

Computer Networks

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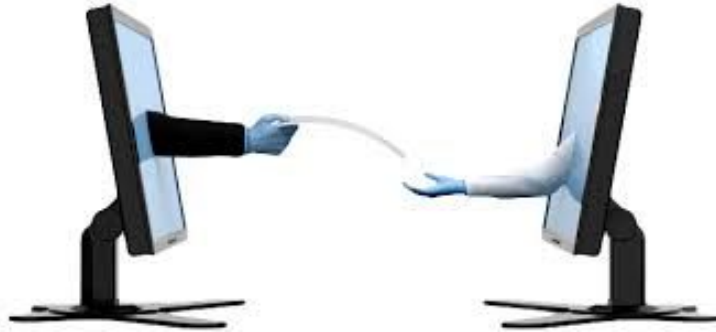
What is Computer Network?

- Computer Network is a system in which multiple computers are **connected** to each other to **share information** and **resources**.



Advantages of Computer Network

File Sharing



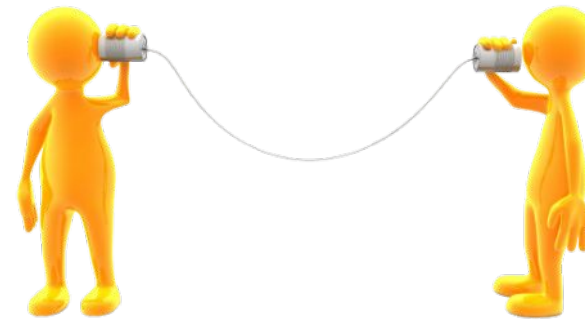
Flexible Access



Entertainment



Better Communication

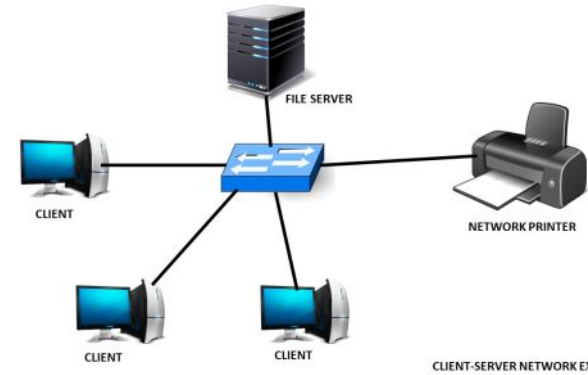


Advantages of Computer Network

Internet Access



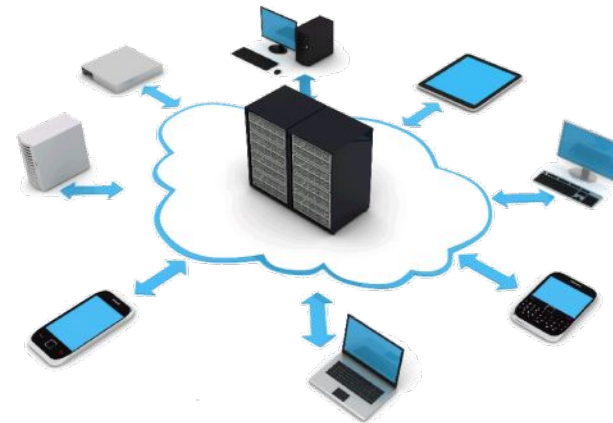
Inexpensive System



Instant and Multiple Access



Resource Sharing



Applications of Computer Network

Email Services



Teleconferencing



Business & Finance



File & Directory Services



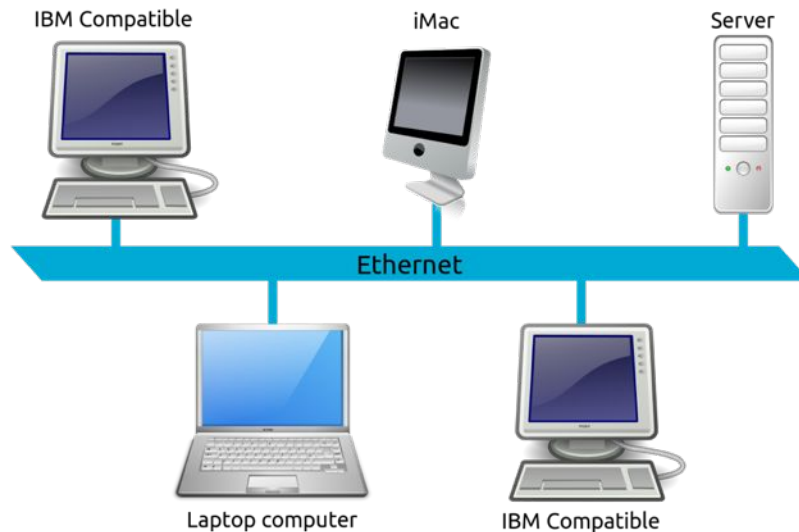
& Many More....

Types of Computer Network

- Computer networks can be categorized by their **size** as well as their **purpose**.
- The **size** of a network can be expressed by the **geographic area**.
- Some of the different networks based on **size** are:
 1. Local Area Network - LAN
 2. Metropolitan Area Network - MAN
 3. Wide Area Network - WAN

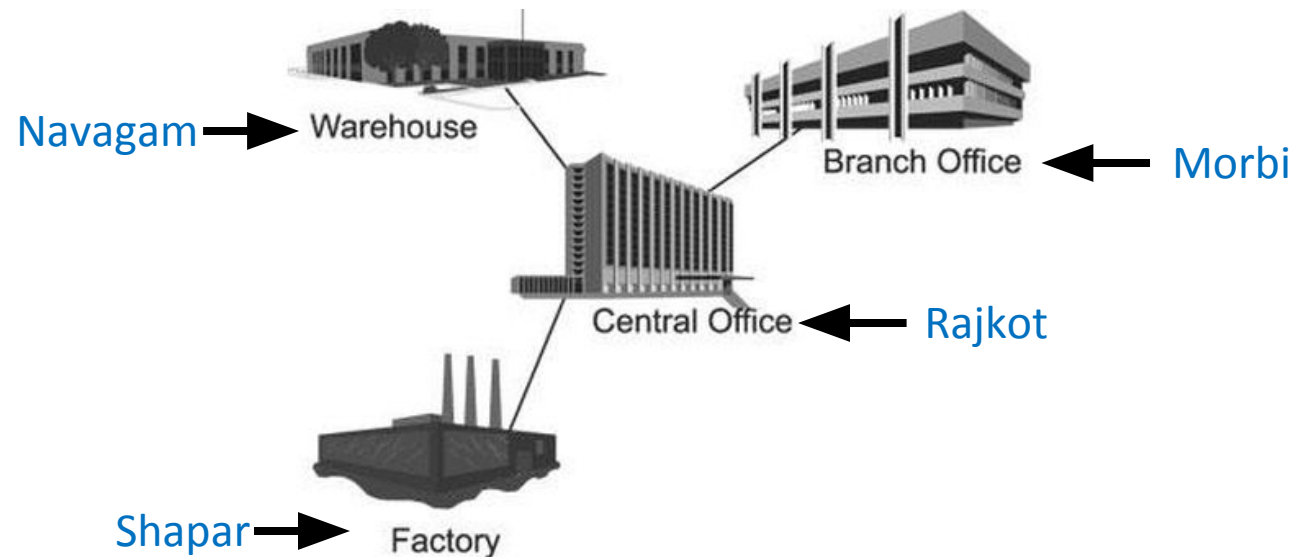
Local Area Network

- A local area network (LAN) is a computer network that **interconnects** computers within a **limited area** such as a residence, school, laboratory, university campus or office building.



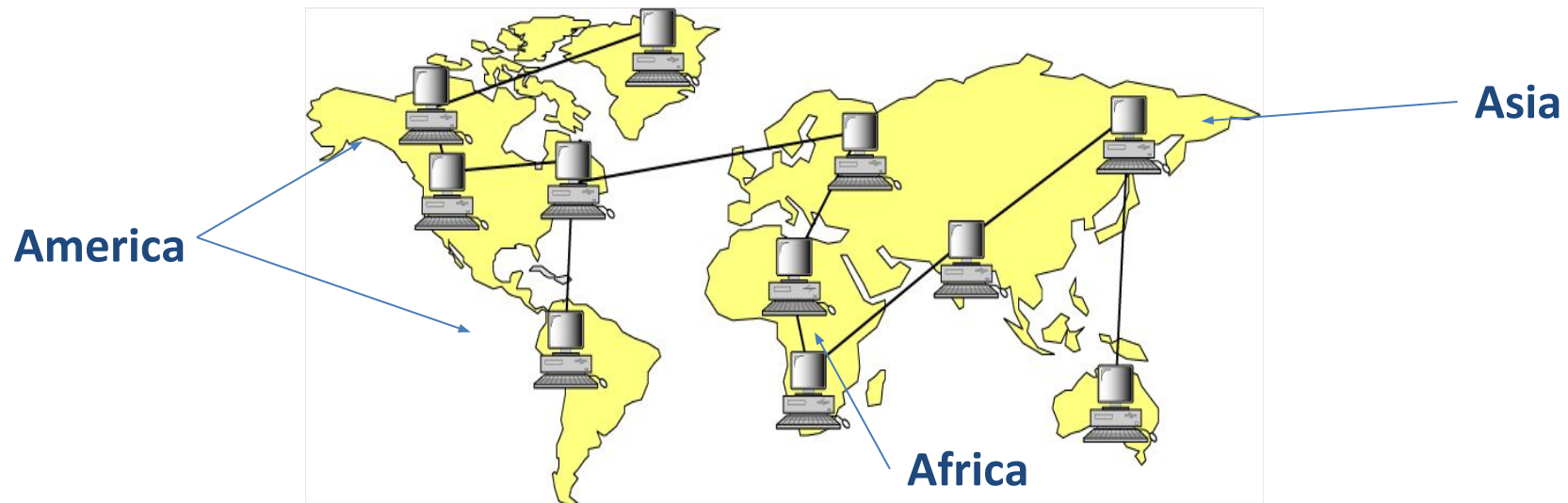
Metropolitan Area Network

- A metropolitan area network (MAN) is a computer network that interconnects with computer in a **metropolitan area** like city.
- MAN is a **larger** than LAN but **smaller** than the area covered by a WAN.
- It is also used to **interconnection of several local area network**.

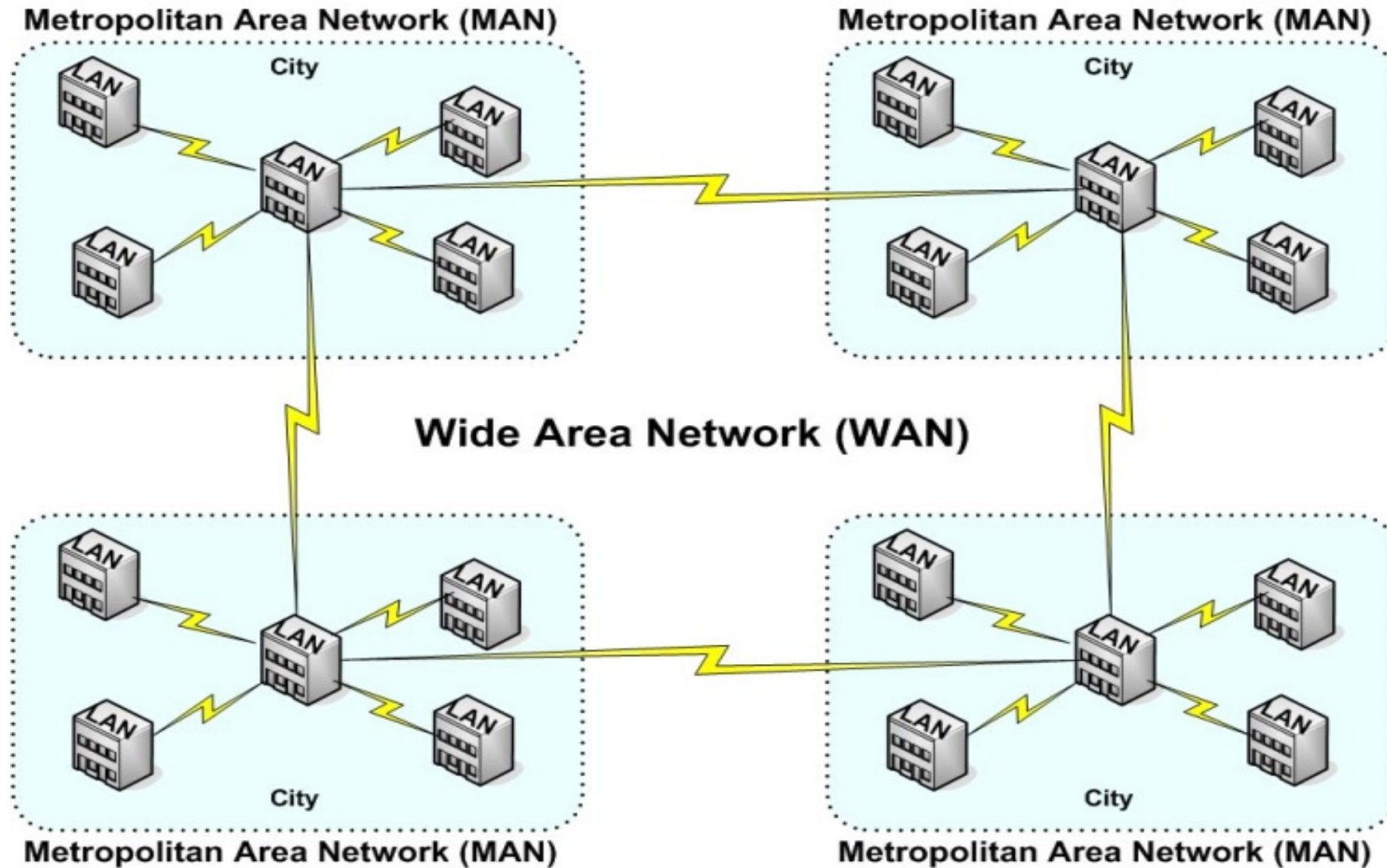


Wide Area Network

- A wide area network (WAN) is a computer network that exists over a **large-scale geographical area**.
- A WAN **connects** different networks, including local area networks (**LAN**) and metropolitan area networks (**MAN**).
- It may be located within a **state** or a **country** or it may be interconnected around the world.



Types of Computer Networks - Summary

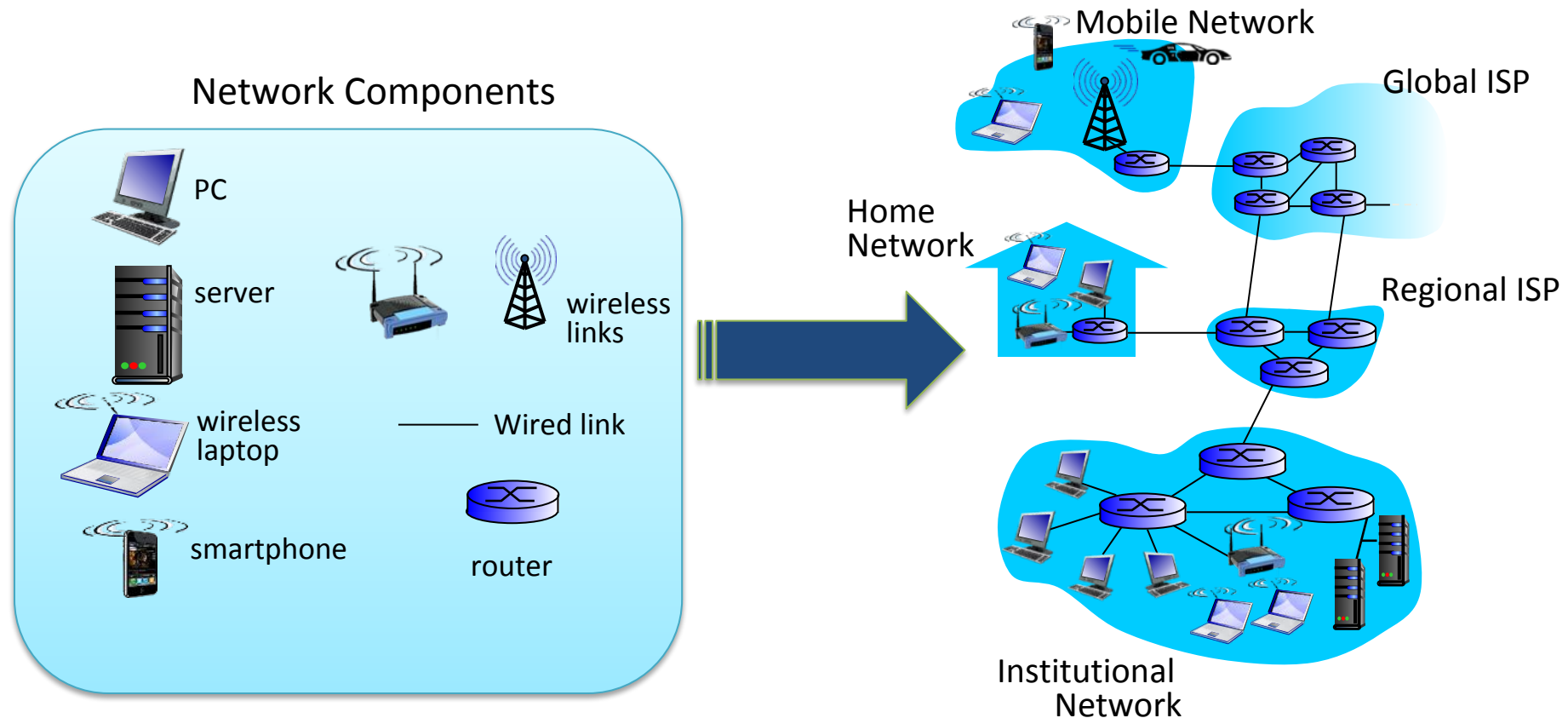


Types of Computer Networks - Summary

Basis Of Comparison	LAN	MAN	WAN
Full Name	Local Area Network	Metropolitan Area Network	Wide Area Network
Meaning	A network that connects a group of computers in a small geographical area	It covers relatively large region such as cities, towns	It spans large locality & connects countries together. e.g. Internet
Ownership of Network	Private	Private or Public	Private or Public (VPN)
Design and Maintenance	Easy	Difficult	Difficult
Propagation Delay	Short	Moderate	Long
Speed	High	Moderate	Low
Equipment Used	NIC, Switch, Hub	Modem, Router	Microwave, Radio Transmitter & Receiver
Range(Approximately)	1 to 10 km	10 to 100 km	Beyond 100 km
Used for	College, School, Hospital	Small towns, City	State, Country, Continent

What is Internet?

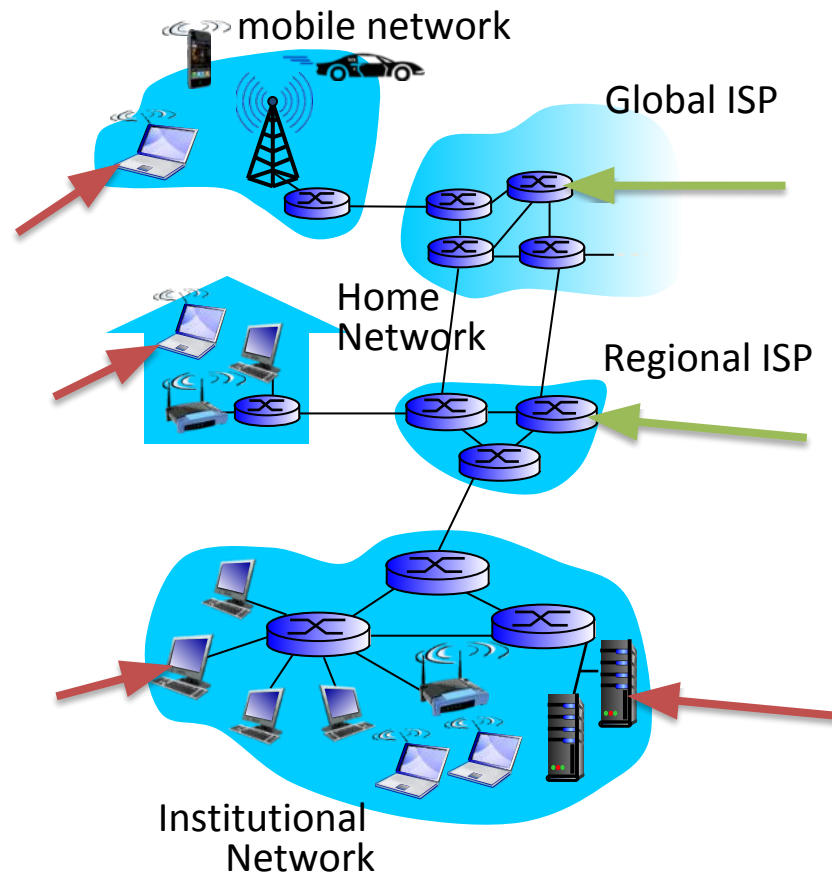
- The internet is a type of **world-wide computer network**.
- The internet is the collection of infinite numbers of **connected computers** that are spread across the world.



NETWORK EDGE & NETWORK CORE

The Network Edge

- Computers and other devices are connected at the **edge** (end) of the network.
- These computers are known as **hosts** or **end systems**. Router is known as **edge router**.

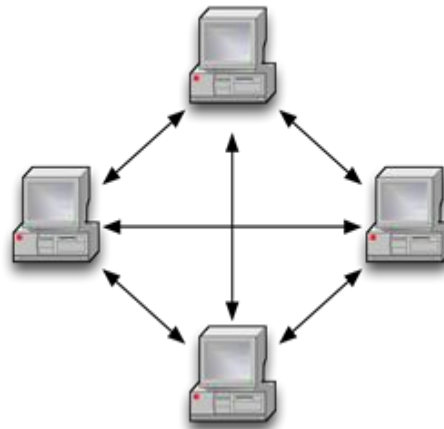


Peer to Peer Network

- Computers are connected **together** so that users can share resources and information.

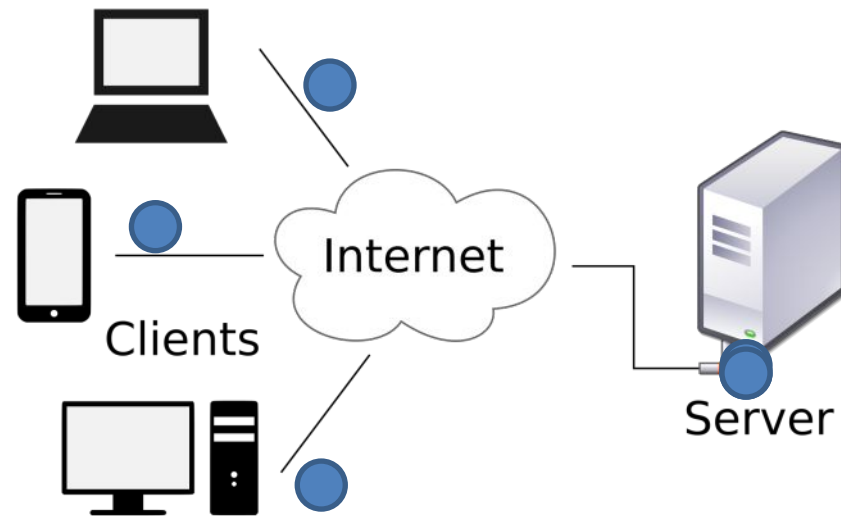


- There is **no central server** for authenticating users, each of them works as both client and server.
- e.g. Bit Torrent



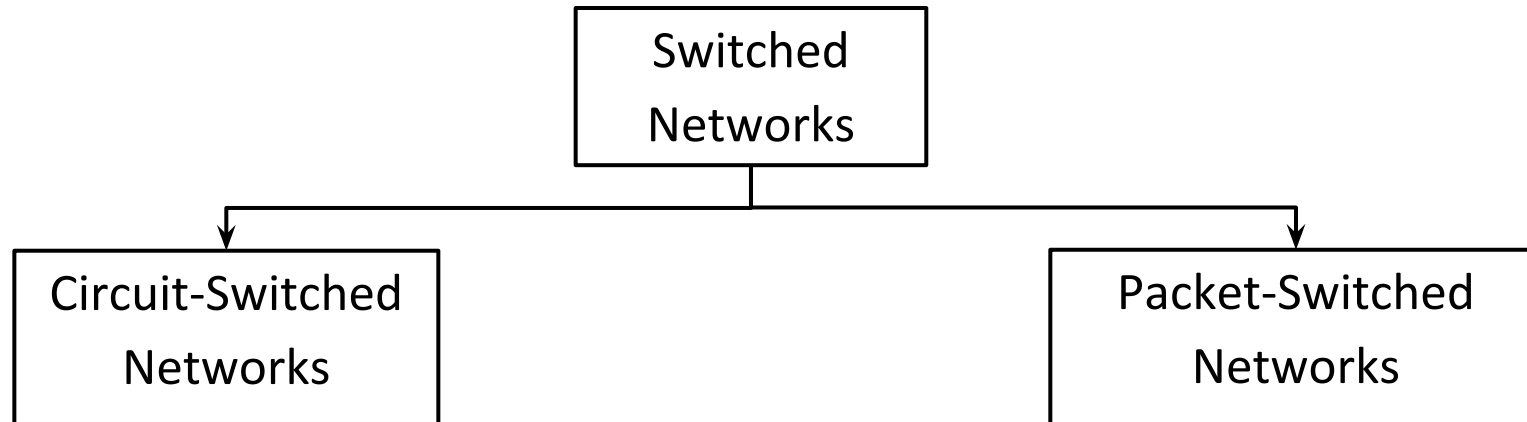
Client – Server Network

- **Client:** Request servers for a task.
 - ✓ Generally called desktop PCs or workstations.
- **Server:** Receive requests from the clients. Process and response them.
 - ✓ e.g. Web Server, Email Server



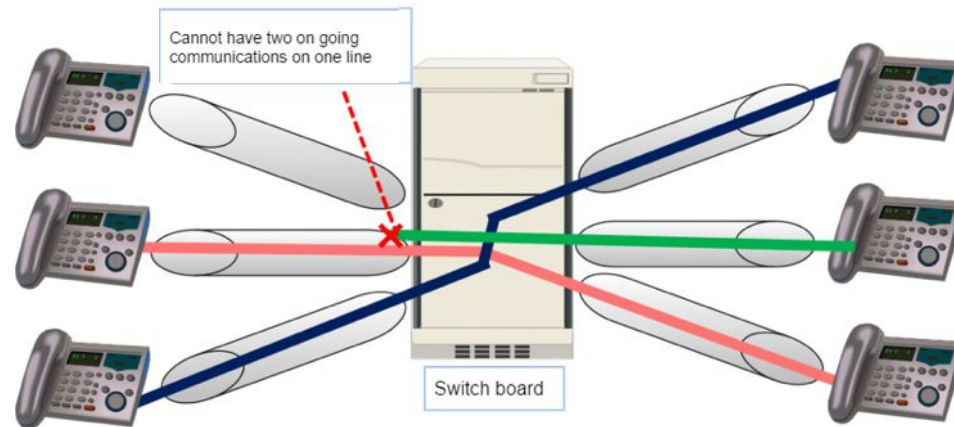
The Network Core

- Defines the connection of different network segments together and process to transmit data packets across the network.
- It is implemented through the use of **switching techniques**.



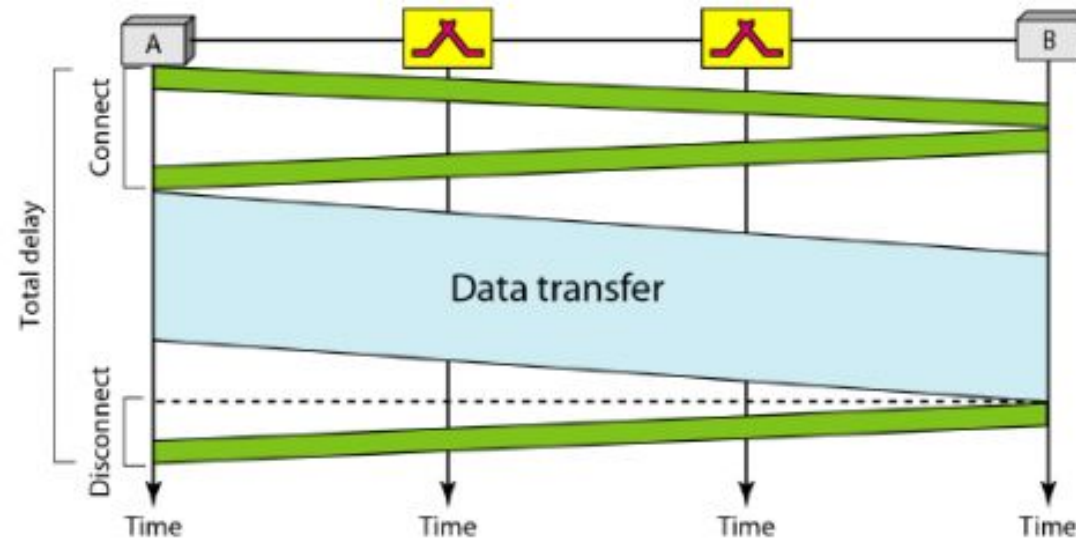
Circuit Switched Network

- A **dedicated** channel has to be established before the call is made between users.
- The channel is **reserved** between the users till the **connection is active**.
- For half duplex(one way) communication, one channel is allocated and for full duplex(two way) communication, two channels are allocated.
- It is mainly used for **voice communication** requiring **real time** services without delay.



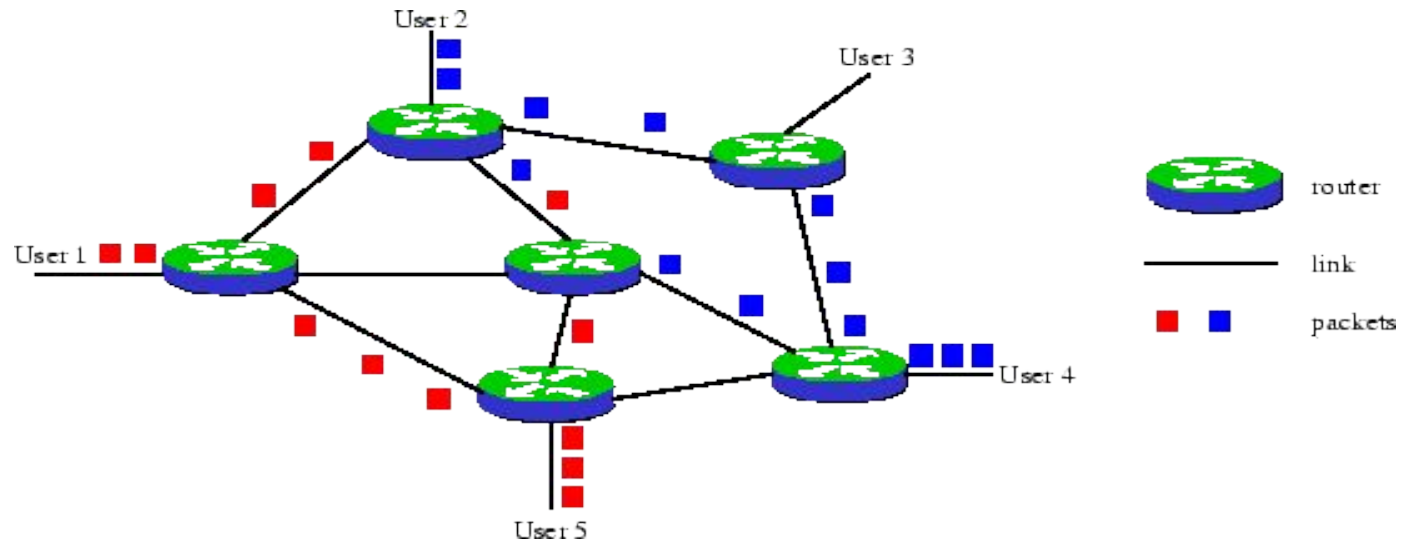
Circuit Switched Network – Cont...

- Communication via circuit switching involves three phases:
 1. Circuit Establishment
 2. Data Transfer
 3. Circuit Disconnect



Packet Switched Network

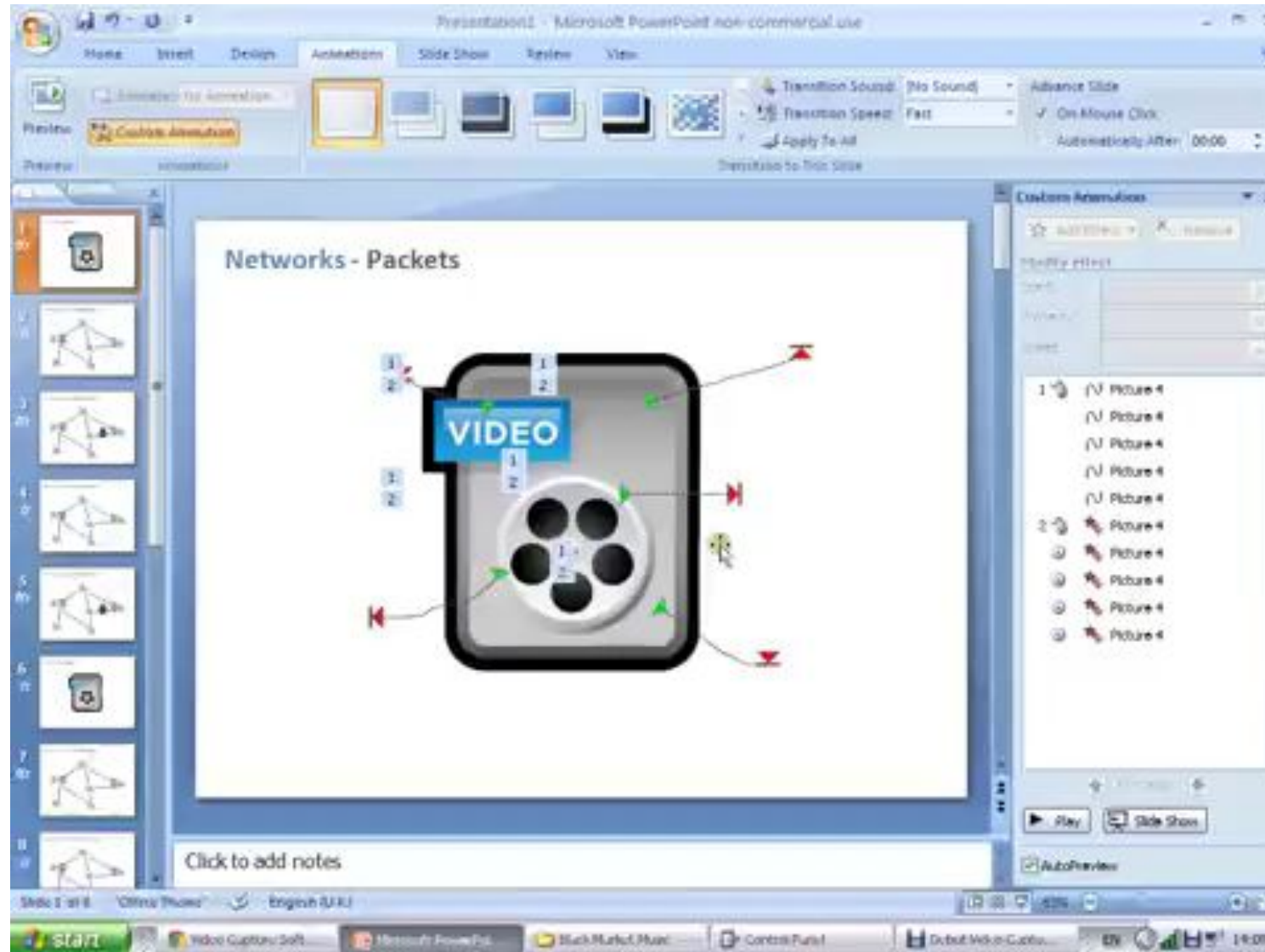
- It is **not required** to establish the connection initially.
- The connection/channel is available to use by users. But when **traffic** or **number of users** increases then it will lead to **congestion** in the network.
- Packet switched networks are mainly used for **data** and **voice** applications requiring **non-real time** scenarios.



Differences

Circuit Switching		Packet Switching	
✓	Dedicated path between source and destination	✓	No dedicated path
✓	All packets use same path	✓	Packets travel independently
✓	Reserve the entire bandwidth in advance	✓	Does not reserve bandwidth
✓	Bandwidth wastage	✓	No bandwidth wastage
✓	No store and forward transmission	✓	Supports store and forward transmission

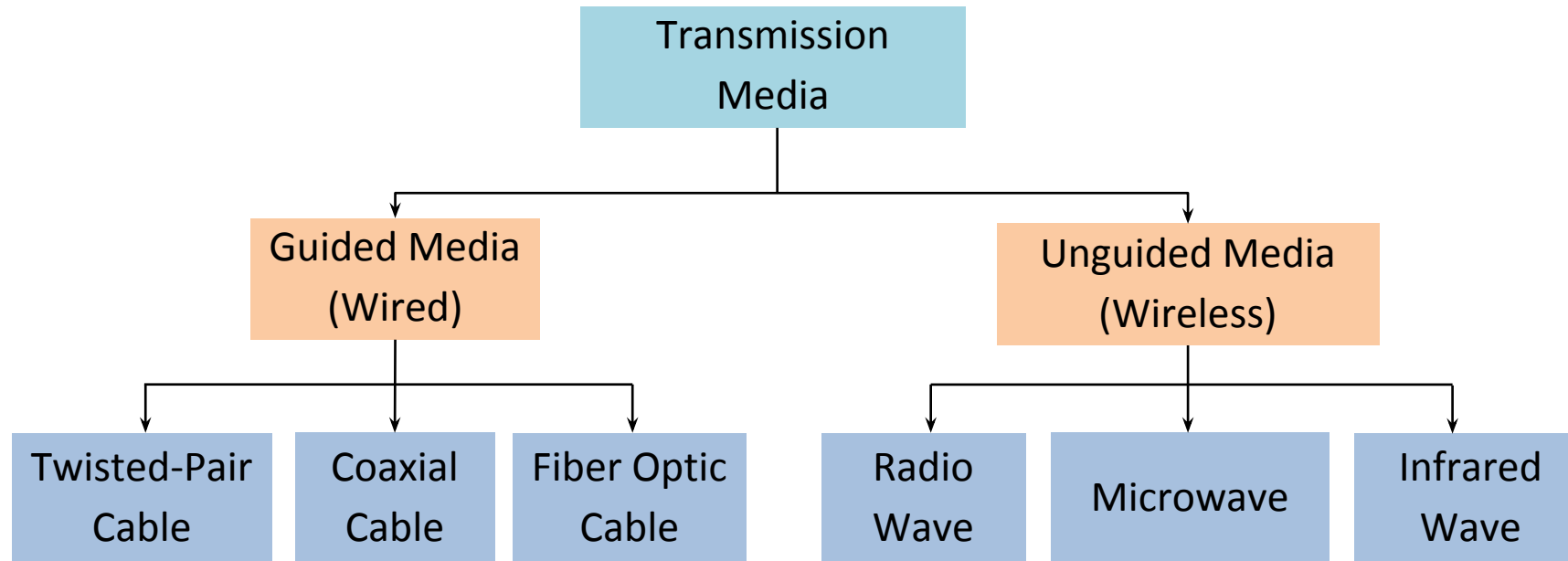
Switching Network



TRANSMISSION MEDIA

Transmission Media

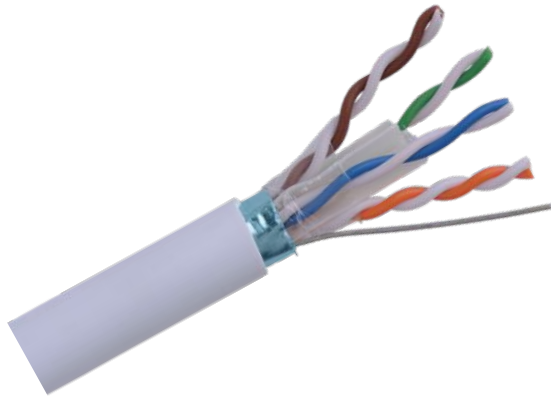
A transmission media can be defined as any medium that can **carry information** from a **source to a destination**.



Guided Media

- Guided media are those that provide a wired - channel from one device to another.
- Three Guided media commonly used for data transmission are:

Twisted Pair Cable



Coaxial Cable



Fiber Optic Cable

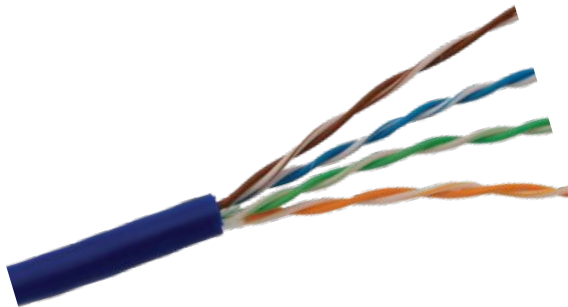


Twisted Pair Cable

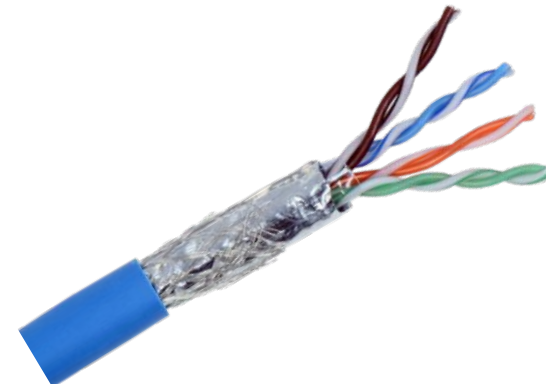
- Separately insulated
- Twisted together
- It is widely used in different kinds of data and voice infrastructure.
- The use of two wires twisted together helps to reduce crosstalk and electromagnetic induction.
- Two types of twisted pair cable:



UTP
(Unshielded Twisted Pair)

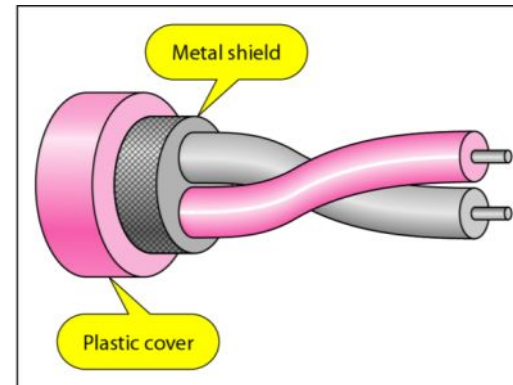
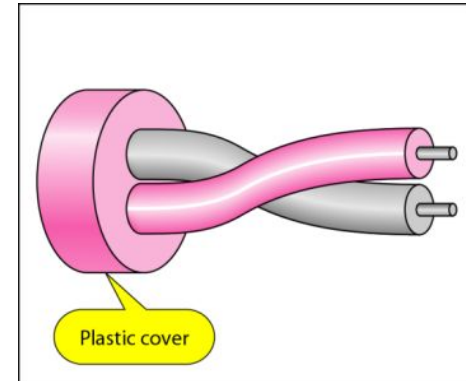


STP
(Shielded Twisted Pair)

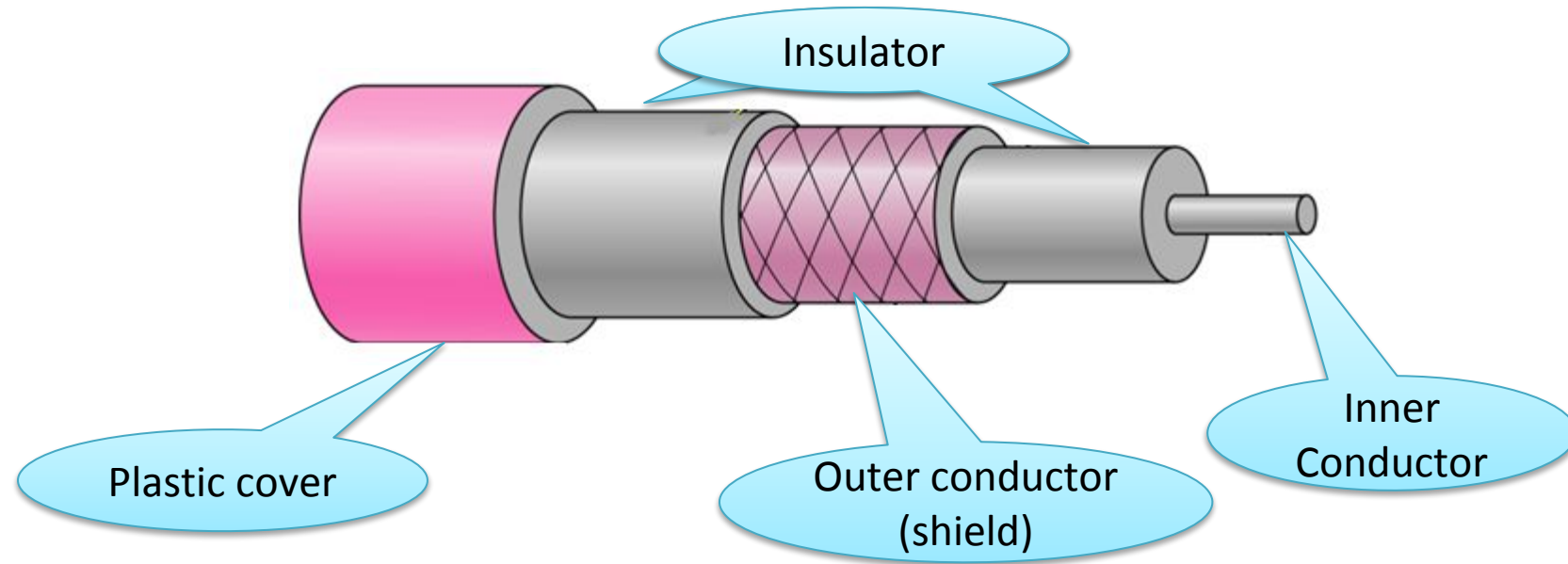


Twisted Pair Cable – Cont...

- **UTP(Unshielded Twisted Pair)**
 - ✓ Ordinary telephone wires
 - ✓ Less expensive
 - ✓ Weak immunity against noise & interferences
 - ✓ Most used in two categories: Cat-3 & Cat-5
 - ✓ Used in laboratory
- **STP(Shielded Twisted Pair)**
 - ✓ An extra metallic shield on each pair
 - ✓ Relatively more expensive
 - ✓ Better performance than UTP
 - ✓ Used in exterior network(outside of building).



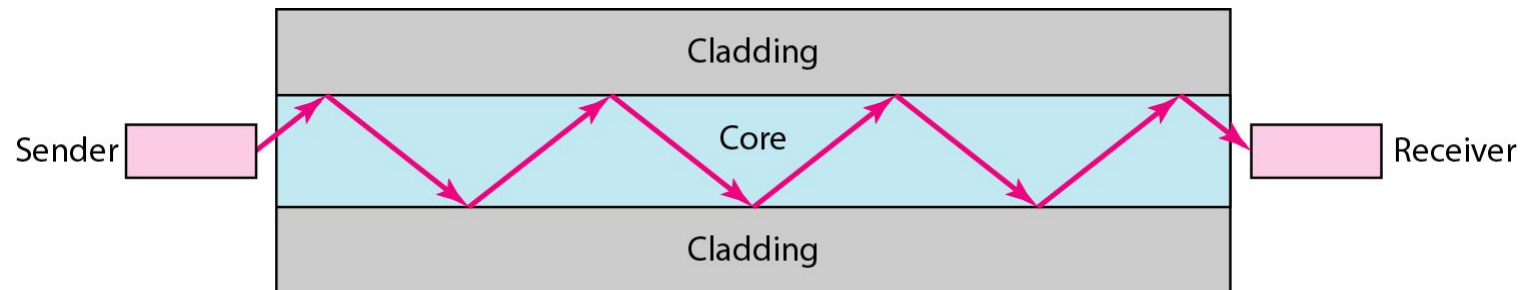
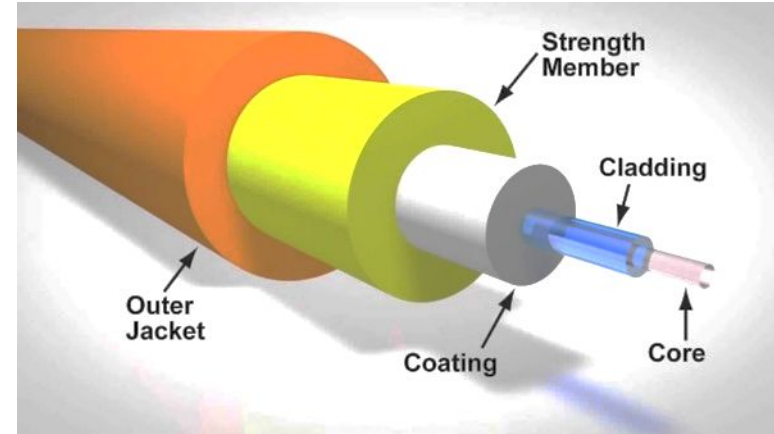
Coaxial Cable



- Outer conductor is braided shield
- Inner conductor is solid metal
- Separated by insulating material, and whole cover by plastic cover
- Used in television, long distance telephone transmission
- High bandwidth and excellent noise immunity

Fiber Optic Cable

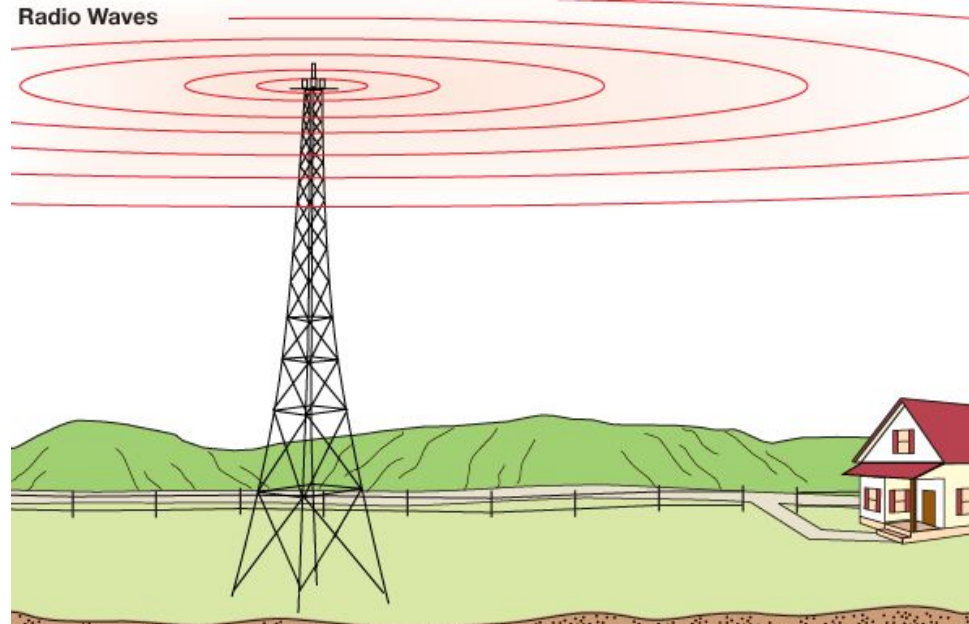
- Glass or plastic core
- Laser or light emitting diode
- Small size & weight
- Used in high bandwidth network
- High data rate & lower attenuation



Unguided Media

- Unguided media transmit electromagnetic waves without using a physical conductor.
- This type of communication is often referred to as **wireless** communication.
 1. Radio wave
 2. Microwave
 3. Infrared Wave

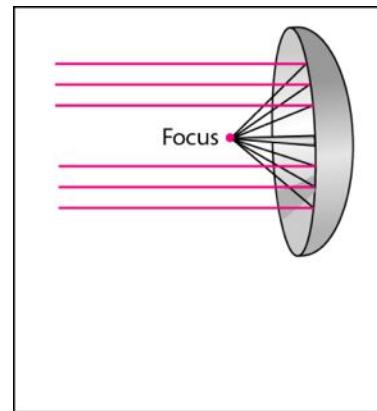
Radio wave



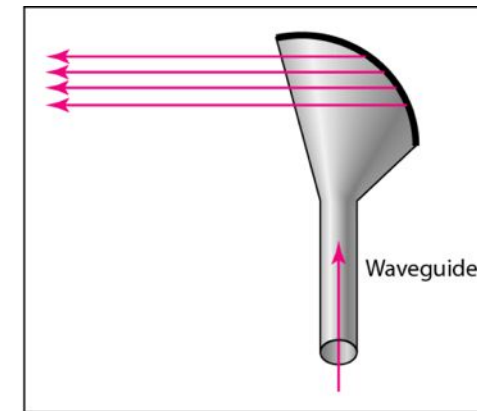
- Highly regulated
- **O**mnidirectional antennas
- Radio waves are used for **m**ulticast communications, such as radio and television, and paging systems
- Penetrate through walls

Microwave

- Use **directional** antennas - point to point line of sight communications
- Microwave communication
- Used for **unicast** communication such as cellular telephones, satellite networks
- Higher frequency ranges cannot efficiently penetrate walls



a. Dish antenna



b. Horn antenna

Infrared wave

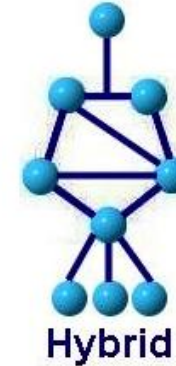
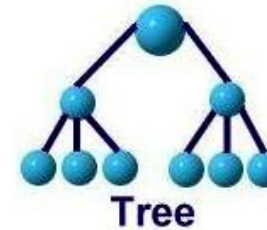
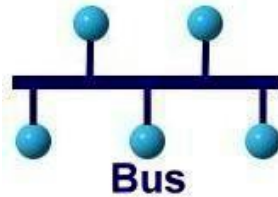
- Infrared signals can be used for **short-range** communication in a closed area using line-of-sight propagation
- Used on televisions, VCRs, and stereos all use infrared communication.
- Relatively directional
- Cheap, easy to build but they do not pass through solid objects



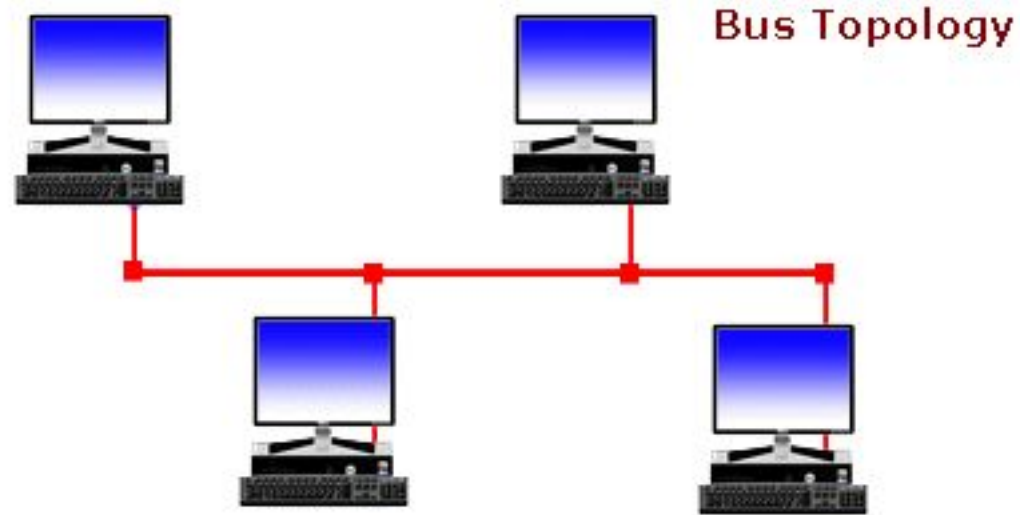
NETWORK TOPOLOGIES

Network Topologies

- Network topology is the **arrangement** of the various components(links, nodes, etc.) of a computer network.
- Types of network topologies :
 1. Bus
 2. Ring
 3. Star
 4. Mesh
 5. Tree
 6. Hybrid

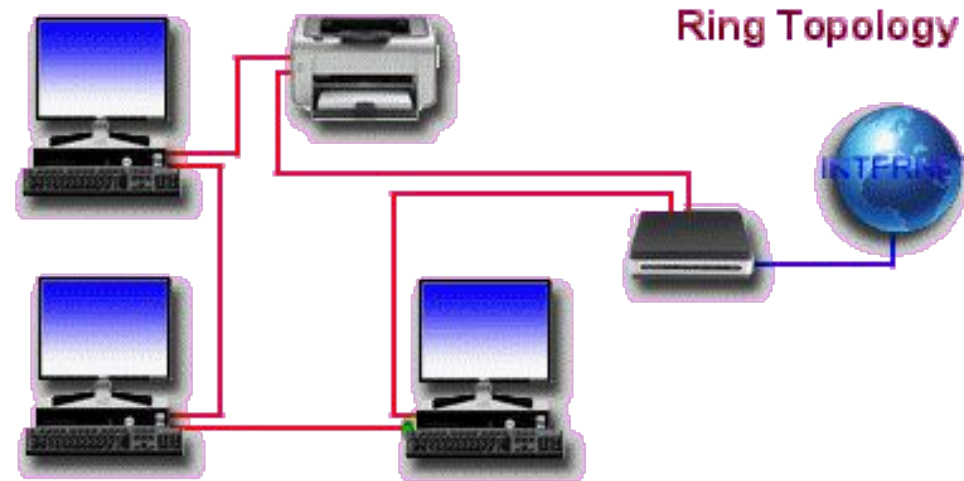


Bus Topology



- Every computer and network device is connected to **single** cable
- It transmits data only in **one direction**
- Cost effective
- Used in small networks
- Easy to expand joining two cables together
- It is used in early LAN connection

Ring Topology



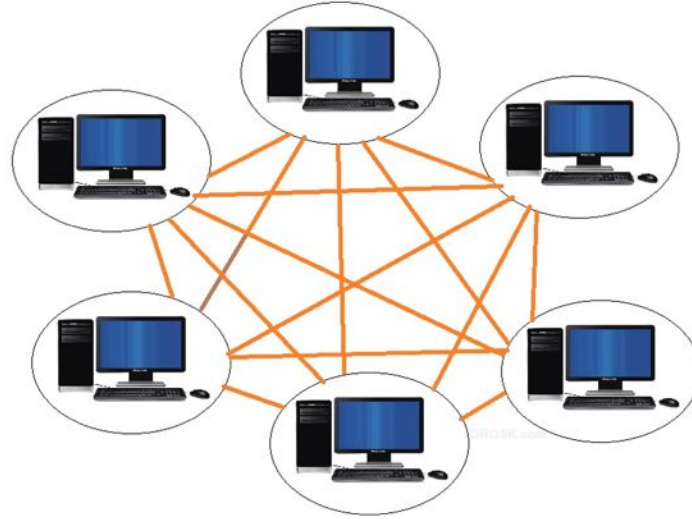
- It forms a **ring** as each computer is connected to another computer, with the last one connected to the first.
- Transmission is **unidirectional** & **sequential** way that is bit by bit.
- Transmitting network is not affected by high traffic or by adding more nodes, as only the nodes having **tokens** can transmit data.
- **Cheap** to install and expand.

Star Topology



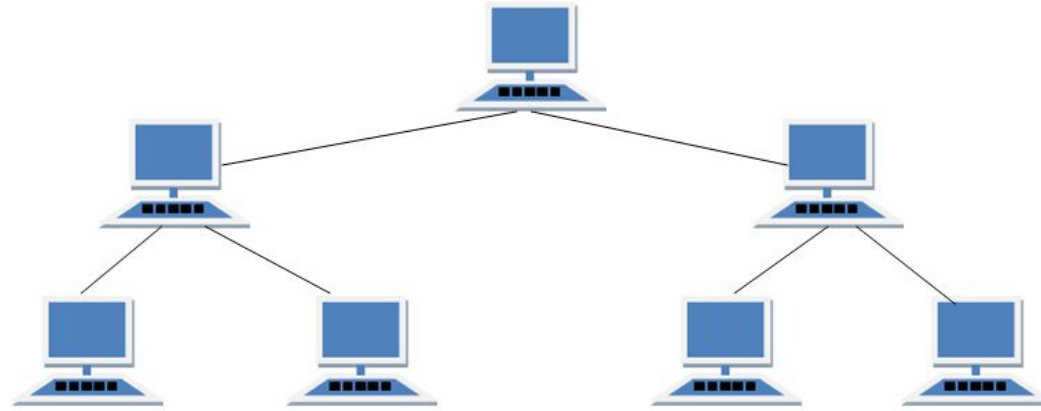
- Computers are connected to a single **central hub** through a cable.
- **Fast** performance with few nodes and low network traffic.
- **Easy** to troubleshoot & **Easy** to setup and modify.
- Only that node is affected which has failed rest of the nodes can work smoothly.
- **Hub** can be upgraded easily.

Mesh Topology



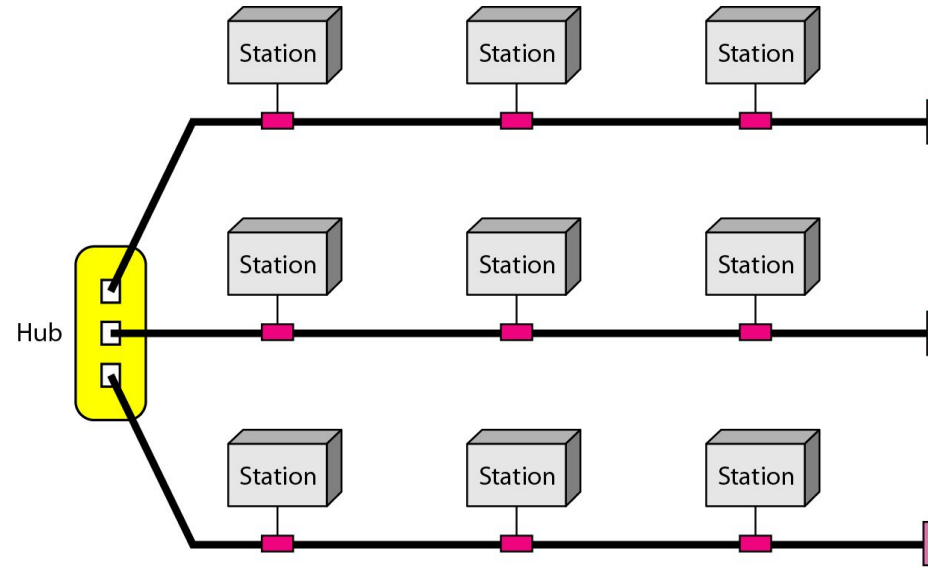
- **Point-to-point** connection to other devices or fully connected.
- Traffic is carried only between **two connected** devices.
- Robust, costly but not flexible.
- Fault is diagnosed **easily**.
- More cable resource used in setup.

Tree Topology



- It has a root node and all other nodes are connected to it forming a **hierarchy**.
- Also called **hierarchical** topology.
- Mostly used in Wide Area Network – **WAN**.
- **Expansion** of nodes is possible and easy.
- Easily managed and maintained.

Hybrid Topology



- A network structure whose design contains **more than one topology** is said to be hybrid topology.
- It is a combination of two or more topologies.
- Flexible & reliable as error detection and easy to troubleshoot.
- **Scalable** as size can be increased easily.

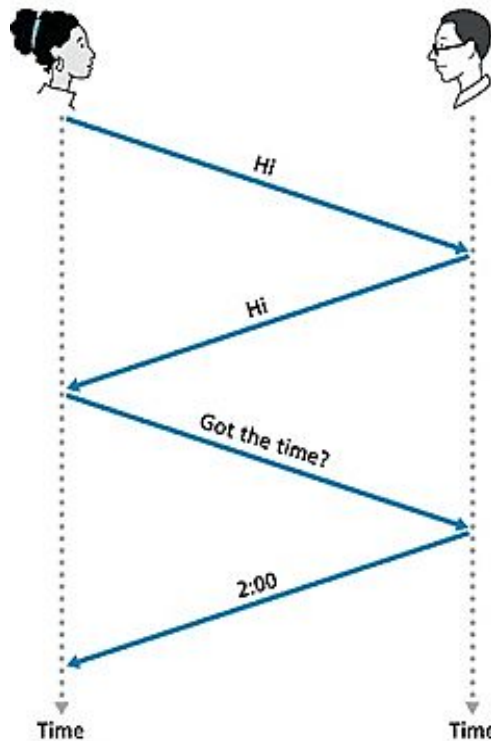
Comparison of Topologies

	Bus	Ring	Star	Mesh	Tree
Means	every computer and network device is connected to single cable.	Each computer is connected to another, with the last one connected to the first.	All the computers are connected to a single hub through a cable.	All the network nodes are connected to each other.	It has a root node and all other nodes are connected to it forming a hierarchy.
Cost	Average	Cheap	High	High	High
Used in	Small Network	Expand Network	Small Network	Expand Network	Expand Network
Troubleshoot	Easy, But Cables fail then whole network fails.	Difficult; Failure of one computer disturbs the whole network.	Easy; If the hub fails then the whole network is down.	Difficult; Installation and configuration is difficult.	Easy; Central root hub fails, network fails.

What is Protocol?

- Human Protocol(Language)

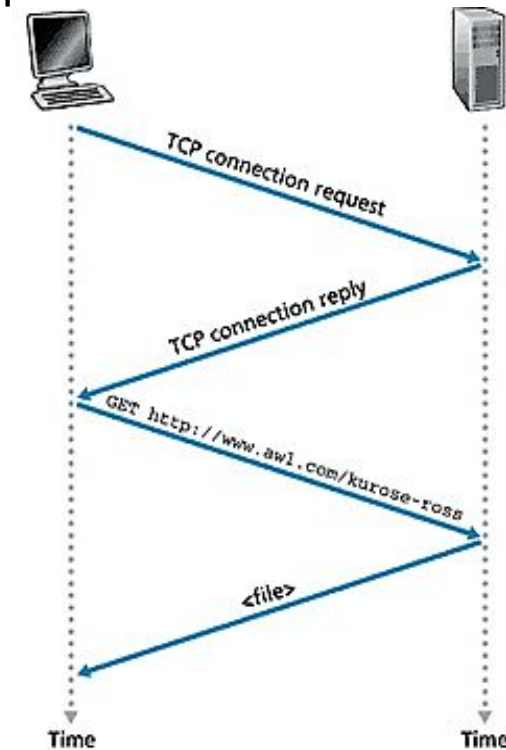
- ✓ “what’s the time?”
- ✓ “I have a question”
- ✓ Introduction Talk



- Network Protocol

- ✓ Set of rules
- ✓ machines rather than humans
- ✓ all **communication** activity in Internet **governed** by protocols.

*Protocol is define **format**,
order of message sent
and received among
network entities, and
actions taken on message
transmission and
reception*

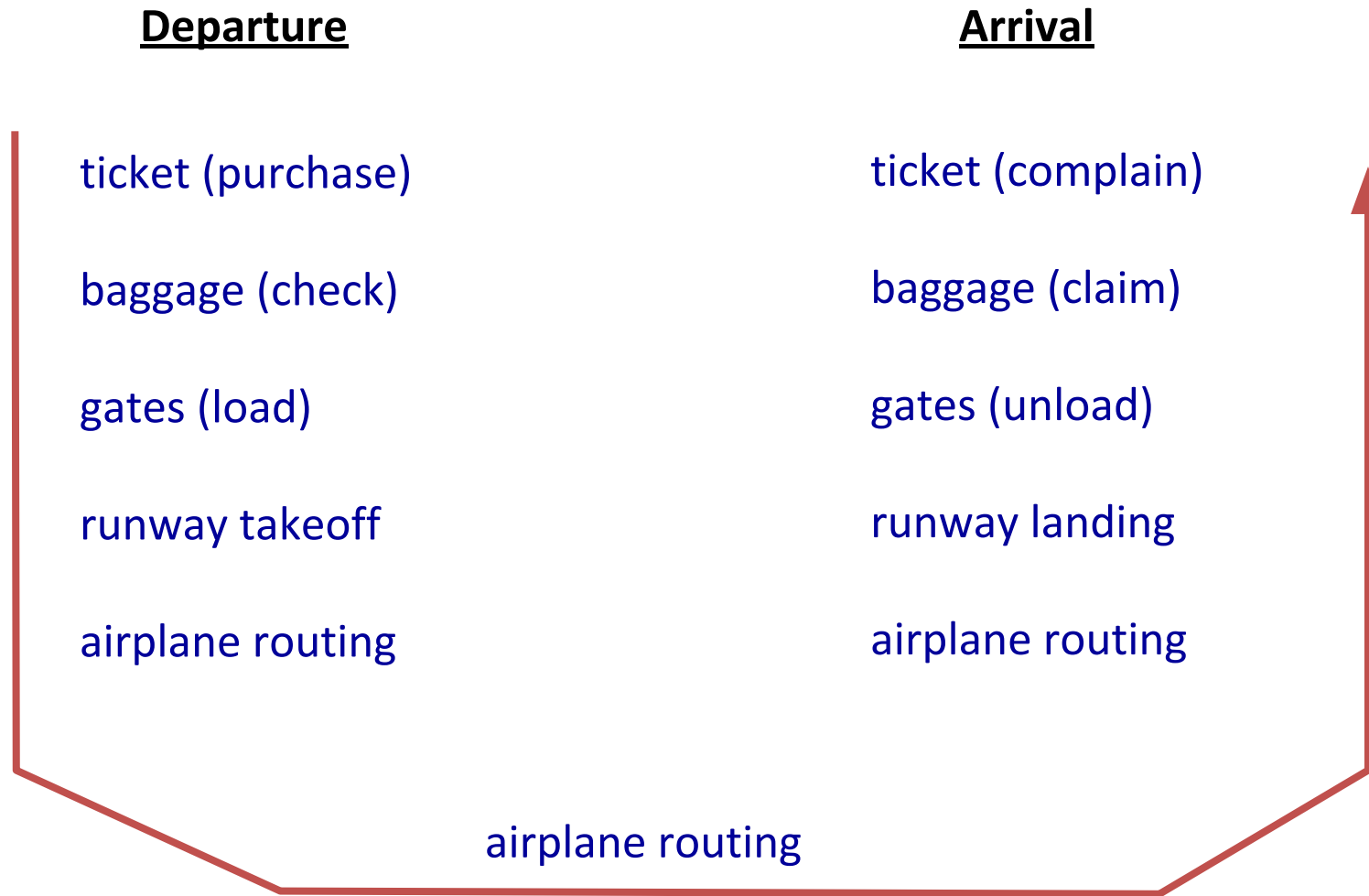


PROTOCOL LAYERS

Protocols Layers

- To deals with connecting systems that are open for communication with other systems.
- **OSI Layer Model** (Open Systems Interconnection)
- Developed by the International Standards Organization (**ISO**) with **seven** different layers.
 1. Physical Layer
 2. Data Link Layer
 3. Network Layer
 4. Transport Layer
 5. Session Layer
 6. Presentation Layer
 7. Application Layer

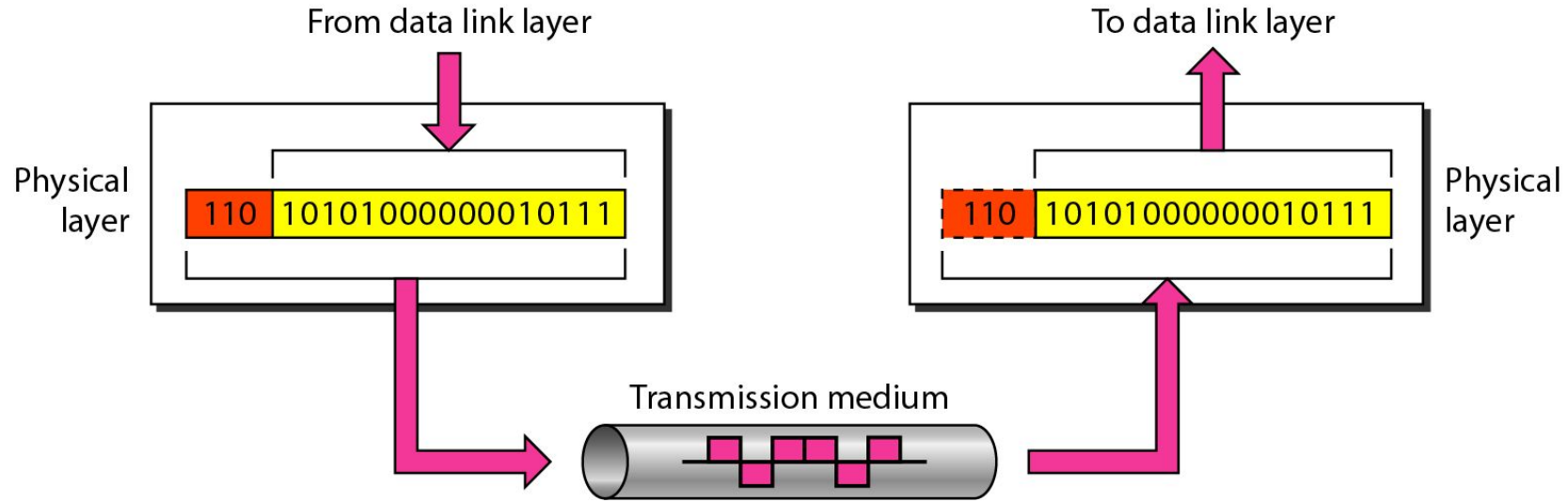
Example – Air Plane Travel



How OSI Layer Works?



Physical Layer

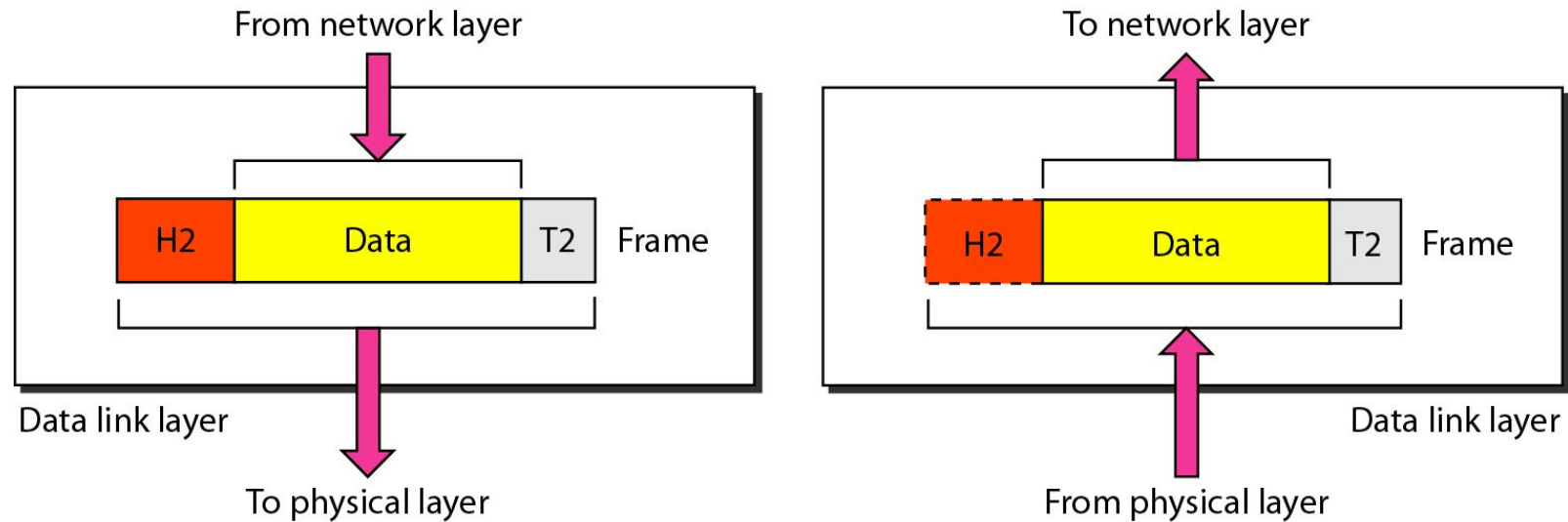


- The physical layer is responsible for **movements of individual bits** from one hop (node) to the next.

Physical Layer – Cont...

- Carries the bit stream over a physical media.
- Physical Layer is concerned with:
 - ✓ Interface and Medium like guided cables
 - ✓ Representation of bits
 - ✓ Data rate
 - ✓ Synchronization of bits
 - ✓ Line configuration
 - ✓ Physical topology
 - ✓ Transmission mode

Data Link Layer

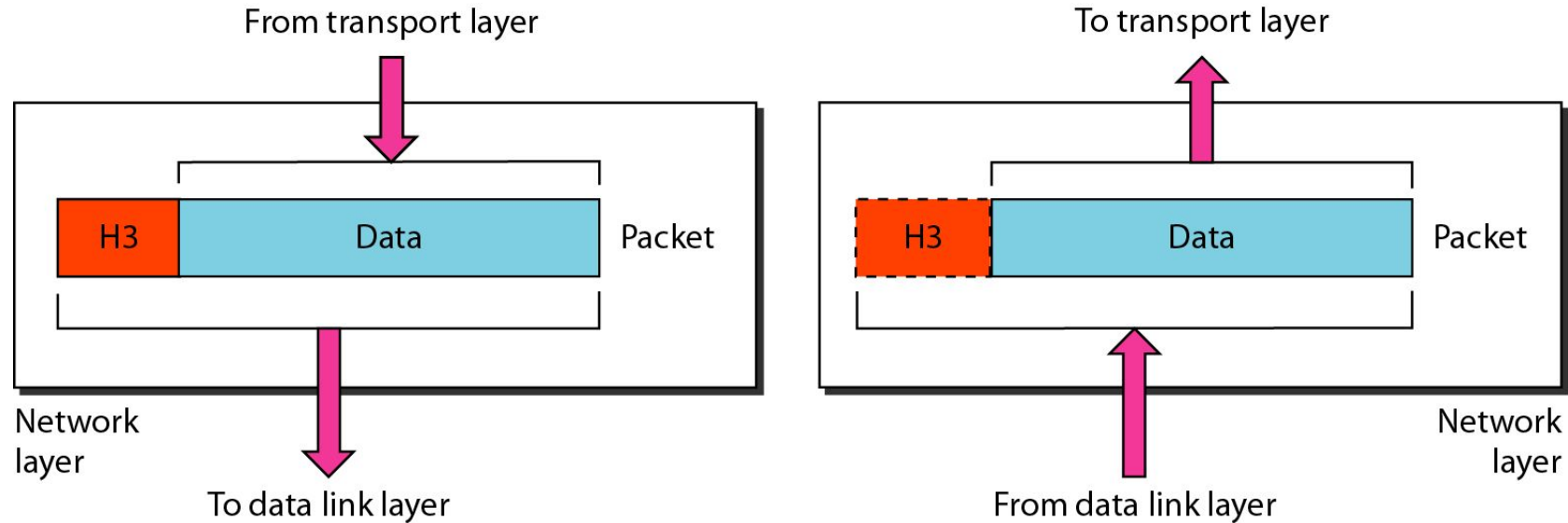


- The data link layer is responsible for **moving frames** from one hop (node) to the next.

Data Link Layer – Cont...

- Data link layer is concerned with:
 - ✓ Framing – divide bits stream into data unit (frame)
 - ✓ Physical addressing
 - ✓ Flow control – avoid over overwhelming
 - ✓ Error control – bit loses, retransmission
 - ✓ Access control

Network Layer

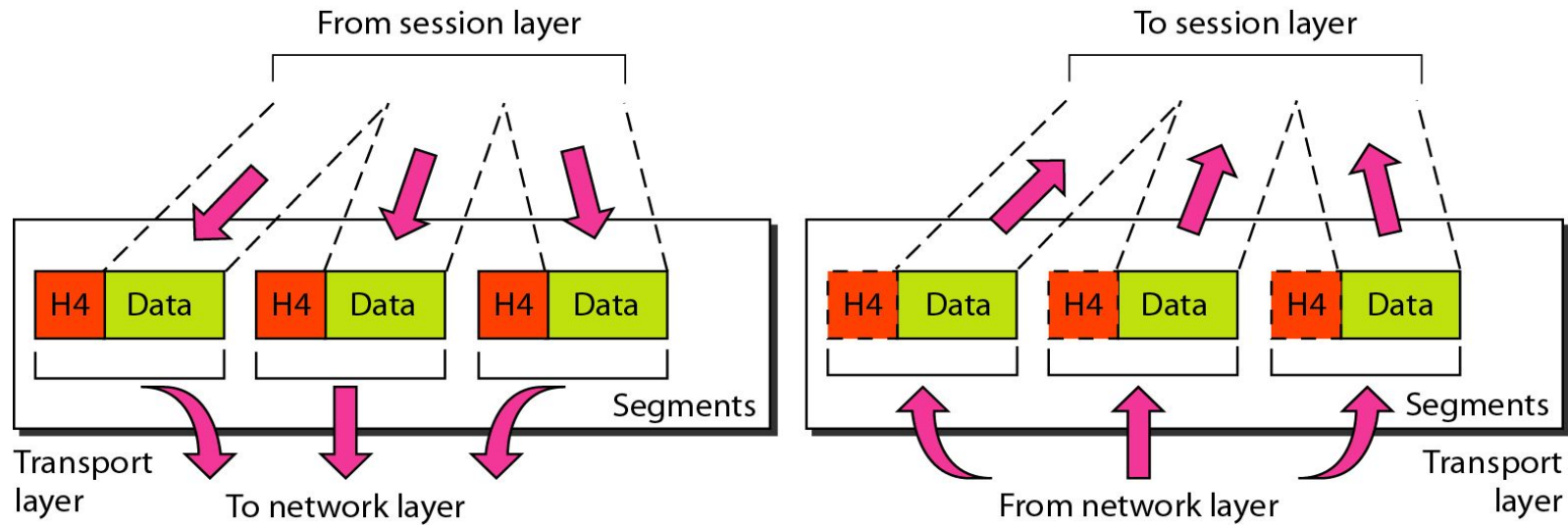


- The network layer is responsible for the **delivery of individual packets** from the source host to the destination host.

Network Layer – Cont...

- In this layer, packet is combined with header and data.
- In case of data link layer, packet delivers on the **same network**.
- If two **different networks** are connected then packet is concern with network layer.
- Network layer is concerned with:
 - ✓ Logical addressing e.g. 192.168.1.1 (IP Address)
 - ✓ Routing

Transport Layer

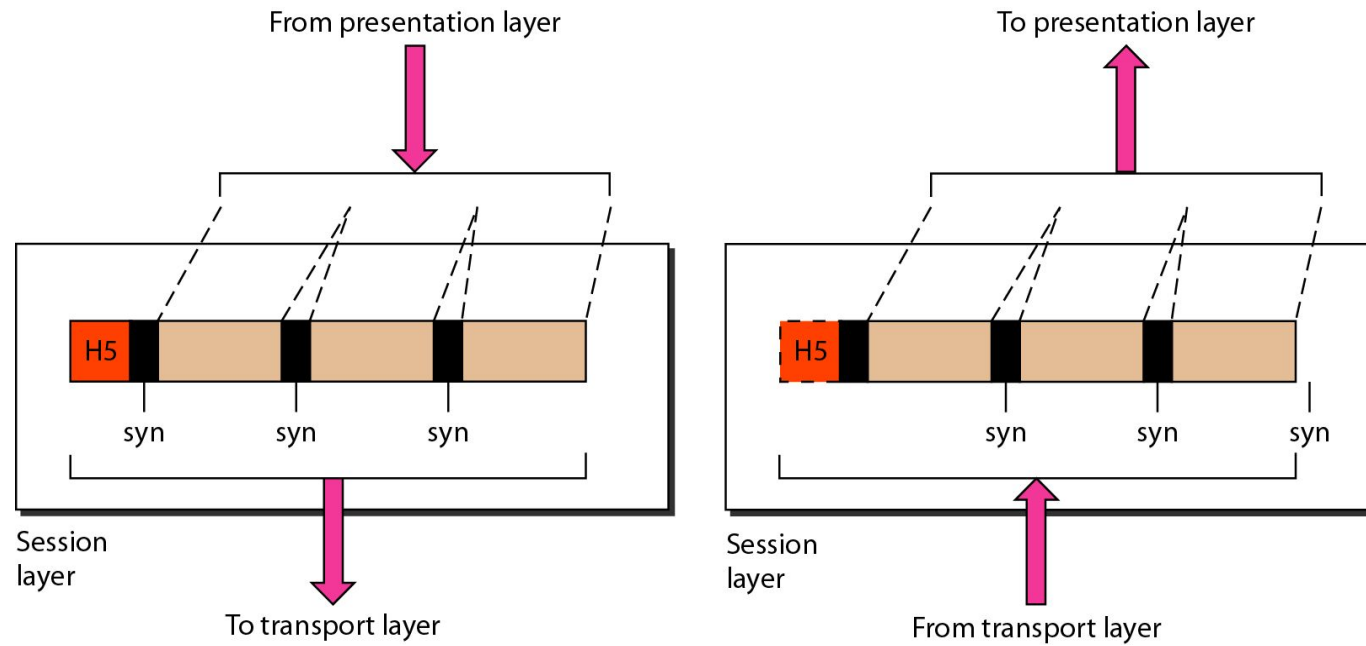


- The transport layer is responsible for the **delivery of a message** from one process to another.

Transport Layer – Cont...

- This layer ensures that the whole message arrives intact and in order.
- Transport layer is concerned with:
 - ✓ Service-point addressing (port address)
 - ✓ Segmentation and reassembly
 - ✓ Connection control
 - ✓ Flow and error control

Session Layer

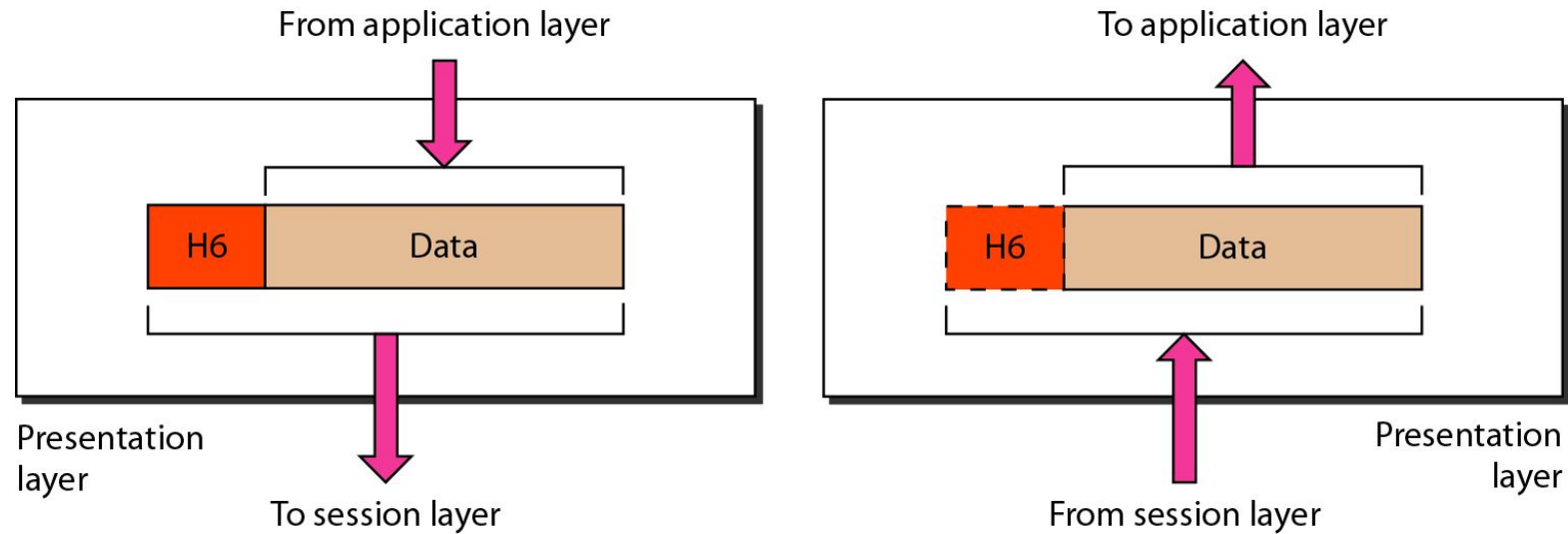


- The session layer is responsible for **dialog control and synchronization**.

Session Layer – Cont...

- This layer is network dialog controller – establishes, maintains, synchronizes the interaction among computers.
- Session layer is concerned with:
 - ✓ Dialog control
 - ✓ Synchronization

Presentation Layer

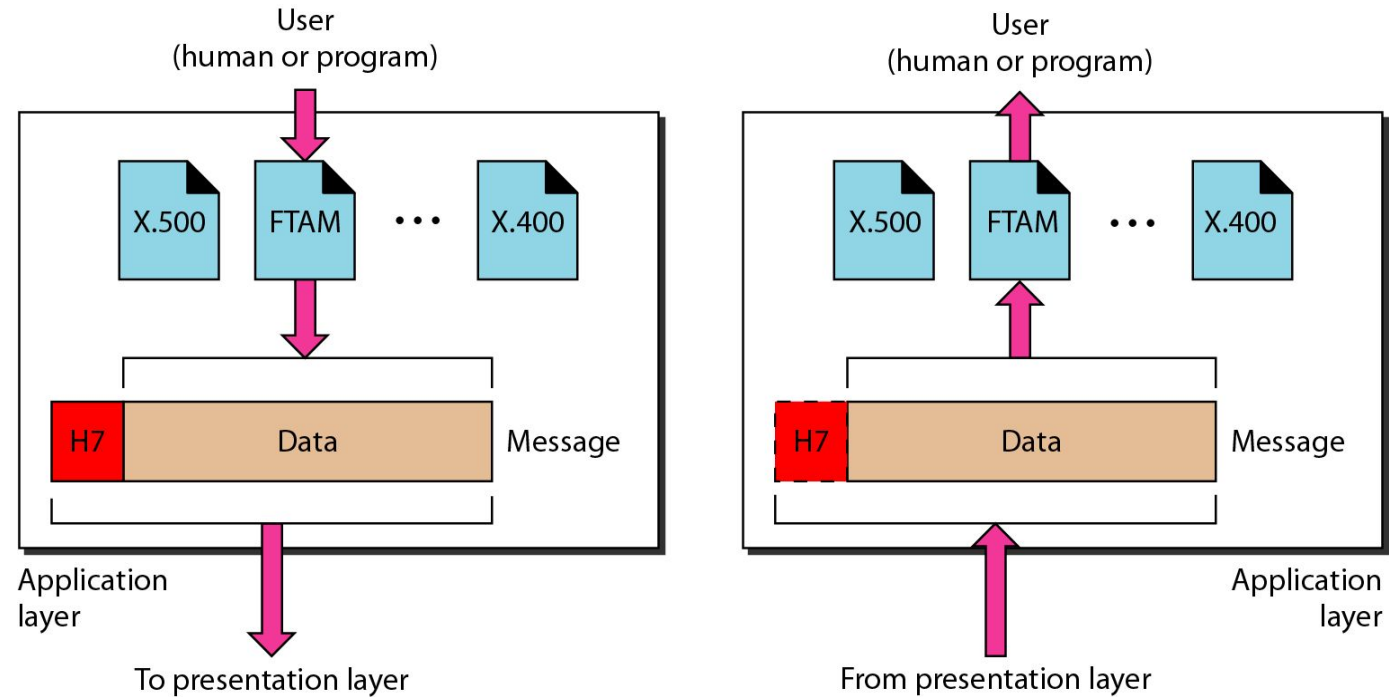


- The presentation layer is responsible for **translation, compression, and encryption**.

Presentation Layer – Cont...

- This layer is concerned with the syntax which refers to order in which data is presented and semantics helps in interpreting a particular pattern.
- Presentation layer is responsible for:
 - ✓ Translation
 - ✓ Encryption
 - ✓ Compression

Application Layer

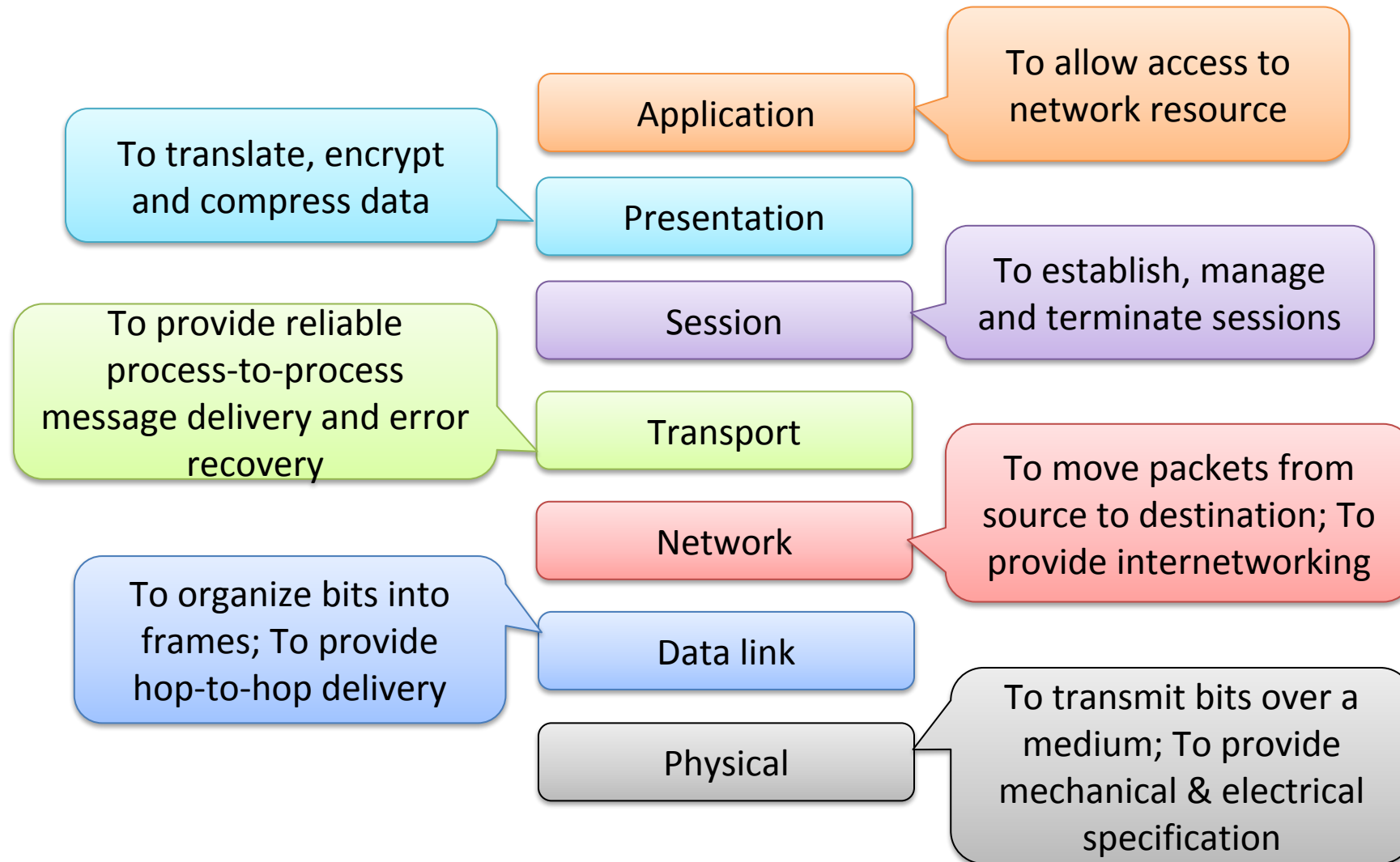


- The application layer is responsible for **providing services** to the user.

Application Layer – Cont...

- This layer provides various services like:
 - ✓ Network virtual terminal
 - ✓ File transfer, access and management
 - ✓ Mail services
 - ✓ Directory services

Summary – OSI Layer

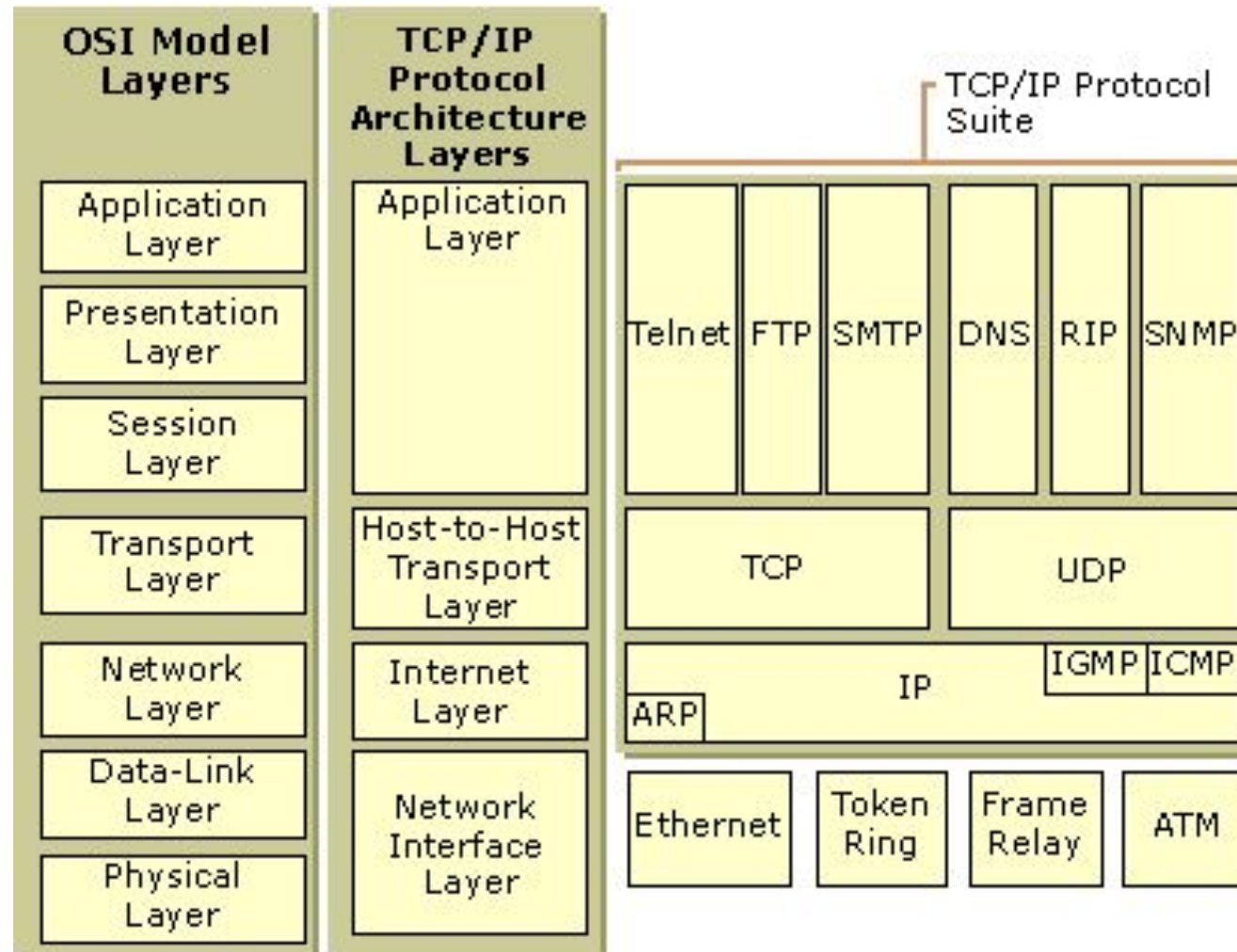


TCP/IP Reference Model

(Transmission Control Protocol/Internet Protocol)

- It was originally defined as having **five** layers:
- TCP/IP is a **set of protocols** developed to allow cooperating computers to share resources across the network.
 1. Application Layer
 2. Transport Layer
 3. Network Layer
 4. Data Link Layer
 5. Physical Network

TCP/IP Model Architecture



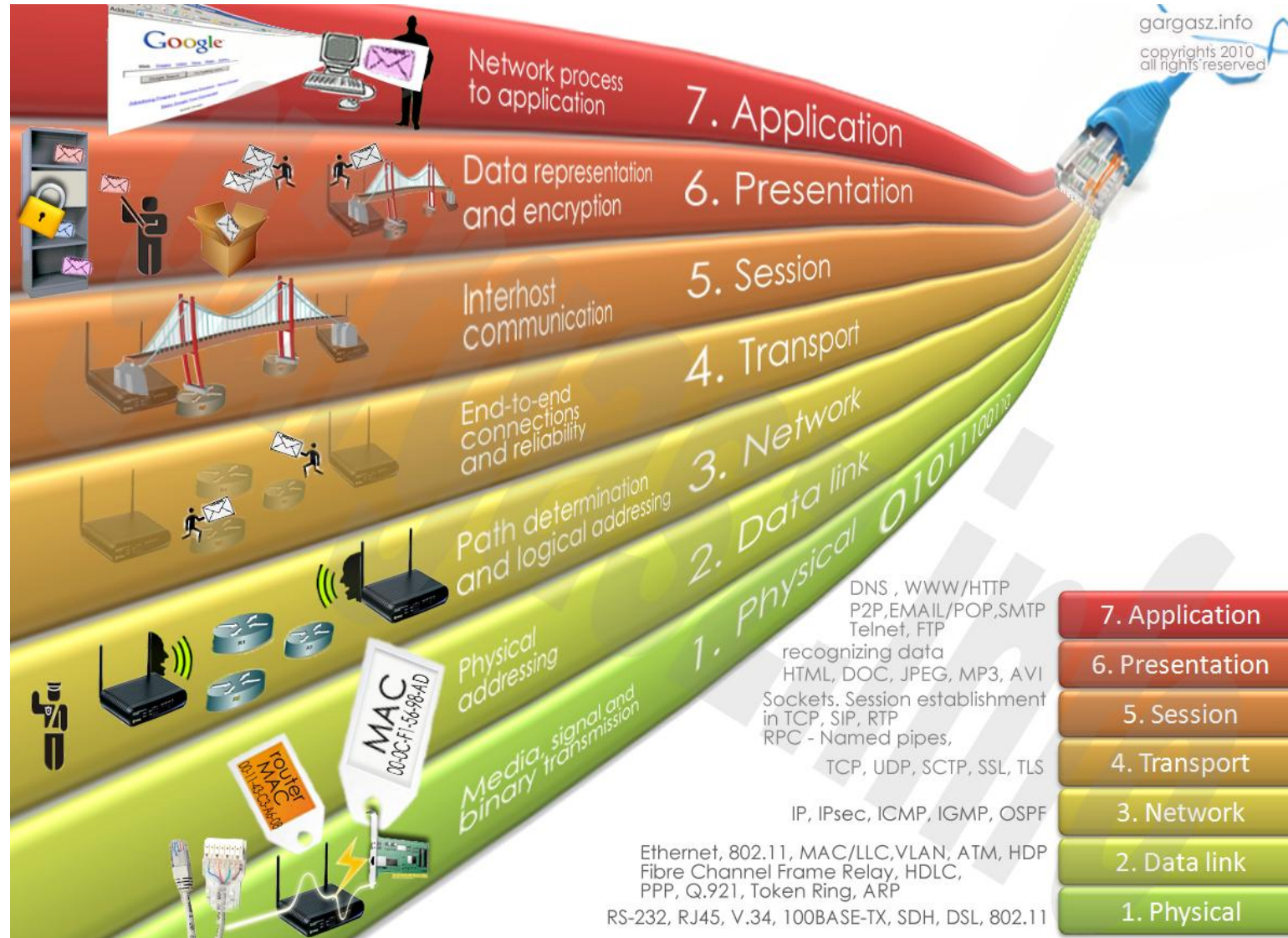
Difference

OSI (Open System Interconnection)	TCP/IP (Transmission Control Protocol/ Internet Protocol)
It has 7 layers	It has 5 layers
OSI provides layer functioning and also defines functions of all the layers	TCP/IP model is more based on protocols and protocols are not flexible with other layers
In OSI model the transport layer guarantees the delivery of packets	In TCP/IP model the transport layer does not guarantees delivery of packets
Follows horizontal approach	Follows vertical approach
OSI model has a separate presentation layer	TCP/IP doesn't have a separate presentation layer
OSI is a general model	TCP/IP model cannot be used in any other application

Difference - Cont...

OSI (Open System Interconnection)	TCP/IP (Transmission Control Protocol/ Internet Protocol)
Network layer of OSI model provide both connection oriented and connectionless service	The Network layer in TCP/IP model provides connectionless service
OSI model has a problem of fitting the protocols in the model	TCP/IP model does not fit any protocol
Protocols are hidden in OSI model and are easily replaced as the technology changes	In TCP/IP, replacing protocol is not easy
OSI model defines services, interfaces and protocols very clearly and makes clear distinction between them	In TCP/IP, it is not clearly separated its services, interfaces and protocols

Protocol Layers: Summary



Delay, Loss & Throughput

■ Delay

- ✓ As a packet travels from one node (host or router) to the subsequent node (host or router) along this path, the packet suffers from **several types of delays** at each node along the path.

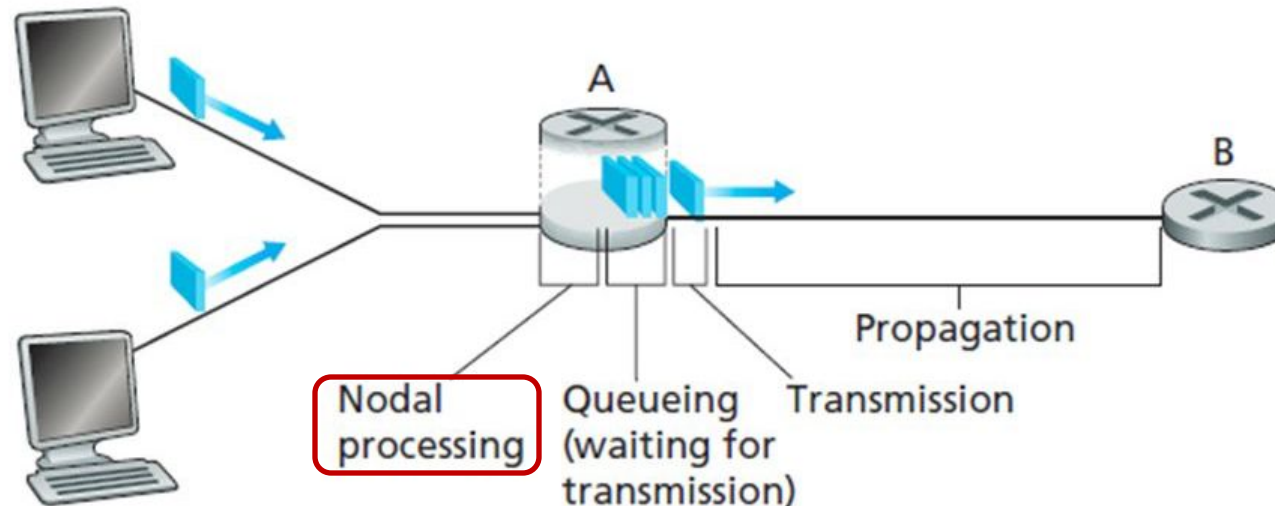
Where

$$d_{\text{nodal}} = d_{\text{proc}} + d_{\text{queue}} + d_{\text{tran}} + d_{\text{prop}}$$

- d_{nodal} = Total Delay
- d_{proc} = Processing Delay
- d_{queue} = Queuing Delay
- d_{tran} = Transmission Delay
- d_{prop} = Propagation Delay

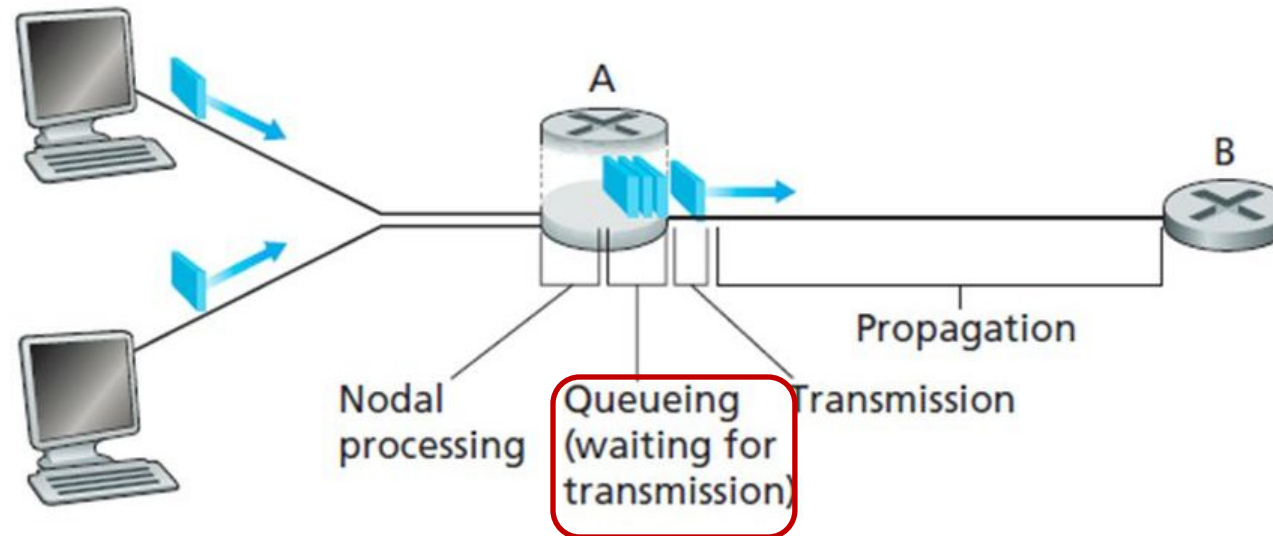
Delay – Cont...

- Processing Delay (d_{proc})
 - ✓ The time required to **examine** the packets header and **determine** where to **direct** the packet.
 - ✓ To check bit level error
 - ✓ Determine output link
 - ✓ Delay in terms of microseconds



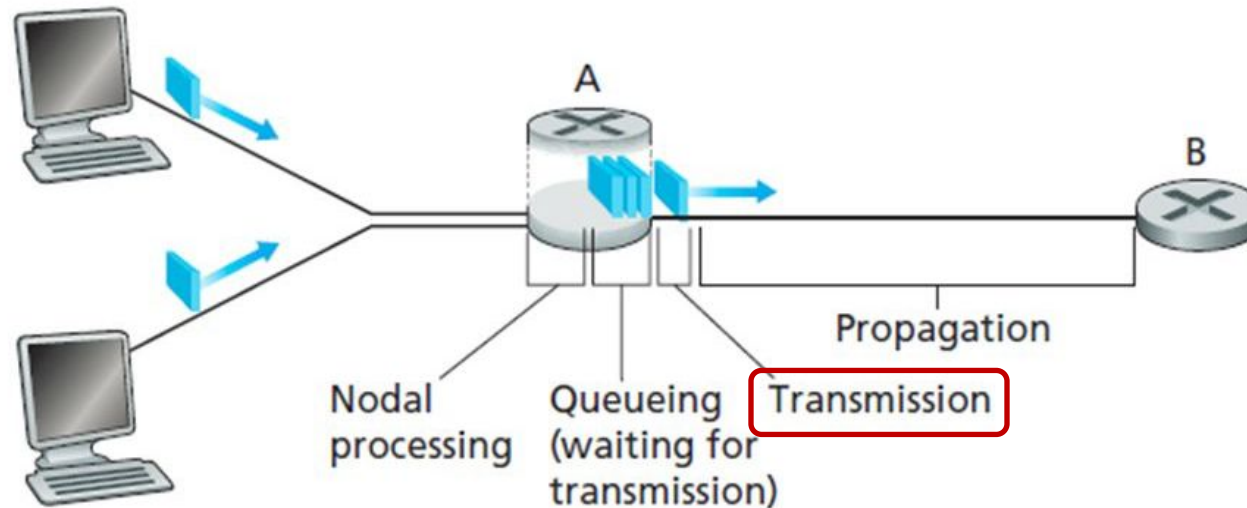
Delay – Cont...

- Queuing Delay (d_{queue})
 - ✓ A time to **wait** at output link for transmission.
 - ✓ Depends on **congestion** level of router.
 - ✓ If queue is empty then delay will be **zero**.
 - ✓ If queue is full (heavy traffic) then delay will be **long**.
 - ✓ Delay in terms of micro second to millisecond.



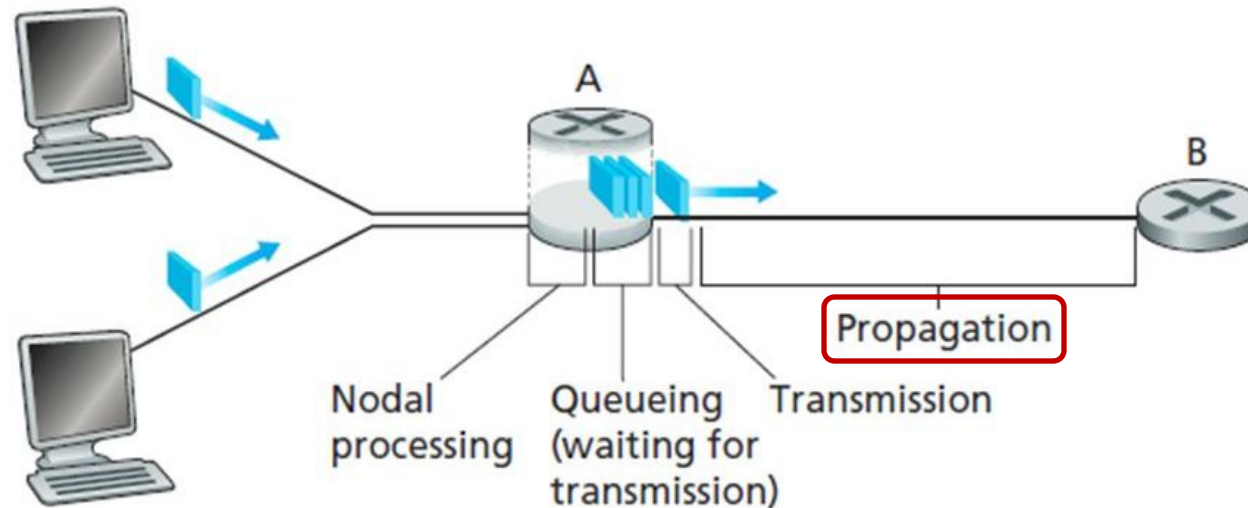
Delay – Cont...

- Transmission Delay ($d_{\text{tran}} = L/R$)
 - ✓ An amount of time required for the router to transmit the packet.
 - ✓ Its depends on **packet length(L)** and **transmission rate(R)** of link.



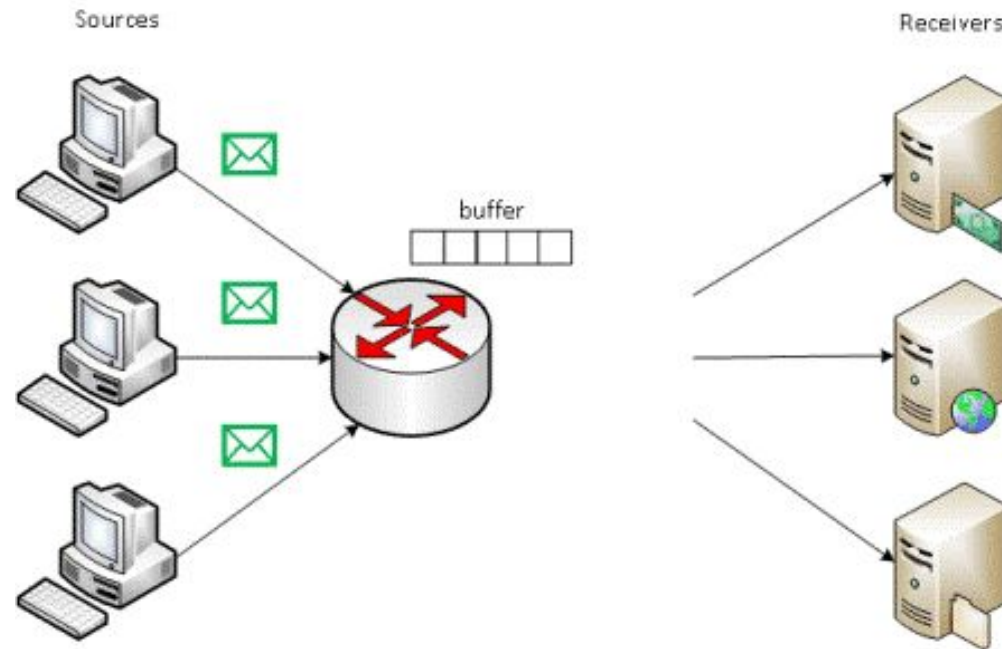
Delay – Cont...

- Propagation Delay ($d_{\text{prop}} = d/s$)
 - ✓ A time required to propagate from the beginning of the link to router B.
 - ✓ Depends on the **length of physical medium(d)** link and **propagation speed(s)** of link
 - ✓ Delay in terms of millisecond.



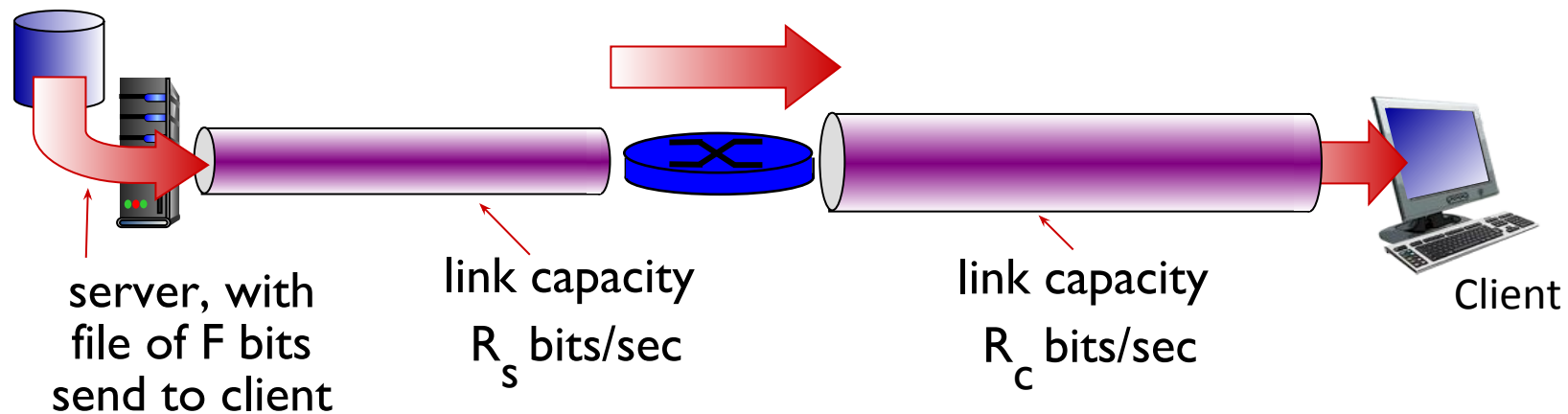
Packet Loss

- Packet loss is the **failure** of one or more transmitted packets to arrive at their destination.
- The loss of data packets depends on the **switch queue/buffer**. The loss of data packets increases with the increases in the **traffic intensity**.
- It affects the performance of the network.



Throughput

- Throughput or Network Throughput is the **rate of successful message delivery** over a communication channel.
- Throughput is measured in bits(data) per second (bit/s or bps)



History of Computer Networks

- 1961-1972 : The development of Packet Switching
- 1972-1980 : Proprietary Network and Internetworking
- 1980-1990 : A Proliferation of Networks
- 1990s : The Internet Explosion
- Recent Developments...

Outline - Revised

- What is Computer Network? Connected each other
- Advantages of Computer Network
- Applications of Computer Network
- Type of Computer Network LAN, MAN, WAN
- What is Internet? Infinite nos. of connected computers across the world
- What is Protocol? Set of Rules
- The Network Edge Host-end system & edge router
- The Network Core Circuit Switched & Packet Switched
- Transmission Media Guided- Wired & Unguided-Wireless
- Network Topologies Bus, Ring, Star, Mesh, Tree, & Hybrid
- Protocol Layers OSI Layer & TCP/IP Layer
- Delay, Loss & Throughput

Thank You