Experiment 1

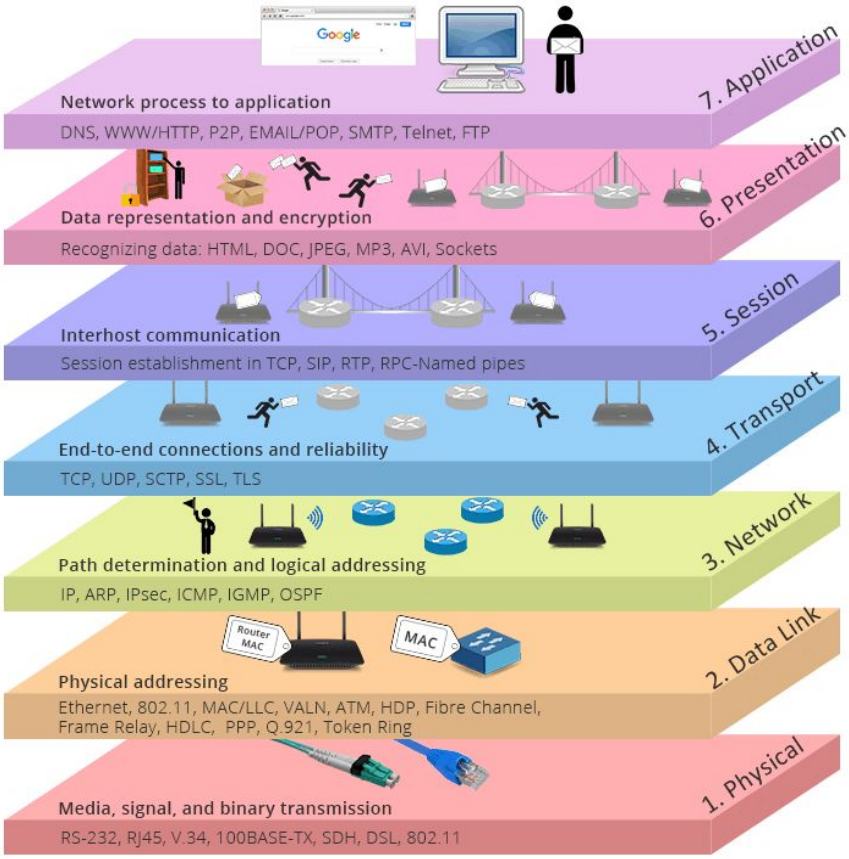
Aim: Study of different types of physical layer wired/wireless connections.

Theory:

OSI Model -

The **Open Systems Interconnection (OSI)** model is a conceptual model created by the International Organization for Standardization which enables diverse communication systems to communicate using standard protocols. In plain English, the OSI provides a standard for different computer systems to be able to communicate with each other.

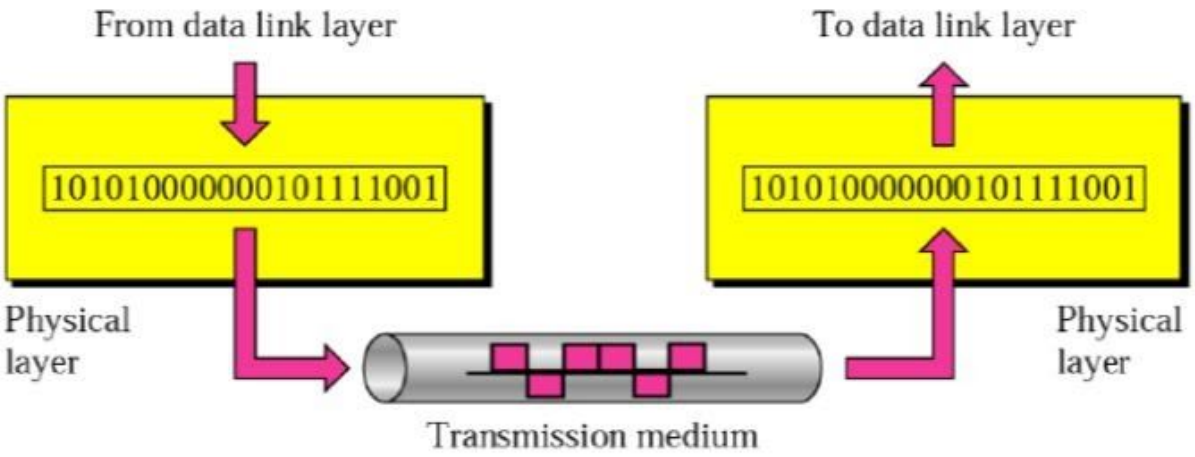
The OSI model can be seen as a universal language for computer networking. It's based on the concept of splitting up a communication system into seven abstract layers, each one stacked upon the last.



We limit our discussion to the lowest layer at the foundation of the Computer Networks and see how they are connected, and it's different forms, over the transmission medium.

Physical layer (OSI model) :

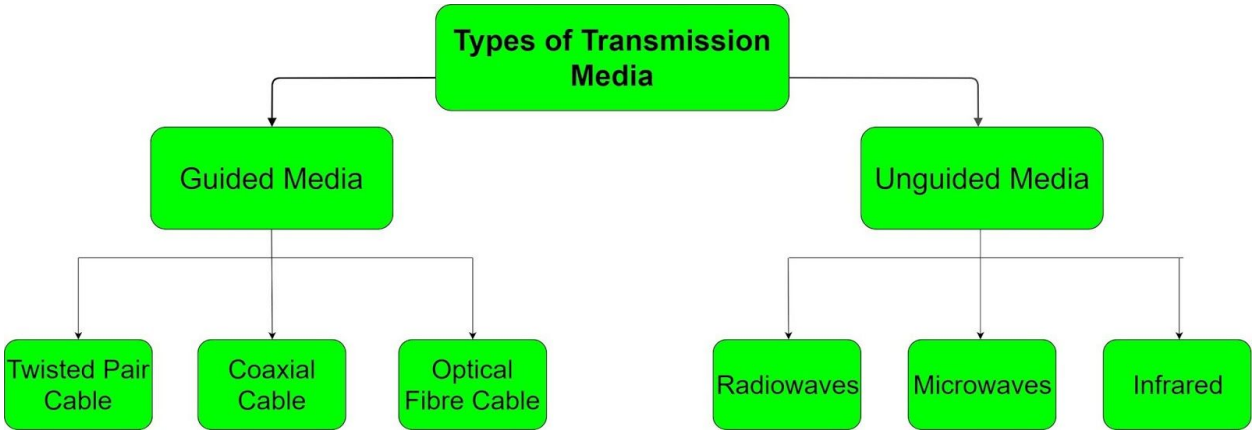
This layer includes the **physical equipment** involved in the data transfer, such as the cables and switches. This is also the layer where the data gets converted into a bitstream, which is a string of **1s and 0s**. The physical layer of both devices must also agree on a signal convention so that the 1s can be distinguished from the 0s on both devices.



In our further discussions, we divide the Physical Layer into two categories as per medium of transmission, discuss their range and specifications, and show their scalability and applicability in different architectures such as LAN, WAN, MAN, etc.

Types of Transmission Media :

In data communication terminology, a transmission medium is a physical path between the transmitter and the receiver i.e it is the channel through which data is sent from one place to another. Transmission Media is broadly classified into the following types:



1. Guided Media:
It is also referred to as Wired or Bounded transmission media. Signals being transmitted are directed and confined in a narrow pathway by using physical links.

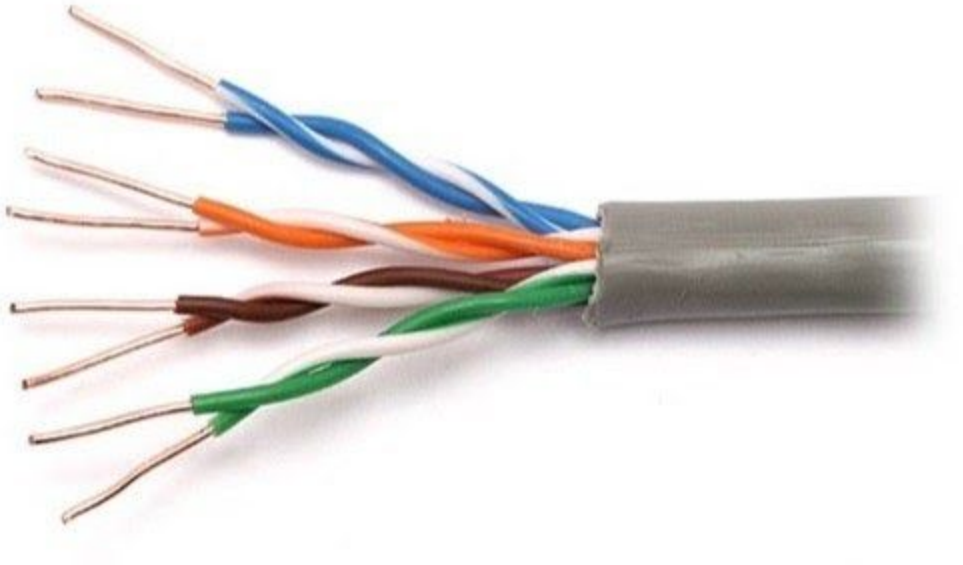
Features:

- Hight Speed
- Secure
- Used for comparatively shorter distances

There are 3 major types of Guided Media:
(i) Twisted Pair Cable –
It consists of 2 separately insulated conductor wires wound about each other. Generally, several such pairs are bundled together in a protective sheath. They are the most widely used Transmission Media.

Twisted Pair is of two types:

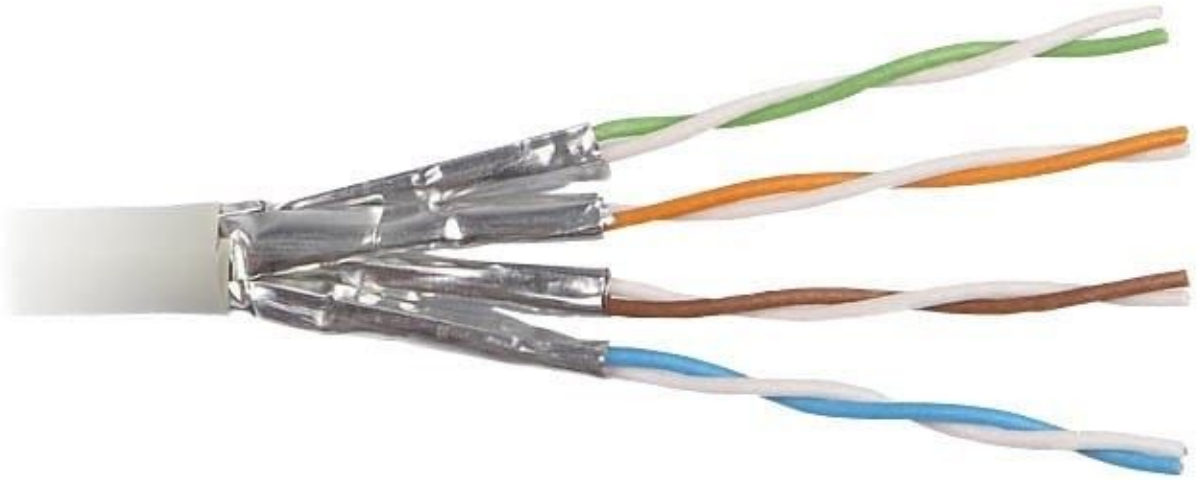
Unshielded Twisted Pair (UTP):
This type of cable has the ability to block interference and does not depend on a physical shield for this purpose. It is used for telephonic applications.



Advantages:

- Least expensive
- Easy to install
- High-speed capacity
- Susceptible to external interference
- Lower capacity and performance in comparison to STP
- Short distance transmission due to attenuation

Shielded Twisted Pair (STP):
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.

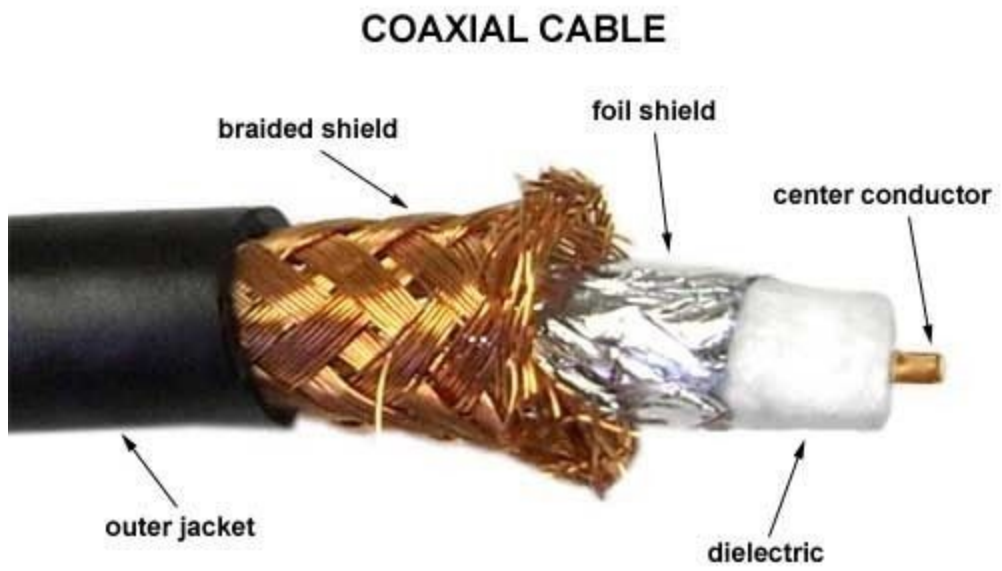


Advantages:

- Better performance at a higher data rate in comparison to UTP
- Eliminates crosstalk
- Comparatively faster
- Comparatively difficult to install and manufacture
- More expensive
- Bulky

(ii) Coaxial Cable –

It has an outer plastic covering containing 2 parallel conductors each having a separate insulated protection cover. The coaxial cable transmits information in two modes: Baseband mode (dedicated cable bandwidth) and Broadband mode(cable bandwidth is split into separate ranges). Cable TVs and analog television networks widely use Coaxial cables.



Advantages:

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

Disadvantages:

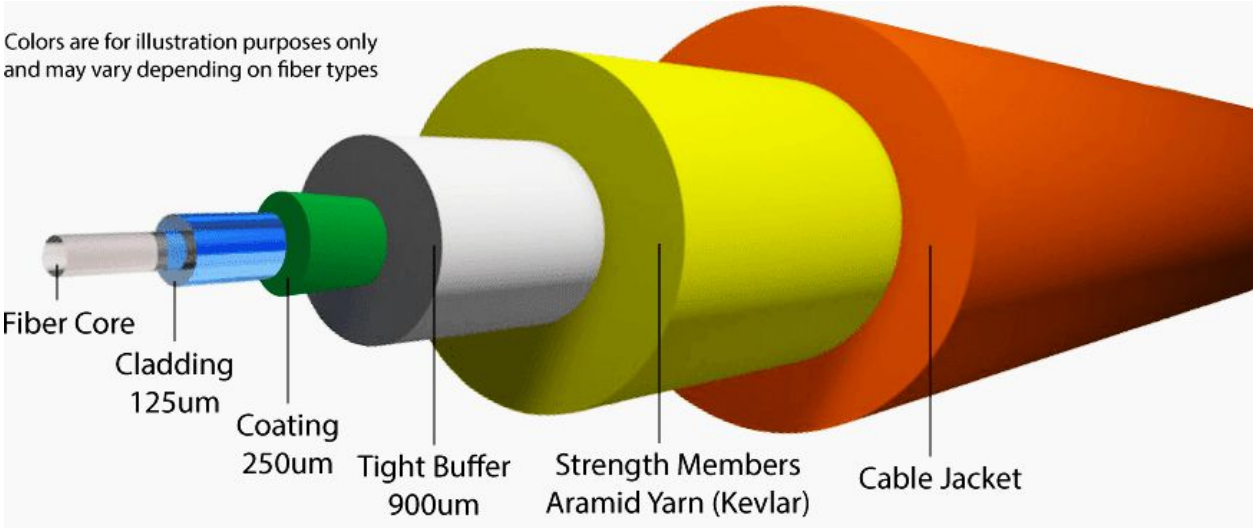
- Single cable failure can disrupt the entire network

(iii) Optical Fibre Cable –

It uses the concept of reflection of light through a core made up of glass or plastic. The core is surrounded by a less dense glass or plastic covering called the cladding. It is used for the transmission of large volumes of data.

The cable can be **unidirectional or bidirectional**. The WDM (Wavelength Division Multiplexer) **supports two modes, namely unidirectional and bidirectional mode**.

The t**hree prime wavelengths for fiber optics, 850, 1300 and 1550 nm** drive everything we design or test. NIST (the US National Institute of Standards and Technology) provides power meter calibration at these three wavelengths for fiber optics. **Multimode fiber** is designed to operate at **850 and 1300 nm**, while **singlemode fiber** is optimized for **1310 and 1550 nm**.



Advantages:

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

Disadvantages:

- Difficult to install and maintain
- High cost
- Fragile

2. Unguided Media:

It is also referred to as Wireless or Unbounded transmission media.No physical medium is required for the transmission of electromagnetic signals.

Features:

- The signal is broadcasted through air
- Less Secure
- Used for larger distances

There are 3 major types of Unguided Media:

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

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

(ii) 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.

(iii) 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.

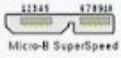
Wired Technologies

1. **Universal Serial Bus (USB) :**

   Universal Serial Bus (USB) is an industry-standard that establishes specifications for cables and connectors and protocols for connection, communication, and power supply (interfacing) between computers, peripherals, and other computers. A broad variety of USB hardware exists, including several different connectors, of which USB-C is the most recent.

Released in 1996, the USB standard is currently maintained by the USB Implementers Forum (USB-IF). There have been four generations of USB specifications: USB 1.x, USB 2.0, USB 3.x, and USB4.

Available receptacles for each connector

Connectors		USB 1.0 1996	USB 1.1 1998	USB 2.0 2001	USB 2.0 Revised	USB 3.0 2011	USB 3.1 2014	USB 3.2 2017	USB4 2019
Data rate		1.5 Mbit/s	1.5 Mbit/s (*Low Speed*) 12 Mbit/s (*Full Speed*)	1.5 Mbit/s (*Low Speed*) 12 Mbit/s (*Full Speed*) 480 Mbit/s (*High Speed*)		5 Gbit/s (*SuperSpeed*)	10 Gbit/s (*SuperSpeed+*)	20 Gbit/s (*SuperSpeed++*)	40 Gbit/s (*SuperSpeed++ and Thunderbolt 3*)
Standard	A	Type A  Type-A					Type A  Type-A SuperSpeed		Deprecated
	B	Type B  Type-B				Type B  Type-B SuperSpeed		Deprecated	
	C	N/A					Type C (*enlarged*) 		
Mini	A	N/A	Mini A  Mini-A			Deprecated			
	B		Mini B  Mini-B						
	AB	N/A		Mini AB  Mini-AB					
Micro	A	N/A							
	B	N/A		Micro B  Micro-B	Micro B  Micro-B SuperSpeed		Deprecated		
	AB			Micro AB  Micro-AB	Deprecated				
Connectors		USB 1.0 1996	USB 1.1 1998	USB 2.0 2001	USB 2.0 Revised	USB 3.0 2011	USB 3.1 2014	USB 3.2 2017	USB4 2019

2. **Ethernet**

Ethernet is a family of computer networking technologies commonly used in **local area networks (LAN), metropolitan area networks (MAN) and wide area networks (WAN).** It was commercially introduced in 1980 and first standardized in 1983 as **IEEE 802.3**. Ethernet has since been refined to support higher bit rates, a greater number of nodes, and longer link distances, but retains much backward compatibility. Over time, **Ethernet has largely replaced competing wired LAN technologies such as Token Ring, FDDI, and ARCNET.**

As per the OSI model, **Ethernet provides services up to and including the data link layer.** The 48-bit MAC address was adopted by other IEEE 802 networking standards, including IEEE 802.11 Wi-Fi, as well as by FDDI, and EtherType values are also used in Subnetwork Access Protocol (SNAP) headers.

Ethernet is widely used in homes and industry and interworks well with Wi-Fi. The Internet Protocol is commonly carried over Ethernet and so it is considered one of the key technologies that make up the Internet.

There are different Ethernet standards.
All cable types:

10Base2 and 10Base5: These coaxial cables are like those used in television, but thinner. They are also called "thinnet" or "coax". Each computer has a "T" plugged into it, and cables plug into each side of the "T". Sometimes, instead of a "T", a vampire tap is used. It supports 10MBits per second transfer speed. It was the first to be adopted and became rare during the 21st century.

10BaseT: Cables look like thick phone cables, but with 8 copper wires instead of 2 or 4, and they go from each computer' to a Hub or a Switch. Supported speed is 10 MBit/second.

10BaseF: Same as 10BaseT, but cables transmit light pulses, instead of electrical signals.

100BaseT: Cables look the same as 10BaseT, but can run at up to 100 MBits per second

1000BaseT: Cables look the same as 10BaseT, but can run at up to 1GBit (1000MBit) per second.

Wireless Technologies -

1. **WiMAX**

   WiMax stands for **Worldwide Interoperability for Microwave Access**. This wireless technology allows data to be transferred at a rate of **30-40 megabits per second**. The term refers specifically to interoperable implementations of the **IEEE 802.16** wireless family. The technology was once used by several mobile carriers, notably Sprint, to deliver wireless data to its customers. Sprint, along with many of the other carriers who used the technology, has since switched over to using faster LTE 4G networks for data.

   The WiMax Forum certifies devices before they can be sold to consumers or businesses. The technology can be used both indoors and outdoors, however, **WiMax devices typically produce a better signal when used outside or by a window.**

   There is **no uniform global licensed spectrum for WiMAX**, however the **WiMAX Forum published three licensed spectrum** profiles: **2.3 GHz, 2.5 GHz and 3.5 GHz**, in an effort to drive standardisation and decrease cost

2. **Wifi**

   WiFi uses **radio waves (RF)** to allow two devices to communicate with one another. The technology is most commonly used to connect Internet routers to devices like computers, tablets, and phones; however, it can be used to connect together any two hardware components. WiFi is a local wireless network that runs of the **802.11 standards** set forth by the Institute of Electrical and Electronics Engineers (IEEE).

   WiFi can utilize both the global **2.4GHz UHF and 5GHz SHF ISM radio bands**. The WiFi Alliance certified some products, allowing them to be labeled as "Wi-Fi Certified." In order to receive that designation, a product must go through the Alliance's interoperability certification testing.

   802.11b, 802.11g, and 802.11n run on the 2.4GHz ISM band. The band is susceptible to interference from some Bluetooth devices as well as some microwave ovens and cordless phones. Devices that run on either band can be operated in the United States without a

license from the FCC, but still, require FCC part 15 certification. The first six channels of frequencies from each are considered part of the amateur radio band.

3. **Bluetooth and BLE**

   Bluetooth and Bluetooth Low Energy (BLE) are wireless technologies used to transfer data over **short distances**. The technology is frequently used in small devices that connect to user's phones and tablets. For instance, the technology is used in many speaker systems. Bluetooth Low Energy uses less power than standard Bluetooth and is used in hardware such as fitness trackers, smartwatches, and other connected devices in order to wirelessly transmit data without heavily compromising the battery power in a user's phone.

   BLE has only recently started to pick up steam. The technology was initially introduced by smartphone maker Nokia in 2006 but didn't become part of the Bluetooth standard until 2010. Today, BLE, which is also referred to as **Bluetooth Smart**, is supported by the majority of smartphone and computer makers as well as most major operating systems including Windows 8, OS X, Linux, Windows Phone, Android, and iOS.

   Bluetooth uses **UHF radio waves for data transfer**. The technology was originally standardized as **IEEE 802.15.1**, but the **IEEE no longer maintains that specific standard**. Companies that work with Bluetooth are often affiliated with the Bluetooth Special Interest group (SIG). The group currently has over 20,000 members and must certify a product before it can be marketed as a Bluetooth device to the consumer or business market. That certification helps ensure that all Bluetooth devices work in a standardized way and provide a similar experience for consumers.

4. **Zigbee:**

   Zigbee is an **IEEE 802.15.4**-based specification for a suite of high-level communication protocols used to create personal area networks with small, low-power digital radios, such as for home automation, medical device data collection, and other low-power low-bandwidth needs, designed for small scale projects which need wireless connection. Hence, Zigbee is a **low-power, low data rate, and close proximity** (i.e., personal area) wireless ad hoc network.

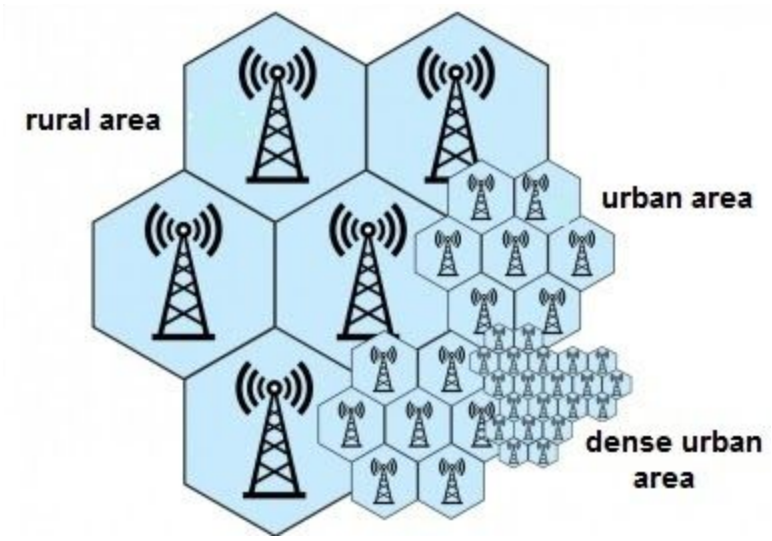
Its low power consumption limits transmission distances to **10–100 meters** line-of-sight, depending on power output and environmental characteristics. Zigbee devices can transmit data over long distances by passing data through a mesh network of intermediate devices to reach more distant ones. Zigbee is typically used in low data rate applications that require long battery life and secure networking (Zigbee networks are **secured by 128 bit symmetric encryption keys.**) Zigbee has a defined **rate of 250 kbit/s**, best suited for intermittent data transmissions from a sensor or input device.

Zigbee operates in the industrial, scientific and medical (ISM) radio bands: **2.4 GHz** in most jurisdictions worldwide; though some devices also use **784 MHz** in China, **868 MHz** in Europe and **915 MHz** in the US and Australia, however even those regions and countries still use **2.4 GHz** for most commercial Zigbee devices for home use. Data rates vary from **20 kbit/s (868 MHz band) to 250 kbit/s (2.4 GHz band)**

5. **Cellular network**

A cellular network or mobile network is a communication network where the last link is wireless. **The network is distributed over land areas called "cells"**, each served by at least one fixed-location transceiver, but more normally, three cell sites or base transceiver stations. These base stations provide the cell with the network coverage which can be used for transmission of voice, data, and other types of content. A cell typically uses a different set of frequencies from neighbouring cells, to avoid interference and provide guaranteed service quality within each cell.

When joined together, these cells provide radio coverage over a wide geographic area. This enables numerous portable transceivers (e.g., mobile phones, tablets and laptops equipped with mobile broadband modems, pagers, etc.) to communicate with each other and with fixed transceivers and telephones anywhere in the network, via base stations, even if some of the transceivers are moving through more than one cell during transmission.

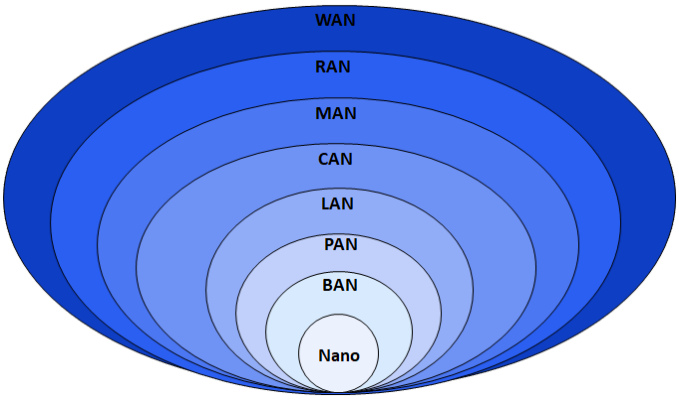


6. **LTE**

In telecommunications, **Long-Term Evolution (LTE)** is a standard for wireless broadband communication for mobile devices and data terminals, based on the **GSM/EDGE and UMTS/HSPA** technologies. It increases the capacity and speed using a different radio interface together with core network improvements. LTE is the upgrade path for carriers with both GSM/UMTS networks and CDMA2000 networks. The different **LTE frequencies and bands used in different countries mean that only multi-band phones are able to use LTE in all countries where it is supported**.

The standard is developed by the 3GPP (3rd Generation Partnership Project) and is specified in its Release 8 document series, with minor enhancements described in Release 9. LTE is sometimes known as 3.95G and has been marketed both as "4G LTE" and as "Advanced 4G",[citation needed] but it does not meet the technical criteria of a 4G wireless service, as specified in the 3GPP Release 8 and 9 document series for LTE Advanced.

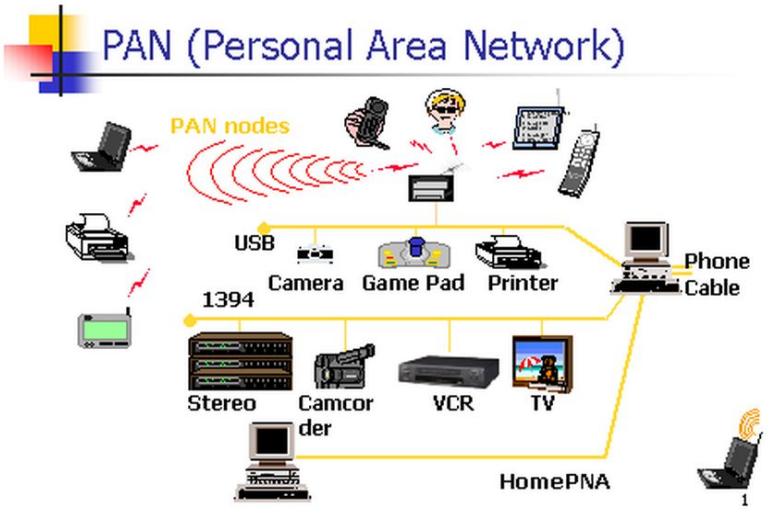
Types of Computer Networks -



1. **Personal Area Network (PAN):**
   A personal area network, or PAN, is a computer network **organized around an individual person within a single building**. This could be inside a small office or residence. A typical PAN would include one or more computers, telephones, peripheral devices, video game consoles, and other personal entertainment devices.

   If multiple individuals use the same network within a residence, the network is sometimes referred to as a home area network or HAN. In a very typical setup, a residence will have a single wired Internet connection connected to a modem. This modem then provides both wired and wireless connections for multiple devices. The network is typically managed from a single computer but can be accessed from any device.

   A personal area network, or PAN, is a computer network that enables communication between computer devices near a person. PANs can be **wired, such as USB or FireWire, or they can be wireless, such as infrared, ZigBee, Bluetooth and ultrawideband, or UWB**

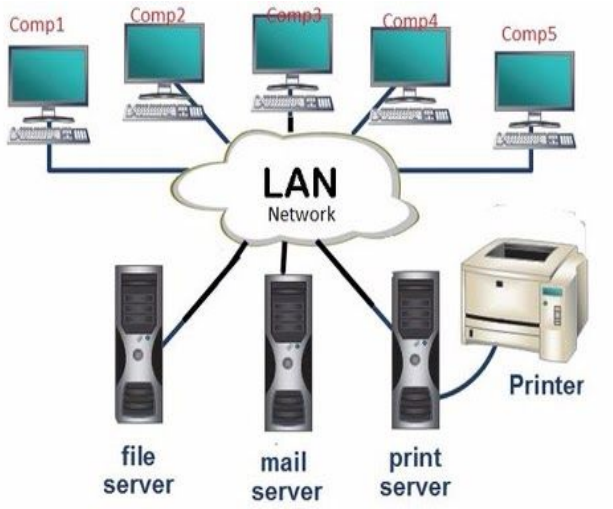


2. **Local Area Network (LAN):**

A local area network (LAN) is a group of computers and peripheral devices that share a common communications line or wireless link to a server within a distinct geographic area. A local area network may serve as few as two or three users in a home-office or several hundred users in a corporation's central office. Homeowners and information technology (IT) administrators set up LANs so that network nodes can share resources such as printers or network storage.

LAN networking requires cables, switches, routers, and other components that let users connect to internal servers, websites, and other LANs that belong to the same wide area network (WAN). Ethernet and Wi-Fi are the two primary ways to enable LAN connections. Ethernet is a specification that enables computers to communicate with each other. Wi-Fi uses radio waves to connect computers to the LAN.

Other LAN technologies, including **Token Ring, fiber distributed data interface FIDDI and ARCNET lost favor as Ethernet and Wi-Fi speed increased and connectivity costs decreased**.

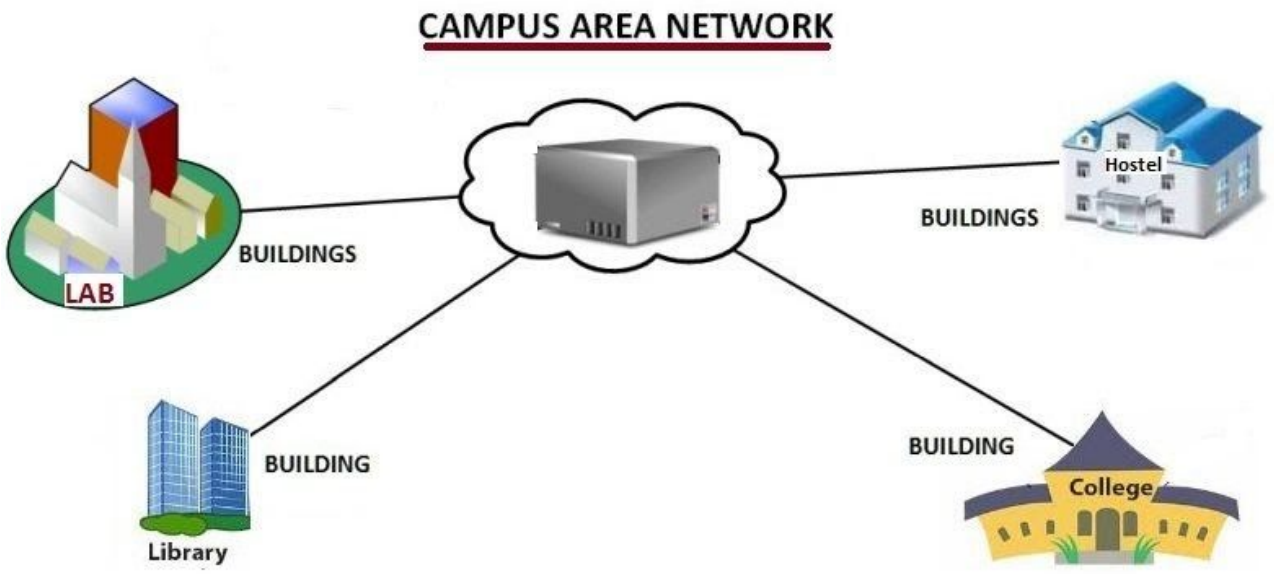


3. **Campus Area Network (CAN):**

"Campus Area Network." A CAN is a network that covers an educational or corporate campus. Examples include elementary schools, university campuses, and corporate buildings.

A **campus area network is larger than a local area network LAN** since it may span multiple buildings within a specific area. Most **CANs are composed of several LANs** connected via switches and routers that combine to create a single network. They operate similar to LANs, in that users with access to the network (wired or wireless) can communicate directly with other systems within the network.

Nodes in a campus network are interconnected by means of **Optical fiber media**, i.e., Fiber optics and take advantage of 10-Gigabit Ethernet technology. Besides this 10-Gigabit ethernet technology, Wi-Fi hotspots and hot zones are different ways of accessing the network.



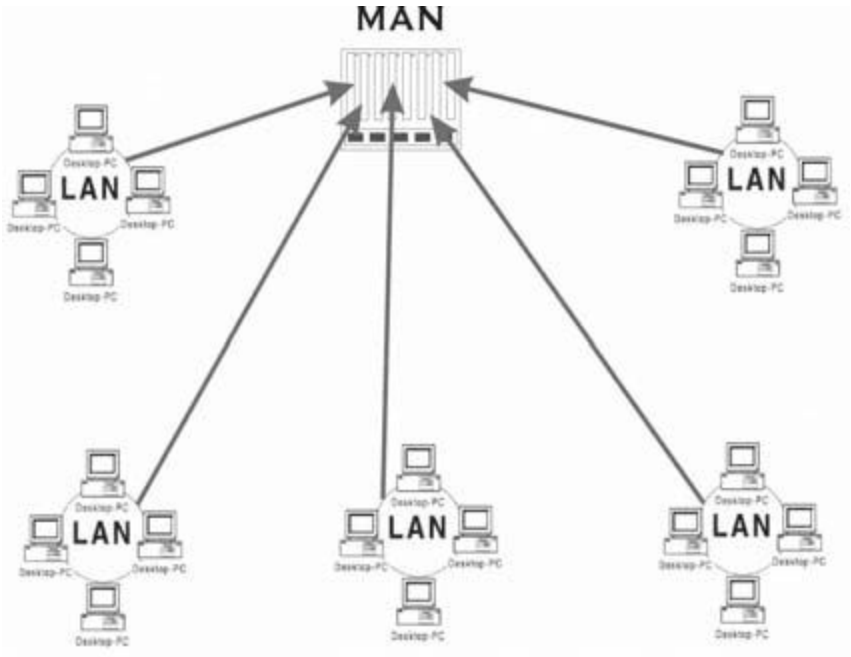
4. **Metropolitan Area Network (MAN):**

A metropolitan area network (MAN) is a network with a size greater than LAN but smaller than a WAN. It normally comprises networked interconnections within a city that also offers a connection to the Internet.

Network size generally ranges from **5 to 50 km**. It may be as small as a group of buildings on campus to as large as covering the whole city. Data rates are moderate to high. In general, a MAN is either owned by a user group or by a network provider who sells

service to users, rather than a single organization as in LAN. It facilitates the sharing of regional resources. They provide uplinks for connecting LANs to WANs and the Internet.

The primary goal of a MAN is to establish a connection between geographically separated LANs. It means that a MAN seeks to form a communication link between two independent LAN nodes. **It establishes using optical fibers cables.** In order to refresh memory, a switch is responsible for filtering data inflowing in the shape of frames. The switch lies as one of the fundamental components as it is actively responsible for dual tasks. At one end, it filters data and on the other end, it manages the connection.



5. **Wide Area Network (WAN):**

A wide area network (WAN) is a telecommunications network that extends over a large geographic area for the primary purpose of computer networking. Wide area networks are often established with leased telecommunication circuits.

Business, as well as education and government entities, use wide area networks to relay data to staff, students, clients, buyers, and suppliers from various locations across the world. In essence, this mode of telecommunication allows a business to effectively

carry out its daily function regardless of location. The Internet may be considered a WAN

6. **Storage area network (SAN) :**

   A storage area network (SAN) is a dedicated high-speed network or subnetwork that interconnects and presents shared pools of storage devices to multiple servers. A SAN moves storage resources off the common user network and reorganizes them into an independent, high-performance network. This enables each server to access shared storage as if it were a drive directly attached to the server. When a host wants to access a storage device on the SAN, it sends out a block-based access request for the storage device.

   A storage area network is typically assembled using three principle components: cabling, host bus adapters (HBAs), and switches attached to storage arrays and servers. Each switch and storage system on the SAN must be interconnected, and the physical interconnections must support bandwidth levels that can adequately handle peak data activities. IT administrators manage storage area networks centrally.

   Storage arrays were initially all hard disk drive systems, but are increasingly populated with flash solid-state drives (SSDs).

7. **Global Area Networks (GAN):**

   A global network, such as the internet, is referred to as the Globe Area Network (GAN). The internet is, however, not the only computer network of its kind. Internationally operating companies also support local networks that comprise several WANs and connect company computers across the world. GANs use the fiber optic infrastructure from wide area networks and combine these with international undersea cables or satellite transmissions.

Conclusion :

We have discussed different types of physical layer wired/wireless connections, in great detail, highlighting some interesting facts and focusing on the applicability of the various technologies in the various network architectures.

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