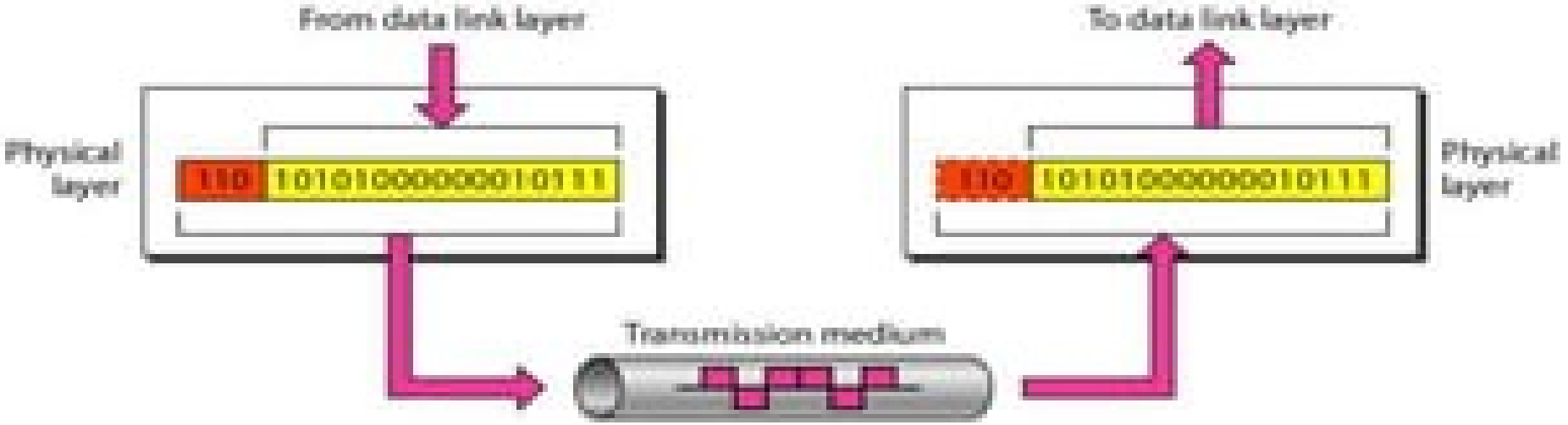
Physical Layer

Unit 2

Physical Layer

- **Physical Layer**
  - The physical layer is responsible for movements of individual bits from one hop (node) to the next.
  - The physical layer coordinates the functions required to carry a bit stream over a physical medium.
  - It deals with the mechanical and electrical specifications of the interface and the transmission medium.



Functions of physical layer

- **Physical characteristics of interfaces and medium:** characteristics of Interface between devices and types of transmission media.
- **Representation of bits:** It encodes the bit stream into electrical or optical signal.
- **Data rate:** Transmission rate, number of bits sent each second.
- **Synchronization of bits:** Sender and the receiver clocks must be synchronized.
- **Line configuration:** Connection of devices to the media. Point-to-point or multipoint connection.
- **Physical topology:** How devices are connected to make a network?
- **Transmission mode:** It defines direction of the transmission between two devices. Ex. Simplex , half-duplex or full duplex mode).

Data and signal

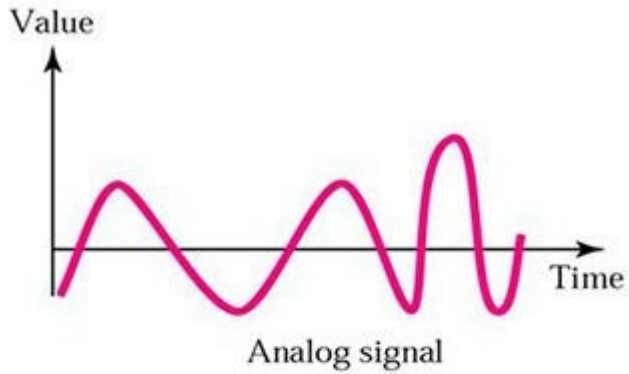
- Data
  - are entities that convey meaning
    - Examples: computer files, music on CD, results from a blood gas analysis machine)
- Signals
  - are the electric or electromagnetic encoding of data (telephone conversation, web page download)
    - Examples: Computer networks and data/voice communication systems transmit signals
- Data and signals can be analog or digital
  - Analog Vs Digital (to p5)

(to p2)

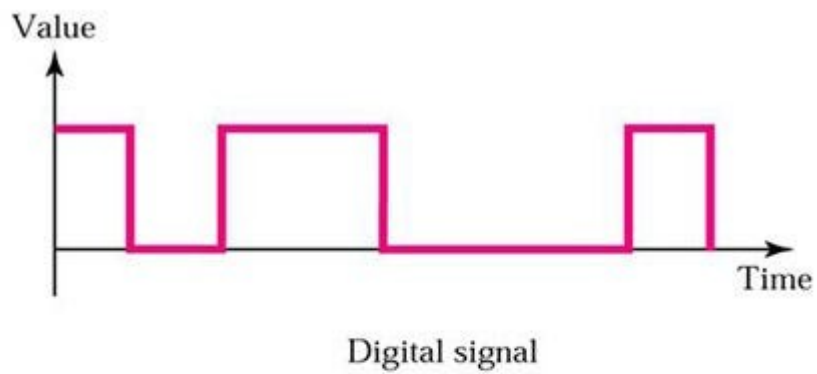
Data and Signals

Analog signal	Digital signal
Analog signals are continuous waveforms that vary continuously over time. An analog signal is represented by a voltage level.	Digital signals are discrete waveforms that have only two possible values at any given moment. A digital signal is represented by a series of ones and zeros.

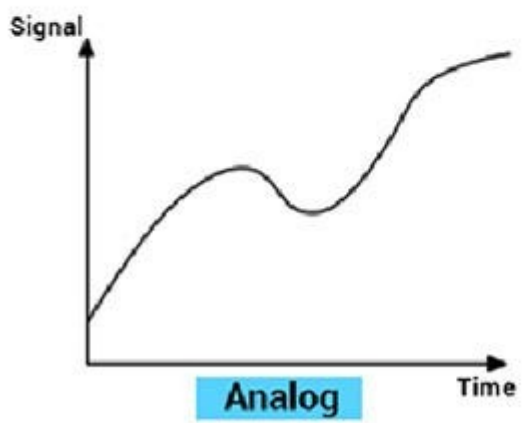
Analog Signals	Digital Signals
Analog signal is continuous and time varying.	Digital signal have two or more states and in binary form.
Troubleshooting of analog signals are difficult.	Troubleshooting of digital signals are easy.
An analog signal is usually in the form of sine wave.	An digital signal is usually in the form of square wave.
Easily affected by the noise.	These are stable and less prone to noise.
Analog signals use continous values to represent the data.	Digital signals use discrete values to represent the data.
Accuracy of the analog signals may be affected by noise.	Accuracy of the digital signals are immune from the noise.
Analog signals may be affected during data transmission.	Digital signals are not affacted during data transmission.
Analog signal use more power.	Digital signal use less power.
Examples: Temperature, Pressure, Flow measurements, etc.	Examples: Valve Feedback, Motor Start, Trip, etc.
Components like resistors, Capacitors, Inductors, Diodes are used in analog circuits.	Components like transistors, logic gates, and microcontrollers are used in Digital circuits.

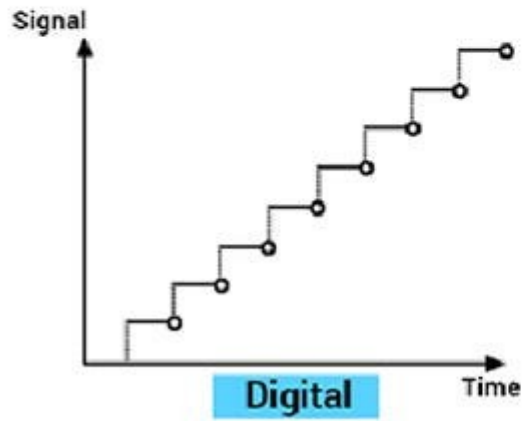


Analog signal



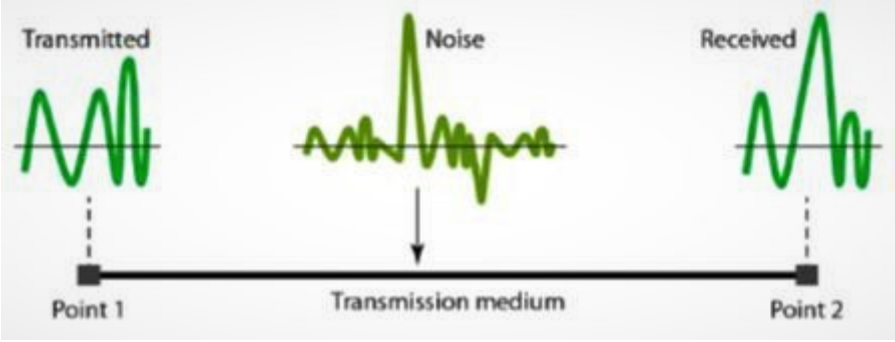
Digital signal





TRANSMISSION IMPAIREMENT

- When a signal transmit from one transmission medium to other, the signal that is received may differ from the signal that is transmitted, due to various transmission impairments.
- Consequences:
  - For analog signals: degradation of signal quality
  - For digital signals: bit errors
- The most significant impairments include
  - **Attenuation**
  - **Distortion**
  - **Noise**



3-5 DATA RATE LIMITS

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)*

Network performance factors

Bandwidth - directly proportional to the amount of data that can be transferred per second, e.g. 500mbs. Higher bandwidth will typical improve performance.

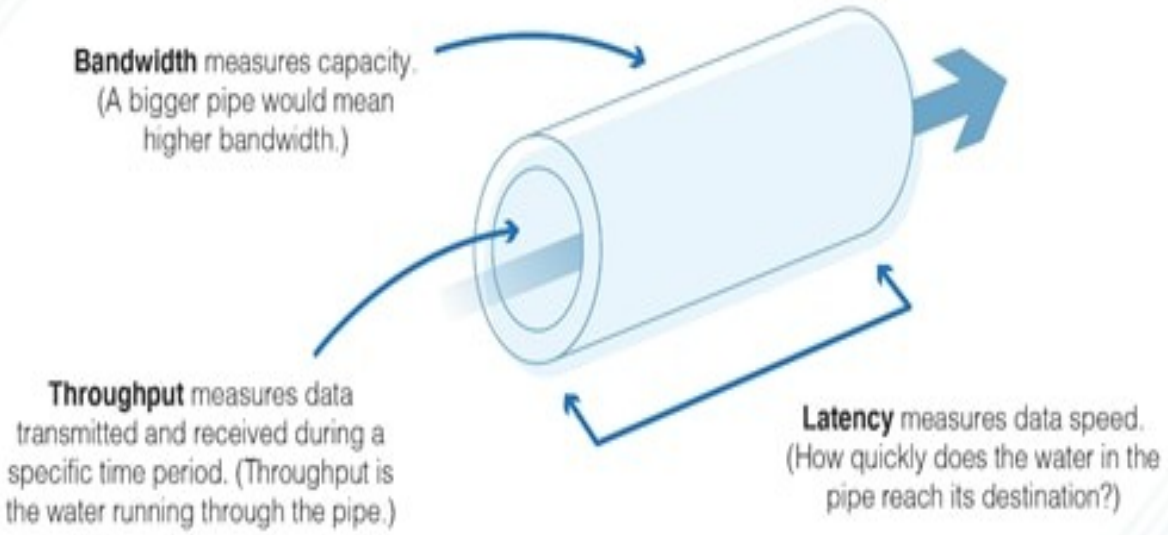
Number of Users - Bandwidth must be split between users, therefore increasing this will reduce overall performance.

Media Type - The type of media can have a dramatic impact upon the performance of a network, e.g. fibre optic is faster than copper.

Interference - Physical objects such as thick walls can cause interference on wireless signals. Electrical interference from other devices or severe weather can also cause interference.

Hardware Choices - Beyond the type of cabling choice such as topology and device layout can have a big impact on the performance of a network.

Network Latency vs. Throughput vs. Bandwidth

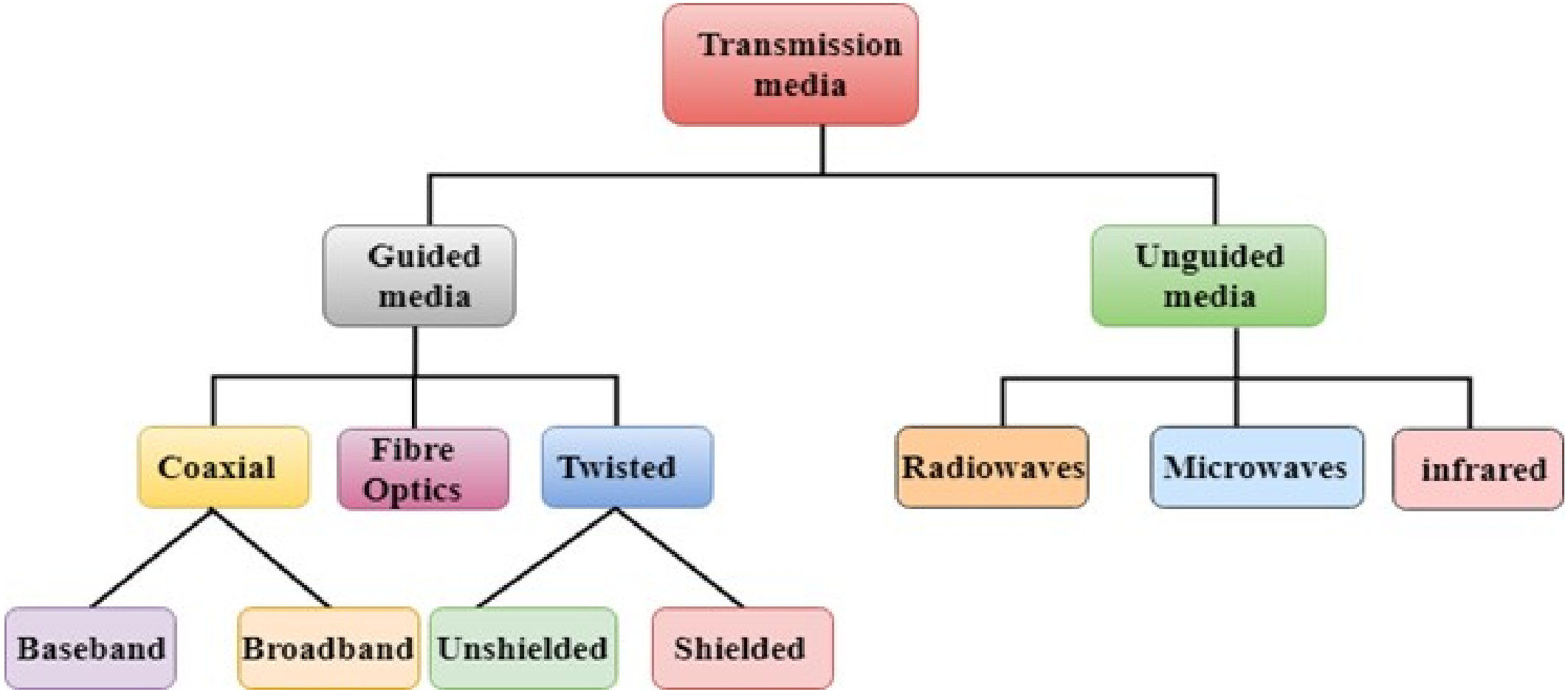


Latency & Jitter

Latency is generally defined as the time it takes for a source to send a packet of data to a receiver. In simple terms, half of Ping time. This is also referred to as **one way latency**.

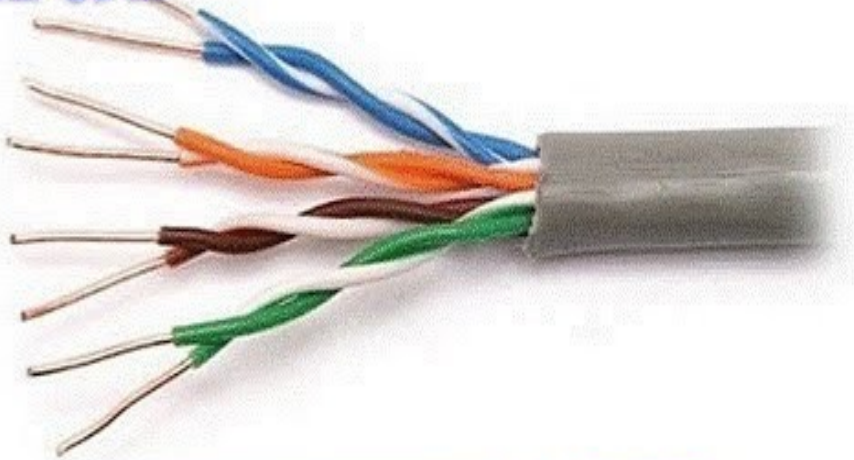
Sometimes the term **Round trip latency** or round trip time (RTT) is also used to define latency. This is the same as ping time.

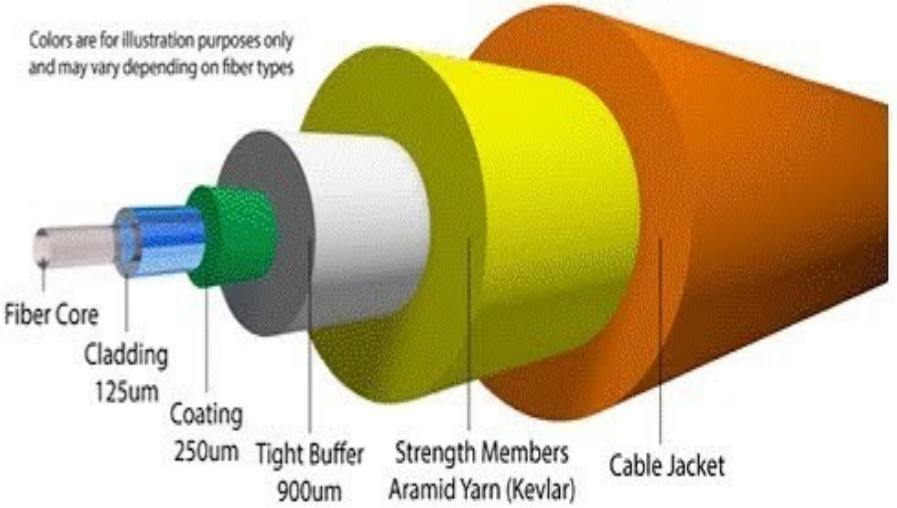
Jitter is defined as the variation in the delay (or latency) of received packets. It is also referred to as 'delay jitter'.


Transmission media
Guided media
Unguided media
Coaxial
Fibre Optics
Twisted
Radiowaves
Microwaves
infrared
Baseband
Broadband
Unshielded
Shielded


Transmission Medium/ Media
Guided Media
Unguided Media
Twisted Pair Cable
Fiber Optic Cable
Radio Transmission
Microwave Transmission
Coaxial Cable
Shielded
Unshielded
Baseband
Broadband

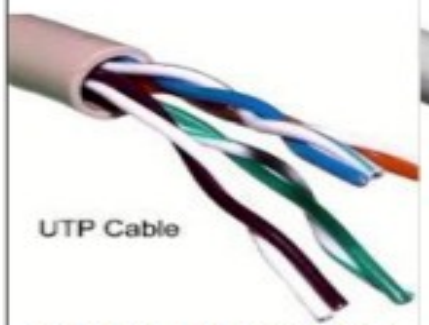
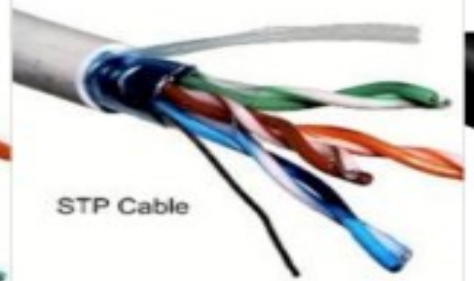
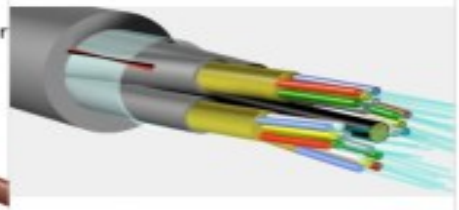
WiFi




Colors are for illustration purposes only and may vary depending on fiber types
Fiber Core
Cladding 125um
Coating 250um
Tight Buffer 900um
Strength Members Aramid Yarn (Kevlar)
Cable Jacket

Wired Transmission Media

Credit. Iris Xu

	Electricity			Light
	Twisted-Pair		Coaxial	Fiber Optic
	Unshielded (UTP)	Shielded (STP)		
Cost	Least	Low	Moderate	High
Speed	Low	Low	Moderate	High
Distance	short	short	Moderate Distance	Long distance
Ease of use	Easy to install	More difficult to install than UTP	Professional Installation	Professional Installation
Reliability (degradation of analogous signals)	Least	Low	Moderate	High
	Use analogy electricity→electronic interference No outer protection			
Security (physically break down, extend, attack, steal)	Low	Low	Moderate	High
			Professional experts required to cut/test with proper tools	
Illustration				
	8 copper wires twisted	8 copper wires twisted	two copper conductors	carries a beam of light
Real-life Application	Telephone networks		TV Cable	Data transmission & telephone lines

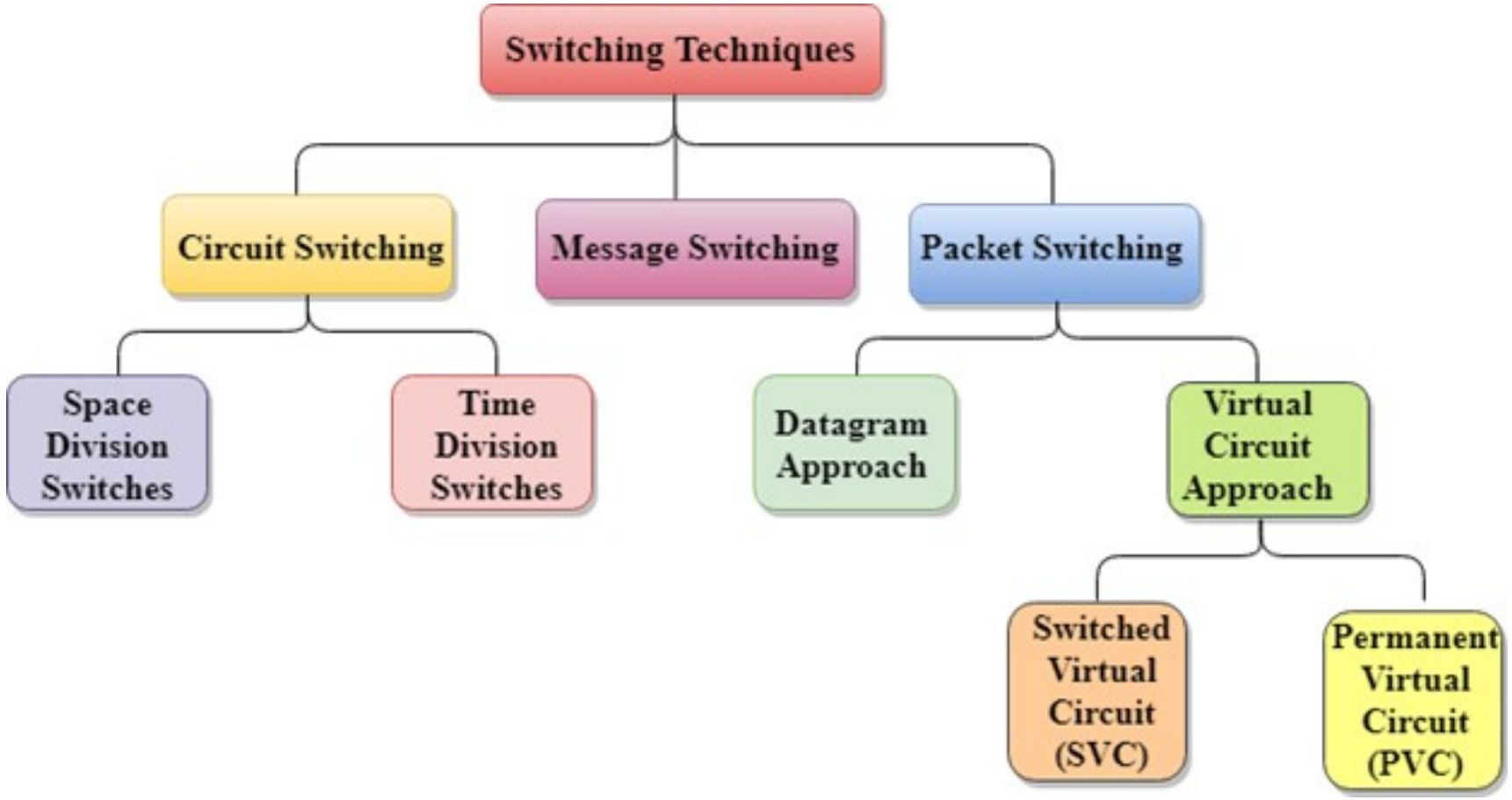
Bandwidth Utilization

- Bandwidth utilization is the wise use of available bandwidth to achieve specific goals.

- Efficiency can be achieved by multiplexing; privacy and anti-jamming can be achieved by spreading.

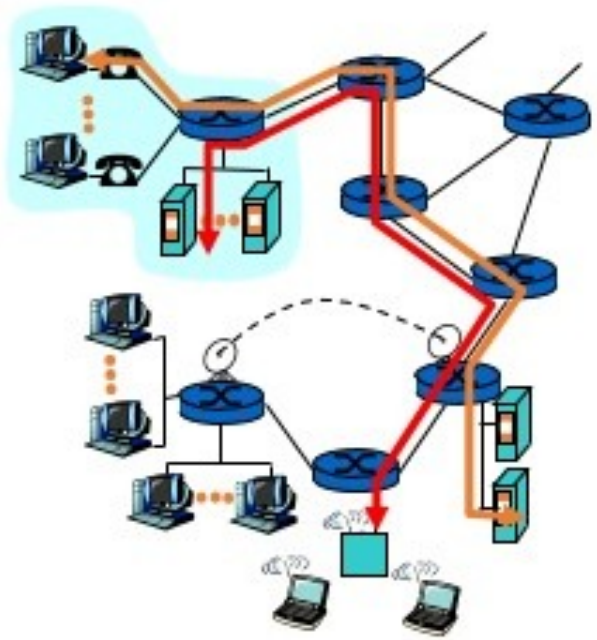
Multiplexing

- Whenever the bandwidth of a medium linking two devices is greater than the bandwidth needs of the devices, the link can be shared. Multiplexing is the set of techniques that allows the simultaneous transmission of multiple signals across a single data link. As data and telecommunications use increases, so does traffic
- **Multiplexing**
  - Is the set of techniques that allows the simultaneous transmission of multiple signals across a single data link.
- **Multiplexer (MUX)**
  - Combines multiple streams into a single stream (many to one).
- **Demultiplexer (DEMUX)**
  - Separates the stream back into its component transmission (one to many) and directs them to their corresponding lines.


Switching Techniques
Circuit Switching
Message Switching
Packet Switching
Space Division Switches
Time Division Switches
Datagram Approach
Virtual Circuit Approach
Switched Virtual Circuit (SVC)
Permanent Virtual Circuit (PVC)

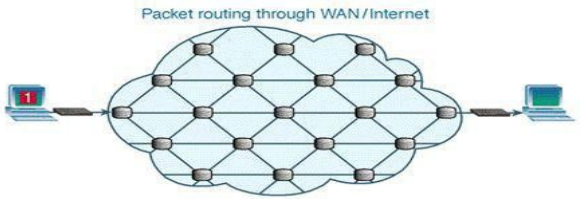
Circuit Switching

- Circuit switching is a technique that directly connects the sender and the receiver in an unbroken path.
- Telephone switching equipment, for example, establishes a path that connects the caller's telephone to the receiver's telephone by making a physical connection.
- With this type of switching technique, once a connection is established, a dedicated path exists between both ends until the connection is terminated.
- Routing decisions must be made when the circuit is first established, but there are no decisions made after that time



Packet Switching

- In packet-based networks, the message gets broken into small data packets.
- These packets are sent out from the computer and they travel around the network seeking out the most efficient route to travel as circuits become available.
- This does not necessarily mean that they seek out the shortest route.
- Each packet may go a different route from the others.



Packet Switching

- To improve the efficiency of transferring information over a shared communication line, messages are divided into fixed-sized, numbered **packets**
- Network devices called routers are used to direct packets between networks

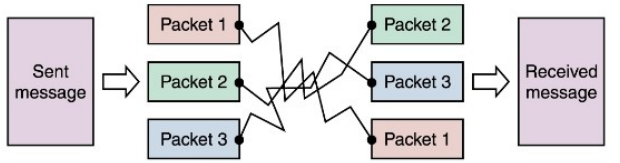


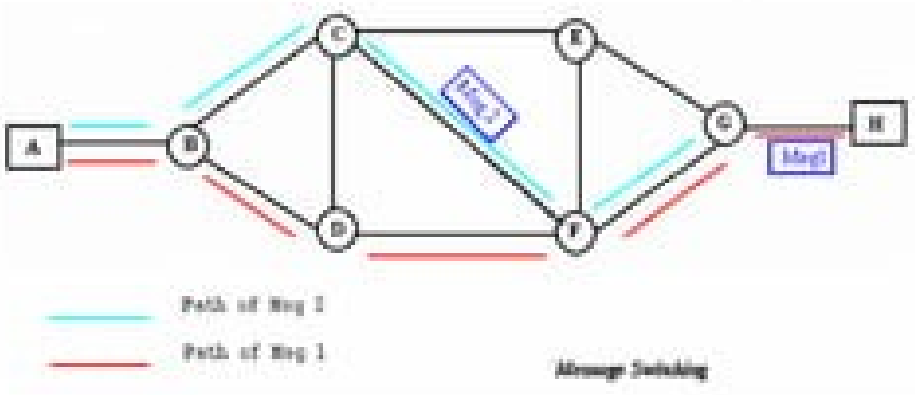
Figure 15.4
Messages sent by packet switching

Message is divided into packets

Packets are sent over the Internet by the most expedient route

Packets are reordered and then reassembled

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.

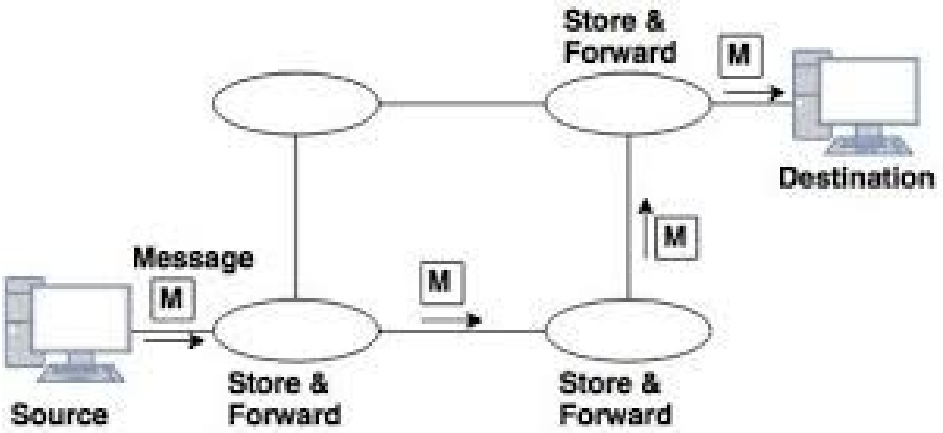


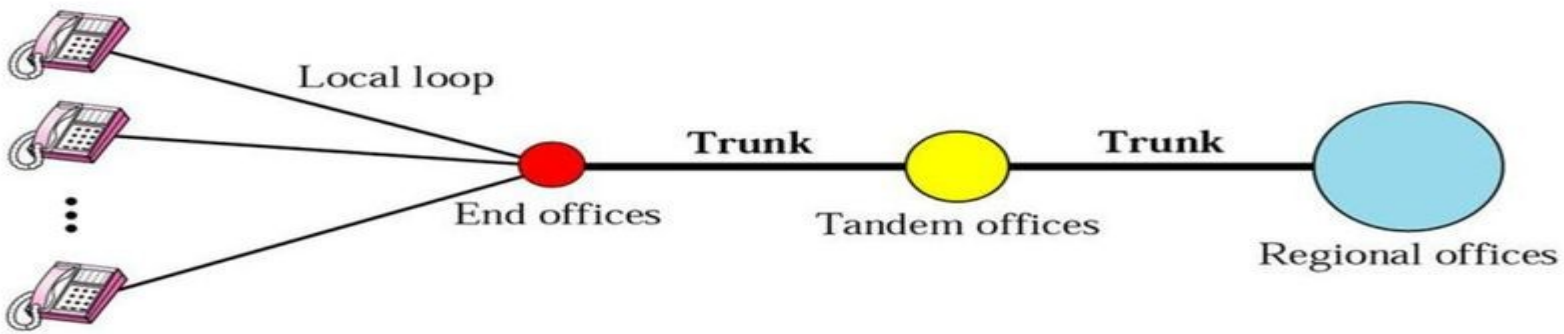
Fig: Message Switching

Telephone Network

- Telephone Network is used to provide voice communication which uses Circuit Switching.
- Originally, the entire network was referred to as a plain old telephone system (POTS) which used analog signals.
- With the advancement of technology, i.e., in the computer era, there comes a feature to carry data in addition to voice. Today’s network is both analogous and digital.
- The telephone network is made of three major components: local loops, trunks, and switching offices.
- The telephone network has several levels of switching offices such as end offices, tandem offices, and regional offices.

Major Components

- The telephone network is made of three major components: local loops, trunks, and switching offices.
- It has several levels of switching offices such as end offices, tandem offices, and regional offices.

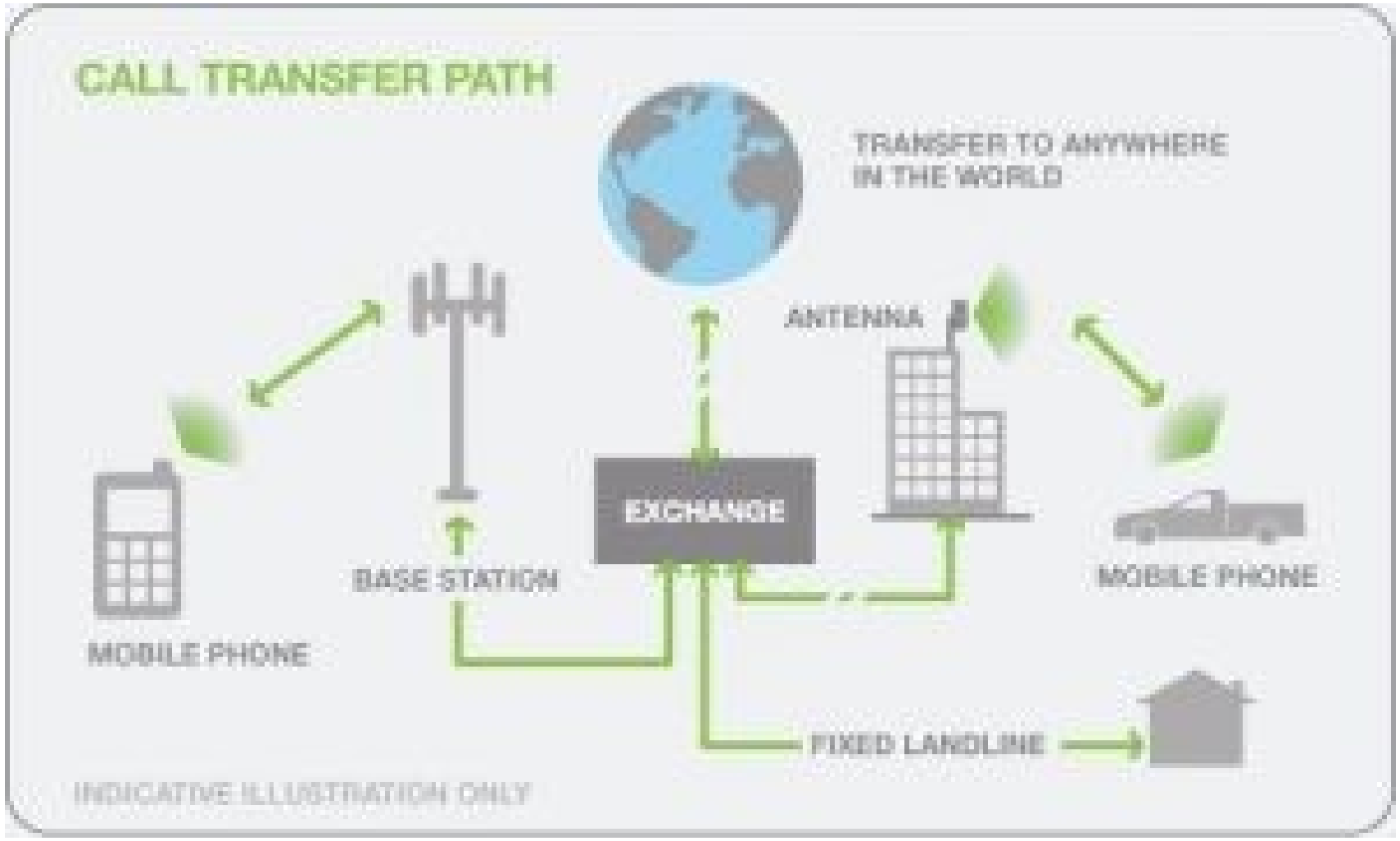


Mobile Networks

- Mobile Networks or Cellular networks are high-speed, high-capacity voice and data communication networks with enhanced multimedia and seamless roaming capabilities for supporting cellular devices (wireless end devices).
- With the increase in popularity of cellular devices, these networks are used for more than just entertainment and phone calls.
- Cellular telephony is designed to provide communications between two moving units, called mobile stations (MSs), or between one mobile unit and one stationary unit, often called a land unit.
- A service provider must be able to locate and track a caller, assign a channel to the call, and transfer the channel from base station to base station as the caller moves out of range.
- To make this tracking possible, each cellular service area is divided into small regions called cells.

Mobile Network

- Each cell contains an antenna and is controlled by a solar or AC powered network station, called the base station (BS).
- Each base station, in turn, is controlled by a switching office, called a mobile switching center (MSC).
- The MSC coordinates communication between all the base stations and the telephone central office.
- It is a computerized center that is responsible for connecting calls, recording call information, and billing.


CALL TRANSFER PATH
TRANSFER TO ANYWHERE IN THE WORLD
ANTENNA
EXCHANGE
BASE STATION
MOBILE PHONE
MOBILE PHONE
FIXED LANDLINE
INDICATIVE ILLUSTRATION ONLY

Cable Networks

- The cable TV network started as a video service provider, but it has moved to the business of Internet access.
- Traditional Cable Networks:
- Cable TV started to distribute broadcast video signals to locations with poor or no reception in the late 1940s.
- It was called community antenna TV (CATV) because an antenna at the top of a tall hill or building received the signals from the TV stations and distributed them, via coaxial cables, to the community.

Cable Network

- The cable TV office, called the head end, receives video signals from broadcasting stations and feeds the signals into coaxial cables.
- The signals became weaker and weaker with distance, so amplifiers were installed through the network to renew the signals. There could be up to 35 amplifiers between the head end and the subscriber premises.
- At the other end, splitters split the cable, and taps and drop cables make the connections to the subscriber premises.
- The traditional cable TV system used coaxial cable end to end.
- Due to attenuation of the signals and the use of a large number of amplifiers, communication in the traditional network was unidirectional (one-way).
- Video signals were transmitted downstream, from the head end to the subscriber premises.

Communication in the traditional cable TV network is unidirectional.

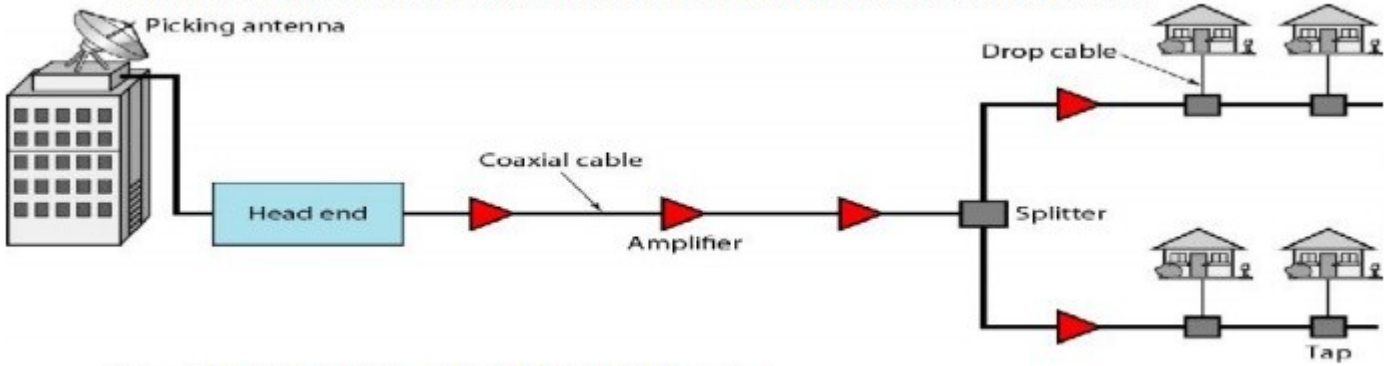


Figure 1.59 Traditional Cable TV Networks