Name : Prathamesh Bagekari

Branch : TE Computer

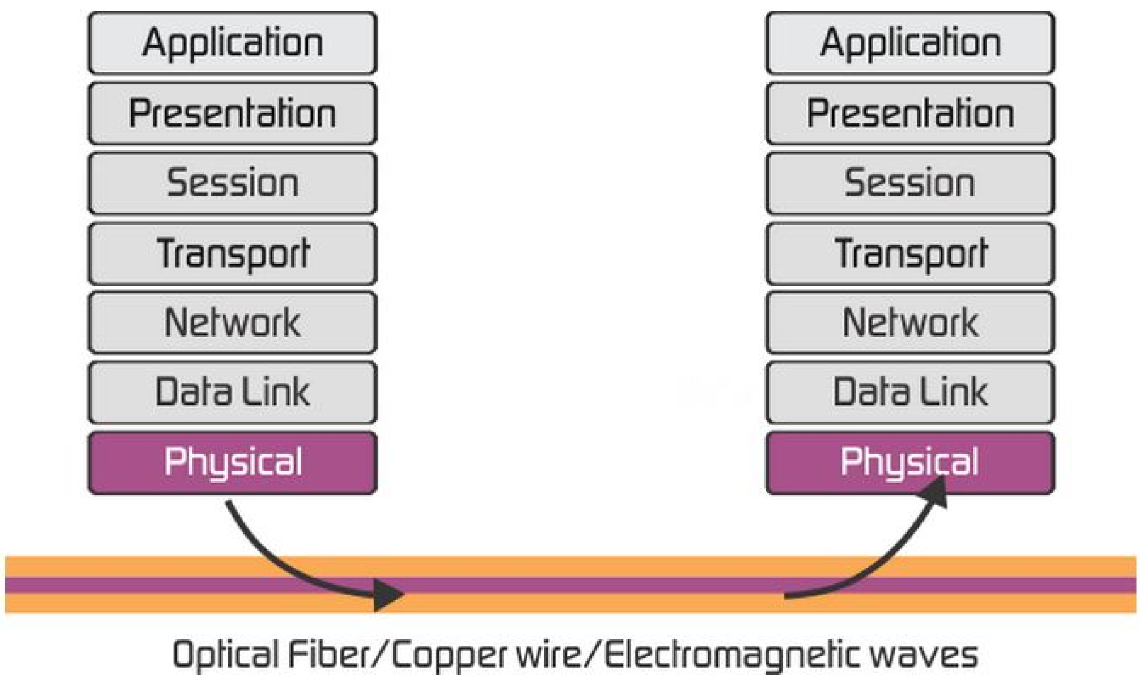
Batch : A

UID : 2018130002

Lab 1

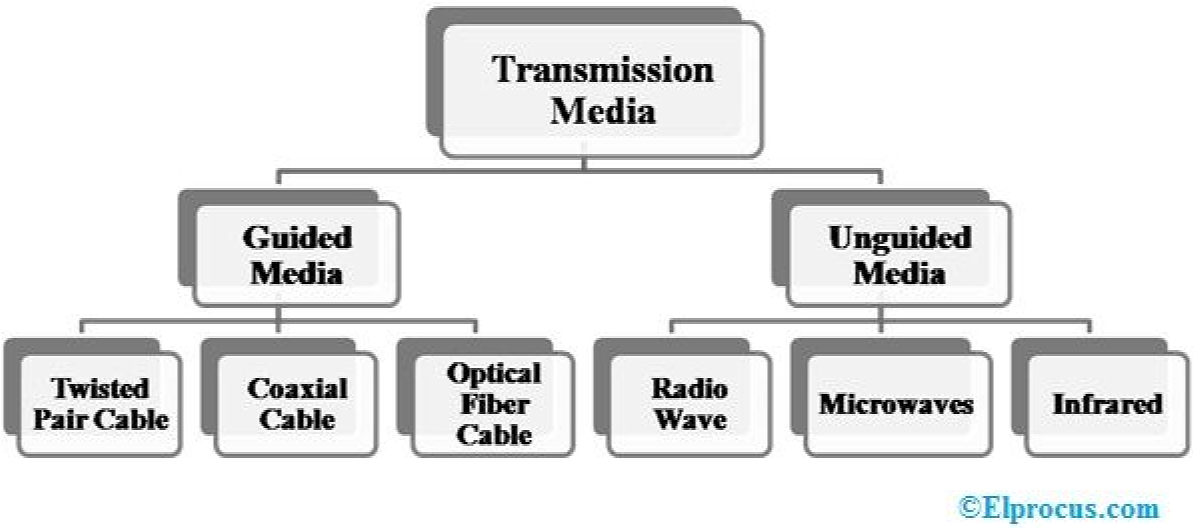
Study of different types of physical layer wired/wireless connections

- **Physical Layer of the OSI model :**

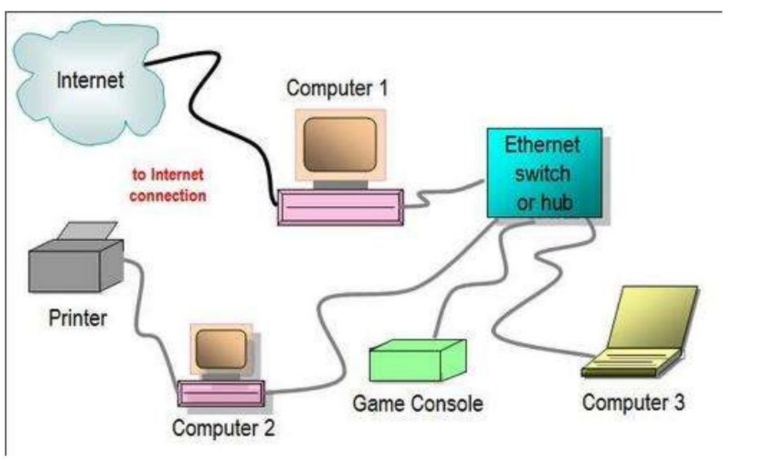


1. Physical layer in the OSI model plays the role of interacting with actual hardware and signaling mechanisms. Physical layer is the only layer of OSI network model which actually deals with the physical connectivity of two different stations. This layer defines the hardware equipment, cabling, wiring, frequencies, pulses used to represent binary signals etc.
2. Physical layer provides its services to the Data-link layer. Data-link layer hands over frames to the physical layer. Physical layer converts them to

electrical pulses, which represent binary data. The binary data is then sent over the wired or wireless media.



- **Guided Media** :

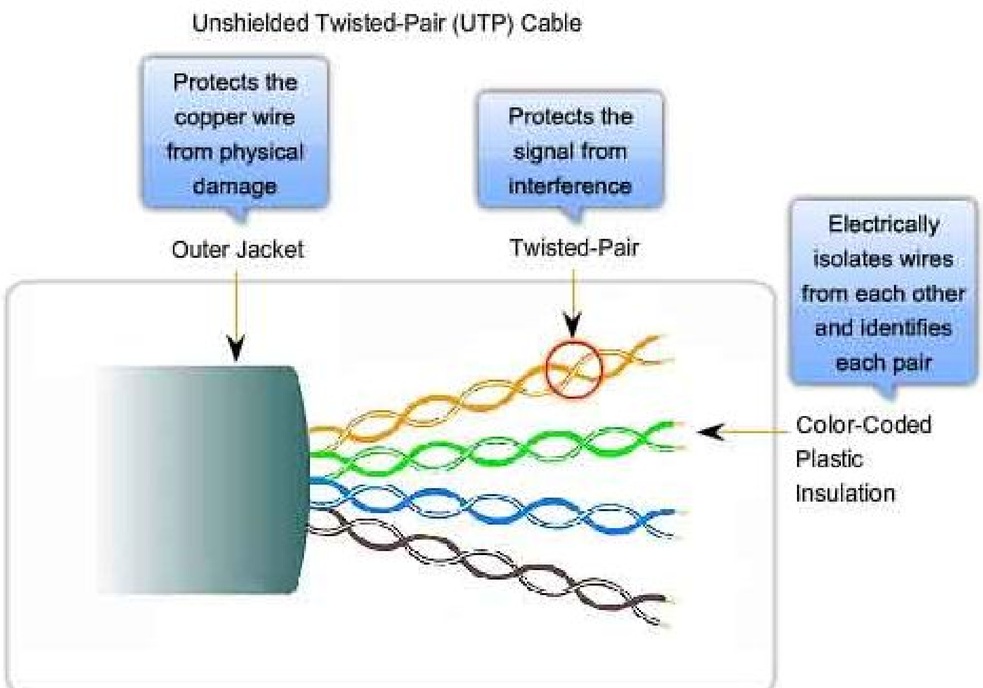


Guided media is also known as **Wired Transmission Media** or **Bound Transmission Media**. In this case, there exists a physical connection between the sender and the recipient and the data stream is mainly passed in the form of **electromagnetic waves** by converting the data stream into a transmissible data signal or wave at the sender side and the signal is converted back into the data stream at the physical layer of the recipient side.

(1) Twisted Pair Cable :

Twisted pair cabling is a type of wiring in which two conductors of a single circuit are twisted together for the purposes of improving **electromagnetic compatibility**. Compared to a single conductor or an untwisted balanced pair, a twisted pair reduces **electromagnetic radiation** from the pair and **crosstalk** between neighboring pairs and improves rejection of external electromagnetic interference. It was invented by **Alexander Graham Bell**.

(a) <u>UTP (Unshielded Twisted Pair) cable</u> :



Unshielded twisted pair (UTP) cables are found in many **Ethernet** networks and telephone systems. For indoor telephone applications, UTP is often grouped into sets of 25 pairs according to a standard 25-pair color code originally developed by AT&T Corporation. A typical subset of these colors (white/blue, blue/white, white/orange, orange/white) shows up in most UTP cables. The cables are typically made with copper wires measured at 22 or 24 American Wire Gauge (AWG), with the colored insulation typically made from an insulator such as **polyethylene** or **FEP** and the total package covered in a **polyethylene jacket**.

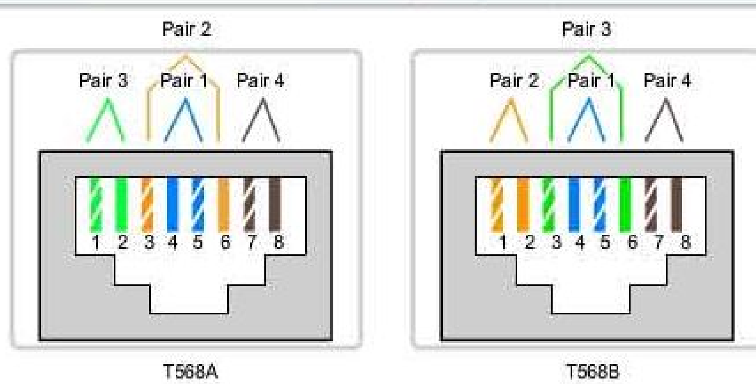
For urban outdoor telephone cables containing hundreds or thousands of pairs, the cable is divided into small but identical bundles. Each bundle consists of twisted pairs that have different twist rates, as pairs having the same twist rate within the cable can still experience some degree of **crosstalk**. The bundles are in turn twisted together to make up the cable.

UTP is also the most common cable used in computer networking. **Modern Ethernet**, the most common data networking standard, can use UTP cables. Twisted-pair cabling is often used in data networks for short and medium-length connections because of its relatively lower costs compared to optical fiber and coaxial cable.

As UTP cable bandwidth has improved to match the baseband of television signals, UTP is now used in some **video applications**, primarily in **security cameras**.

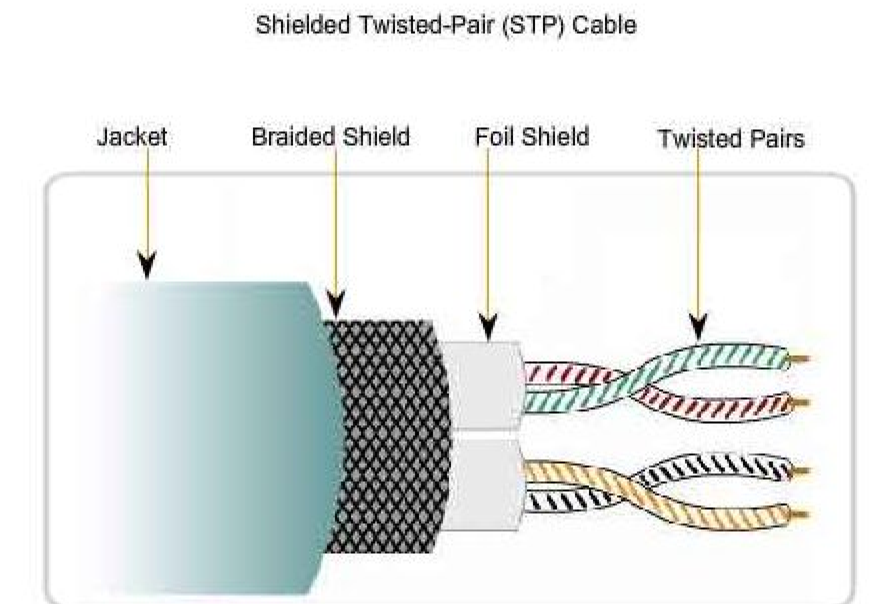
Straight-through, Crossover, and Rollover Cable Types

Cable Type	Standard	Application
Ethernet Straight-through	Both end T568A or both end T568B	Connecting a network host to a network device such as a switch or hub.
Ethernet Crossover	One end T568A, other end T568B	Connecting two network hosts. Connecting two network intermediary devices (switch to switch, or router to router).
Rollover	Cisco proprietary	Connect a workstation serial port to a router console port, using an adapter.



Cables are placed into categories according to their ability to carry higher bandwidth rates. For example, Category 5 (**Cat5**) cable is used commonly in **100BASE-TX FastEthernet** installations. Other categories include Enhanced Category 5 (**Cat5e**) cable and Category 6 (**Cat6**). Cables in higher categories are designed and constructed to support higher data rates. As new gigabit speed Ethernet technologies are being developed and adopted, Cat5e is now the minimally acceptable cable type, with **Cat6** being the recommended type for new building installations. Often the cabling in these systems are some form of UTP that are lower grade than the current **Cat5+** standards.

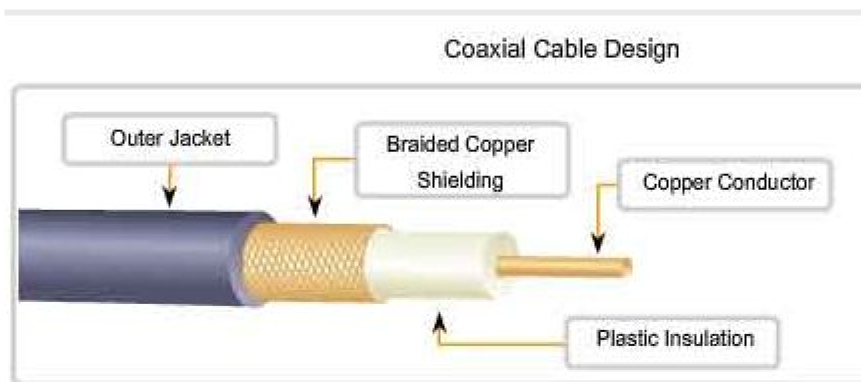
(b) STP (Shielded Twisted Pair) cable :



Another type of cabling used in networking is shielded twisted-pair (STP). As shown in the figure, STP uses two pairs of wires that are wrapped in an overall metallic braid or foil. STP cable shields the entire bundle of wires within the cable as well as the individual wire pairs. STP provides **better noise protection** than UTP cabling, however at a significantly higher price. For many years, STP was the cabling structure specified for use in **Token Ring network** installations. With the use of Token Ring declining, the demand for shielded twisted-pair cabling has also waned. The new **10 GB standard for Ethernet** has a provision for the use of STP cabling. This may provide a renewed interest in shielded twisted-pair cabling.

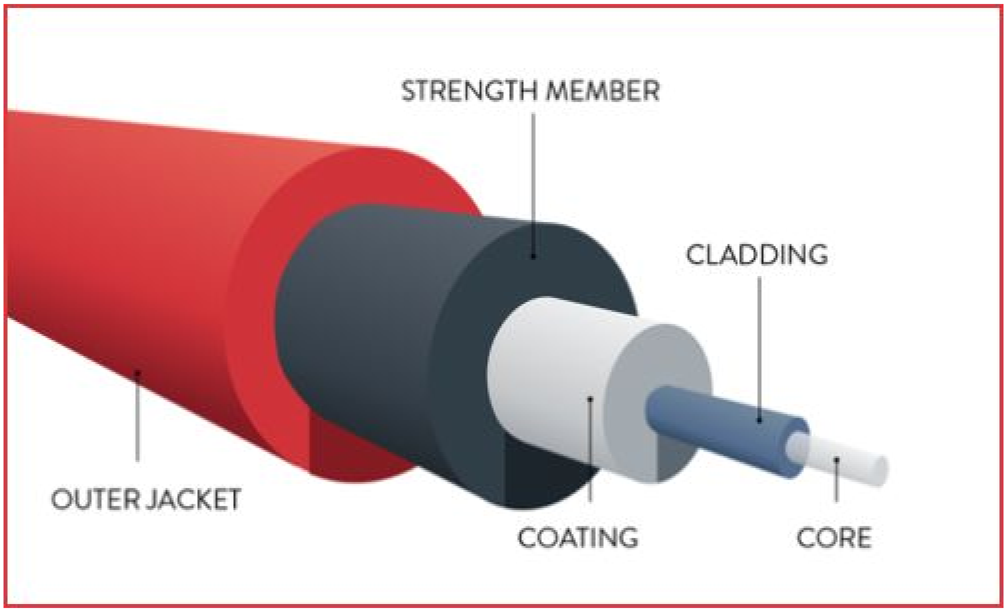
(2) **Coaxial Cable :**

Coaxial cable conducts electrical signals using an inner conductor (usually **a solid copper, stranded copper or copper plated steel wire**) surrounded by an insulating layer and all enclosed by a shield, typically **one to four layers** of woven metallic braid and metallic tape. The cable is protected by an outer **insulating jacket**. Normally, the outside of the shield is kept at ground potential and a signal carrying voltage is applied to the center conductor. The advantage of coaxial design is that with differential mode, equal push-pull currents on the inner conductor, and inside of the outer conductor, the signal's electric and magnetic fields are restricted to the dielectric, with little leakage outside the shield. Further, electric and magnetic fields outside the cable are largely kept from interfering with signals inside the cable, if unequal currents are filtered out at the receiving end of the line. This property makes coaxial cable a good choice both for carrying **weak signals**, that cannot tolerate interference from the environment, and for stronger electrical signals, that must not be allowed to radiate or couple into adjacent structures or circuits. Larger diameter cables and cables with multiple shields have less leakage.



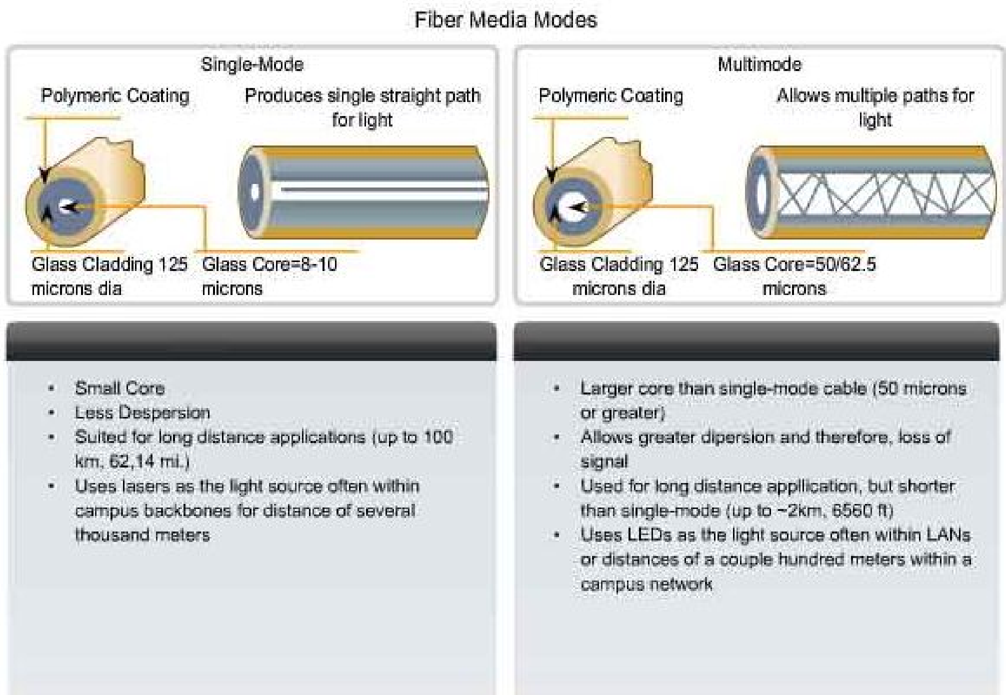
Coaxial cable is a type of transmission line, used to carry **high-frequency electrical signals** with low losses. It is used in such applications as **telephone trunklines**, **broadband internet networking cables**, **high-speed computer data busses**, **cable television signals**, and connecting radio transmitters and receivers to their antennas. It differs from other shielded cables because the dimensions of the cable and connectors are controlled to give a precise, constant conductor spacing, which is needed for it to function efficiently as a transmission line.

(3) **Optical Fiber Cable :**



Fiber-optic cabling uses either **glass** or **plastic fibers** to guide light impulses from source to destination. The bits are encoded on the fiber as **light impulses**. Optical fiber cabling is capable of very large raw data bandwidth rates. Most current transmission standards have yet to approach the potential bandwidth of this media. Optical fiber cables consist of a **PVC jacket** and a series of strengthening materials that surround the optical fiber and its **cladding**. The cladding surrounds the actual glass or plastic fiber and is designed to prevent light loss from the fiber. Because light can only travel in one direction over optical fiber, two fibers are required to support **full duplex operation**. Fiber-optic patch cables bundle together two optical fiber cables and terminate them with a pair of standard single fiber connectors. Some fiber connectors accept both the transmitting and receiving fibers in a single connector.

Fiber optic cables can be broadly classified into two types: **single-mode** and **multimode**.



Optical fiber is used as a medium for **telecommunication** and **computer networking** because it is flexible and can be bundled as cables. It is especially advantageous for **long-distance communications**, because infrared light propagates through the fiber with much **lower attenuation compared to electrical cables**. This allows long distances to be spanned with few repeaters.

The per-channel light signals propagating in the fiber have been modulated at rates as high as **111 gigabits per second (Gbit/s)** by NTT, although **10 or 40 Gbit/s is typical** in deployed systems. In June 2013, researchers demonstrated transmission of **400 Gbit/s** over a single channel using **4-mode orbital angular momentum multiplexing**. Each fiber can carry many independent channels, each using a different wavelength of light (wavelength-division multiplexing (**WDM**)). The net data rate (data rate without overhead bytes) per fiber is the per-channel data rate reduced by the FEC overhead, multiplied by the number of channels (usually up to 80 in commercial dense WDM systems as of 2008). As of 2011 the record for bandwidth on a single core was **101 Tbit/s** (370 channels at 273 Gbit/s each). The record for a multi-core fiber as of January 2013 was **1.05 Pbit/s**. In 2009, Bell Labs broke the 100 (Pbit/s)·km barrier (**15.5 Tbit/s over a single 7000 km fiber**). For short-distance applications, such as a network in an office building, fiber-optic cabling can save space in cable ducts.

Physical Media - Characteristics

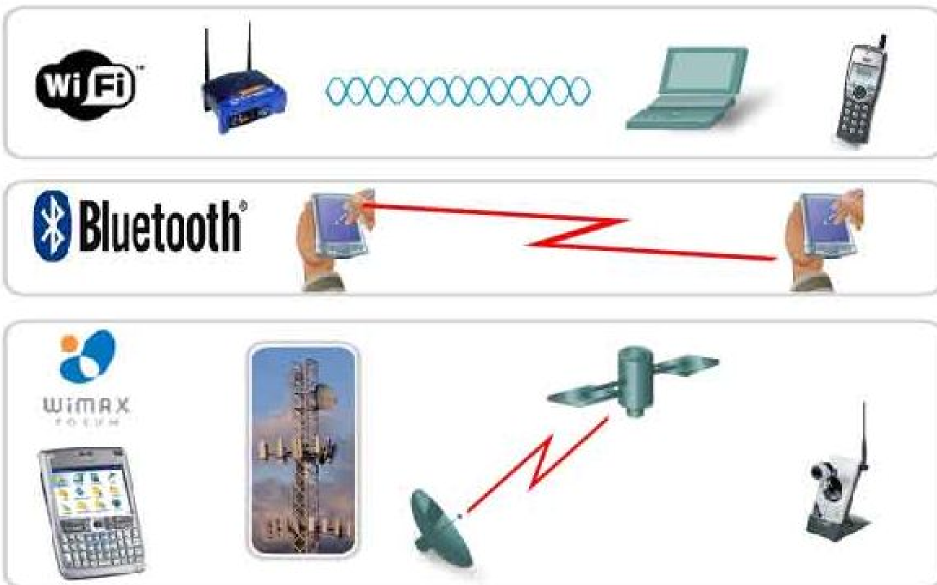
Ethernet Media

	10BASE-T	100BASE-TX	100BASE-FX	1000BASE-CX	1000BASE-T	1000BASE-SX	1000BASE-LX	1000BASE-ZX	10GBASE-ZR
Media	EIA/TIA Category 3, 4, 5 UTP - four pair	EIA/TIA Category 5 UTP - two pair	50/62.5 mmulti mode fiber	STP	EIA/TIA Category 5 (or greater) UTP, four pair	50/62.5 micron multimode fiber	50/62.5 micron multimode fiber or 9 micron single mode fiber	9m single mode fiber	9m single mode fiber
Maximum Segment Length	100m (328 feet)	100m (328 feet)	2 km (6562 ft)	25 m (82 feet)	100 m (328 feet)	Up to 550 m (1,804 ft) depending on fiber used	550 m (MMF)10 km (SMF)	Approx. 70 km	Up to 80 km
Topology	Star	Star	Star	Star	Star	Star	Star	Star	Star
Connector	ISO 8877 (RJ-45)	ISO 8877 (RJ-45)		ISO 8877 (RJ-45)	ISO 8877 (RJ-45)				

Characteristics of Ethernet Physical Media

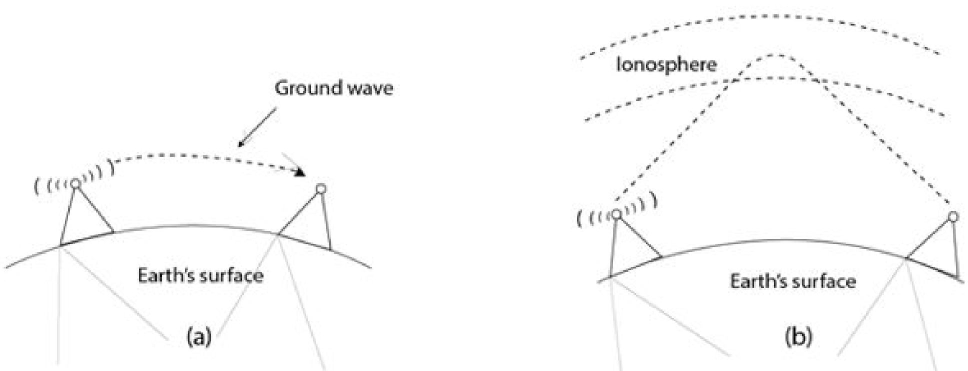
- **Unguided Media** :

Wireless Media Standards and Types



(1) Radio Waves :

Radio waves are a type of **electromagnetic radiation** with wavelengths in the electromagnetic spectrum **longer than infrared light**. Radio waves have frequencies as high as **300 gigahertz** (GHz) to as low as **30 hertz** (Hz). At 300 GHz, the corresponding wavelength is **1 mm**, and at 30 Hz is **10,000 km**. The wavelength of a radio wave can be anywhere from shorter than a grain of rice to longer than the radius of the Earth. Like all other electromagnetic waves, radio waves travel at the **speed of light** in vacuum. They are generated by **electric charges undergoing acceleration**, such as time varying electric currents. Naturally occurring radio waves are emitted by lightning and astronomical objects.

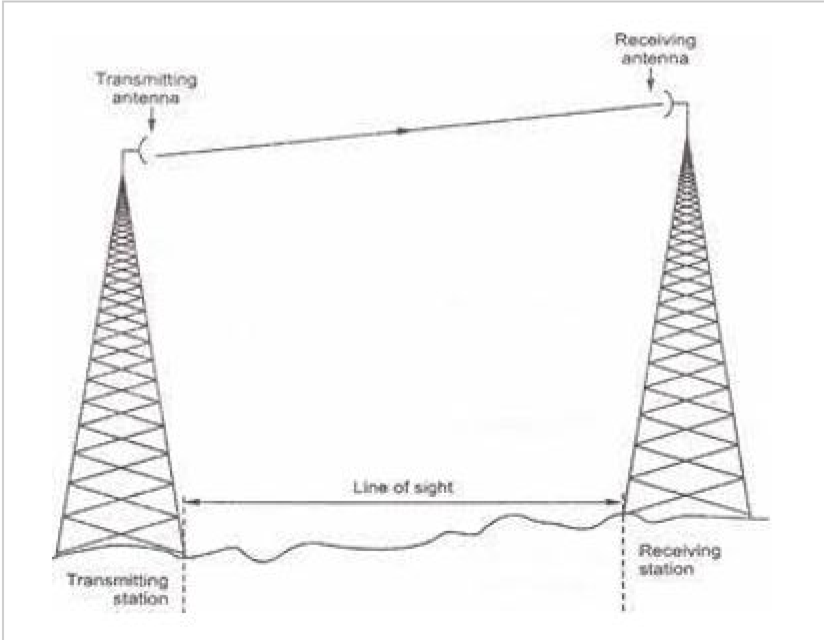


Radio waves are generated artificially by **transmitters** and received by **radio receivers**, using antennas. Radio waves are very widely used in modern technology for **fixed and mobile radio communication**, **broadcasting**, **radar and radio navigation systems**, **communications satellites**, **wireless computer networks** and many other applications. Different frequencies of radio waves have different propagation characteristics in the Earth's atmosphere; long waves can diffract around obstacles like mountains and follow the contour of the earth (ground waves), shorter waves can reflect off the ionosphere and return to earth beyond the horizon (skywaves), while much shorter wavelengths bend or diffract very little and travel on a line of sight, so their propagation distances are limited to the visual horizon.

To prevent interference between different users, the artificial generation and use of radio waves is strictly regulated by law, coordinated by an international body called the **International Telecommunications Union** (ITU), which defines radio waves as “electromagnetic waves of frequencies arbitrarily **lower than 3 000 GHz**, propagated in space without artificial guide”.

(2) Microwaves :

MicroWaves includes a line of sight transmission that is the sending and receiving antennas that need to be properly aligned with each other. The distance is directly proportional to the height of the antenna which is covered by the signal. In mobile phone communication and television distribution, these are majorly used. Due to the unidirectional properties of MicroWaves, they are very useful when **unicast (one-to-one) communication** is needed between the sender and the receiver. **Cellular phones**, **satellite networks**, and **wireless LANs** are using Microwaves.



Microwave Transmission

Two types of Microwave Transmission are as follows,

1. Terrestrial Microwave
2. Satellite Microwave

(i) Terrestrial Microwave

The frequency of Electromagnetic waves **between 300 MHz and 300 GHz** are called microwaves. These waves are **unidirectional**. Whenever microwaves are transmitting through the antenna, they can be narrowly focused. That is the sending and receiving antennas need to be aligned. It is inexpensive for **short distances** as it requires high towers for long distances. Due to environmental conditions and antenna size attenuation (loss of signal) occurs. There is a capacity in very high-frequency microwaves that they cannot penetrate walls. This characteristic can be a disadvantage of microwaves if the receiver is inside the buildings.

(ii) Satellite Microwave

A satellite is an entity that revolves around the earth at a certain height. Satellite communication offers more flexibility than fiber optic and cable systems. We can transmit signals from any point on the globe by using satellite transmission. The satellite receives the signal that is transmitted from the earth station, and it amplifies these signals. It is retransmitted the amplified signal to another earth station. Satellite transmission is much like the **line-of-sight transmission** in which one of the stations is a satellite orbiting the earth. The principle is the same as the terrestrial microwave. Signals still travel in straight lines in satellite transmission. It provides transmission capability to and from any location on earth. Deployment of Satellite microwaves for orbiting satellites is difficult.

Microwave technology is extensively used for **point-to-point telecommunications** (i.e. non-broadcast uses). Microwaves are especially suitable for this use since they are more easily focused into narrower beams than radio waves, allowing **frequency reuse**; their comparatively higher frequencies allow **broad bandwidth** and **high data transmission rates**, and antenna sizes are smaller than at lower frequencies because antenna size is inversely proportional to transmitted frequency. Microwaves are used in **spacecraft communication**, and much of the world's data, **TV**, and **telephone communications** are transmitted long distances by microwaves between ground stations and communications satellites. Microwaves are also employed in **microwave ovens** and in **radar technology**.

(3) Infrared Waves :

The frequency of Infrared waves is about **300 GHz to 430 THz**, which can be used for **short-range communication**. Infrared waves of high frequencies cannot penetrate walls. This characteristic of Infrared waves prevents interference between one system and another. This means a short-range communication system in a room cannot be affected by another system in the adjacent room.

If we are using the infrared remote control, we do not interfere with the use of the remote by our neighbors. However, by this characteristic, infrared signals become useless for long-range communication. Also, we cannot use infrared waves outside a building because the sun's rays contain infrared waves that can interfere with communication. This type of wide bandwidth can be used to transmit digital data with a **very high data rate**. The Infrared Data Association (IrDA) has established standards for using these signals for communication between devices and it is also responsible for sponsoring the use of infrared waves. This type of communication provides better security with **minimum interference**. Applications of Infrared Waves include **remote controls for television, stereos and other home appliances, wireless LANs, wireless modem, keyboard, mouse, printer, fire detectors, night vision systems, IDs, motion detectors, etc.**

Types of Wireless Networks

WLANS: Wireless Local Area Networks

WLANS allow users in a local area, such as a university campus or library, to form a network or gain access to the internet. A temporary network can be formed by a small number of users without the need of an access point; given that they do not need access to network resources.

WPANS: Wireless Personal Area Networks

The two current technologies for wireless personal area networks are Infra Red (IR) and Bluetooth (IEEE 802.15). These will allow the connectivity of personal devices within an area of about 30 feet. However, IR requires a direct line of site and the range is less.

WMANS: Wireless Metropolitan Area Networks

This technology allows the connection of multiple networks in a metropolitan area such as different buildings in a city, which can be an alternative or backup to laying copper or fiber cabling.

WWANS: Wireless Wide Area Networks

These types of networks can be maintained over large areas, such as cities or countries, via multiple satellite systems or antenna sites looked after by an ISP. These types of systems are referred to as 2G (2nd Generation) systems.

Type	Coverage	Performance	Standards	Applications
Wireless PAN	Within reach of a person	Moderate	Wireless PAN within reach of a person Moderate Bluetooth, IEEE 802.15, and IrDa Cable replacement for peripherals	Cable replacement for peripherals
Wireless LAN	Within a building or campus	High	IEEE 802.11, Wi-Fi, and HiperLAN	Mobile extension of wired networks
Wireless MAN	Within a city	High	Proprietary, IEEE 802.16, and WIMAX	Fixed wireless between homes and businesses and the Internet
Wireless WAN	Worldwide	Low	CDPD and Cellular 2G, 2.5G, and 3G	Mobile access to the Internet from outdoor areas

Comparison of Wireless Network Types

Some Technologies using Wireless Media :

(1) Wireless Fidelity (Wi-Fi) :

Wi-Fi is a family of wireless network protocols, based on the **IEEE 802.11** family of standards, which are commonly used for **local area networking** of devices and Internet access. Wi-Fi uses multiple parts of the **IEEE 802** protocol family and is designed to interwork seamlessly with its wired sibling Ethernet. Compatible devices can network through wireless access points to each other as well as to wired devices and the Internet.

Wi-Fi stations communicate by sending each other data packets: blocks of data individually sent and delivered over radio. As with all radio, this is done by the modulating and demodulation of carrier waves. Different versions of Wi-Fi use different techniques, **802.11b uses DSSS** on a **single carrier**, whereas **802.11a, Wi-Fi 4, 5 and 6** use **multiple carriers** on slightly different frequencies within the channel (OFDM).

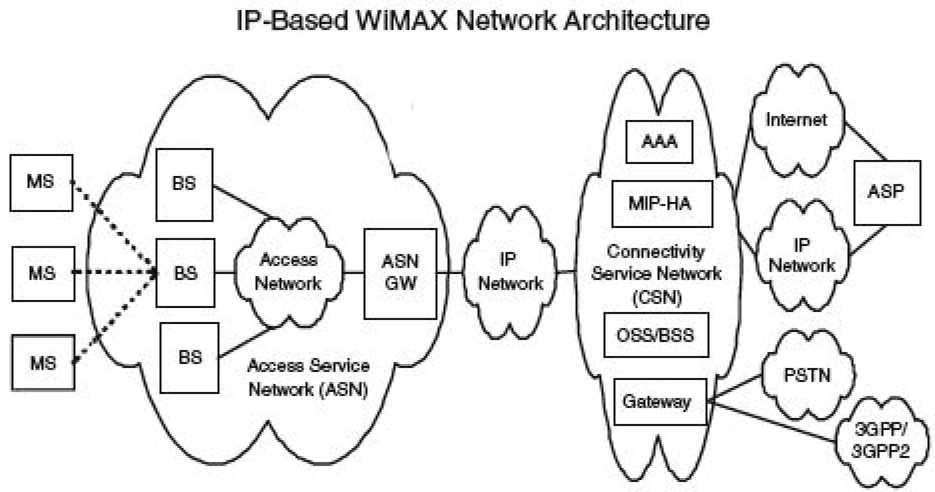
The 802.11 standard provides several distinct radio frequency ranges for use in Wi-Fi communications: **900 MHz, 2.4 GHz, 5 GHz, 5.9 GHz, and 60 GHz bands**. An access point (or hotspot) often has a range of about **20 metres indoors** while some modern access points claim up to a **150-metre range outdoors**. Hotspot coverage can be as small as a single room with walls that block radio waves, or as large as many square kilometres using many overlapping access points with roaming permitted between them. Over time the speed and spectral efficiency of Wi-Fi have increased. As of 2019, at close range, some versions of Wi-Fi, running on suitable hardware, can achieve speeds of over **1 Gbit/s**.

(2) Bluetooth :

Bluetooth, based on the **IEEE 802.15** (**802.15.1**) family of standards, is used for exchanging data between fixed and mobile devices over **short distances** using **short-wavelength UHF radio waves** in the industrial, scientific and medical radio bands, from **2.402 GHz to 2.480 GHz**, and building **personal area networks (PANs)**. Bluetooth is a packet-based protocol with a **master/slave architecture**. One master may communicate with up to seven slaves in a piconet. All devices within a given piconet use the clock provided by the master as the base for packet exchange. Bluetooth is a standard wire-replacement communications protocol primarily designed for **low power consumption**, with a short range based on low-cost transceiver microchips in each device. Because the devices use a radio (broadcast)/communications system, they do not have to be in visual line of sight of each other; however, a **quasi optical wireless path** must be viable. Range is power-class-dependent, but effective ranges vary in practice. Most Bluetooth applications are battery-powered Class 2 devices, with little difference in range whether the other end of the link is a Class 1 or Class 2 device as the lower-powered device tends to set the range limit. The Bluetooth Core Specification mandates a range of **not less than 10 metres**, but there is no upper limit on actual range. Manufacturers' implementations can be tuned to provide the range needed for each case.

Class	Max. permitted power		Typ. range (m)
	(mW)	(dBm)	
1	100	20	~100
1.5 (BT 5 Vol 6 Part A Sect 3)	10	10	~20
2	2.5	4	~10
3	1	0	~1
4	0.5	−3	~0.5

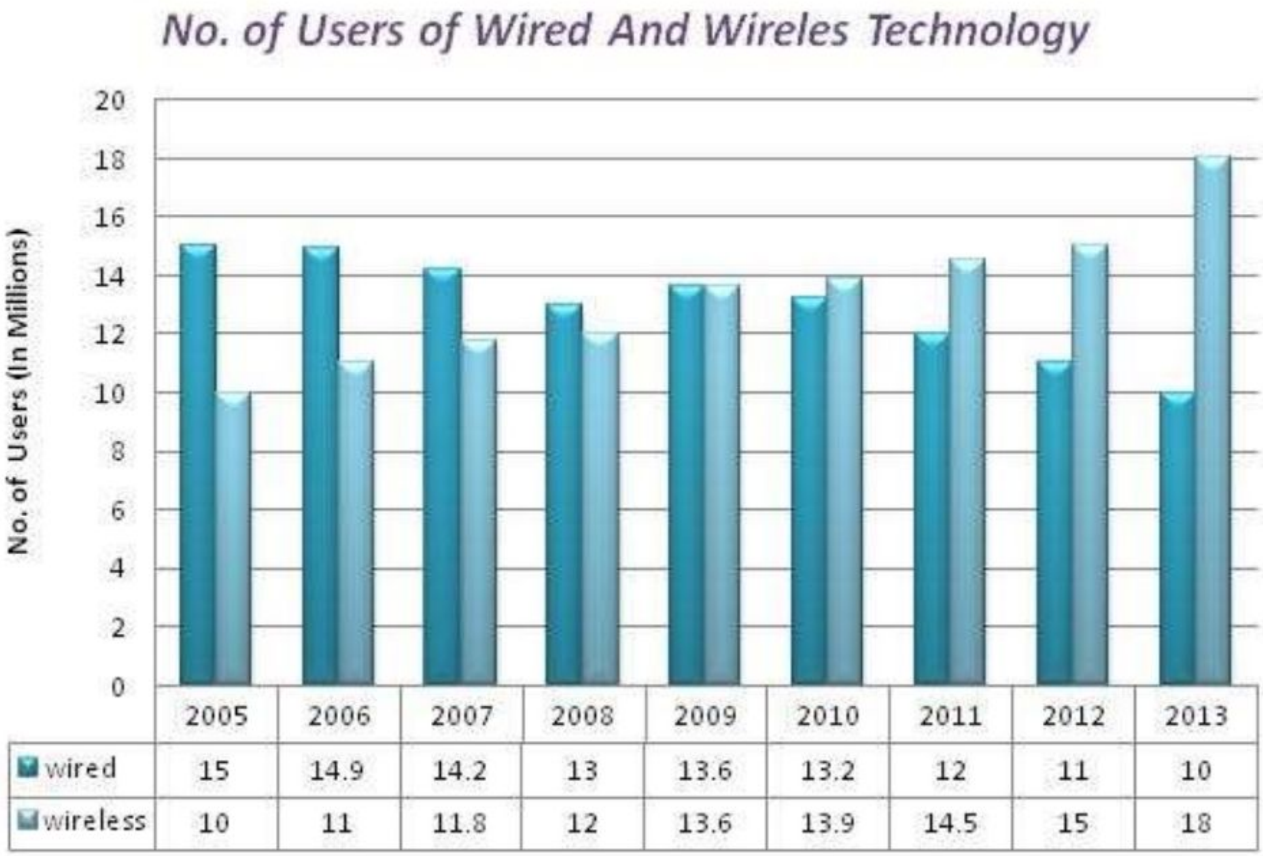
(3) WiMax :



WiMax is a standardized wireless version of Ethernet intended primarily as an alternative to wire technologies (such as Cable Modems, DSL and T1/E1 links) to provide broadband access to customer premises. More strictly, WiMAX is an industry trade organization formed by leading communications, component, and equipment companies to promote and certify compatibility and interoperability of broadband wireless access equipment that conforms to the **IEEE 802.16** and **ETSI HIPERMAN standards**. WiMAX would operate similar to WiFi, but at higher speeds over greater distances and for a greater number of users. WiMAX has the ability to provide service even in areas that are difficult for wired infrastructure to reach and the ability to overcome the physical limitations of traditional wired infrastructure. WiMAX was formed in **April 2001**, in anticipation of the publication of the original **10-66 GHz IEEE 802.16** specifications. WiMAX is to 802.16 as the WiFi Alliance is to 802.11.

WiMAX is expected to offer initially up to about **40 Mbps** capacity per wireless channel for both **fixed and portable applications,** enough to support hundreds of businesses with T-1 speed connectivity and thousands of residences with **DSL speed connectivity**. WiMAX can support **voice and video** as well as **Internet data**. It can also be used to connect WLAN hotspots to the Internet. WiMAX is also intended to provide **broadband connectivity to mobile devices**. It would not be as fast as in these fixed applications, but expectations are for about **15 Mbps capacity in a 3 km cell** coverage area. With WiMAX, users could really cut free from today's Internet access arrangements and be able to go online at broadband speeds, almost wherever they like from within a MetroZone. WiMAX could potentially be deployed in a variety of spectrum bands: **2.3GHz, 2.5GHz, 3.5GHz, and 5.8GHz**.

Statistics of Wired and Wireless users :



References :

1. https://www.slideshare.net/nimx106/wired-transmission-media
2. https://www.tutorialspoint.com/data_communication_computer_network/physical_layer_introduction.htm#:~:text=Physical%20layer%20is%20the%20only,services%20to%20Data%2Dlink%20layer.
3. https://en.wikipedia.org/wiki/Twisted_pair
4. http://www.highteck.net/EN/Physical/OSI_Physical_Layer.html
5. https://www.includehelp.com/computer-networks/unguided-transmission-media.aspx
6. https://www.computernetworkingnotes.com/ccna-study-guide/types-of-wireless-network-explained-with-standards.html
7. https://www.tutorialspoint.com/wimax/what_is_wimax.htm