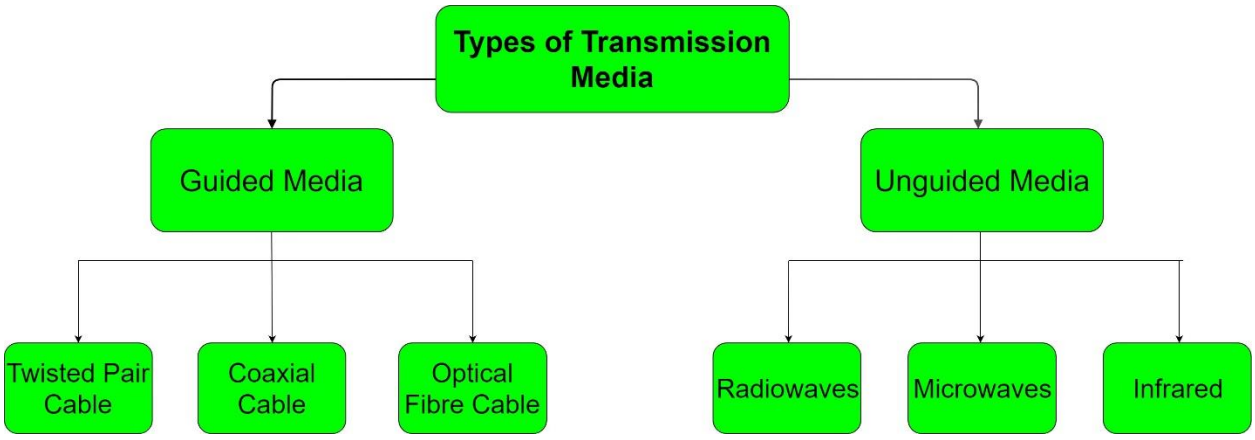
6.2 Signal transmission media

Transmission Media (Communication Channel)

A transmission medium (Communication channels) is an essential element of every communication system. These channels actually carry the data from one computer to another. There are two categories of communication channels. One category connects sending and receiving devices by providing a physical connection, such as a wire or cable. The other category is wireless

Types of Transmission Media

1. Guided / Wired / Bound Transmission Media
2. Unguided / Wireless / Unbound Transmission Media



Wired or Guided Media or Bound Transmission Media

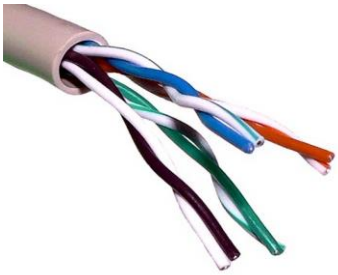
Physical connections use a solid medium to connect sending and receiving devices. These connections include twisted-pair, coaxial, and fiber-optic cables.

Features:

High Speed
Secure
Used for comparatively shorter distances

Twisted-pair cable

Twisted-pair cable consists of pairs of copper wire that are twisted together. Both standard telephone lines and Ethernet cables use twisted pair. Ethernet cables are often used in networks and to connect a variety of components to the system unit.

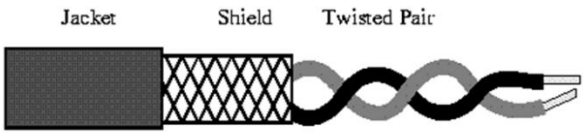


Ethernet cable

There are two types of Twisted-pair cables

- **Shielded Twisted Pair (STP) Cable**

  This type of cable consists of a special jacket to block external interference. It is used in fast-data-rate Ethernet and in voice and data channels of telephone lines.



Advantages:

- Better performance at a higher data rate in comparison to UTP
- Eliminates crosstalk
- Comparatively faster

Disadvantages:

- Comparatively difficult to install and manufacture
- More expensive
- Bulky

- **Unshielded Twisted Pair (UTP) Cable**

  This type of cable has the ability to block interference and does not depend on a physical shield for this purpose. It is used for telephonic applications.

  Advantages:

  - Least expensive
  - Easy to install
  - High speed capacity

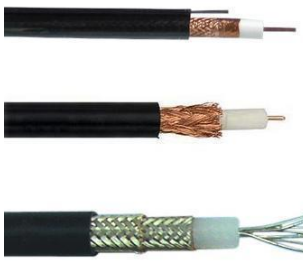
  Disadvantages:

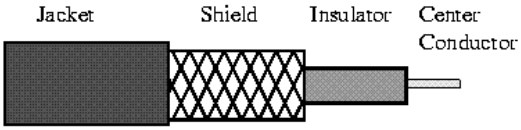
  - Susceptible to external interference
  - Lower capacity and performance in comparison to STP
  - Short distance transmission due to attenuation

Coaxial cable

Coaxial cable, a high-frequency transmission cable, replaces the multiple wires of telephone lines with a single solid-copper core. In terms of the number of telephone connections, a coaxial cable has over 80 times the transmission capacity of twisted pair. Coaxial cable is used to deliver television signals as well as to connect computers in a network.
Cable TVs and analog television networks widely use Coaxial cables.

Coaxial cable





Advantages:

- High Bandwidth
- Better noise Immunity
- Easy to install and expand
- Inexpensive

Disadvantages:

- Single cable failure can disrupt the entire network

Fiber-optic cable

Fiber-optic cable transmits data as pulses of light through tiny tubes of glass. The data transmission speeds of fiber-optic cables are incredible; recently speeds of 1 petabit per second were measured (a petabit is 1 million gigabits). Compared to coaxial cable, it is lighter, faster, and more reliable at transmitting data. Fiber-optic cable is rapidly replacing twisted-pair cable telephone lines.

Fiber-optic cable

Advantages:

- Increased capacity and bandwidth
- Light weight
- Less signal attenuation
- Immunity to electromagnetic interference
- Resistance to corrosive materials

Disadvantages:

- Difficult to install and maintain
- High cost
- Breakable
- Unidirectional. If we need bidirectional communication, will need another fiber.

Media versus Bandwidth

The following table compares the usable bandwidth between the different Guided Transmission Media

Cable Type	*Bandwidth*
Open Cable	0 - 5 MHz
Twisted Pair	0 - 100 MHz
Coaxial Cable	0 - 600 MHz
Optical Fibre	0 - 1 GHz

Unguided / Wireless / Unbound Transmission Media

Wireless connections do not use a solid material to connect sending and receiving devices. Rather, they move data through the air. Most wireless connections use radio waves to communicate. For example, smartphones and many other Internet-enabled devices use radio waves to place telephone calls and to connect to the Internet. Primary technologies used for wireless connections are Bluetooth, Wi-Fi, microwave, WiMax, cellular, and satellite connections.

There are three types of unguided media such as,

Radio waves - These are easy to generate and can penetrate through buildings. The sending and receiving antennas need not be aligned. Frequency Range: 3 KHz – 1GHz. AM and FM radios and cordless phones use Radio waves for transmission.

Further Categorized as (i) Terrestrial and (ii) Satellite.

Microwaves - It is a line of sight transmission i.e. the sending and receiving antennas need to be properly aligned with each other. The distance covered by the signal is directly proportional to the height of the antenna. Frequency Range: 1GHz – 300GHz. These are majorly used for mobile phone communication and television distribution.

Infrared - Infrared waves are used for very short distance communication. They cannot penetrate through obstacles. This prevents interference between systems. Frequency Range: 300GHz – 400THz. It is used in TV remotes, wireless mouse, keyboard, printer, etc.

Features of unguided media:

- Signal is broadcasted through air
- Less Secure
- Used for larger distances

• **Bluetooth**

Bluetooth is a short-range radio communication standard that transmits data over short distances of up to approximately 33 feet. Bluetooth is widely used for wireless headsets, printer connections, and handheld devices.

• **Wi-Fi**

Wi-Fi (wireless fidelity) uses high-frequency radio signals to transmit data. A number of standards for Wi-Fi exist, and each can send and receive data at a different speed. Most home and business wireless networks use Wi-Fi.

Standard	Maximum speed
802.11g	54 Mbps
802.11n	600 Mbps
802.11ac	2.6 Gbps
802.11ax	10.5 Gbps

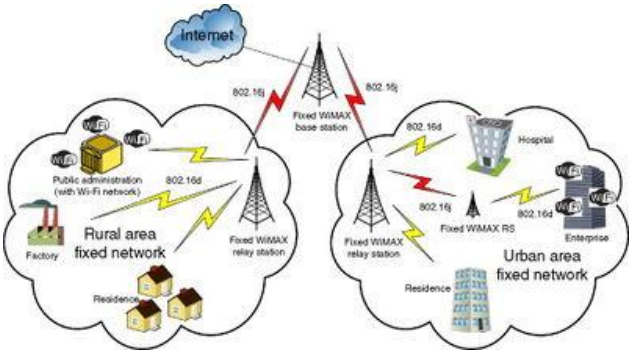
Wi-Fi standards

• **Microwave communication**

Microwave communication uses high-frequency radio waves. It is sometimes referred to as line-of-sight communication because microwaves can only travel in a straight line. Because the waves cannot bend with the curvature of the earth, they can be transmitted only over relatively short distances. Thus, microwave is a good medium for sending data between buildings in a city or on a large college campus. For longer distances, the waves must be relayed by means of microwave stations with microwave dishes or antennas.

Microwave dish

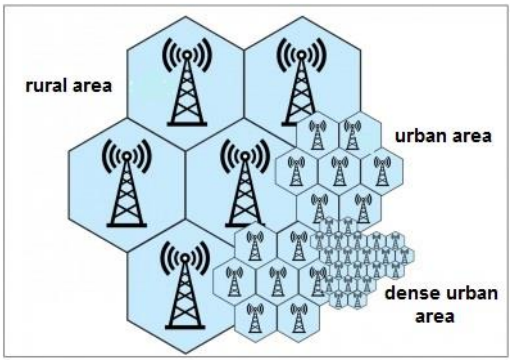
• **WiMax**



WiMax (Worldwide Interoperability for Microwave Access) is a new standard that extends the range of Wi-Fi networks using microwave connections. WiMax is commonly used by universities and others to extend the capability of existing Wi-Fi networks.

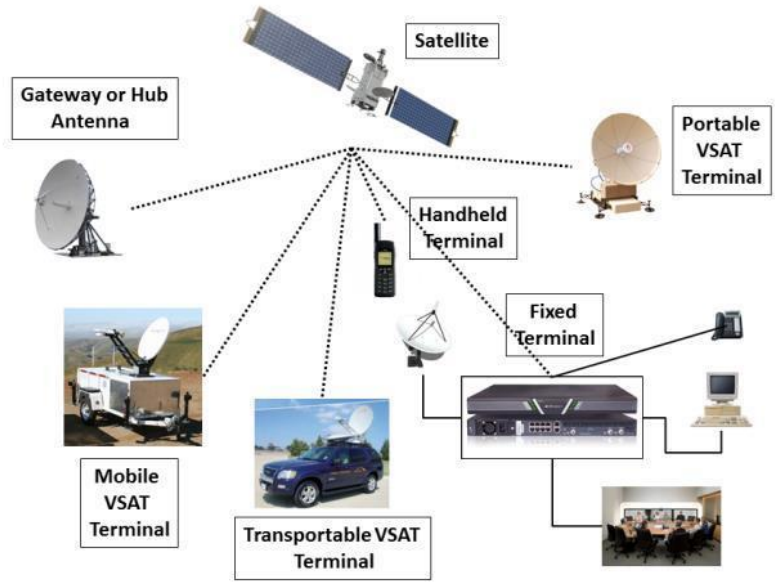
• Cellular communication

Cellular communication uses multiple antennae (cell towers) to send and receive data within relatively small geographic regions (cells). Most cell phones and mobile devices use cellular networks.

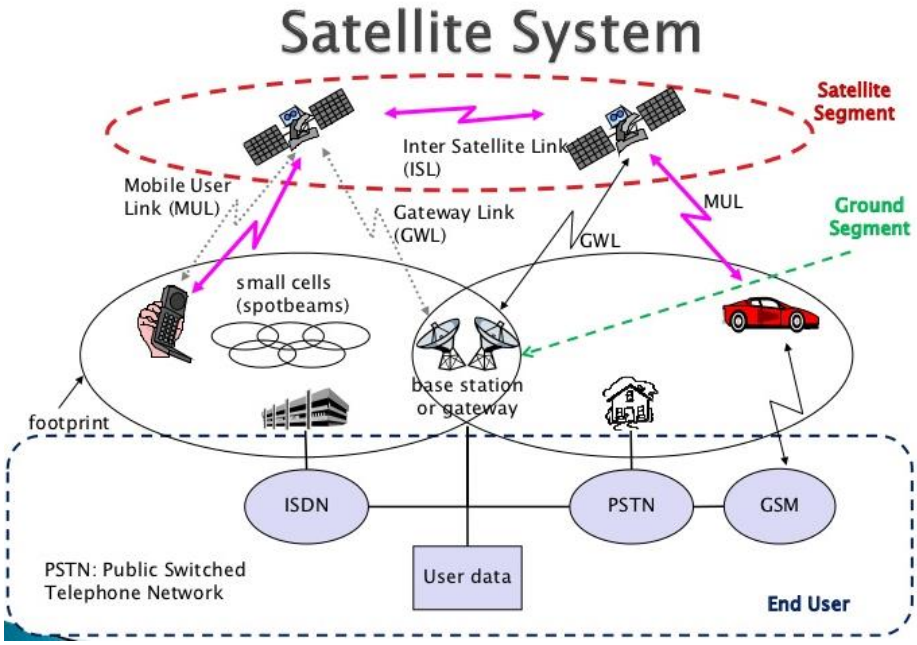


• Satellite communication

Satellite communication uses satellites orbiting about 22,000 miles above the earth as microwave relay stations. Many of these are offered by Intelsat, the International Telecommunications Satellite Consortium, which is owned by 114 governments and forms a worldwide communication system. Satellites orbit at a precise point and speed above the earth. They can amplify and relay microwave signals from one transmitter on the ground to another. Satellites can be used to send and receive large volumes of data. Uplink is a term relating to sending data to a satellite. Downlink refers



to receiving data from a satellite. The major drawback to satellite communication is that bad weather can sometimes interrupt the flow of data. One of the most interesting applications of satellite communications is for global positioning. A network of satellites owned and managed by the Department of Defense continuously sends location information to earth. Global positioning system (GPS) devices use that information to uniquely determine the geographic location of the device. Available in many automobiles to provide navigational support, these systems are often mounted into the dash with a monitor to display maps and speakers to provide spoken directions. Most of today's smartphones and tablets use GPS technology for handheld navigation.

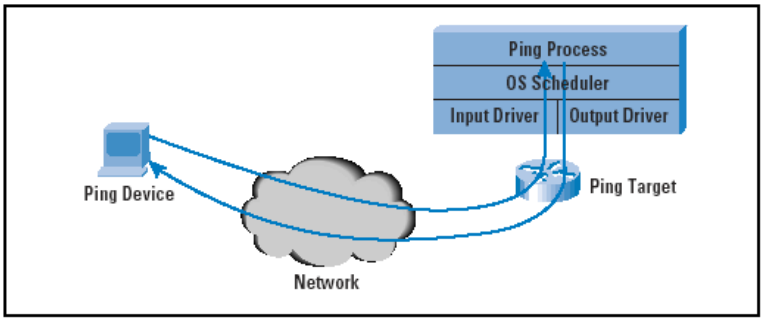


Unlike radio waves, infrared uses infrared light waves to communicate over short distances. Like microwave transmissions, infrared is a line-of-sight communication. Because light waves can only travel in a straight line, sending and receiving devices must be in clear view of one another without any obstructions blocking that view. One of the most common infrared devices is the TV remote control.

How latency, bandwidth, noise, attenuation, and distortion affect signal transmission?

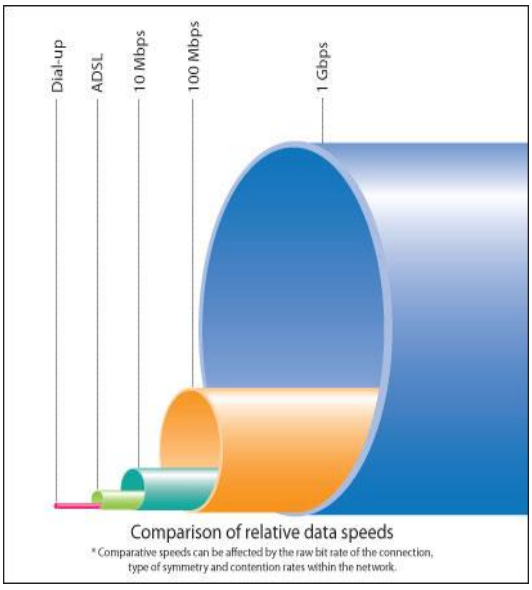
Latency

Latency is a networking term to describe the total time it takes a data packet to travel from one node to another. In other contexts, when a data packet is transmitted and returned back to its source, the total time for the round trip is known as latency. Latency refers to time interval or delay when a system component is waiting for another system component to do something. This duration of time is called latency.



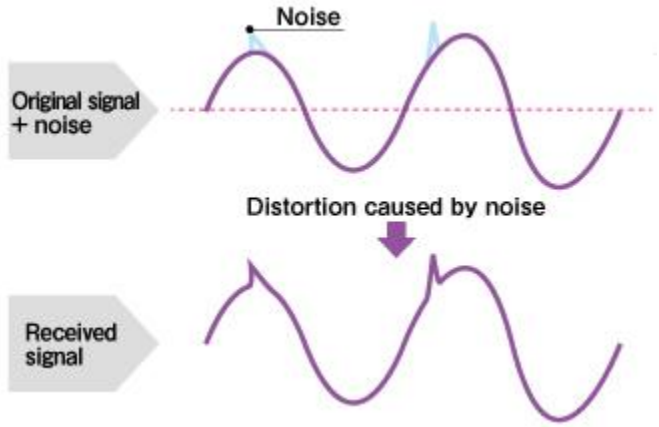
Bandwidth.

It refers to the data carrying capacity of a channel or medium. Higher bandwidth communication channels support higher data rates. **Bandwidth** is also the amount of data that can be transmitted in a fixed amount of time. For digital devices, the **bandwidth** is usually expressed in bits per second (bps) or bytes per second. For analog devices, the **bandwidth** is expressed in cycles per second, or Hertz (Hz).



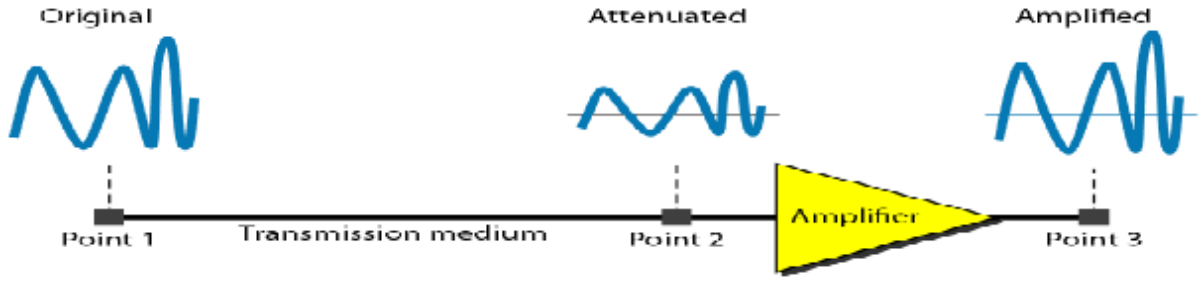
Noise

Noise refers to any external and unwanted information that interferes with a **transmission** signal. **Noise** can diminish **transmission** strength and disturb overall communication efficiency. In communications, **noise** can be created by radio waves, power lines, lightning and bad connections.



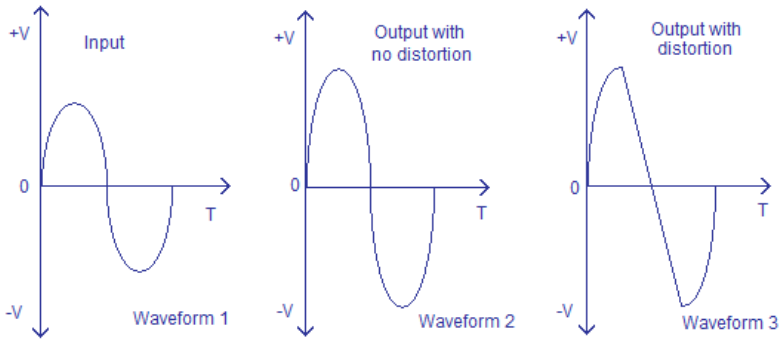
Attenuation

It refers to loss of energy as signal propagates outwards. The amount of energy lost depends on frequency. Radiations and physical characteristics of media contribute to attenuation.



Distortion

Distortion is alteration (distort) of properties of a transferred signal caused by the capacitance and inductance of the communication medium.



Distortion in power amplifiers www.circuitstoday.com

Simple topology: point-to-point connection

Point-to-**Point**. **Point**-to-**point topology** is the **simplest** of all the network **topologies**. The network consists of a direct **link** between two computers. This is faster and more reliable than other types of **connections** since there is a direct **connection**.

POINT-TO-POINT TOPOLOGY

Extra Reference

- IEEE standard notation for cables

The mostly used Ethernet cable standards and Specifications

Term	Standard	Specifications	Medium	Speed	Distance
Ethernet	10BaseT	IEEE 802.3i	CAT5 UTP	10 Mbits/s	100 meters
Ethernet	10BaseF: 10BaseFB 10BaseFL 10BaseFP	IEEE 802.3j	Fiber	10 Mbits/s	2000 meters 2000 meters 500 meters
Fast Ethernet	100BaseT	IEEE 802.3u	CAT5 UTP	100 Mbits/s	100 meters
Fast Ethernet	100BaseFX	IEEE 802.3u	MMF MMF SMF	100 Mbits/s 100 Mbits/s 100 Mbits/s	412m half duplex 2km full duplex 15 -20km full duplex
Gigabit Ethernet	1000BaseT	IEEE 802.3ab	CAT5/CAT6 UTP	1 Gbit/s	100 meters
Gigabit Ethernet	1000BaseCX	IEEE 802.3z	Shielded, balanced coax	1 Gbit/s	25 meters
Gigabit Ethernet	1000BaseSX	IEEE 802.3z	MMF (850 nm) MMF (850 nm)	1 Gbit/s 1 Gbit/s	550 meters 220 to 275 meters
Gigabit Ethernet	1000BaseLX	IEEE 802.3z	SMF (1300 nm) MMF (1300 nm)	1 Gbit/s 1 Gbit/s 1 Gbit/s	5000 meters 550 meters 550 meters

			MMF (1300 nm)		
Gigabit Ethernet	1000BaseLH	IEEE 802.3z	SMF (1300 nm) MMF (1300 nm)	1 Gbit/s	10km 550 meters
10Gigabit Ethernet	10GBaseX: 10GBaseS 10GbaseL 10GbaseE (Each has R or W mode where R is for dark fiber and W is for SONET)	IEEE 802.3ae	MMF (850 nm) MMF (1310 nm) (with 4 CWDM) SMF (1310 nm) (with 4 CWDM) SMF (1310 nm) SMF (1550 nm)	9.953 Gbits/s 12.5 Gbits/s 10 Gbits/s 9.953 Gbits/s 10.3 Gbits/s	65 meters 300 meters 10 km 10 km 40 km
10Gigabit Ethernet	10GBaseT	IEEE 802.3an	UTP	10 Gbits/s	100 meters
10Gigabit Ethernet	10GBaseCX4	IEEE 802.3ak	thin twin-axial cables	4 x 2.5Gbits/s	25 meters

- MMF = multimode fiber
- SMF = single-mode fiber
- UTP = unshielded twisted pair
- CAT5 = category 5 UTP
- CAT6 = category 6 UTP
- CWDM = coarse wavelength division multiplexing

References

https://www.geeksforgeeks.org/types-transmission-media/

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