15.111 → Class E.

Example

- Find the class of each address.

1. 00000001 00001011 00001011 11101111
2. 11000001 10000011 00011011 11111111
3. 14.23.120.8
4. 252.5.15.111

Solution

1. The first bit is O. This is a class A address.
2. The first 2 bits are 1; the third bit is O. This is a class C address.
3. The first byte is 14 (between 0 and 127); the class is A.
4. The first byte is 252 (between 240 and 255); the class is E.

Points to be noted

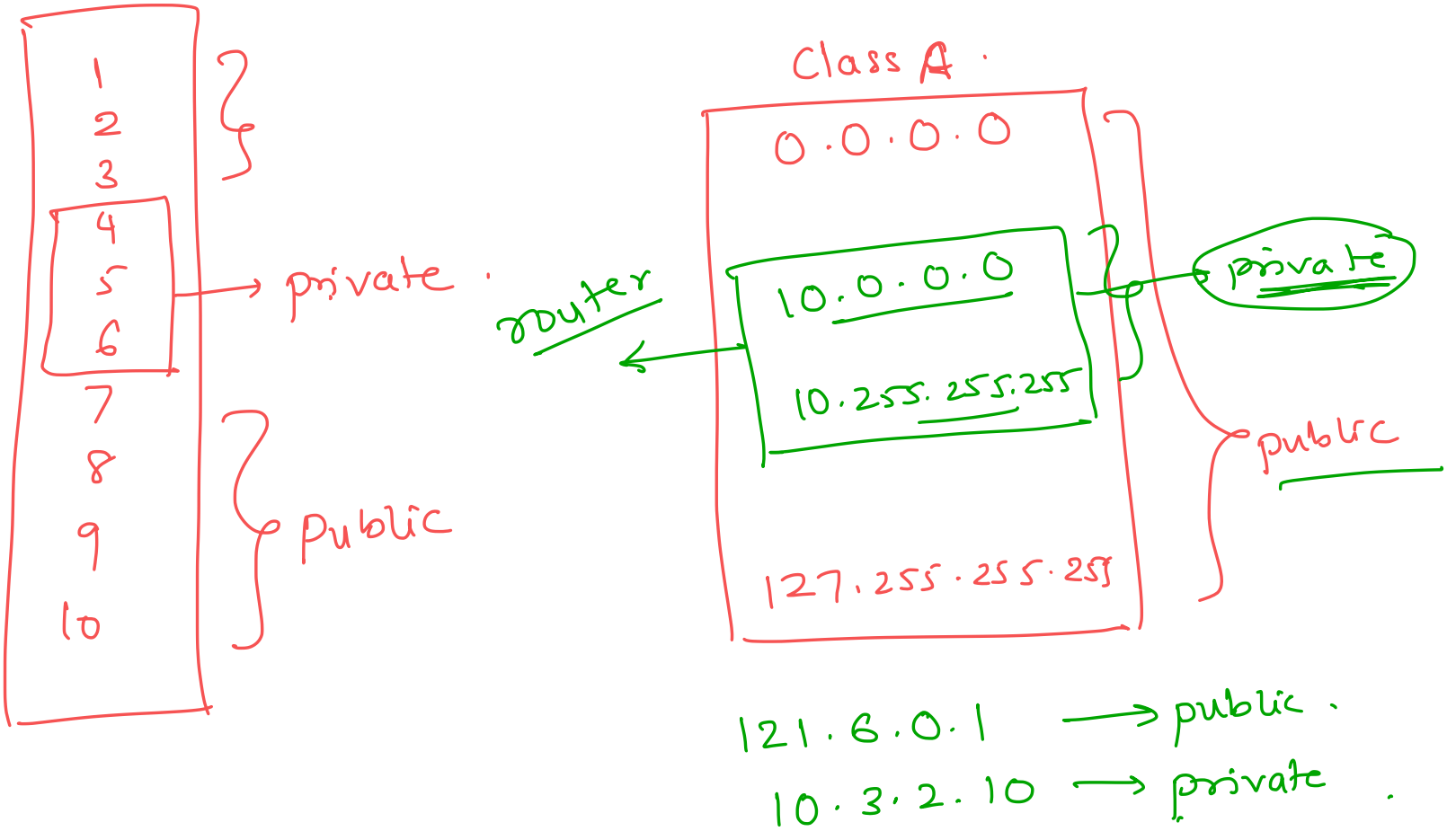
- Any IP Address start with 127, That is : 127.x.x.x means its **a loop back series** that is used for **self testing**.
- E.g. Ping 127.0.0.1 (ping to yourself)
- That is 127.0.0.1 is **Universal IP** ,
- We can not configure **universal IP**. Its by default configured.
- PING (Packet Internet Groper) is a tool used to troubleshoot networking issues .

IANA(Inter Associated Number Association) manages private IP's.

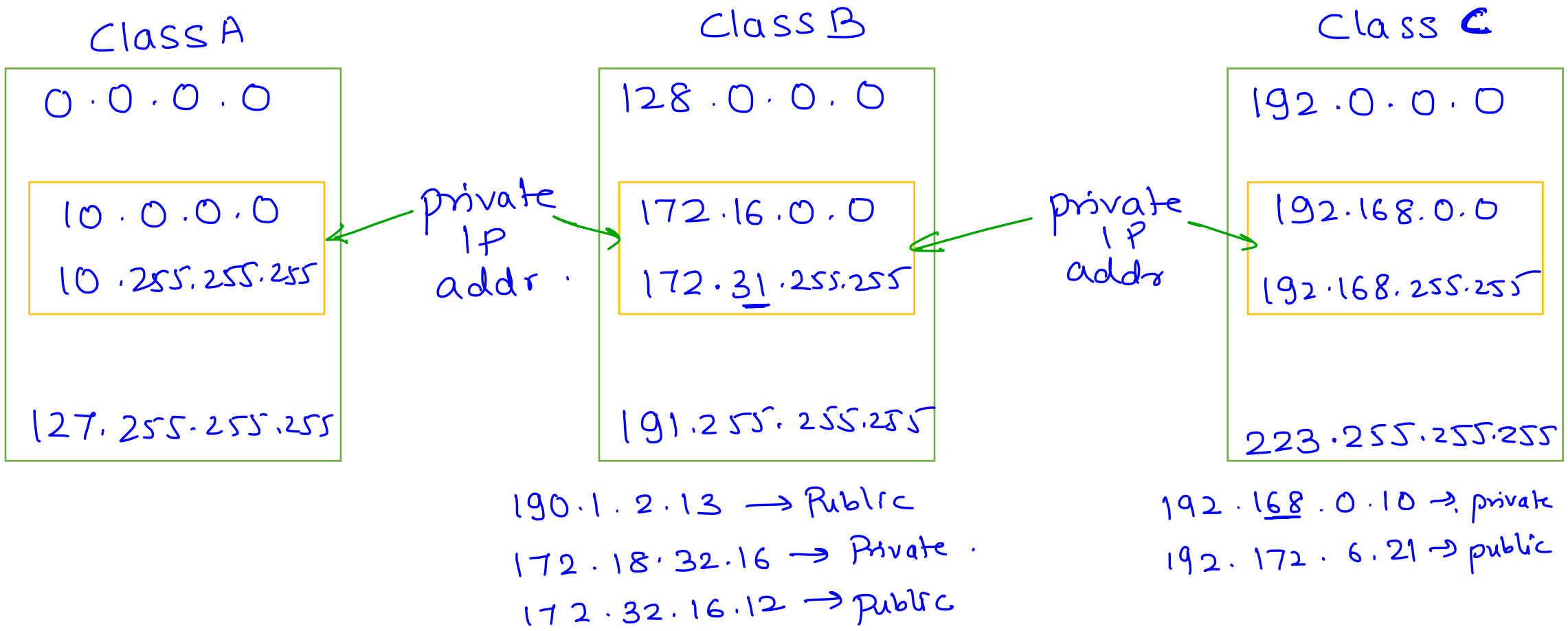
Regular Private IP Addresses

Address Class	Reserved Private IP Addresses
Class A	10.0.0.0 - 10.255.255.255
Class B	172.16.0.0 - 172.31.255.255
Class C	192.168.0.0 - 192.168.255.255

Private network will have private IP's means devices that we connect to our router will get private IP addresses provided by IANA.


1
2
3
4
5
6
7
8
9
10
private
Public
Class A
0.0.0.0
10.0.0.0
10.255.255.255
router
private
public
127.255.255.255
121.6.0.1 → public
10.3.2.10 → private

Private and Public



Sunbeaminfo → Precat PM-30. → RollNo-26

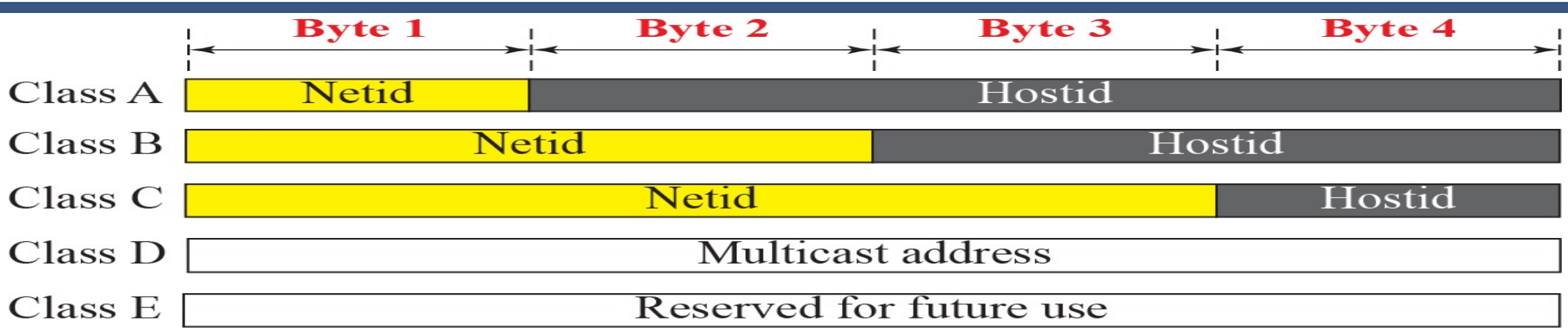
↓ Organization

↓ Network

↓ host

IP address → Net id + host id.

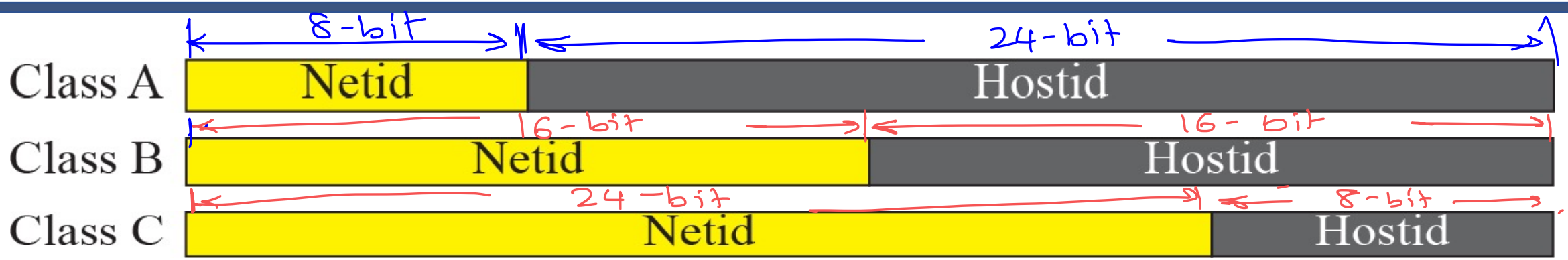
Netid and hostid of A, B, and C Classes



Class	Network bits	Networks	Host bits	Hosts Per Network	Suitable for
Class A	8	2^8=256	24	2^{24} - 2* =16,777,214 maximum hosts	For large organizations like Apple/Google/MS/Amazon
Class B	16	2^{16}=65536	16	2^{16} - 2* = 65,534 maximum hosts	for medium scaled organizations like Sunbeam
Class C	24	2^{24}=16million	8	2^8 - 2* = 254 maximum hosts	for small organizations/home network

* ***Subtracting the network and broadcast address***

NetId and HostId



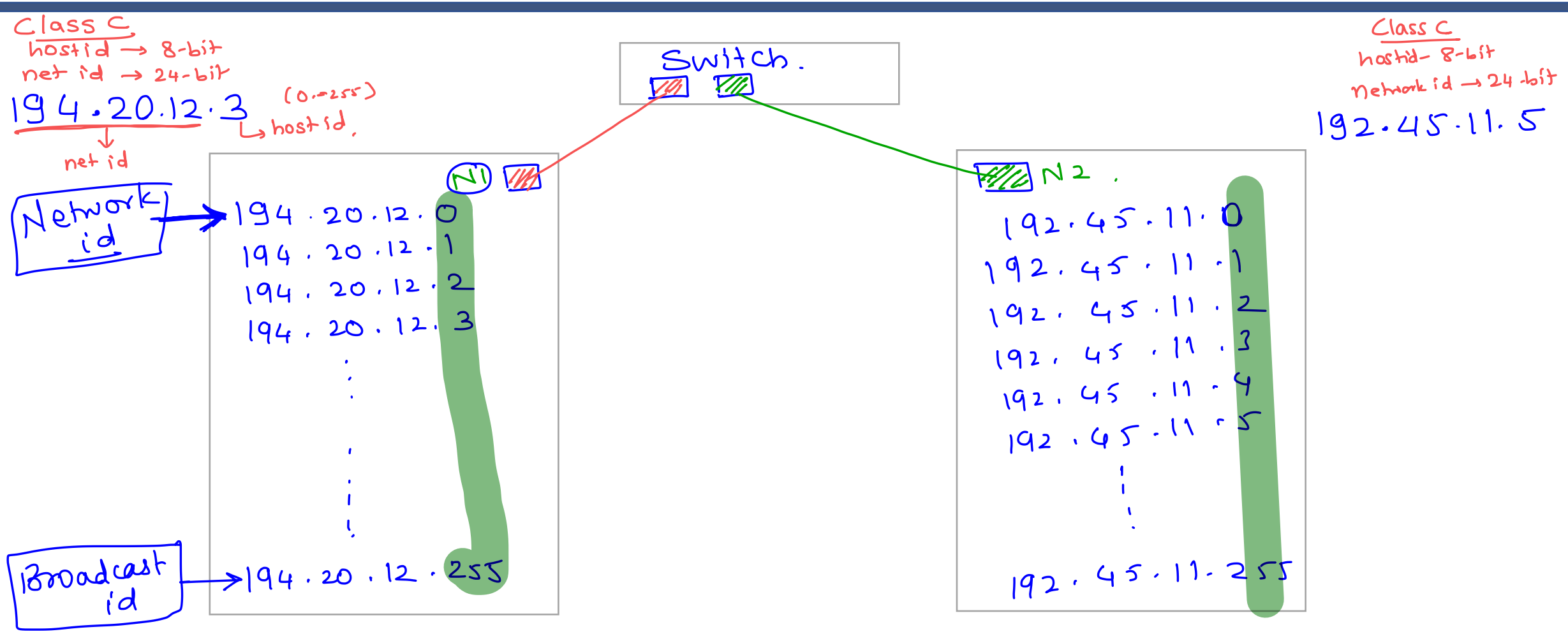
hostid

Class A → 24bit → 2^{24} → 16777214 - 2 = 16777212

Class B → 16-bit → 2^{16} = 65536 - 2 = 65534

Class C → 8-bit → 2^{8} = 256 - 2 = 254

NetId and HostId



In every n/w 2 id's are reserved, One n/w id and other is broadcast id

Example: What is the type of the given IP address

(private & public) (class).

1. 11.34.56.66
2. 10.46.34.67
3. 156.46.36.46
4. 172.20.34.56
5. 172.45.66.77
6. 192.168.2.5
7. 192.169.34.6

Example (Solution): What is the type of the given IP address

1. 11.34.56.66 : public
2. 10.46.34.67 : private
3. 156.46.36.46 : public
4. 172.20.34.56 : private
5. 172.45.66.77 : public
6. 192.168.2.5 : private
7. 192.169.34.6 : public

Example : which class needs to be used for following number of Devices?

1. 200 devices → Class C
2. 3000 devices → Class B
3. 50000 devices → Class B
4. 200000 devices → Class A

Example (Solution) : which class needs to be used for following number of Devices?

1. 200 devices : class C
2. 3000 devices : class B
3. 50000 devices : class B
4. 200000 devices : class A

Protocol

Protocol and Standards

- Protocols define the format and order of messages sent and received among network entities, and actions taken on message transmission and receipt.

- Standards

- Standards are developed by cooperation among standards creation committees, forums, and government regulatory agencies.
- Standards Creation Committees
  1. International Standards Organization (ISO) → OSI
  2. International Telecommunications Union (ITU)
  3. American National Standards Institute (ANSI) → C.
  4. Institute of Electrical and Electronics Engineers (IEEE) → Ethernet

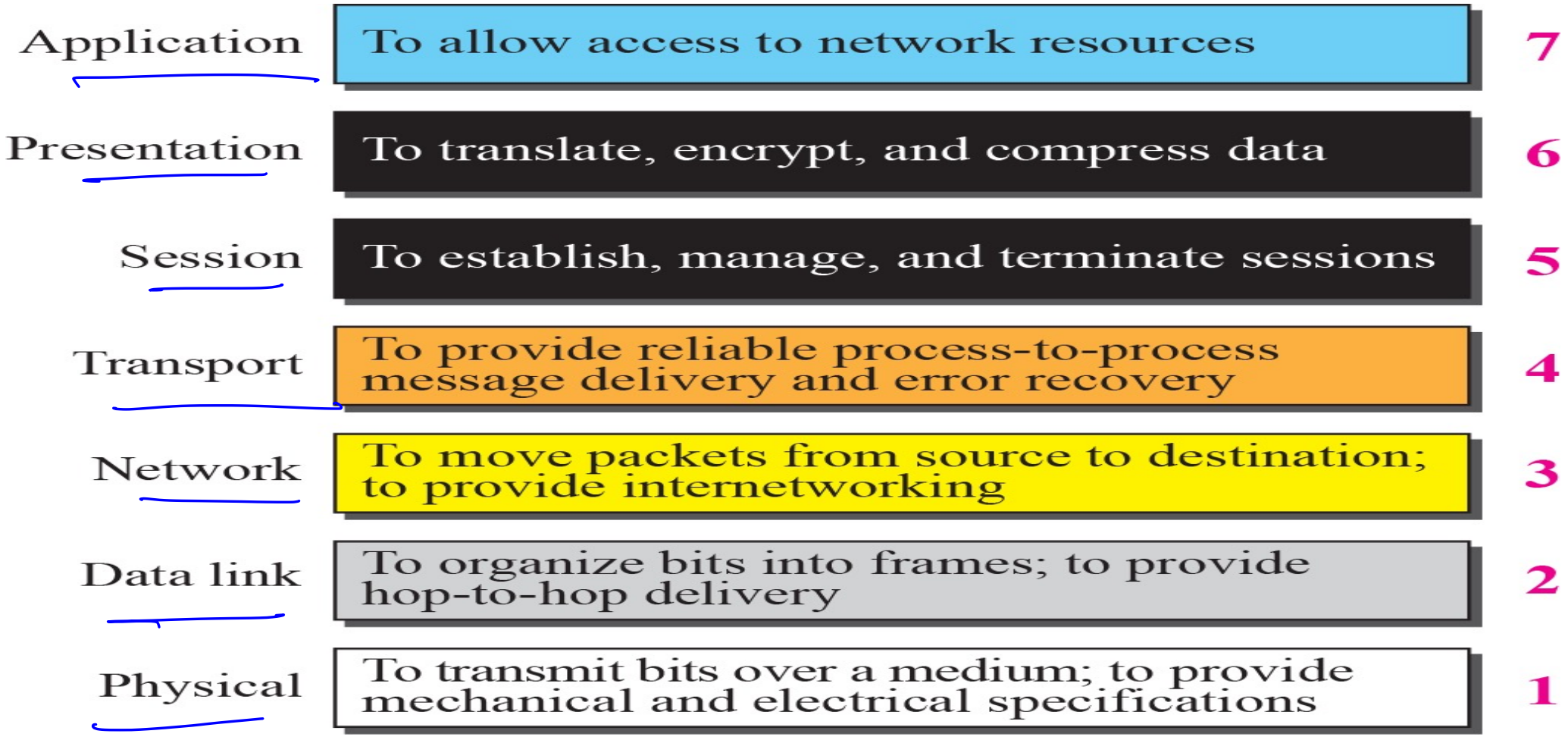
kg, l.

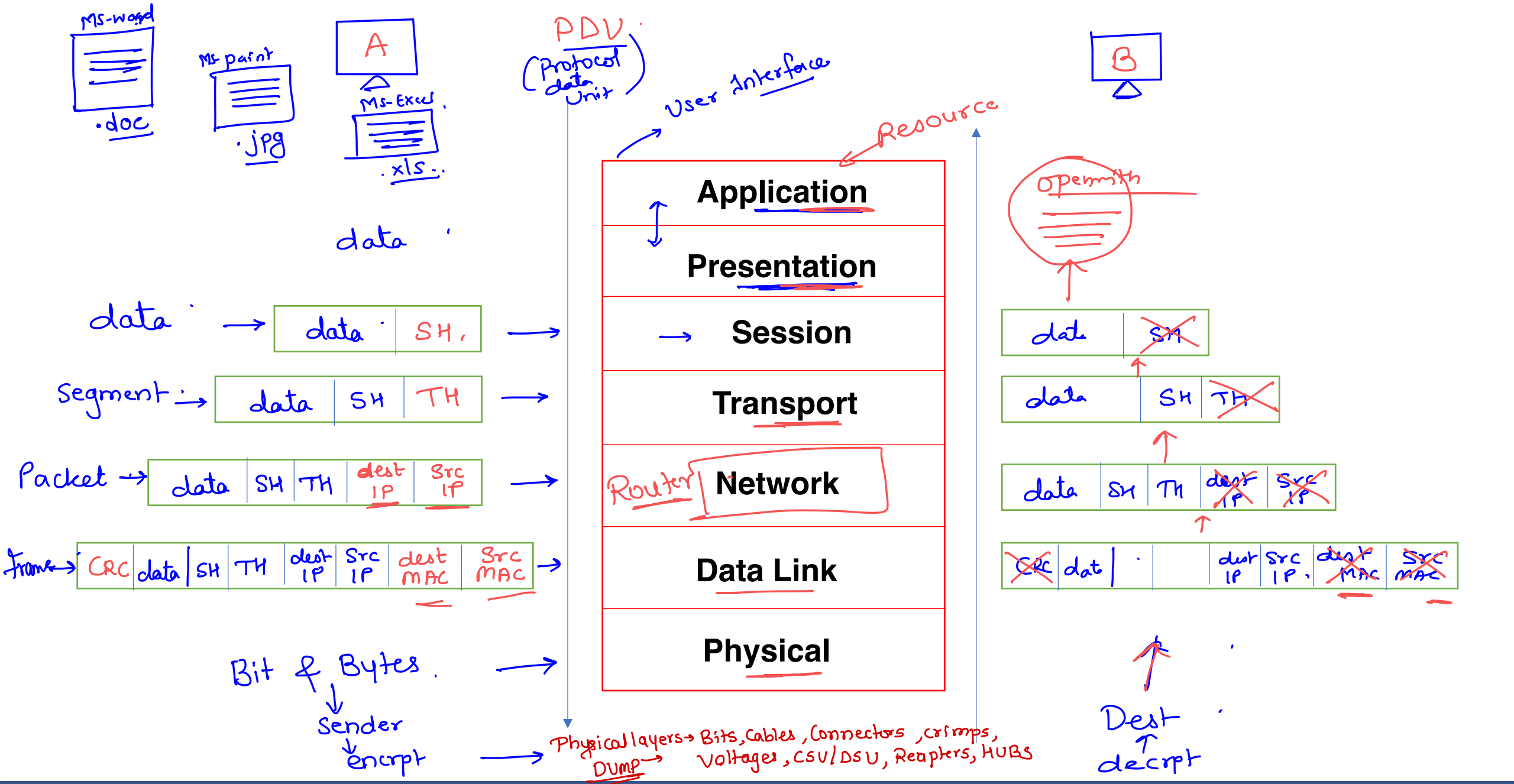
OSI Model & Layers

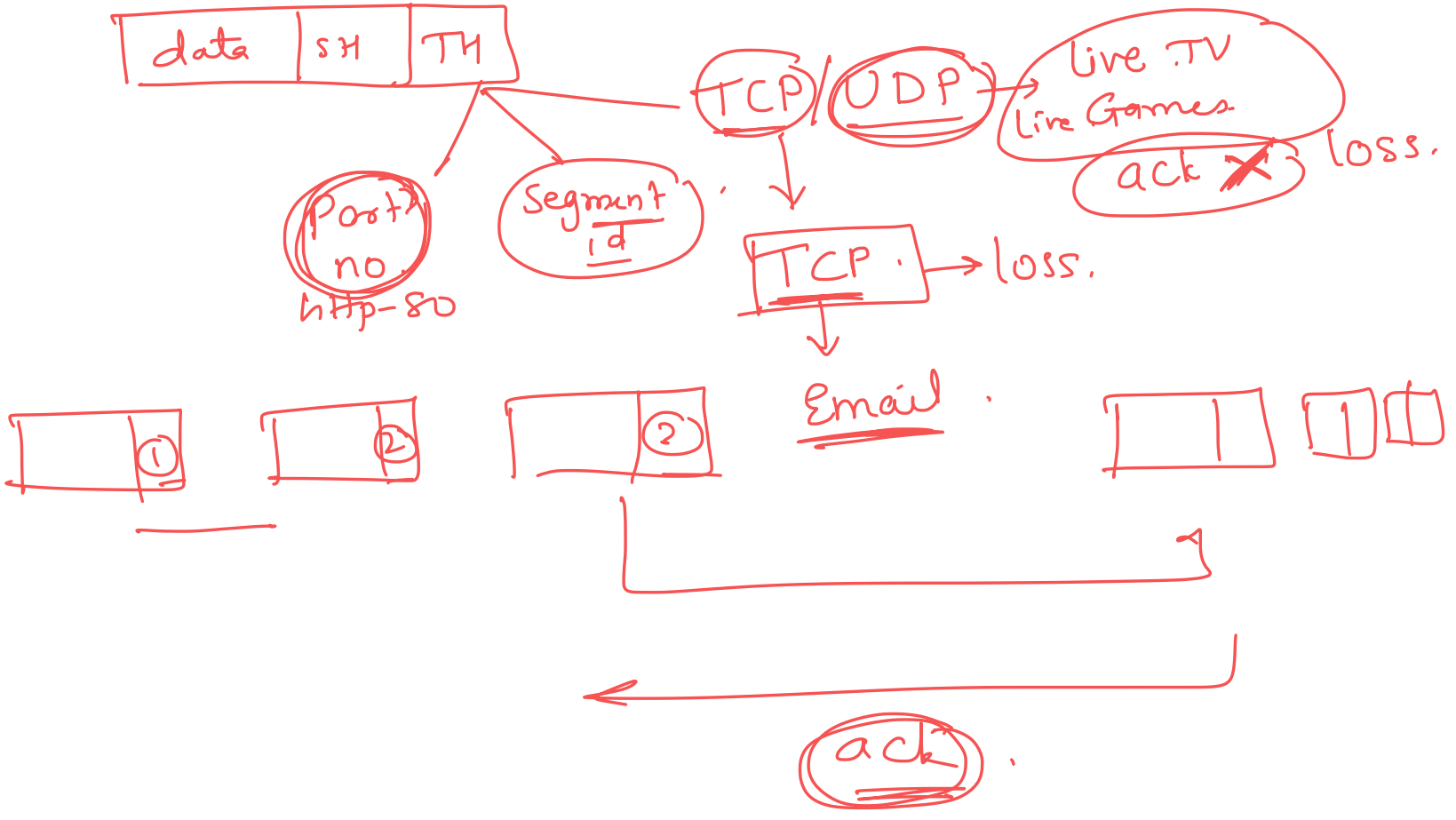
- Established in 1947, **the International Standards Organization (ISO)** is a multinational body dedicated to worldwide agreement on international standards.
- We can not see standard but we can represent them.
- An ISO standard that covers all aspects of network communications is the **Open Systems Interconnection (OSI)** model.
- OSI model is now considered the primary Architectural model for inter-computer communications.
- **Term "open" denotes the ability to connect any two systems which conform to the reference model and associated standards.**

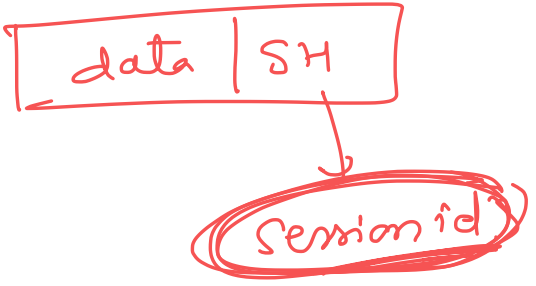
7 - layers

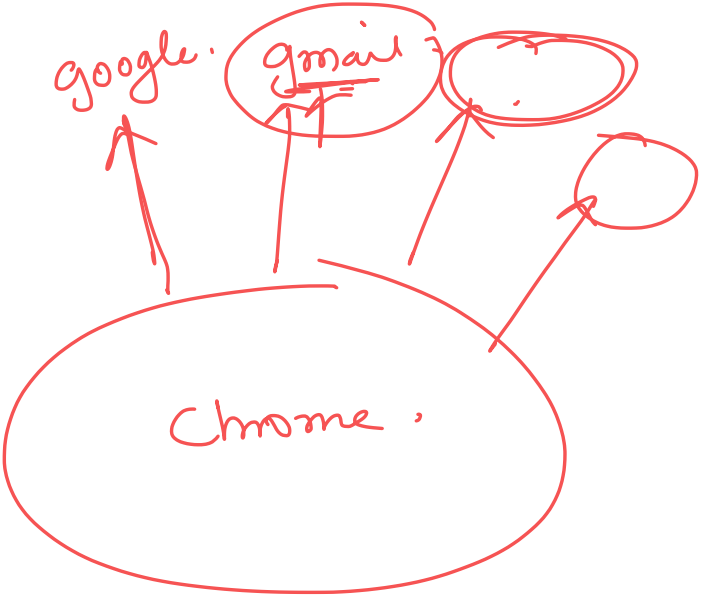
OSI Layers

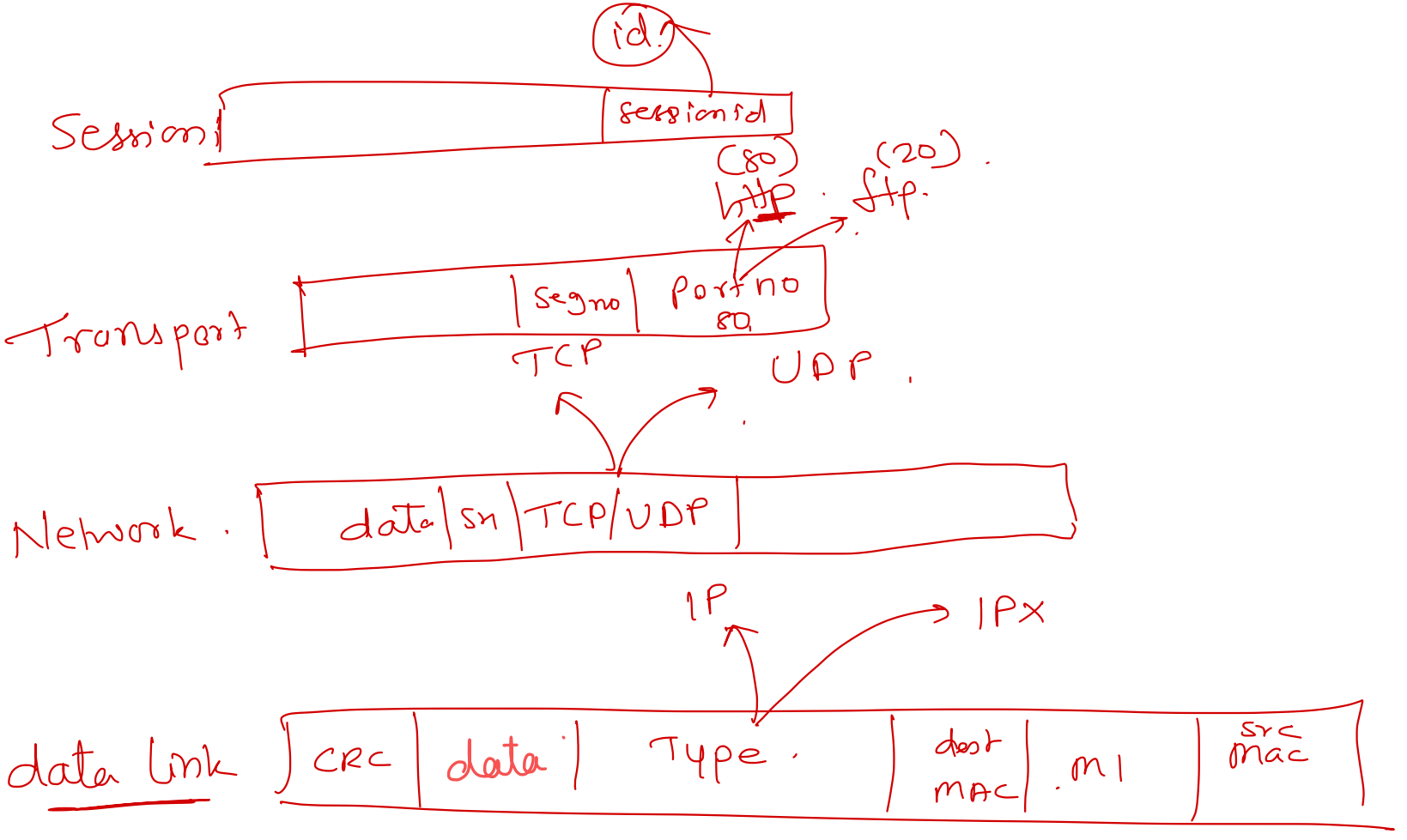

Application
To allow access to network resources
7
Presentation
To translate, encrypt, and compress data
6
Session
To establish, manage, and terminate sessions
5
Transport
To provide reliable process-to-process message delivery and error recovery
4
Network
To move packets from source to destination; to provide internetworking
3
Data link
To organize bits into frames; to provide hop-to-hop delivery
2
Physical
To transmit bits over a medium; to provide mechanical and electrical specifications
1


MS-word
.doc
MS paint
.jpg
A
MS-Excel
.xls
PDU
(Protocol data Unit)
User Interface
Resource
B
Application
Presentation
Session
Transport
Network
Data Link
Physical
Router
data
data
SH
Segment
TH
Packet
dest IP
Src IP
Frame
CRC
dest MAC
Src MAC
Bit & Bytes
Sender
encrypt
Physical layers → Bits, Cables, Connectors, crimps,
DUMP → Voltages, CSU/DSU, Repeaters, HUBS
Openssh
Dest
decrypt


data
SH
TH
TCP
UDP
Live TV
Live Games
ack
loss.
Port no
http-80
Segment id
TCP
loss.
Email
1
2
2
1
ack


data
SH
session id


google.
gmail
Chrome.


id
Session
sessionid
(80)
http
(20)
ftp
Transport
Segno
Portno
80
TCP
UDP
Network
data
SN
TCP/UDP
IP
IPX
data link
CRC
data
Type
dest MAC
n1
src MAC

Application Layer

- Interacts with application programs and is the highest level of OSI model.
- contains management functions to support distributed applications.
- enables the user, whether human or software, to access the network
- Examples : browser , applications such as file transfer, electronic mail, remote login etc.
- Protocols
  - http [80]: hyper text transfer protocol
  - https [443]: secure hyper text transfer protocol
  - ftp [20/21]: file transfer protocol
  - Smtp (25) : simple mail transfer protocol
  - Pop3 (110) : post office protocol
  - telnet(23) : used to connect to the remote machine
  - ssh [22]: secure shell
  - dns (53) : domain name service (used to get the IP address from the domain name)

Presentation Layer

Translation

- **On sender side : translates from ASCII to EBDIC (Extended Binary Coded Decimal Interchange Code)**
- **On receiver side: translates from EBDIC to ASCII**

Encryption/Decryption

- **Plain Text to Cipher Text**
- **Algorithms : RSA, SHA**

Compression / Decompression

- **Sender Side : Compression**
- **Receiver Side : Decompression**

Data Representation [Content-type] (Used to Decide Common File Formats)

- For text (plain: text/plain , html: text/html , json: application/json , xml: text/xml)
- For image (bmp: image/bmp , png: image/png, jpg: image/jpg , jpeg: image/jpeg)
- For audio & Video (wave: audio/wav, mp3: audio/mp3, mp4: video/mp4, fllv: video/flv

Session Layer

- **To start/manage/terminate the session.**
  - how to start, control and end conversations (called sessions) between applications.
  - log-on or password validation is also handled by this layer.
- **The session layer is the network *dialog controller.***
  - mechanism for controlling the dialogue between the two end systems and synchronization.
  - Allows the communication between two processes to take place in either half duplex (one way at a time) or full-duplex (two ways at a time) mode.
- **Synchronization**
  - Session layer can also provide check-pointing mechanism such that if a failure of some sort occurs between checkpoints, all data can be retransmitted from the last checkpoint.
  - It establishes, maintains, and synchronizes the interaction among communicating systems.
- **Protocols**
  - SIP: session initiation protocol
  - NetBIOS : Network Basic Input Output Service
  - RPC: Remote Procedure Call

Transport Layer

- Most Important Layer of OSI
- Responsible **for process-to-process/ End to End delivery** of the entire message.
- Provide a reliable mechanism for the **exchange of data between two processes** in different computers.
- Segment
  - smaller part of session PDU
  - every segment contains sequence number
  - every segment contains checksum for error checking
  - Segment contains:
    - **data** (from the session layer PDU)
    - **sequence number** : used for re-assembling the segments on the receiver machine
    - **checksum :** used to check if the data is not damaged

Transport Layer Protocol

TCP

- Transmission Control Protocol (Reliable)
- connection oriented protocol
  - connection will kept alive till the data transfer in progress
- flow control, error checking and sequencing
- slower than UDP
- E.g. Email (no data loss)

UDP

- User Datagram Protocol (Unreliable)
- Connection Less Protocol
- does not provide error checking/ flow control
- Faster than TCP because no ACK only sending of data packets
- E.g: Online Games, Streaming

Network Layer

- The network layer is responsible for the source-to-destination delivery of a packet, possibly across multiple networks (links).
- It determines the route from the source to the destination and also manages the traffic problems such as switching,

- routing and controls the congestion of data packets.
- Segment Contains :
  - data
  - source IP address
  - destination IP address
- **Network Layer Responsibilities:**
  - Logical Addressing : The network layer translates the logical addresses into physical addresses
  - Routing : sending the data across the network
  - Internetworking : provides the logical connection between different types of networks
  - Fragmentation : breaking the packets into the smallest individual data units that travel through different networks.

Network Layer

- **Protocols :**
  - IP : internet protocol
  - IPx : internetwork packet exchange
  - ICMP : Internet Control Messaging Protocol
  - NAT : Network Address Translation
  - ARP : Address Resolution Protocol
  - PPP: Point to Point Protocol
- **Device** : Router

Data Link Layer

- Data link layer attempts to provide reliable communication over the physical layer interface.
- **DATA LINK Layer Responsibilities :**
  - **Framing:**
    - Breaks the outgoing data into frames and reassemble the received frames.
    - every frame contains (Source MAC address and Destination MAC address)
  - **Physical Addressing:**
    - uses MAC address to identify every NIC uniquely
  - **Flow Control:**
    - A flow control mechanism to avoid a fast transmitter from running a slow receiver by buffering the extra bit is provided by flow control. This prevents traffic jam at the receiver side.
  - **Error Control:**
    - Error control is achieved by adding a trailer at the end of the frame. Duplication of frames are also prevented by using this mechanism. Data Link Layers adds mechanism to prevent duplication of frames.
  - **Access Control:**
    - Protocols of this layer determine which of the devices has control over the link at any given time, when two or more devices are connected to the same link.
- **Protocols**
  - ARP(Address Resolution Protocol) : getting physical address from logical address
  - RARP: Reverse Address Resolution Protocol
- **Device :** Switch

Physical Layer

- Provides physical interface for transmission of information.
- Covers all - mechanical, electrical, functional and procedural - aspects for physical communication. Characteristics like voltage levels, timing of voltage changes, physical data rates, etc.
- send data in the form of 1's and 0's.
- senders and receivers clock must be synchronized.
- **Transmission mode:**
  - Defines direction of transmission simplex, half duplex and full duplex
- **Devices:**
  - NIC , Cables , hubs , repeaters , connectors

7 Layers of OSI Model

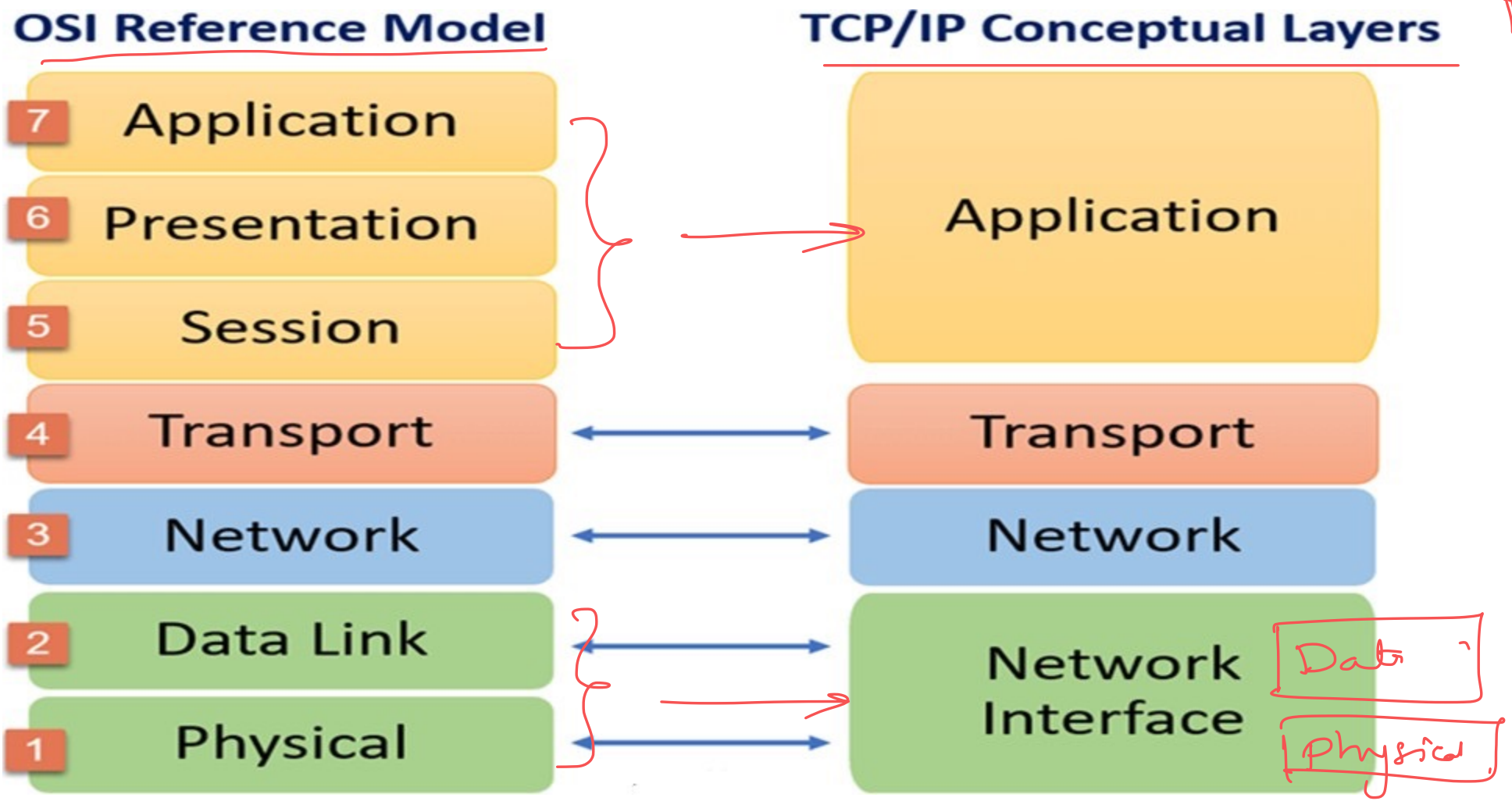
Application (PDU : Data)	• End user Layer • HTTP, FTP, IRC, SSH, DNS
Presentation (PDU : Data)	• Syntax Layer • SSL, SSH, IMAP, FTP, MPEG, JPEG
Session (PDU : Data)	• Synch and Send to port • API's, Sockets
Transport (PDU : Segment)	• End to end Connections • TCP , UDP
Network (PDU : Packet)	• Packets • IP, ICMP, IPSec, IGMP Router
Data Link (PDU : Frame)	• Frames • Ethernet, PPP. Switch, Bridge
Physical (PDU : Bits)	• Physical Structure • Coax, Fiber, Wireless, Hubs, Repeaters

OSI and TCP/IP Model

- OSI model is a generic model that is based upon functionalities of each layer. TCP/IP model is a protocol-oriented standard.
- OSI model distinguishes the three concepts, namely, services, interfaces, and protocols. TCP/IP does not have a clear distinction between these three.
- OSI model gives guidelines on how communication needs to be done, while TCP/IP protocols layout standards on which the Internet was developed. So, TCP/IP is a more practical model.
- In OSI, the model was developed first and then the protocols in each layer were developed. In the TCP/IP suite, the protocols were developed first and then the model was developed.
- The OSI has seven layers while the TCP/IP has four layers.

OSI and TCP/IP Model

4 layers / 5 layers



QUIZ

1) Which of the following is correct IPv4 address?

1. 124.201.3.1.52
2. 01.200.128.123
3. 300.142.210.64
4. 10110011.32.16.8
5. 128.64.0.0

2) The length of an IPv6 address is?

1. 32 bits
2. 64 bits
3. 128 bits
4. 256 bits

Thank You