Brief Introduction to Subject

- Computer network is a group of devices connected with each other through a transmission medium such as wires, cables etc.

- These devices can be computers, printers, scanners, Fax machines etc.

- The purpose of having computer network is to send and receive data stored in other devices over the network.

Topic Mapping with Course Outcome

Topics	Course outcome
•Introductory Concepts: Goals and applications of networks.	CO1
• Categories of networks	CO1
• Organization of the Internet, ISP, Network structure and architecture (layering principles, services, protocols and standards),	CO2
•The OSI reference model, TCP/IP protocol suite, Network devices and components.	CO1
•Physical Layer: Network topology design, Types of connections, Transmission media, Signal transmission and encoding, Network performance and transmission impairments, Switching techniques and multiplexing.	CO1

Communication (CO1)

Topic Objective

- The student will get an insight of communications, networking
- Medium used for transmission
- Various topologies used
- The LAN, WAN and MAN concept

Communication (CO1)

- For communication we share the information
- Data refers to any information
- Data communication
  - exchange of data between two devices by some transmission medium.
- Effectiveness of data communication depends on
  - Delivery
  - Accuracy
  - Timeliness
  - Jitter

Computer Networks (CO1)

- A computer network is an interconnection of two or more computers that are able to exchange information
- Network is a set of devices connected by communication link
- The computer may be connected via any data communication link
- Computers can be personal or main frames
- The computer network may be located anywhere in the world and its size can vary
- Generally follow a client server model.

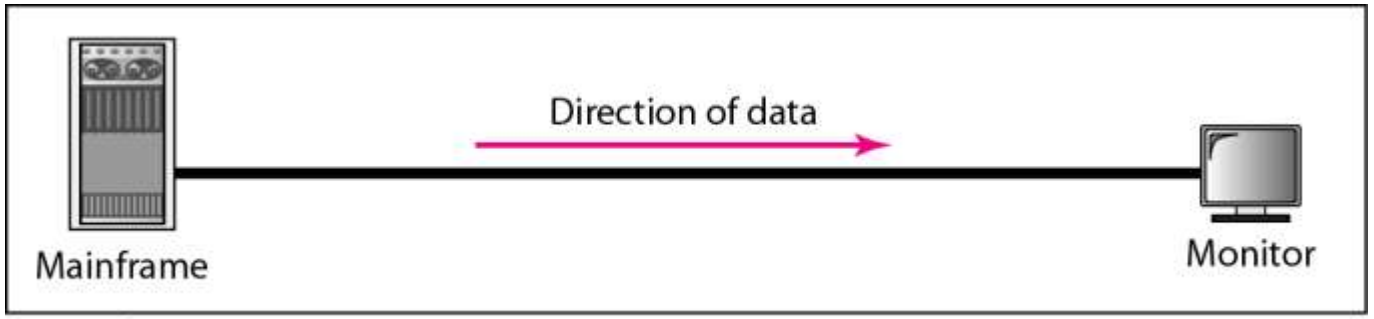
Computer network Communication(CO1)

- Components
  - Message – information to be communicated
  - Sender – a device that sends the data
  - Receiver – a device that receives the data
  - Transmission medium – physical path by which message transmits
  - Protocol – a set of rules that govern data communications
- We transmits information or data by two types of signals
  - Analog – telephones and radios
  - Digital - computers

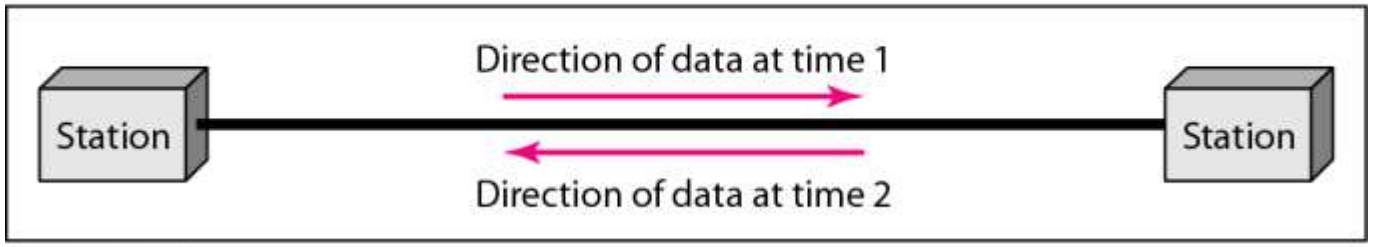
Data representation

- Text
  - Bit pattern, sequence of bits
  - set of bits – code, process is coding
- Numbers
  - Number system
- Images
  - Matrix of pixels
  - Size of the pixel depends on resolution
- Audio
  - Continuous
- Video
  - Continuous / combination of images

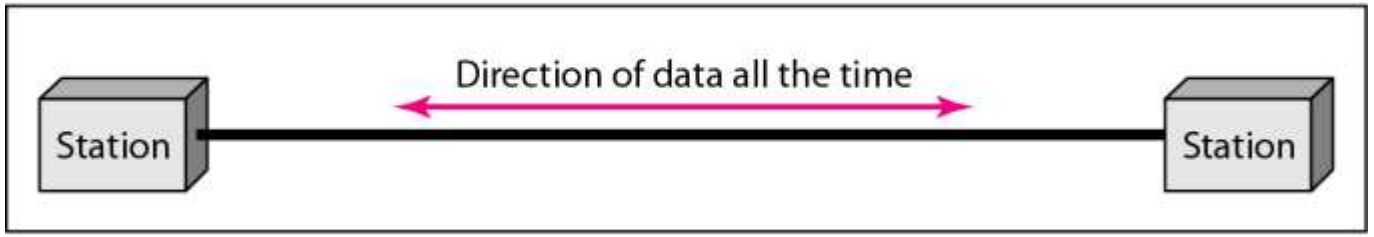
Modes of transmission(CO1)



a. Simplex



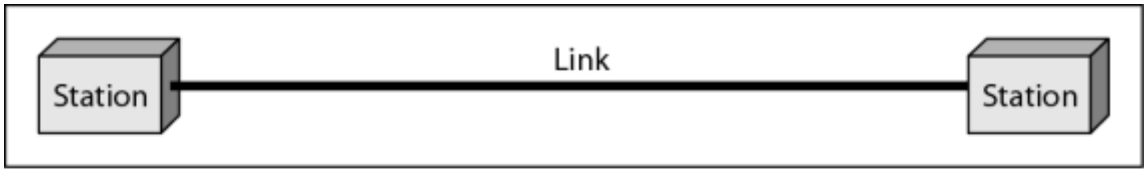
b. Half-duplex



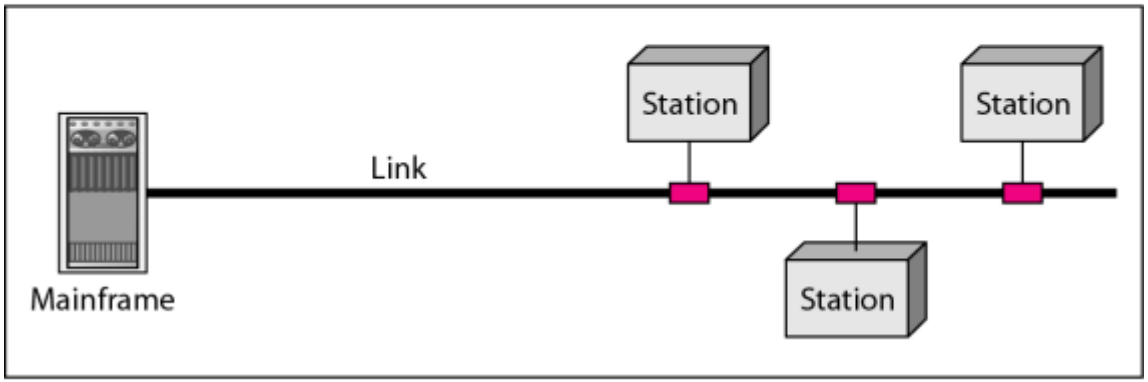
c. Full-duplex

Computer networks

- A network is a set of devices (often referred to as nodes) connected by communication links. A node can be a computer, printer, or any other device capable of sending and/or receiving data generated by other nodes on the network.
- Types of connections



a. Point-to-point



b. Multipoint

Computer networks

- Distributed Processing
  - Most networks use distributed processing, in which a task is divided among multiple computers.
  - Instead of one single large machine being responsible for all aspects of a process, separate computer (usually a personal computer or workstation) handle a subset.

Computer networks

- Network Criteria
  - Performance
    - Transmit time is the amount of time required for a message to travel from one device to another.
    - Response time is the elapsed time between an inquiry and a response.
    - depends on
      - the number of users,
      - the type of transmission medium,
      - the capabilities of the connected hardware,
      - and the efficiency of the software.
    - evaluated by two networking metrics: throughput and delay.

Computer networks

- Network Criteria
  - Reliability
    - the frequency of failure,
    - the time it takes a link to recover from a failure.
  - Security
    - protecting data from unauthorized access,
    - protecting data from damage and development,
    - and implementing policies and procedures for recovery from breaches and data losses.

Computer networks

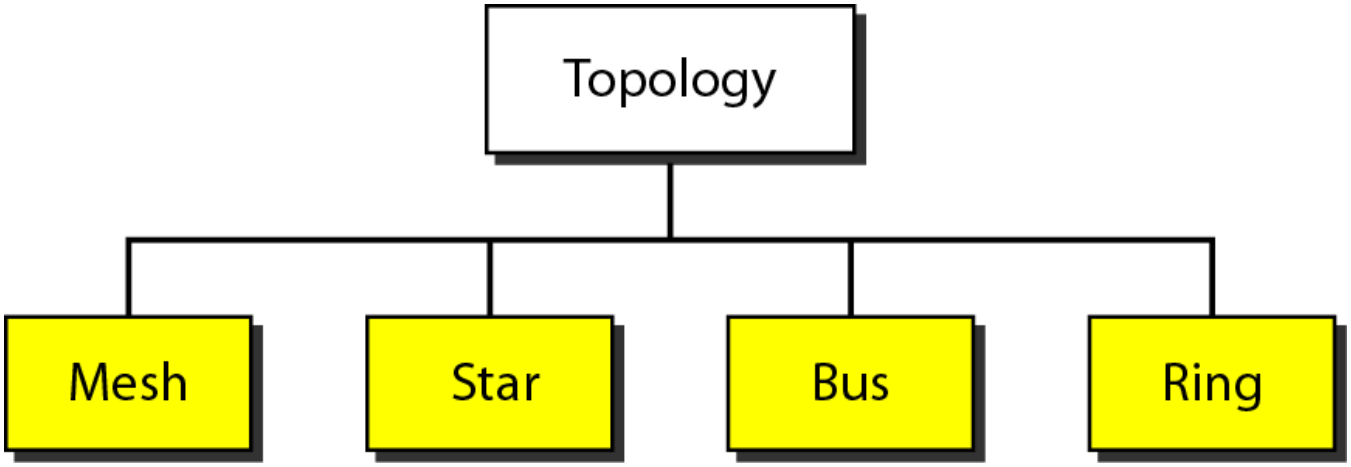
- Goals of networking
  - Resource sharing
  - High reliability
  - Saving Money
  - Interprocess Communication
  - Flexible access
  - Distribution of Process
  - Peer to Peer communication (equal)
  - Centralized communication (one)

Computer networks

- Applications of networking
  - Accessing Remote Database
  - Virtual Access Communication Facility
  - Marketing & Sales
  - Financial Services
  - Manufacturing
  - E-messages
  - Direct Services
  - Teleconferencing
  - Cable TV

Topology(CO1)

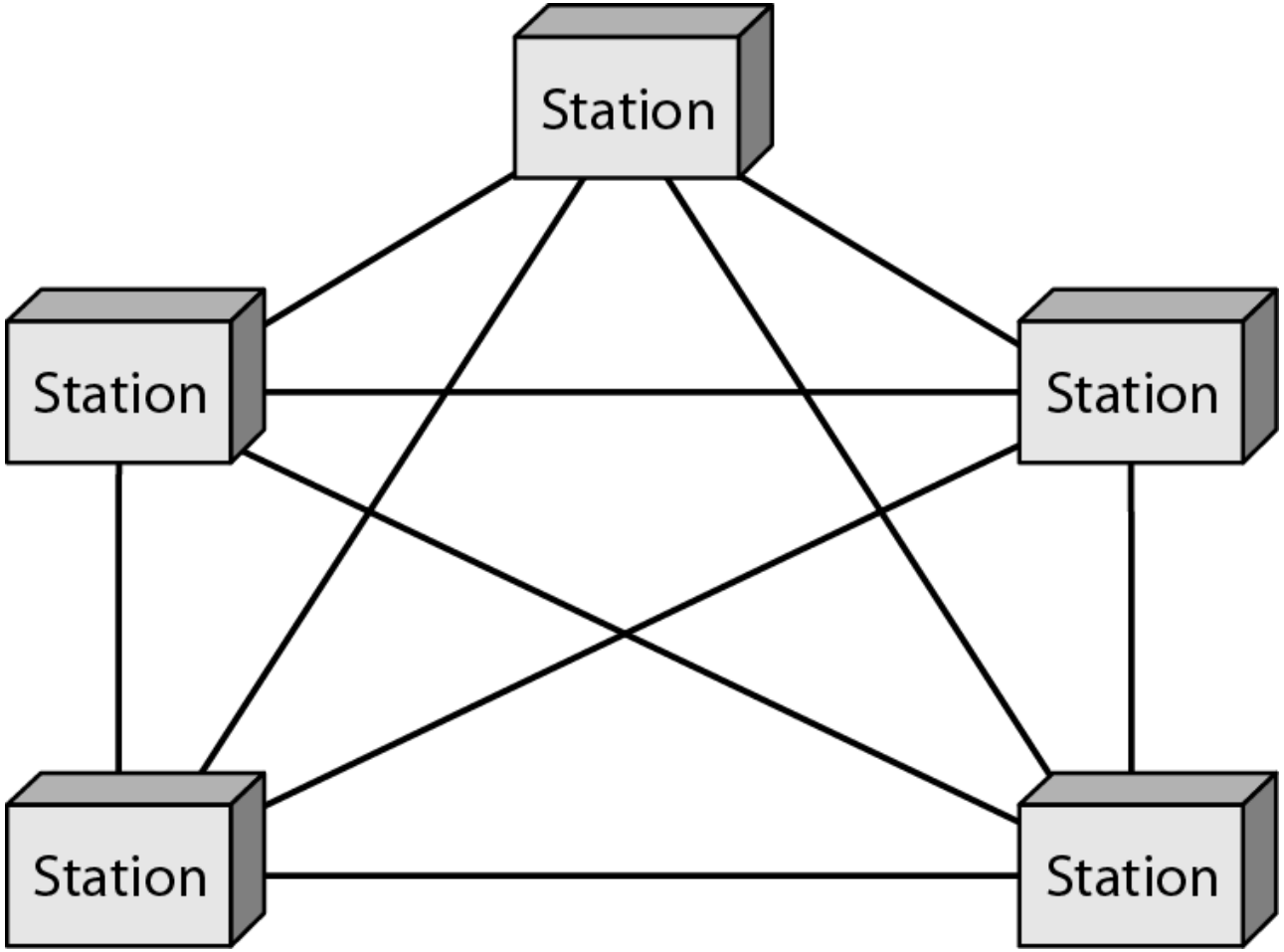
- Categories of topology



Topology(CO1)

- Mesh Topology
  - every device has a dedicated point-to-point link to every other device.
  - the number of physical links in a fully connected mesh network with n nodes = n(n - 1)
  - Advantages
    - carry its own data load
    - Robust
    - privacy or security
    - fault identification and fault isolation easy
  - Disadvantages
    - amount of cabling and the number of I/O ports required
    - installation and reconnection are difficult
    - sheer bulk of the wiring
    - expensive

Topology (CO1)

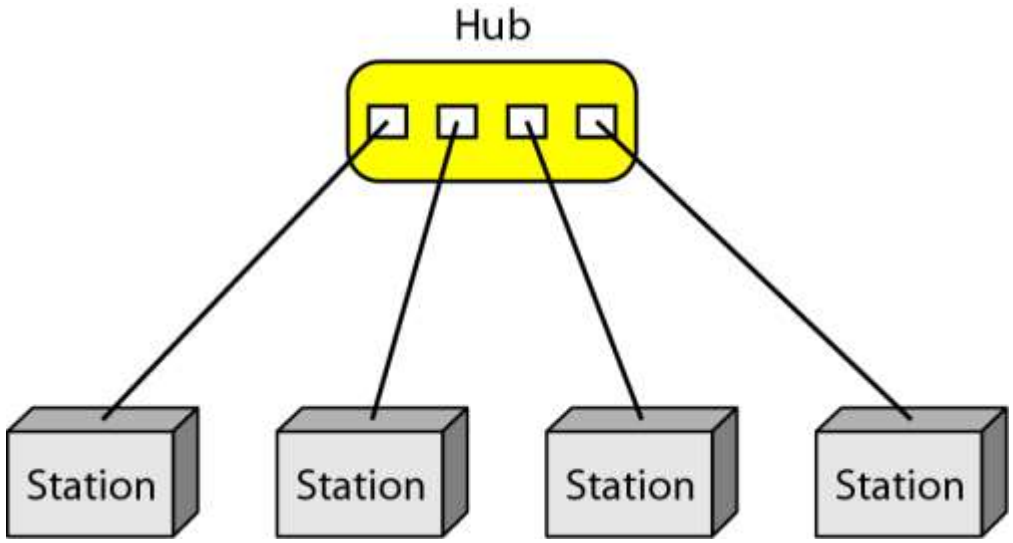


Mesh Topology

Topology (CO1)

- Star Topology
  - each device has a dedicated point-to-point link only to a central controller, usually called a hub. The devices are not directly linked to one another
  - Advantages
    - less expensive
    - easy to install and reconfigure
    - less cabling
    - Robustness
    - easy fault identification and fault isolation
  - Disadvantages
    - dependency of the whole topology on one single point, the hub
    - often more cabling is required

Topology (CO1)

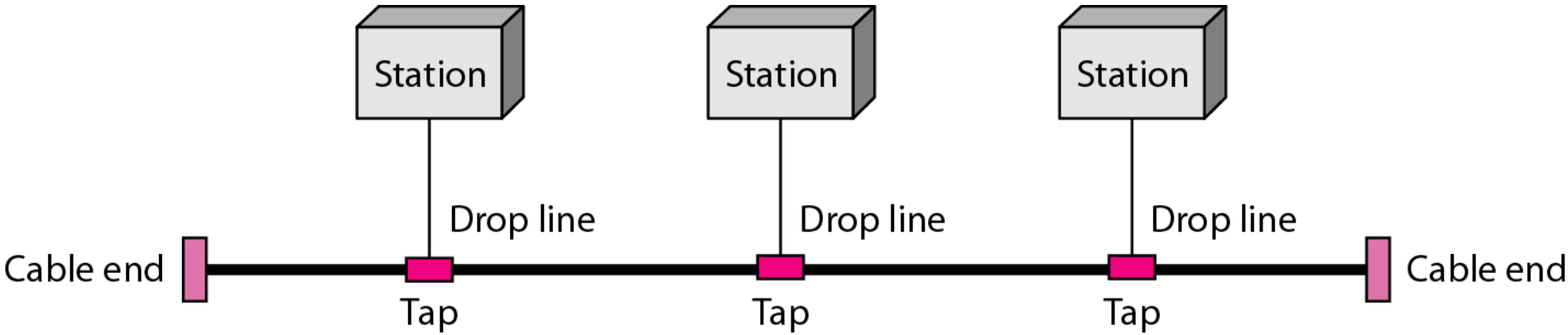


Star Topology

Topology (CO1)

- Bus Topology
  - Multipoint
  - 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
  - Advantages
    - ease of installation
    - less cabling than mesh or star topologies
  - Disadvantages
    - difficult reconnection and fault isolation
    - difficult to add new devices
    - a fault or break in the bus cable stops all transmission

Topology (CO1)

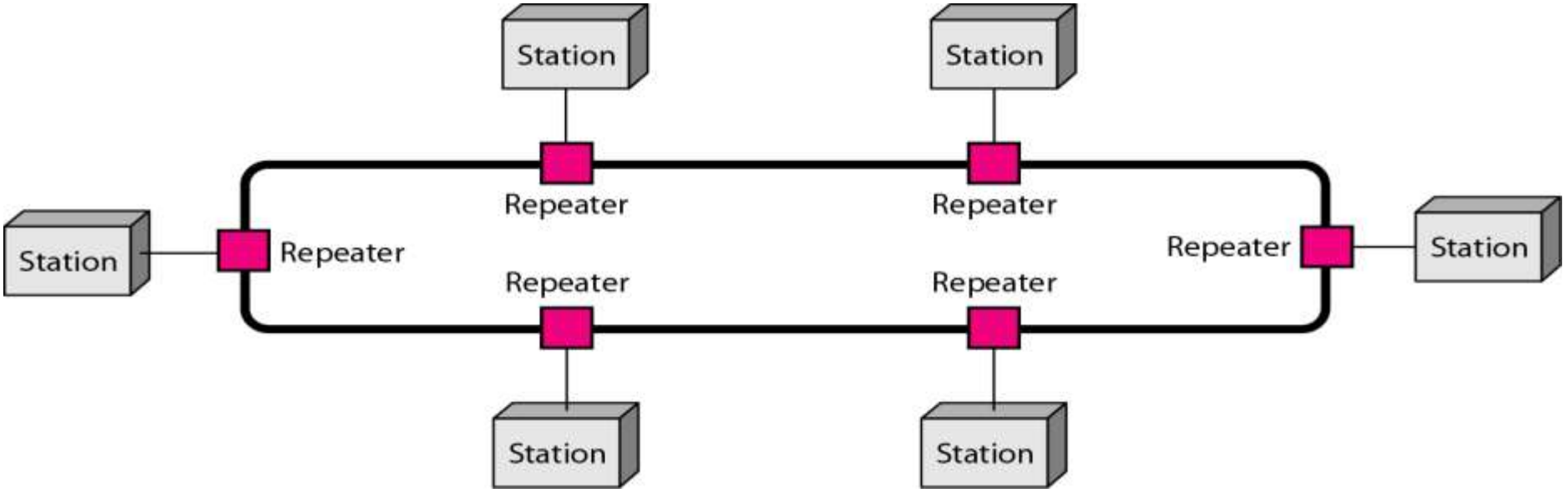


Bus Topology

Topology (CO1)

- 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.
  - When a device receives a signal intended for another device, its repeater regenerates the bits and passes them along
  - Advantages
    - easy to install and reconfigure
    - To add or delete a device requires changing only two connections
    - fault isolation is simplified
  - Disadvantages
    - constraints are media and traffic considerations (maximum ring length and number of devices)
    - unidirectional traffic can be a disadvantage
    - a break in the ring can disable the entire network

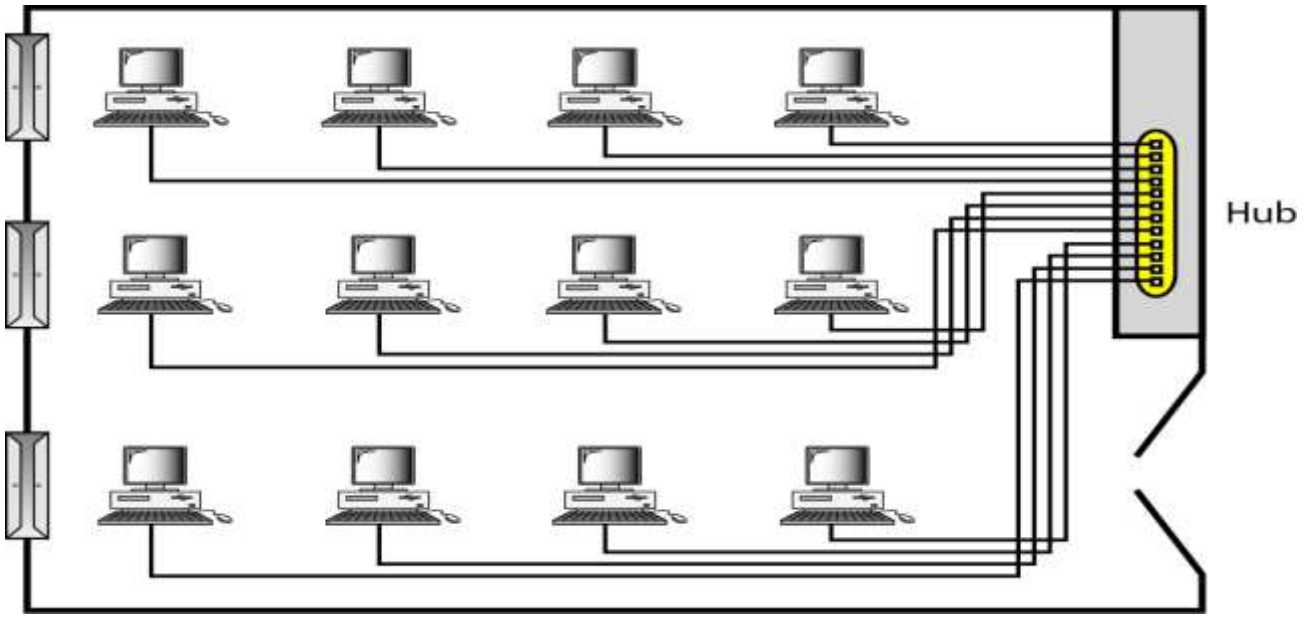
Topology (CO1)



Ring topology

Types of Networks (CO1)

- LAN
  - A local area network (LAN) is usually privately owned and links the devices in a single office, building, or campus
  - resources can be shared
  - In addition to size, LANs are distinguished from other types of networks by their transmission media and topology

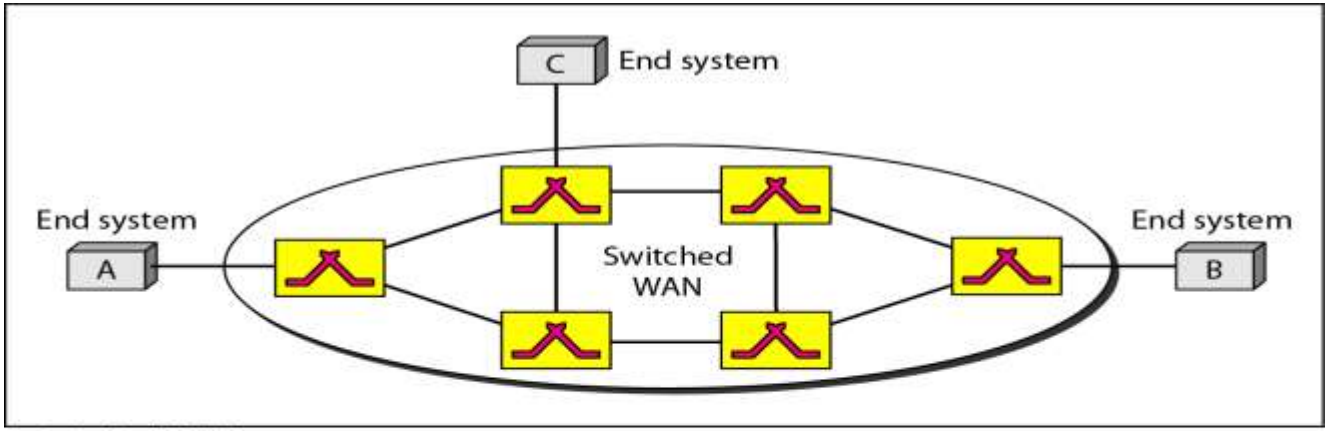


Types of Networks (CO1)

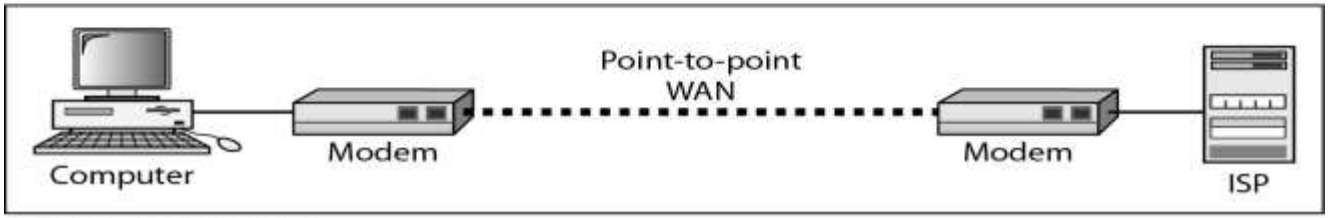
- MAN
  - A metropolitan area network (MAN) is a network with a size between a LAN and a WAN. It normally covers the area inside a town or a city.
  - It is designed for customers who need a high-speed connectivity, normally to the Internet, and have endpoints spread over a city or part of city

Types of Networks (CO1)

- WAN
  - 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



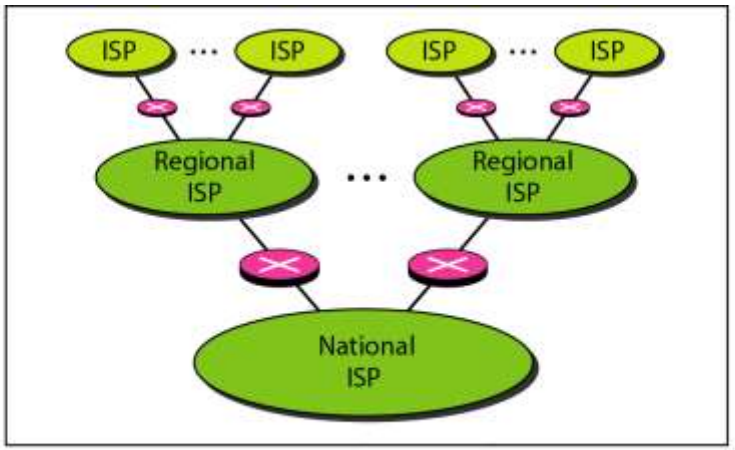
a. Switched WAN



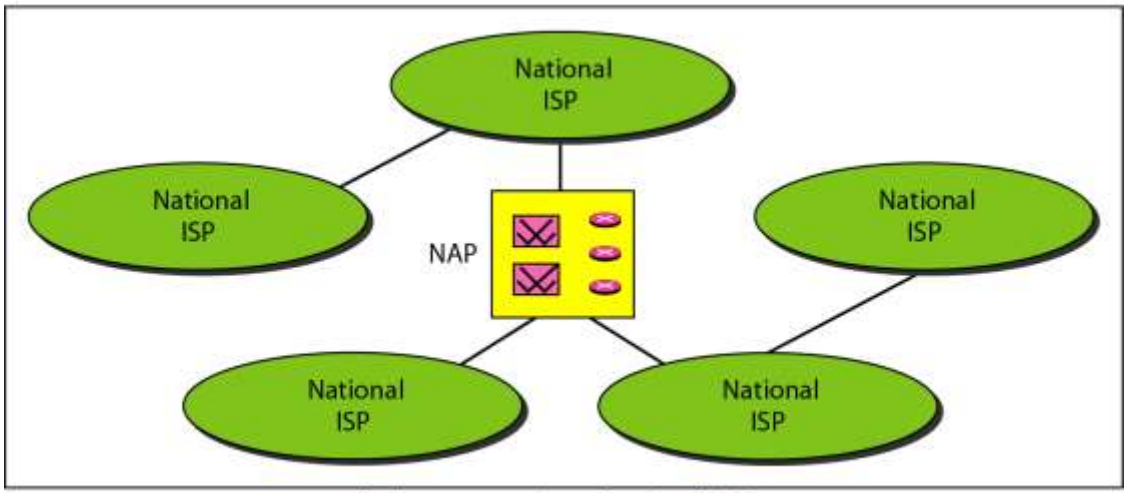
b. Point-to-point WAN

Internet(CO1)

- When two or more networks are connected, they become an internetwork, or internet.



a. Structure of a national ISP



b. Interconnection of national ISPs

Physical layer (CO1)

Topic Objective

- To understand the Physical Layer
- Various transmission medium and
- Switching methods

Recap of previous topic

- The layered architecture of OSI and TCP/IP model
- Comparison of both the models

OSI & TCP/IP models (CO1)

Topic Objective

- To understand the OSI and TCP/IP models
- Differences between two and the protocols supported

Recap of previous topic

- The basic networking layout and topology were studied
- Data flow mode supported

OSI Reference model(CO1)

- ISO OSI Reference model
- Standardization of protocols used in various layers
- Developed in 1983 revised in 1995
- layers based on
  - A layer should be created where a different abstraction is needed
  - Each layer should perform a well-defined function
  - The function of each layer should be according to internationally standardized protocols
  - The layer boundaries should be chosen to minimize the information flow across the interfaces
  - The number of layers should be large enough for necessary functions required and small enough not to become unwieldy

Layered architecture(CO1)

- Peer to peer process
- Interfaces
- Protocols
- Header and trailer
- Encapsulation
- Seven layers
  - Physical
  - Data link
  - Network
  - Transport
  - Session
  - Presentation
  - Application

OSI Model(CO1)

- Physical layer - coordinates the functions required to carry a bit stream over a physical medium
  - Physical characteristics of interfaces and medium
  - Representation of bits
  - Data rate
  - Synchronization of bits
  - Line configuration
  - Physical topology
  - Transmission mode
- Data Link Layer - transforms the physical layer, a raw transmission facility, to a reliable link
  - Framing
  - Physical addressing
  - Flow control
  - Error control
  - Access control

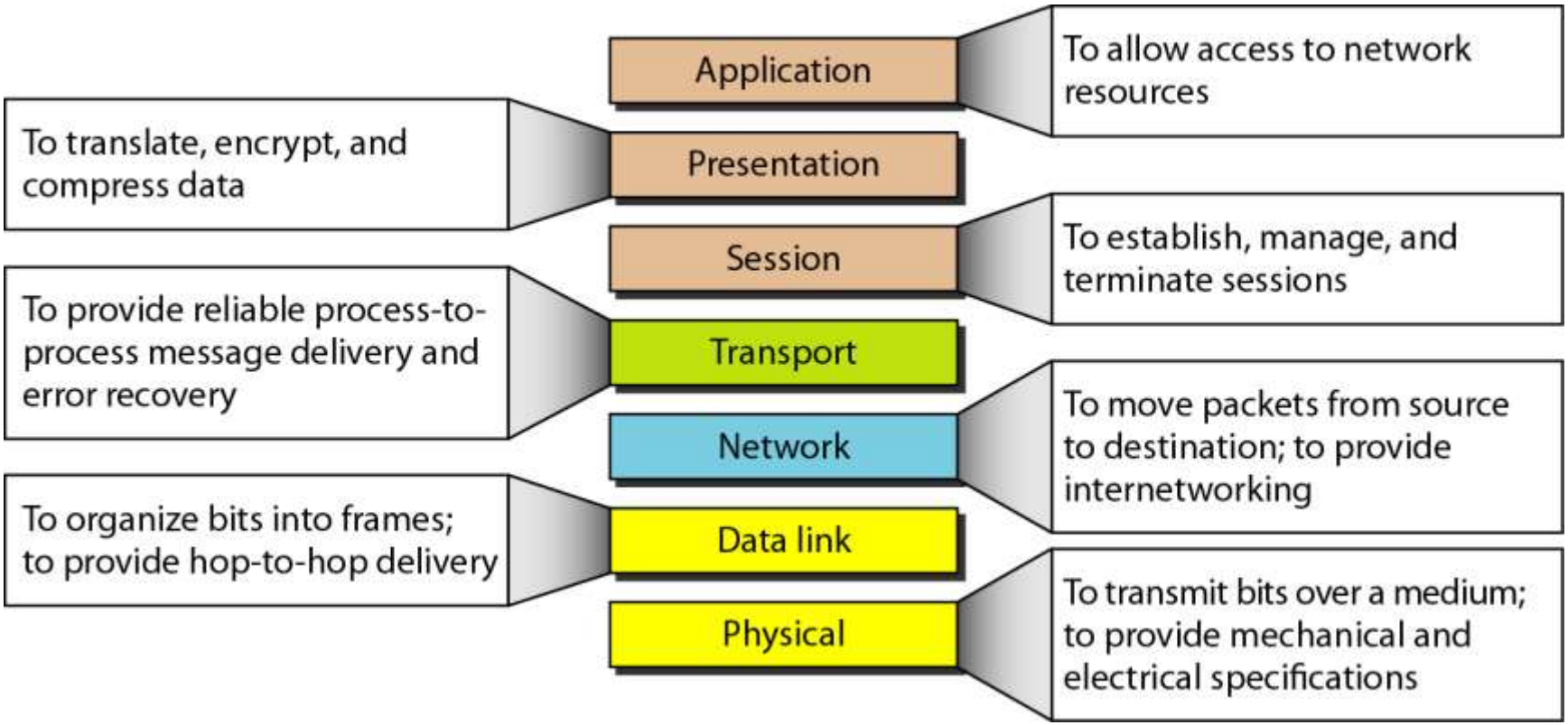
OSI Model(CO1)

- Network Layer - responsible for the source-to-destination delivery of a packet, possibly across multiple networks
  - Logical addressing
  - Routing
- Transport Layer - process-to-process delivery of the entire message
  - Service-point addressing
  - Segmentation and reassembly
  - Connection control
  - Flow control
  - Error control
- Session Layer - establishes, maintains, and synchronizes the interaction among communicating systems
  - Dialog control
  - Synchronization

OSI Model(CO1)

- Presentation Layer - concerned with the syntax and semantics of the information exchanged between two systems
  - Translation
  - Encryption
  - Compression
- Application Layer - enables the user to access the network
  - Network virtual terminal
  - File transfer, access, and management
  - Mail services
  - Directory services

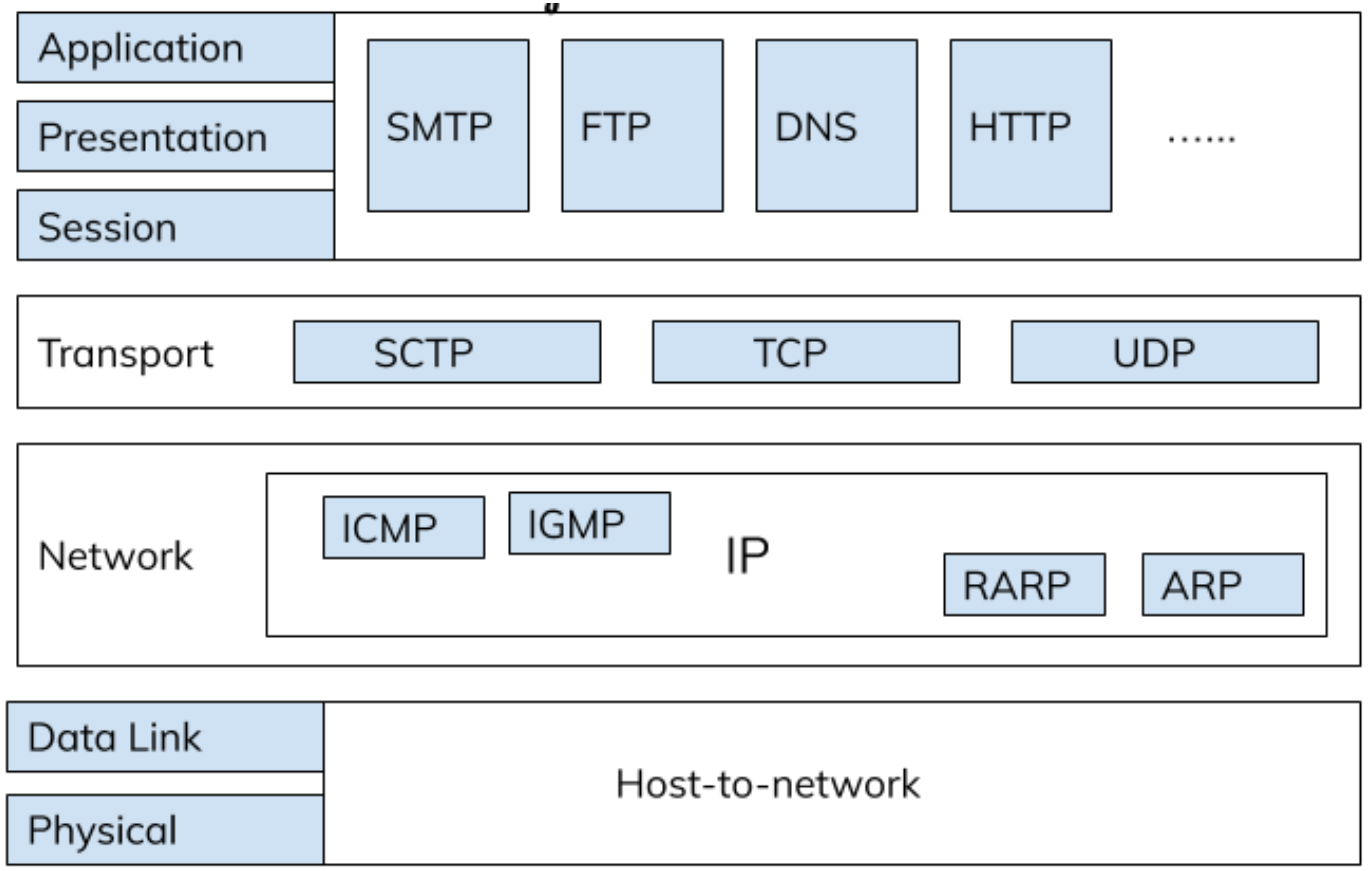
OSI Model(CO1)



TCP/IP model(CO3)

- Prior to OSI Model
- Basically had 4 layers
  - Host –to-network
  - Internet
  - Transport
  - Application
- TCP/IP is a hierarchical protocol made up of interactive modules, each of which provides a specific functionality
- TCP/IP protocol suite contain relatively independent protocols that can be mixed and matched depending on the needs of the system

TCP/IP Model(CO3)



Comparison between OSI and TCP/IP(CO1)

TCP/IP	OSI
TCP refers to Transmission Control Protocol.	OSI refers to Open Systems Interconnection.
TCP/IP has 4 layers.	OSI has 7 layers.
TCP/IP is more reliable	OSI is less reliable
TCP/IP does not have very strict boundaries.	OSI has strict boundaries
TCP/IP follow a horizontal approach.	OSI follows a vertical approach.
TCP/IP uses both session and presentation layer in the application layer itself.	OSI uses different session and presentation layers.
TCP/IP developed protocols then model.	OSI developed model then protocol.

Comparison between OSI and TCP/IP

TCP/IP	OSI
TCP does not clearly distinguish between service, protocols and interfaces	OSI has explicit distinction between these.
Specific protocols	protocols are better hidden
Protocol based model	Protocols can be replaced as technology changes
Description of the protocols	General model
Protocols do not fit in the function	Protocols do not fit in the function

Physical layer

Addressing

- Physical addressing
- Logical addressing
- Port Address
- Specific address

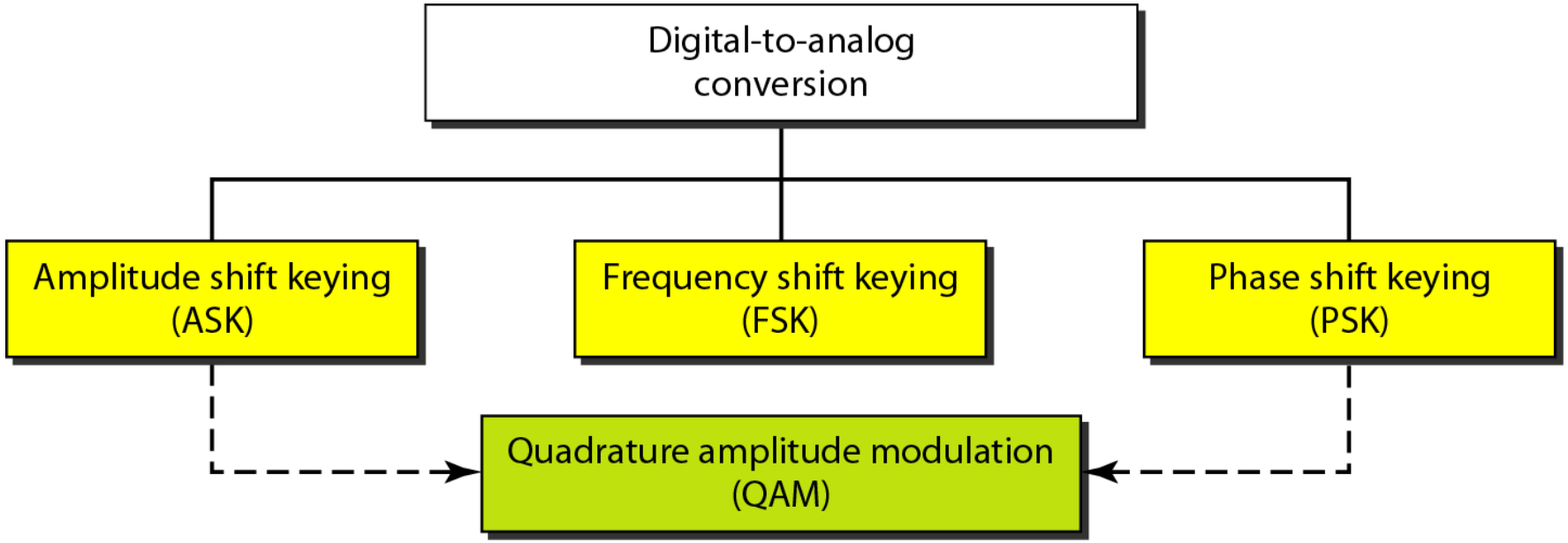
Physical Layer(CO1)

- Analog data and digital data
  - Continuous values and discrete values
- Analog and digital signals
  - Infinite number of values and limited number of values
- Periodic and non periodic signals
  - Repeat a pattern
- Data communications uses periodic analog signals
  - Sine wave
    - Peak amplitude
    - Period and Frequency (f=1/t)
    - Phase
    - Wavelength
    - Time and frequency domain
    - Composite signals
    - Bandwidth

Digital to Analog

- *Digital-to-analog conversion is the process of changing one of the characteristics of an analog signal based on the information in digital data.*
- Digital data needs to be carried on an analog signal.
- A carrier signal (frequency f_c) performs the function of transporting the digital data in an analog waveform.
- The analog carrier signal is manipulated to uniquely identify the digital data being carried.

Digital to Analog conversion(CO2)



Digital Data

- PERIODIC ANALOG SIGNALS
  - A simple periodic analog signal, a sine wave.
  - A composite periodic analog signal is composed of multiple sine waves.
- The three parameters: the peak amplitude, the frequency, and the phase
- Time and Frequency Domains
- Bandwidth
- Bitrate
- Bit length

Transmission impairment

- Causes
  - Attenuation – loss of energy
  - Distortion– change in shape & form of signal
  - Noise – extra signal

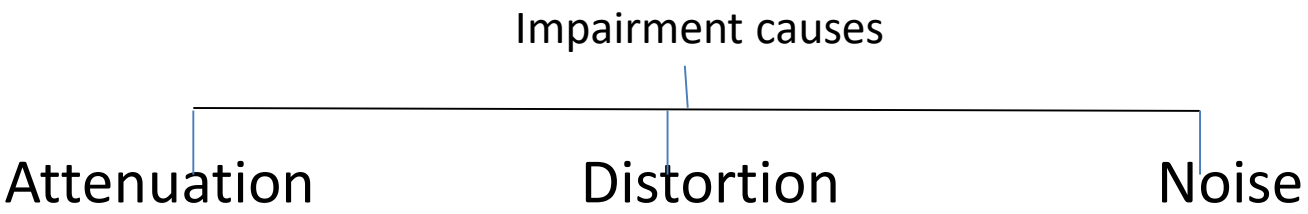
Data Rate(CO2)

- A very important consideration in data communications is how fast we can send data, in bits per second, over a channel. Data rate depends on three factors:
- 1. The bandwidth available
- 2. The level of the signals we use
- 3. The quality of the channel (the level of noise)

- Noiseless Channel: Nyquist Bit Rate
- Noisy Channel: Shannon Capacity
- Using Both Limits

Physical Layer

- Digital signals
  - 0 and 1
  - For no. of levels (L) require $\log_2$ L bits
  - Bit rate – no. of bits send per second(bps)
  - Bit length
- Transmitted by
  - Baseband transmission
  - Broadband transmission (using modulation)
- TRANSMISSION IMPAIRMENT



Physical Layer

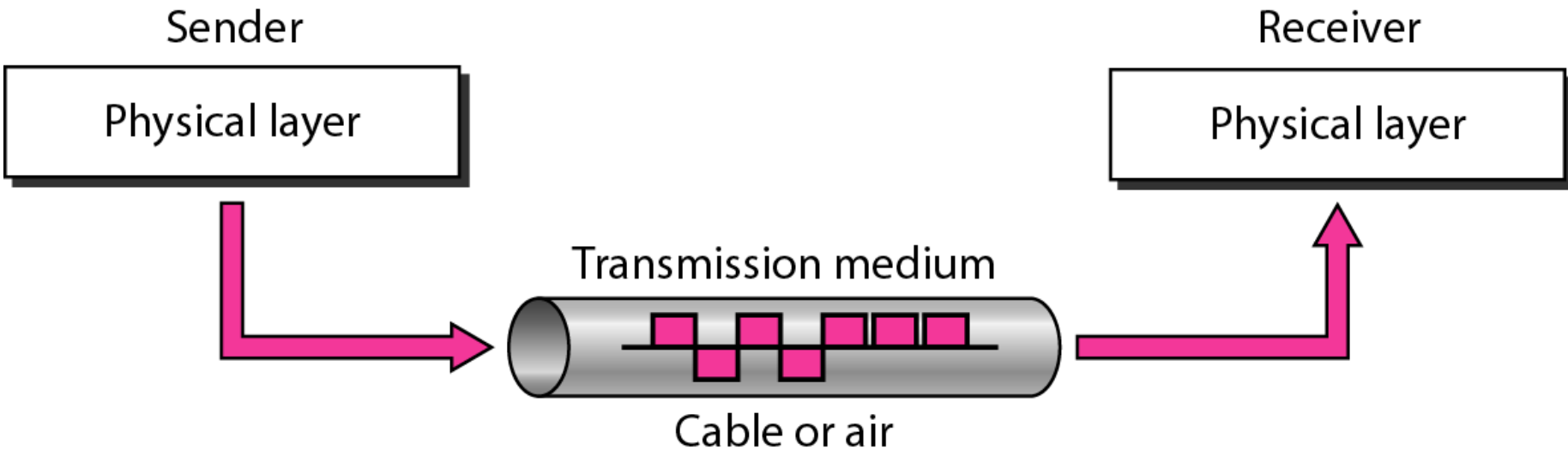
- Data rate limit
  - The bandwidth available
  - The levels of signals that we use
  - The quality of channel
  - To calculate data rate
    - Nyquist for noiseless channel
    - Shannon for noisy channel
  - Performance
    - Bandwidth
      - In hertz and bits per second
    - Throughput
    - Latency
      - Propagation time + transmission time +queuing time + processing time
      - Jitter

Physical Layer

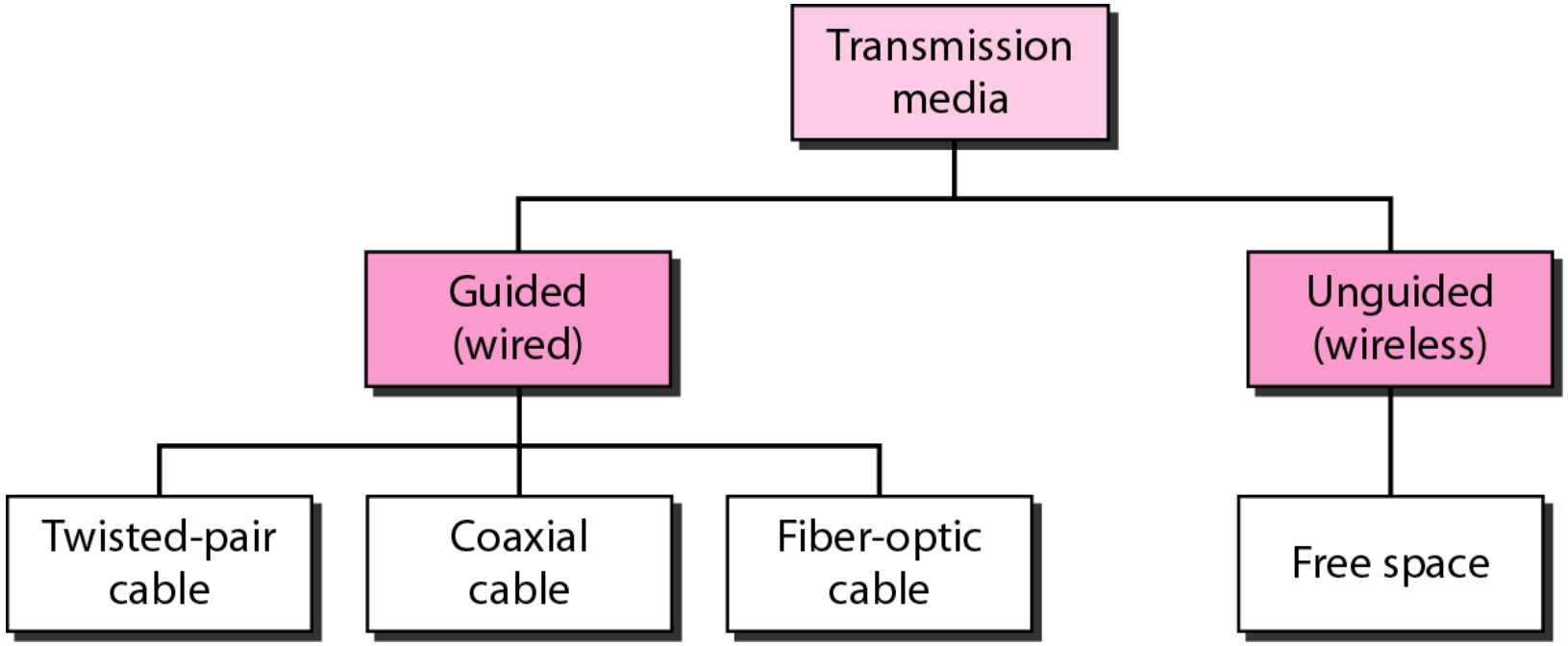
- Conversion from digital to analog
  - ASK
  - FSK
  - PSK
  - QAM

- Bandwidth utilization
  - Multiplexing
  - Spreading
  - three basic multiplexing techniques:
    - frequency-division multiplexing,
    - wavelength-division multiplexing,
    - time-division multiplexing

Transmission medium(CO2)



Transmission media(CO2)



Transmission media - guided

- Guided media, which are those that provide a conduit from one device to another
  - Twisted-Pair Cable
  - Coaxial Cable
  - Fiber-Optic Cable

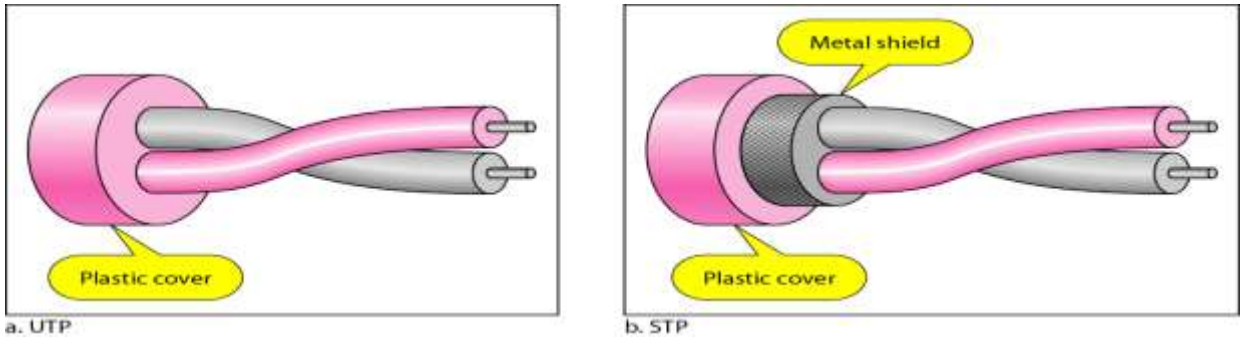
Transmission media - guided

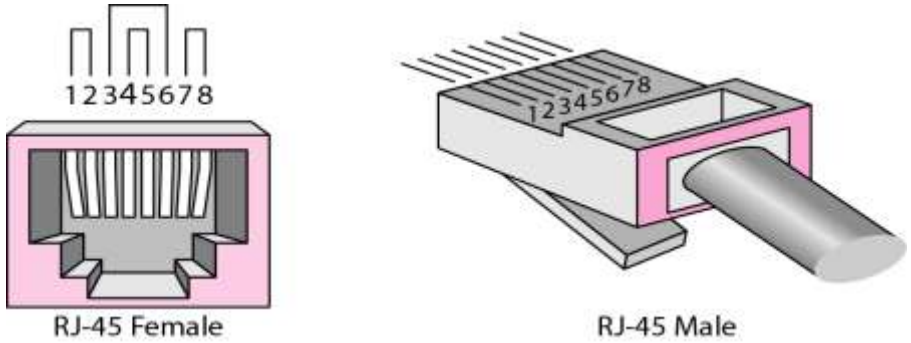
- Twisted Pair cable

Category	*Specification*	*Data Rate (Mbps)*	*Use*
1	Unshielded twisted-pair used in telephone	< 0.1	Telephone
2	Unshielded twisted-pair originally used in T-lines	2	T-1 lines
3	Improved CAT 2 used in LANs	10	LANs
4	Improved CAT 3 used in Token Ring networks	20	LANs
5	Cable wire is normally 24 AWG with a jacket and outside sheath	100	LANs
5E	An extension to category 5 that includes extra features to minimize the crosstalk and electromagnetic interference	125	LANs
6	A new category with matched components coming from the same manufacturer. The cable must be tested at a 200-Mbps data rate.	200	LANs
7	Sometimes called SSTP (shielded screen twisted-pair). Each pair is individually wrapped in a helical metallic foil followed by a metallic foil shield in addition to the outside sheath. The shield decreases the effect of crosstalk and increases the data rate.	600	LANs

Transmission media - guided

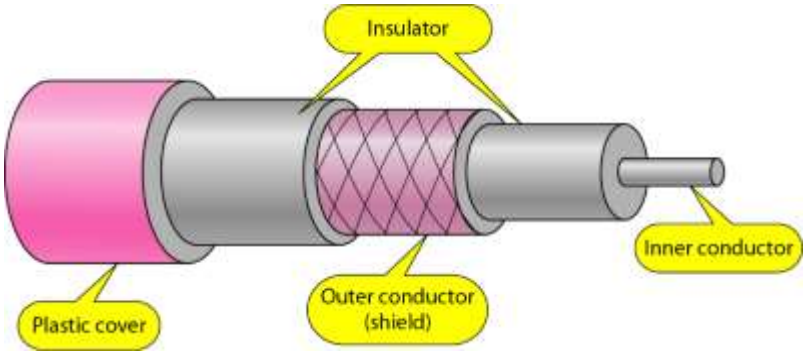
- Twisted Pair cable

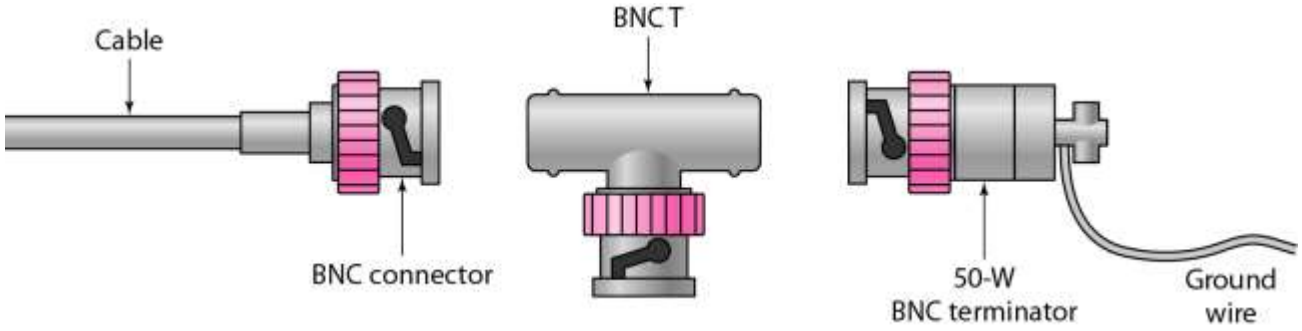




Transmission media - guided

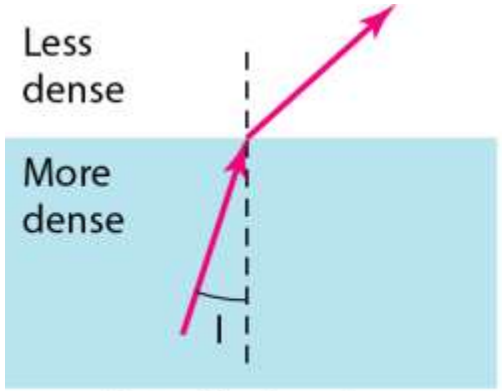
- Coaxial Cable



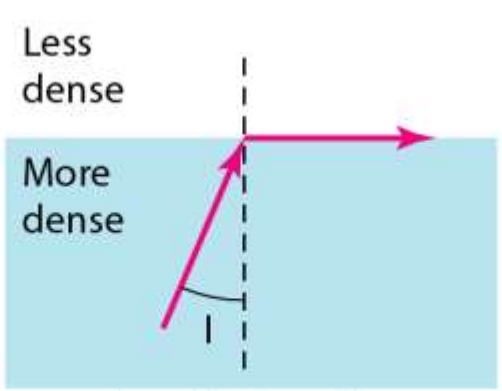


Transmission media - guided

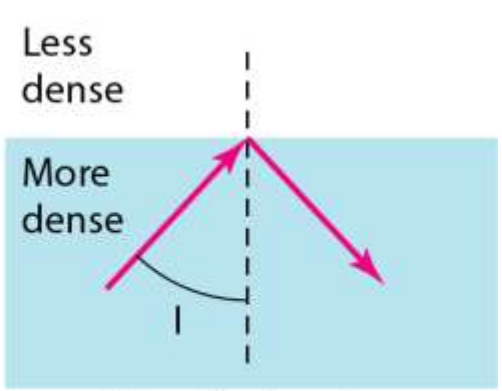
- Fiber Optic Cable based on



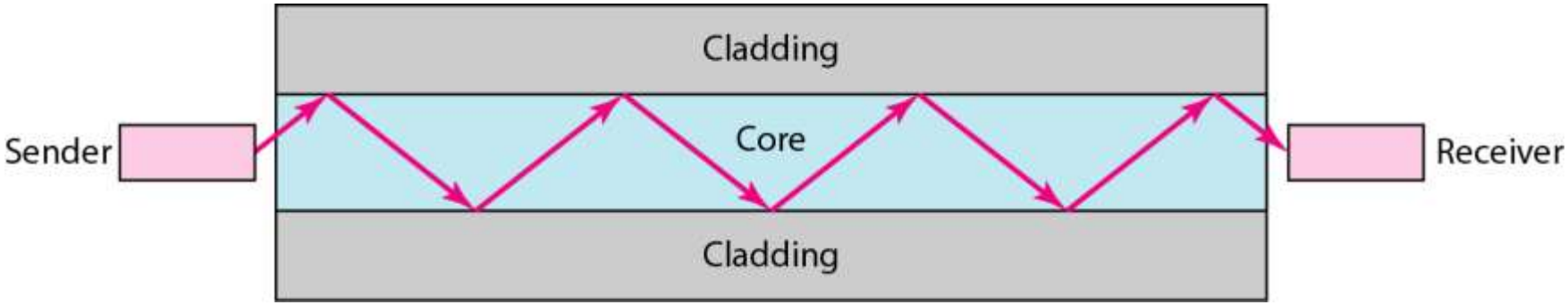
I < critical angle, refraction



I = critical angle, refraction

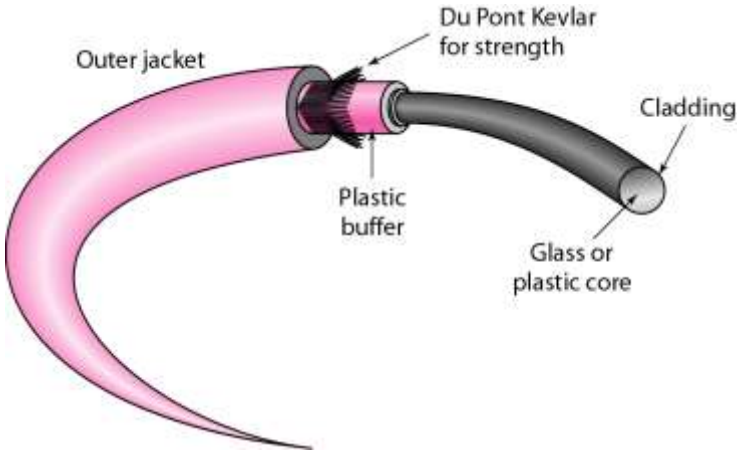


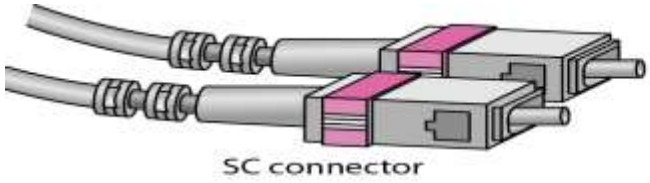
I > critical angle, reflection

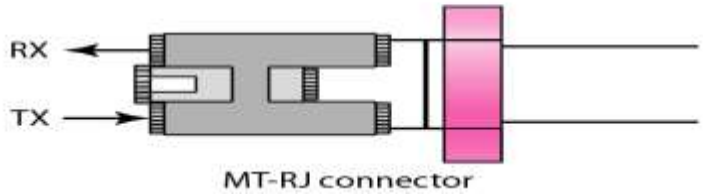


Transmission media - guided

- Fiber optic Cable

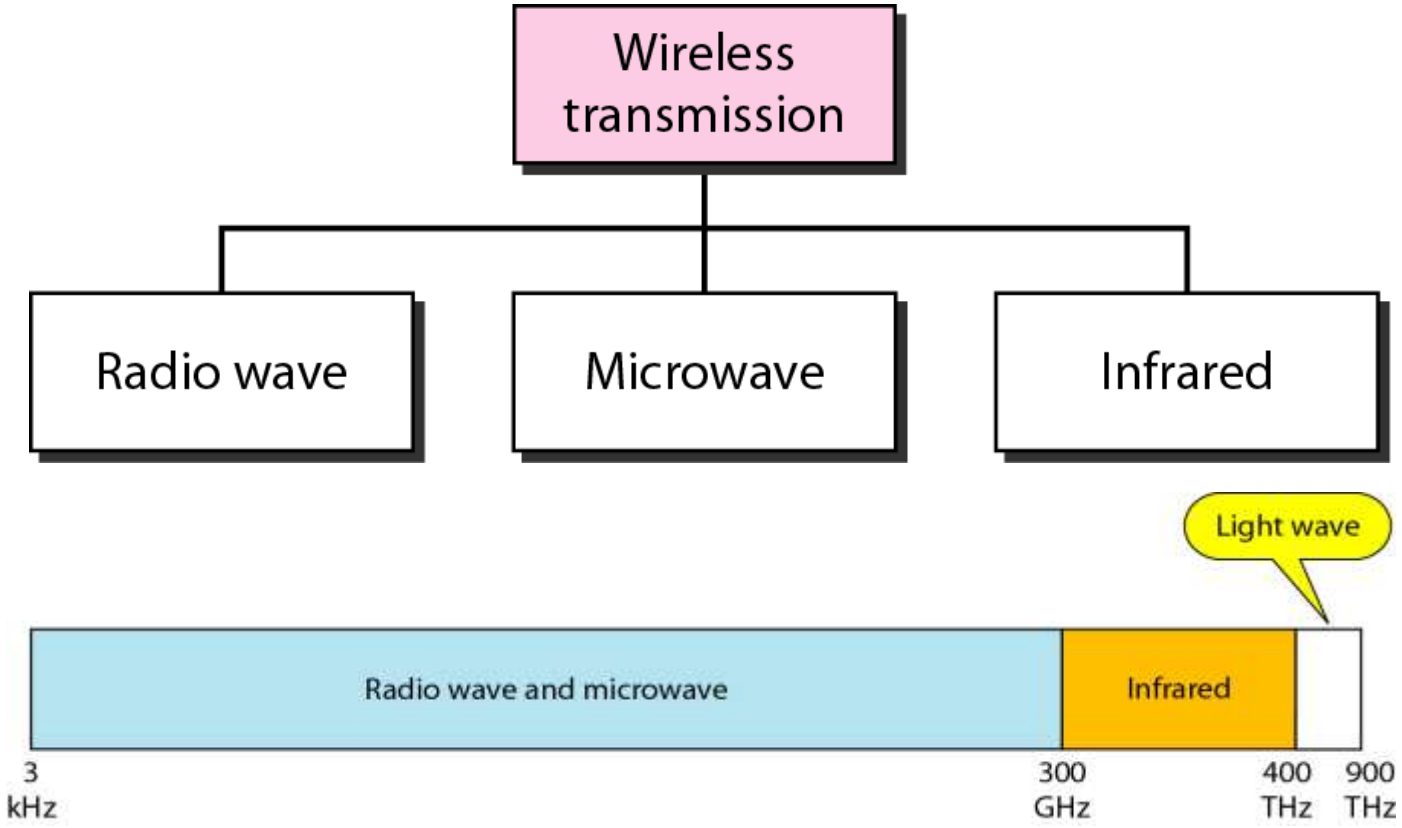






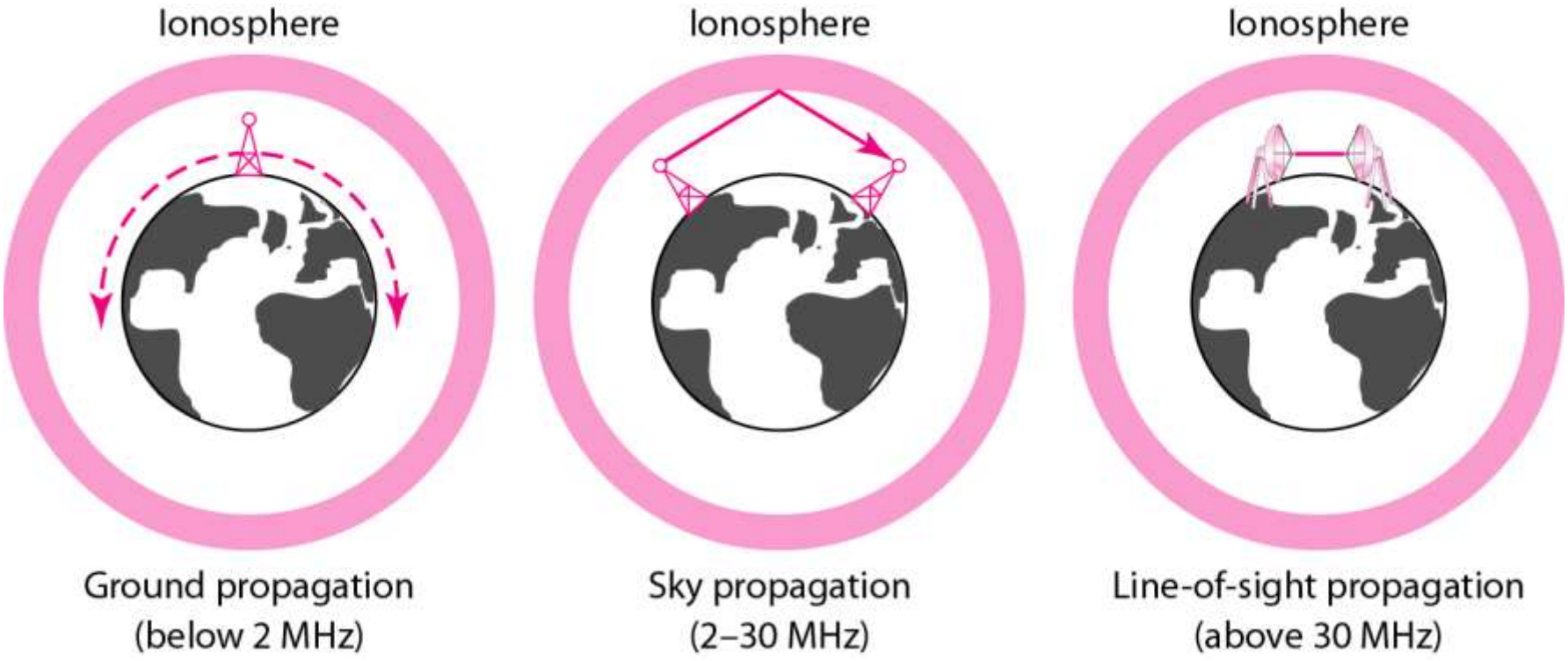
Transmission media - unguided

- Unguided media transport electromagnetic waves without using a physical conductor. This type of communication is often referred to as wireless communication.



Transmission media - unguided

- Propagation modes

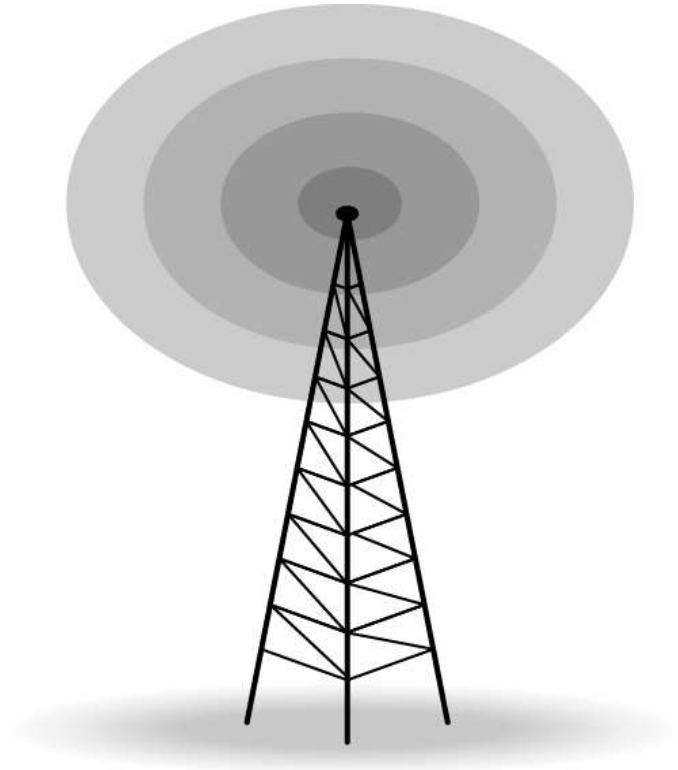


Transmission media - unguided

Band	*Range*	*Propagation*	*Application*
VLF (very low frequency)	3–30 kHz	Ground	Long-range radio navigation
LF (low frequency)	30–300 kHz	Ground	Radio beacons and navigational locators
MF (middle frequency)	300 kHz–3 MHz	Sky	AM radio
HF (high frequency)	3–30 MHz	Sky	Citizens band (CB), ship/aircraft communication
VHF (very high frequency)	30–300 MHz	Sky and line-of-sight	VHF TV, FM radio
UHF (ultrahigh frequency)	300 MHz–3 GHz	Line-of-sight	UHF TV, cellular phones, paging, satellite
SHF (superhigh frequency)	3–30 GHz	Line-of-sight	Satellite communication
EHF (extremely high frequency)	30–300 GHz	Line-of-sight	Radar, satellite

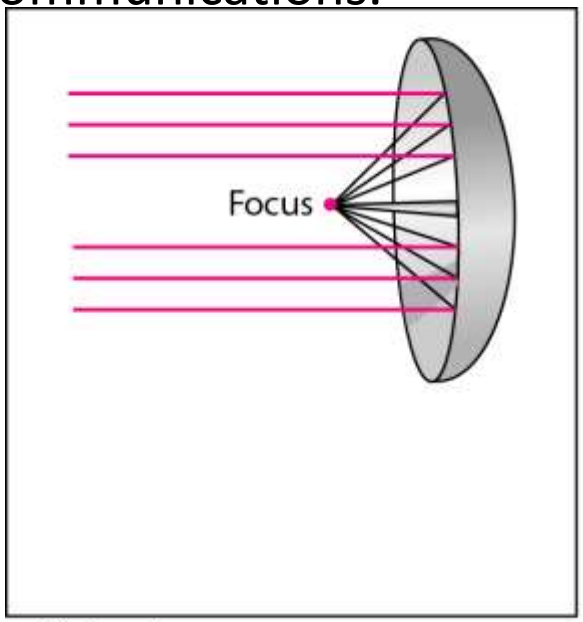
Transmission media - unguided

- Wireless communication
  - Radio waves are used for multicast communications, such as radio and television, and paging systems. They can penetrate through walls. Highly regulated. Use omni directional antennas

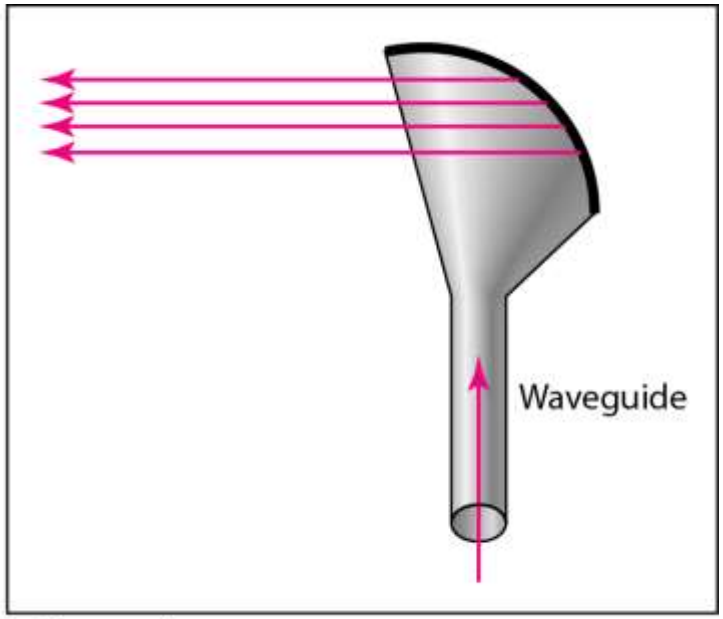


Transmission media - unguided

- Wireless communication
  - Microwaves are used for unicast communication such as cellular telephones, satellite networks,
    and wireless LANs. Higher frequency ranges cannot penetrate walls. Use directional antennas - point to point line of sight communications.



a. Dish antenna

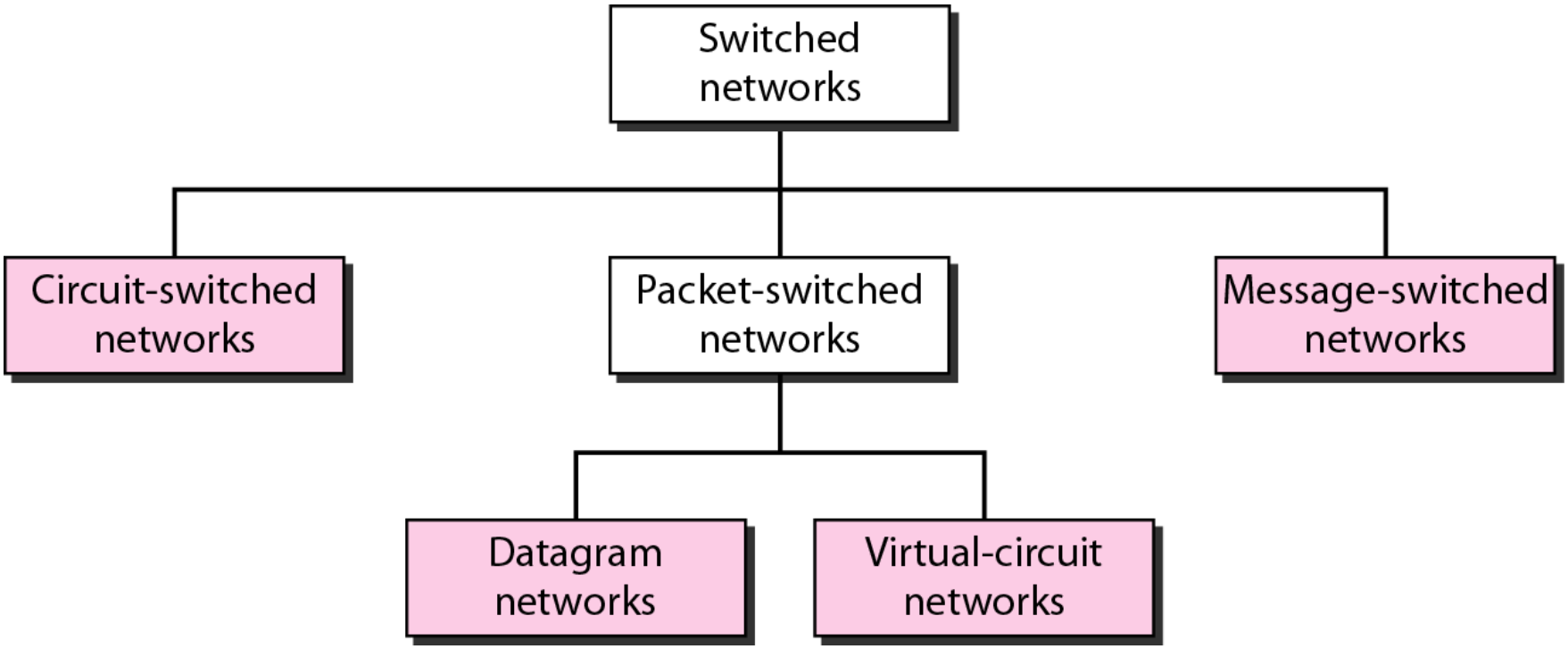


b. Horn antenna

Transmission media - unguided

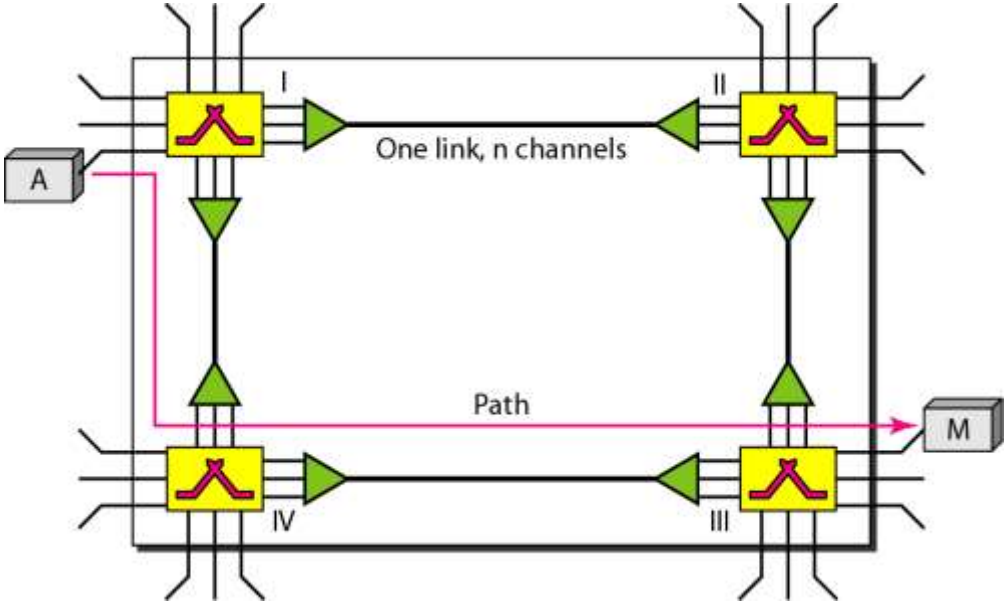
- Wireless communications
  - Infrared signals can be used for short-range communication in a closed area using line-of-sight propagation.
- Disadvantages of wireless channels
  - Are subject to a lot more errors than guided media channels.
  - Interference is one cause for errors, can be circumvented with high SNR.
  - The higher the SNR the less capacity is available for transmission due to the broadcast nature of the channel.
  - Channel also subject to fading and no coverage holes.

Switching methods(CO2)



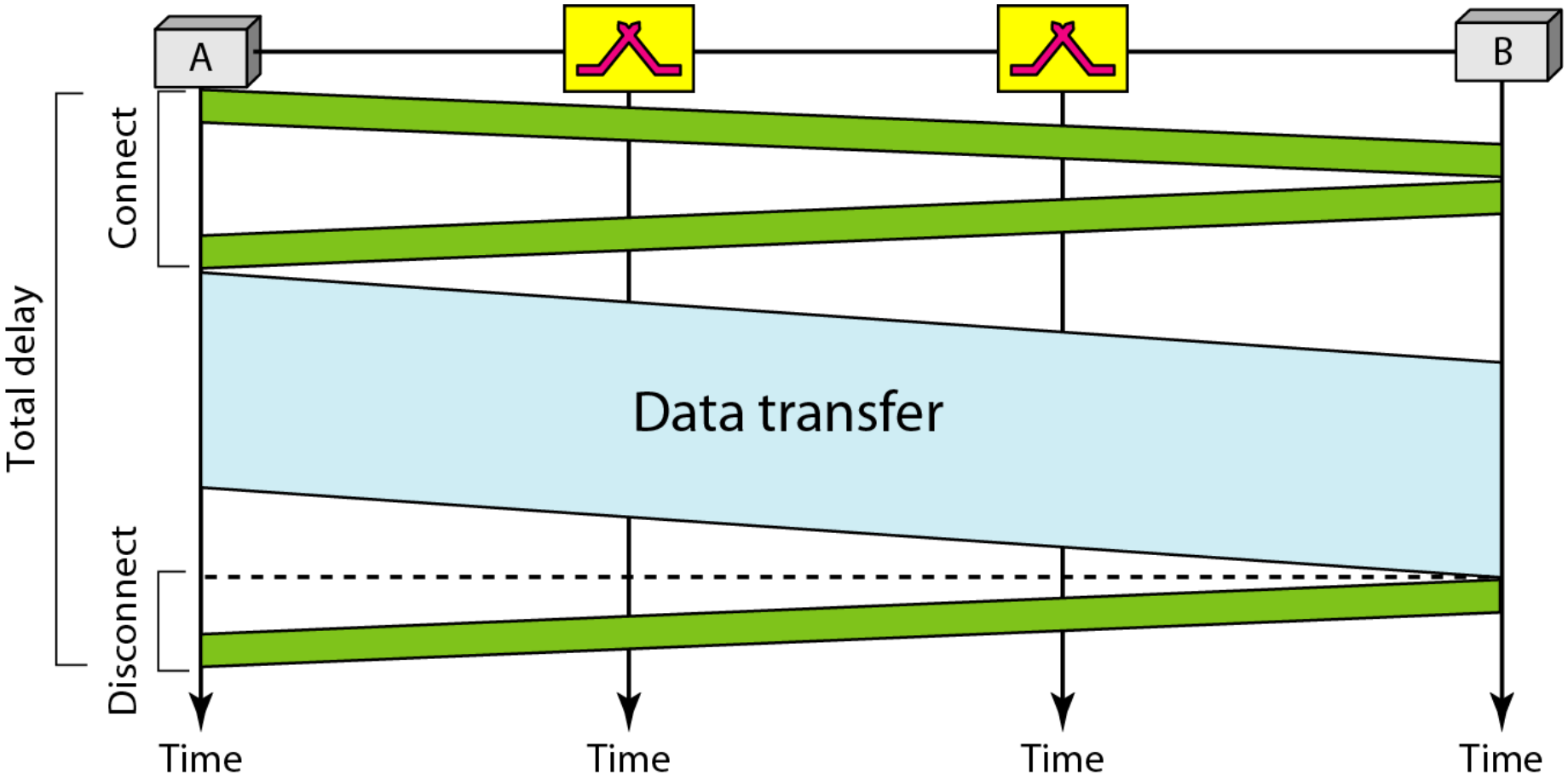
Switching methods(CO2)

- Circuit switched
  - *consists of a set of switches connected by physical links.*
  - *A connection between two stations is a dedicated path made of one or more links.*
  - *Each connection uses only one dedicated channel on each link.*
  - *Each link is normally divided into n channels by using FDM or TDM.*
-



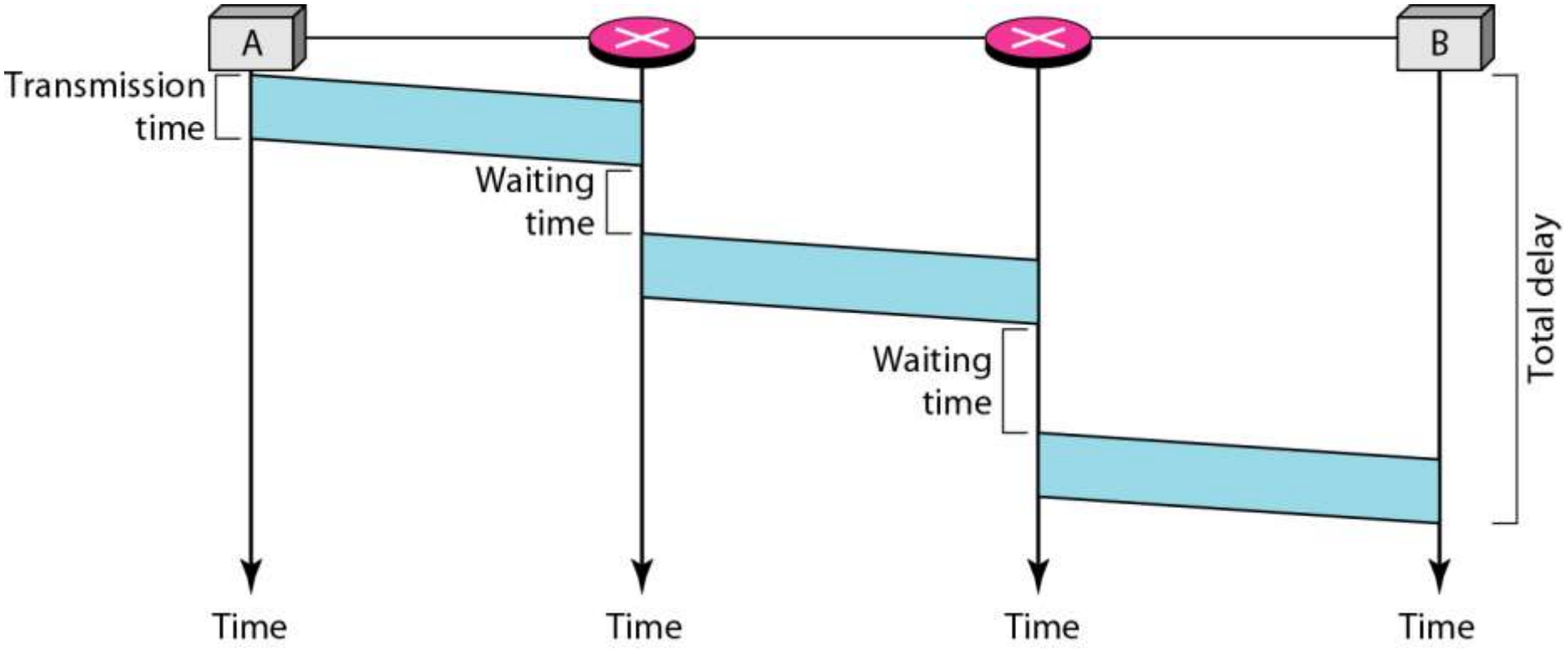
Switching methods(CO2)

- Delay in Circuit switched



Switching methods(CO2)

- Delay in datagram network

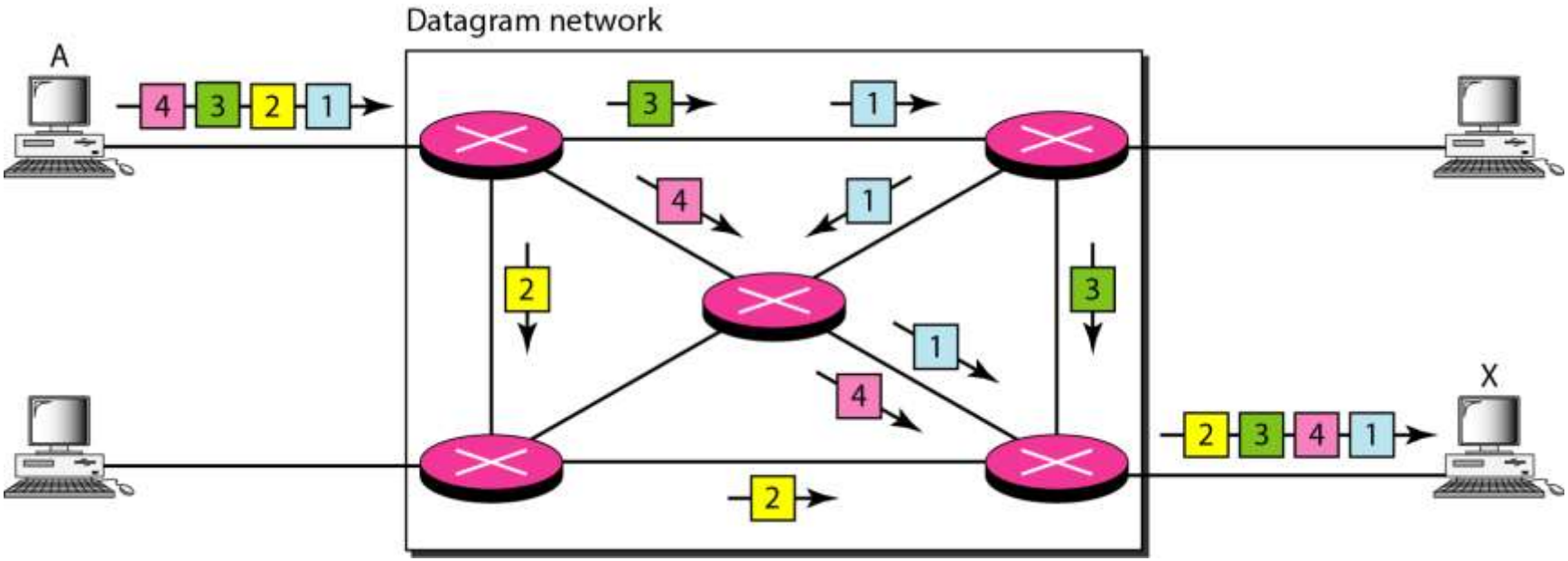


Switching methods(CO2)

- Packet switched
  - send messages from one end system to another.
  - If the message is going to pass through a packet-switched network, it needs to be divided into packets of fixed or variable size.
  - The size of the packet is determined by the network and the governing protocol.
  - In a packet-switched network, there is no resource reservation; resources are allocated on demand.

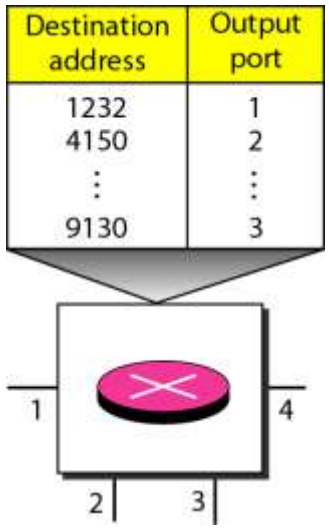
Switching methods(CO2)

Packet switched – Datagram network



Switching methods(CO2)

- Packet Switched – Datagram Network
  - Routing table
    - A switch in a datagram network uses a routing table that is based on the destination address.
    - The destination address in the header of a packet in a datagram network remains the same during the entire journey of the packet.

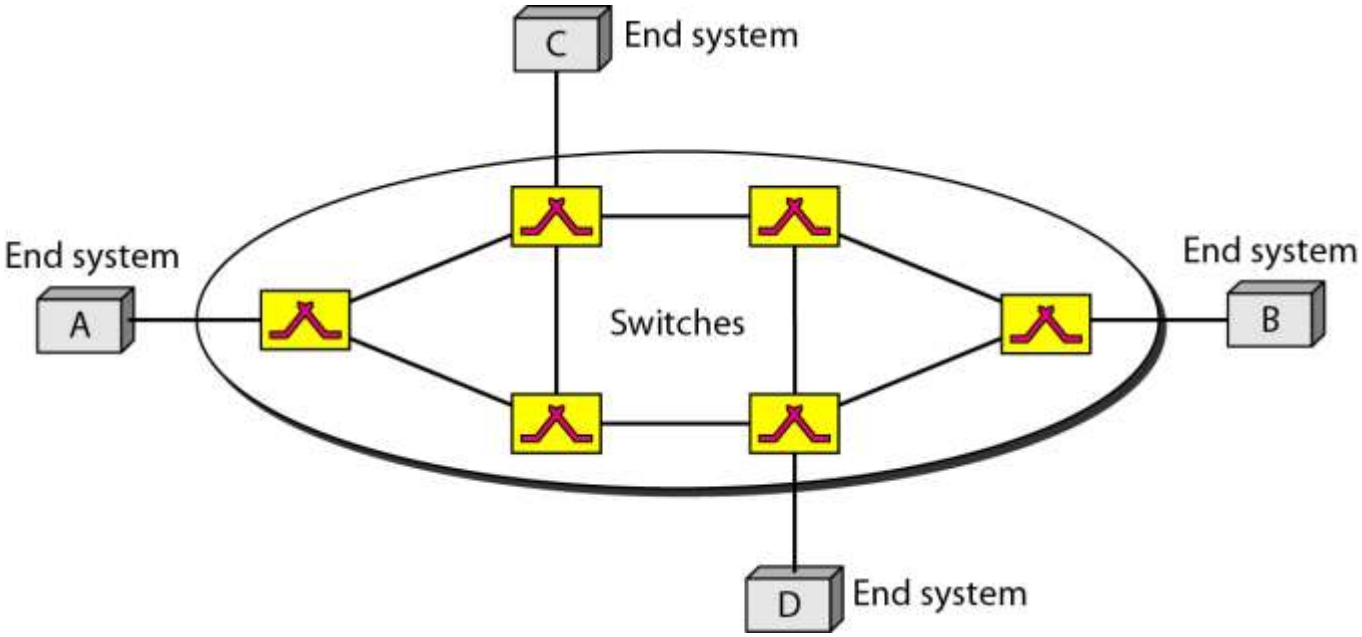


Switching methods(CO2)

- Packet Switched - Virtual-circuit network
  - a cross between a circuit-switched network and a datagram network.
  - It has some characteristics of both.
  - all packets belonging to the same source and destination travel the same path;
  - but the packets may arrive at the destination with different delays
    if resource allocation is on demand.

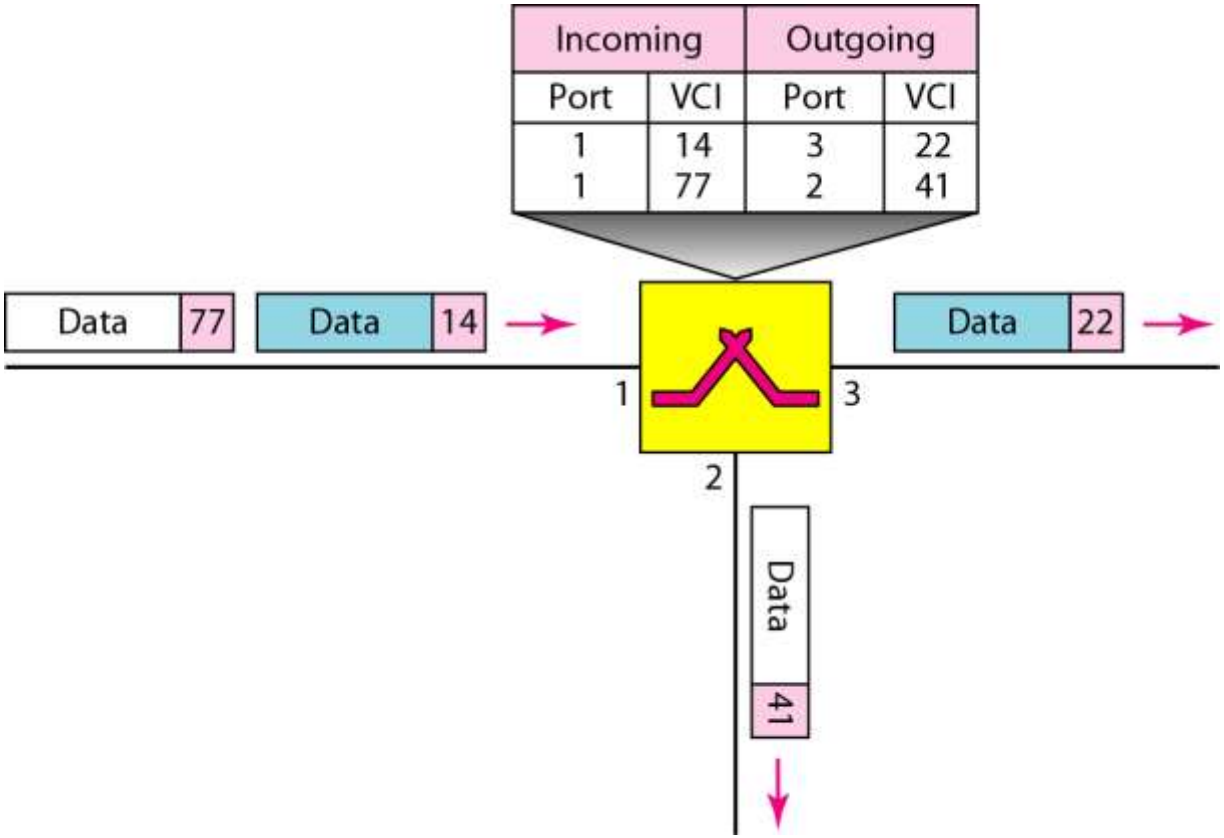
Switching methods(CO2)

- Packet Switched - Virtual-circuit network



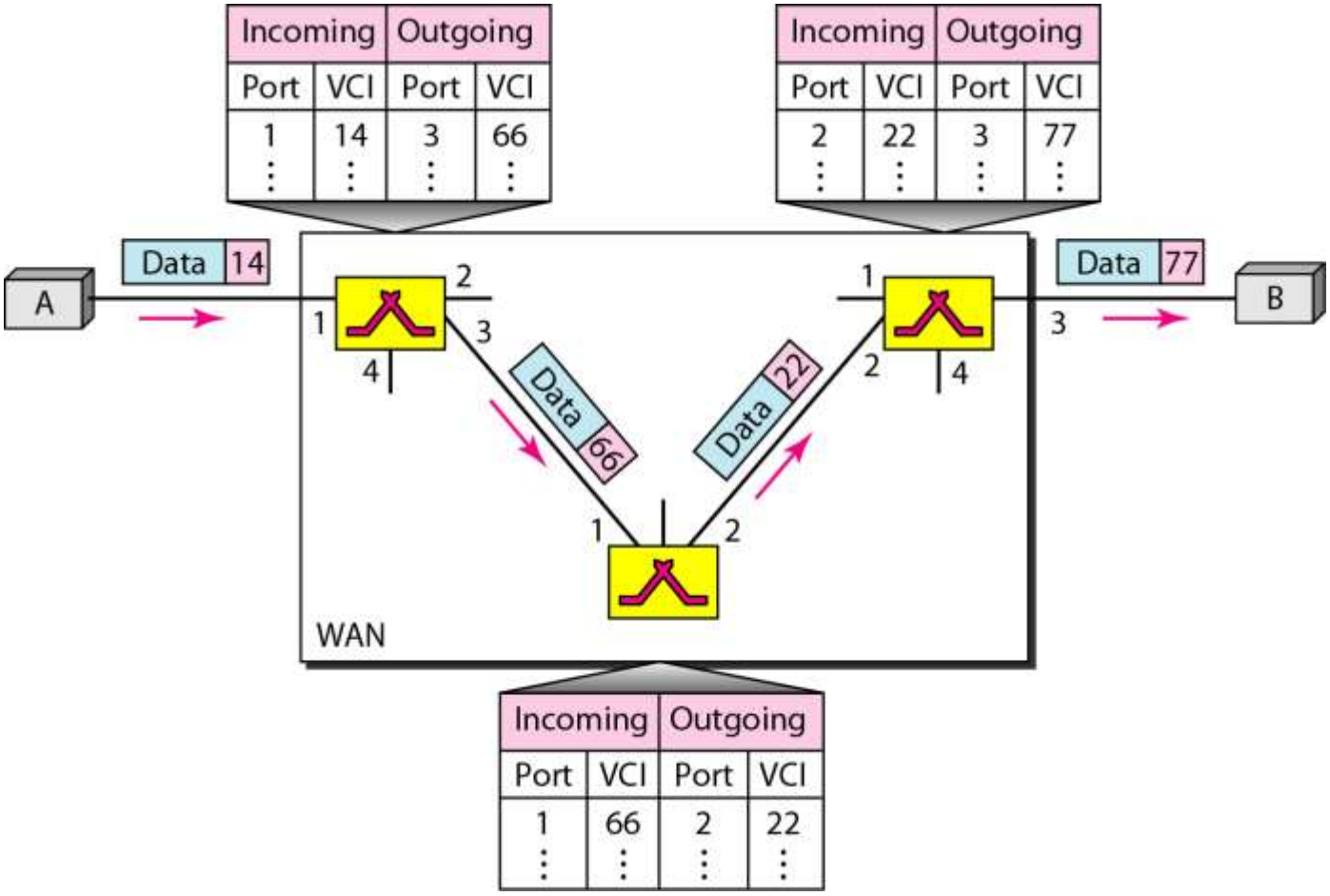
Switching methods(CO2)

- Packet Switched - Virtual-circuit network



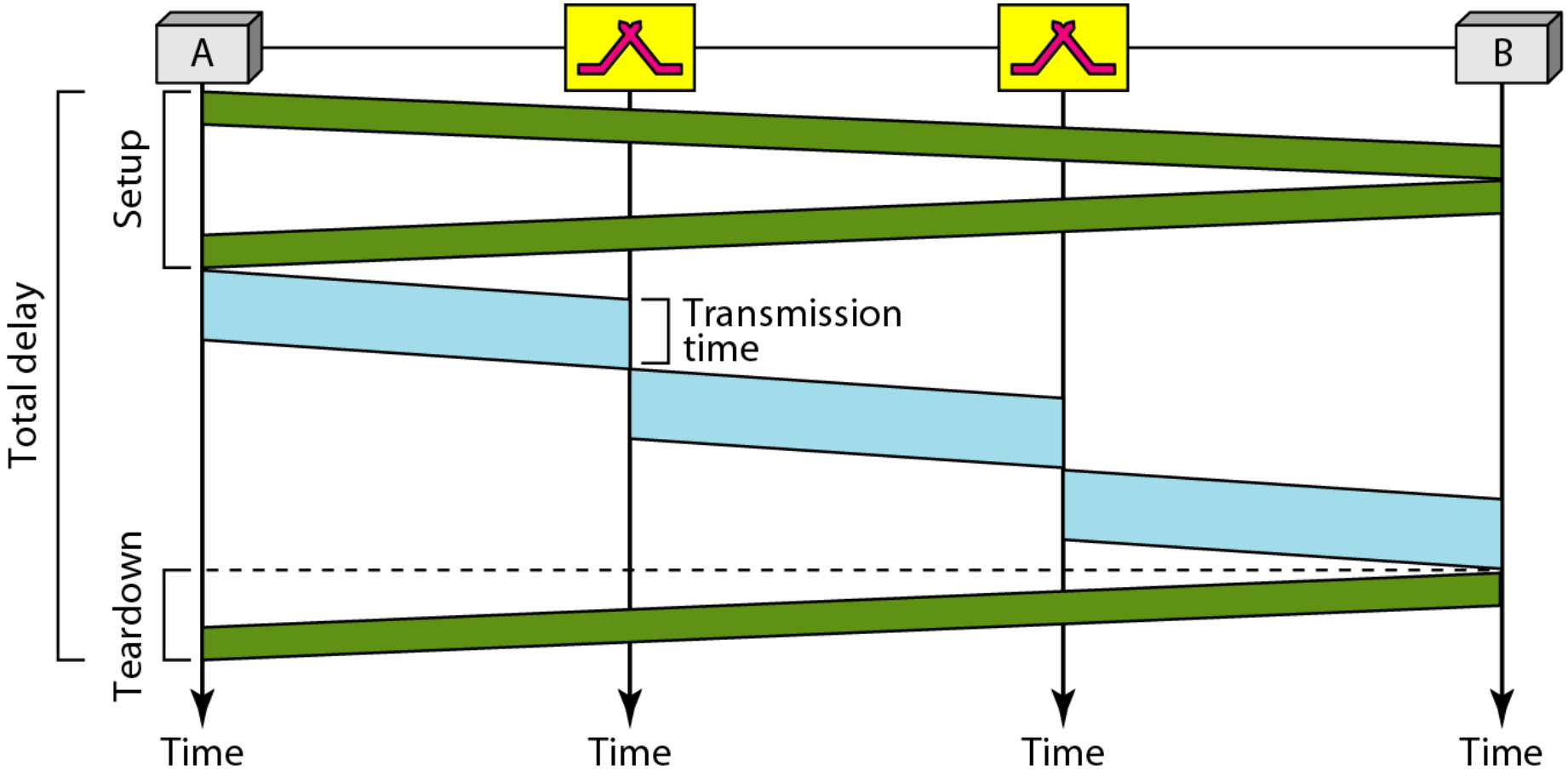
Switching methods(CO2)

- Packet Switched - Virtual-circuit network



Switching methods(CO2)

- Delay in virtual circuit



ISDN and Terminal Handling(CO2)

Topic Objective

- To understand the ISDN services
- Understand Terminal Handling

Recap of previous topic

- Various transmission media used in physical layer
- Switching methods used for transmission

Integrated Services Digital Network(CO2)

- ISDN
  - These are a set of communication standards for simultaneous digital transmission of voice, video, data, and other network services
  - a circuit-switched telephone network system, but it also provides access to packet switched networks that allows digital transmission of voice and data.
  - ISDN is employed as the network in data-link and physical layers
  - The ISDN works based on the standards defined by ITU-T
  - The various principles of ISDN
    - To support switched and non-switched applications
    - To support voice and non-voice applications
    - Reliance on 64-kbps connections
    - Intelligence in the network
    - Layered protocol architecture
    - Variety of configurations

Integrated Services Digital Network(CO2)

- Services
  - **Bearer Services-**Transfer of information between users without the network manipulating the content of that information
  - **Teleservices -** the network may change or process the contents of the data.
  - **Supplementary Service -** Additional functionality to the bearer services and teleservices

Terminal Handling

- A computer terminal is an electromechanical or electronic hardware device which is used for entering data into, and displaying data from a computing system or computer.
- The early terminals were inexpensive but slower than punched cards or paper tape for input.
- Video displays were introduced with the advancement in technology.
- Time sharing systems also developed.
- Multiple users could work on the same machine at their own terminals.
- A smart terminal has a significant local programmable data processing capability.
- A terminal which depends on the host computer for its processing power is known as a client.
- A personal computer can run software which emulates the function of a terminal and can sometimes allow concurrent use of local programs and access to a distant terminal host system