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BATCH: B

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

The lowest layer of the OSI reference model is the physical layer. It is responsible for the actual physical connection between the devices. The physical layer contains information in the form of **bits.** It is responsible for transmitting individual bits from one node to the next. When receiving data, this layer will get the signal received and convert it into 0s and 1s and send them to the Data Link layer, which will put the frame back together.

 Types of Connections:-

Wired Connections: - A wired network uses cables to connect devices, such as laptop or desktop computers, to the Internet or another network.
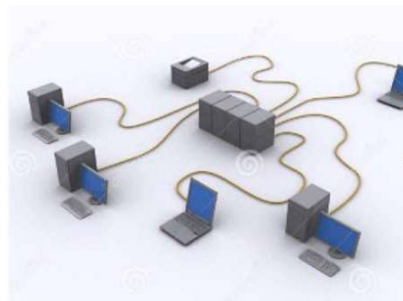
Wireless Connections: - Wireless network refers to the use of infrared or radio frequency signals to share information and resources between devices. Wireless technologies are designed to reduce the time and different type of obstacles created by the cables. Access points amplify Wi-Fi signals, so a device can be far from a router but still be connected to the network.

# Types of physical layer wireless connections*(ref.3)*
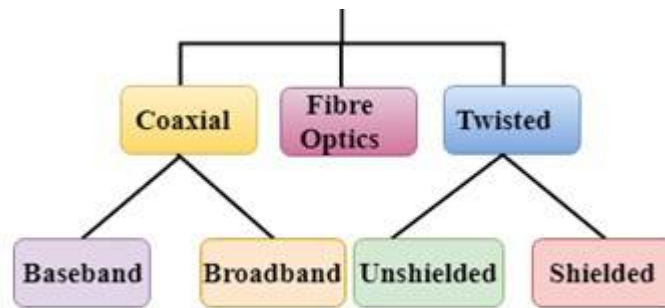
Twisted pair:

Twisted pair is a physical media made up of a pair of cables twisted with each other. A twisted pair cable is cheap as compared to other transmission media. Installation of the twisted pair cable is easy, and it is a lightweight cable. The frequency range for twisted pair cable is from 0 to 3.5 KHz.

A twisted pair consists of two insulated copper wires arranged in a regular spiral pattern. The degree of reduction in noise interference is determined by the number of turns per foot. Increasing the number of turns per foot decreases noise interference.

Types of Twisted pair:
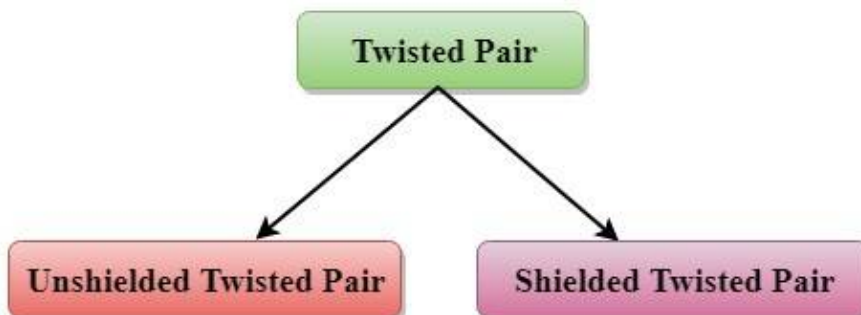
Unshielded Twisted Pair:

An unshielded twisted pair is widely used in telecommunication. Following are the categories of the unshielded twisted pair cable:

- o Category 1: Category 1 is used for telephone lines that have low-speed data.
- o Category 2: It can support up to 4Mbps.
- o Category 3: It can support up to 16Mbps.
- o Category 4: It can support up to 20Mbps. Therefore, it can be used for long-distance communication.
- o Category 5: It can support up to 200Mbps.

Advantages of Unshielded Twisted Pair:

- o It can be used for high-speed LAN.

Disadvantage:

- o This cable can only be used for shorter distances of 100 meters because of attenuation.

Shielded Twisted Pair

A shielded twisted pair is a cable that contains the mesh surrounding the wire that allows the higher transmission rate.

Characteristics of Shielded Twisted Pair:

- o It has higher capacity as compared to unshielded twisted pair cable.
- o It has a higher attenuation.
- o It is shielded that provides the higher data transmission rate.

Disadvantages

- o It has a higher attenuation rate.

Coaxial Cable *(ref.3)*

Coaxial Cable

- o Coaxial cable is very commonly used transmission media, for example, TV wire is usually a coaxial cable.
- o It has a higher frequency as compared to Twisted pair cable.
- o The middle core is responsible for the data transferring whereas the copper mesh prevents from the EMI (Electromagnetic interference).
- o It can cover up to 500m.

Jacket   Shield   Insulator   Centre Conductor
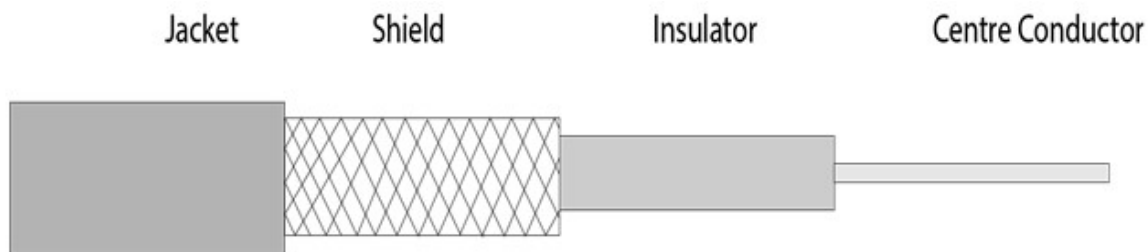
Coaxial cable is of two types:

1. **Baseband transmission:** It is defined as the process of transmitting a single signal at high speed.
2. **Broadband transmission:** It is defined as the process of transmitting multiple signals simultaneously.

Advantages of Coaxial cable:

- o The data can be transmitted at high speed.
- o It has better shielding as compared to twisted pair cable.
- o It provides higher bandwidth.

Fibre Optic *(ref.3)*

- o Fibre optic cable is a cable that uses electrical signals for communication.
- o Fibre optic is a cable that holds the optical fibres coated in plastic that are used to send the data by pulses of light.
- o The plastic coating protects the optical fibres from heat, cold, electromagnetic interference from other types of wiring.
- o Fibre optics provide faster data transmission than copper wires.

Diagrammatic representation of fibre optic cable:
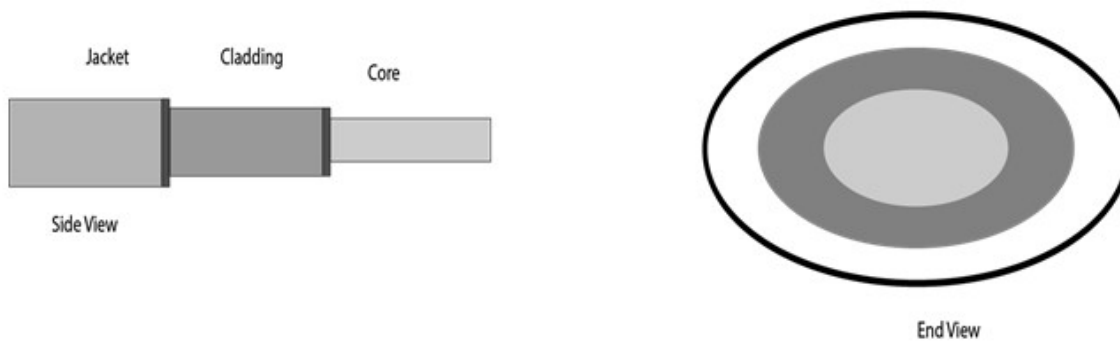
Following are the advantages of fibre optic cable over copper:

o Greater Bandwidth: The fibre optic cable provides more bandwidth as compared copper. Therefore, the fibre optic carries more data as compared to copper cable.

o Faster speed: Fibre optic cable carries the data in the form of light. This allows the fibre optic cable to carry the signals at a higher speed.

o Longer distances: The fibre optic cable carries the data at a longer distance as compared to copper cable.

o Better reliability: The fibre optic cable is more reliable than the copper cable as it is immune to any temperature changes while it can cause obstruct in the connectivity of copper cable.

Scalability

Fibre optics are much more scalable meaning that new equipment can easily be laid over the original fibre, with wavelengths turned on and off to allow for quick scaling if needed. Spare fibre optics can be included for future use and additional cables also laid at a later stage

**Protocols under Wireless Networks:-**

1. 802.15.1 (Bluetooth)

2. 802.15.4 & ZigBee
3. Worldwide Interoperability for Microwave Access (WiMax) 802.16a

The 802.15 standard is defined through several specifications of WPANs.

802.15.1:- *(ref.1)*

➢ 802.15.1, more commonly known as Bluetooth, is a low-data-rate, low- power wireless networking standard aimed at replacing cables between lightweight devices.
➢ A Bluetooth network is called piconet and a collection of interconnected piconets is called scatternet.
➢ Bluetooth has master slave configuration.
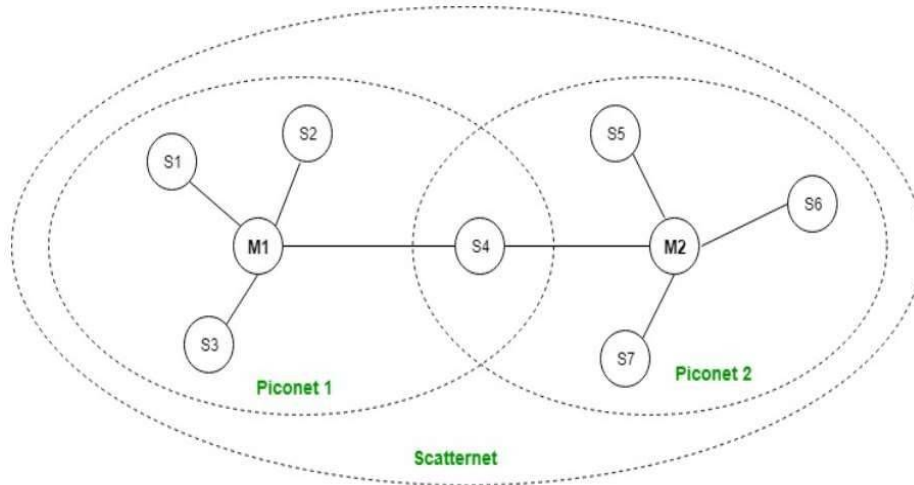
802.15.4:-

➢ Although Bluetooth's power requirements are much lower than that of 802.11b, it is still assumed that Bluetooth-enabled devices will be recharged every few days.
➢ The IEEE 802.15.4 standard is defined for very low-power, low-duty network links.
➢ This standard is intended for deployment on long-lived systems with low data rate requirements, where devices must be able to operate autonomously for months or even years without recharging the battery.

Bluetooth Scalability :

The primary constraining factor in the scalability of a system that uses any wireless communications technology concerns the fact that radio is a shared resource with a finite capacity. Bluetooth has been developed to facilitate wireless local area networks (LANs), in which the networks of different handheld computing terminals and mobileterminals can communicate and exchange data - even on the move or when there is no line-of-sight between the terminals

ZigBee :- *(ref.1)*

- ➢ The 802.15.4 standard only defines the PHY and MAC layers.
- ➢ ZigBee builds on top of 802.15.4's radio layer, specifying network, security, and application layers.

Name	Bluetooth (802.15.1)	802.1.5.4	
		standard	ZigBee
Radio Spectrum	2.4 GHz	868 MHz, 915 MHz, 2.4 GHz	
Max. Data Rate	3 Mbps	250Kbps	
Radio Power	< 100mW	> 1mW	
Max Range	1m – 100m	1m – 100m	
Network Topology	cluster	Star, peer to peer	Star , cluster, Mesh
Application	Low-bandwidth cable replacement	Sensors, home automation	

Wi-Fi *(ref.6)*

Wi-Fi is a family of wireless network protocols, based on the IEEE family of standards, which are commonly used for local area networking of devices and Internet access. Wi-Fi is a trademark of the non-profit Wi-Fi Alliance, which restricts the use of the term Wi-Fi Certified to products that successfully complete interoperability certification testing.

Wi-Fi Specifications :

The full list of versions of Wi-Fi is:

Wi-Fi generations

Generation/IEEE Standard	Maximum Linkrate	Adopted	Frequency
Wi-Fi 6 (802.11ax)	600–9608 Mbit/s	2019	2.4/5 GHz 1–6 GHz ISM
Wi-Fi 5 (802.11ac)	433–6933 Mbit/s	2014	5 GHz
Wi-Fi 4 (802.11n)	72–600 Mbit/s	2009	2.4/5 GHz
Wi-Fi 3 (802.11g)	3–54 Mbit/s	2003	2.4 GHz
Wi-Fi 2 (802.11a)	1.5 to 54 Mbit/s	1999	5 GHz
Wi-Fi 1 (802.11b)	1 to 11 Mbit/s	1999	2.4 GHz

- Range

  - A wireless network's range can vary wildly depending on the type of network. A standard home network using one wireless router can serve a single-family dwelling, but often not much more.
  - Business networks with grids of access points can serve large office buildings, and wireless hotspots spanning several square miles have been built in some cities.
  - A general rule of thumb in home networking says that Wi-Fi routers operating on the 2.4 GHz band can reach up to 150 feet indoors and 300 feet outdoors. Older 802.11a routers that ran on 5 GHz bands reached approximately one-third of these distances.

- Newer 802.11n and 802.11ac routers that operate on both 2.4 GHz and 5 GHz bands reach greater distances.

- Modulation

  WiFi systems use two primary radio transmission techniques:

  - 802.11b (<=11 Mbps) – The 802.11b radio link uses a direct sequence spread spectrum technique called complementary code keying (CCK).

    The bitstream is processed with a special coding and then modulated using Quadrature Phase Shift Keying (QPSK).

  - 802.11a and g (<=54 Mbps) – The 802.11a and g systems use 64-channel orthogonal frequency division multiplexing (OFDM). In an OFDM modulation system, the available radio band is divided into a number of sub-channels and some of the bits are sent on each. The transmitter encodes the bitstreams on the 64 subcarriers using Binary Phase Shift Keying (BPSK), Quadrature Phase Shift Keying (QPSK), or one of two levels of Quadrature Amplitude Modulation (16, or 64-QAM). Some of the transmitted information is redundant, so the receiver does not have to receive all of the sub-carriers to reconstruct the information.

Wi-Fi Scalability :

Compared to cell phones and similar technology, Wi-Fi transmitters are low power devices. In general, the maximum amount of power that a Wi-Fi device can transmit is limited by local regulations, such as FCC Part 15 in the US. Equivalent isotropically radiated power (EIRP) in the European Union is limited to 20 dBm (100 mW).To reach requirements for wireless LAN applications, Wi-Fi has higher power consumption compared to some other standards designed to support wireless personal area network (PAN) applications. For example, Bluetooth provides a much shorter propagation range between 1 and 100m[74] and so in general have a lower power consumption. Other low-power technologies such as ZigBee have fairly long range, but much lower data rate. The high power consumption of Wi-Fi makes battery life in some mobile devices a concern.

WiMax*(ref.2)*

Worldwide Interoperability for Microwave Access (WiMax) 802.16a:-WiMAX is one of the hottest broadband wireless technologies around today. WiMAX systems are expected to deliver broadband access services to residential and enterprise customers in an economical way. It is based on Wireless MAN technology.
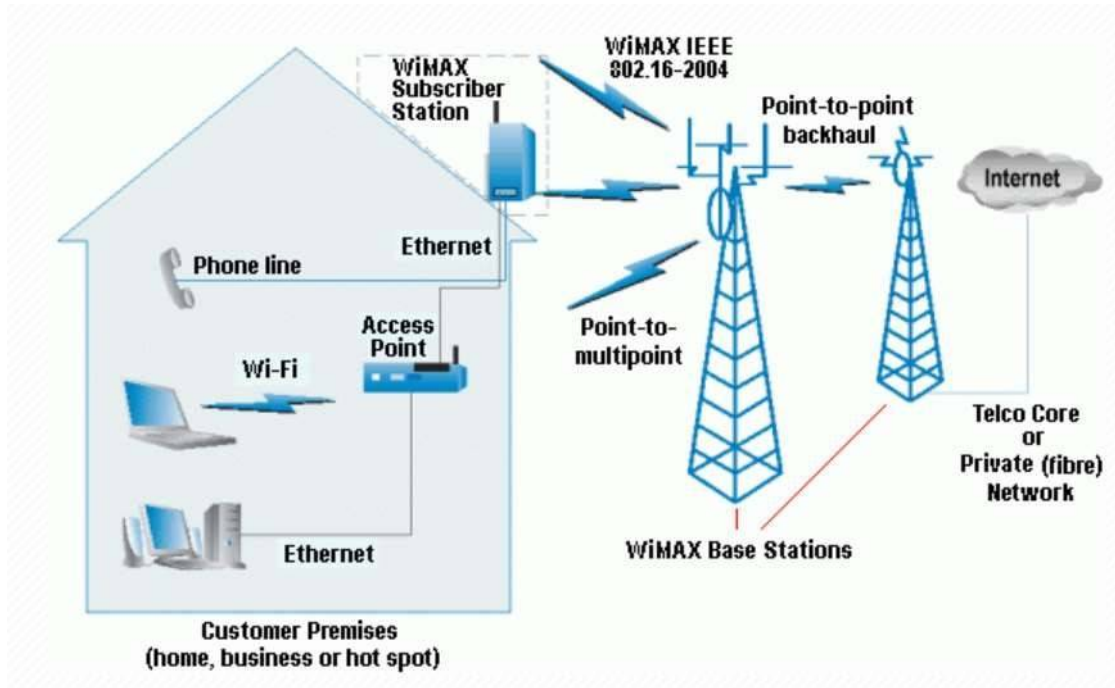
Primary Application	Frequency Band	Half/Full duplex	Radio Technology	Modulation
Broadband wireless access in MAN	2 GHz to 11 GHz	Full	OFDM (256-channels)	BPSK, QPSK, 16-, 64-, 256-QA

Protocols under Wired Technology:

1. 802.3 (Ethernet)
2. 802.3u (Fast Ethernet)
3. Fiber Distribution Data Interface (FDDI)

Ethernet:- IEEE 802.3*(ref.4)*

➢ Ethernet is the technology that is commonly used in wired local area networks (LANs).
➢ A LAN is a network of computers and other electronic devices that covers a small area such as a room, office, or building.
➢ Signalling :- baseband (digital signalling. Baseband comm. is bidirectional)

IEEE shorthand identifiers, such as *10Base5, 10Base2, 10BaseT, and 10BaseF* include three pieces of information:

- The number 10: At the front of each identifier, 10 denotes the standard data transfer speed over these media - ten megabits per second (10Mbps).

- The word Base: Short for Baseband, this part of the identifier signifies a type of network that uses only one carrier frequency for signaling and requires all network stations to share its use.

- The segment type or segment length: This part of the identifier can be a digit or a letter:

- Digit - shorthand for how long (in meters) a cable segment may be before attenuation sets in. For example, a 10Base5 segment can be no more than 500 meters long.

- Letter - identifies a specific physical type of cable. For example, the T at the end of 10BaseT stands for twisted-pair.

Parts of Physical Layer:-

➢ Medium dependent sublayer: specifies the medium, physical connectors, related mechanical and electrical characteristics
➢ Medium independent sublayer: covers line coding – how to transmit 0 and 1 bits; other issues not directly linked to the medium

name	10Base5	10Base2	10BaseT
medium	Thick coax cable	Thin coax cable	Twisted pair
Max-length of transmission	500m	200m	100m
No. of nodes	100	30	1024
Data rate	10mbps	10mbps	10mbps
Topology	bus	Bus	Star
Physical connectors	Vampire taps	BNC	RJ45
Fault tolerant	no	no	yes
Data flow	Half duplex	Half duplex	Full/half duplex

Ethernet Scalability :

Ethernet is a family of computer networking technologies commonly used in local area networks (LAN), metropolitan area networks (MAN), and wide area networks(WAN). Ethernet is currently the most widely used technology in enterprise networking. Unfortunately, it is widely acknowledged that Ethernet does not have the scalability to meet the emerging networking needs of large enterprises. Ethernet does not scale well to large networks. The flat MAC address space, whilst having obvious benefits for the user and administrator, is the primary cause of this poor scalability. Ethernet exhibits scalability issues on networks of more than a few thousand devices, such as costly and energy-dense address table logic and storms of broadcast traffic. Ethernet's inability to handle networks containing loops also presents a scalability problem.

Fast Ethernet (802.3u):- *(ref.4)*

Fast ethernet is a technology commonly used in wired LAN. Signalling :-

Baseband (Digital)

name	100BaseT4	100BaseTX	100BaseFX
medium	4 Twisted pair (UTP-3)	2 Twisted pair (UTP-5)	2 multimode optical fibre
Max-length of transmission	100m	100m	2000m
Data rate	100mbps	100mbps	100mbps
Topology	Star	Star	Star
Physical connectors	RJ45	RJ45	ST
Fault tolerant	yes	yes	yes
Data flow	Half duplex	Full duplex	Full duplex

Fiber Distribution Data Interface (FDDI):- *(ref.4)*

Fiber Distributed Data Interface (FDDI) is a set of ANSI and ISO standards for transmission of data in local area network (LAN) over fiber optic cables. It is applicable in large LANs that can extend up to 200 kilometers in diameter.

Features

- FDDI uses optical fiber as its physical medium.

- It provides high data rate of 100 Mbps and can support thousands of users.

- It is used in LANs up to 200 kilometers for long distance voice and multimedia communication.

- It uses ring based token passing mechanism and is derived from IEEE
  802.4 token bus standard.

- It contains two token rings, a primary ring for data and token transmission and a secondary ring that provides backup if the primary ring fails.

- FDDI technology can also be used as a backbone for a wide area network (WAN).
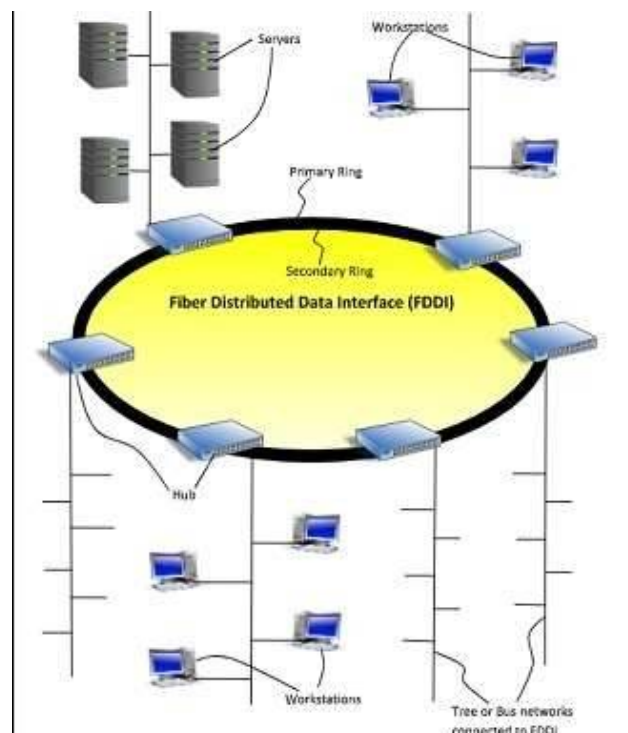
Communication Networks can be of following 5 types: *(ref.7)*

1. Local Area Network (LAN)
2. Metropolitan Area Network (MAN)
3. Wide Area Network (WAN)
4. Campus Area Network (CAN)
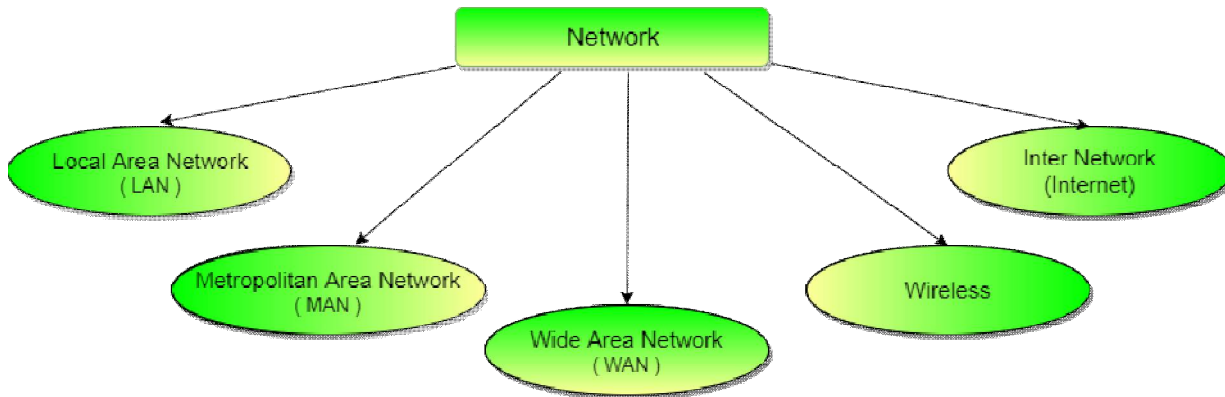
Local Area Network (LAN)

It is also called LAN and designed for small physical areas such as an office, group of buildings or a factory. LANs are used widely as it is easy to design and to troubleshoot. Personal computers and workstations are connected to each other through LANs. We can use different types of topologies through LAN, these are Star, Ring, Bus, Tree etc.

LAN can be a simple network like connecting two computers, to share files and network among each other while it can also be as complex as interconnecting an entire building.

LAN networks are also widely used to share resources like printers, shared hard-drive etc.
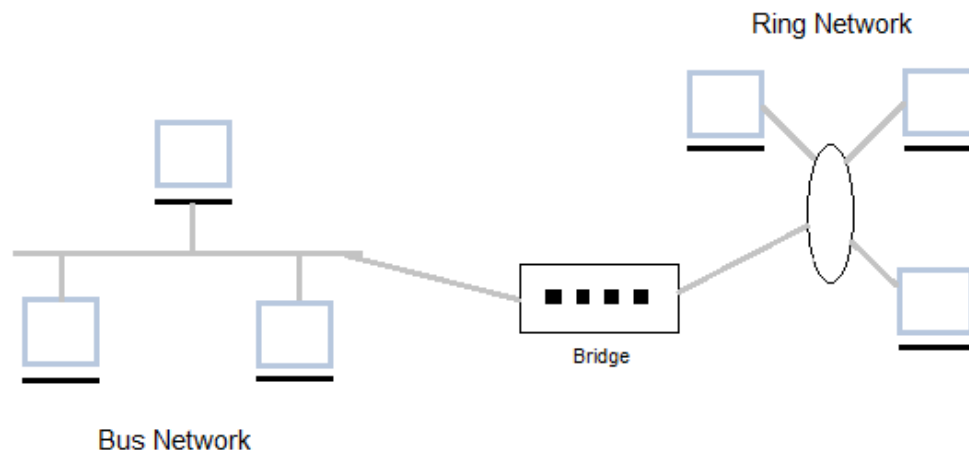
(Different Topologies interconnected in a Local Area Network)

Characteristics of LAN

- LAN's are private networks, not subject to tariffs or other regulatory controls.
- LAN's operate at relatively high speed when compared to the typical WAN.
- There are different types of Media Access Control methods in a LAN, the prominent ones are Ethernet, Token ring.
- It connects computers in a single building, block or campus, i.e. they work in a restricted geographical area.

Applications of LAN

- One of the computers in a network can become a server serving all the remaining computers called clients. Software can be stored on the server and it can be used by the remaining clients.
- Connecting Locally all the workstations in a building to let them communicate with each other locally without any internet access.
- Sharing common resources like printers etc are some common applications of LAN.

Advantages of LAN

- **Resource Sharing:** Computer resources like printers, modems, DVD-ROM drives and hard disks can be shared with the help of local area networks. This reduces cost and hardware purchases.
- **Data Security:** Since, data is stored on server computer centrally, it will be easy to manage data at only one place and the data will be more secure too.
- **Internet Sharing:** Local Area Network provides the facility to share a single internet connection among all the LAN users. In Net Cafes, single internet connection sharing system keeps the internet expenses cheaper.

Scalability

Scalability is limited in LAN because more user affects the overall performance each time the amount of users are increased

Campus Area Network (CAN) *(ref.7)*

It is a group of interconnected Local Area Networks (LAN) within a limited geographical area like school campus, university campus, military bases, or organizational campuses and corporate buildings etc. A Campus Area Network is larger than Local Area Network but smaller than Metropolitan Area Network (MAN) and Wide Area Network (WAN). Campus Area Network covers areas of around 1 to 5 km range and it can be both wired or wireless connectivity.

Example of CAN:

Let's think about a university where university networks interconnect academic building, admission building, library, account section, examination section, placement section etc of an institution when connected with each other combine to form Campus Area Network (CAN).The below figure illustrates a Campus Area Network:
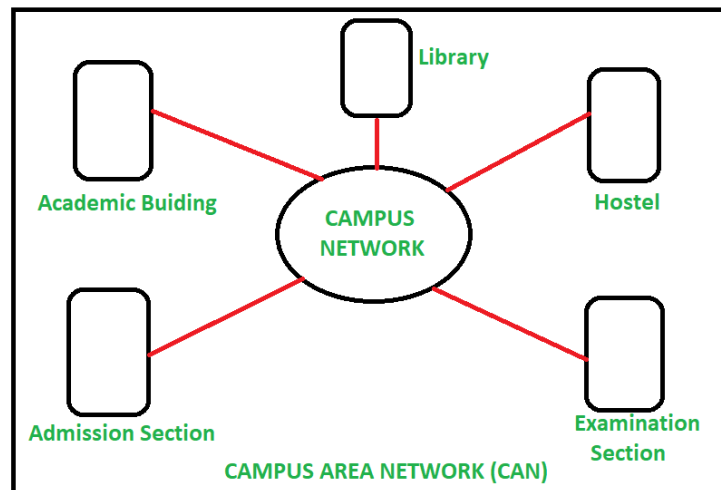
Infrastructure of CAN :

Within a limited geographical area, LANs are interconnected with help of Switches and Routers and connects buildings to buildings of a single campus where all networking resources like wiring, hubs, switches, routers etc are owned by organization itself. In this, they use same kind of technologies like Local Area Network only interconnection between different buildings is there. Nodes in a campus network are interconnected by means of Optical fiber media, i.e., Fiber optics and takes advantage of 10-Gigabit Ethernet technology. Besides this 10-Gigabit ethernet technology, Wi-Fi hotspots and hot zones are different ways of accessing network.

Benefits of CAN:

- **Speed –**

  Communication within a CAN takes place over Local Area Network (LAN) so data transfer rate between systems is little bit fast than Internet.

- **Security –**

  Network administrators of campus take care of network by continuous monitoring, tracking and limiting access. To protect network from unauthorized access firewall is placed between network and internet.

Metropolitan Area Network (MAN) *(ref.7)*

It was developed in 1980s.It is basically a bigger version of LAN. It is also called MAN and uses the similar technology as LAN. It is designed to extend over the entire city. It can be means to connecting a number of LANs into a larger network or it can be a single cable. It is mainly hold and operated by single private company or a public company.
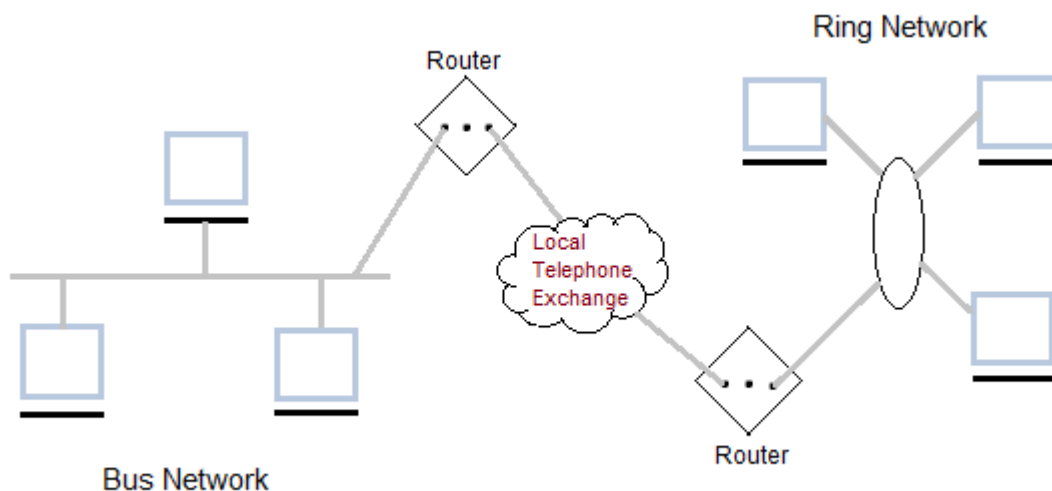
Characteristics of MAN

- It generally covers towns and cities (50 km)
- Communication medium used for MAN are optical fibers, cables etc.
- Data rates adequate for distributed computing applications.

Advantages of MAN

- Extremely efficient and provide fast communication via high-speed carriers, such as fibre optic cables.
- It provides a good back bone for large network and provides greater access to WANs.
- The dual bus used in MAN helps the transmission of data in both directions simultaneously.
- A MAN usually encompasses several blocks of a city or an entire city.

Disadvantages of MAN

- More cable required for a MAN connection from one place to another.
- It is difficult to make the system secure from hackers and industrial espionage(spying) graphical regions.

Wide Area Network (WAN) *(ref.7)*

It is also called WAN. WAN can be private or it can be public leased network. It is used for the network that covers large distance such as cover states of a country. It is not easy to design and maintain. Communication medium used by WAN are PSTN or Satellite links. WAN operates on low data rates.

Ring Network

Router

Over Internet

Router

Bus Network
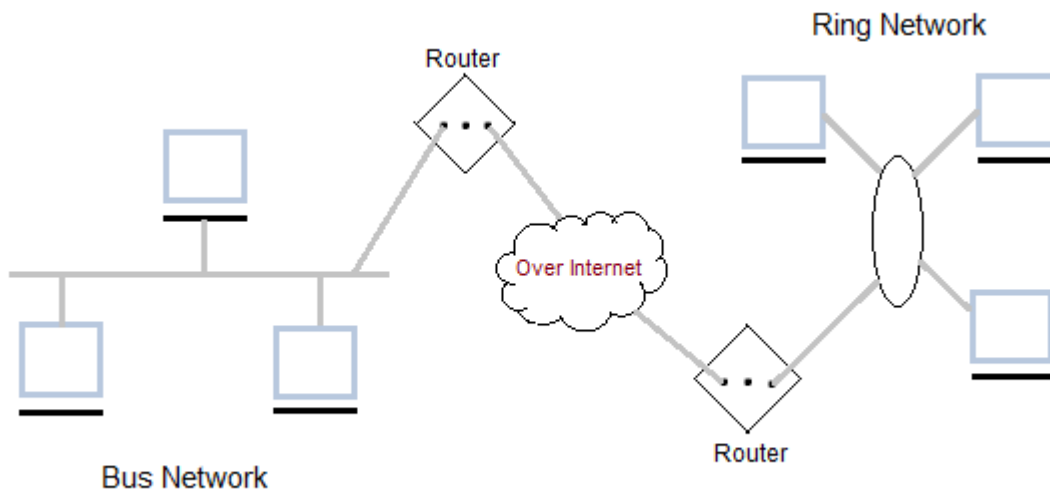
Characteristics of WAN

- It generally covers large distances (states, countries, continents).
- Communication medium used are satellite, public telephone networks which are connected by routers.

Advantages of WAN

- Covers a large geographical area so long distance business can connect on the one network

Personal Area Network (PAN) *(ref.5)*

It is a the computer network that connects computers/devices within the range of an individual person. As PAN provides a network range within a person's range typically within a range of 10 meters(33 feet) it is called as Personal Area Network. A Personal Area Network typically involves a computer, phone, tablet, printer, PDA (Personal Digital Assistant) and other and other entertainment devices like speakers, video game consoles etc.

Thomas Zimmerman and other researchers at M.I.T.'s Media Lab first developed the concept of PAN. It is very useful in home, offices and small network areas due to its high performance in terms of flexibility and efficiency.
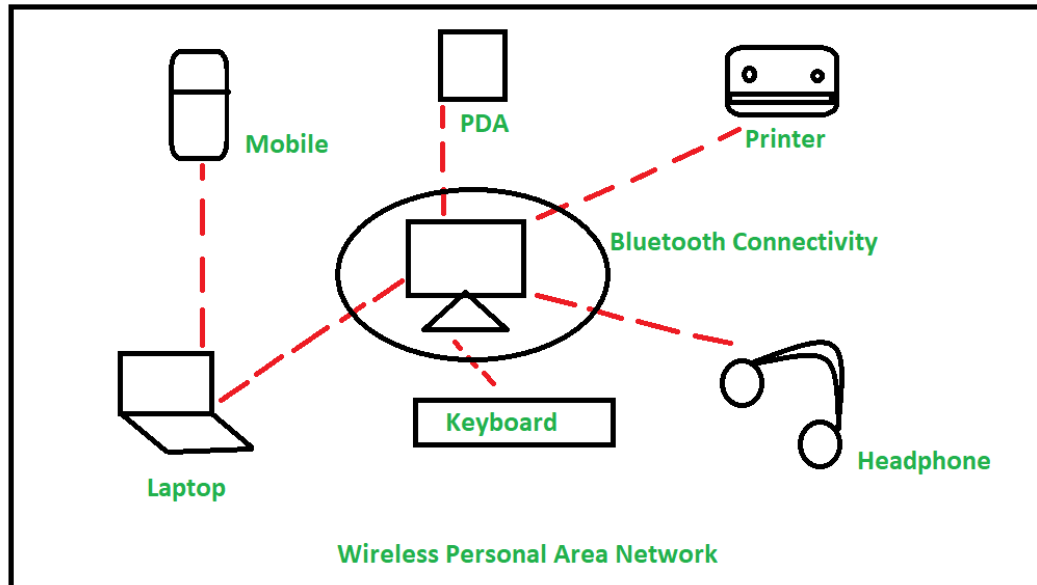
Types of Personal Area Network (PAN) :

Personal Area Network can be of 2 types depending upon its connection i.e., Wireless PAN, and Wired PAN.
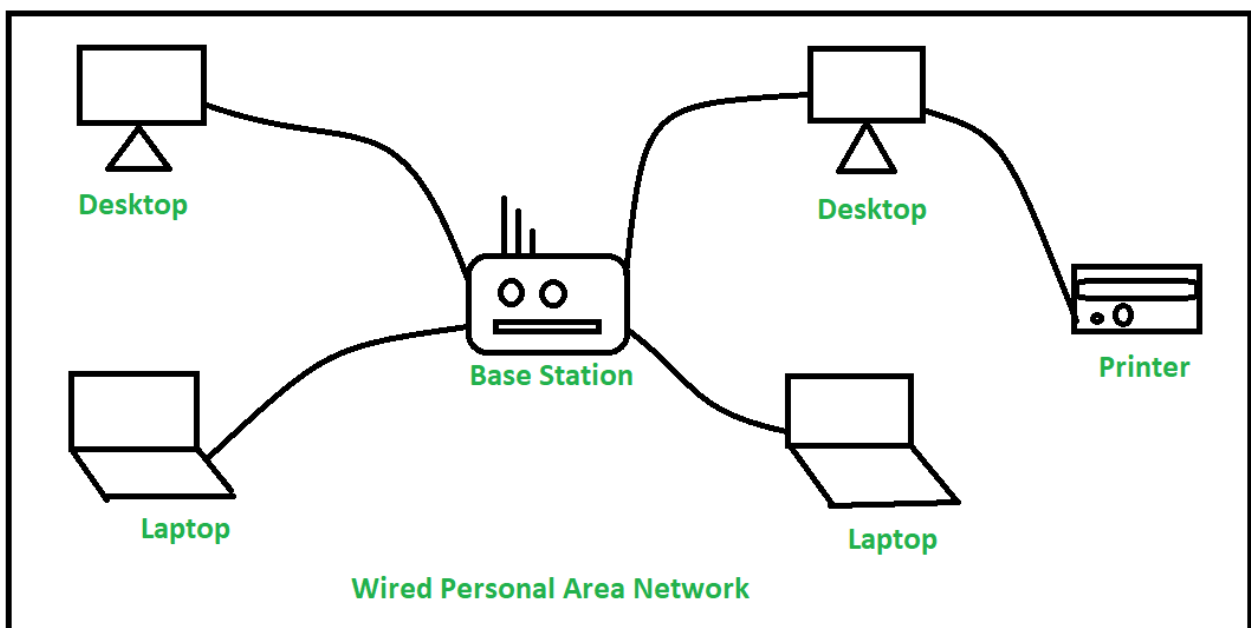
These are explained as following below.

1. **Wireless PAN –**
   Wireless Personal Area Network (WPAN) is connected through signals such as infrared, ZigBee, Bluetooth and ultrawideband etc.

2. **Wired PAN –**
   Wired PAN is connected through cables/wires such as Firwire or USB (Universal Serial Bus).

Examples of PAN :

- **Body Area Network –** It is a mobile network that moves with a persona range for example when person connects his smart phone to the Bluetooth headphone and moves in the market that refers to a body area network.

- **Offline Network –** In this multiple devices are connected through Bluetooth or Wi-Fi. The devices attached to your computer including printers, mouse, speakers, and other appliances are integrated using a Personal Area Network (PAN) and do not use internet. So a communication network is formed between the devices used in a small single space for example home.

- **Home Office –** In Home Office setup a separate smaller network is setup for work purpose which is separate from the network used by other home appliances. This network works as a separate body with multiple other devices connected for office work purpose.

Advantages and disadvantages of PAN –

These are some of the Advantages of PAN :

- PAN is relatively flexible and provides high efficiency for short network range.
- It needs easy setup and relatively low cost.
- It does not require frequent installations and maintenance
- It is easy portable.
- Needs less technical skill to use.

These are some of the disadvantages of PAN :

- Low network coverage area/range.
- Limited to relatively low data rates.
- Devices are not compatible with each other.
- Inbuilt WPAN devices are little bit costly.

Applications of PAN –

- Home and Offices
- Organizations and Business sector
- Medical and Hospital

Hybrid Network: *(ref.8)*

A computer network uses more than one type of technology or topology is called a hybrid network. A hybrid network is based on peer-to-peer and client-server relationship. The most general hybrid access point is a hybrid router**.** The hybrid network uses Ethernet 802.3 and Wi-Fi 802.11 standards. This network relies on hubs, switches, routers to connect both wired and wireless computers and another network-enabled device.

Wired Networking	Wireless Networking
uses **network cables**	uses **radio frequencies**
allows for a faster and more secure connection	wireless network is a lot less secure
can only be used for distances shorter than 2,000 feet	transmission speeds can suffer from outside interference

- Although wireless networking is lot more mobile than wired networking the range of the network is usually 150-300 indoors and up to 1000 feet outdoors depending on terrain.

- The cost for wired networking has become rather inexpensive. Ethernet cables, hubs and switches are very inexpensive. Some connection sharing software packages, like ICS, are free; some cost a nominal fee. Broadband routers cost more, but these are optional components of a wired network, and their higher cost is offset by the benefit of easier installation and built-in security features.

- Wireless gear costs somewhat more than the equivalent wired Ethernet products. At full retail prices, wireless adapters and access points may cost three or four times as much as Ethernet cable adapters and hubs/switches, respectively.

- The greater mobility of wireless LANs helps offset the performance disadvantage. Mobile computers do not need to be tied to an Ethernet cable and can roam freely within the wireless network range.

- In theory, wireless LANs are less secure than wired LANs, because wireless communication signals travel through the air and can easily be intercepted. The weaknesses of wireless security are more theoretical than practical. Wireless networks protect their data through the Wired Equivalent Privacy (WEP) encryption standard that makes wireless communications reasonably as safe as wired ones.

- No computer network is completely secure. Important security considerations for organizations tend to not be related to whether the network is wired or wireless but rather ensuring that the firewall is properly configured, employees are aware of the dangers of spoof emails, they are away of spy ware and how to avoid and that anyone outside the organization does not have unauthorized access to the network

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