Computer Network(CSC 503)

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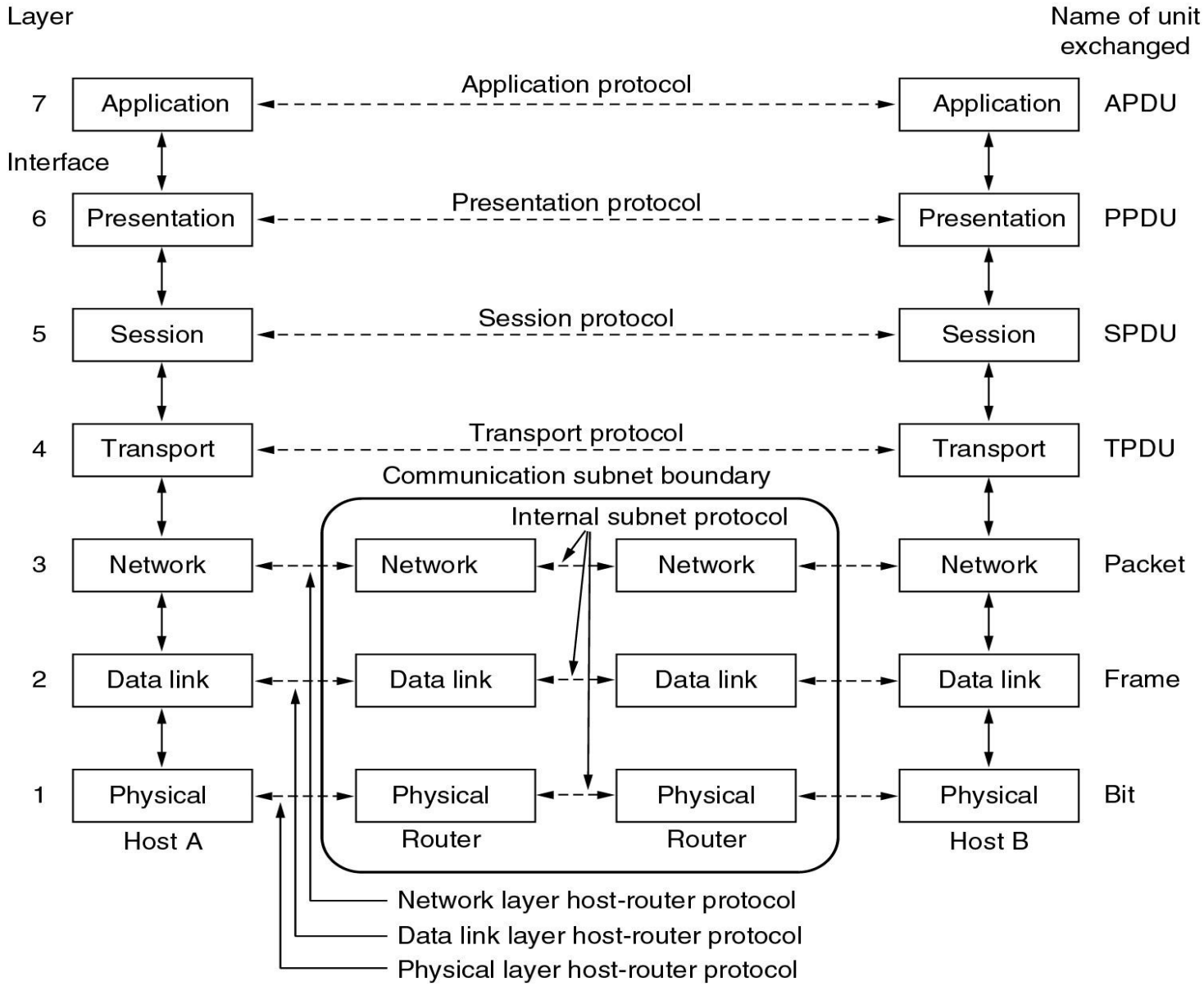
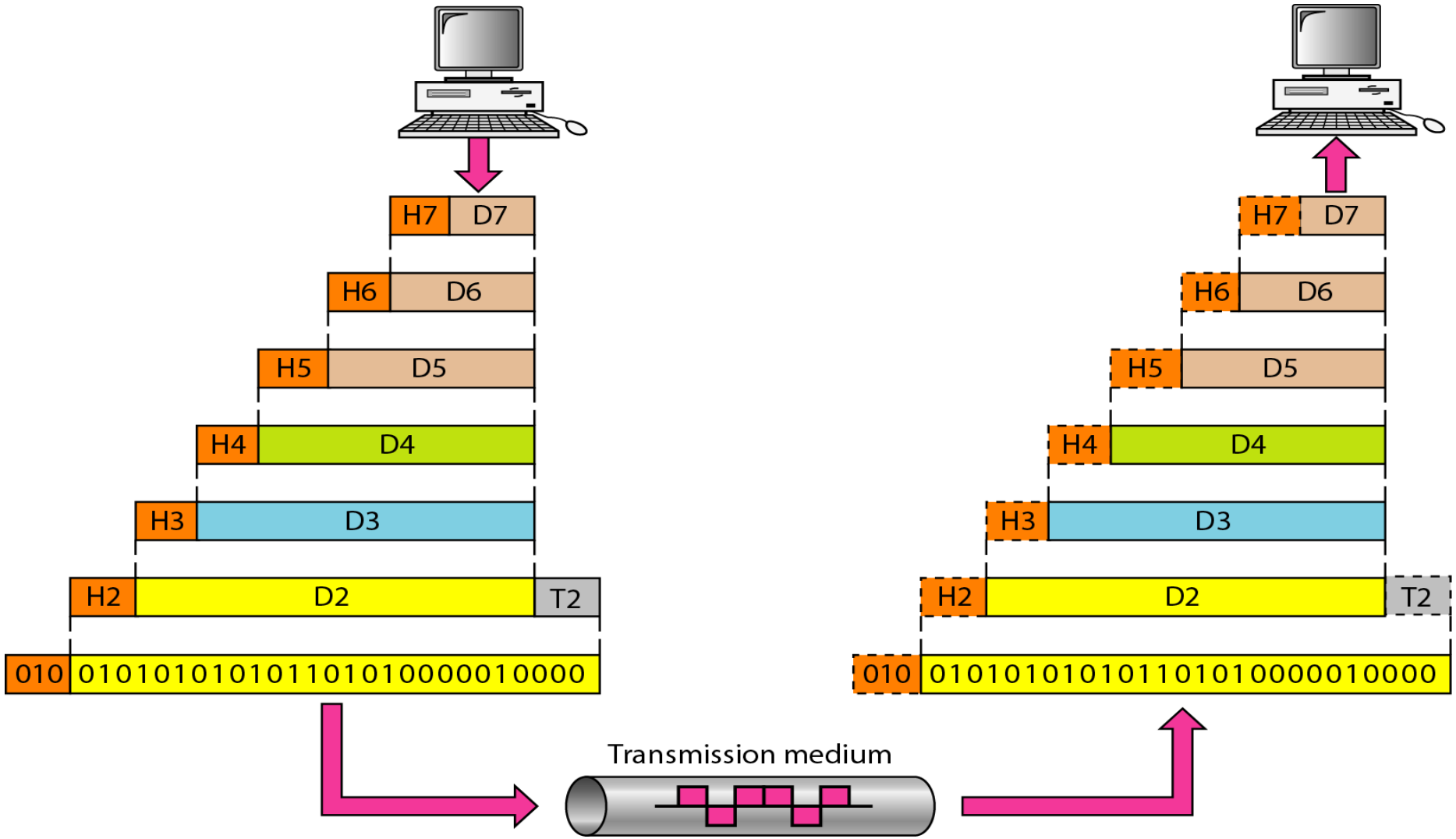
Lecture 7 and 8

Reference Models

The OSI reference model.



Data Encapsulation



Physical layer

It provides the hardware means of sending and receiving data on a carrier.

Functions

1. **Representation of Bits**: Data in this layer consists of stream of bits. The bits must be encoded into signals for transmission. It defines the type of encoding i.e. how 0's and 1's are changed to signal.
2. **Data Rate**: This layer defines the rate of transmission which is the number of bits per second.
3. **Synchronization**: It deals with the synchronization of the transmitter and receiver. The sender and receiver are synchronized at bit level.
4. **Interface**: The physical layer defines the transmission interface between devices and transmission medium.

Contd...

5. **Line Configuration**: This layer connects devices with the medium:

   Point to Point configuration(dedicated link between 2 devices) &

   Multipoint configuration(shared link between more than 2 devices)

6. **Topologies**: Devices must be connected using the following topologies: Mesh, Star, Ring and Bus.

7. **Transmission Modes**: Physical Layer defines the direction of transmission between two devices:

   Simplex(signals can flow only in one direction)

   Half Duplex(signals can flow in both directions not at the same time).

   Full Duplex(signals can flow in both directions at the same time).

Data Link Layer

- When sending data to the physical layer it puts a header(MAC address) and a frame check sequence(trailer).
- When obtaining data from the Physical layer, the Data Link layer checks for physical transmission errors and packages bits into data "frames".
- **The data link layer provides error-free transfer of data frames from one node to another over the physical layer.**
- The data link layer is divided into two sub layers:
  - The Media Access Control (MAC) layer
  - The Logical Link Control (LLC) layer.

Contd…

DLL Functions

1. **Framing:** Divide the stream of bits received from network layer into data units called frames **-attaching special bit patterns** to the **beginning and end** of the **frame**
2. **Physical Addressing/MAC address:** The Data Link layer adds a header to the frame in order to define physical address of the sender or receiver of the frame, if the frames are to be distributed to different systems on the network.
3. **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.

Contd…

4. Error Control:

- Add mechanisms to detect and retransmit damaged or lost frames.
- Prevent also duplication of frames.
- Error control is normally achieved through a trailer added to the end of frame.

5. 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. MAC sub-layer of **data link layer helps** to determine which device has control over the channel at a given time.

Physical and Logical Addresses

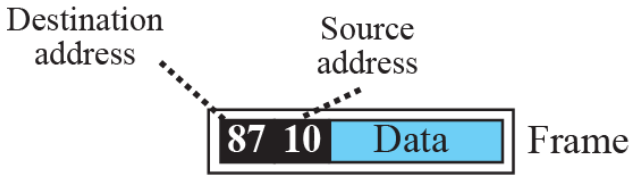
- The physical address, also known as the MAC(Media Access control) address, is the address of a node as defined by its LAN. It is included in the frame used by the data link layer.
- It is the lowest-level address. The size and format of these addresses vary depending on the network.
- For example, Ethernet uses a 6-byte (48-bit) physical address that is imprinted on the network interface card (NIC).
- Most local area networks use a 48-bit (6-byte) physical address written as 12 hexadecimal digits; every byte (2 hexadecimal digits) is separated by a colon, as shown below.
- Eg 07:01:02:01:2C:4B

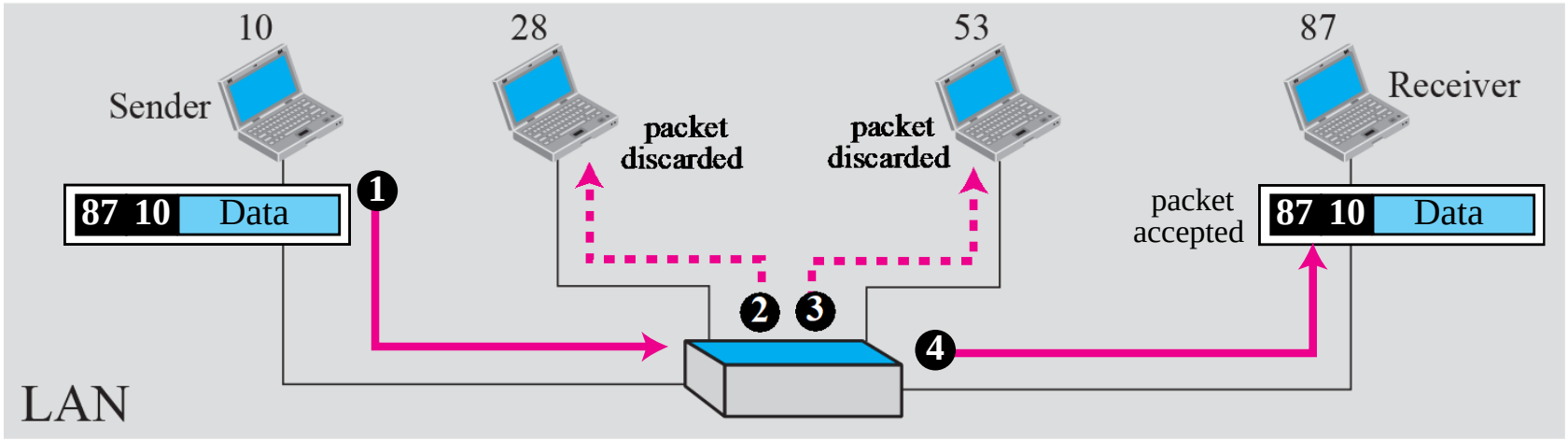
Contd…

Physical Address

- A node with physical address 10 sends a frame to a node with physical address 87. The two nodes are connected by a LAN. At the data link layer, this frame contains physical (link/MAC) addresses in the header. These are the only addresses needed. The rest of the header contains other information needed at this level. The trailer usually contains extra bits needed for error detection. The data link layer at the sender receives data from an upper layer. It encapsulates the data in a frame, adding a header and a trailer. The header, among other pieces of information, carries the receiver and the sender physical (link) addresses.
- The frame is propagated through the LAN. Each node with a physical address other than 87 drops the frame because the destination address in the frame does not match its own physical address. The intended destination computer, however, finds a match between the destination address in the frame and its own physical address. The frame is checked, the header and trailer are dropped, and the data part is decapsulated and delivered to the upper layer.

Physical addresses





Contd…

Logical Address

- Logical addresses are necessary for universal communications that are independent of underlying physical networks.
- **Physical addresses are not adequate in an internetwork environment.**
- A universal addressing system is needed in which each host can be identified uniquely, regardless of the underlying physical network.
- The logical addresses are designed for this purpose.

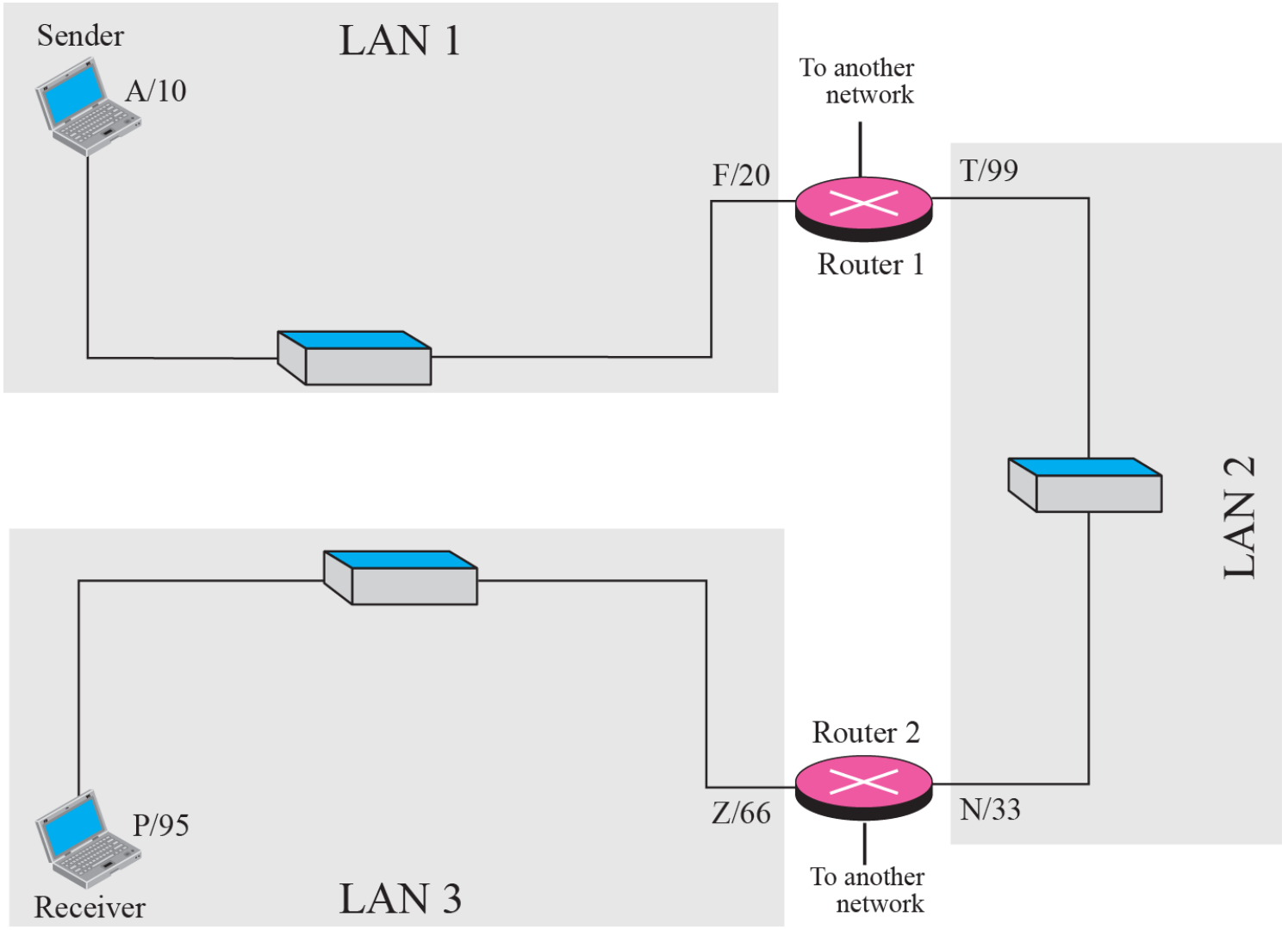
A logical address in the Internet is currently a **32- bit address** that can uniquely define a host connected to the Internet.

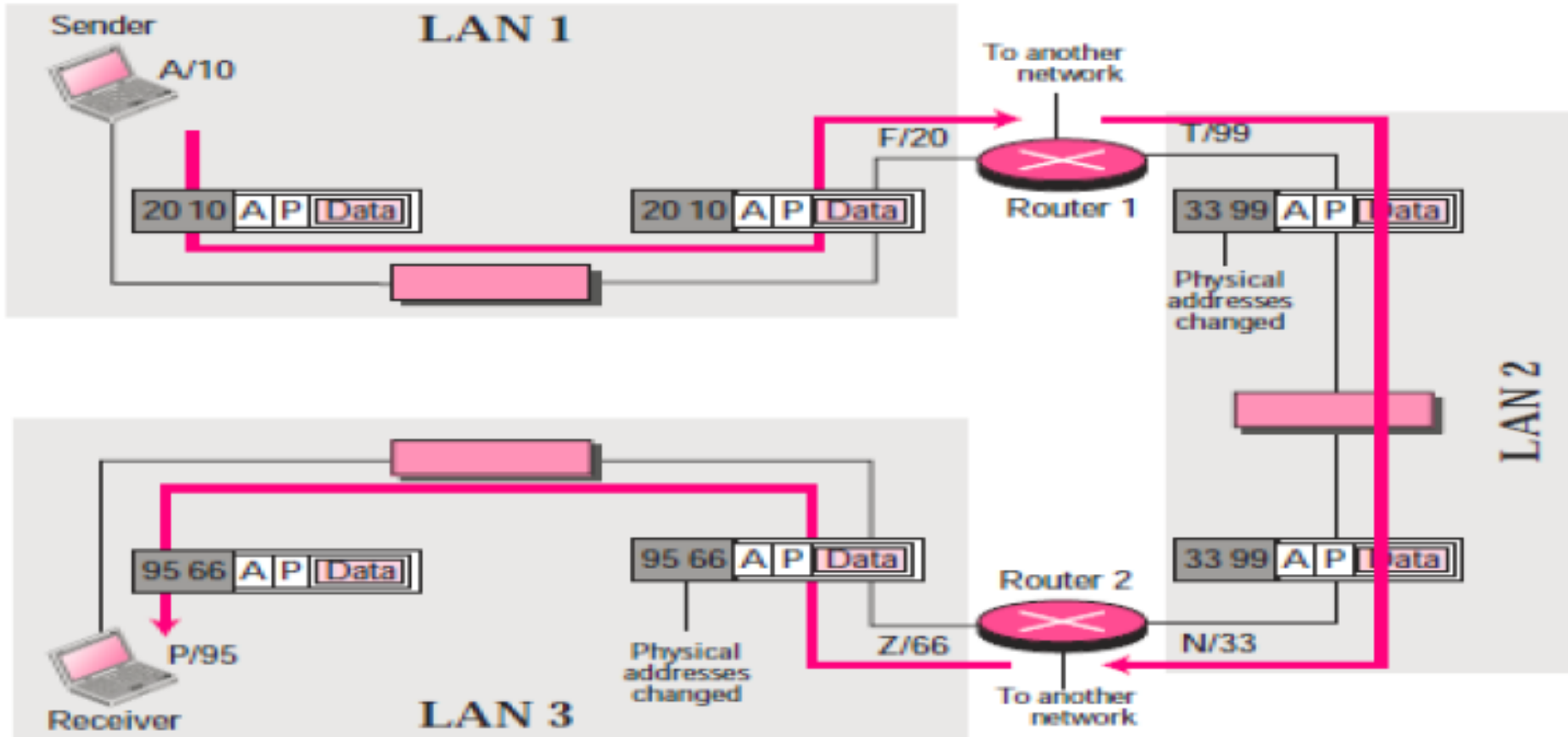
- No two hosts on the Internet can have the same IP address.
- **The physical addresses will change from hop to hop, but the logical addresses remain the same**

Contd…

- The Figure below shows a part of an internet with two routers connecting three LANs. Each device (computer or router) has a pair of addresses (logical and physical) for each connection.
- The computer with logical address A and physical address 10 needs to send a packet to the computer with logical address P and physical address 95.
- The sender encapsulates its data in a packet at the network layer and adds two logical addresses (A and P).
- The network layer, however, needs to **find the physical address of the next hop** before the packet can be delivered. The network layer consults its routing table and finds the logical address of the next hop (router 1) to be F.

Figure 2.17 *Example 2.5: logical addresses*




Sender
LAN 1
A/10
To another network
F/20
T/99
20 10 A P Data
20 10 A P Data
Router 1
33 99 A P Data
Physical addresses changed
LAN 2
95 66 A P Data
95 66 A P Data
Router 2
33 99 A P Data
P/95
Physical addresses changed
Z/66
N/33
Receiver
LAN 3
To another network

Network Layer

- **Routing Function:**

  Routing is concerned with the question: Which line should router J use when forwarding a packet to router K?

- The network layer controls the operation of deciding which physical path the data should.
- **When data arrives at the Network layer, the source and destination addresses contained inside each frame are examined to determine if the data has reached its final destination.**
- If the data has reached the final destination, then network layer delivers data to the Transport layer. Otherwise, the Network layer updates the destination address and pushes the frame back down to the lower layers.
- **Logical Addressing :** In order to **identify each device** on internetwork uniquely, **network layer defines an addressing scheme**. The sender and receiver's IP address is placed in the header by network layer. Such an address distinguishes each device uniquely and universally.

Contd…

- **Congestion Control:**

  The network layer also must deal with congestion:

•When more packets enter an area than can be processed, delays increase and performance decreases. If the situation continues, the subnet may have no alternative but to discard packets.

•If the delay increases, the sender may (incorrectly) retransmit, making a bad situation even worse.

•Overall, performance degrades because the network is using (wasting) resources processing packets that eventually get discarded.

Transport Layer

- Responsible for process to process delivery of the entire message.
- **Segmentation and Reassembly :** This layer accepts the message from the (session) layer, **breaks the message into smaller units**. Each of the segment produced has a header associated with it. The transport layer at the destination station **reassembles the message.**

- **Service Point Addressing /Port Address:** Computers often run several processes at the same time. For this reason, process-to-process delivery means delivery not only from one computer to the other but also from a specific process on one computer to a specific process on the other.
- In order to deliver the **message to correct process,** transport layer header includes a type of address called service point address or port address. Thus by specifying this address, transport layer makes sure that the message is delivered to the correct process.
- The transport layer header therefore must include a type of address called a port address.

Contd…

The transport layer can be either

Connection less or connection oriented

- **Connection Oriented Service :** It is a three-phase process which include :
  - Connection Establishment
  - Data Transfer
  - Termination / disconnection
- In this type of transmission, the receiving device sends an acknowledgement, back to the source after a packet or group of packet is received. **This type of transmission is reliable and secure.**
- **Connection less service :** It is a one-phase process and includes Data Transfer. In this type of transmission, the receiver does not acknowledge receipt of a packet. This approach allows for much faster communication between devices. Connection-oriented service is more reliable than connectionless Service

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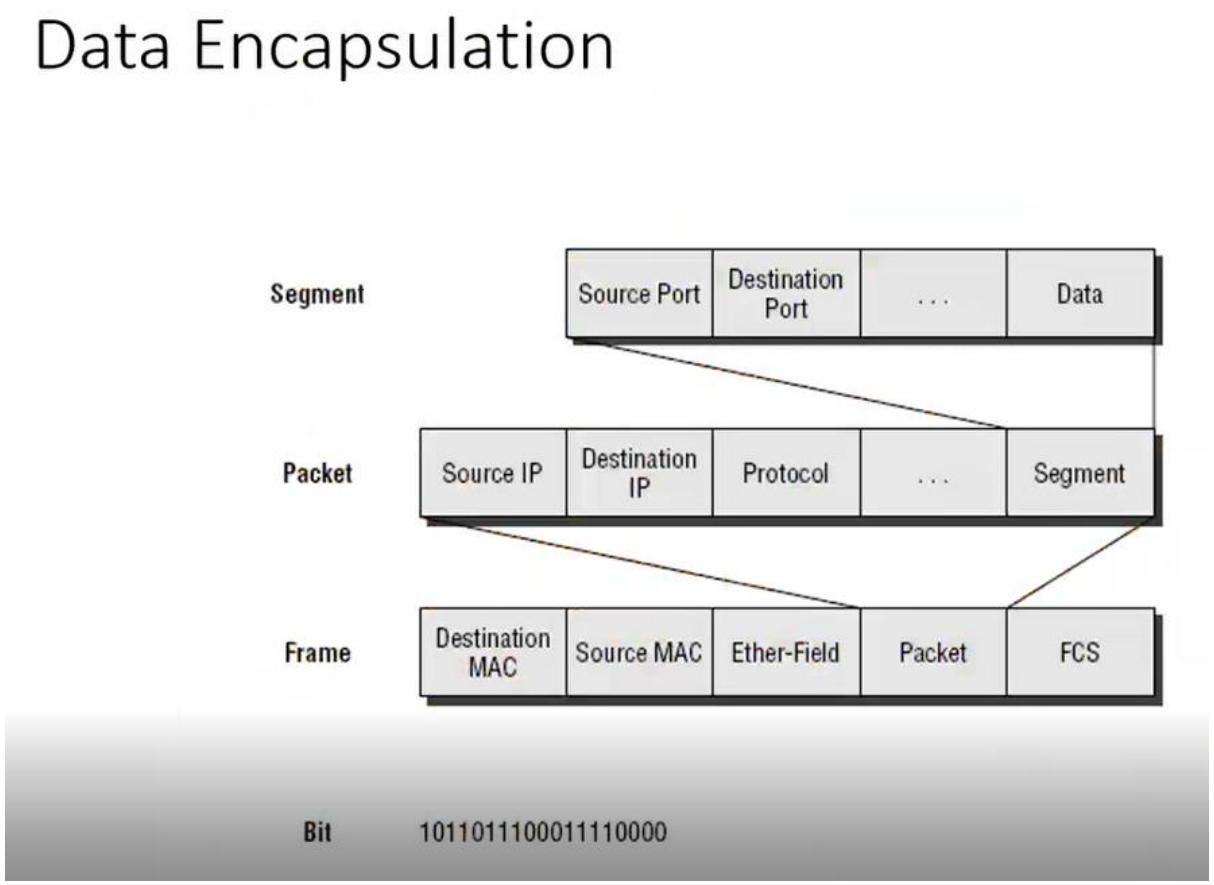

Data Encapsulation
Segment
Source Port
Destination Port
. . .
Data
Packet
Source IP
Destination IP
Protocol
. . .
Segment
Frame
Destination MAC
Source MAC
Ether-Field
Packet
FCS
Bit
1011011100011110000

Contd…

- Flow control: Flow control is performed end – to –end rather than across the link(unlike DLL)

Flow control is mechanism in which receiving system must notify the sender that must decreases the transmission rate or risk overwhelming and losing data

- Error control: In TL Error control is end – to –end than across a ingle link(unlike DLL).

It deals with damage/loss/duplicate frames.

Error correction is usually achieved through retransmission.

- Multiple network connections : To improve throughput

Session layer

- The session layer is an important layer as it is responsible for maintaining a session between two end-user applications.
- *When we open browser and open Facebook in one tab, second tab we open Twitter, and another tab for some banking transaction. The information from sever will come to same from which you have requested.*
- For example, if you are downloading some pictures from Facebook, a the requests for the photos and responses by Facebook to you is handled by the session layer.
- **(1) Session establishment, maintenance and termination :** The layer allows the two processes to establish, use and terminate a connection.
- **(2) Synchronization :** This layer allows a **process to add checkpoints** which are considered as synchronization points into the data. These synchronization point help to identify the error so that the data is re-synchronized properly, and ends of the messages are not cut prematurely and data loss is avoided.
- **(3) Dialog Controller :** The session layer **allows two systems** to start communication with each other in half-duplex or full-duplex.

Presentation Layer

- The Presentation Layer represents the area that is independent of data representation at the application layer - in general, it

  represents the preparation or translation of application format to network format, or from network formatting to application format.
- In other words, the layer “presents” data for the application or the network. A good example of this is encryption and decryption of data for security/compression and decompression.

Contd…

- **Functions of Presentation layer**
- **(1) Translation :** For example, ASCII to EBCDIC.

  Interoperability between theses encoding methods
- **(2) Encryption/ Decryption :** Data encryption translates the data into another form or code. The encrypted data is known as the cipher text and the decrypted data is known as plain text. A key value is used for encrypting as well as decrypting data.
- **(3) Compression :** Reduces the number of bits that need to be transmitted on the network.

Application layer

- The Application Layer is the one at the top - it’s what most users see.
- In the OSI model, this is the layer that is the “closest to the end user”.
- Applications that work at Layer 7 are the ones that users interact with directly.
- A web browser (Google Chrome, Firefox, Safari, etc.) or other app - Skype, Outlook, Office - are examples of Layer 7 applications.

Contd…

- **Functions of Application Layer**
- **(1) File transfer, access, and management (FTAM) :** An application layer allows a user to access the files in a remote computer, to retrieve the files from a computer and to manage the files in a remote computer.
- **(2) Mail services :** An application layer provides the facility for email forwarding and storage.
- **(3) Directory services :** An application provides the distributed database sources and is used to provide that global information about various objects.
- **(4) Network Virtual Terminal**

OSI Layers

OSI Model			
	Data unit	Layer	Function
Host layers	Data	7. Application	Network process to application, Provide Service to the user
		6. Presentation	Data representation Compression , encryption and decryption
		5. Session	Interhost communication, Used to establish, manage and terminate Session
	Segments	4. Transport	End-to-end connections- delivery from process to process and reliability, Flow control
Media layers	Packet	3. Network	Path determination and logical addressing; moving the packets from source to destination
	Frame	2. Data Link	Physical addressing, error free transfer of data frames
	Bit	1. Physical	Media, signal and binary transmission-bit transmission.

Going from layer 7 to 1: **All People Seem To Need Data Processing**

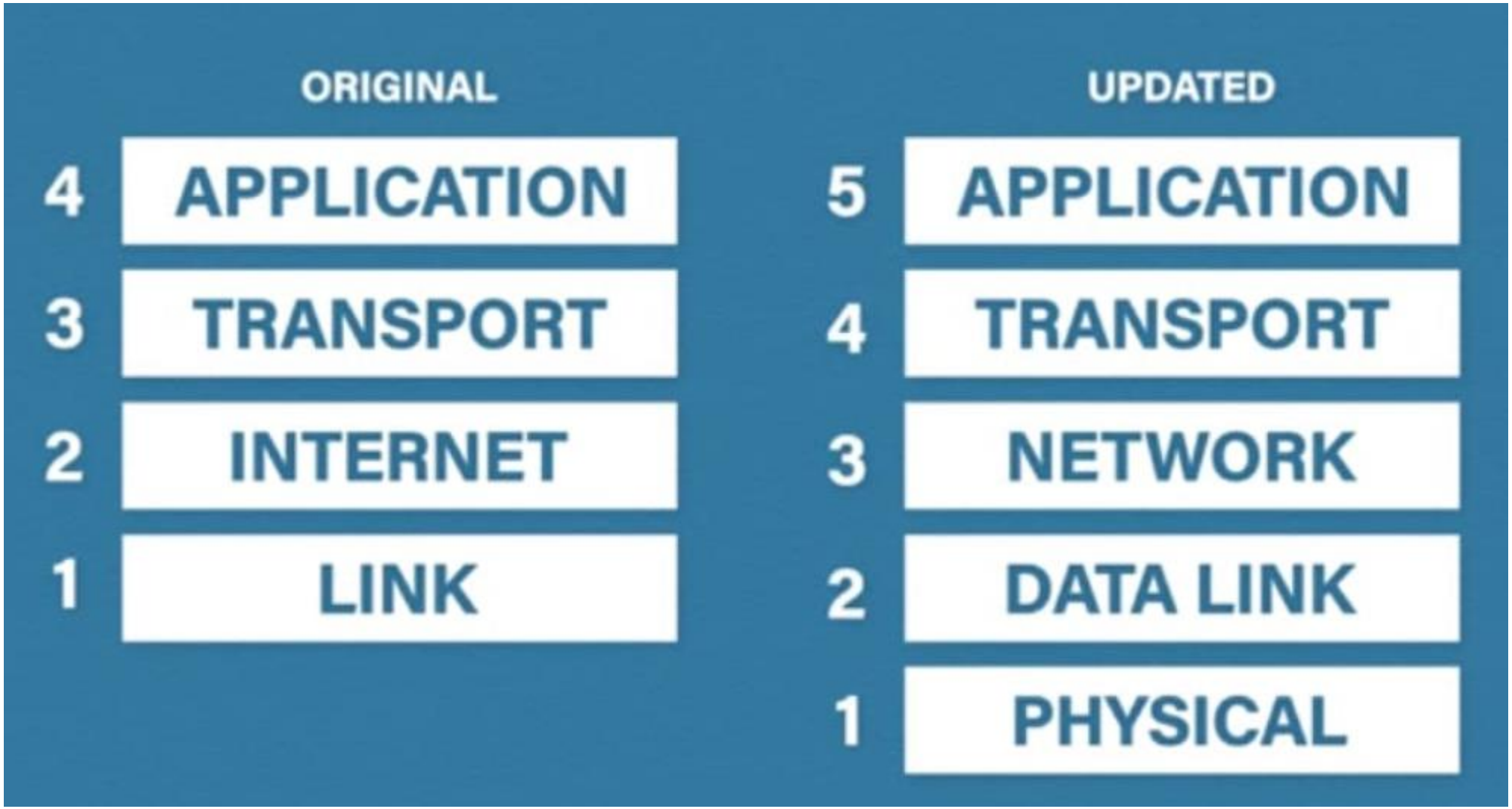
Introduction TCP/IP

- The **Internet Protocol Suite** (commonly known as **TCP/IP**) is the set of communications protocols used for the Internet and other similar networks.
- It is named from two of the most important protocols in it:
  - The Transmission Control Protocol (TCP)(layer 4) and
  - The Internet Protocol (IP)(layer 3), which were the first two networking protocols defined in this standard.

Contd...

- TCP/IP predated to OSI, developed in 1970s
- Nonproprietary protocol
- Platform independent
- Quality of service
- Simultaneous development

TCP/IP Models with 4 and 5 layers



Contd...

The 4 layers are :

1. **Process/Application Layer**
2. **Host-to-Host/Transport Layer**
3. **Internet Layer/Host-to-Network layer/Network Layer**
4. **Network Access/Link Layer**

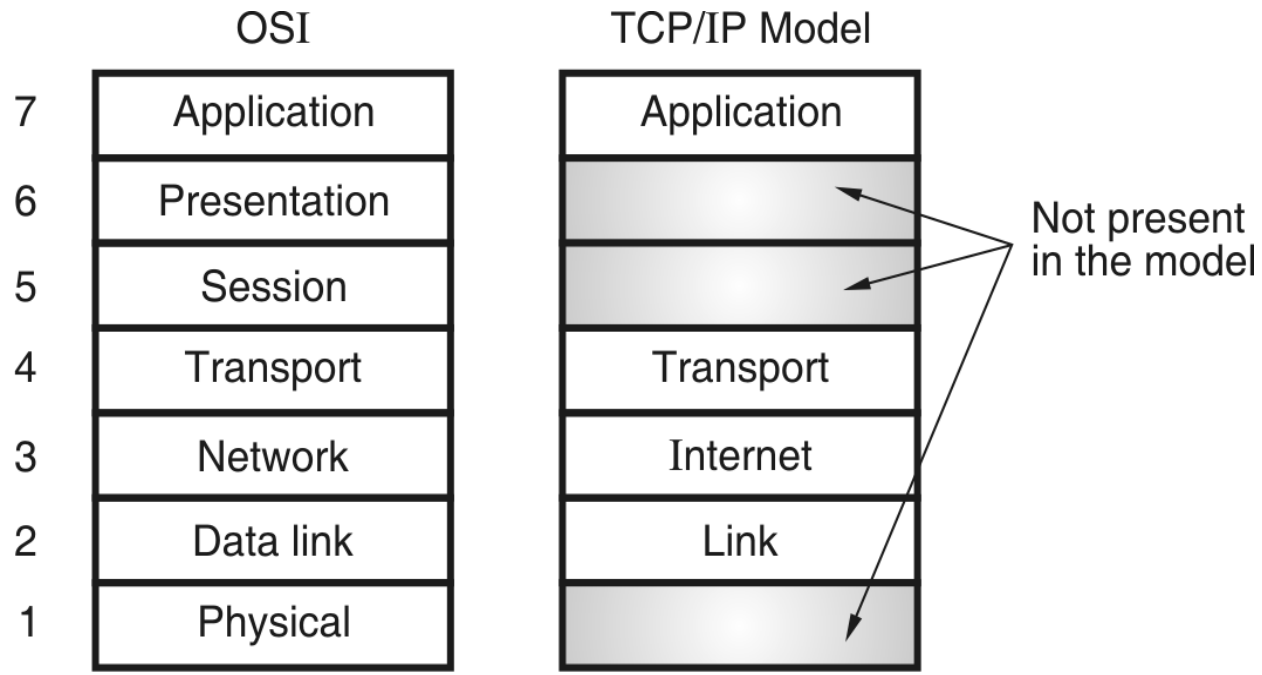
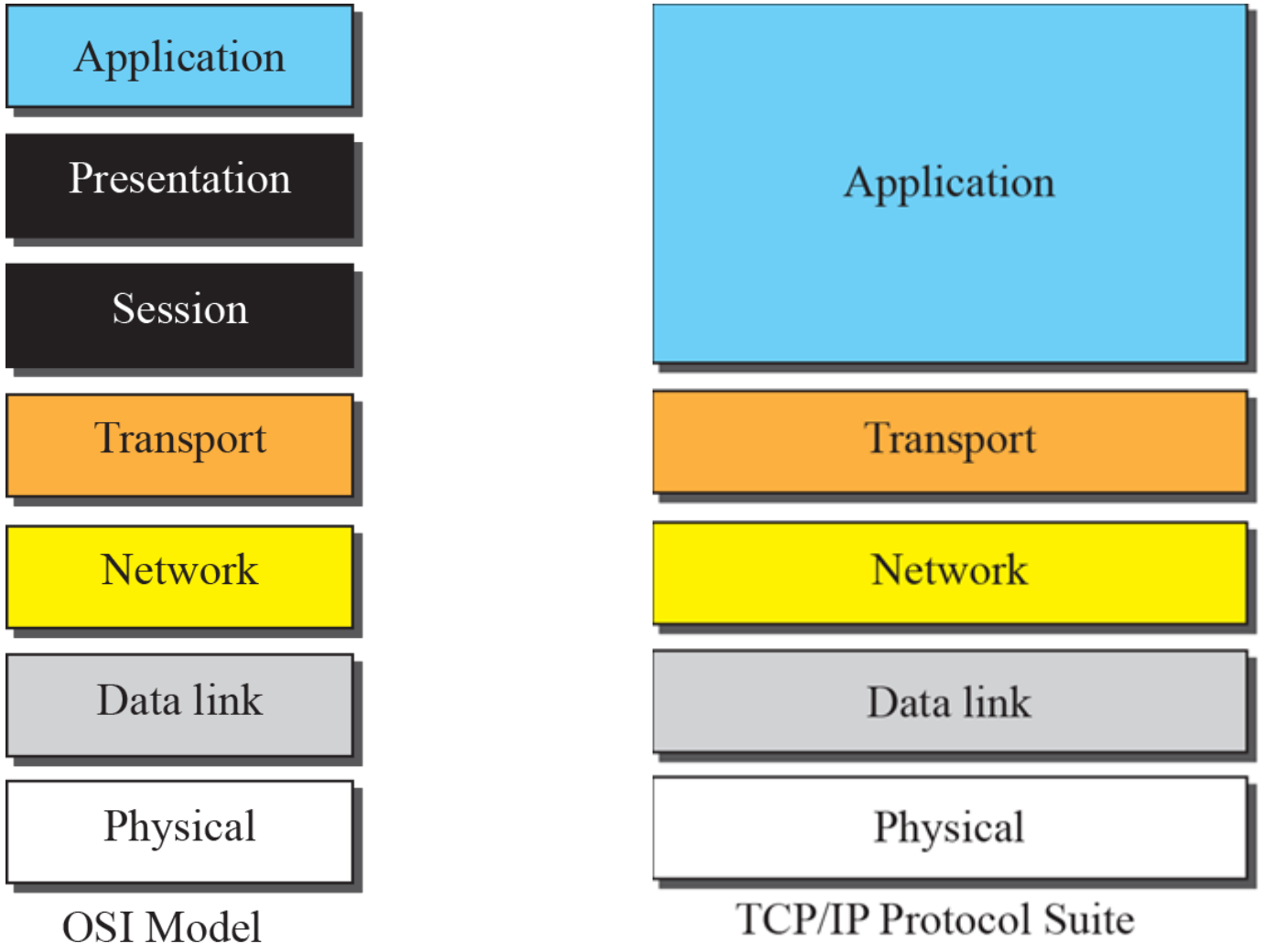


Fig: Mapping of OSI with TCP/IP(4 layers)

Mapping OSI to TCP/IP(5layers)



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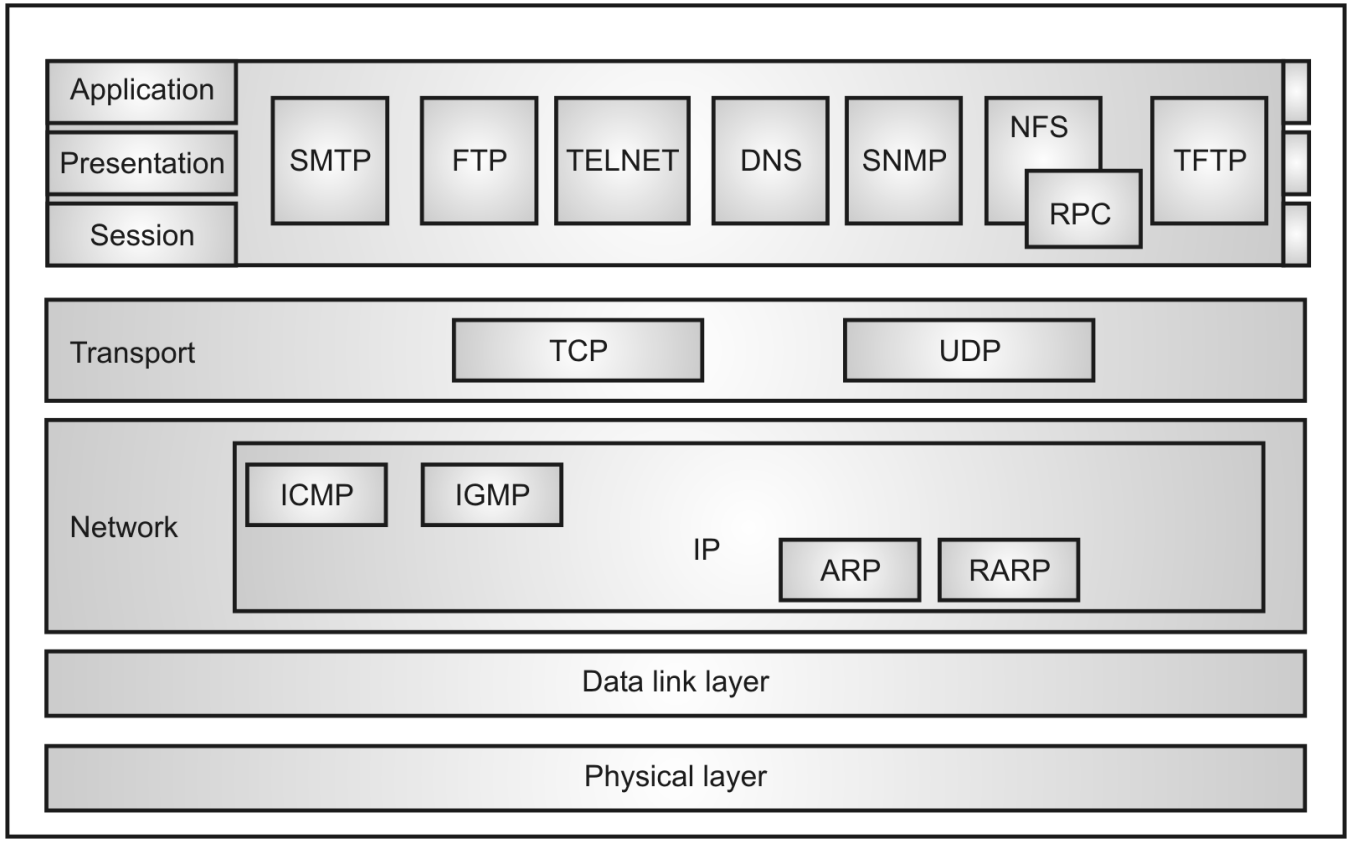
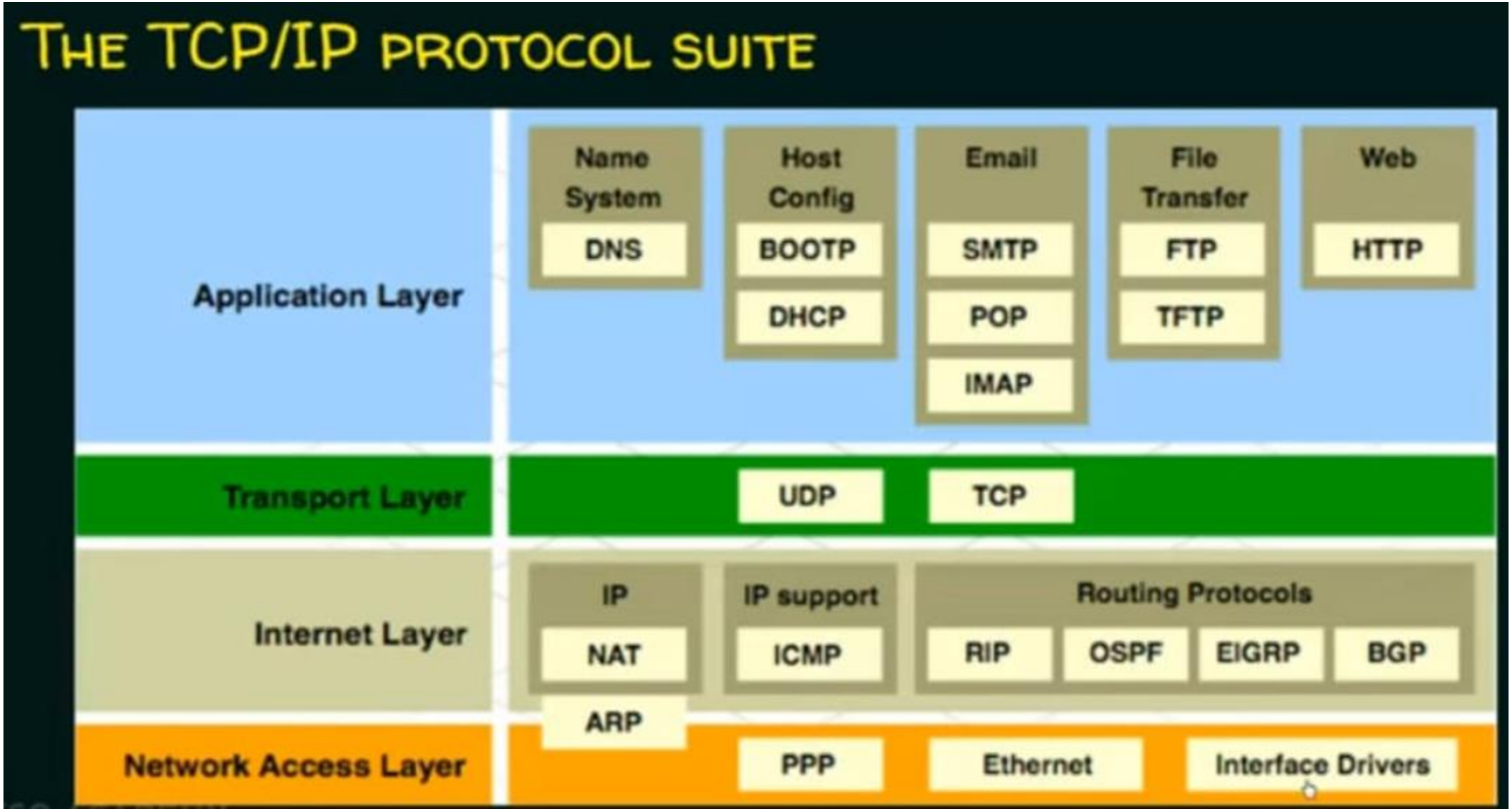
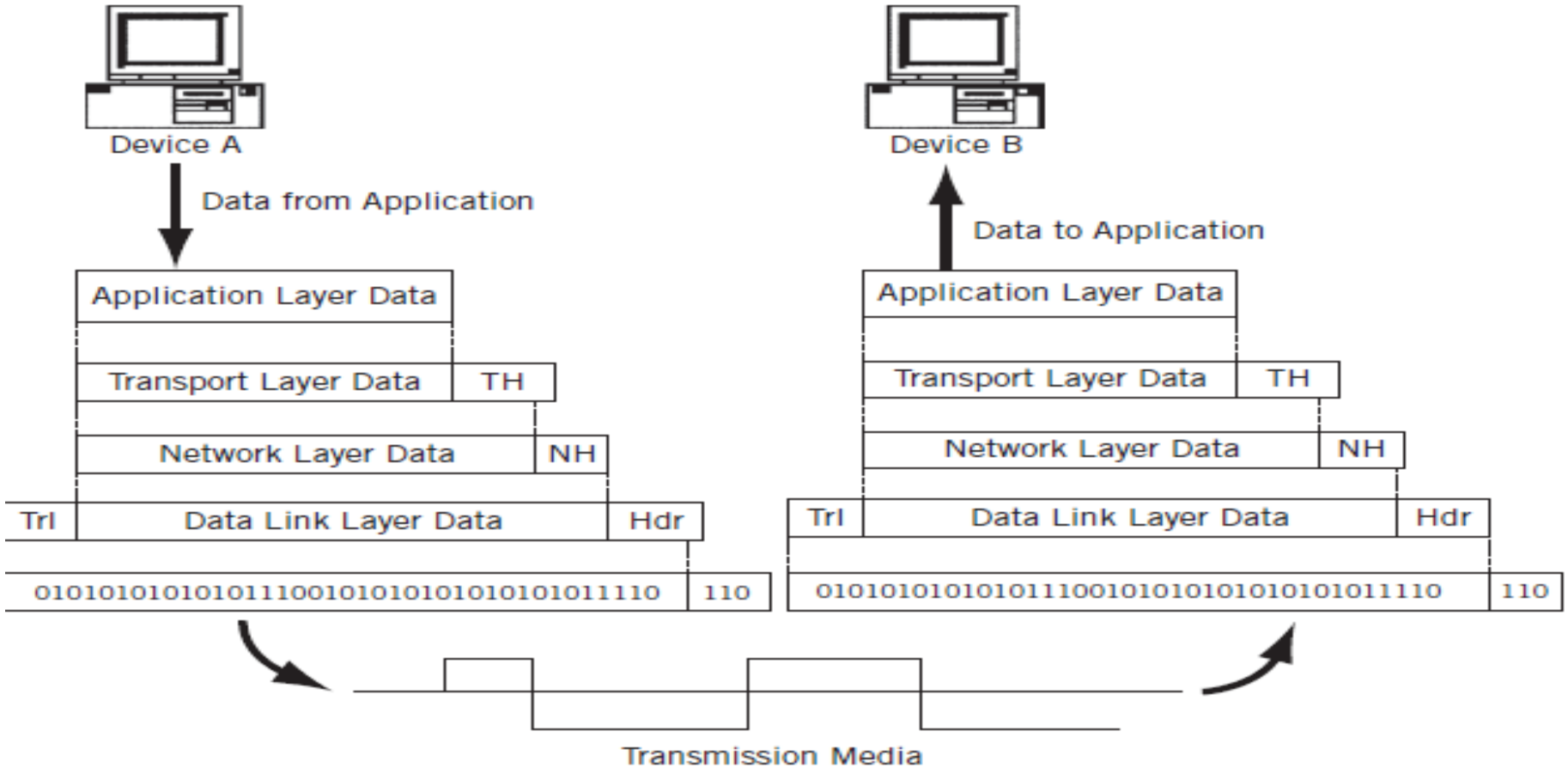

Application
Presentation
Session
SMTP
FTP
TELNET
DNS
SNMP
NFS
RPC
TFTP
Transport
TCP
UDP
Network
ICMP
IGMP
IP
ARP
RARP
Data link layer
Physical layer

Contd…


THE TCP/IP PROTOCOL SUITE
Application Layer
Name System
DNS
Host Config
BOOTP
DHCP
Email
SMTP
POP
IMAP
File Transfer
FTP
TFTP
Web
HTTP
Transport Layer
UDP
TCP
Internet Layer
IP
NAT
ARP
IP support
ICMP
Routing Protocols
RIP
OSPF
EIGRP
BGP
Network Access Layer
PPP
Ethernet
Interface Drivers

TCP/IP data encapsulation



Protocol Data Unit (PDU)

Protocol Data Units (PDUs) are named according to the protocols of the TCP/IP suite: data, segment, packet, frame, and bits.

TCP/IP Layers

5. Application layer

- User interacts directly with the application software, where application process creates user data and transmits this data to other application process on same or another host via one of the transport layer protocol (TCP or UDP).

Application layer protocols:

- HTTP(hyper text transfer protocol): Is the protocol that web browsers and web servers use to communicate with each other.
- FTP protocol : Used to exchange computer files within hosts. Setting up an FTP server becomes necessary for businesses that manage their own network and need to establish a file transfer (exchange of documents) between company employees.
- DNS protocol: Domain names are alphabetic which are easier to remember. Internet is however based on IP addresses.DNS involves converting a host name into its IP address.

Contd..

- **SNMP :** SNMP stands for **Simple Network Management Protocol**. It is a framework **used for managing the devices** on the internet by using the TCP/IP protocol suite.

- **SMTP :** SMTP stands for **Simple mail transfer protocol**. The TCP/IP protocol that supports the e-mail is known as a Simple mail transfer protocol. This protocol is **used to send the data to another e-mail address**.
- **TELNET** : It is an abbreviation for **Terminal Network**. It **establishes the connection between the local computer and remote computer** in such a way that the local terminal appears to be a terminal at the remote system.

Contd…

4.Transport layer

Transport layer is the fourth layer in the TCP/IP reference model.

The transport layer is **responsible for the reliability, flow control, and correction of data** which is being sent over the network

The transport layer receives the data from the application layer and splits it into separate packets, with an order number and port number.

The core protocols of transport layer are Transmission Control Protocol (TCP) and User Datagram Protocol (UDP).

- **TCP** - is a connection-oriented protocol.

  Connection-oriented - Establishes a logical connection between sender and receiver before sending any data packets.

- **UDP** - is a **connectionless**, protocol. Connectionless - Establishing a connection between sender and receiver is not required.

Contd…

3.Network layer

The network layer is responsible for attaching the sender and

destination IP address. The IP addresses combined with the ports create sender and receiver sockets. It is also responsible for packet routing, forwarding the data packets to the next router towards their destination.

The protocol at the network layer is called the **Internet protocol(IP)**.

- IP prepares segments received from Transport layer for delivery by splitting them into units called **IP datagrams**. Splitting is required if the packet exceeds the allowable byte size for network.
- IP attaches an **IP header** to the segment or packet's header, in addition to the information that is added by TCP or UDP. Information in the IP header includes the IP addresses of the sending and receiving hosts.

Contd...

Functions of Internet Layer

- The main responsibility of the internet layer is **to send the packets from any network**, and they arrive at the destination irrespective of the route they take.

Following are the protocols/functions used in this layer are :

- **IP protocol** is used in this layer, and it is the most significant part of the entire TCP/IP suite.

Following are the responsibilities of this protocol :

- **IP Addressing :** This protocol implements logical host addresses known as IP addresses. The IP addresses are used by the internet and higher layers are used to identify the device and to provide internetwork routing.
- **Data Encapsulation and Formatting :** An IP protocol accepts the data from the transport layer protocol. An IP protocol ensures that the data is sent and received securely, it encapsulates the data into message known as IP datagram.
- **Fragmentation and Reassembly :** The limit imposed on the size of the IP datagram by data link layer protocol is known as Maximum Transmission unit (MTU). If the size of IP datagram is greater than the MTU unit, then the IP protocol splits the datagram into smaller units so that they can travel over the local network.

Fragmentation can be done by the sender or intermediate router. At the receiver side, all the fragments are reassembled to form an original message.

- **Routing :** When IP datagram is sent over the same local network such as LAN, MAN, WAN, it is known as direct delivery. When source and destination are on the distant network, then the IP datagram is **sent indirectly**. This can be **accomplished by routing** the IP datagram through various devices such as routers.
- **Protocol Identification:**

Contd…

Network Access Layer (First layer in 4 layer TCP/IP model)

Functions of Network Access Layer

- A network layer is the **lowest layer of the TCP/IP** model. A network layer is the **combination** of the **Physical layer and Data Link layer** defined in the OSI reference model.
- It defines how the **data should be sent physically** through the network. This layer is mainly responsible for the **transmission of the data between two devices** on the same network.
- The functions carried out by this layer are **encapsulating the IP datagram** into **frames** transmitted by the network and mapping of IP addresses into physical addresses.
- The **protocols used** by this layer are **ethernet, token ring, FDDI, X.25, frame relay.**

Contd…

2.Data Link Layer Functions

1. **Framing:** Divide the stream of bits received from network layer into data units called frames
2. **Physical Addressing:** The Data Link layer adds a header to the frame in order to define physical address of the sender or receiver of the frame, if the frames are to be distributed to different systems on the network.
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Contd…

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- It provides the hardware means of sending and receiving data on a carrier.

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3. **Synchronization**: It deals with the synchronization of the transmitter and receiver. The sender and receiver are synchronized at bit level.

4. **Interface**: The physical layer defines the transmission interface between devices and transmission medium.

Contd…

5. **Line Configuration**: This layer connects devices with the medium: Point to Point configuration and Multipoint configuration
6. **Topologies**: Devices must be connected using the following topologies: Mesh, Star, Ring and Bus.
7. **Transmission Modes**: Physical Layer defines the direction of transmission between two devices: Simplex, Half Duplex, Full Duplex.

Main Difference between OSI and TCP/IP

OSI	TCP/IP
1. The OSI model is a reference model.	1. The TCP/IP model is an implementation of the OSI model. It is a client server model used for transmission of data over the internet.
2.The OSI model has 7 layers.	2. The TCP/IP model has only 5 layers.
3. Layers- Application, Presentation, Session, Transport, Network, Data Link, Physical.	3. Layers- Application, Transport, Network, Data Link, Physical.
4. Separate Presentation and Session Layer	4. TCP/IP combines the presentation and session layer into its application layer
5. The OSI model supports only connection -oriented communication in transport layer.	5 The TCP/IP model supports both connection-less and connection-oriented communication in the transport layer