Physical Layer and Media I

Networks Classification and Topology, Net Hardware and Transmission Media

Agenda

- Network Classification
- Network Topology
- Network Hardware
- Collision and Broadcast Domain
- Transmission Media

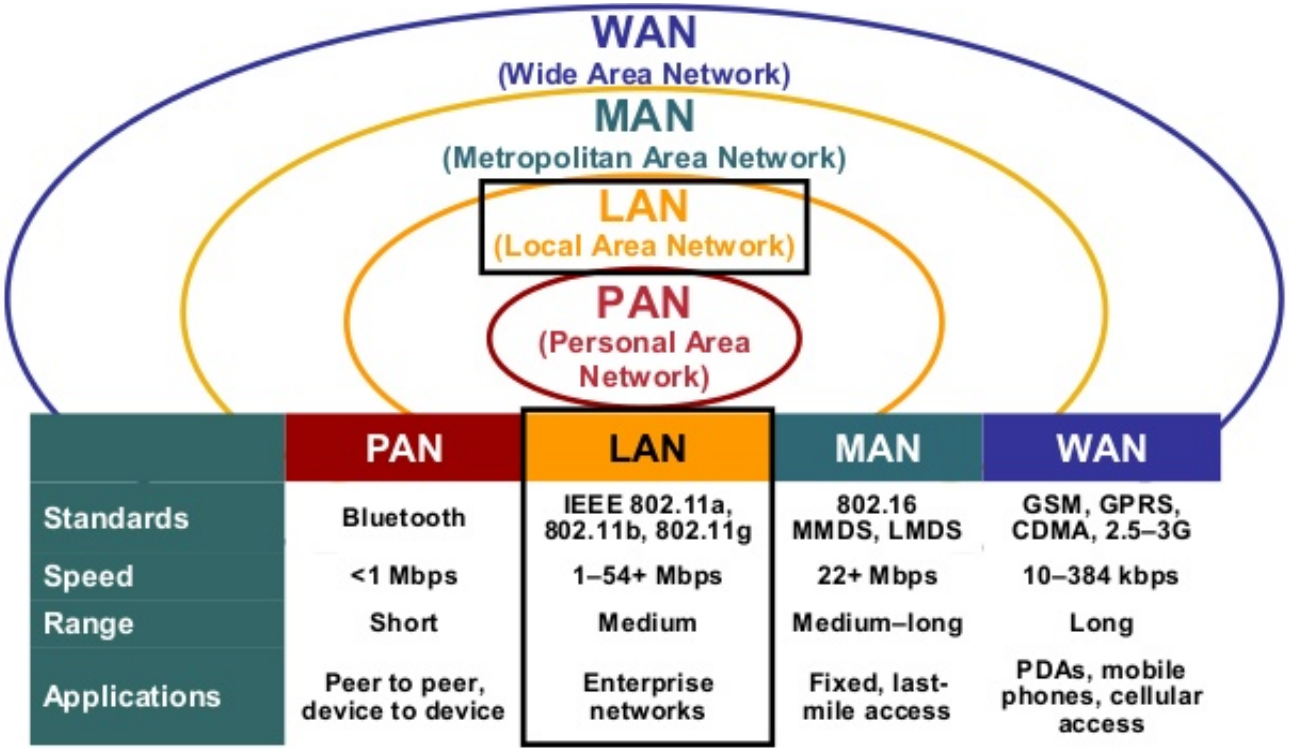
Network Classification

1. Scope: LAN, MAN, WAN
2. Topology: bus, star, ring, mesh
3. Physical medium: copper, fiber, wireless
4. Transmission rate: 10Mb/s, Gigabit
5. Switching style: circuit, packet
6. Protocol: IP, OSI, Ethernet, ATM
7. Application: voice, data, video

Classification of Networks by Scale

BAN, PAN, LAN (RAN, HAN, CAN), MAN, WAN

Example: Wireless Standard



	PAN	LAN	MAN	WAN
Standards	Bluetooth	IEEE 802.11a, 802.11b, 802.11g	802.16 MMDS, LMDS	GSM, GPRS, CDMA, 2.5–3G
Speed	<1 Mbps	1–54+ Mbps	22+ Mbps	10–384 kbps
Range	Short	Medium	Medium–long	Long
Applications	Peer to peer, device to device	Enterprise networks	Fixed, last-mile access	PDAs, mobile phones, cellular access

Body	< 1 m
Personal	< 10 m
Local	10-1000 m
Room	< 10
Home	< 100 m
Campus	< 1000 m
Metropolitan	< 100 km
Wide	< 40 000 km

LANs - Definition

Local Area Network

Is a group of computers and associated devices that share a common communications line or wireless link and typically share the resources of a single processor or server within a small geographic area (for example, within an office building).

Usually, the server has applications and data storage that are shared in common by multiple computer users.

A local area network may serve as few as two or three users (for example, in a home network) or many as thousands of users.

LANs - Characteristics

1. Topology
The geometric arrangement of devices on the network or the shape of a local-area network (LAN) or other communications system.

2. Hardware
A number of hardware devices are used to implement LAN. These devices provide connectivity with in a single LAN or interface with other LANs/Networks.

3. Media
Devices can be connected by twisted-pair wire, coaxial cables, or fiber optic cables. Some networks do without connecting media altogether, communicating instead via radio waves.

4. Protocols
The rules and encoding specifications for sending data. The protocol defines the format and meaning of the data that is exchanged. The protocols also determine whether the network uses a peer-to-peer or client/server architecture.

Network Topology

Computer network topology is the way various components of a network (like nodes, links, peripherals, etc) are arranged and using connections.

Topology can be physical or logical.

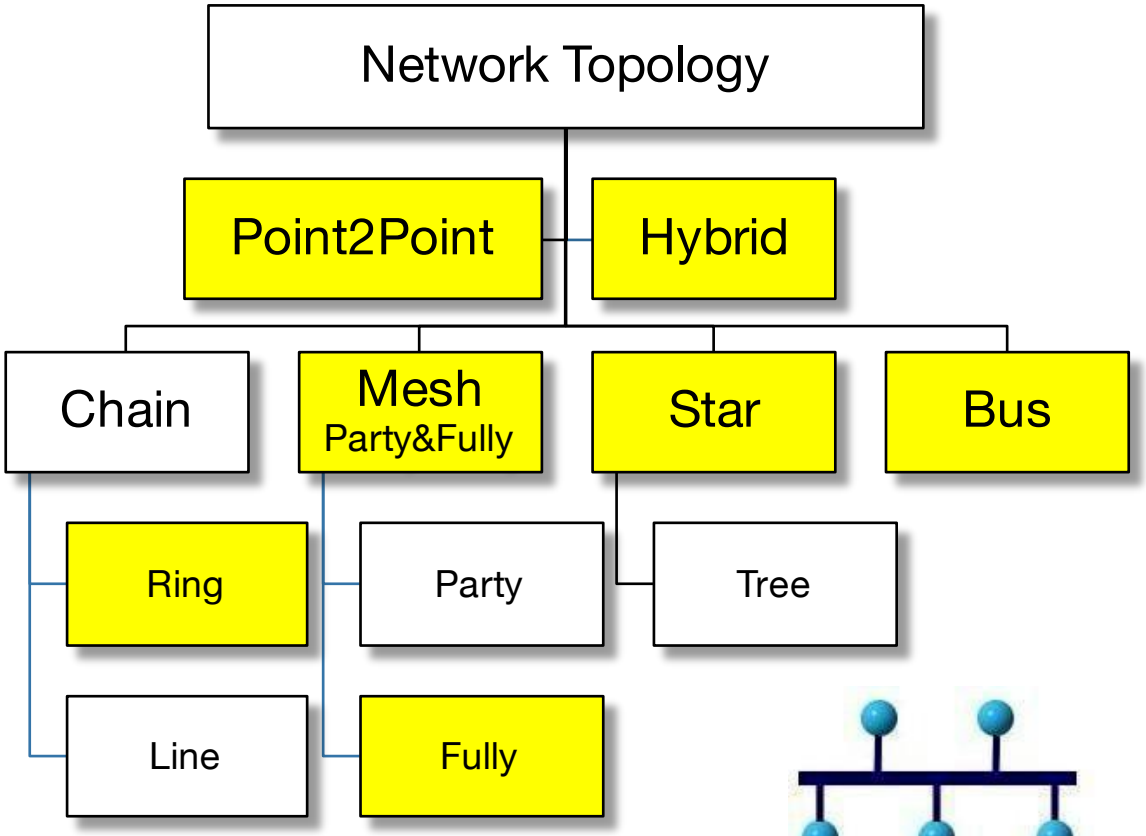
Physical topology is the physical layout of nodes, workstations and cables in the network.

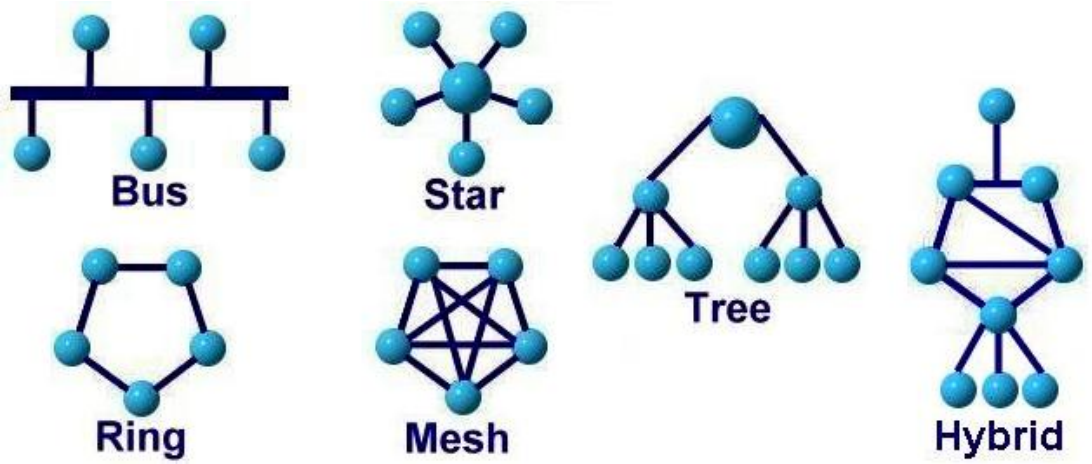
Logical topology is the way information flows between different components.

Factors consideration while choosing a network topology:

1) Scale project (in terms of number of components to be connected).
2) Amount of traffic expected on the network.
3) Budget allotted for the network.
4) Required response time.

Network Topology





Network Topology

Point To Point Topology

Point-to-Point Topology is the simplest of all the network topologies.
The network consists of a direct link between two computers.

Advantages

- This is faster and more reliable than other types of connections since there is a direct connection.

Disadvantages

- It can only be used for small areas where computers are in close proximity.

Daisy Chain Topology

Chain Topology - connecting each computer in series to the next. If a message is intended for a computer partway down the line, each system bounces it along in sequence until it reaches the destination.

A daisy-chained network can take two basic forms: Line and Ring.

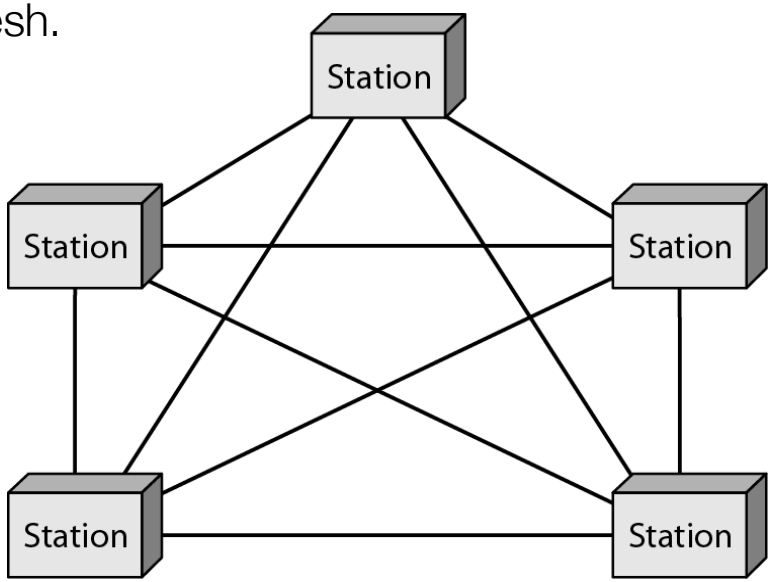
Network Topology

Mesh Topology

Mesh Topology - every node has a direct Point2Point connection to every other node. Have Fully mesh and Party mesh.

c=s(s-1)/2 or c~1/2s^2
c – connections, s – stations

s=2 -> c=1
s=5 -> c=10
s=10 -> c=45
s=100 -> c~5000
s=1000 -> c~500000



Advantages:

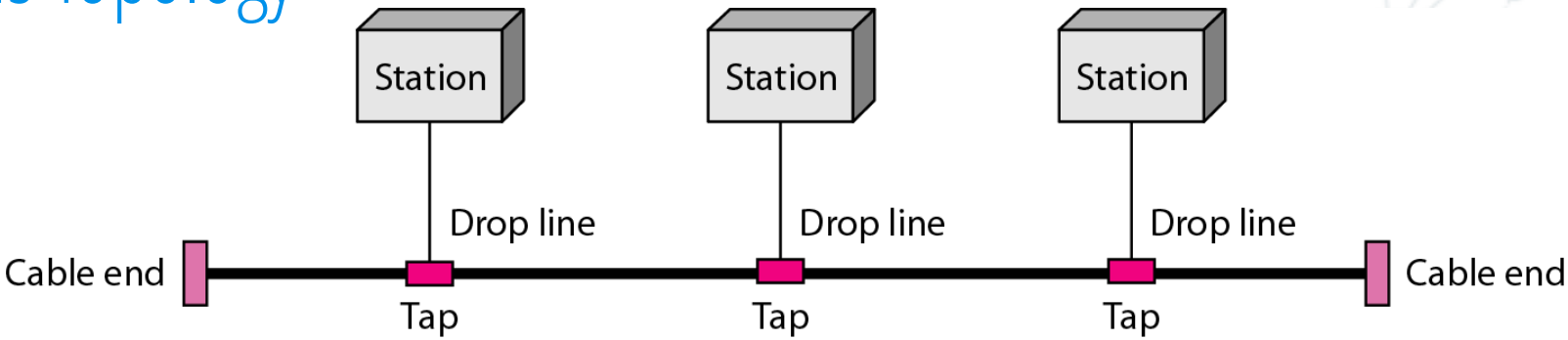
- Because all connections are direct, the network can handle high traffic.
- It is also robust because if one connection fails, the others remain intact.
- Security is also high since data travels along a dedicated connection.
- Modification in topology can be done without disrupting other nodes.

Disadvantages:

- This type of topology requires a lot of cables and is, therefore, expensive.

Network Topology

Bus Topology



Bus Topology is the simplest of network topologies. In this type of topology, all the nodes (computers as well as servers) are connected to the single cable (called bus). This central cable is the backbone of the network.

Advantages

- It is easy to set-up and extend bus network.
- Cable length required for this topology is the least compared to other networks.
- Bus topology costs very less.
- Linear Bus network is mostly used in small networks. Good for LAN.

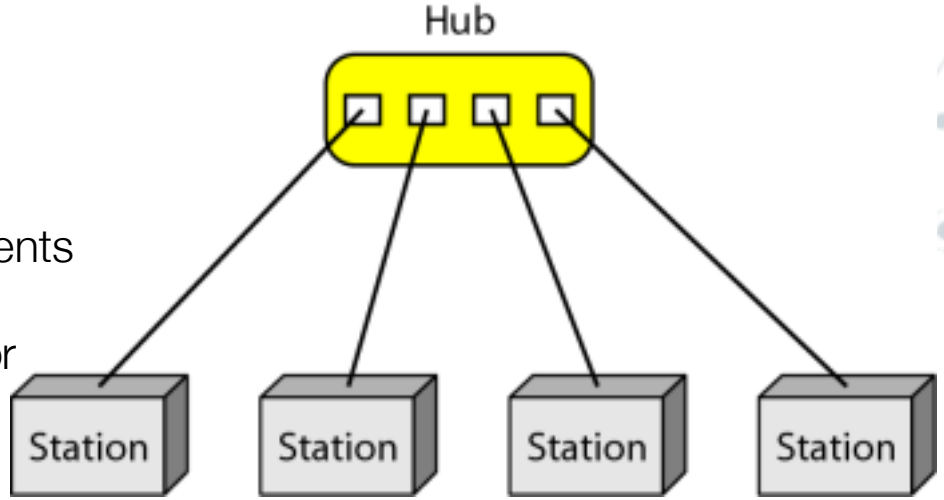
Disadvantages

- There is a limit on central cable length and number of nodes that can be connected.
- If the main cable (i.e. bus) encounters some problem, whole network breaks down.
- Efficiency of Bus network reduces, as the number of devices connected to it increases.
- It is not suitable for networks with heavy traffic.
- Security is very low because all the computers receive the sent signal from the source.

Network Topology

Star Topology

In **Star topology**, all the components of network are connected to the central device called hub, router or switch.



Advantages

- As compared to Bus topology it gives far much better performance, signals don't necessarily get transmitted to all the workstations.
- Easy to connect new nodes or devices without affecting rest of the network. Similarly components can also be removed easily.
- Centralized management. It helps in monitoring the network.
- Failure of one node or link doesn't affect the rest of network, easy detection the failure and troubleshoot it.

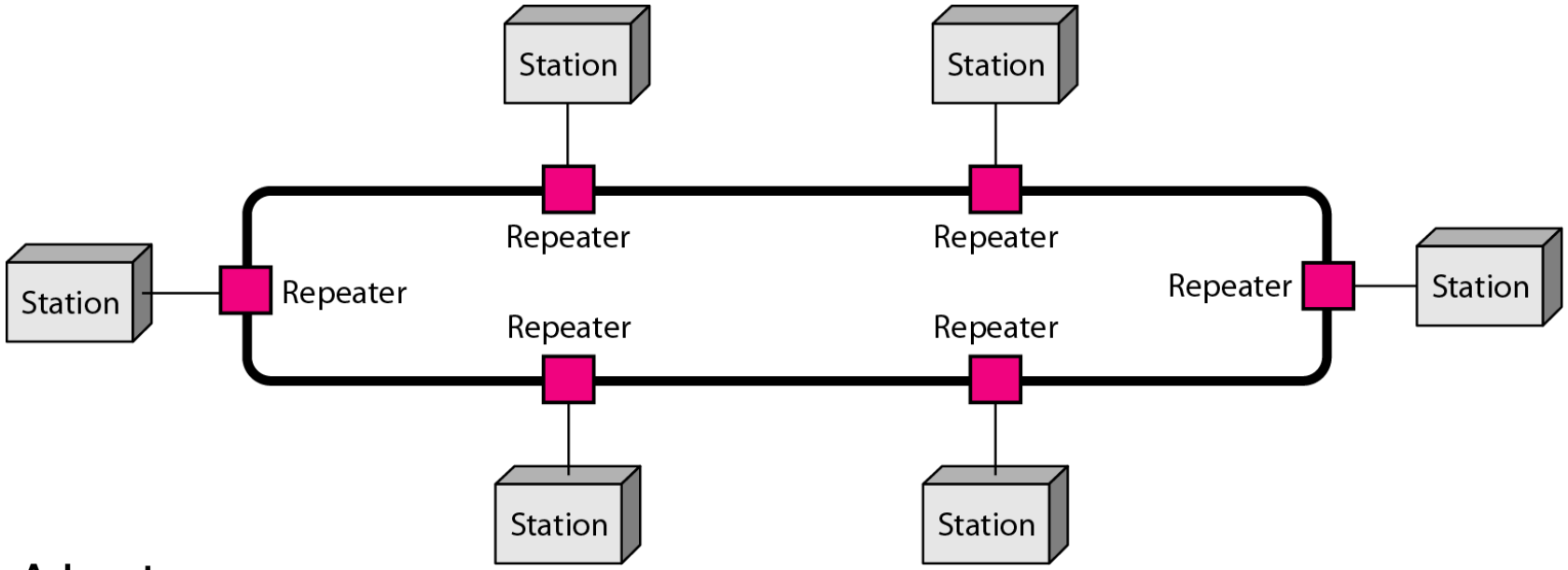
Disadvantages

- Too much dependency on central device has its own drawbacks. If it fails whole network goes down.
- The use of hub, a router or a switch as central device increases the overall cost of the network.
- Performance of the network is dependent on the capacity of central device.

Network Topology

Ring Topology

All the nodes are connected to each-other in such a way that they make a closed loop. Data travels around the network, in one direction at very high speed. Sending and receiving of data takes place by the help of TOKEN, this helps to reduces chances of collision.



Advantages:

- When the load on the network increases, its performance is better than bus topology.
- There is no need of network server to control the connectivity between workstations.

Disadvantages:

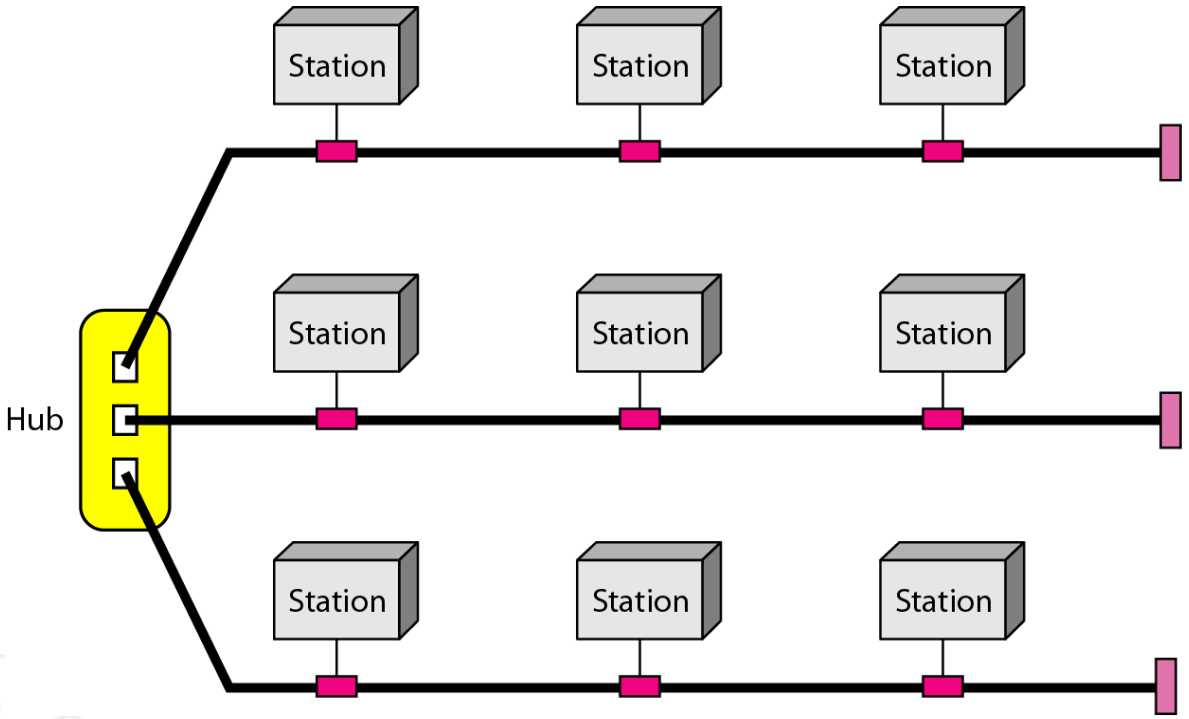
- Aggregate network bandwidth is bottlenecked by the weakest link between two nodes.
- Network is highly dependent on the wire which connects different components.

Network Topology

Hybrid Topology

Hybrid networks combine two or more topologies in such a way that the resulting network does not exhibit one of the standard topologies.

For example, star-bus network. a star backbone with 3 bus networks.



Network Hardware

- Network Interface Cards (NICs)
- Repeater
- Hub
- Switch
- Bridge
- Router
- Gateway
- Proxy server

Resides on different Layer of the OSI model.

OSI Model Layers

7 Application
6 Presentation
5 Session
4 Transport
3 Network
2 Data Link
1 Physical

Networking Hardware

Network Boxes

Router

Label Switched Router

Load balancer

Switch

Scrubber

Repeater

Gateway

Intrusion Detection System

Bridge

Route Reflector

Deep Packet Inspection

DHCP server

Packet shaper

Firewall

NAT

Hub

Packet sniffer

WAN accelerator

DNS server

Base station

Proxy

Networking Hardware

Network Interface Cards (NICs)

Network Interface Cards (NICs) puts the data into packets and transmits packet onto the network.

May be wired or wireless.

Resides on Layer 1 of the OSI model.

OSI Model Layers

7 Application
6 Presentation
5 Session
4 Transport
3 Network
2 Data Link
1 Physical

Networking Hardware

Repeater

Used to boost the signal between two cable segments or wireless access points.

Can not connect different network architecture.

Does not simply amplify the signal, it regenerates the packets and retimes them.

Resides on Layer 1 of the OSI model.

OSI Model Layers

7 Application
6 Presentation
5 Session
4 Transport
3 Network
2 Data Link
1 Physical

Networking Hardware

Hub

An unintelligent network device that sends one signal to all of the stations connected to it.

All computers/devices are competing for attention because it takes the data that comes into a port and sends it out all the other ports in the hub.

Traditionally, hubs are used for star topology networks, but they are often used with other configurations to make it easy to add and remove computers without bringing down the network.

Resides on Layer 1 of the OSI model

OSI Model Layers

7 Application
6 Presentation
5 Session
4 Transport
3 Network
2 Data Link
1 Physical

Networking Hardware

Switch

Split large networks into small segments, decreasing the number of users sharing the same network resources and bandwidth.

Understands when two devices want to talk to each other, and gives them a switched connection.

Helps prevent data collisions and reduces network congestion, increasing network performance.

Most home users get very little, if any, advantage from switches, even when sharing a broadband connection.

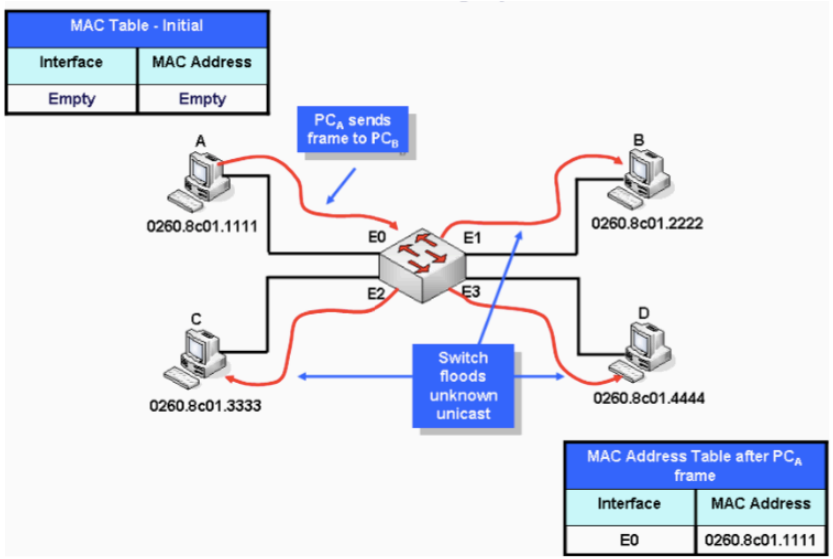
Resides on Layers 1, 2 of the OSI model.

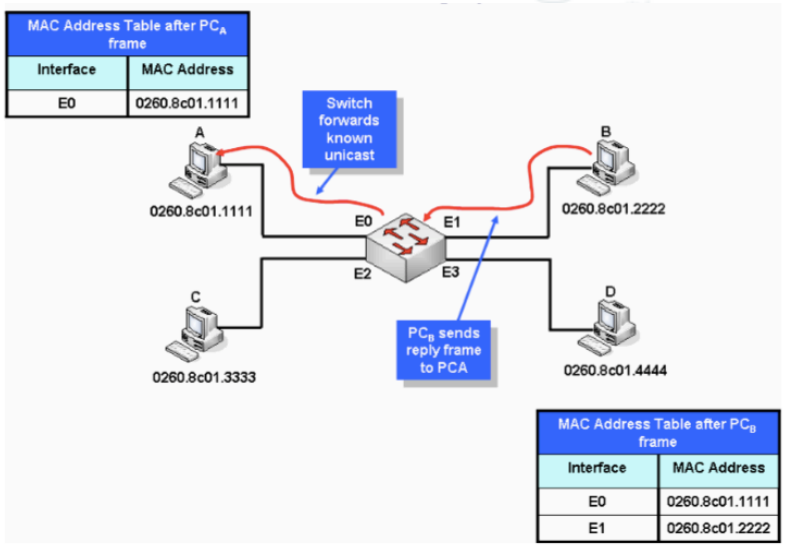
OSI Model Layers

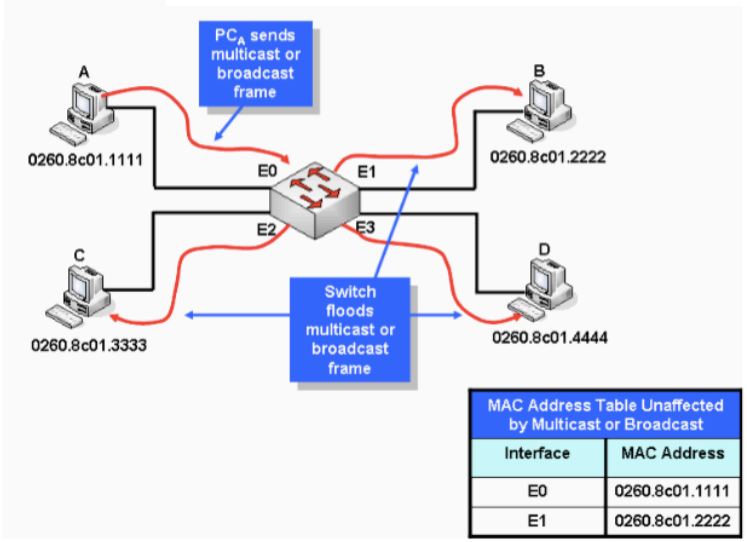
7 Application
6 Presentation
5 Session
4 Transport
3 Network
2 Data Link
1 Physical

Networking Hardware

Switch – learning send frame







Networking Hardware

Bridge

Connects two LANs and forwards or filters data packets between them.

Creates an extended network in which any two workstations on the linked LANs can share data.

Transparent to protocols and to higher level devices like routers.

Forward data depending on the Hardware (MAC) address, not the Network address (IP).

Resides on Layers 1, 2 of the OSI model.

OSI Model Layers

7 Application
6 Presentation
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1 Physical

Networking Hardware

Router

Routers that connects any number of LANs.

Uses standardized protocols to move packets efficiently to their destination.

More sophisticated than bridges, connecting networks of different types (for example, star and token ring).

Forwards data depending on the Network address (IP), not the Hardware (MAC) address.

Routers are the only one of these four devices that will allow you to share a single IP address among multiple network clients.

Resides on Layer 1, 2, 3 of the OSI model.

OSI Model Layers

7 Application
6 Presentation
5 Session
4 Transport
3 Network
2 Data Link
1 Physical

Networking Hardware

Gateway & Proxy server

Gateways connects networks with different protocols like TCP/IP network and IPX/SPX networks.

Proxy server isolates internal network computers from the internet. The user first access the proxy server and the proxy server accesses the internet and retrieves the requested web page or document. The user then gets a copy of that page from the proxy server.

Gateways & Proxy server often refer to the same device.

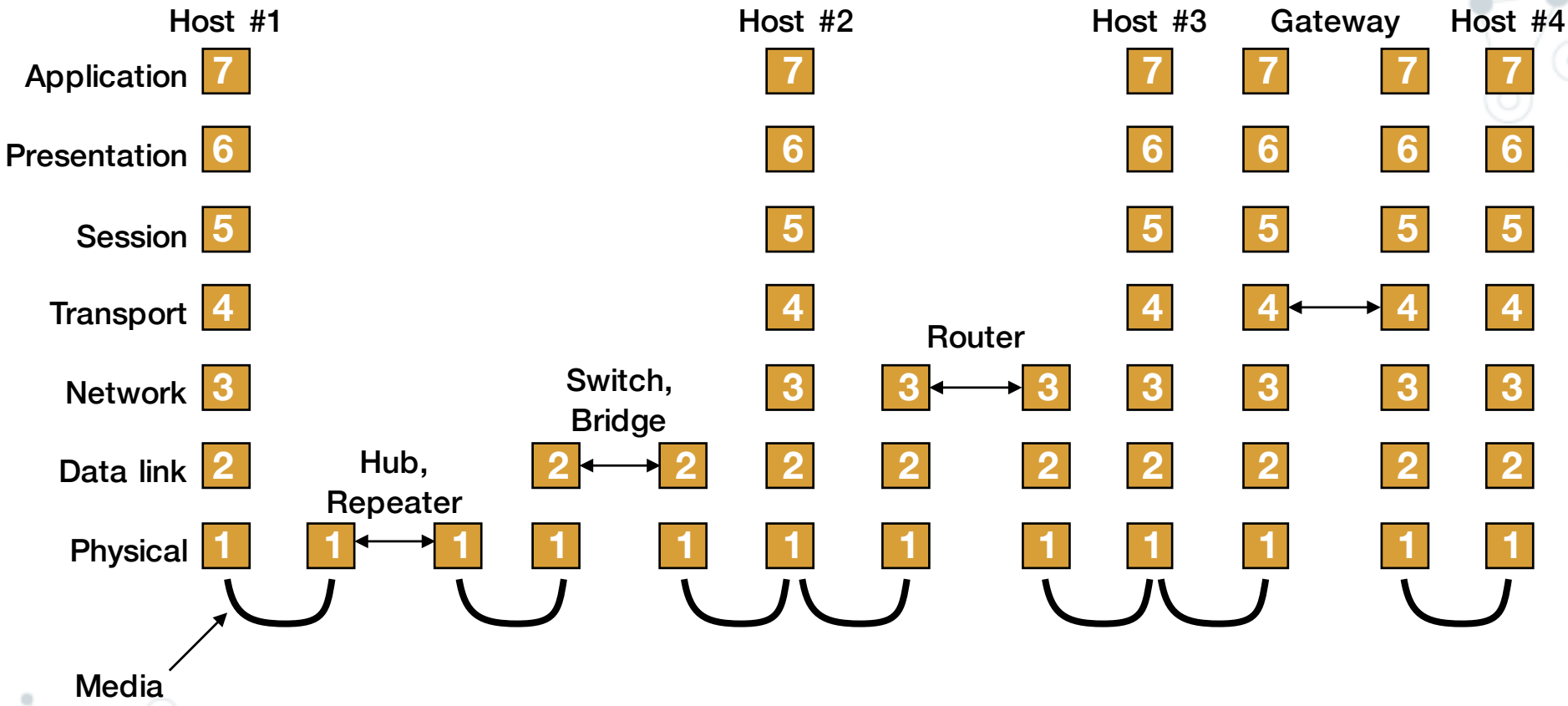
Resides on Layer 1, 2, 3, 4, 5, 6, 7 of the OSI model.

OSI Model Layers

7 Application
6 Presentation
5 Session
4 Transport
3 Network
2 Data Link
1 Physical

Networking Hardware

Hubs, Switches, Routers, Gateways, Hosts and OSI/RM



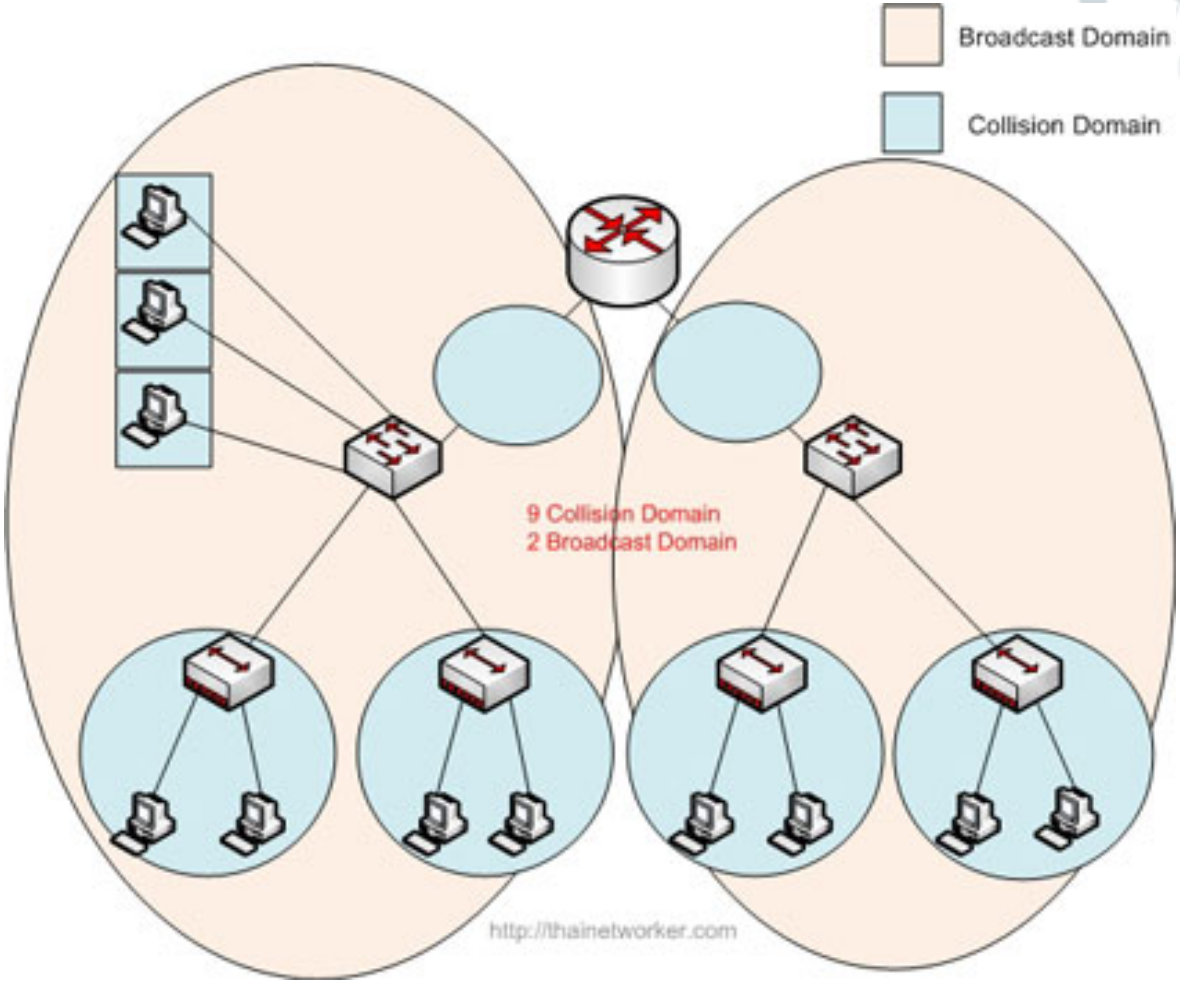
Networking Hardware

Collision and Broadcast Domains

Now we can conclude that switch creates separate collision domains and router creates separate broadcast domains. All ports of hub are one collision domain.

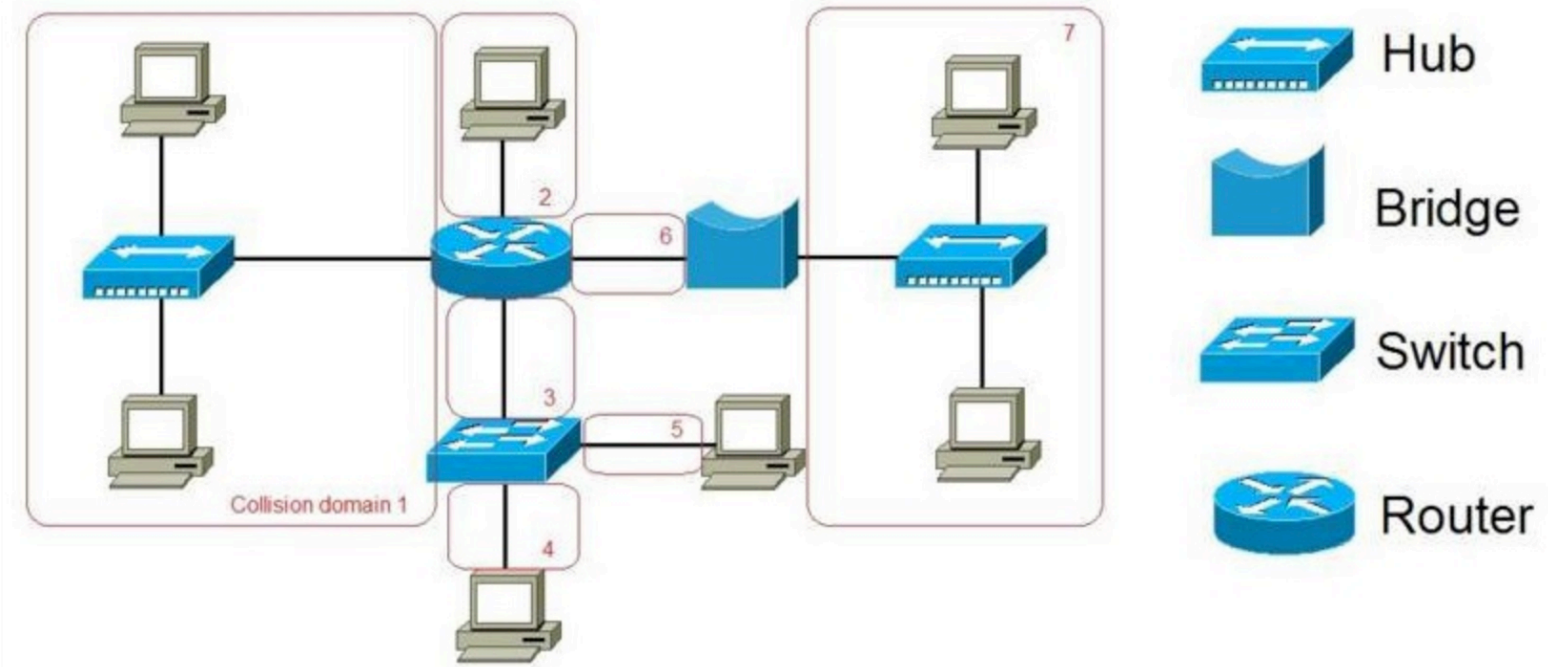
A collision domain is defined as a single CSMA/CD network segment in which there will be a collision if two computers attached to the system both transmit at the same time.

A broadcast domain is a logical division of a computer network, in which all nodes can reach each other by broadcast at the data link layer.



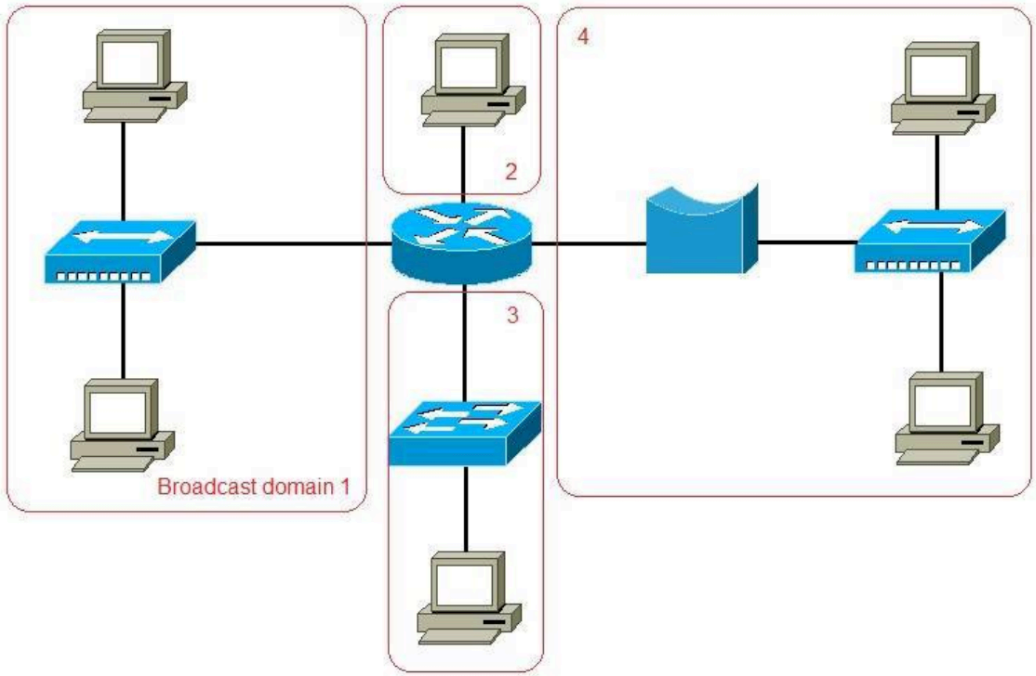
Networking Hardware

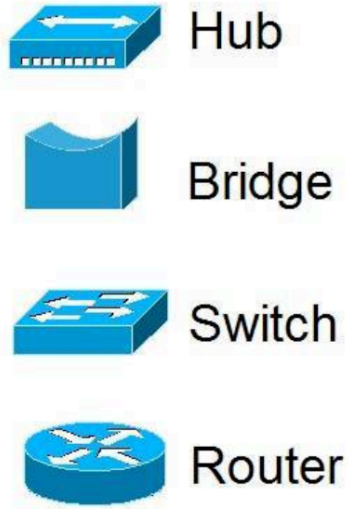
Collision Domain



Networking Hardware

Broadcast Domain





Three types of Ethernet addresses exist:
unicast addresses – represents a single LAN interface. A unicast frame will be sent to a specific device, not to a group of devices on the LAN.
multicast addresses – represents a group of devices in a LAN. A frame sent to a multicast address will be forwarded to a group of devices on the LAN.
broadcast addresses – represents all device on the LAN. Frames sent to a broadcast address will be delivered to all devices on the LAN.

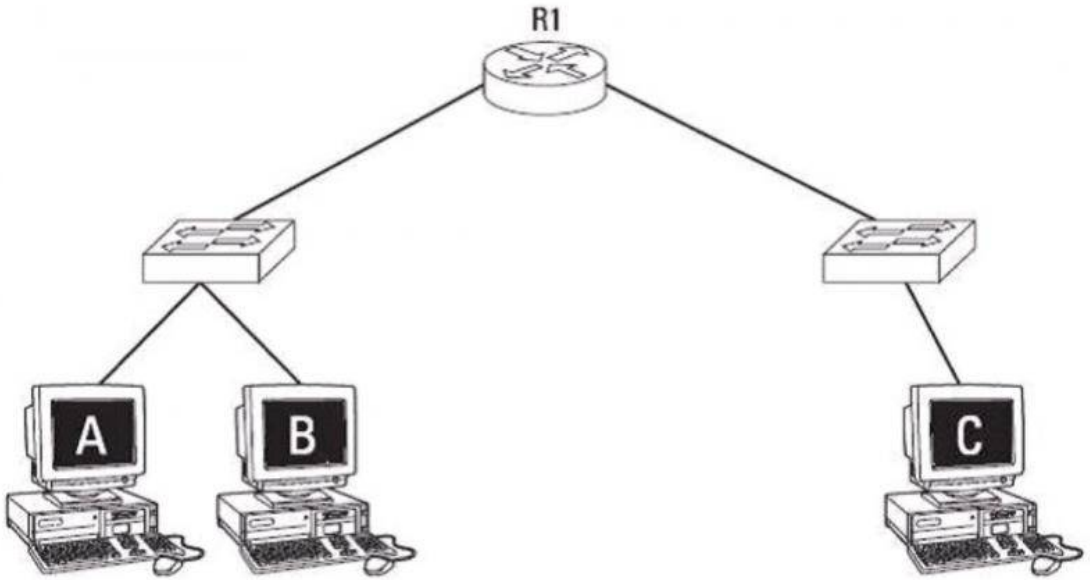
The broadcast address has the value of FFFF.FFFF.FFFF (all binary ones). The switch will flood broadcast frames out all ports except the port that it was received on.

Networking Hardware

Collision and Broadcast Domains – Question?

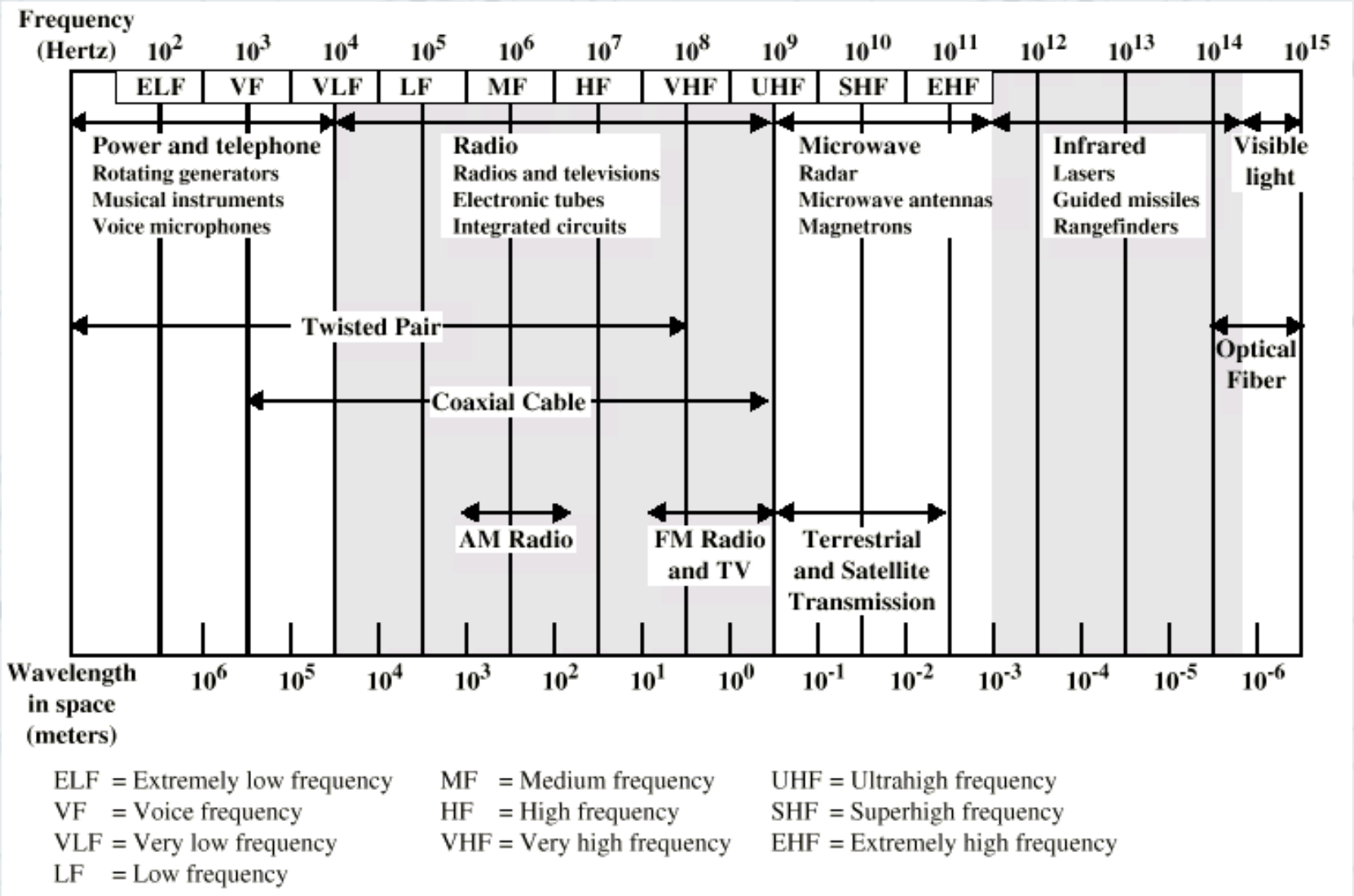
How many broadcast domains and collision domains are there in the diagram below?

(A) 1 broadcast domain and 5 collision domains
(B) 2 broadcast domains and 3 collision domains
(C) 1 broadcast domain and 3 collision domains
(D) 2 broadcast domains and 5 collision domains



Transmission Media

Transmission Media & Electromagnetic Spectrum

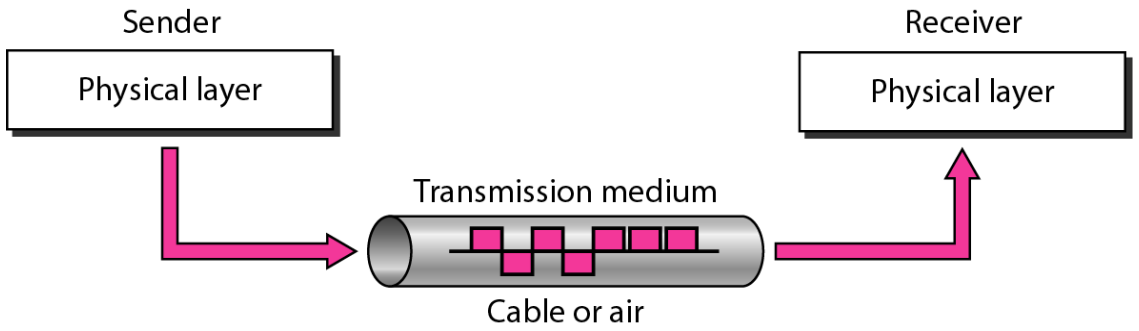


ELF = Extremely low frequency
VF = Voice frequency
VLF = Very low frequency
LF = Low frequency
MF = Medium frequency
HF = High frequency
VHF = Very high frequency
UHF = Ultrahigh frequency
SHF = Superhigh frequency
EHF = Extremely high frequency

Transmission Media

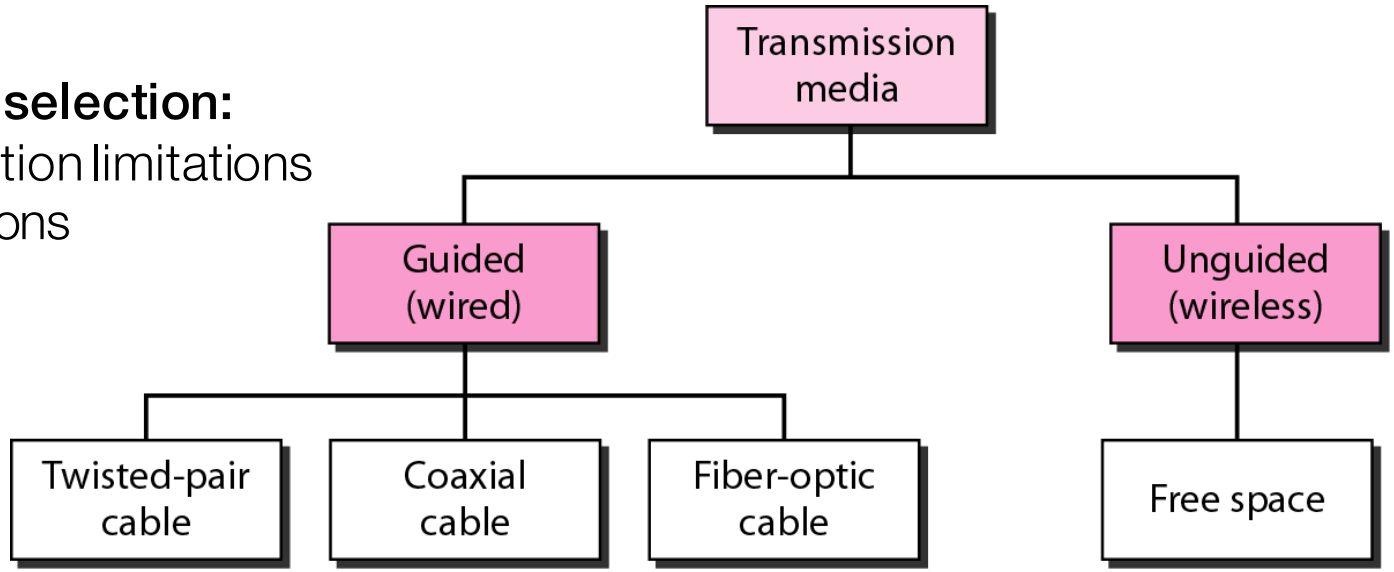
Classes of transmission media

Transmission media and physical layer



Criteria for media selection:

- Distance and location limitations
- Wiring configurations
- Reliability
- Security
- Budget
- Speed



Transmission Media

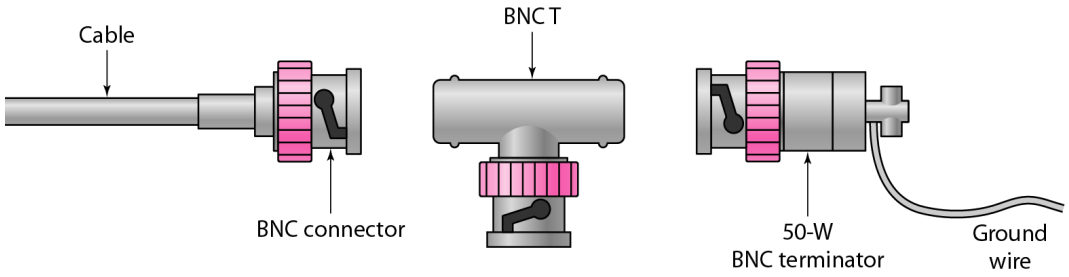
Common Network Media

Electrical (copper)

- **Coaxial Cable** – Single copper conductor in the center surrounded by a plastic layer for insulation and a braided metal outer shield.
- **Twisted pair** – Four pairs of wires twisted to certain specifications. Available in shielded and unshielded versions.
- **Power Lines** – Power Line communication (PLC) is Layer-1 (Physical Layer) technology which uses power cables to transmit data signals.

Fiber-optic - A cable, consisting of a center glass core surrounded by layers of plastic, that transmits data using light rather than electricity.

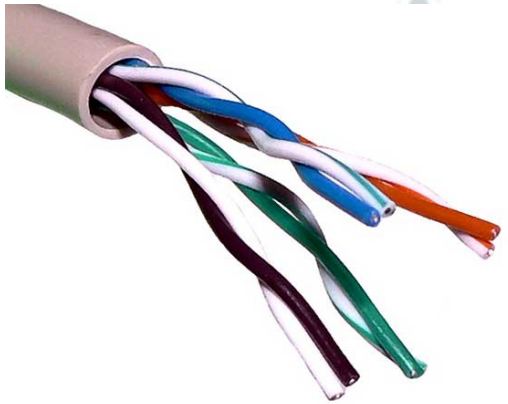
Atmosphere/Wireless – Uses Electromagnetic waves. whose frequency range is above that of microwaves, but below that of the visible spectrum.



Transmission Media

Copper - Twisted Pair

Dialup over telephone line.
DSL (Digital Subscriber Line)
High-speed (256 Kbps – 55 Mbps), Full-duplex.
Asymmetric Digital Subscriber Line (ADSL) and
High-bit-rate Digital Subscriber Line (HDSL)



CAT 3, 4, 5, 5e, 6, 6a, 7, 8
Ethernet cable standard defined by the Electronic Industries Association and Telecommunications. Industry Association (EIA/TIA).
Speeds from 10 Mbps up to 10 Gbps.

Connector
RJ-45 - Standard connectors used for unshielded twisted-pair cable.

Transmission Media

Categories of unshielded twisted-pair cables

UTP Categories - Copper Cable				
UTP Category	**Data Rate**	**Max. Length**	**Cable Type**	**Application**
CAT1	Up to 1Mbps	-	Twisted Pair	Old Telephone Cable
CAT2	Up to 4Mbps	-	Twisted Pair	Token Ring Networks
CAT3	Up to 10Mbps	100m	Twisted Pair	Token Rink & 10BASE-T Ethernet
CAT4	Up to 16Mbps	100m	Twisted Pair	Token Ring Networks
CAT5	Up to 100Mbps	100m	Twisted Pair	Ethernet, FastEthernet, Token Ring
CAT5e	Up to 1 Gbps	100m	Twisted Pair	Ethernet, FastEthernet, Gigabit Ethernet
CAT6	Up to 10Gbps	100m	Twisted Pair	GigabitEthernet, 10G Ethernet (55 meters)
CAT6a	Up to 10Gbps	100m	Twisted Pair	GigabitEthernet, 10G Ethernet (55 meters)
CAT7	Up to 10Gbps	100m	Twisted Pair	GigabitEthernet, 10G Ethernet (100 meters)

CAT8 Up to 40Gbps 100m Twisted Pair 1G, 10G, 40G Ethernet (30m).

Transmission Media

Ethernet Specifications

10BaseT

Ethernet specification for unshielded twisted pair cable (category 3, 4, or 5), transmits signals at 10 Mbps (megabits per second) with a distance limit of 100 meters per segment.

10BaseF

Ethernet specification for fiber optic cable, transmits signals at 10 Mbps (megabits per second) with a distance limit of 2000 meters per segment.

100BaseT

Ethernet specification for unshielded twisted pair cabling that is used to transmit data at 100 Mbps (megabits per second) with a distance limit of 100 meters per segment.

1000BaseTX

Ethernet specification for unshielded twisted pair cabling that is used to transmit data at 1 Gbps (gigabits per second) with a distance limitation of 220 meters per segment.

10GBaseT

Ethernet specification for unshilded and shielded twisted pair cabling that is used to transmit data at 10 Gbps (10 gigabits per second) with a distance limitation of 55 meters (CAT6) or 100 meters (CAT6a or CAT7) per segment, use special connector 8P8C.

40GBaseT

Ethernet specification twisted pair cabling that is used to transmit data at 40 Gbps with a distance limitation of 33 meters (CAT8).

100GBase-XX – different technology and venders

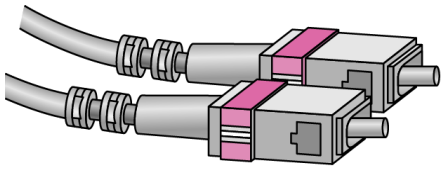
200GBase-XX – project different technology

400GBase-XX – project different technology

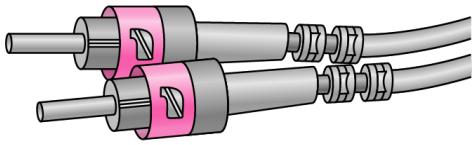
Transmission Media

Optical Fiber

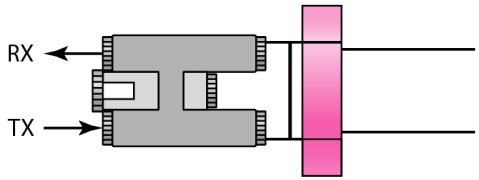
- Infrared light is transmitted through fiber and confined due to total internal reflection.
- Fibers can be made out of either plastic or glass.
- Used for high speed backbones and pipes over long distances.
- Comparatively expensive.



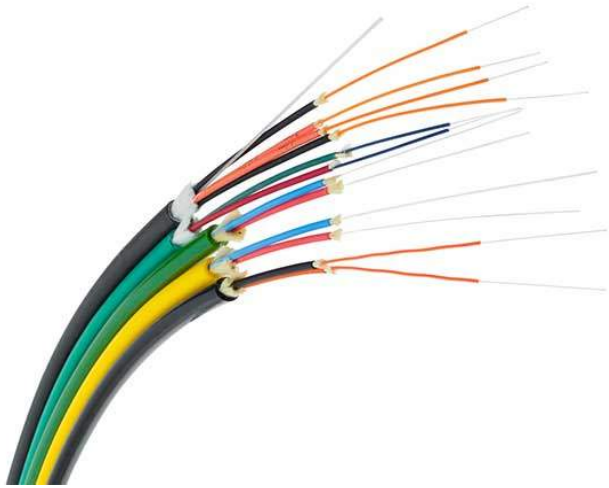
SC connector



ST connector

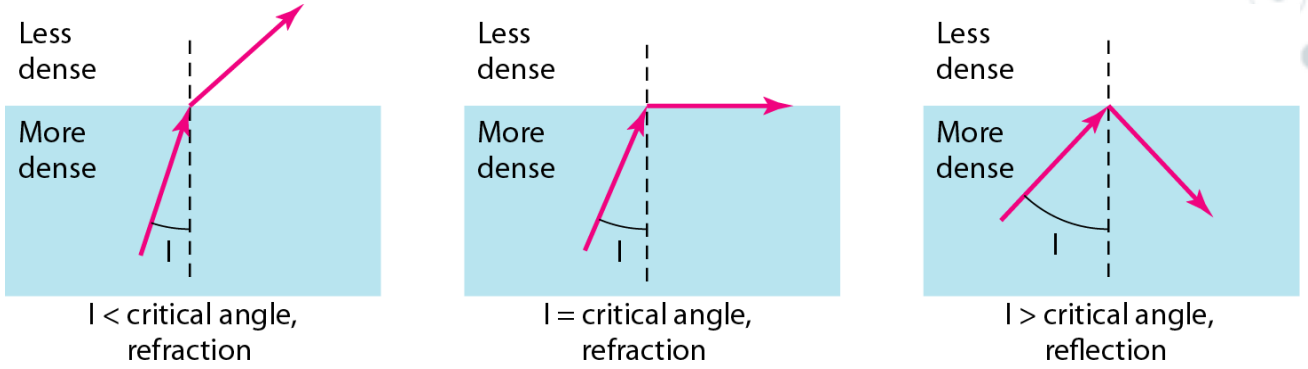


MT-RJ connector

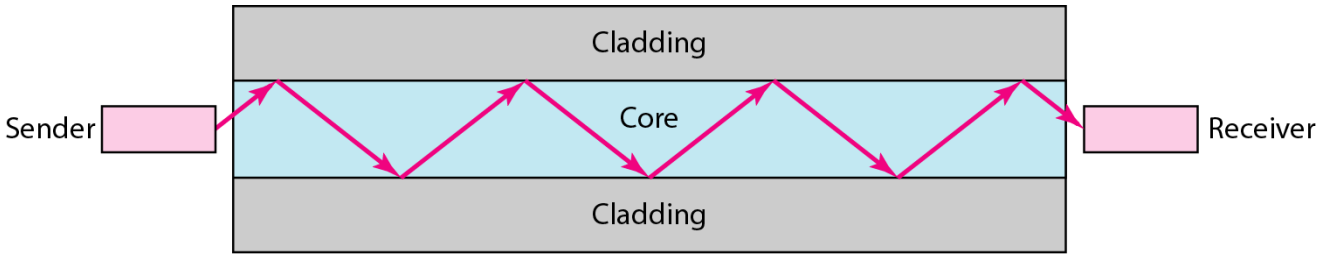


Transmission Media

Fiber Optic

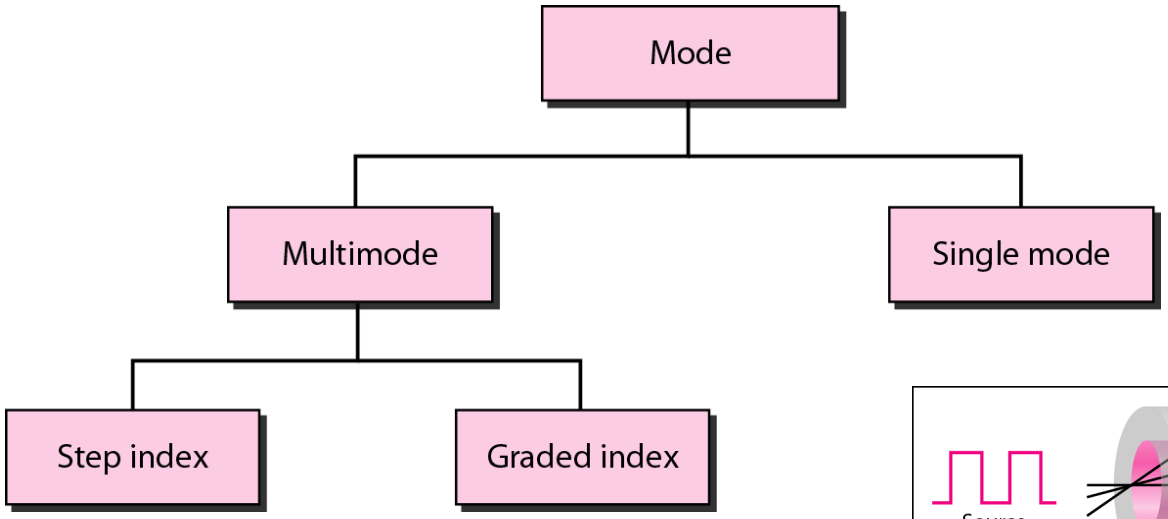


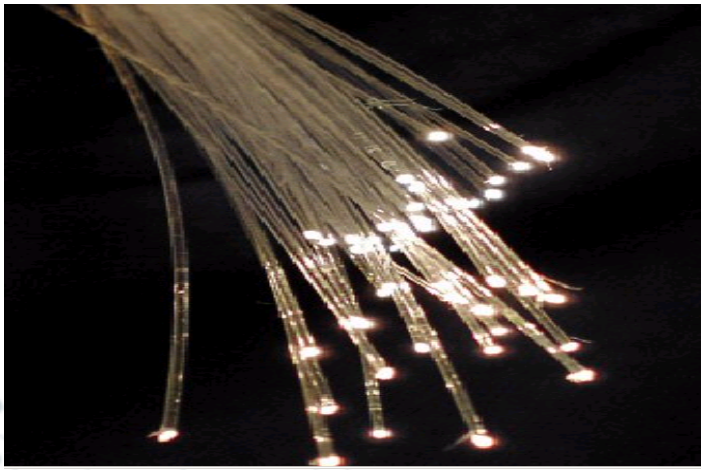
Bending of light ray

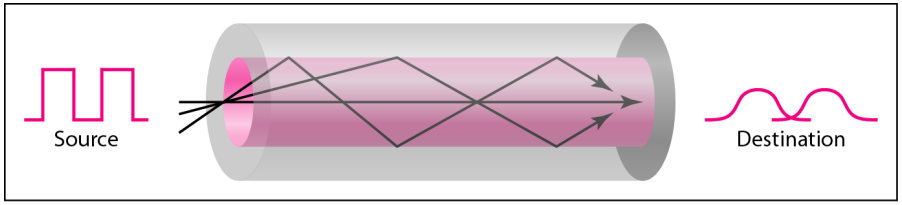


Transmission Media

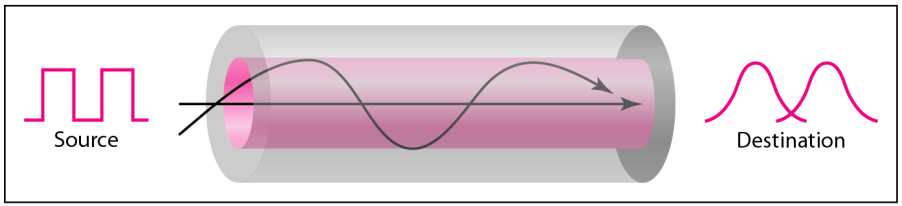
Fiber Optic - Propagation Modes



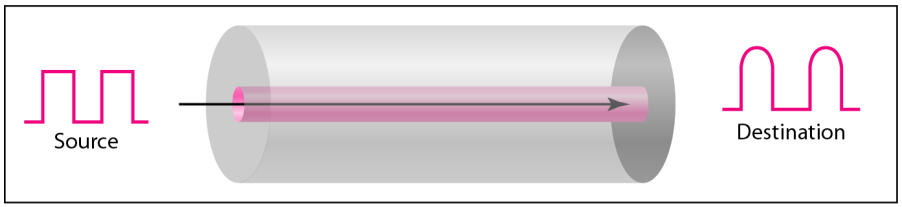




a. Multimode, step index



b. Multimode, graded index

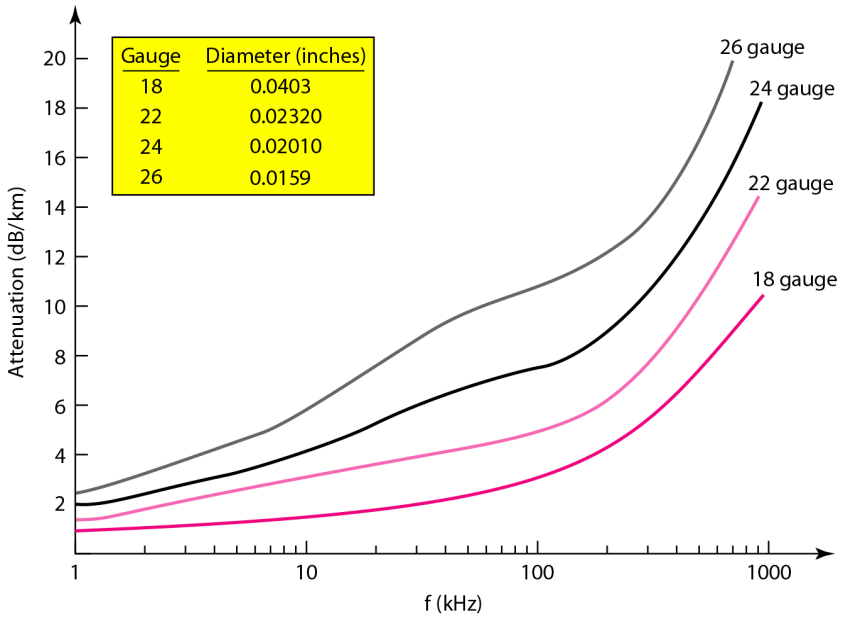


c. Single mode

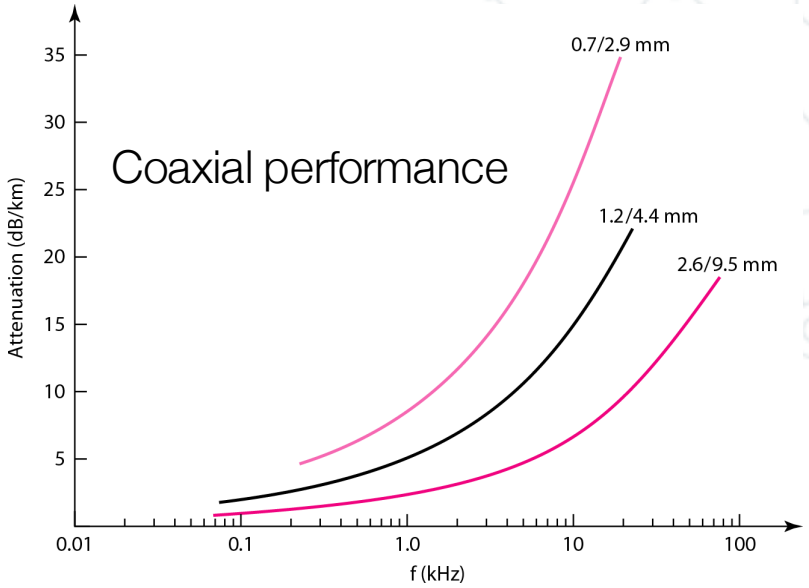
Transmission Media

Cable Performance

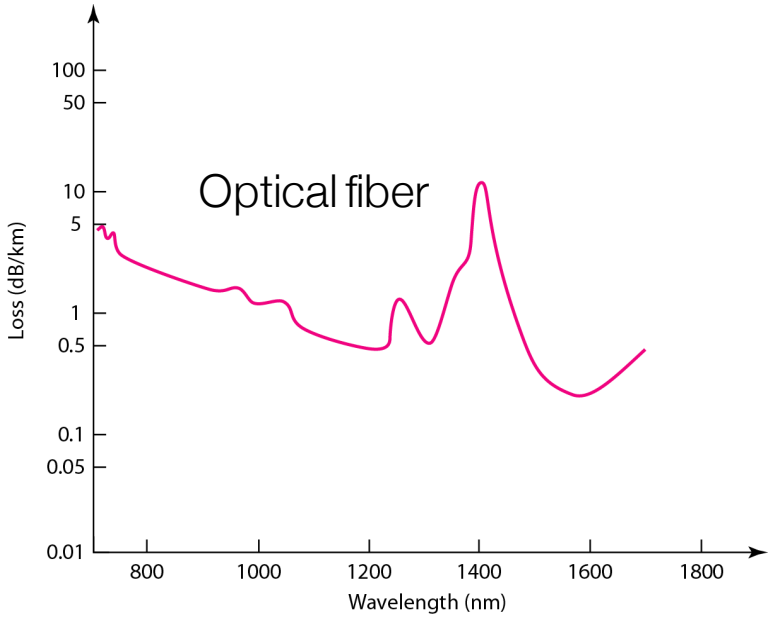
UTP performance



Coaxial performance



Optical fiber

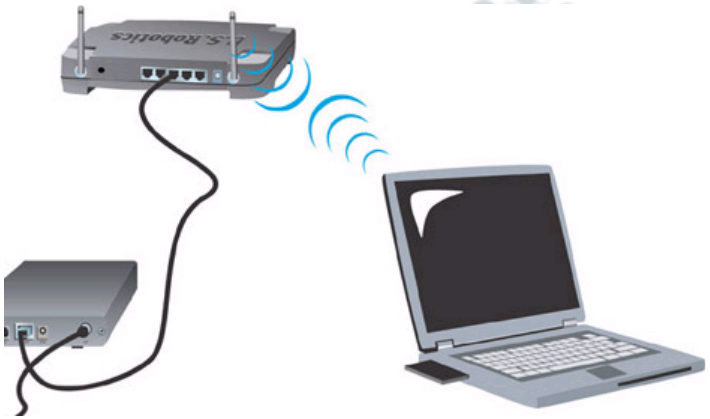


Transmission Media

Wireless Media

Wireless LAN or WLAN

Wireless local area network that uses radio waves as its carrier



Wi-Fi ("Wireless Fidelity“)

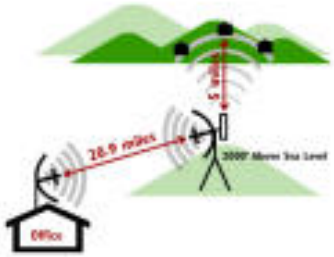
A set of standards for WLANs based on IEEE 802.11

Wi-Max

Emerging technology that can cover ranges up to 15 km or more

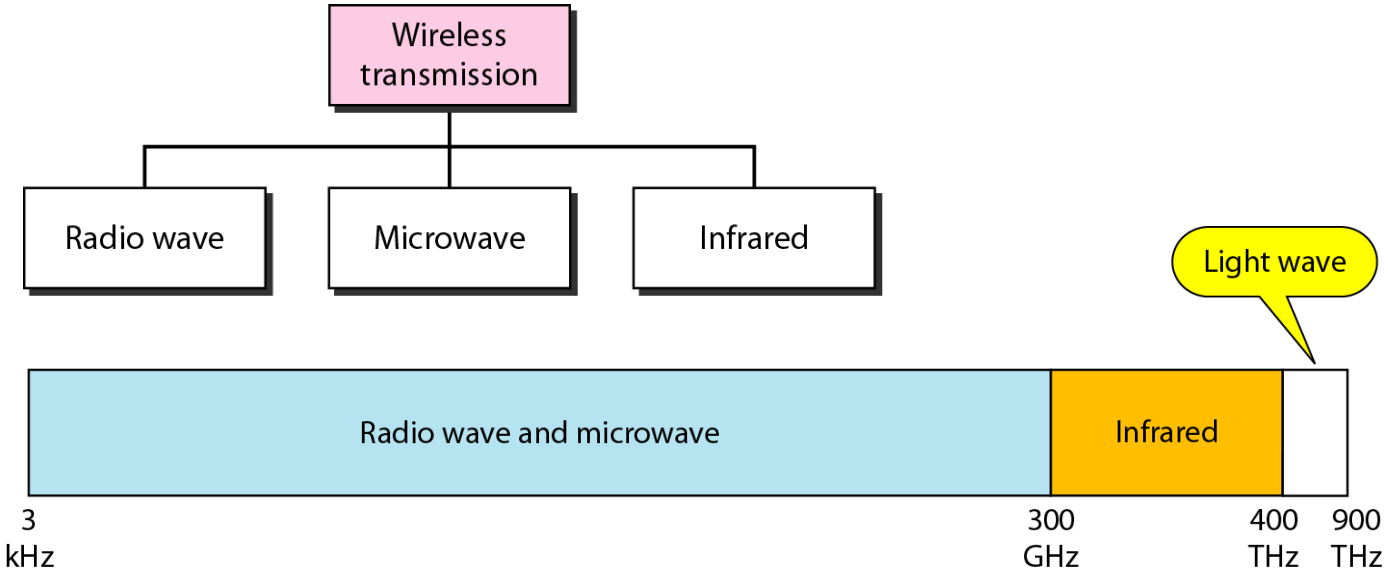
Satellite/Microwave

High speed media used for longer distances and remote locations

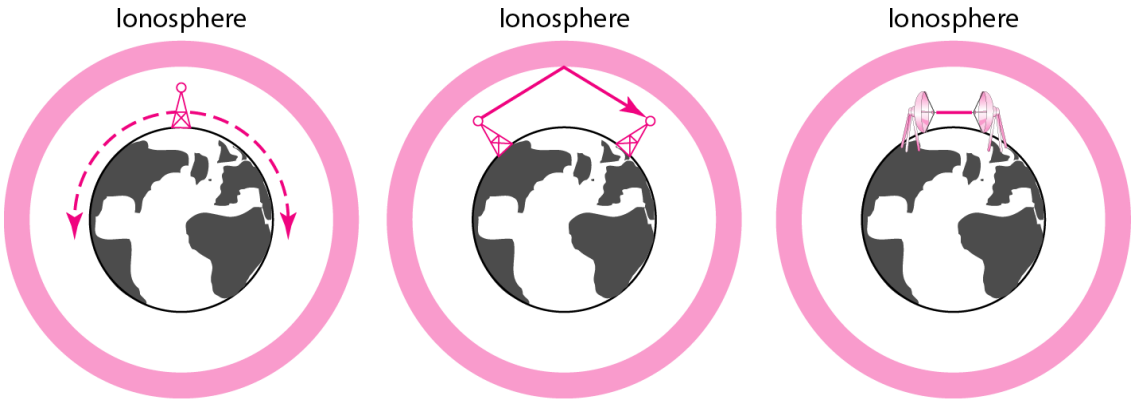


Transmission Media

Wireless Media – Wireless Transmission Wave



Propagation methods



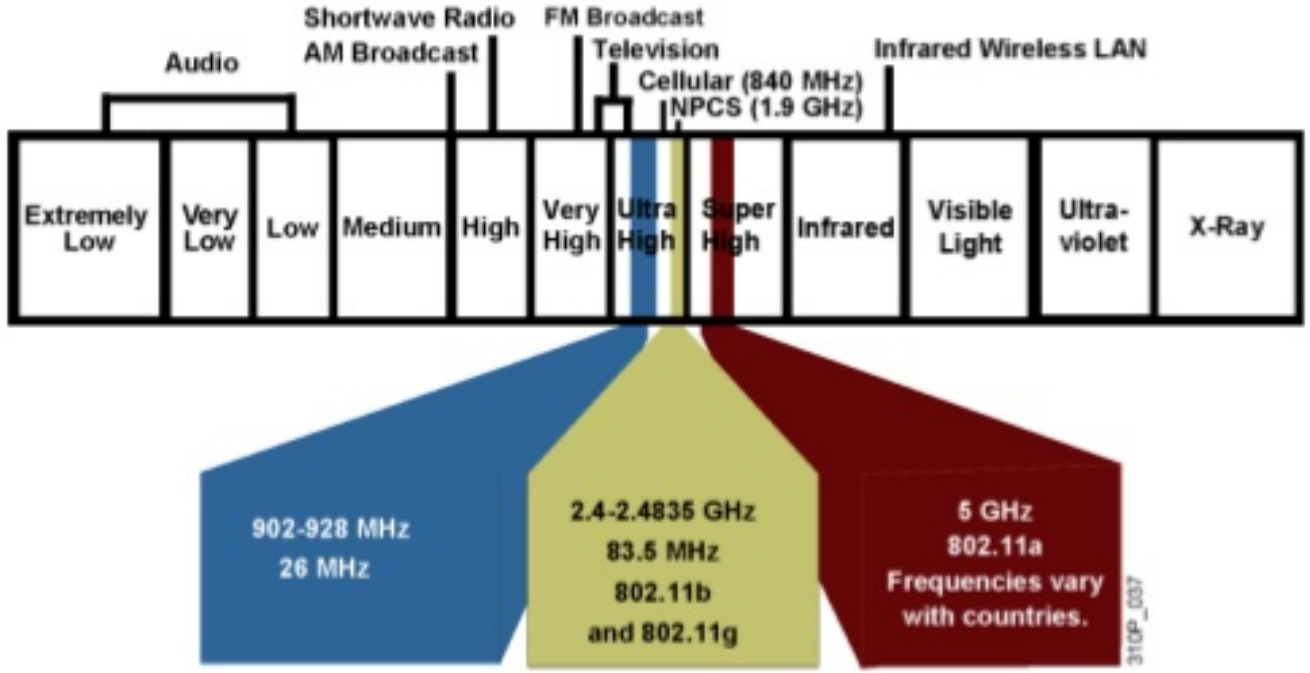
Transmission Media

Wireless Media – Wave Bands

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

Wireless Media – Unlicensed Frequency Bands



- ISM: Industry, scientific, and medical frequency band
- No license required

- No exclusive use
- Best effort
- Interference possible