Computer Networks

Module 1

Introduction to Networking

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Somaiya TRUST

Outline

- Communication System
- Basic Concepts
  - Line Configuration
  - Transmission mode
- Types of Networks
- Network Topology

What is Networking?

In simple term " *A network is simply a collection of computers or other hardware devices that are connected together, either physically or logically using special hardware and software in order to exchange information.*"

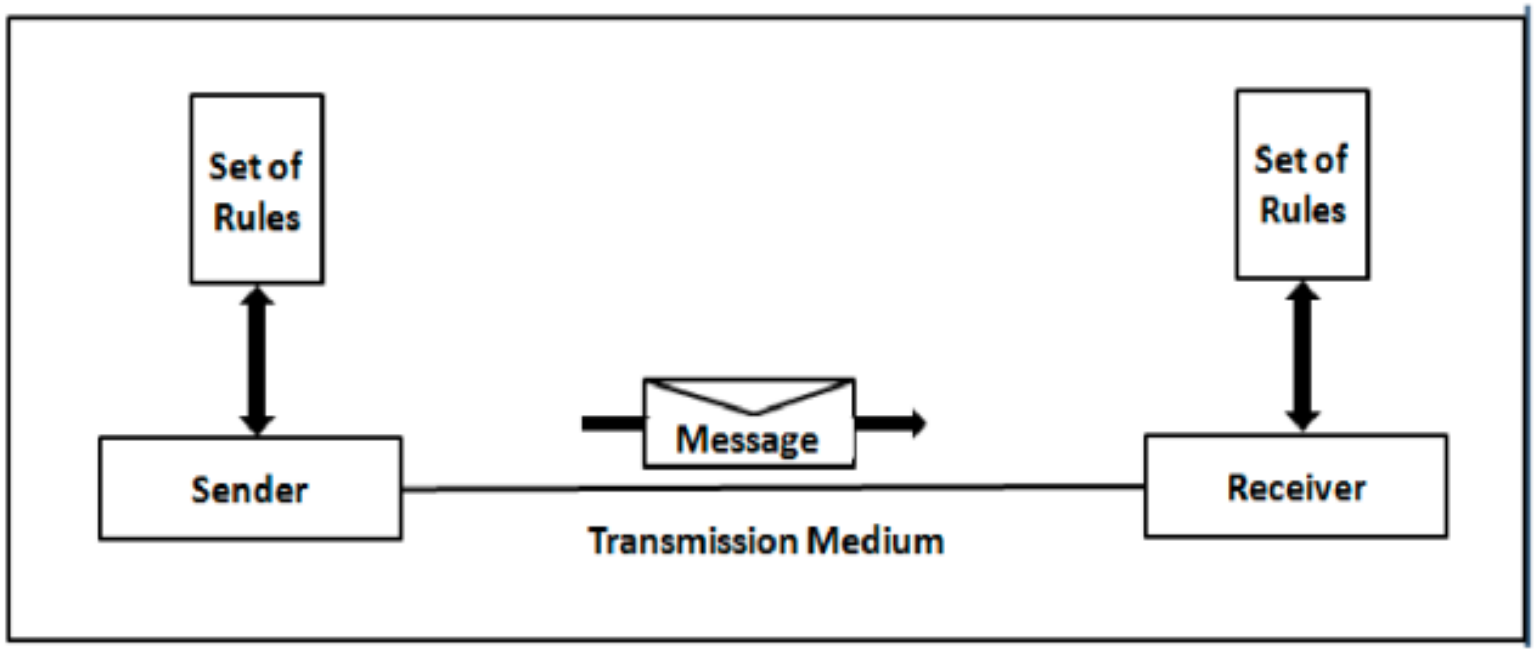
And **Networking** is term that describes the *process involved in design, implementation, management of network* using network technology.

Introduction to Communication System

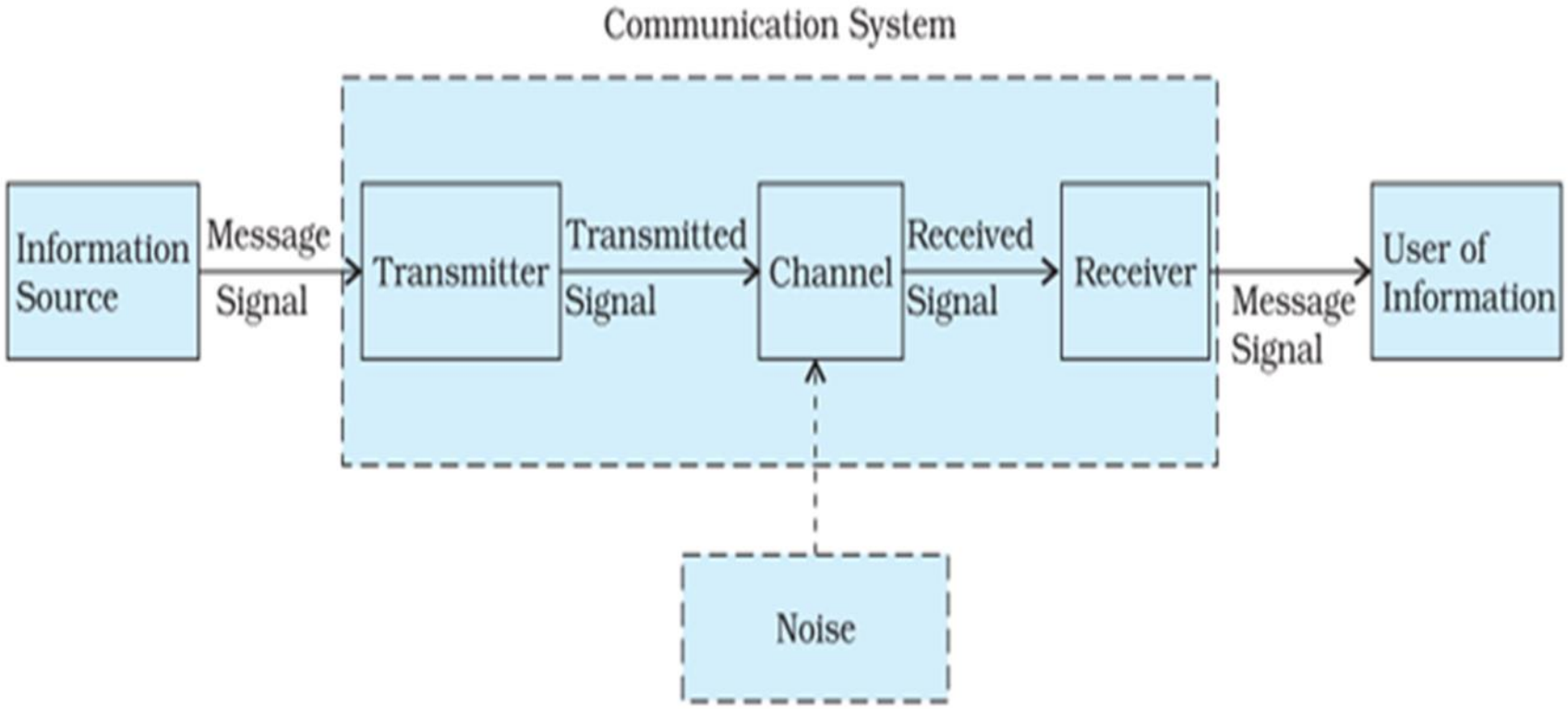
- Data Communication is a process of exchanging data or information and in case of computer networks it done in between two or more devices over a transmission medium.
- Communication system consists of Hardware and Software.
- **Hardware**: Sender, Receiver and Intermediate devices
- **Software**: Set of rules and protocols that need to satisfied.

Components of Data Communication

- Components:
  - Message
  - Sender
  - Receiver
  - Transmission Medium
  - Protocols

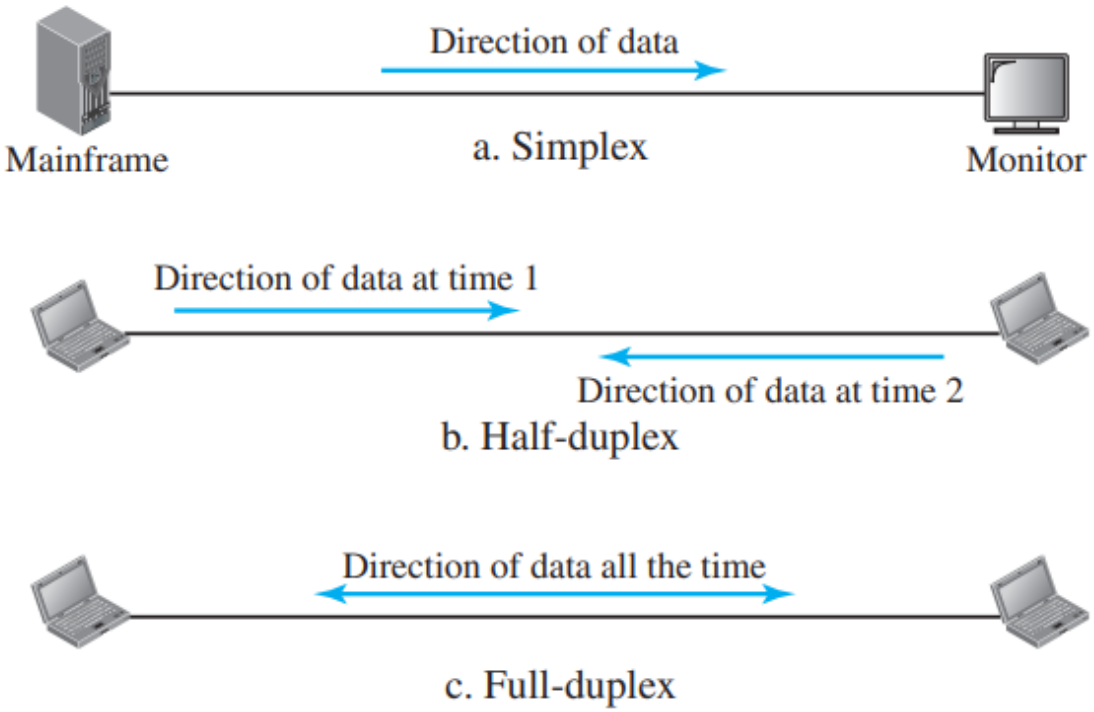


Elements Of Communication System



Data Flow

- Simplex
- Half-Duplex
- Full Duplex



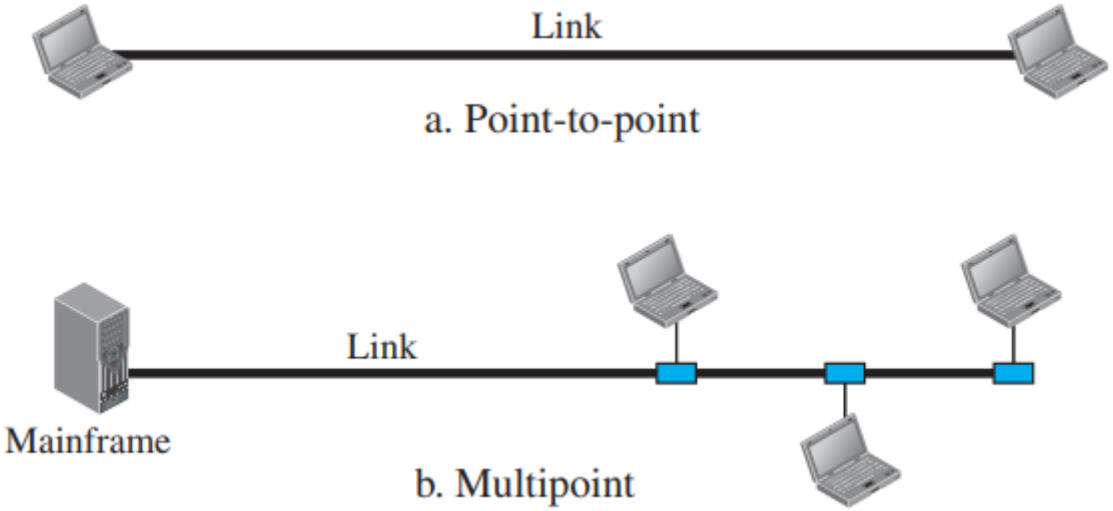
Network Criteria

- **Performance:**
  - Can be measured in terms of
    - Transit time
    - Response time
  - Evaluated by two networking metrics: Throughput & Delay
- **Reliability:** measured by frequency of failure, time taken by link to recover from failure and network robustness ion catastrophe
- **Security:** Securing data from unauthorized access, protecting data from damage, implementing policies, recovery from breaches and data loss.

Physical Structures

Type of Connections:

- Point-to-Point connection:
  - Provides dedicated link between two devices
  - Entire link capacity is reserved between two devices
- Multipoint (Multidrop):
  - More than two devices share a single link.
  - Capacity of channel is shared
  - Channel is shared either *Spatially or Timeshared*.



Physical Topology

Physical Topology refers to a way in which network is laid out physically.

Topology is geometric representation of relationship of all the links and linking devices (also called nodes) to one another.

There are Four basic Topologies:

- Mesh
- Star
- Bus
- Ring

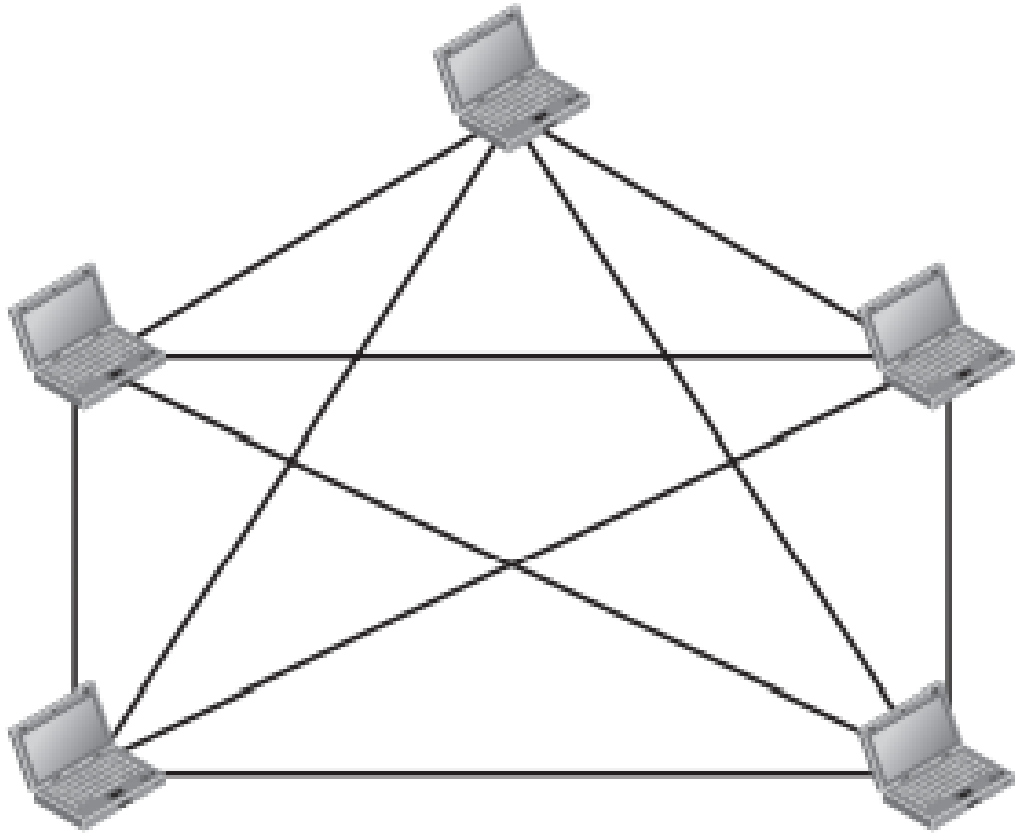
Mesh Topology

- Every device has a dedicated point-to-point link to every other device.
- Link carries traffic only between the two devices it connects.
- Total number of physical links in a fully connected mesh network with n nodes is equal to **n(n-1).**
- In case of communication in both direction : **n(n-1)/2 duplex node links.**
- Every device on network must have **(n-1) input/output** (I/O) ports.

Mesh Topology

- Advantages
  - No traffic problems
  - Robust
  - Privacy and security
  - Point to point link: fault identification and isolation is easy
- Disadvantages
  - Installation and reconnection difficult as devices interconnected.
  - Bulk wiring
  - Expensive: hardware cost

$n = 5$
10 links.



Star Topology

- each device has a dedicated point-to-point link only to a central controller, usually called a ***hub***.
- devices are not directly linked to one another.
- star topology does not allow direct traffic between devices.
- The controller acts as an exchange, it relays the data to the other connected device.
- The star topology is used in local-area networks (LANs)

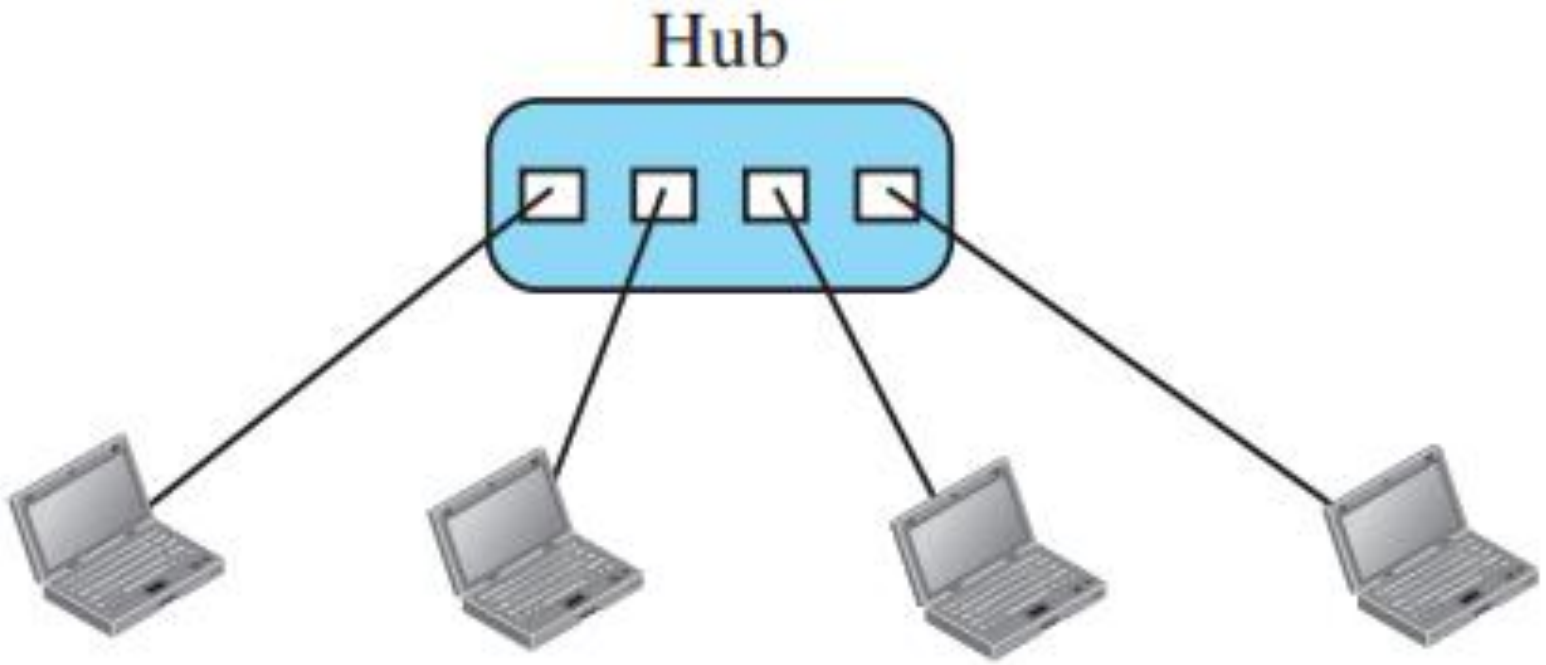
Star Topology

Advantages

- Less expensive than mesh
- Reconfiguration and installation is easy.
- Robustness
- Easy fault identification as long as hub is working

Disadvantages

- Dependency on single point controller.
- Each node must be linked to hub: more cabling required compared to other topologies except mesh.


Hub

Bus Topology

- A bus topology is multipoint connection.
- One long cable acts as a backbone to link all the devices in a network.
- Nodes are connected to the bus cable by drop lines and taps.
- A drop line is a connection running between the device and the main cable.
- A tap is a connector that either splices into the main cable or punctures the sheathing of a cable to create a contact with the metallic core.

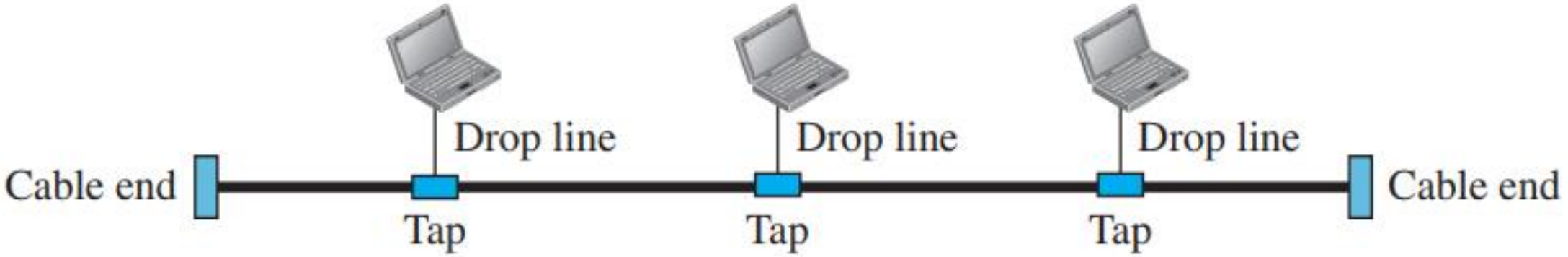
Bus Topology

Advantages

- Ease of installation: less cabling as compared to mesh and star.
- A bus uses less cabling than mesh or star topologies

Disadvantages

- It is Difficult to add new devices.
- Difficult reconfiguration and fault isolation.
- A fault in Backbone stops all transmission
- Limited cable length and number of nodes that can be connected.


Drop line
Drop line
Drop line
Cable end
Cable end
Tap
Tap
Tap

Ring Topology

- Each device has a dedicated point-to-point connection with only the two devices on either side of it.
- A signal is passed along the ring in one direction, from device to device, until it reaches its destination.
- Each device in the ring incorporates a repeater.

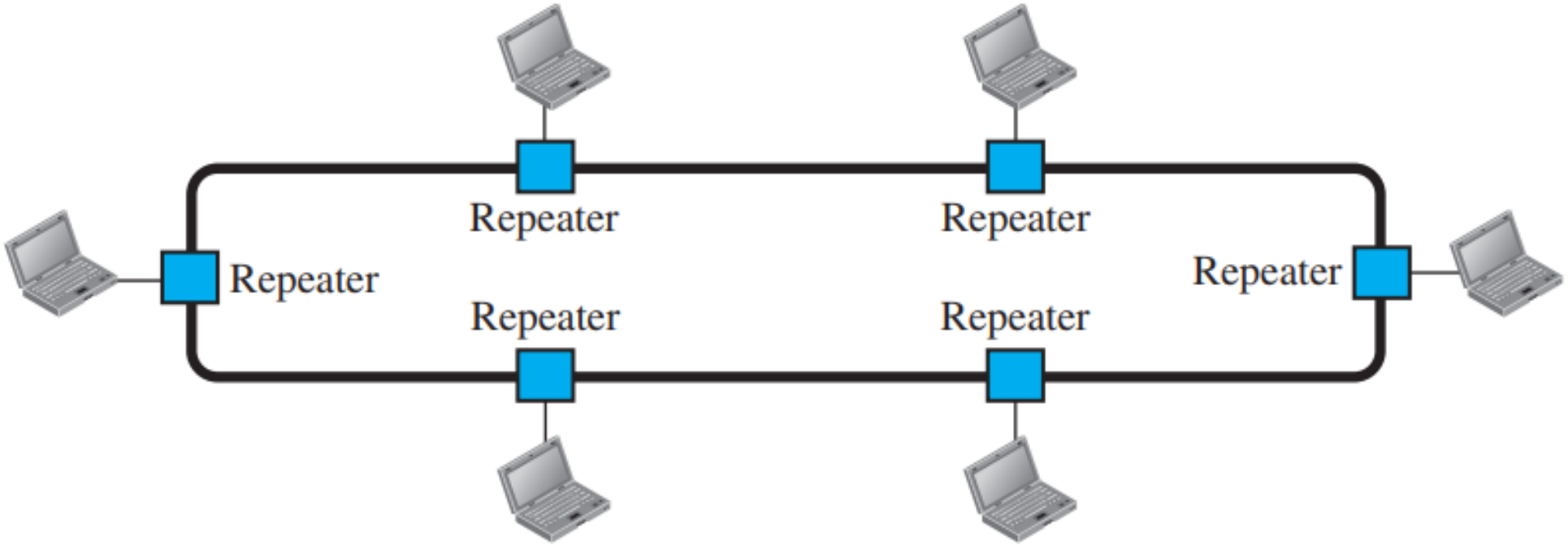
Ring Topology

Advantages

- Easy to install and reconfigure.
- Easy adding and deleting of connections.
- Fault isolation simplified: devices can raise the alarm.

Disadvantages

- Unidirectional traffic can be a disadvantage.
- Breakdown in ring disables the entire network.


Repeater
Repeater
Repeater
Repeater
Repeater
Repeater

Types of Networks

- Local Area Network (LAN)
- Metropolitan Area Network(MAN)
- Wide Area Network(WAN)

Local Area Networks

- A ***l**ocal-**a**rea **n**etwork* (LAN) is a computer network that spans a relatively small area.

- A local area network (LAN) is usually privately owned and links the devices in a single office, building, or campus.

- LAN size is limited to a few kilometers.

Local Area Networks

- LANs are designed to allow resources to be shared between personal computers or workstations.

  Example: hardware or software

- One of the computers may be given a large capacity disk drive and may become a server to clients.

- LAN extends up to 10m to 1km

Local Area Networks

- LANs are distinguished from other types of networks by their transmission media and topology.

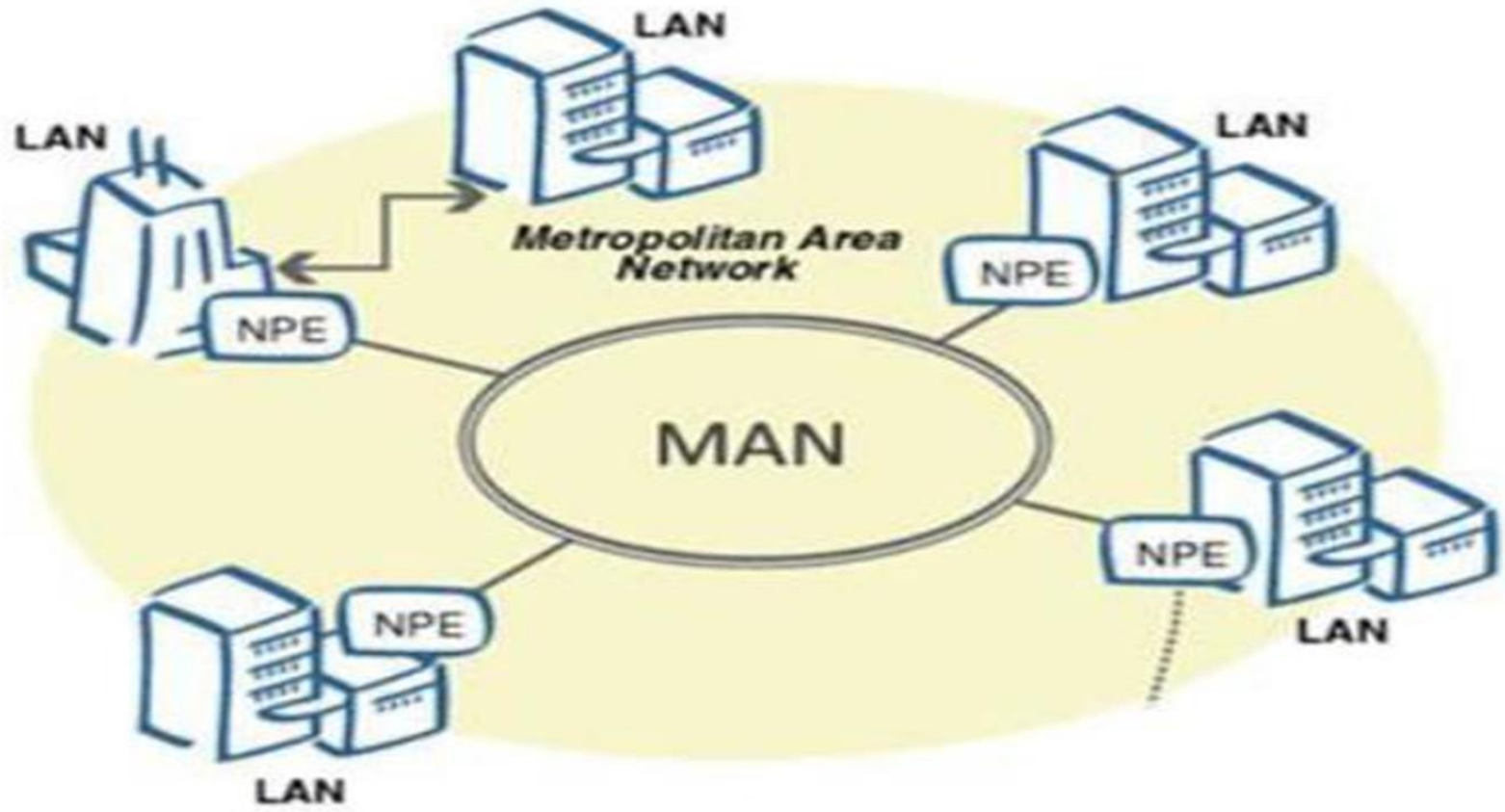
- Speeds: 100 or 1000 Mbps.

Metropolitan Area Networks

- Metropolitan Area Network usually covers area inside a town or a city.
- It is designed for customers who need a high-speed connectivity, normally to the Internet, and have endpoints spread over a city or part of city.

  Example: cable TV network
- MAN extends up to 30-40 km.
- Speed of 34–155 Mbit/s.
- MAN uses Guided Media or Unguided media.

Metropolitan Area Networks



Wide Area Networks

- A wide area network (WAN) provides long-distance transmission of data, image, audio, and video information over large geographic areas that may comprise a country, a continent or even the whole world.

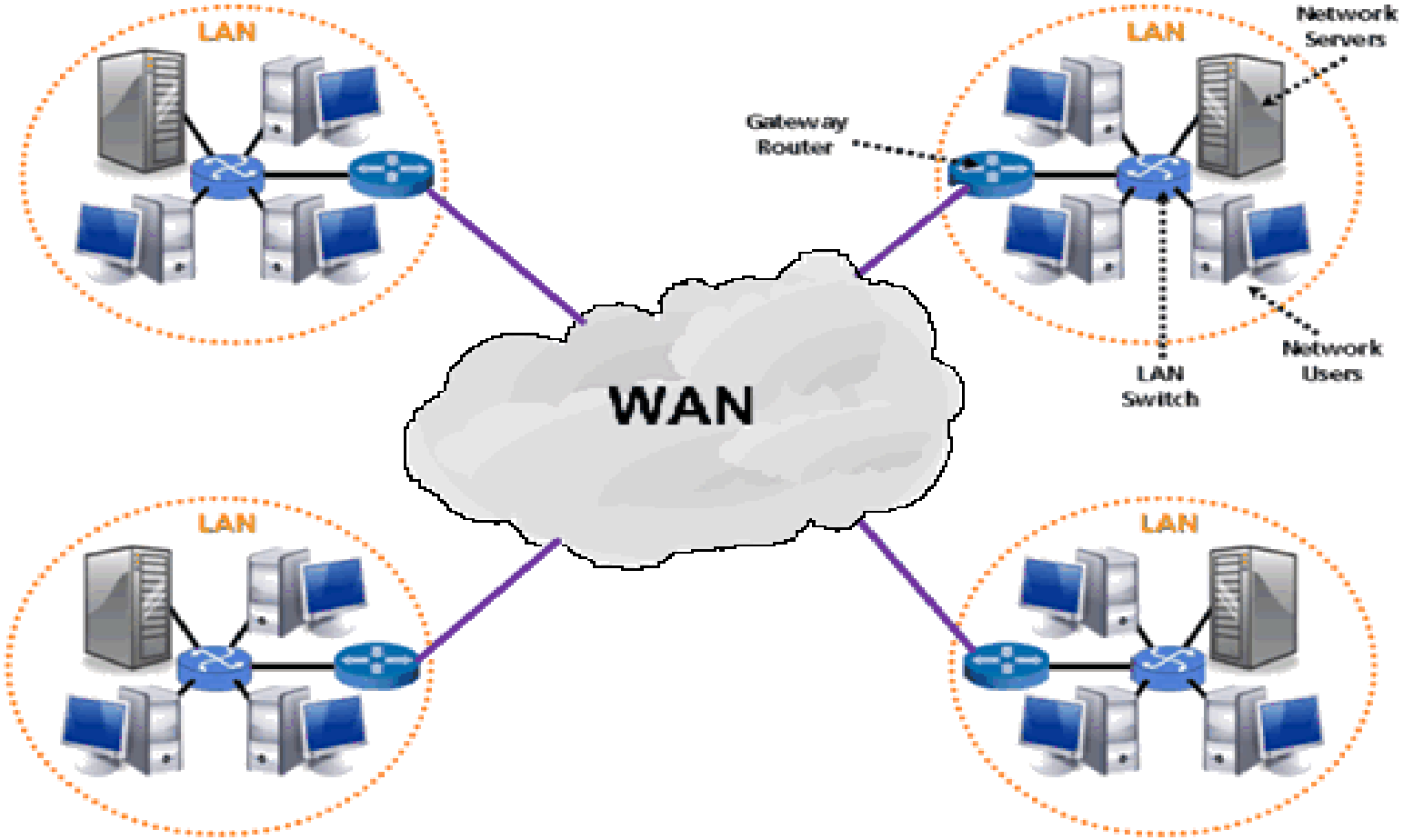
- WAN (Wide Area Network) is a group of computers and other network devices which are connected and not restricted to a geographical location.

- Internet is WAN.

Wide Area Networks

- WAN speed varies based on geographical location of the servers. WAN connects several LANs.
- WAN connection speeds can be 10Mbps or 100Mbps.
- WAN mainly uses Guided Media or Unguided media.

Wide Area Networks



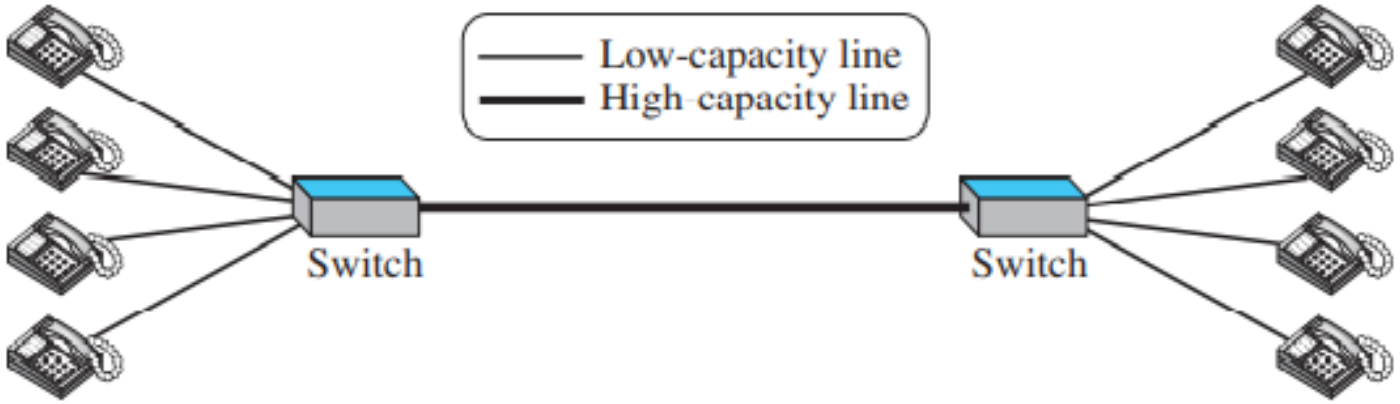
Switching

An internet is a switched network in which a switch connects at least two links together

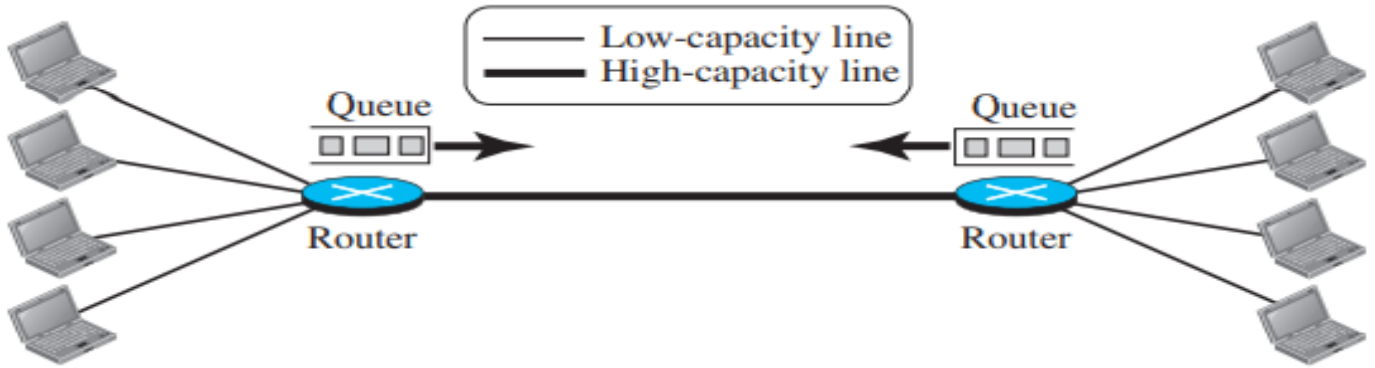
The two most common types of switched networks are circuit-switched and packet-switched networks.

- Circuit-Switched Network
- Packet Switched network

Switching

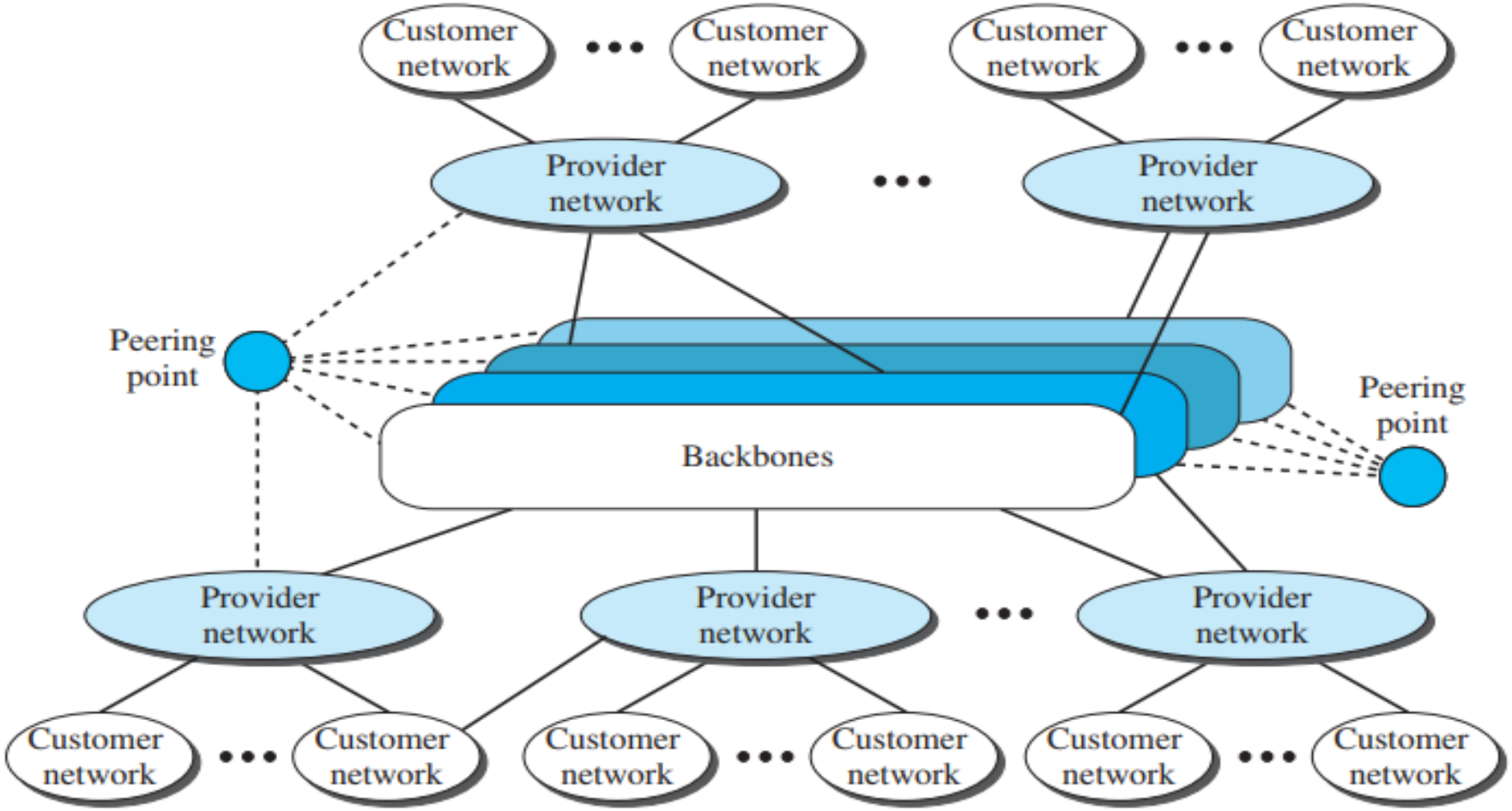


A Circuit Switched network



A Packet Switched network

The Internet Today



Network Models

Protocol Layering:

- ISO OSI Model
- TCP/IP model

Design Issues for Layers

Addressing - whom am I going to talk to? i.e., how do we identify senders and receivers?

Rules for data transfer: Simplex (one-way channels), half-duplex (two-way communication but not simultaneously) and full duplex (2 way)

Logical channels: usually at least 2. One for normal mode and one for urgent transmission.

Design Issues for Layers

Reconstituting messages: Out of order messages need to be numbered.(Flow Control)

Error control: This is all about communicating along imperfect channels and error correction in such cases. (Issues: Attenuation, delay distortion and noise).

Large messages: Procedures for disassembling, transmitting and reassembling. What to do when messages are very small (compared to packet)?

Design Issues for Layers

Multiplexing: One connection per conversation or many on one connection. Important in physical layer where only a few lines are available

Routing: What to do when there are multiple paths between communicating machines

Connection Less Services

- No session connection between sender and receiver.
- No reliability
- Short messages
- Does not maintain state information.
- Less overhead
- Example: Walkie-Talkie

Connection Oriented Services

- Requires session connection (analogous to a phone call).
- Reliable network service.
- Set up virtual links between the end systems through a network.
- Long messages.
- High overhead and places greater demands on B/W.
- Example: Email

The OSI model

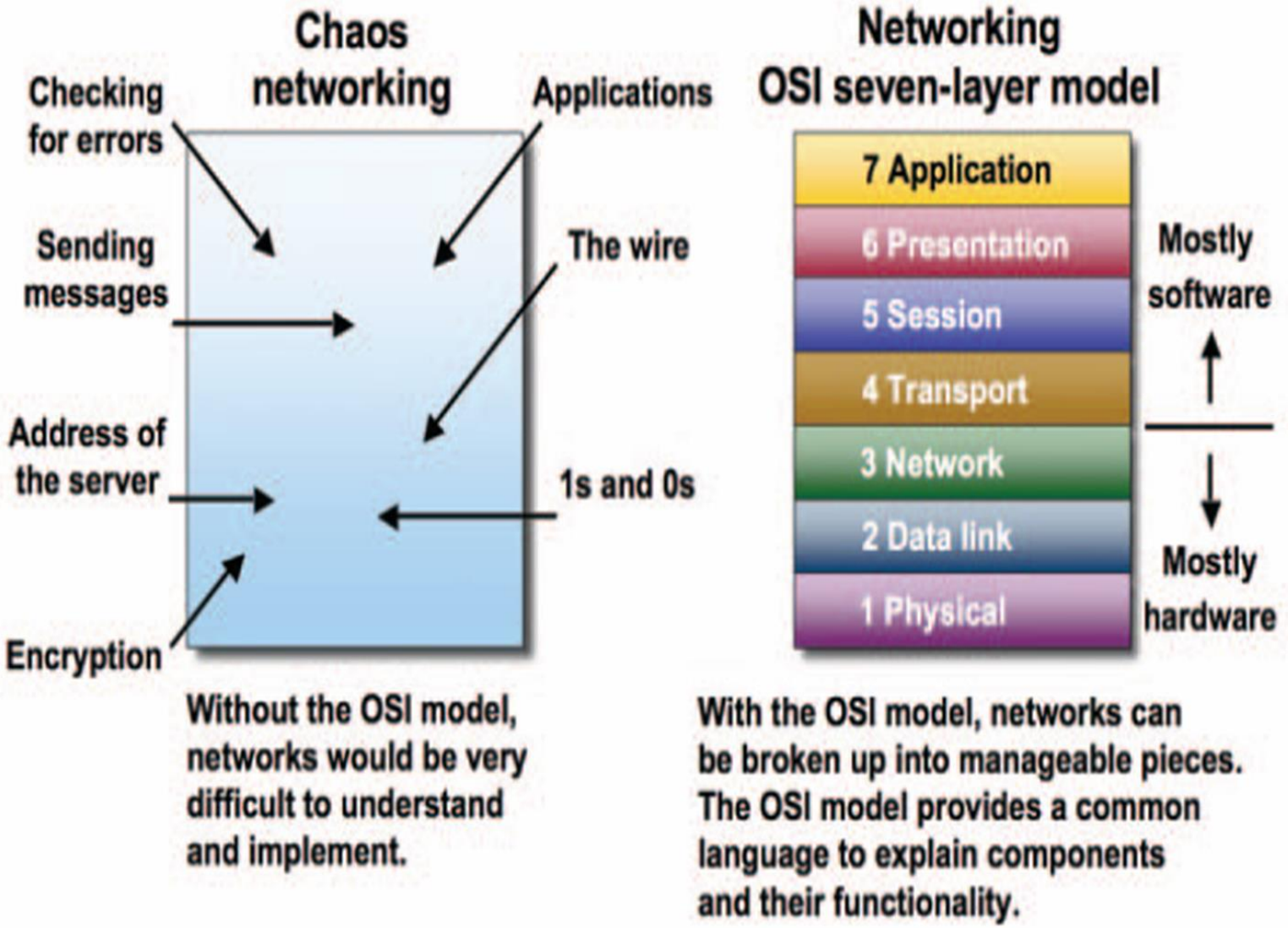
- Over the past couple of decades many of the networks that were built used different hardware and software implementations, as a result they were incompatible, and it became difficult for networks using different specifications to communicate with each other.

- The **Open System Interconnection (OSI)** model includes a set of protocols that allows any two systems to communicate regardless of their architecture.

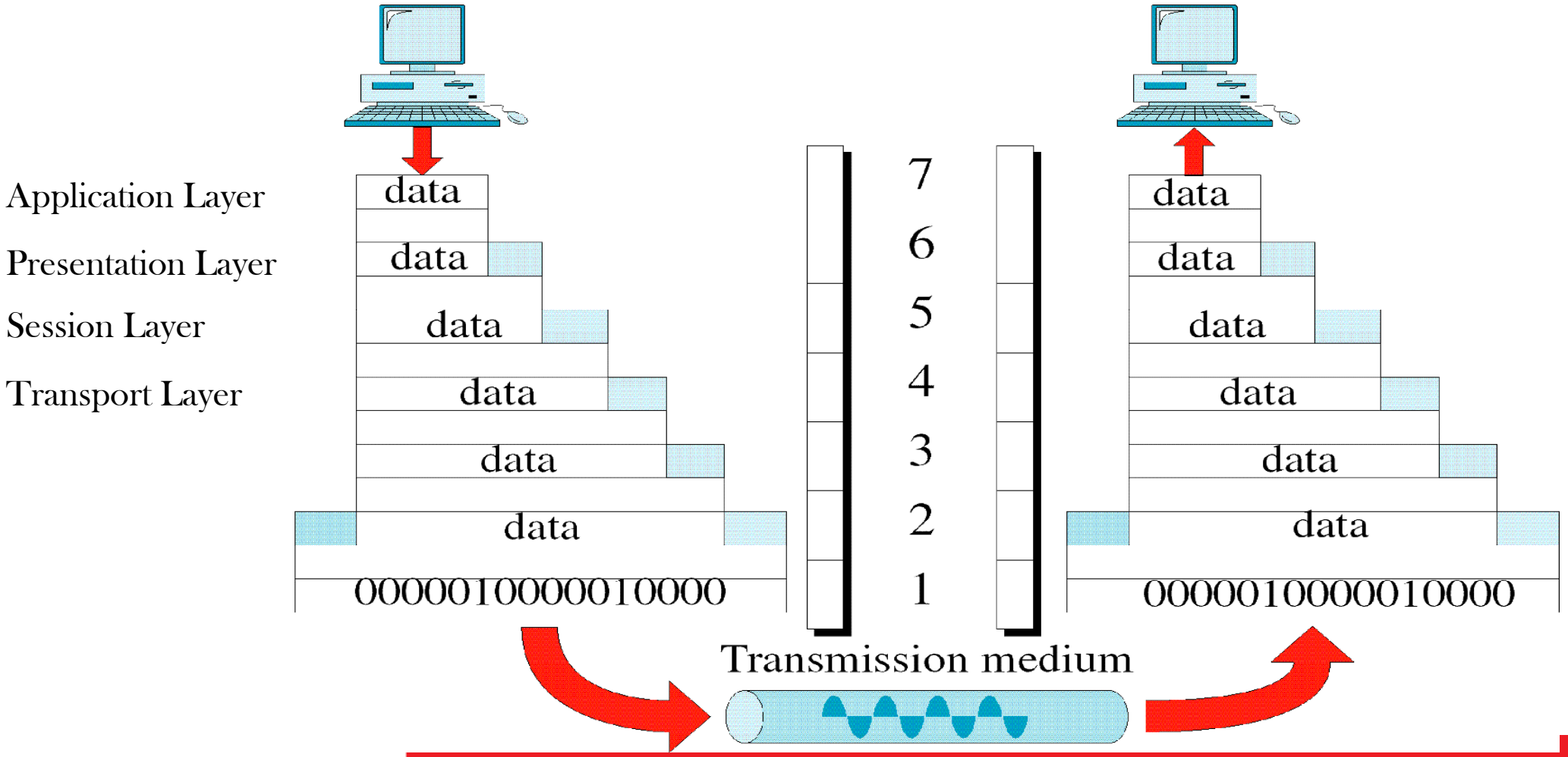
The OSI model

- The OSI model is a concept that describes, how data communications should take place.
- OSI is also called as the framework for design of network systems.
- It divides the process into seven steps called layers.

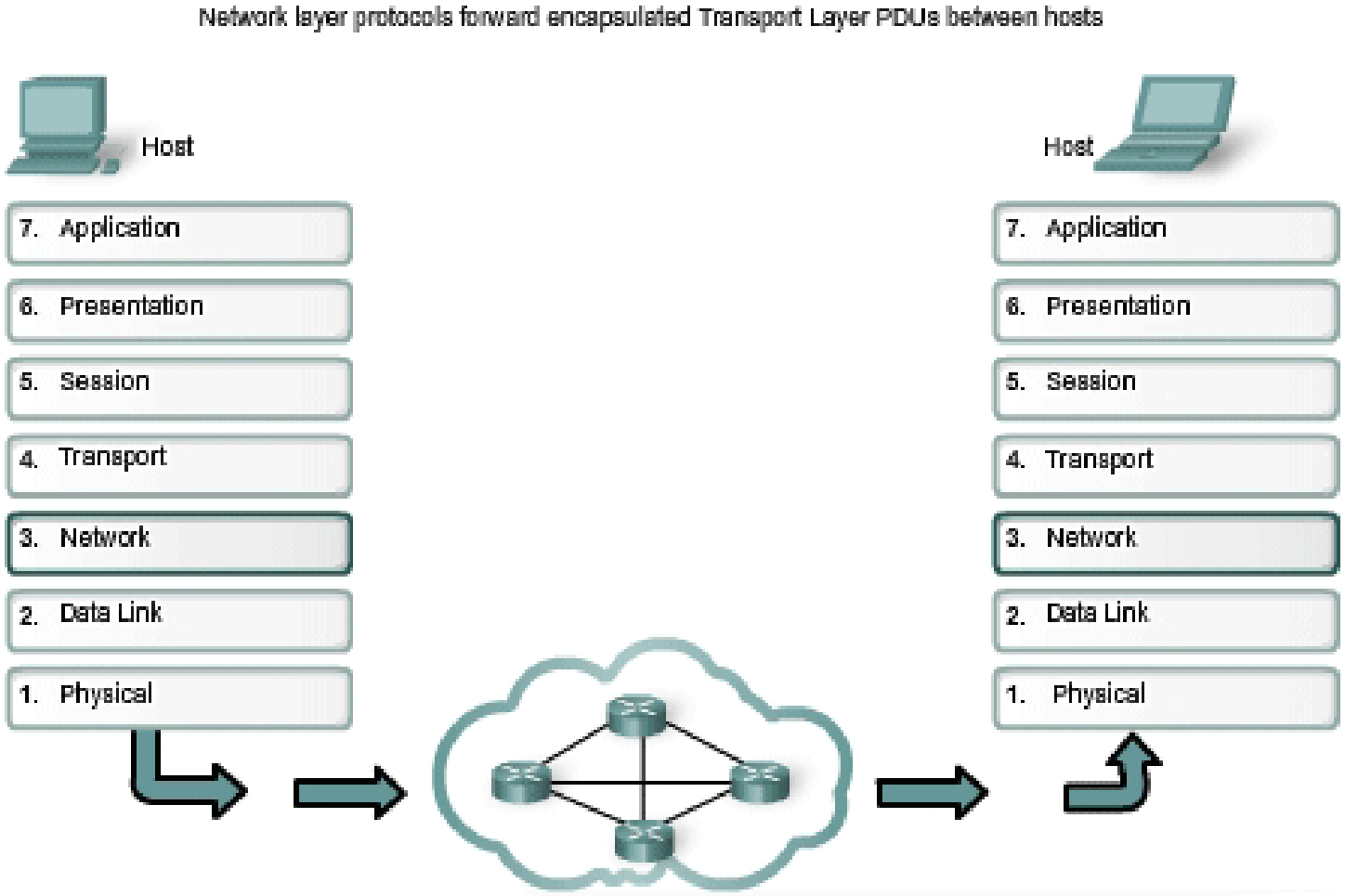
The OSI model



The OSI model



The OSI model



Physical Layer

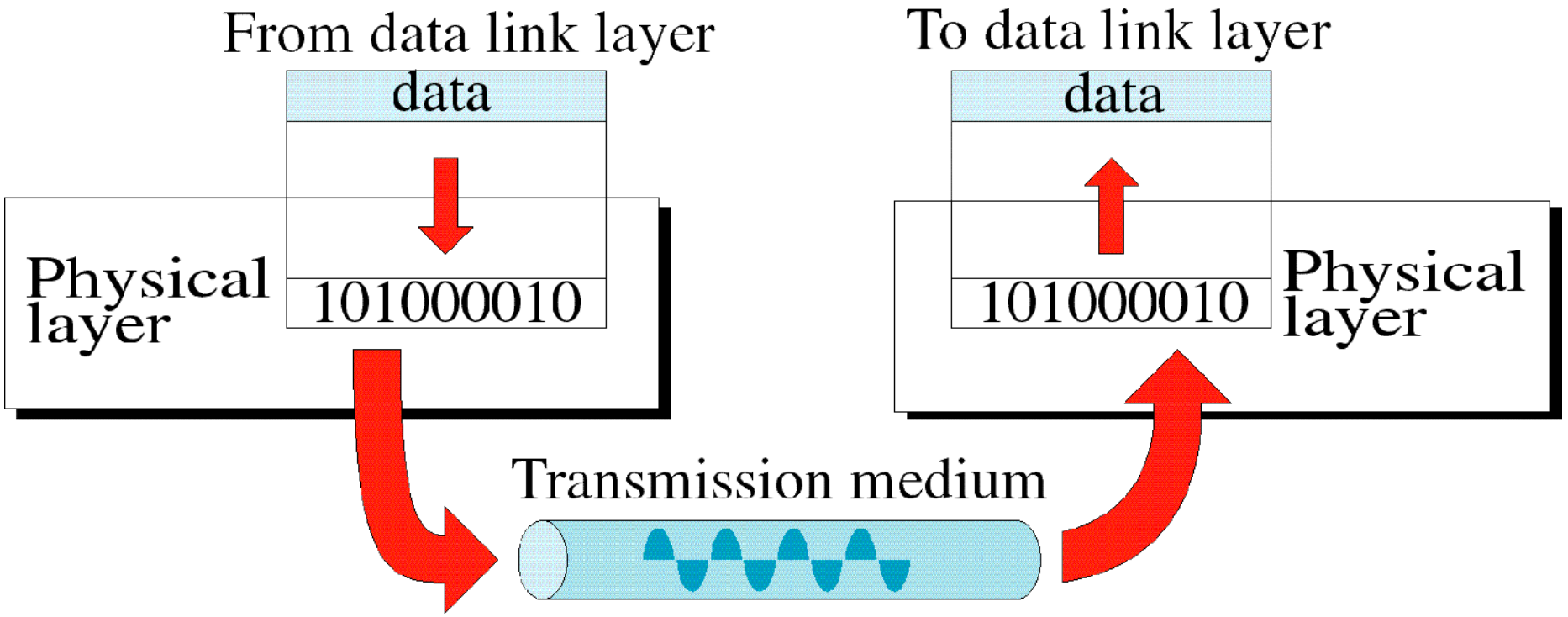
- The physical layer deals with the physical characteristics of the transmission medium.
- This layer consists of simply the wire or media by which the network signals are conducted.
- The physical layer of the OSI model defines connector and interface specifications, as well as the medium (cable) requirements for transmission to occur.

Physical Layer

Functions of physical layer:

- Physical characteristics of interfaces and medium.
- Representation of bits: Conversion from binary to electrical or optical.
- Data rate.
- Synchronization of bits.
- Physical topology
- Line configuration: point to point or multipoint.

Physical Layer



Data Link Layer

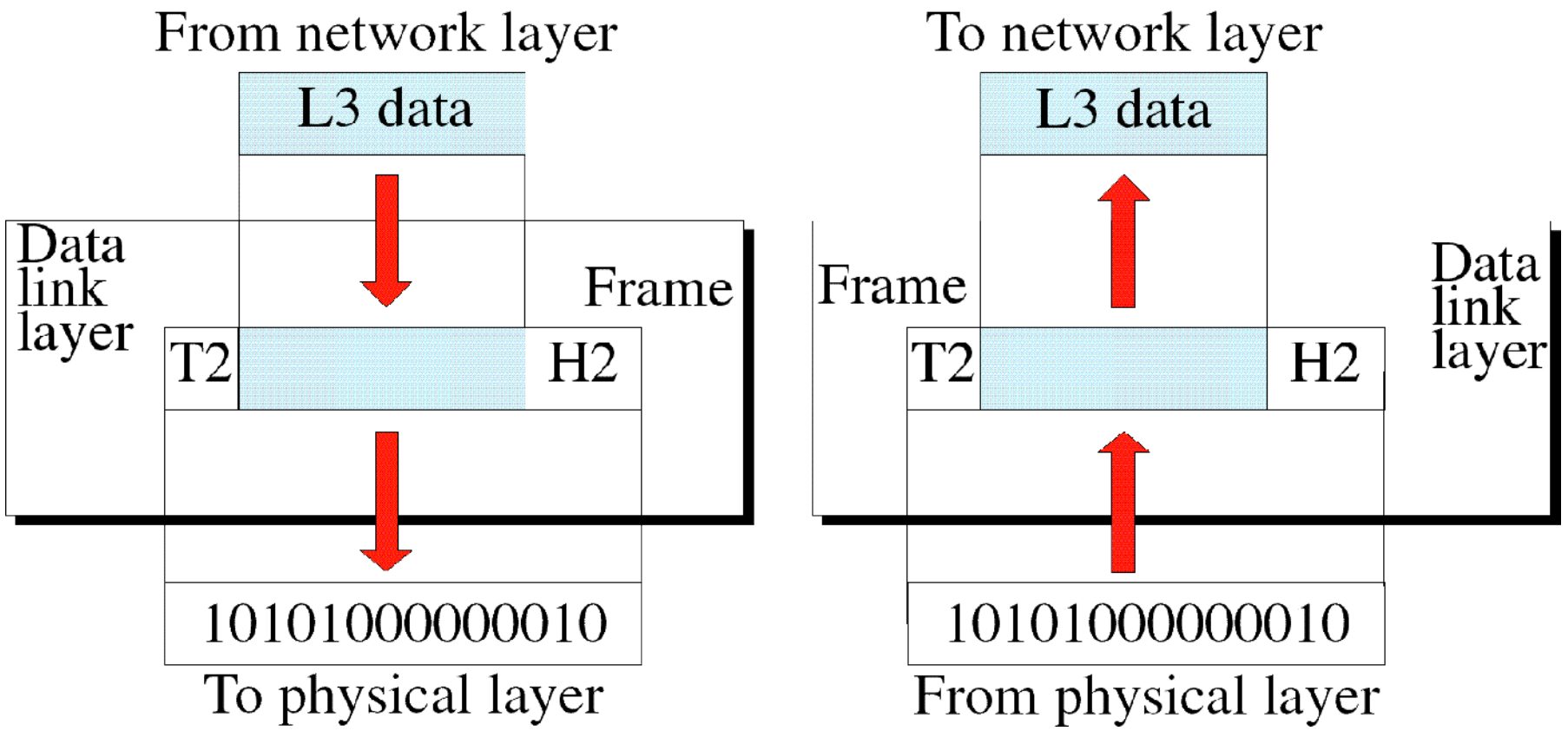
- The data link layer transforms the physical layer, a raw transmission facility, to a reliable link.
- Node to node delivery
- The data link layer uses the **MAC address** to define a hardware or data link address for multiple stations to share the same medium and still uniquely identify each other.
- Concerned with network topology, network access, error notification, ordered delivery of frames, and flow control.

Data Link Layer

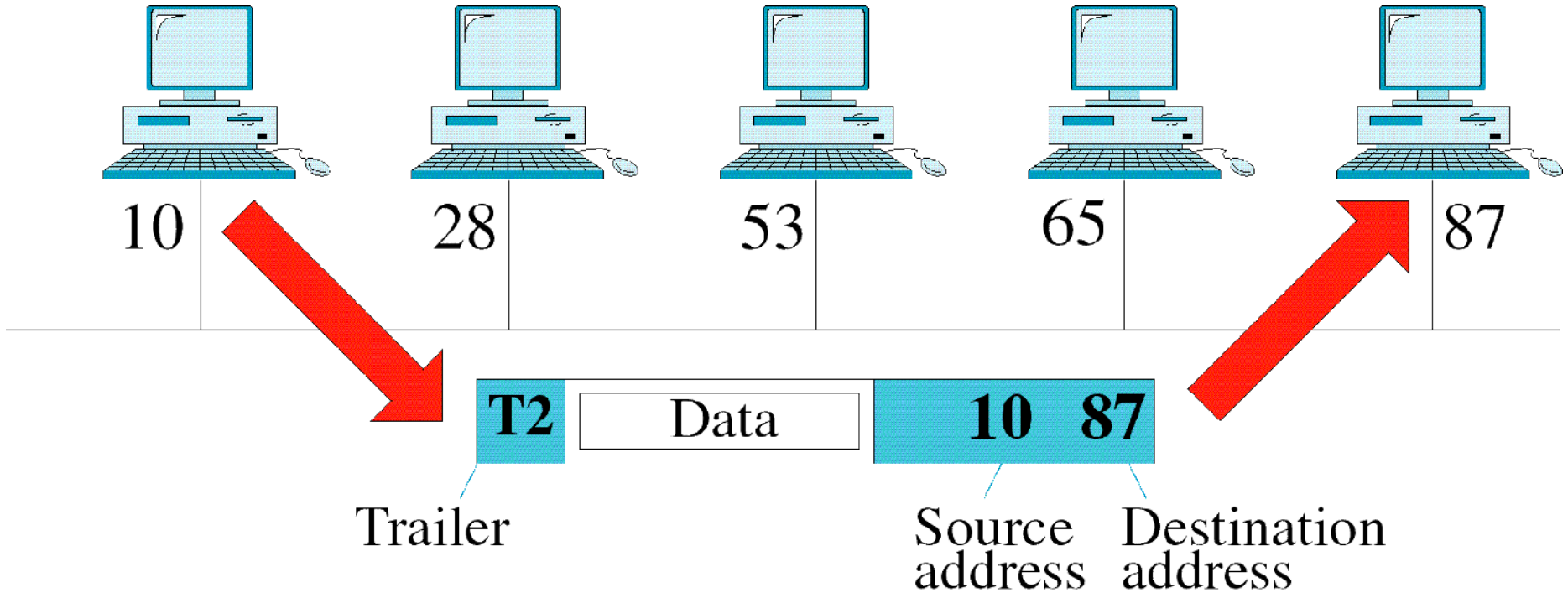
Functions of Data Link layer:

- Framing
- Physical addressing: adding header to frame to identify sender and receiver address.
- Flow control
- Error control
- Access control

Data Link Layer



Data Link Layer



Network Layer

- This layer establishes the route between the sending and receiving stations.
- Responsible for delivery of individual packets from source to destination.
- Two systems connected on same link-no network layer.
- Two systems on different link - need network layer.

Network Layer

- It handles the routing of data (sending in the right direction to the right destination on outgoing transmissions and receiving incoming transmission at the packet). The layer does routing & forwarding of data.

- Network layer addresses can also be referred to as logical addresses.

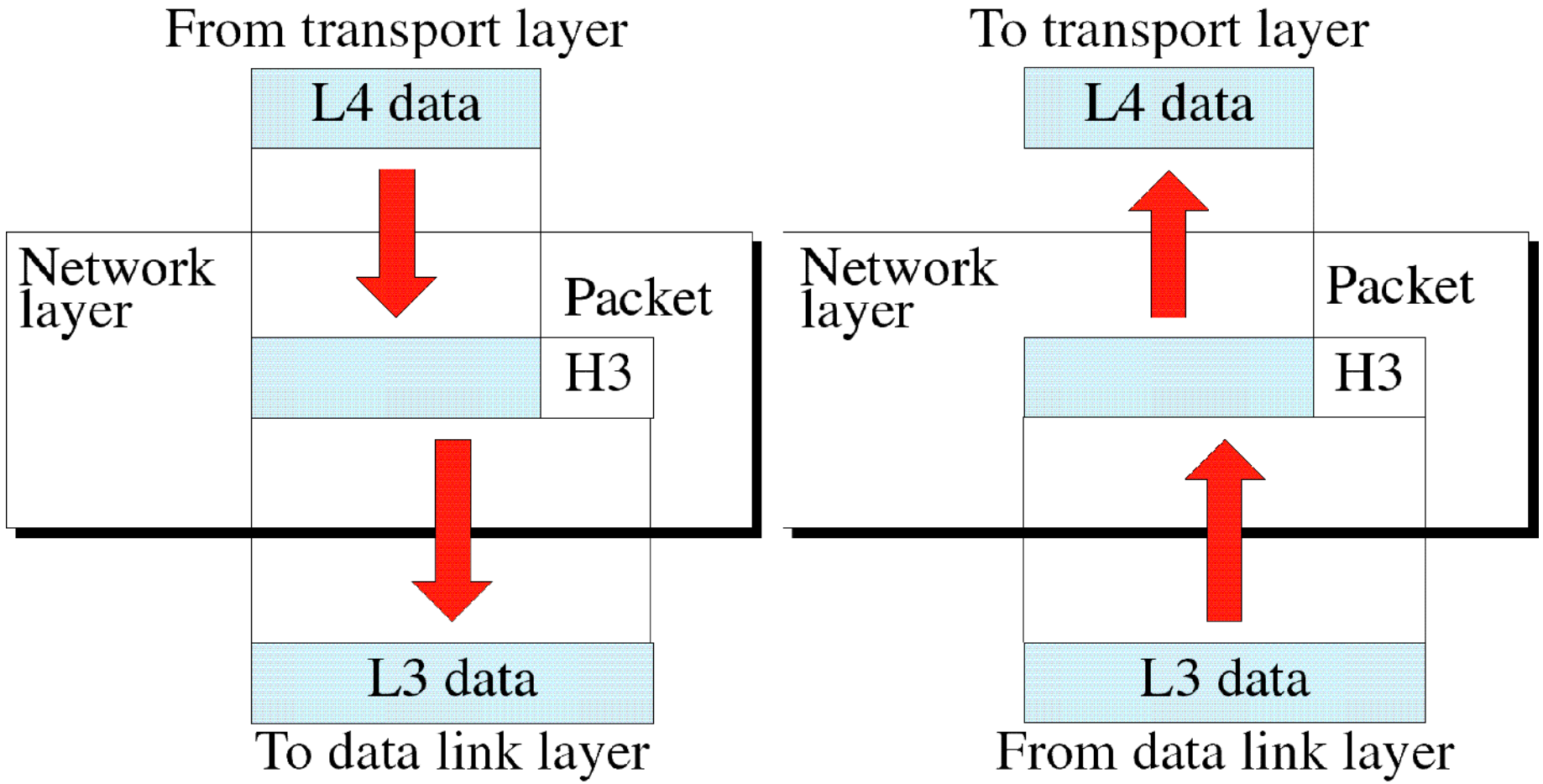
Network Layer

Functions of network layer:

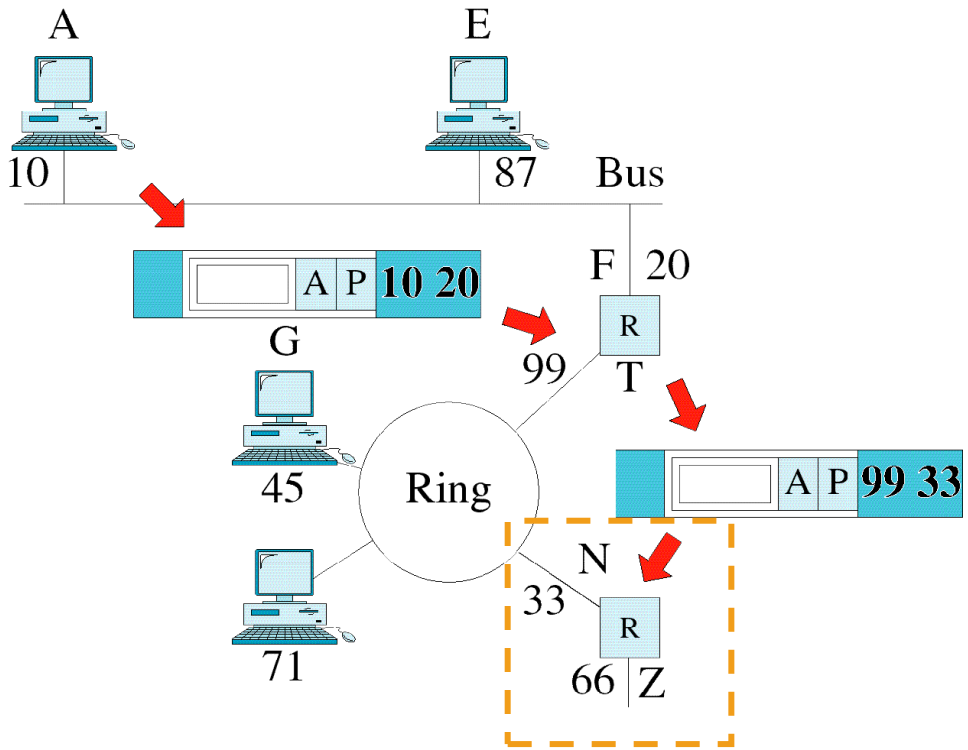
- **Logical addressing:**
  - Data link layer physical addressing-handles addresses locally.
  - Packet crosses network boundary-IP addressing.

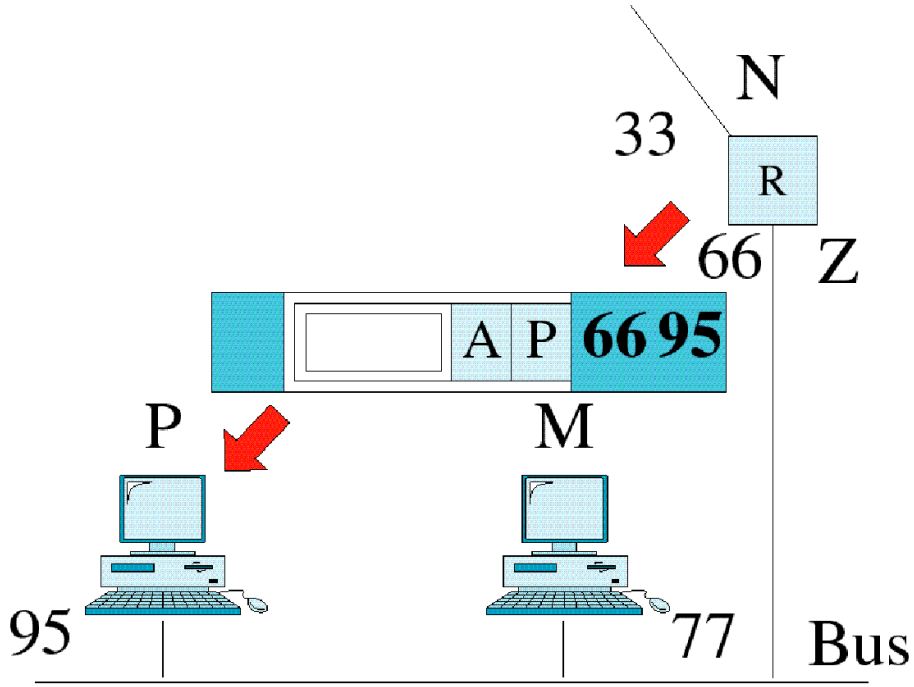
- **Routing** : Routing packets to destination via connecting devices over large networks.

Network Layer

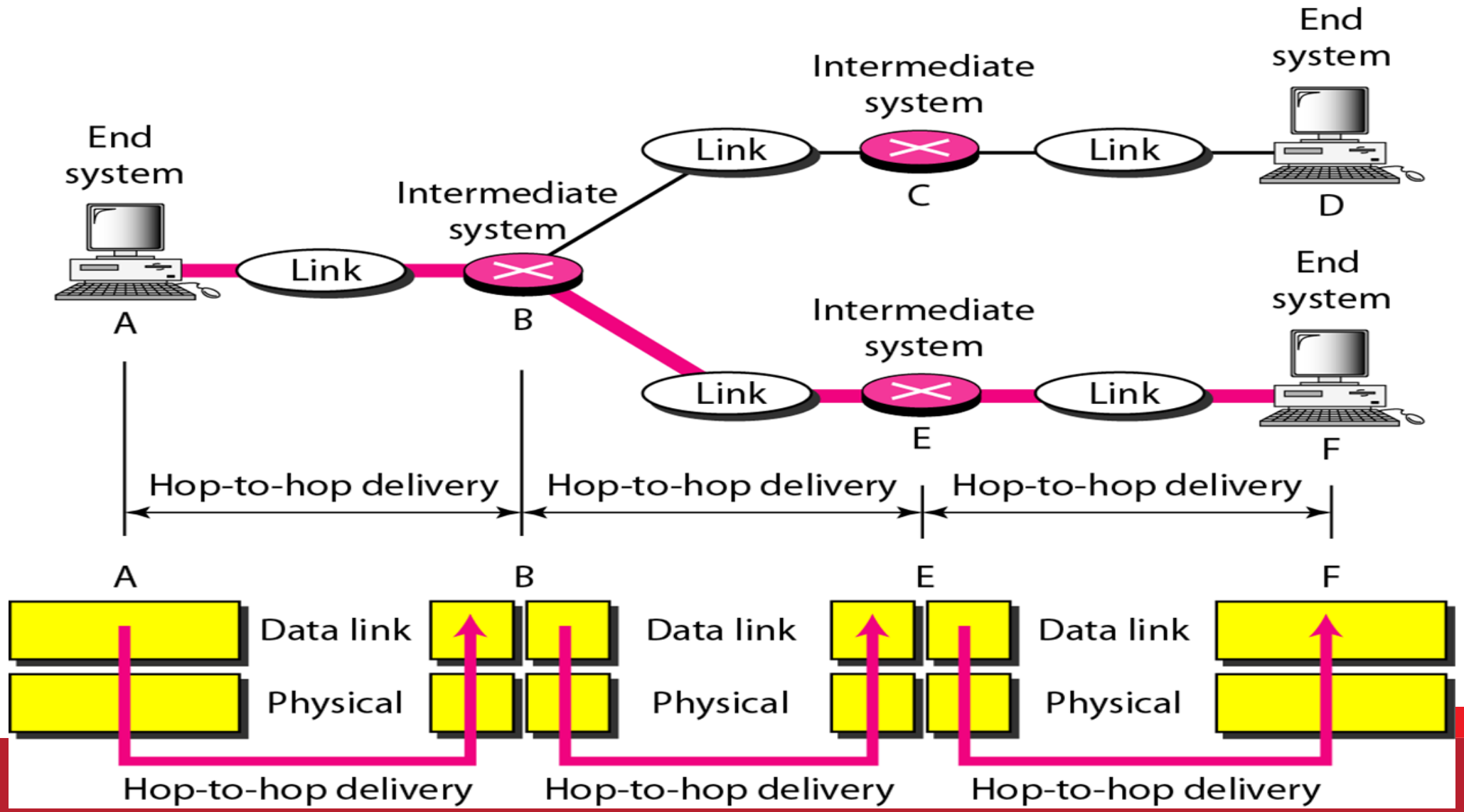


Network Layer Example

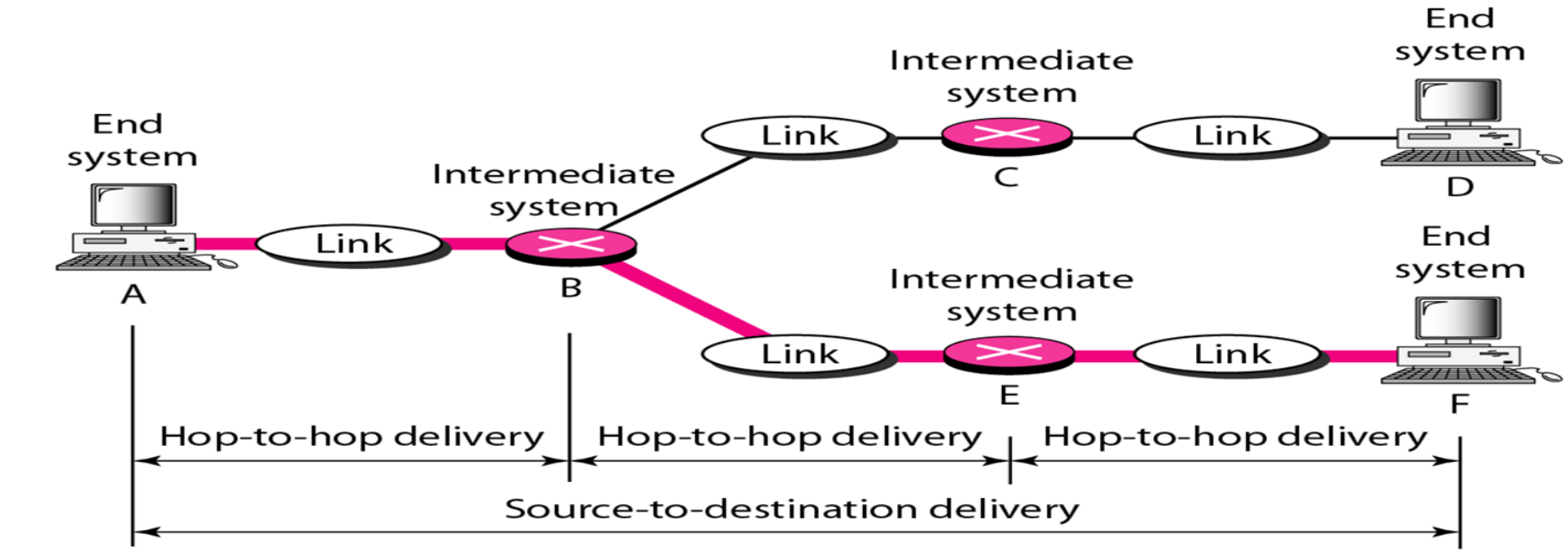


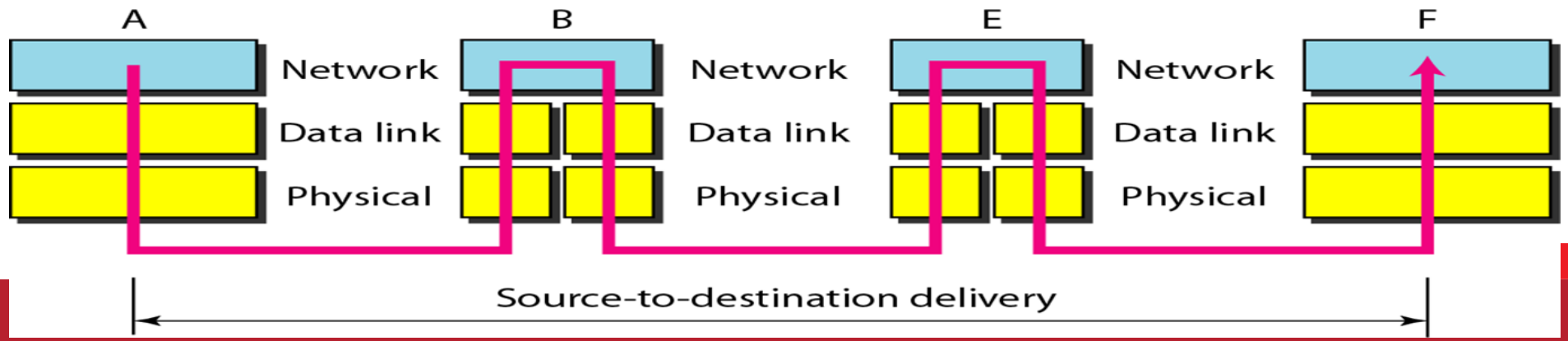


Hop-to-Hop delivery



Source-to-destination delivery





Transport Layer

- The transport layer is responsible for the delivery of a message from one process to another.
- Transport layer recognizes relationship between the packets and makes sure that the whole message arrives intact and in order.
- It is responsible for constructing stream of data segments, sending and checking for correct delivery.

Transport Layer

- If data is sent incorrectly, this layer has the responsibility to ask for retransmission of the data.
- This layer acts as an interface between the bottom and top three layers.

Transport Layer

Responsibilities of transport layer:

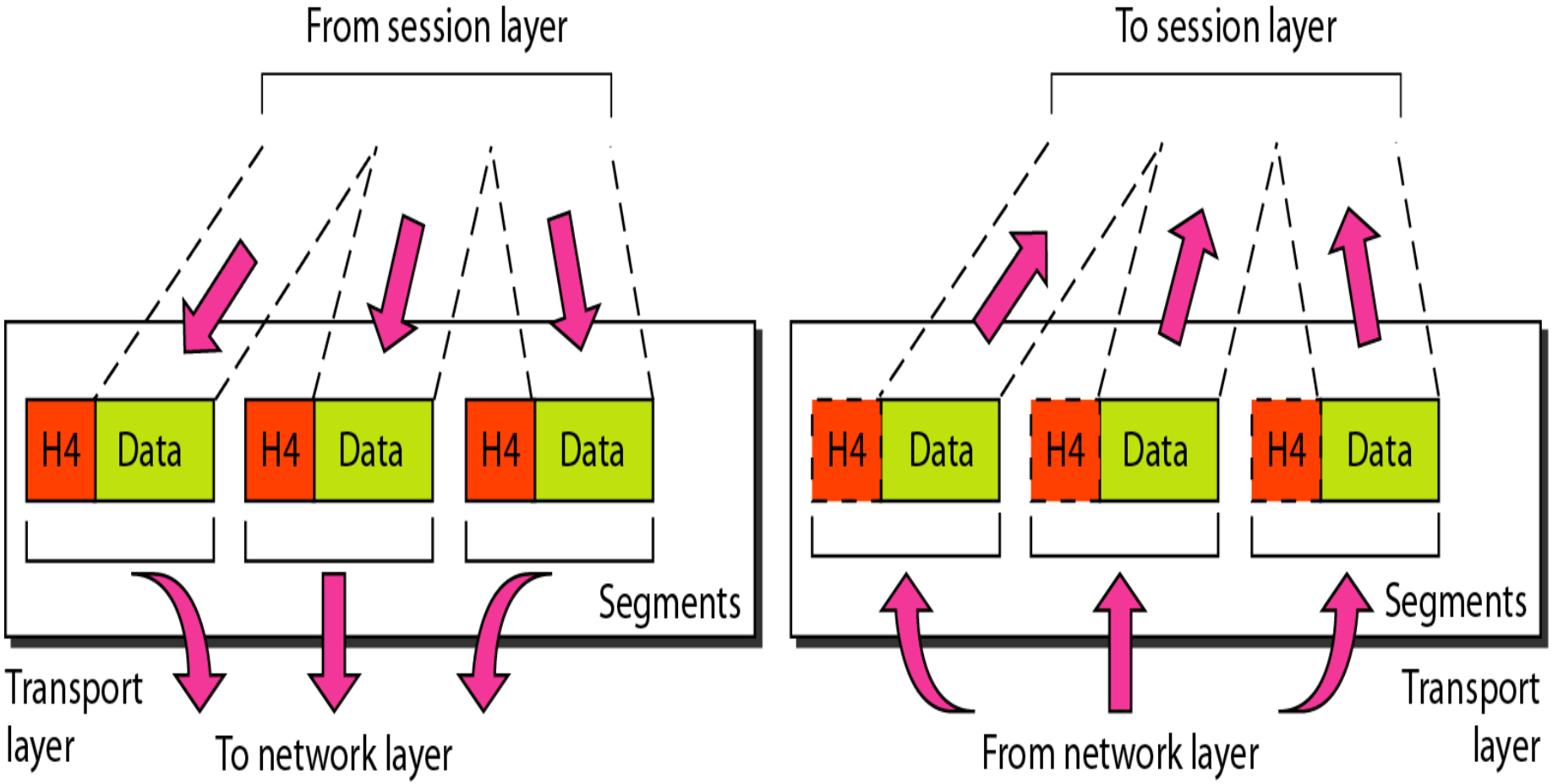
- *Service-point addressing*: Port Address(process to process).
  - Network layer gets each packet to correct computer.
  - Transport layer gets each packet to correct process on that computer.
- *Segmentation and reassembly*: Message divided into segments-sequence number
- *Retransmission* in case of lost segment.

Transport Layer

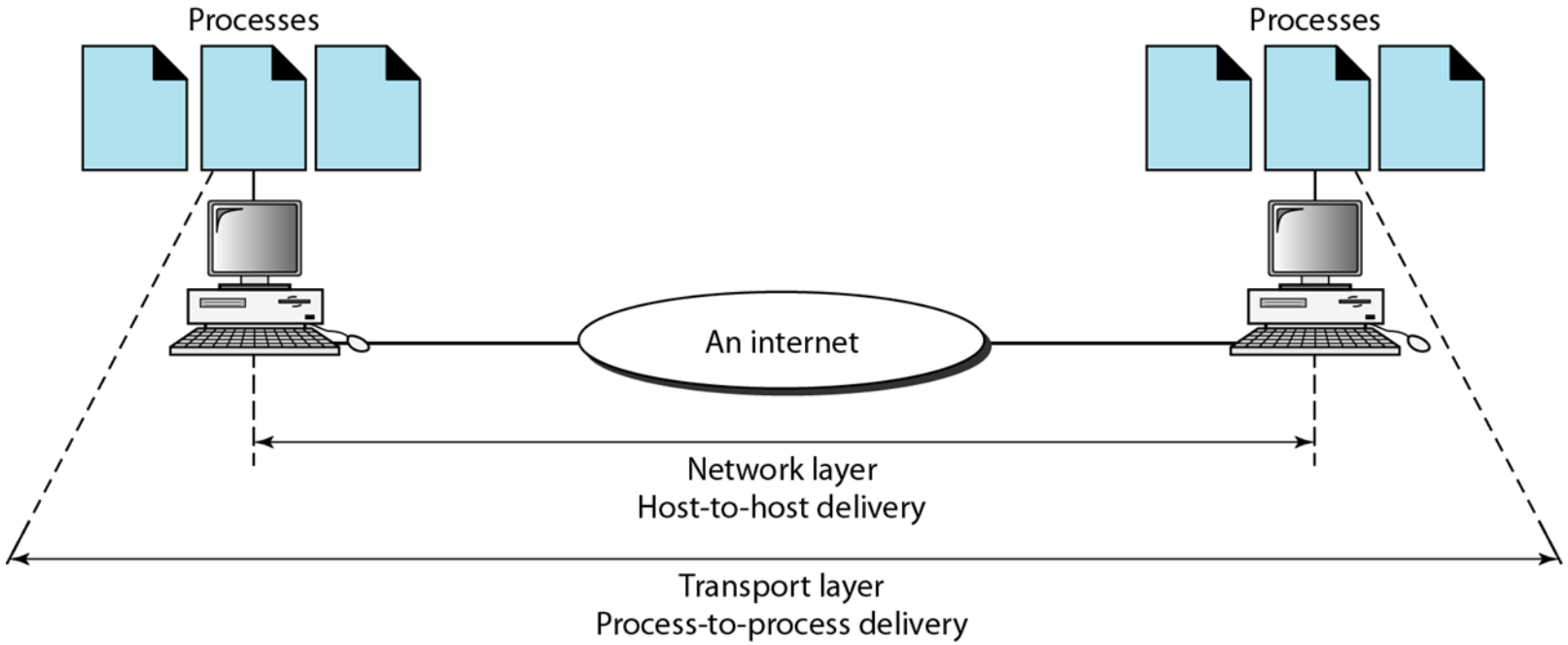
Responsibilities of transport layer:

- *Connection control: Connection-less or connection-oriented.*
- *Flow control : flow control at this layer is performed end to end rather than across a single link.*
- *Error control: error control at this layer is performed process-to-process rather than across a single link.*

Transport Layer



Reliable process-to-process delivery of a message



Session Layer

- The services provided by the first three layers (physical, data link, and network) are not sufficient for some processes.
- The session layer defines how to start, control and end conversations (called sessions) between applications.
- It provides coordination of the communication in an ordering manner.

Session Layer

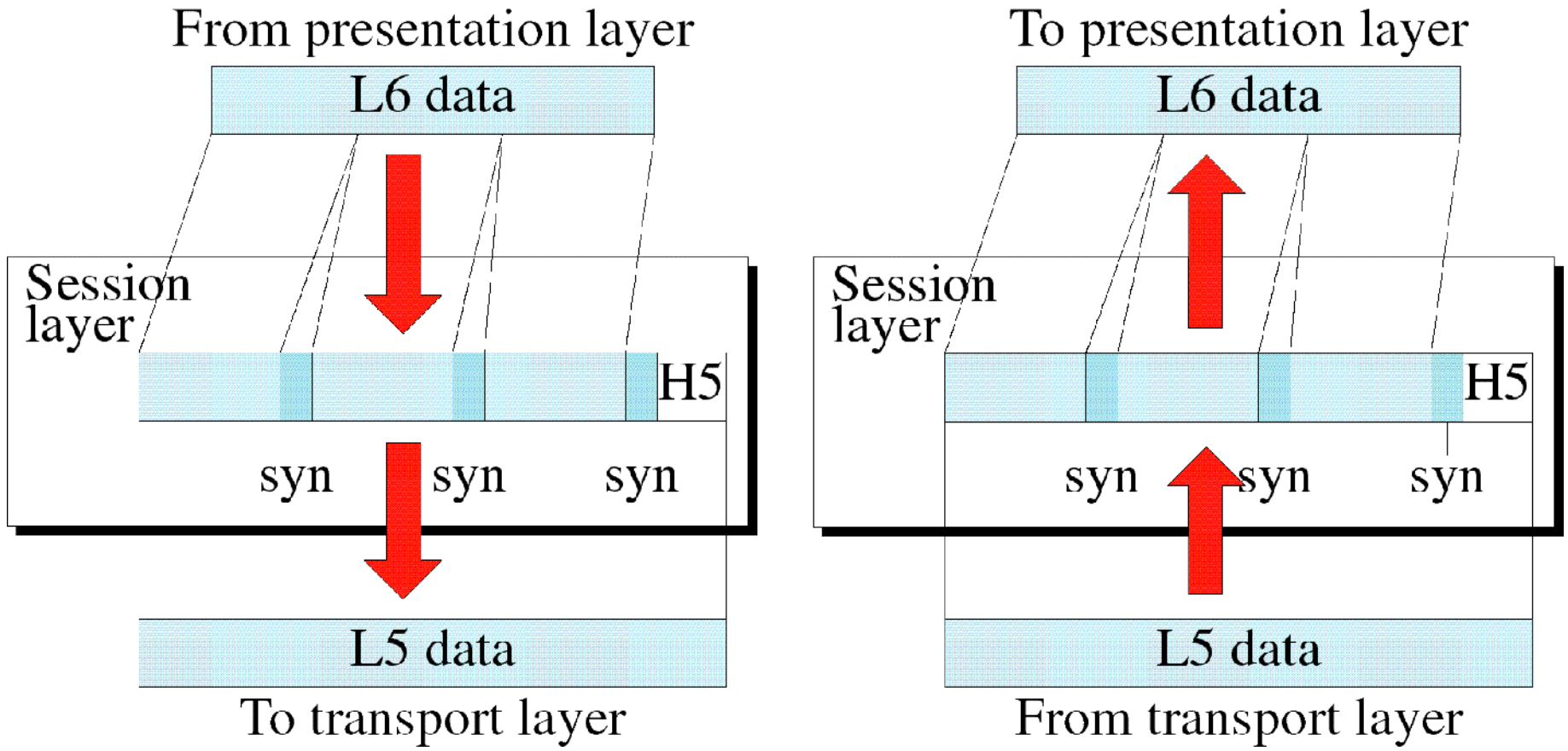
- The session layer offers provisions for efficient data transfer.

Responsibilities of the session layer:

- *Dialog control* : The session layer allows two systems to enter into a dialog.

- *Synchronization*: allows to add checkpoints.

Session Layer



Presentation Layer

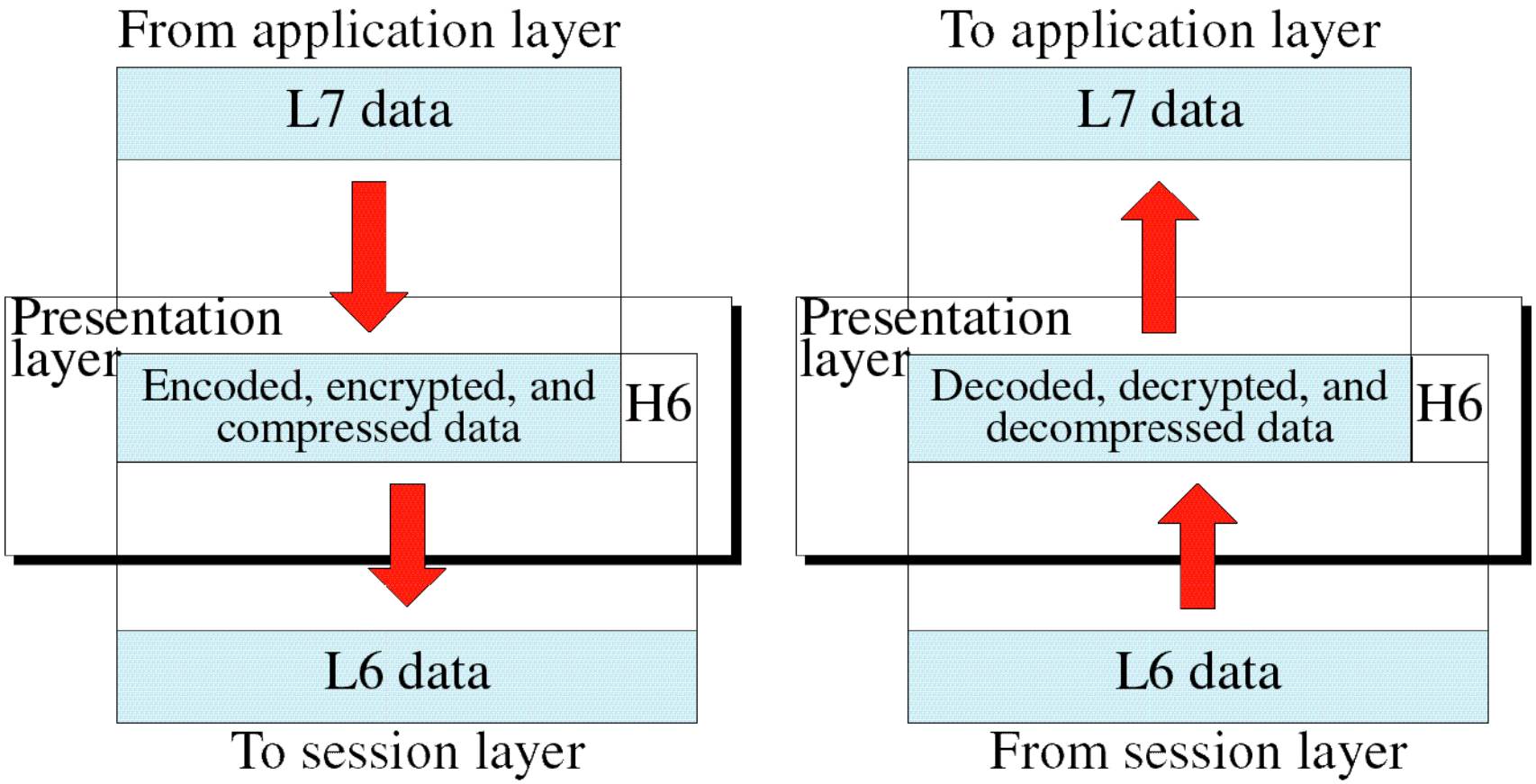
- The presentation layer ensures that the information that the application layer of one system sends out is readable by the application layer of another system.
- If necessary, the presentation layer translates between multiple data formats by using a common format.
- The presentation layer basically allows an application to read (or understand) the message.

Presentation Layer

Responsibilities of presentation layer:

- *Translation*: Changes data so that another computer can read it.
- *Compression*: Makes data smaller to move data in same amount of time.
- *Encryption*: Encodes data to protect from interception.

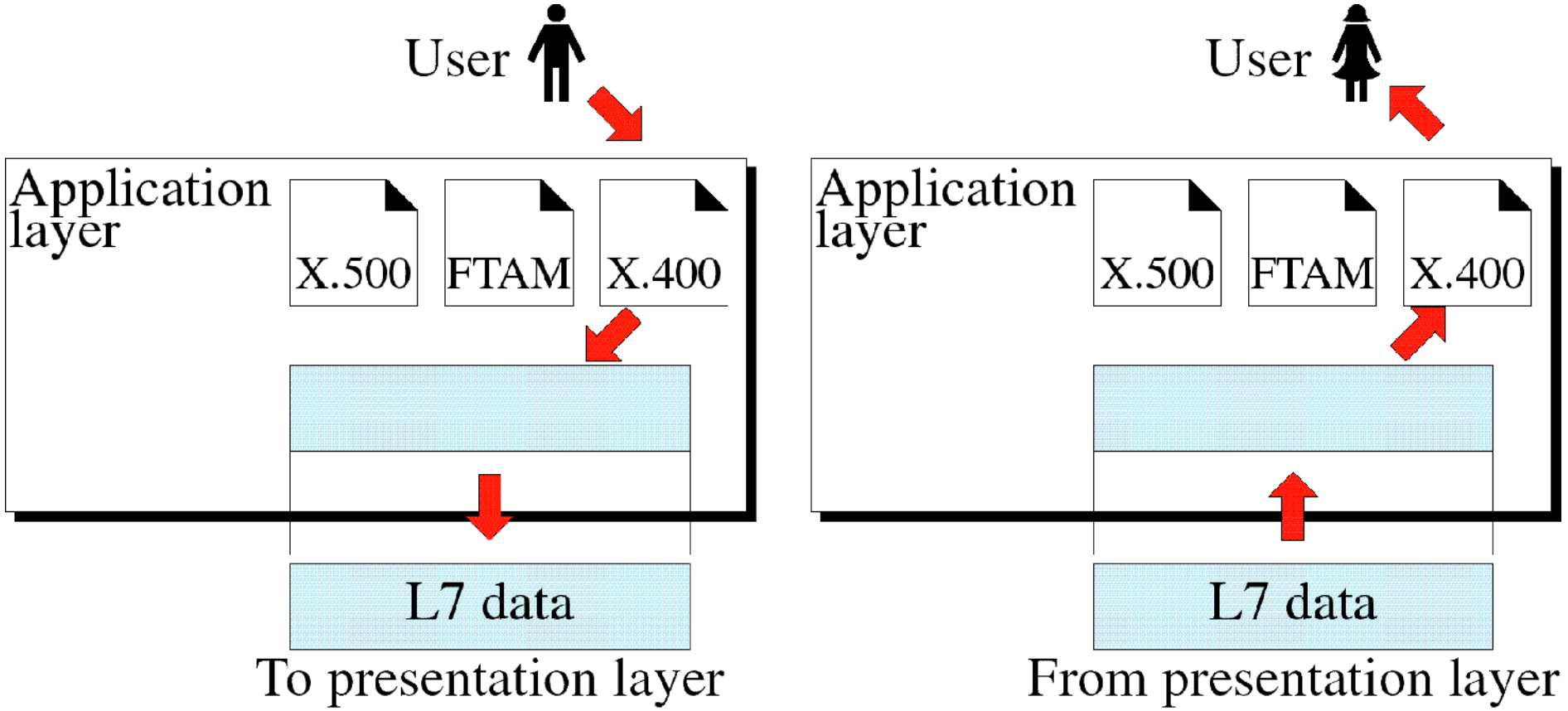
Presentation Layer



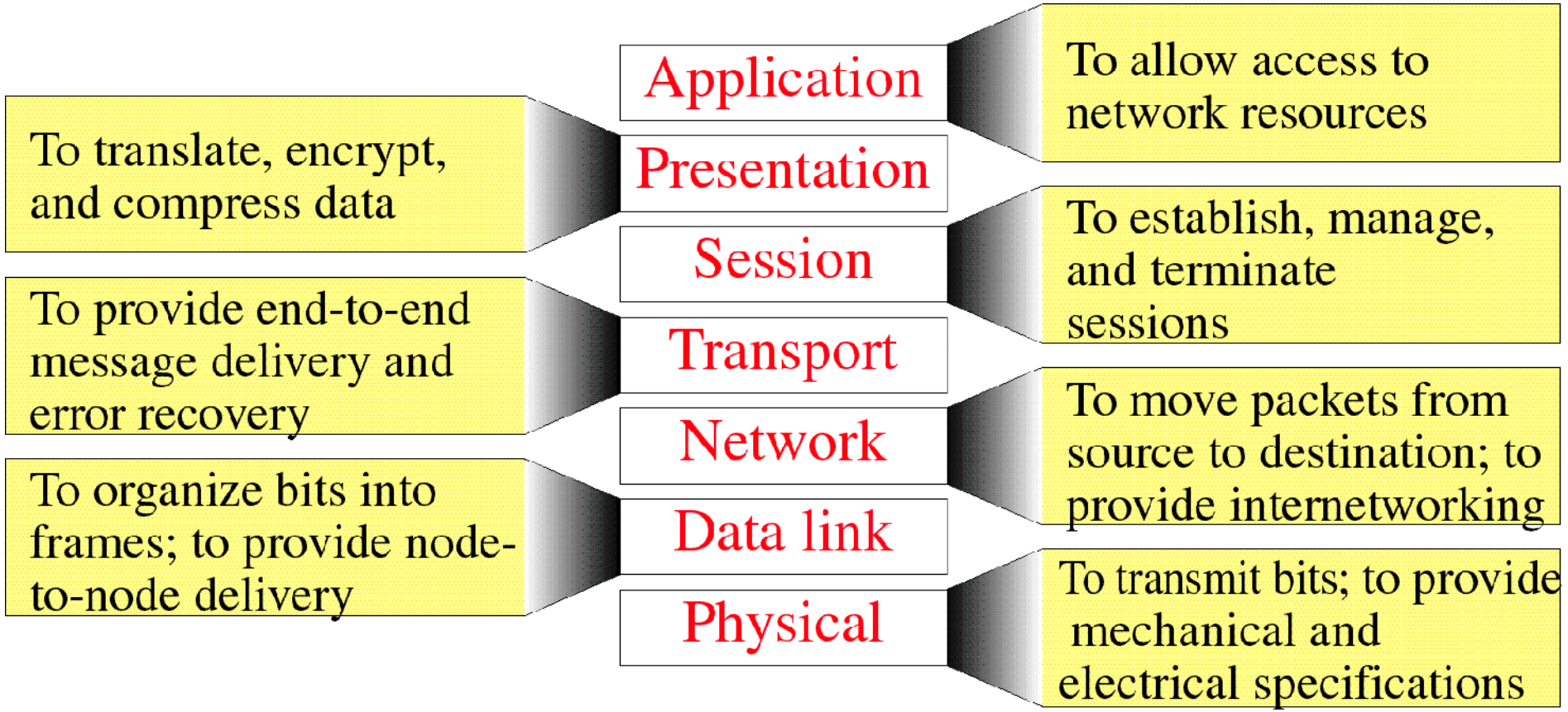
Application Layer

- The application layer enables the user, whether human or software, to access the network.
- It provides user interfaces and support – email, shared database , access to remote file etc.
- It differs from the other layers in that it does not provide services to any other OSI layer, but rather, only to applications outside the OSI model.

Application Layer

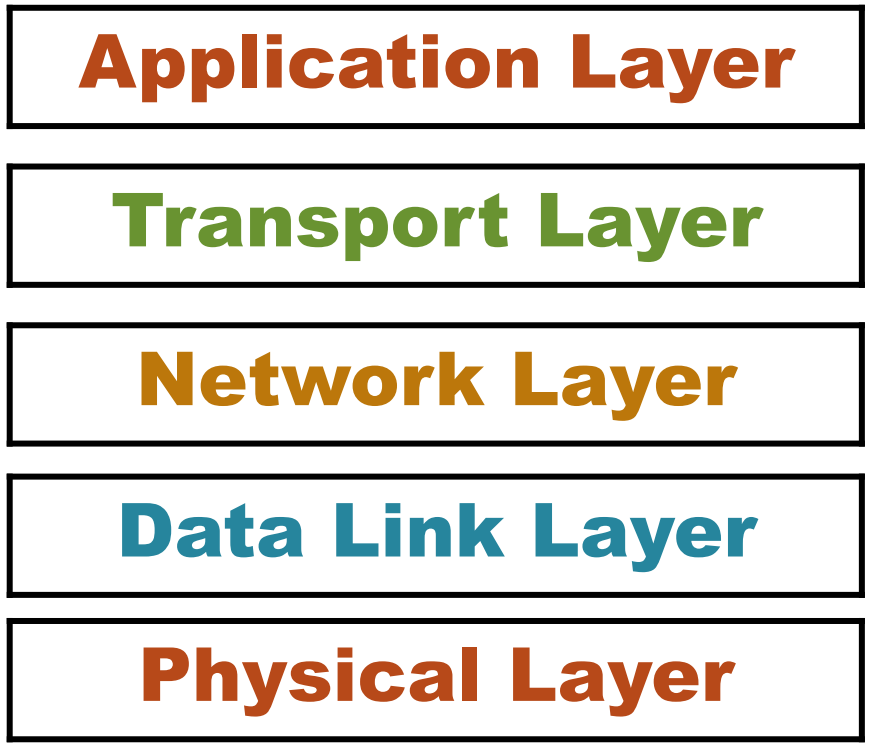


Summary of Layer Functions

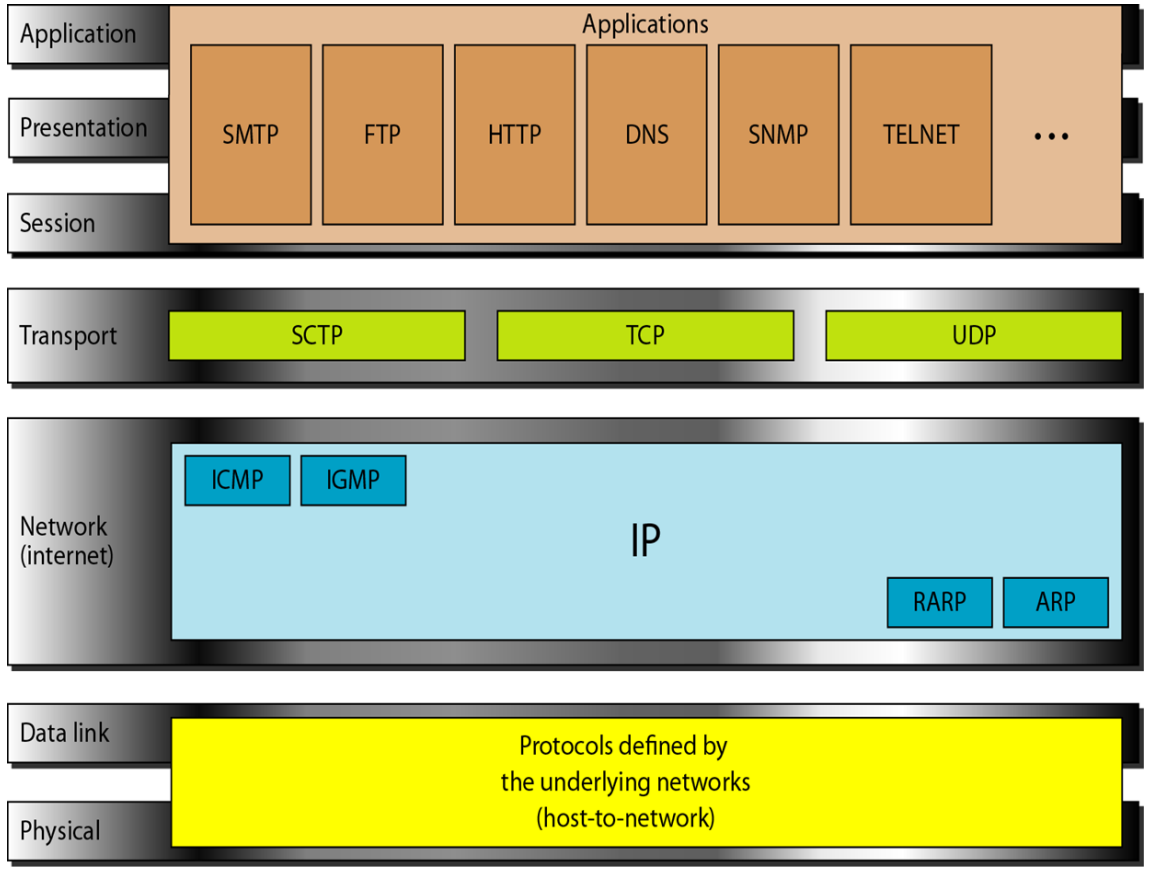


TCP/IP PROTOCOL SUITE

- TCP/IP protocol suite is made of five layers:



TCP/IP PROTOCOL SUITE



TCP/IP Model

- Developed prior to OSI model
- TCP/IP is a hierarchical protocol made up of interactive modules, each providing specific functionality, but they are not interdependent

Network Layer

- TCP/IP does not support any specific protocol
- All standard and proprietary protocols supported at this level.

Network Layer

At this level TCP/IP supports Internetworking protocol(IP).

IP in turn uses 4 supporting protocols.

- ARP
- RARP
- ICMP
- IGMP

Network Layer

- **Internetworking Protocol (IP)**
  - ✓ IP is transmission mechanism used by TCP/IP
  - ✓ Unreliable and connection-less protocol- *best effort delivery*
  - ✓ No error checking or tracking.
  - ✓ Transports data in packets called *datagrams*.
  - ✓ Does not keep track of routes and no facility reordering.

Network Layer

Address Resolution Protocol (ARP)

- Associates logical address with physical address.
- ARP is used to find physical address of node when logical address is known.

Reverse Address Resolution Protocol (RARP)

- RARP is used to find logical address of node when physical address is known.
- Usually used when computer is connected to network for the first time.

Network Layer

Internet Control Message Protocol (ICMP)

- Used by hosts and gateways to send notification of datagram problem to sender.

Internet Group Message Protocol (IGMP)

- Used to facilitate simultaneous transmission of message to group of recipients.

Transport Layer

- IP is host to host protocol

Transport layer has three protocols:

- UDP (User Datagram Protocol)
- TCP (Transmission Control Protocol)
- SCTP (Stream Control Transmission Protocol)

Transport Layer

User Datagram Protocol (UDP):

- Process to Process
- Adds only port address , error control , checksum etc. to data from upper layers.

Transport Layer

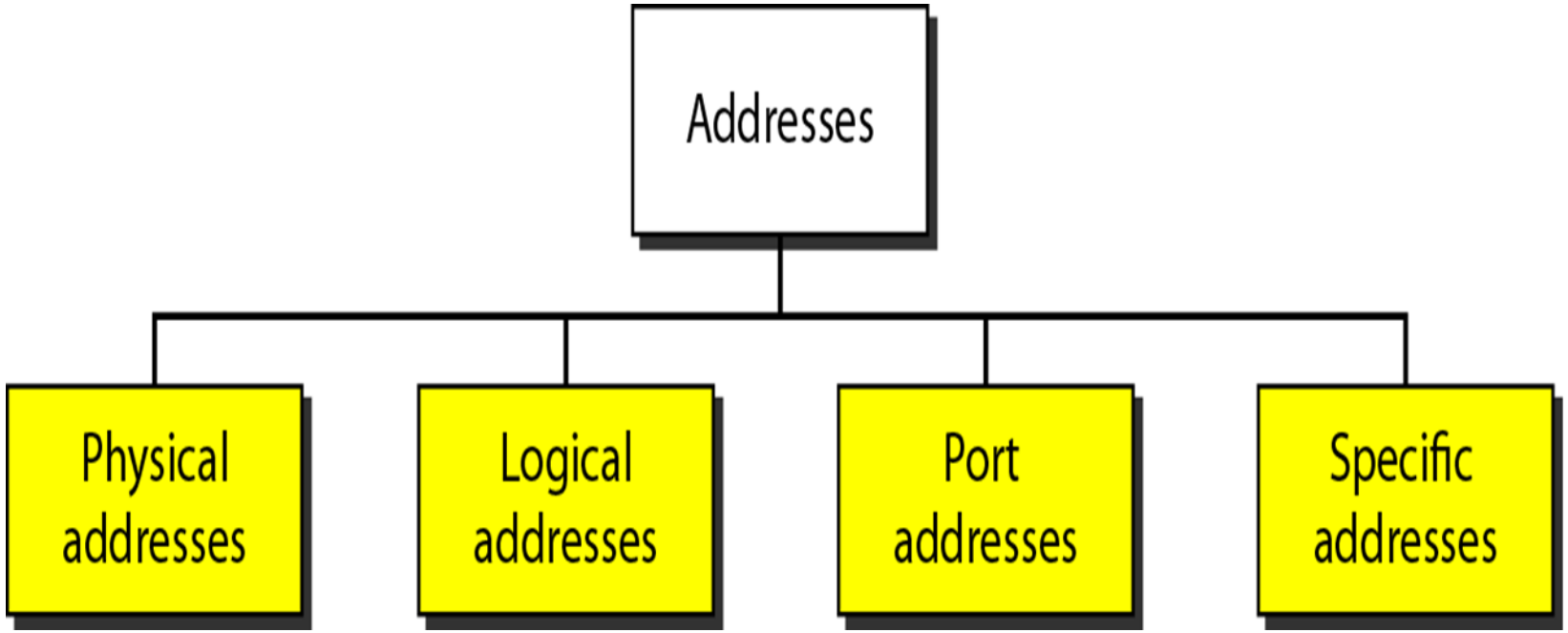
Transmission Control Protocol (TCP)

- Reliable stream protocol.
- Data is divided into segments.
- Segment contain sequence number for reordering.
- At receiving end , TCP collects each datagram and reorders it based on sequence numbers

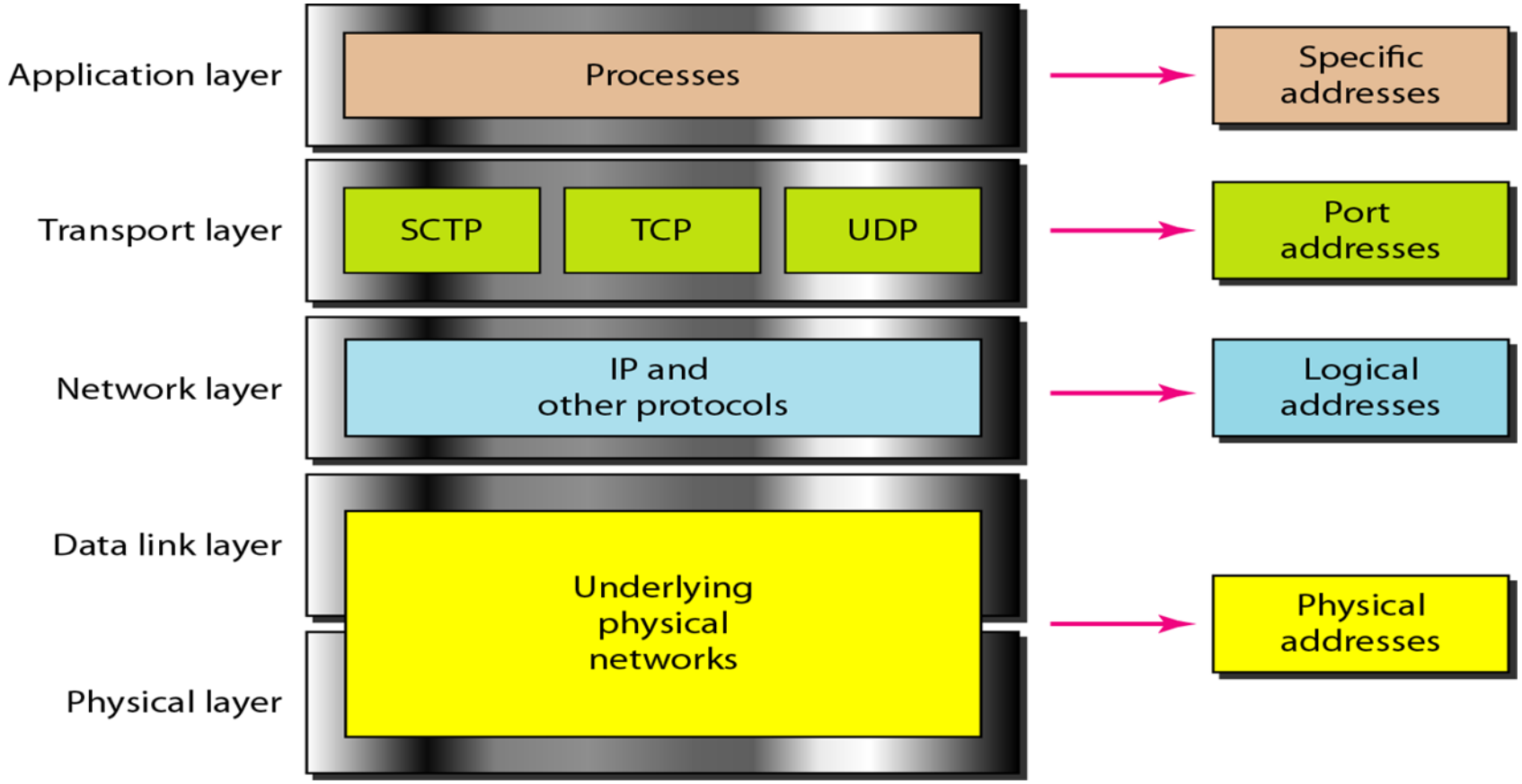
Stream Control Transmission Protocol (SCTP)

- Combines features of TCP and UDP

Addressing



Relationship of layers and addresses in TCP/IP

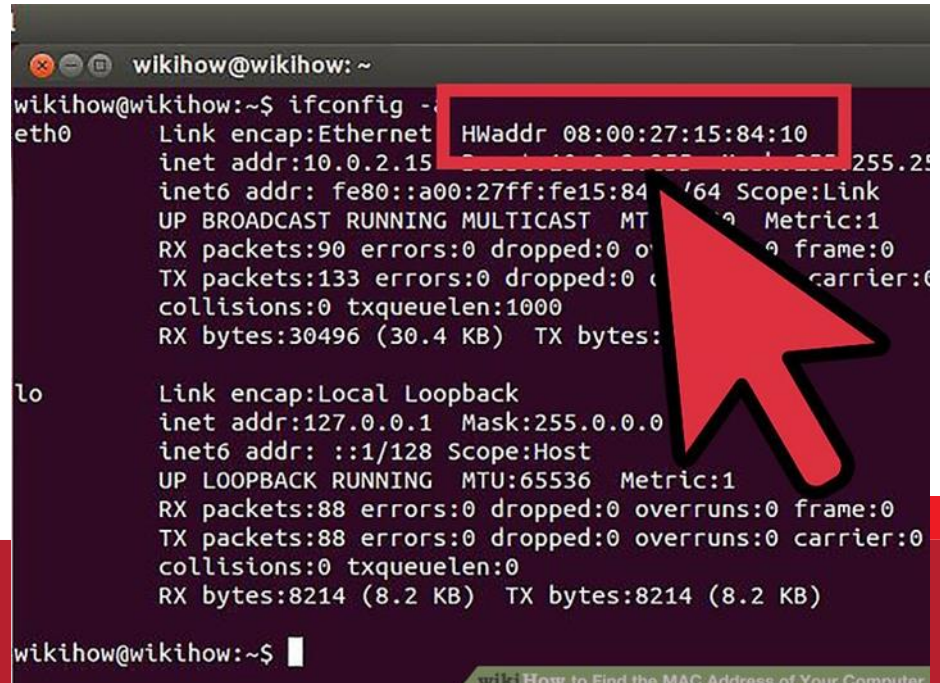


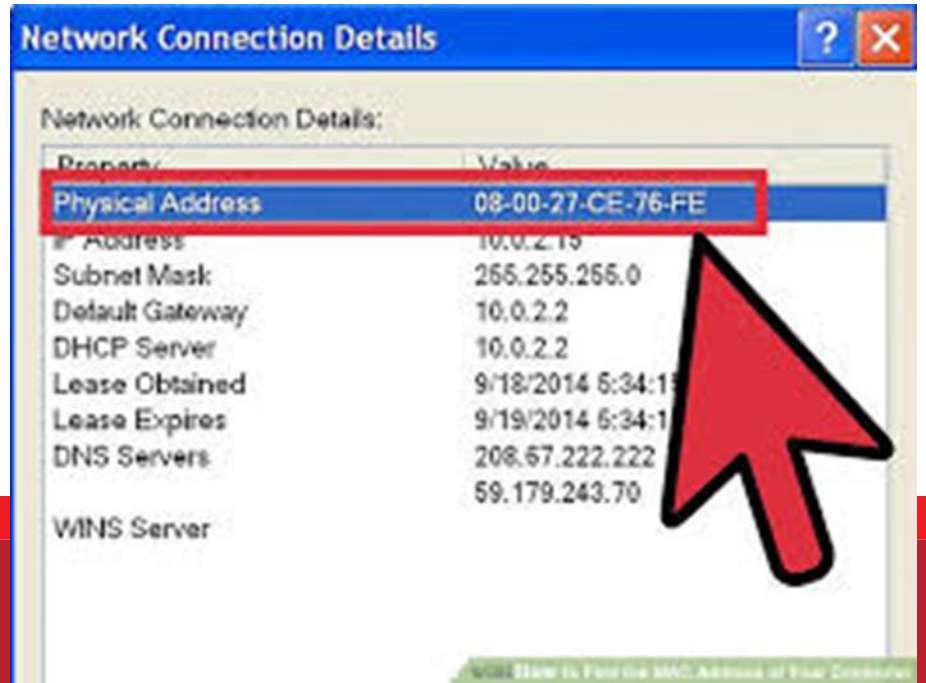
MAC Address

Example MAC Address

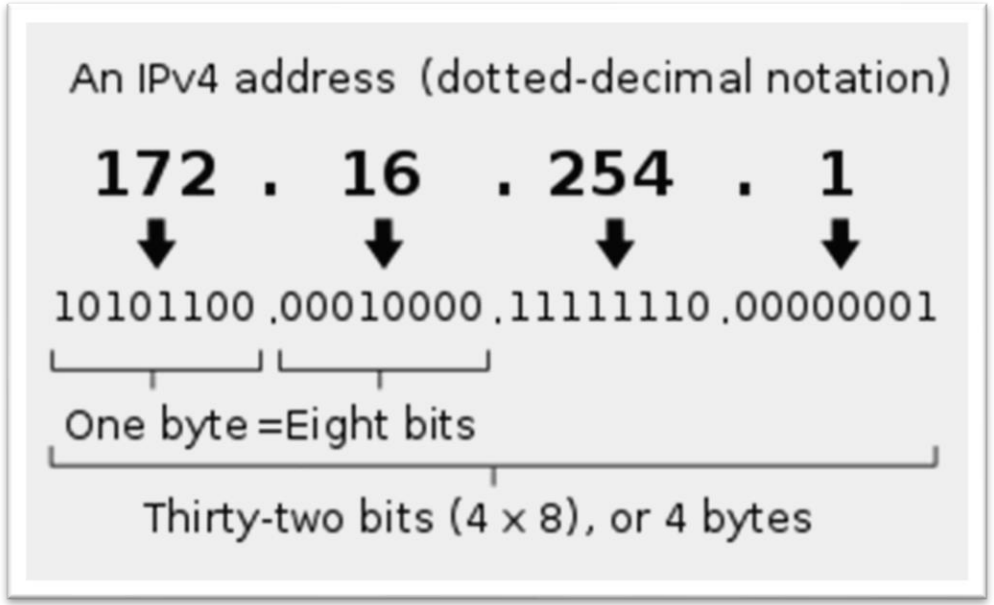
3A-34-52-C4-69-B8

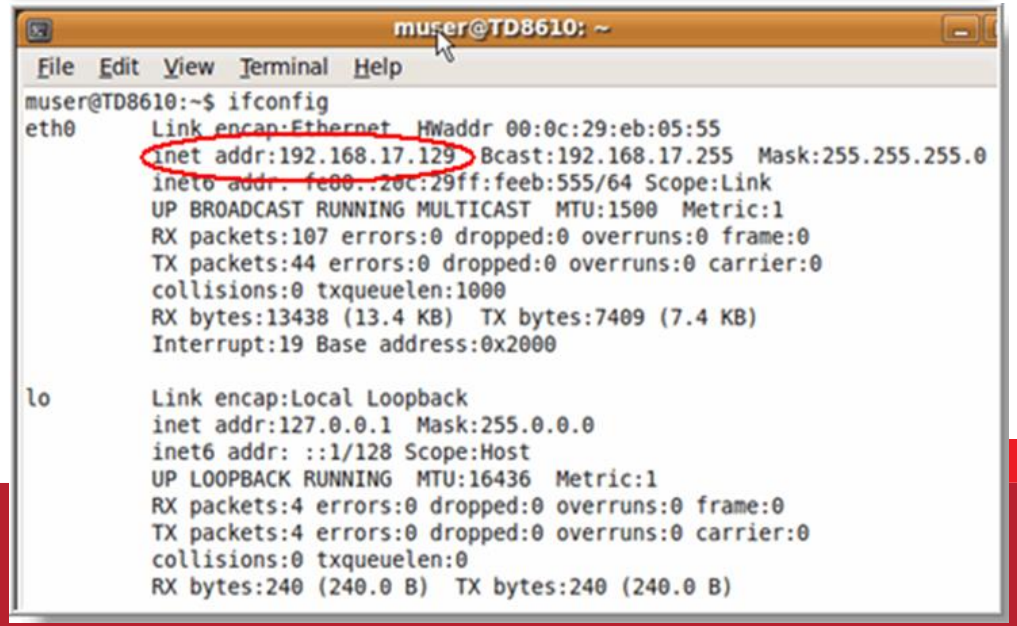
Organizationally Unique Identifier (OUI)	Network Interface Controller (NIC)

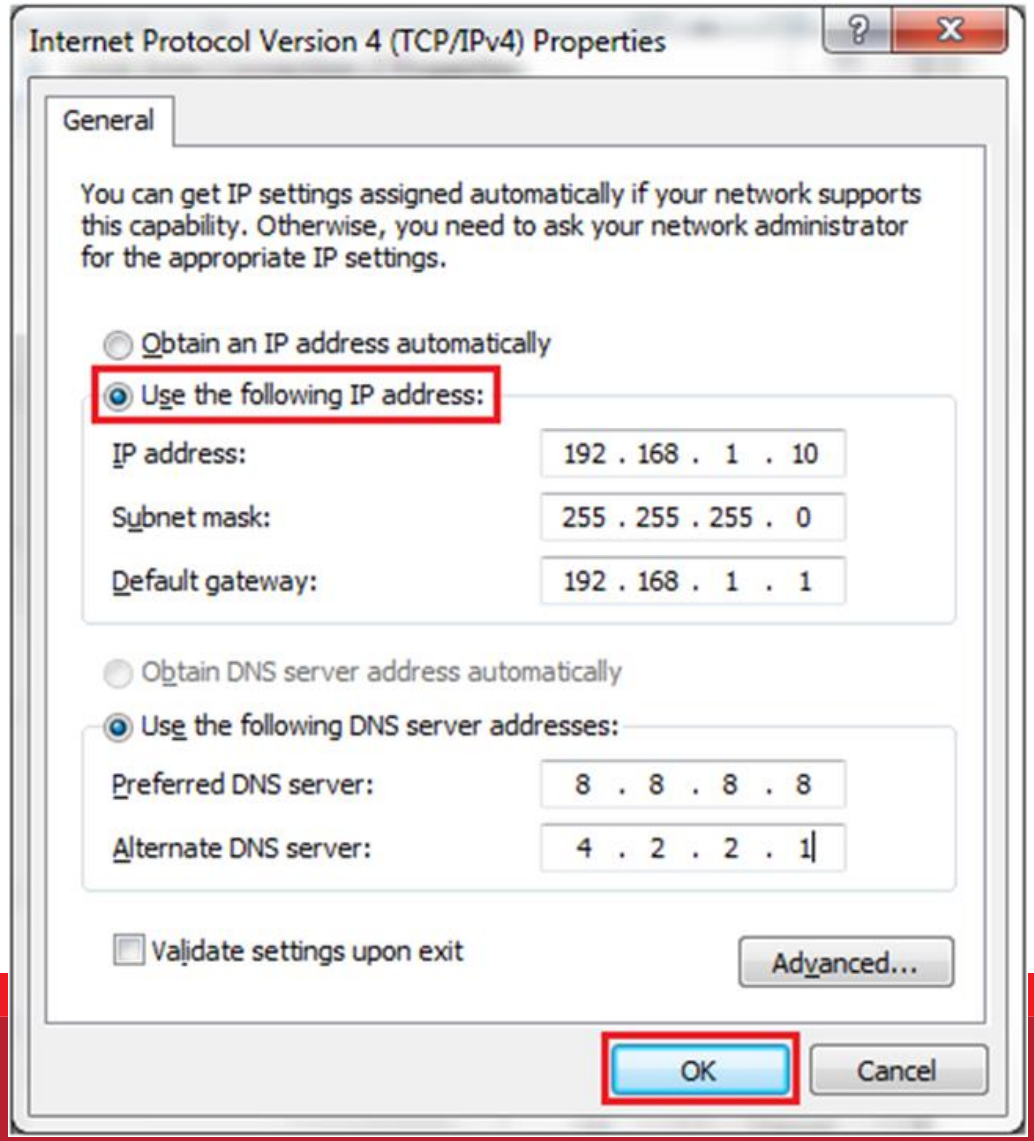




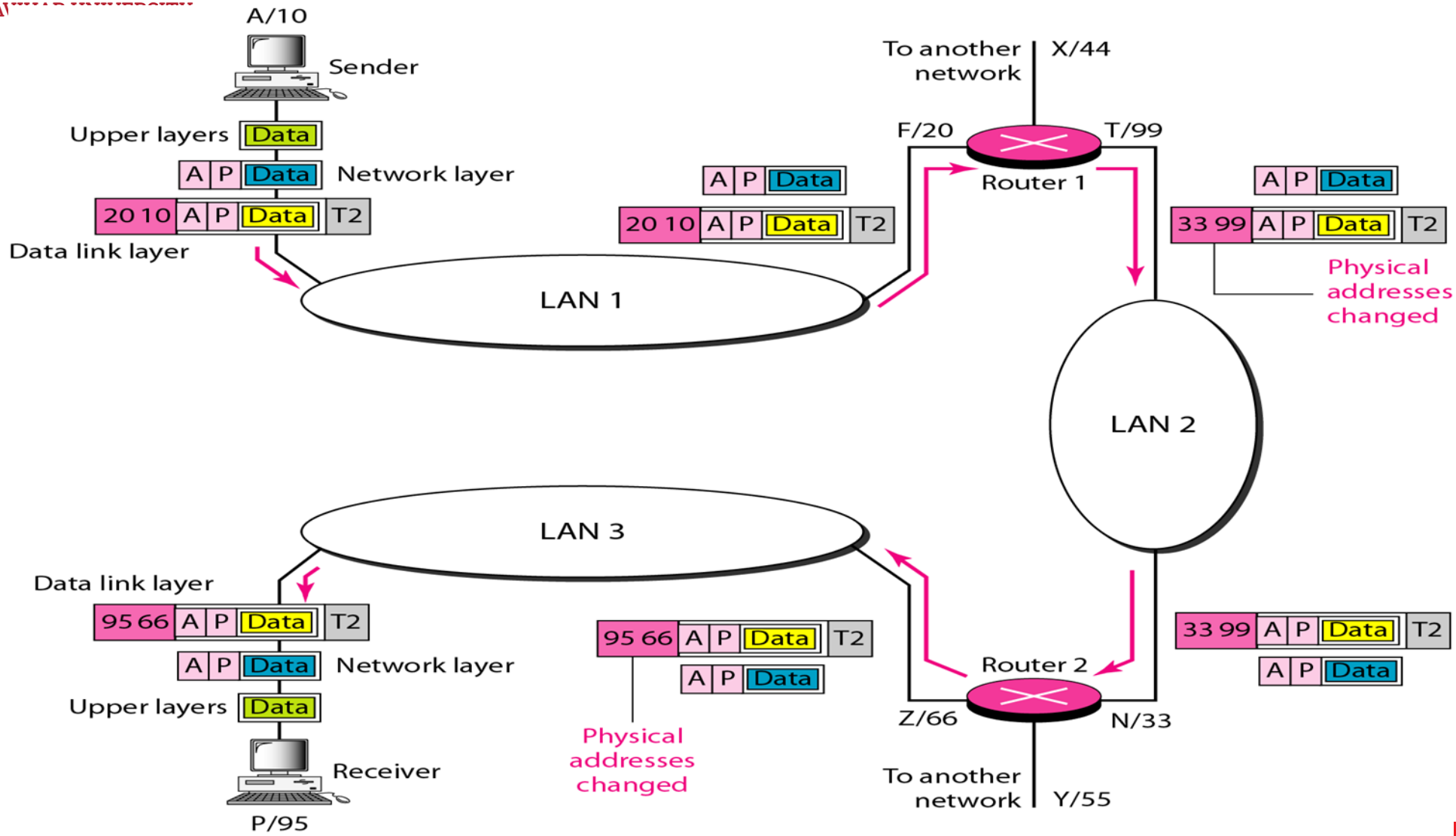
IP Address


An IPv4 address (dotted-decimal notation)
172 . 16 . 254 . 1
10101100.00010000.11111110.00000001
One byte =Eight bits
Thirty-two bits (4 x 8), or 4 bytes


muser@TD8610: ~
File Edit View Terminal Help
muser@TD8610:~$ ifconfig
eth0 Link encap:Ethernet HWaddr 00:0c:29:eb:05:55
inet addr:192.168.17.129 Bcast:192.168.17.255 Mask:255.255.255.0
inet6 addr: fe80::20c:29ff:feeb:555/64 Scope:Link
UP BROADCAST RUNNING MULTICAST MTU:1500 Metric:1
RX packets:107 errors:0 dropped:0 overruns:0 frame:0
TX packets:44 errors:0 dropped:0 overruns:0 carrier:0
collisions:0 txqueuelen:1000
RX bytes:13438 (13.4 KB) TX bytes:7409 (7.4 KB)
Interrupt:19 Base address:0x2000
lo Link encap:Local Loopback
inet addr:127.0.0.1 Mask:255.0.0.0
inet6 addr: ::1/128 Scope:Host
UP LOOPBACK RUNNING MTU:16436 Metric:1
RX packets:4 errors:0 dropped:0 overruns:0 frame:0
TX packets:4 errors:0 dropped:0 overruns:0 carrier:0
collisions:0 txqueuelen:0
RX bytes:240 (240.0 B) TX bytes:240 (240.0 B)


Internet Protocol Version 4 (TCP/IPv4) Properties
General
You can get IP settings assigned automatically if your network supports this capability. Otherwise, you need to ask your network administrator for the appropriate IP settings.
Obtain an IP address automatically
Use the following IP address:
IP address: 192 . 168 . 1 . 10
Subnet mask: 255 . 255 . 255 . 0
Default gateway: 192 . 168 . 1 . 1
Obtain DNS server address automatically
Use the following DNS server addresses:
Preferred DNS server: 8 . 8 . 8 . 8
Alternate DNS server: 4 . 2 . 2 . 1
Validate settings upon exit
Advanced...
OK
Cancel

IP Address


A/10
Sender
Upper layers
Data
A P Data
Network layer
20 10 A P Data T2
Data link layer
LAN 1
To another network
X/44
F/20
T/99
Router 1
A P Data
20 10 A P Data T2
33 99 A P Data T2
Physical addresses changed
LAN 2
LAN 3
Data link layer
95 66 A P Data T2
A P Data
Network layer
Upper layers
Data
Receiver
P/95
95 66 A P Data T2
A P Data
Physical addresses changed
Router 2
33 99 A P Data T2
A P Data
Z/66
N/33
To another network
Y/55

References

- “Data Communication and Networking”, Behrouz Forouzan 5e
- “TCP/IP Protocol Suite “, Behrouz Forouzan 4e.
- “Computer Networks “, A.S.Tanenbaum 5e.