

Physical Layer

Unit 2: Physical Layer and Network Media (4Hrs.)

- 2.1. Network Devices: Repeater, Hub, Switch, Bridge, Router
- 2.2. Different types of transmission medias (wired: twisted pair, coaxial, fiber optic, Wireless: Radio waves, micro waves, infrared)
- 2.3. Ethernet Cable Standards (UTP & Fiber cable standards)
- 2.4. Circuit, Message & Packet Switching
- 2.5. ISDN: Interface and Standards

Guided Transmission Media

- Twisted Pair
- Coaxial Cable
- Optical Fiber

Transmission Characteristics of Guided Media

	Frequency Range	Typical Attenuation	Typical Delay	Repeater Spacing
Twisted pair	0 to 3.5 kHz	0.2 dB/km @ 1 kHz	50 μ s/km	2 km
Coaxial cable	0 to 500 MHz	7 dB/km @ 10 MHz	4 μ s/km	1 to 9 km
Optical fiber	186 to 370 THz	0.2 to 0.5 dB/km	5 μ s/km	40 km

Twisted Pair ? Architecture

- Separately insulated
- Twisted together
- Often "bundled" into cables
- Usually installed in building during construction



(a) Twisted pair

Two Insulated copper wires

Issues:

- (1) Interference due to unwanted electrical coupling of two copper
- (2) Interference due to unwanted electrical coupling between the neighboring twisted pairs

Twisted Pair ☐ Applications

- Most commonly used medium
- **Telephone network**
 - *Between house and local exchange (subscriber loop)*

Twisted Pair - Pros and Cons

- **Advantages**

- Less expensive
- Easy to work with

- **Disadvantages**

- Low data rate
- Short range

Twisted Pair (TP) ☐ Characteristics

- **Analog transmission**
 - Amplifiers every 5km to 6km
- **Digital transmission**
 - Use either *analog* or *digital* signals
 - repeater every 2km or 3km
- **TP is Limited**
 - Distance
 - Bandwidth
 - Data rate
- **Susceptible to interference and noise**
 - Easy coupling of electromagnetic fields

Unshielded and Shielded TP

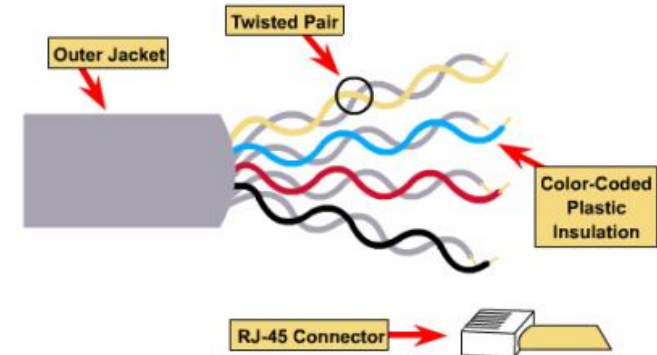
- **Unshielded Twisted Pair (UTP)**

- Ordinary telephone wire
- Less expensive
- Weak immunity against noise and interference
- Suffers from external EM interference

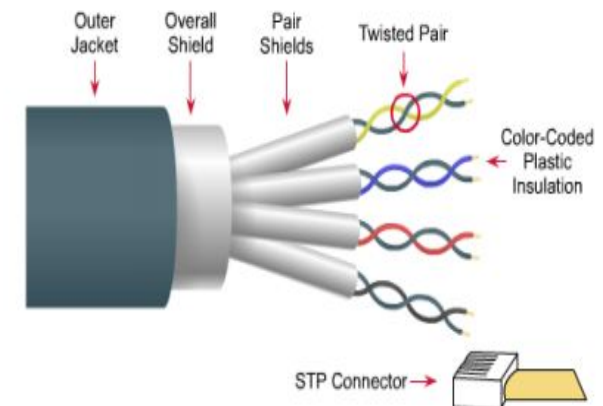
- **Shielded Twisted Pair (STP)**

- An extra metallic sheath on each pair
- Relatively more expensive
- Provide better performance than UTP
 - Increased Data rate
 - Increased Bandwidth

Unshielded Twisted Pair (UTP)



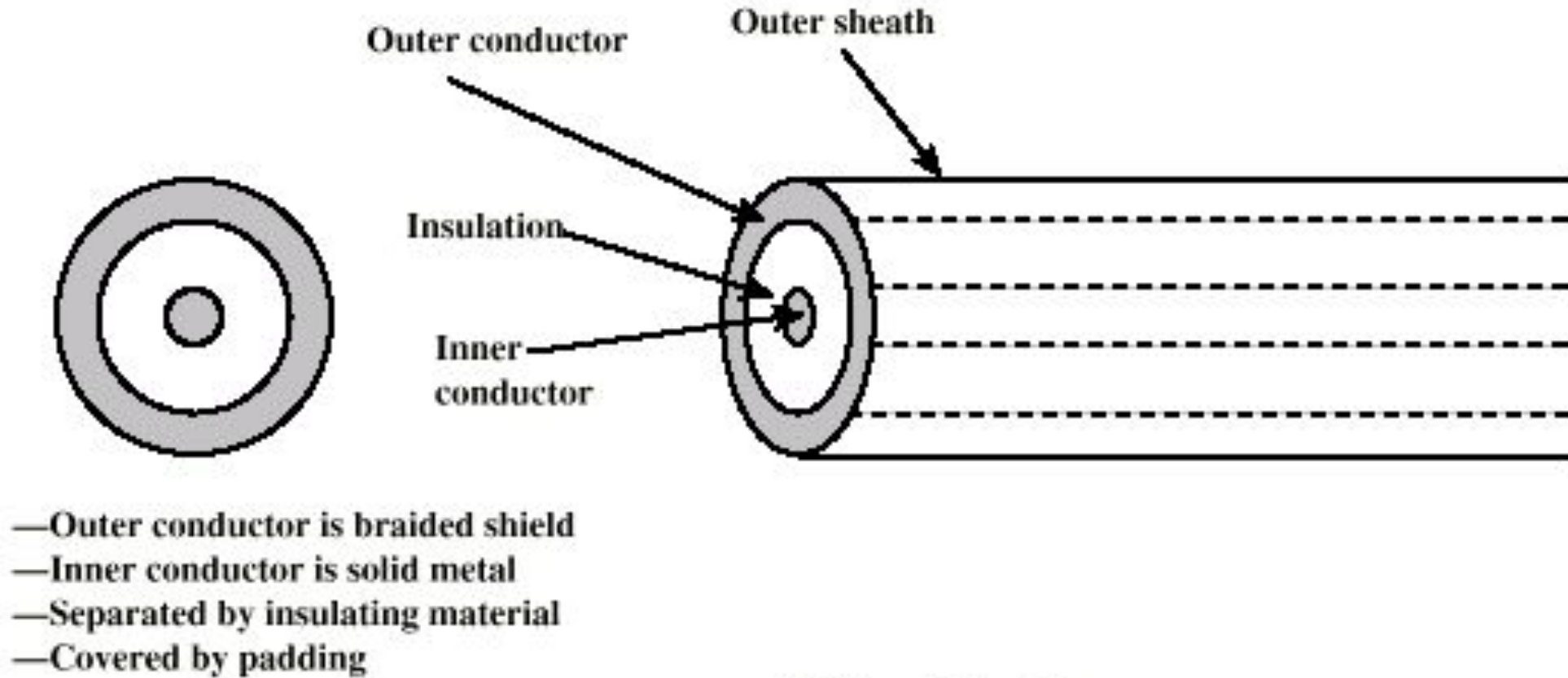
STP (Shielded Twisted Pair)



UTP Categories

- **Cat 3**
 - up to 16MHz
 - Voice grade found in most offices
 - Twist length of 7.5 cm to 10 cm
- **Cat 4**
 - up to 20 MHz
- **Cat 5**
 - up to 100MHz
 - Commonly pre-installed in new office buildings
 - Twist length 0.6 cm to 0.85 cm
- **Cat 6**
- **Cat 7**

Coaxial Cable ☐ Architecture



Coaxial Cable ☐ Applications

- Television (TV) signals distribution
- Long distance telephone transmission
- Short distance computer systems links

Coaxial Cable ☐ Characteristics

- **Analog**

- Amplifiers every few km
- Up to 500MHz

- **Digital**

- Repeater every 1km

- **Problem**

- Inter-modulation noise
- Thermal noise

Coaxial Cable ☐Types

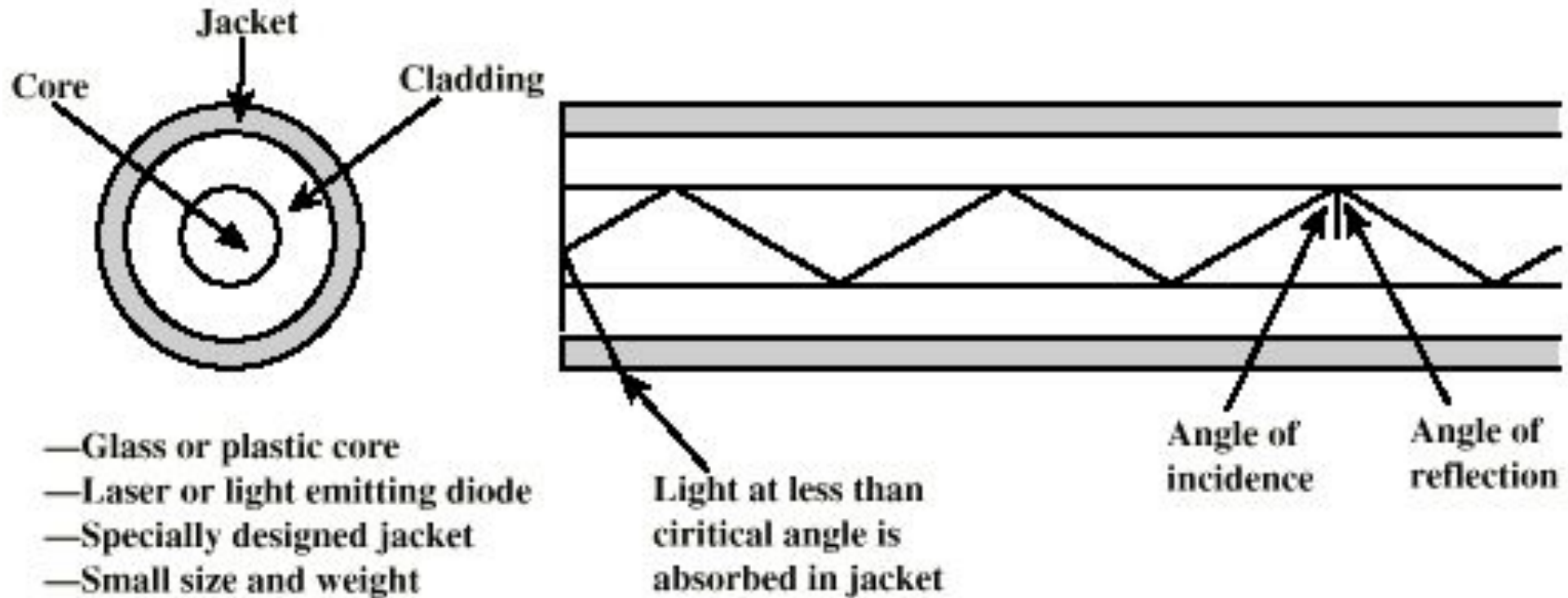
- **Thick Net**

- 0.38 inch in diameter
- Also called 10b5 cable, which means speed 10 mbps and signal can be strong up to 500m.

- **Thin Net**

- 0.25 inch in diameter.
- Similar to the material commonly used in cable TV.
- Also called 10b2 cable, means 10 mbps and can carry up to 200 m before being weak.

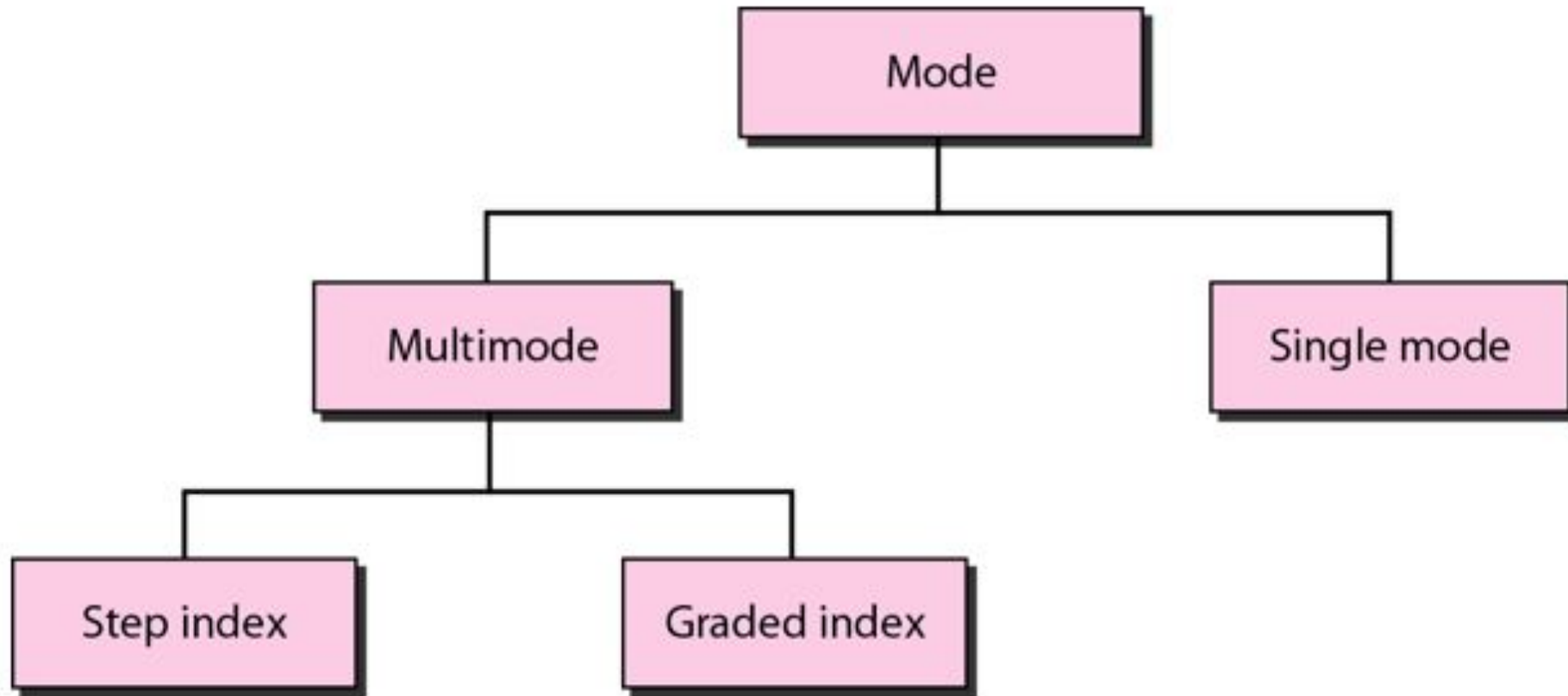
Optical Fiber Architecture

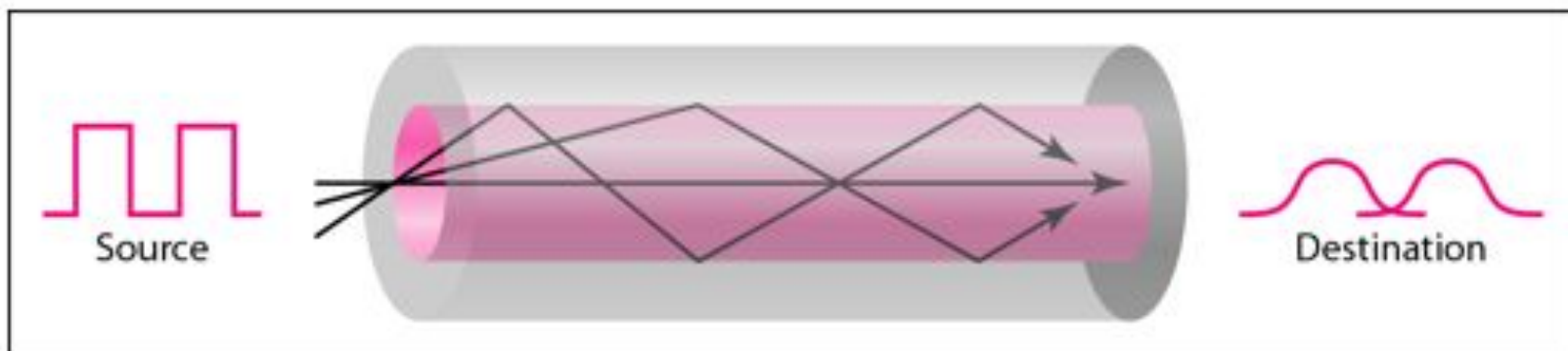


Optical Fiber ☐ Benefits

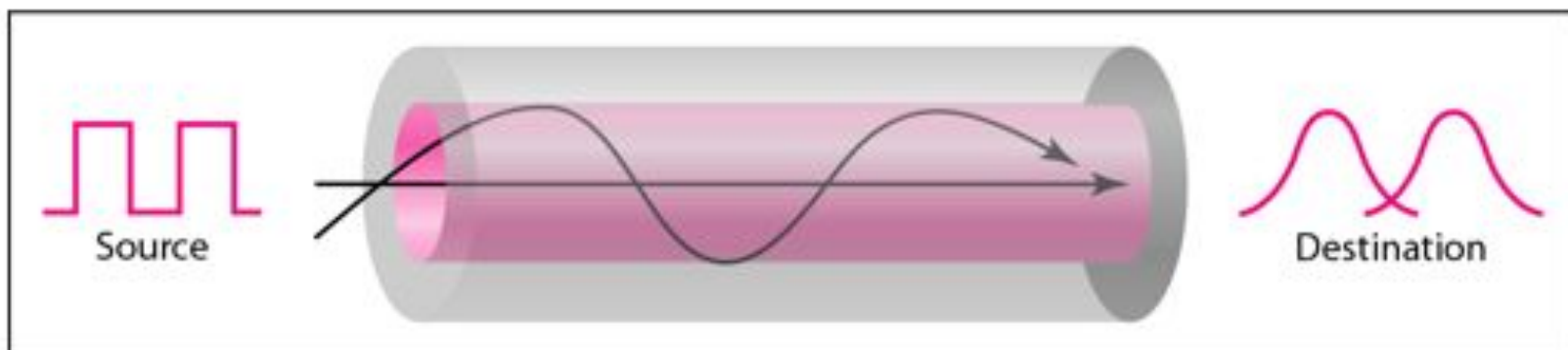
- **Greater capacity**
 - *Data rates of hundreds of Gbps*
- **Smaller size & weight**
 - *Made up of extremely thin fibers*
- **Lower attenuation**
 - *Electromagnetic isolation*
- **Greater repeater spacing**
 - *10s of km at least*

Optical Fiber – Mode

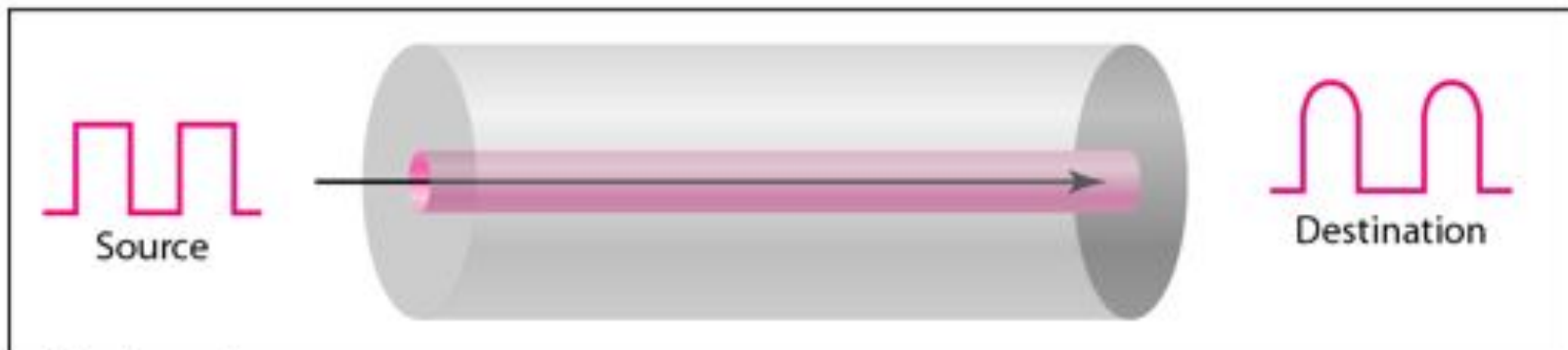




a. Multimode, step index



b. Multimode, graded index



c. Single mode

Multimode

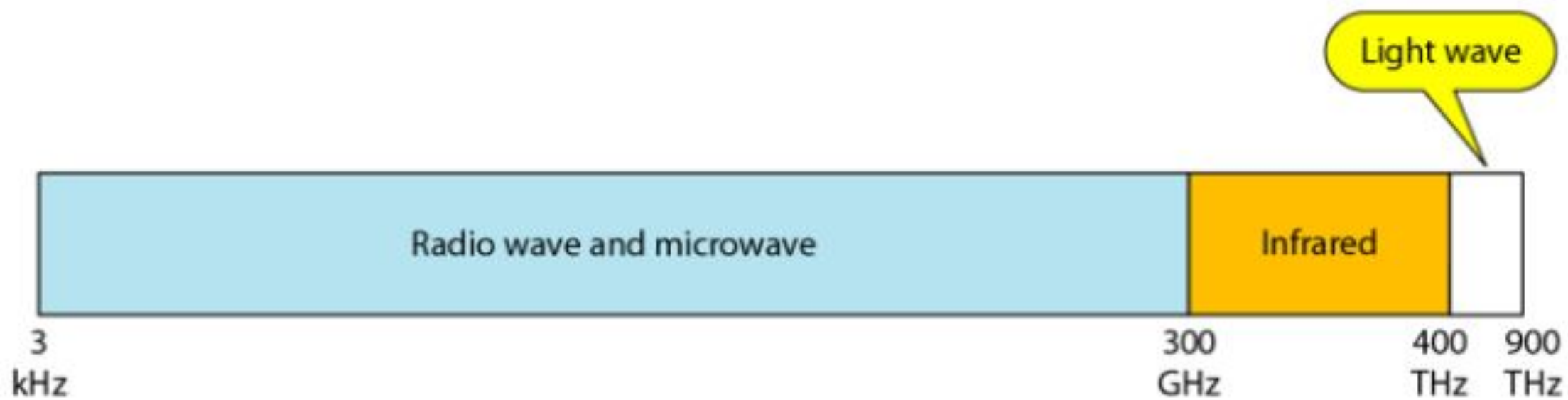
- Multimode is so named because multiple beams from a light source move through the core in different paths.
- In **multimode step-index fibre**, the density of the core remains constant from the centre to the edges. A beam of light moves through this constant density in a straight line until it reaches the interface of the core and the cladding.
The term step-index refers to the suddenness of this change, which contributes to the distortion of the signal as it passes through the fibre.
- In **multimode graded-index fibre**, this distortion gets decreases through the cable. The word index here refers to the index of refraction. This index of refraction is related to the density. A graded-index fibre, therefore, is one with varying densities. Density is highest at the centre of the core and decreases gradually to its lowest at the edge.

Single mode

- Single mode uses step-index fibre and a highly focused source of light that limits beams to a small range of angles, all close to the horizontal.

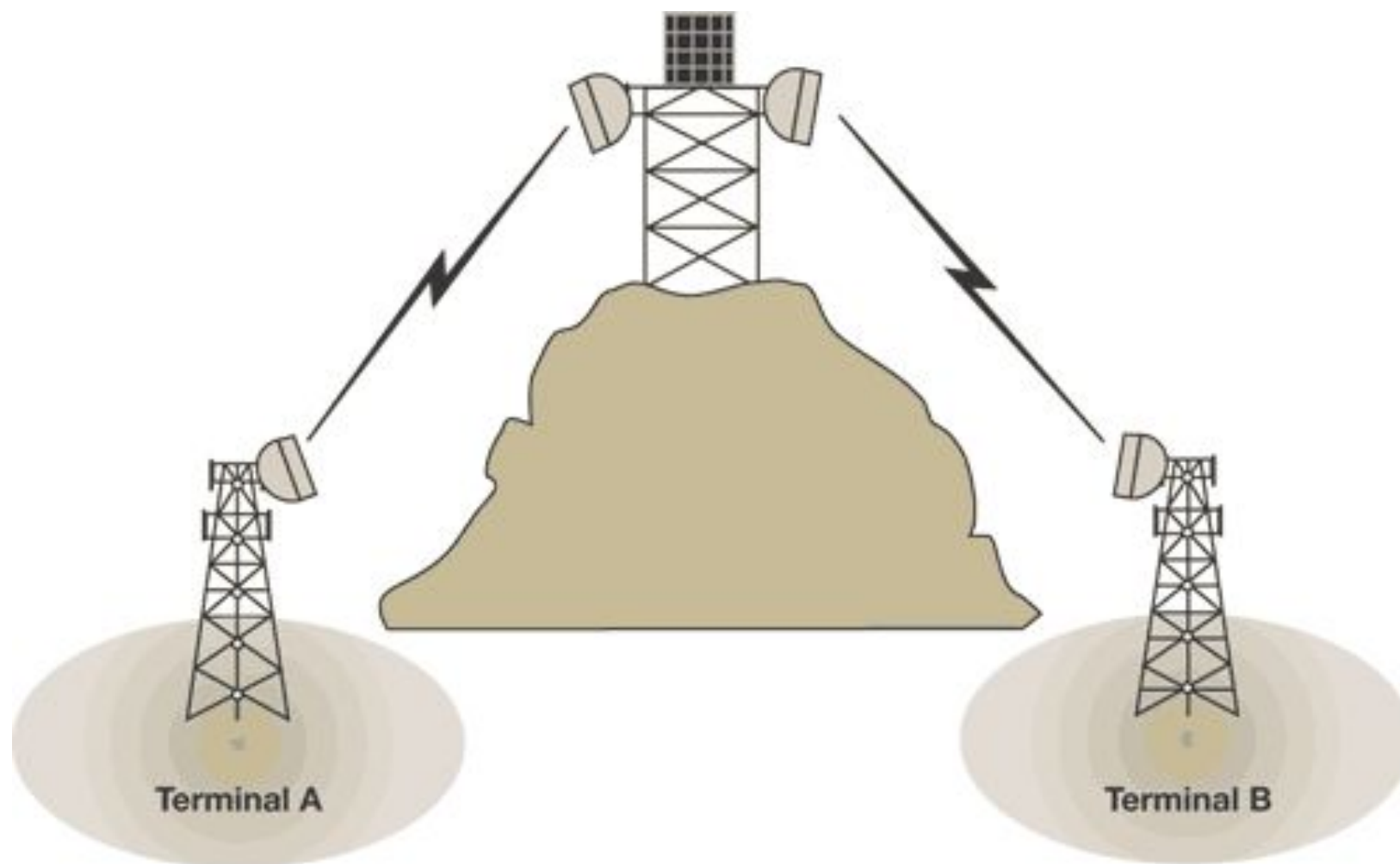
Unguided Media

- The waves propagate in the atmosphere and in outer space, such as in a wireless LAN or a digital satellite channel.
 - Terrestrial Radio Channel
 - Satellite Radio Channel



Terrestrial Radio Channel

- Carry signals in the electromagnetic spectrum.
- No need of physical wire to be installed, can penetrate walls, provide connectivity to mobile user, and potentially carry a signal for long distances.
- Suffers from path loss
- E.g. wireless LAN, cellular access technology.

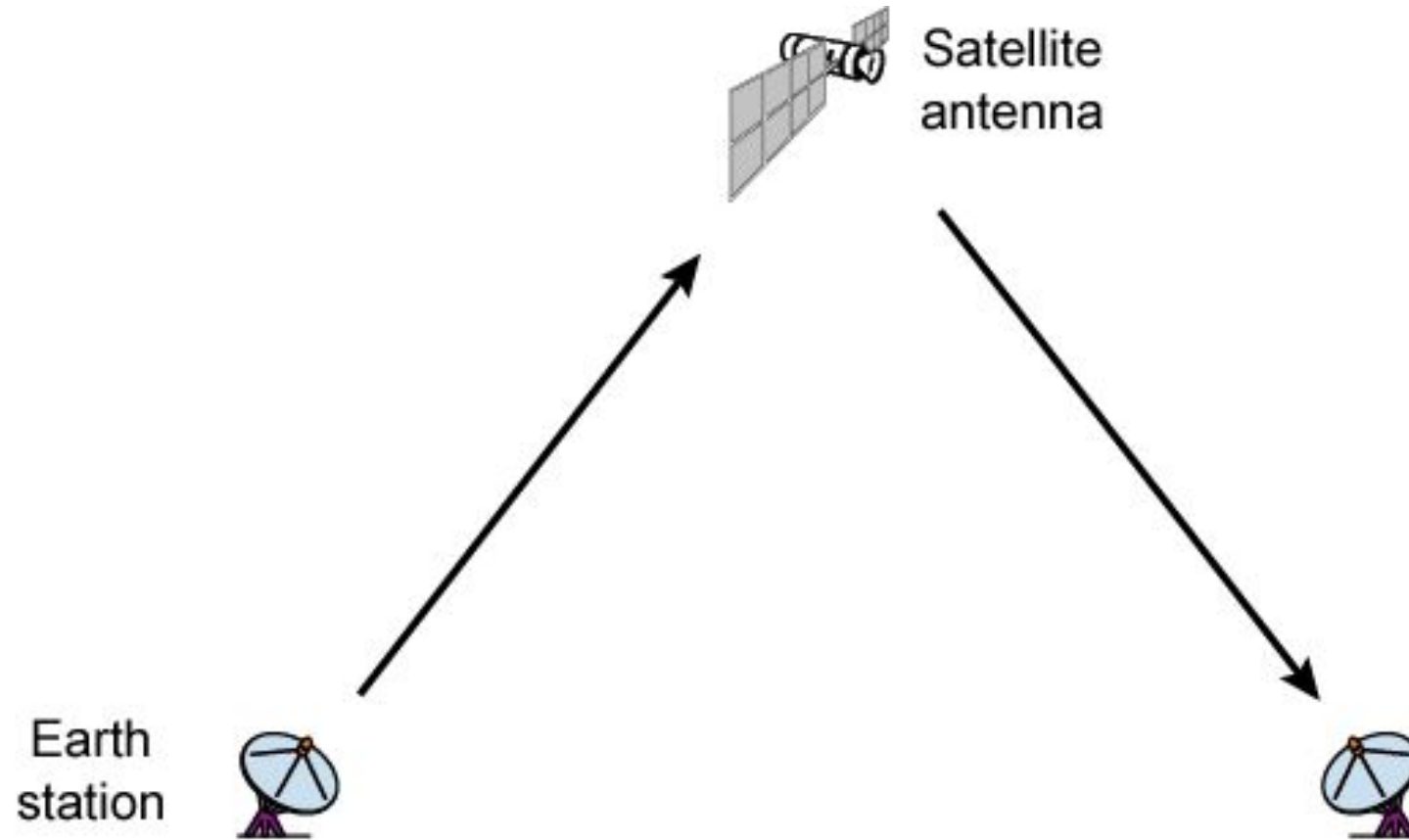


1. A microwave repeater link is designed to transfer signals from one terminal station to another without loss of traffic or signal performance.

Satellite Communication

1. Satellite is relay station
2. Satellite
 - receives on one frequency
 - amplifies or repeats signal
 - transmits on another frequency
3. Applications
 - Television
 - Long distance telephone
 - Private business networks

Satellite Communication



Satellite Communication

- **Geostationary Satellite**

- Permanently remain above the same spot on Earth
- Propagate delay of 280 ms.
- Geo-stationary orbit
 - Height of 35,784km

- **Low Earth Orbiting (LEO) satellite**

- Placed much closer to Earth and do not remain permanently above one spot on Earth.
- Rotate around Earth and may communicate with each other as well as with ground stations.
- For continuous coverage, many satellites need to be placed.

Network Edge

- **End System**
- End system are also referred to as host because they host (run) application program such as a web browser program, a web server program, an email reader program.
- Host are further divided into two categories:
 - Clients
 - Servers

Network Access

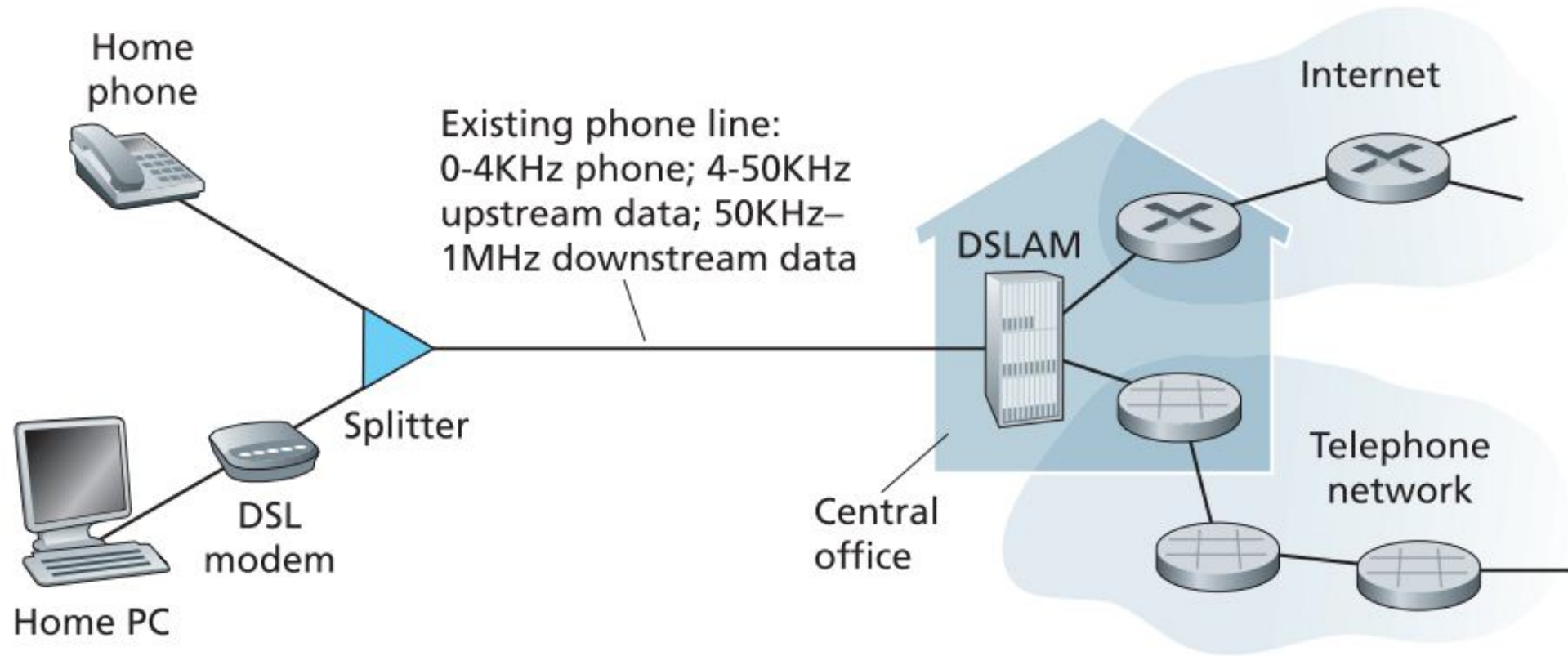
- **Dial-Up**

- Accessing the internet over ordinary analog telephone lines using a dial-up modem.
- The term “dial-up” is used because the user software actually dials an ISP’s phone number and makes a traditional phone connection with the ISP.
- **Two major drawbacks:**
 - Extremely slow, maximum 50 kbps.
 - Cannot use phone line while accessing internet.

- **DSL (Digital Subscriber Line)**

- DSL internet is accessed from the same company that provides it wired local phone access.
- High data rate (download 1-2 mbps, upload 128 kbps-1mbps)
- Users can simultaneously talk on the phone and access internet.

Network Access



Network Access

- **Cable**

- Cable internet access make the use of cable TV company's existing infrastructure
- Both the fiber and co-axial cable are employed, it is also called hybrid fiber coax (HFC)
- Requires cable modem, which connects to the home PC through Ethernet port.

- **Wireless Network**

- Wireless LAN (Wi-Fi)
 - IEEE 802.11
- Wide Area Wireless Access e.g.:- 3G, GPRS.
- WiMAX
 - Intel WiMAX 2009
 - k/a IEEE 802.16 is a long distance derivation of the 802.11 WiFi protocol speed 5-10 Mbps.

Network Core-Switching

- Switching is a method in which communication devices are connected to one another for data transmission.
- Three types of switching:
 - Circuit switching
 - Message switching
 - Packet switching

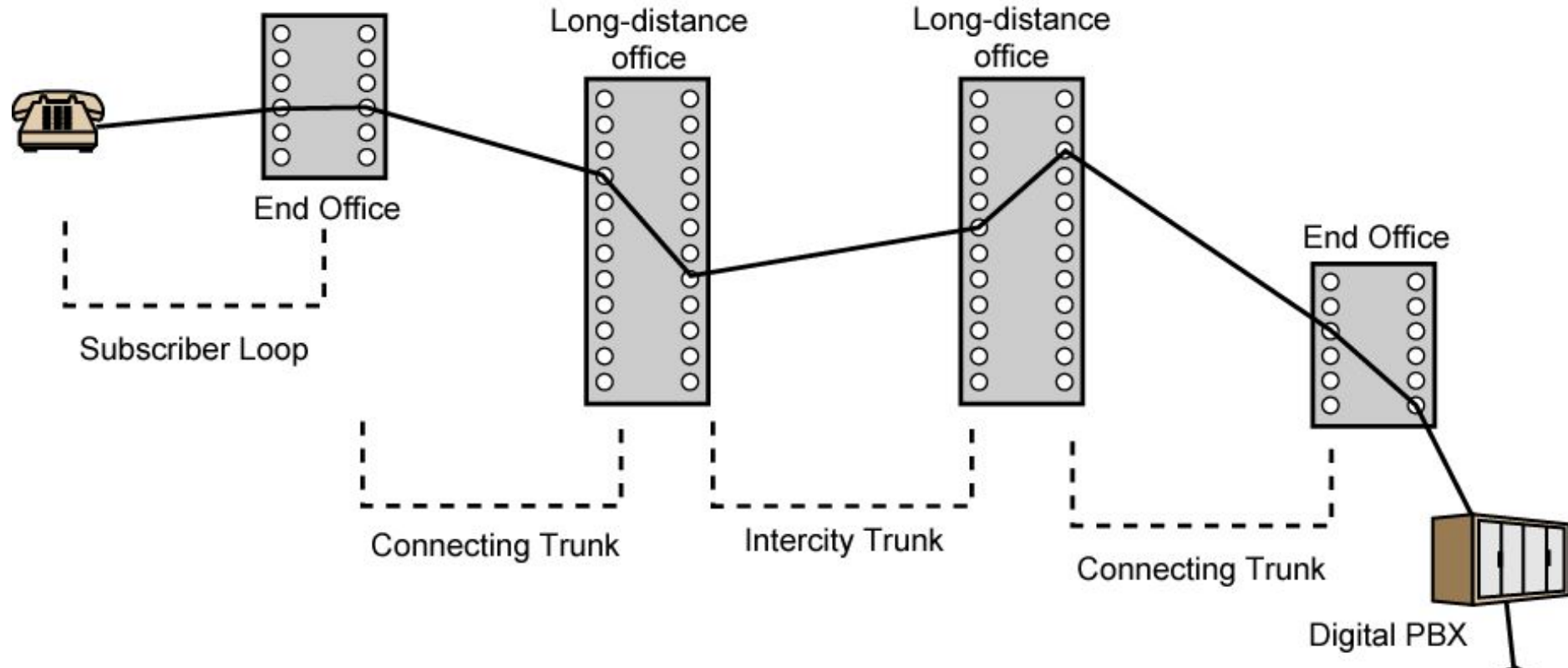
Circuit Switching

- Dedicated communication path between two stations
- It creates a direct physical connection between two devices such as phone, computer etc.
- Circuit switching was developed to handle voice traffic but can handle digital data.
- Three phases
 - Establish
 - Transfer
 - Disconnect

Circuit Switching

- Inefficient
 - Channel capacity dedicated for duration of connection
 - If no data, capacity wasted
- Set up (connection) takes time
- Once connected, transfer is transparent
- Developed for voice traffic (phone)

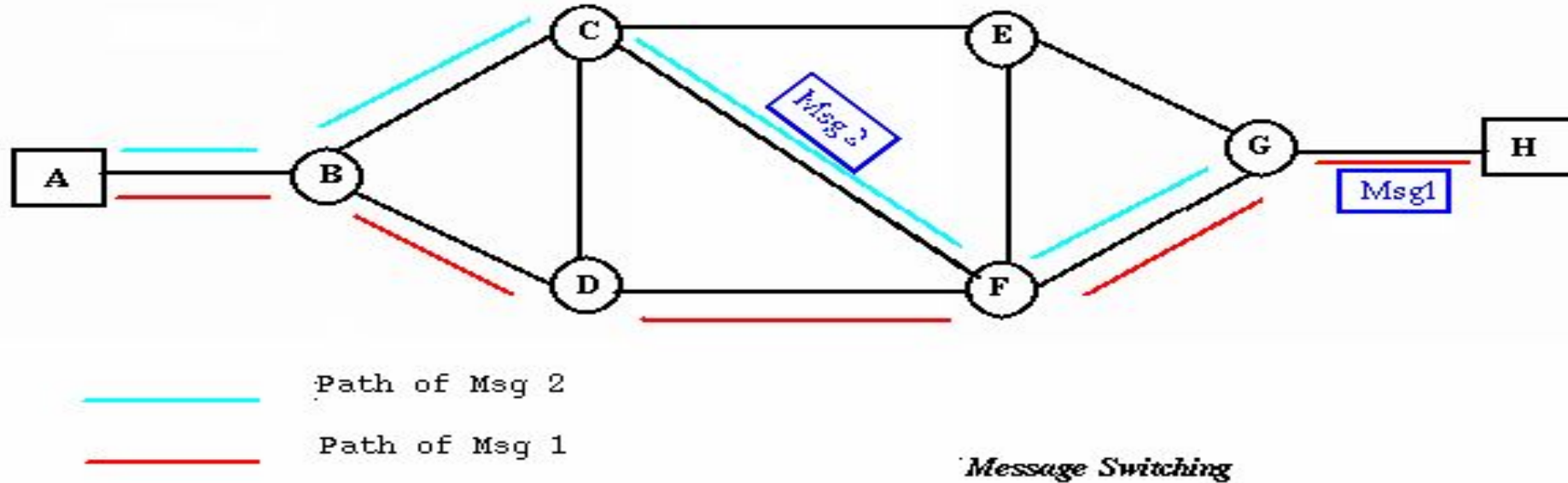
Public Circuit Switched Network



Message Switching

- With message switching there is no need to establish a dedicated path between two stations.
- When a station sends a message, the destination address is appended to the message.
- The message is then transmitted through the network, in its entirety, from node to node.
- Each node receives the entire message, stores it in its entirety on disk, and then transmits the message to the next node.
- This type of network is called a store-and-forward network.

Message Switching



A message-switching node is typically a general-purpose computer. The device needs sufficient secondary-storage capacity to store the incoming messages, which could be long. A time delay is introduced using this type of scheme due to store- and-forward time, plus the time required to find the next node in the transmission path.

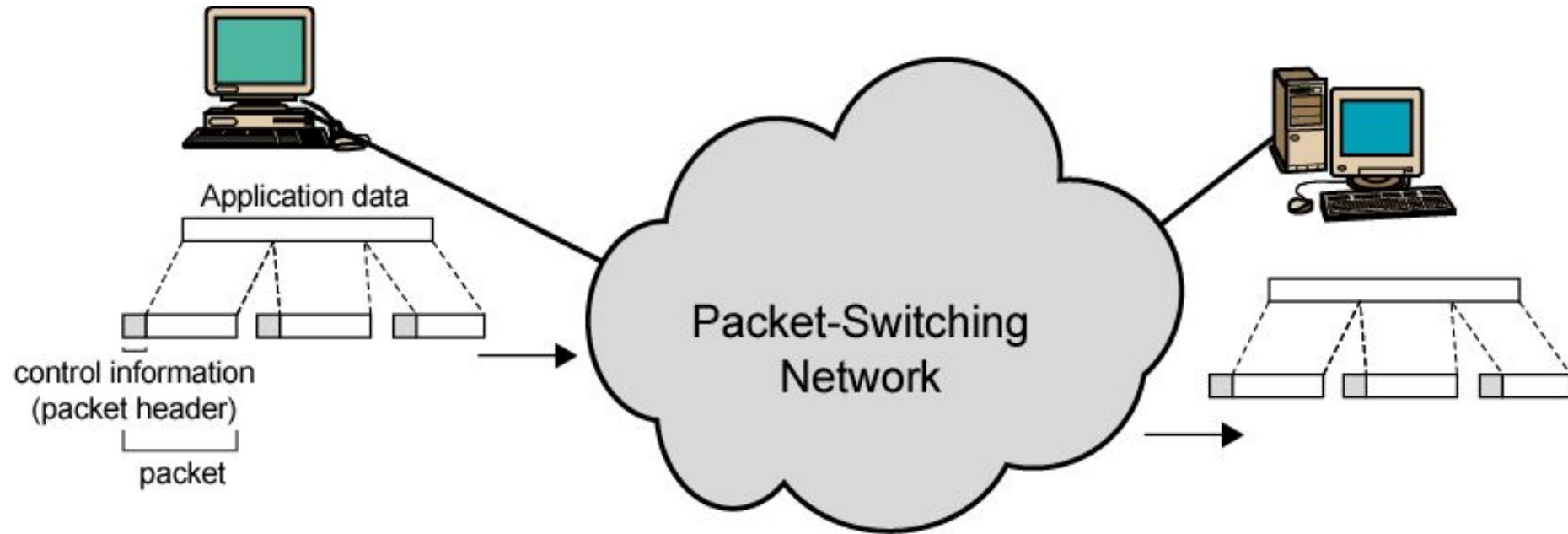
Packet Switching Principles

- Circuit switching designed for voice
 - Resources dedicated to a particular call
 - Much of the time a data connection is idle
 - Data rate is fixed
 - Both ends must operate at the same rate
- In packet switching, data are packetized and sent packet by packet.

Basic Operation

- Data transmitted in small packets
 - Longer messages split into series of packets
 - Each packet contains a portion of user data plus some control information for routing
- Control info
 - Routing (addressing) info
- Packets are received, stored briefly (buffered) and past on to the next node
 - Store and forward

Use of Packets



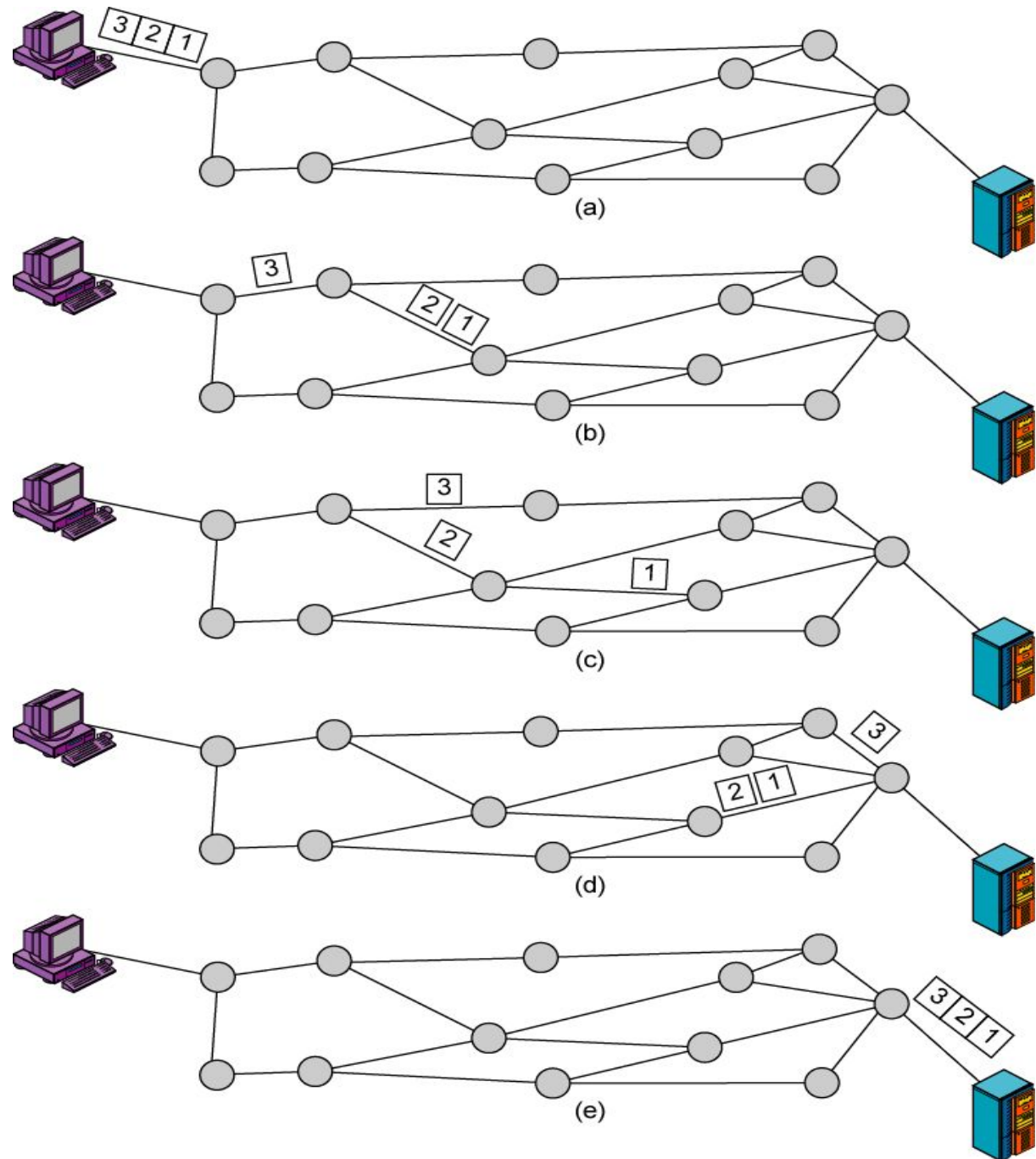
Packet Switching Technique

- Station breaks long message into packets
- Packets sent one at a time to the network
- Packet switching uses two different approaches
 - Datagram
 - Example: Internet
 - Virtual circuit
 - Examples: X.25, Frame relay, ATM technologies.

Datagram

- Each packet treated independently
- Packets can take any practical route
- Packets may arrive out of order
- Packets may go missing

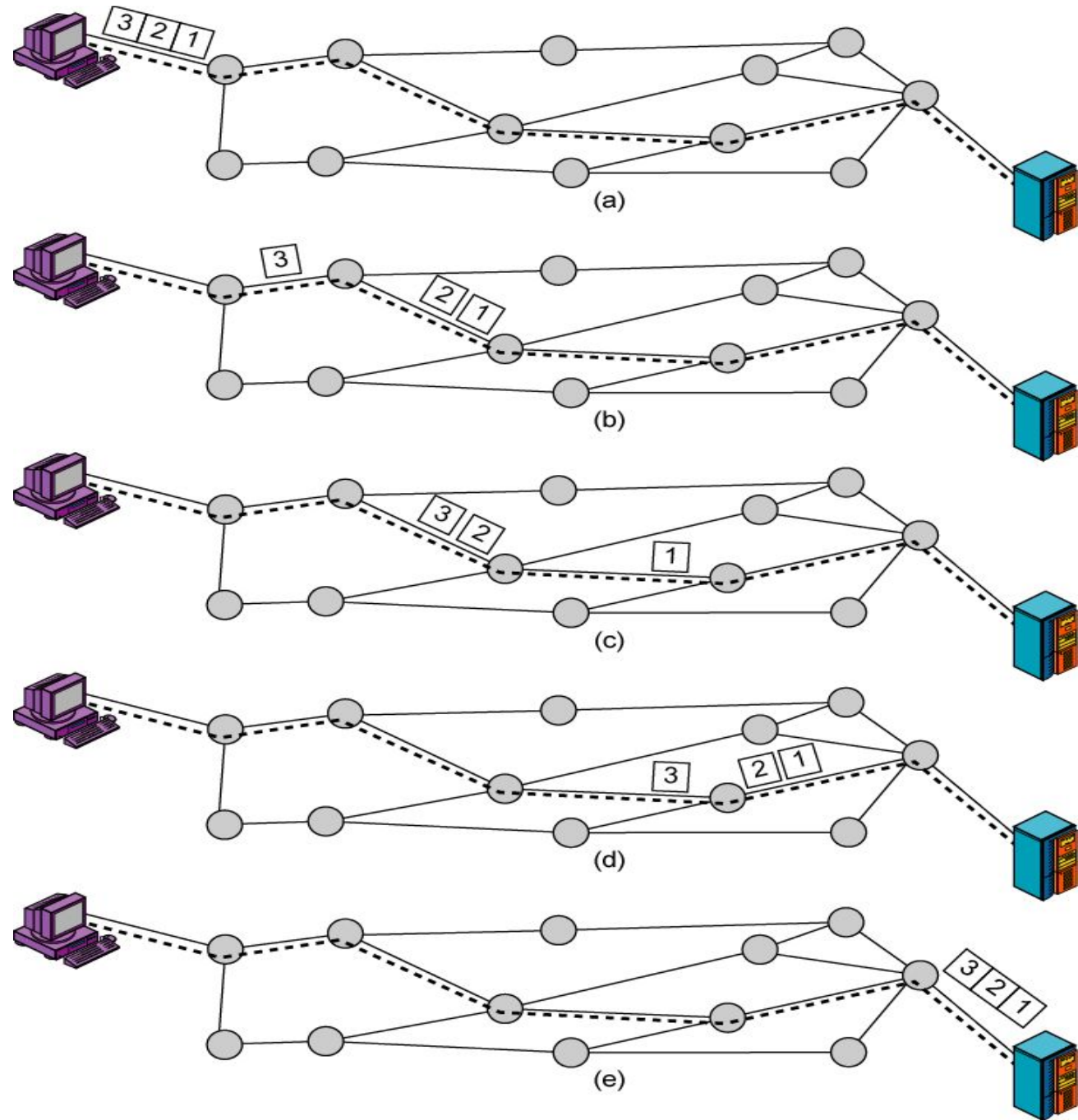
Datagram Diagram



Virtual Circuit

- Preplanned route established before any packets sent
- Call request and call accept packets establish connection (handshake)
- Each packet contains a virtual circuit identifier instead of destination address
- No routing decisions required for each packet

Virtual Circuit Diagram

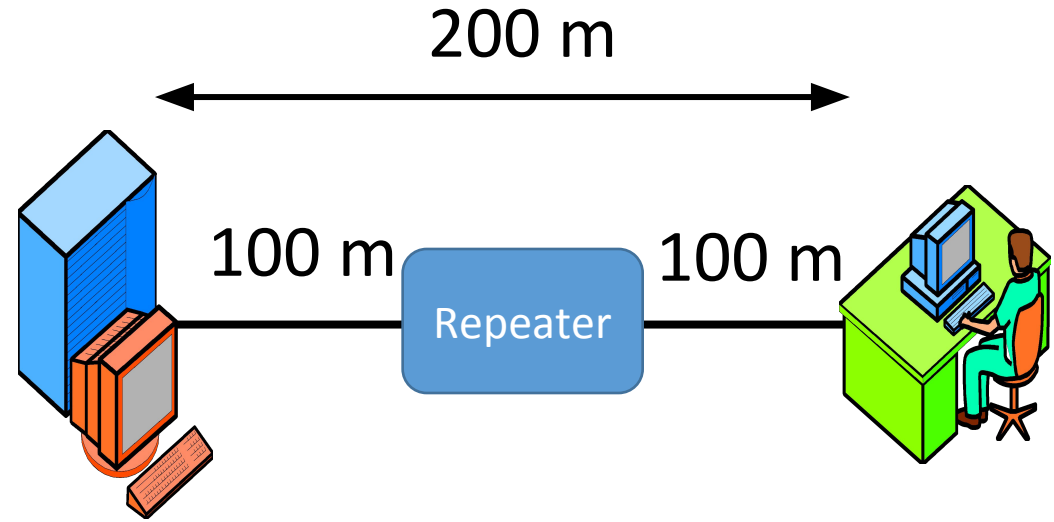


Virtual Circuits vs. Datagram

- Virtual circuits
 - Network can provide sequencing and error control
 - Packets are forwarded more quickly
 - No routing decisions to make
 - Less reliable
 - Loss of a node loses all circuits through that node
- Datagram
 - No call setup phase
 - Better if few packets
 - More flexible
 - Routing can be used to avoid congested parts of the network

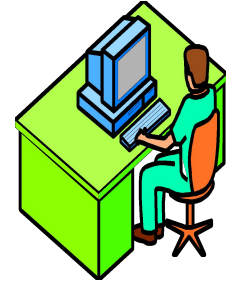
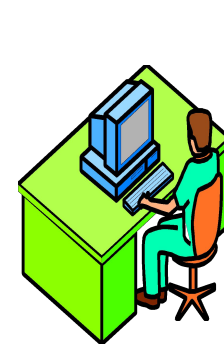
Networking Devices

- Repeater
 - Physical Layer Device
 - Regenerates the signal
 - Extend the distance over which a signal may travel down a cable
 - It is an electronic device that receives a signal and retransmits it at a higher level or higher power, and onto the other side of an abstraction, so that the signal can cover long distances.



Networking Devices

- Hub
 - Physical Layer Device
 - Like a Multiport Repeater
 - Two Types
 - Active Hub
 - Regenerates Signal, needs power
 - Passive Hub
 - A simple Connector (no signal Regeneration)
 - It has multiple I/O ports, in which a signal introduced at the input of any port appears at the output of every port except the original incoming.

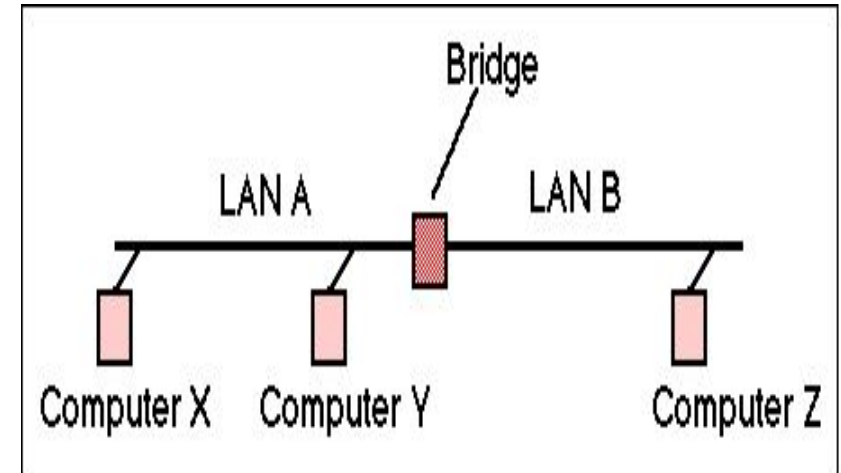


Networking Devices

- Bridge

- Data Link Layer Device
- Maintains MAC table with MAC address and port no. and decides whether to forward the frame or not.
- Divides Network into different LAN Segments
- Smarter than Repeaters

MAC Address	Port No.
2A-3B-AB-45-3B-5F	1
1b-3B-43-45-3B-4F	2
3F-35-6B-46-30-5F	1



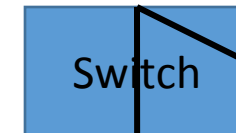
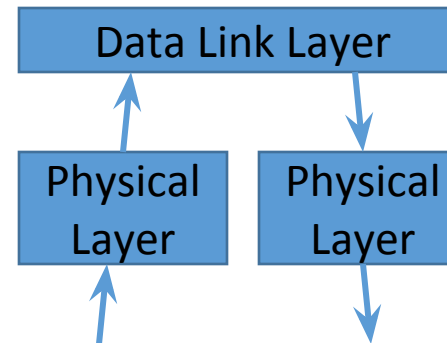
Networking Devices

- Switch

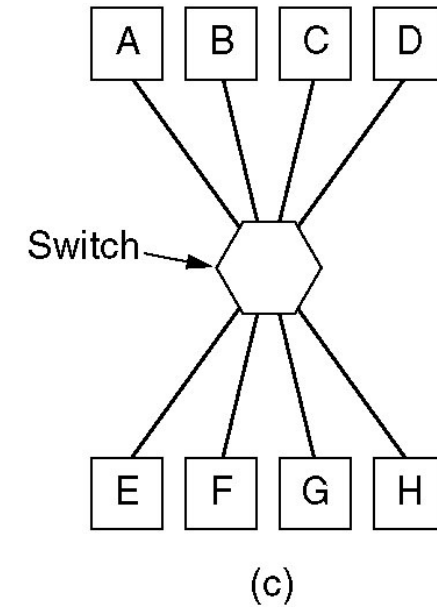
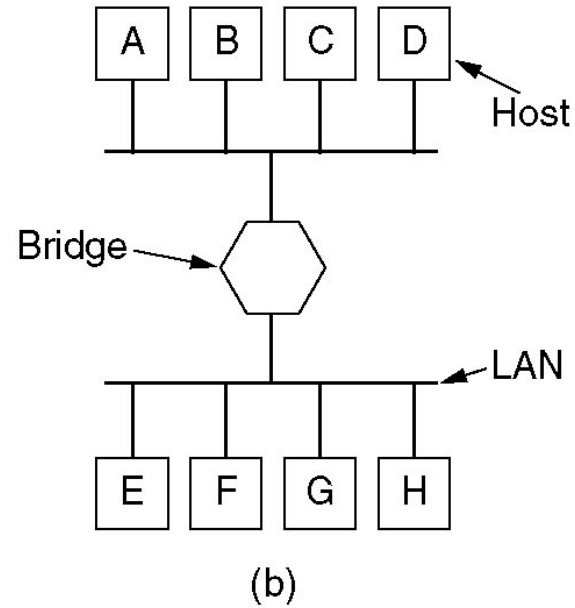
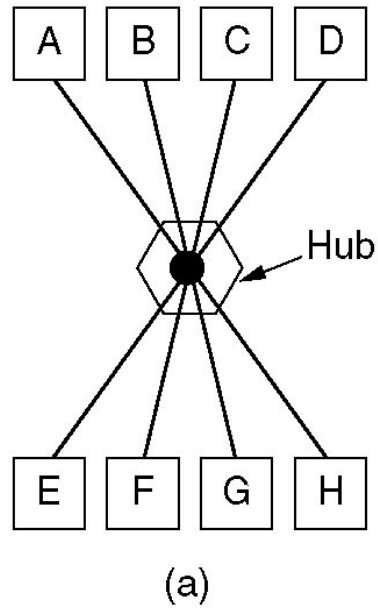
- Data Link Layer Device
- A Multiport Bridge
- Divides Network into different LAN Segments



MAC Address	Port No.
2A-3B-AB-45-3B-5F	1
1b-3B-43-45-3B-4F	2
3F-35-6B-46-30-5F	3



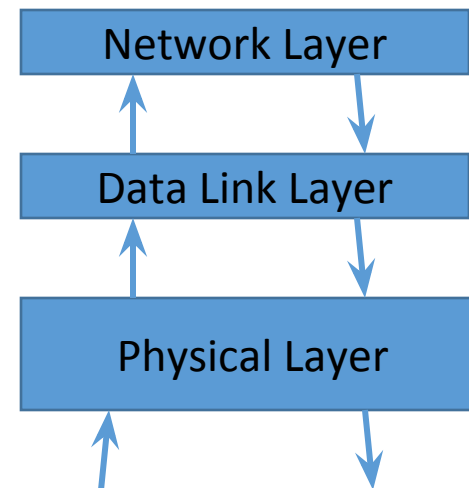
Networking Devices



(a) A hub. (b) A bridge. (c) a switch.

Networking Devices

- Routers
 - Network Layer Device
 - Able to analyse Network layer address and find the route
 - Maintains Routing table to route packet to destⁿ address
 - Expensive and Slower than switch
 - Supports Hierarchical addressing
 - “Use Switch where you can,
Use Router where you must.”



Networking Devices

- Gateway
 - Allows devices in different networks to communicate
 - Generic term for routers
 - The term “gateway” is also used for device that interconnects different Networks and which perform translation of protocols(Multi-Protocol Routers).





Repeater



Hub



Switch



Router



Bridge



Gateway