Experiment 1

NAME: ASHUTOSH NAIK
CLASS: TE COMPS
BATCH: C
ROLL NO: 35
UID: 2018130030
DATE: 07/08/2020

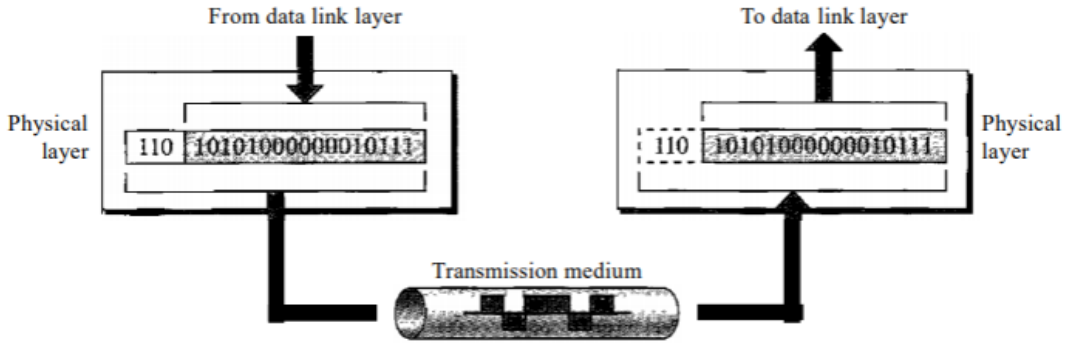
AIM

To study different types of physical layer standards.

THEORY

Physical layer [1][2]:

The physical layer is the lowest layer of the OSI reference model. **It is the layer which actually interacts with the transmission media, the physical part of the network.** The data in the data link layer consists of frames of 1s and 0s. This stream of bits has to be converted to signals which can transmitted over a network. The physical layer provides this service of creating a signal that represents this stream of bits. It also defines the hardware specifications.[1][2]



1. Bluetooth:

Bluetooth is a wireless technology standard used for exchanging data between fixed and mobile devices over short distances using short-wavelength radio waves of frequency 2.4 GHz.[3]

- Specifications:
  - **a. Range:**
    The worst-case range of a device equipped with Bluetooth 5 is 200 meters outdoors and 40 meters indoors.[4]

  - **b. Speed:**
    1 Mbps for Bluetooth 4.x and 2 Mbps for Bluetooth 5.[4]

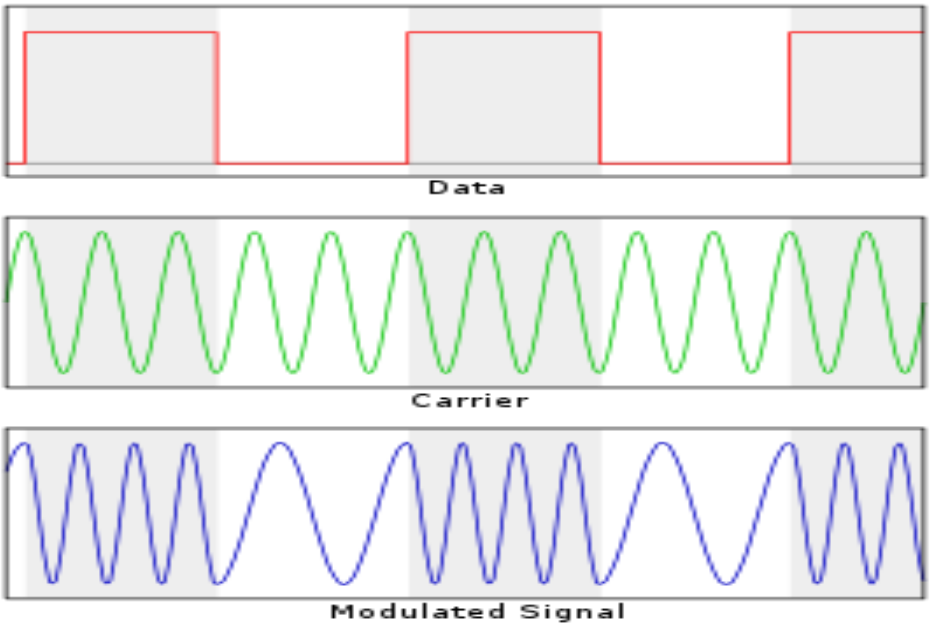
  - **c. Medium access technique:**
    Both Bluetooth 4.x and 5 uses frequency hopping for transmission.[5]

    Frequency hopping spread spectrum is a method for transmitting radio signals by rapidly changing the carrier frequency among many distinct frequencies occupying a large band. These changes are controlled by both the transmitter and receiver. Bluetooth uses a variation of this called adaptive frequency hopping (AFH). This technique is used to reduce radio frequency interference.

  - **d. Nodes:**
    The original Bluetooth had a limit of 7 nodes. Bluetooth 4.x and 5 both can support unlimited nodes.

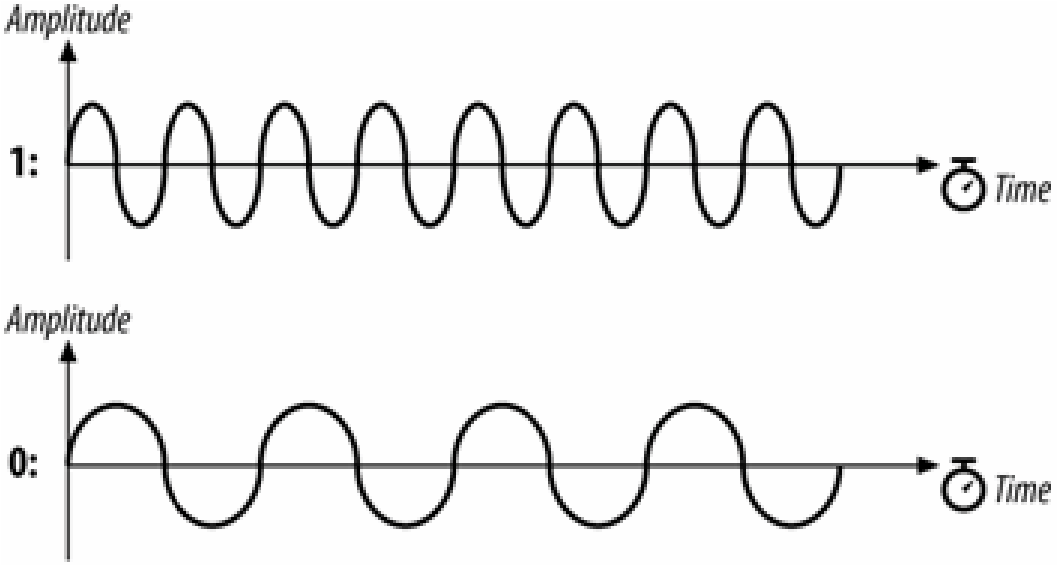
  - **e. Modulation:**
    Bluetooth uses Gaussian frequency shift keying (GFSK).

    Frequency shift keying encodes data as a series of frequency changes in a carrier wave.[6]

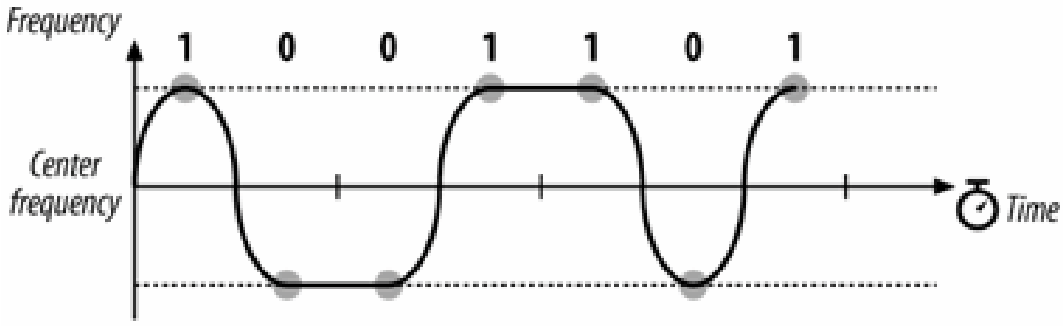


GFSK differs from simple FSK in that before the signal is passed through the FSK modulator, it is passed through a Gaussian filter to make the transitions smoother to limit its spectral width.[7]

2-level GFSK.

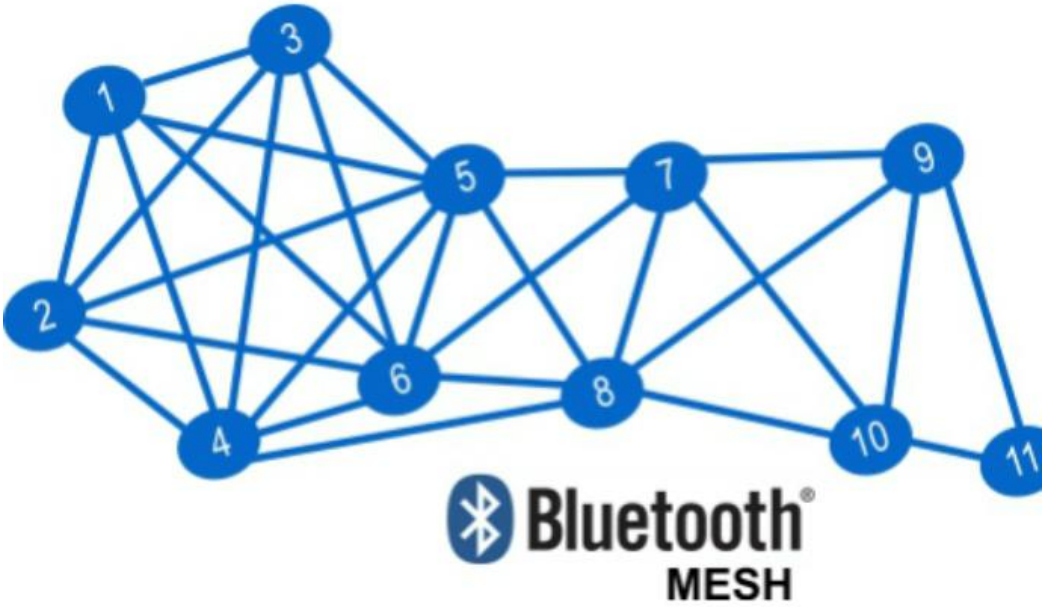


2-level GFSK coding of letter M (ASCII 77: 1001101).

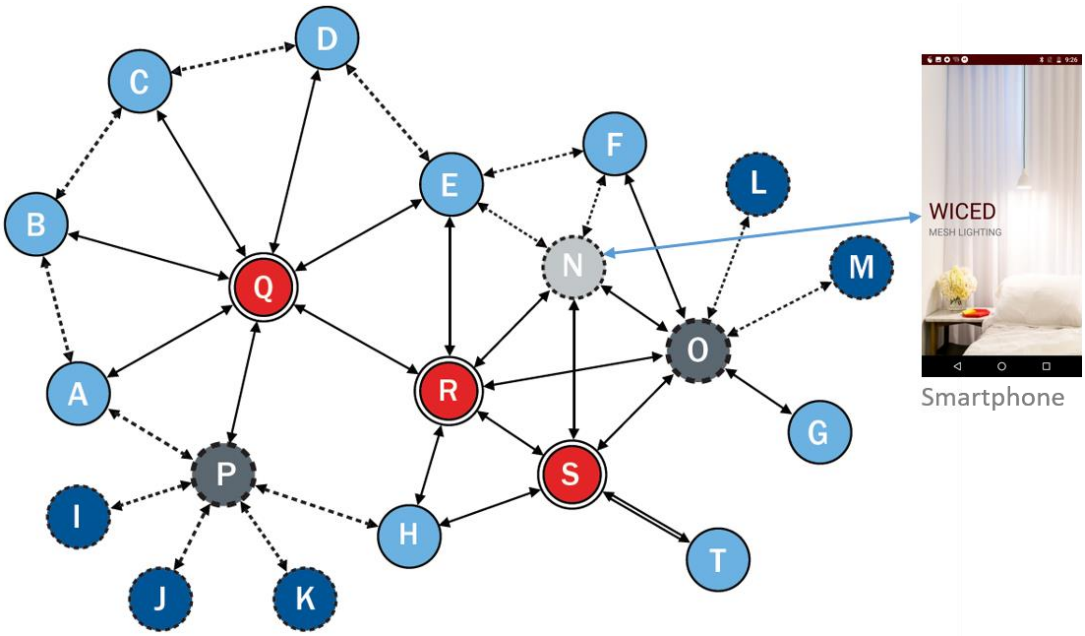


- Scalability [8][9]:
  Bluetooth it typically used in WPAN (Wireless Personal Area Network) to transfer data between devices.

  The network connection style used in classic Bluetooth is a traditional point-to-point connection that looks like a star topology. The central device, for example a smartphone, can be paired with a number of devices, like headphones, smartwatch, fitness bands and other small devices. However, in 2016, with the introduction of Bluetooth 5 there was the development of a new connectivity model – Mesh network. It enables many-to-many style of communication with multiple potential paths between nodes to ensure delivery. It operates on the flood network principle. It can support a maximum of 32767 nodes.



- Schematic diagram [10]:



A **relay node** is one that supports the relay feature. This means it can retransmit messages that are broadcast by other nodes.

To allow communication with a mesh network from a non-mesh-supported BLE device, a special type of node called a **proxy node** can be utilized.

A **friend node** and a **low power node (LPN)** are closely related to each other. In fact, in order for a low power node to participate in a Bluetooth mesh network, it requires a friendship relationship with another node, called the friend node.

2. Near Field Communication:

NFC, as the name implies, enables short-range communication between devices. It is based on older RFID ideas, which used electro-magnetic induction to transmit data.[13]

- Specifications:

a. Range:

NFC has a low range of less than 4 cm. However, it has its benefits. Passive devices like advertising tags can operate without a major power source.

b. Speed:

Data can be sent either at 106, 212 or 424 Kbps. It is quick enough for small data transfers like contact details and music. It is also used for mobile payments.

c. Medium access technique:

NFC utilises **inductive-coupling**, at a frequency of 13.56 MHz.

Inductive coupling is the transfer of energy from one circuit to another via mutual inductance between the two circuits. Conductors are said to be inductively coupled when one wire induces a voltage across the ends of the other wire through electromagnetic induction.

d. Modulation and coding [11]:

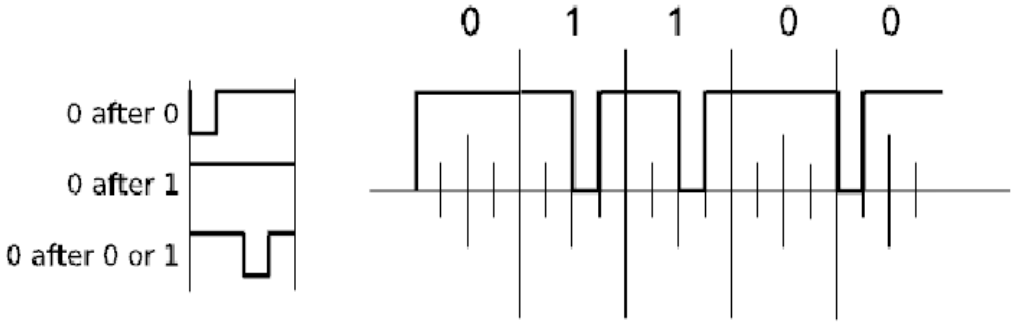
NFC employs two different coding systems to transfer data. In most cases a Manchester coding format is used. However, for an active device transmitting data at 106 kbps, a modified Miller coding scheme is used with 100% modulation. In all other cases Manchester coding is used with a modulation ratio of 10%.

Manchester coding:

A 1 bit is transmitted as a half-width positive pulse followed by a half-width negative pulse, and a 0 bit is another way round.

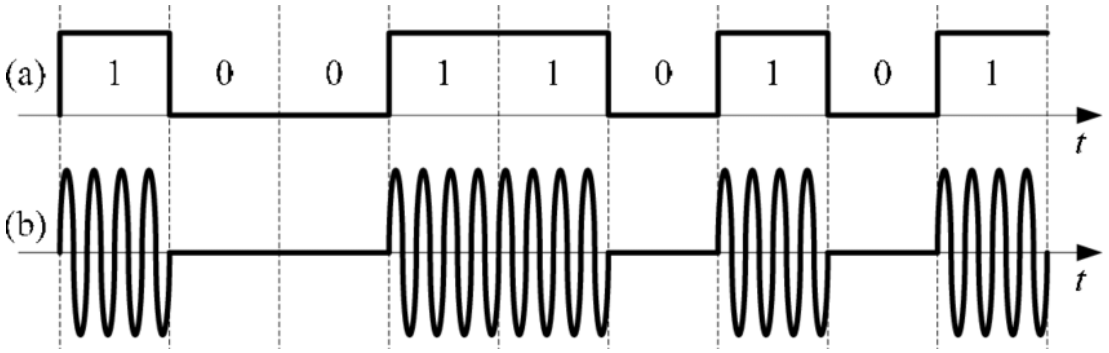
Modified Miller coding:

A high or "1" is always encoded in the same way, but a low or "0" is encoded differently dependent upon what preceded it.



Modulation used:

Amplitude-shift keying (ASK) is a form of amplitude modulation that represents digital data as variations in the amplitude of a carrier wave. If the signal value is 1 then the carrier signal will be transmitted; otherwise, a signal value of 0 will be transmitted.

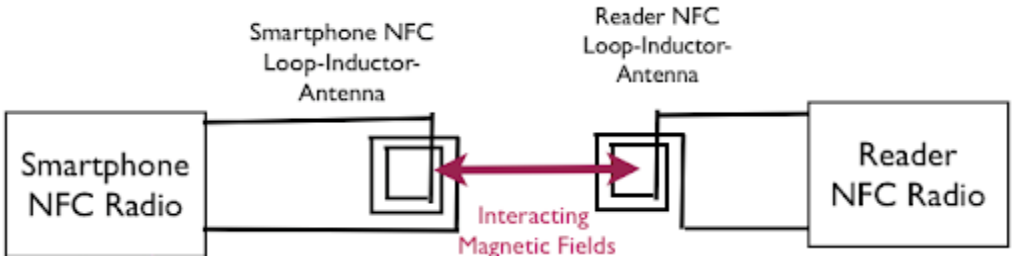


- Scalability:

  NFC has small applications like mobile identification, mobile payments etc. Also, NFC chips can be used to automate small tasks on devices.

  Since NFC utilizes point-to-point network topology between 2 devices it is not scalable to larger networks.

- Schematic diagram:



When the NFC chip is activated inside an **active** device, electricity flows through the circuitry of the chip, generating a weak magnetic field. When the chip is held near a **passive** device it induces electricity in that device. This creates a radio field which is detected and decoded by the active device. If both devices are **active** then it employs half duplex technique wherein one device acts as the transmitter and the other as the receiver.

3. Li-Fi (Light Fidelity) Visible Light Communication

Li-Fi is a light communication system that is capable of transmitting data at high speeds over the visible light, ultraviolet, and infrared spectrums. In its present state, only LED lamps can be used for the transmission of visible light.[16]

- Specifications[17]:
  a. **Range:**
     Since light is transmitted by visible light. The light cannot penetrate opaque surfaces and has a range of 10 meters.

  b. **Speed:**
     Under laboratory conditions scientists have achieved speeds of 1GBps.

  c. **Medium access technique:**
     LiFi is a subset of Visible Light communication and uses waves in the visible spectrum (400 - 800THz) to transmit data. LEDs are flicked on and off at extreme speeds to

transmit data in binary code. The flickering is imperceptible to human eyes.

d. Modulation and coding[18]:

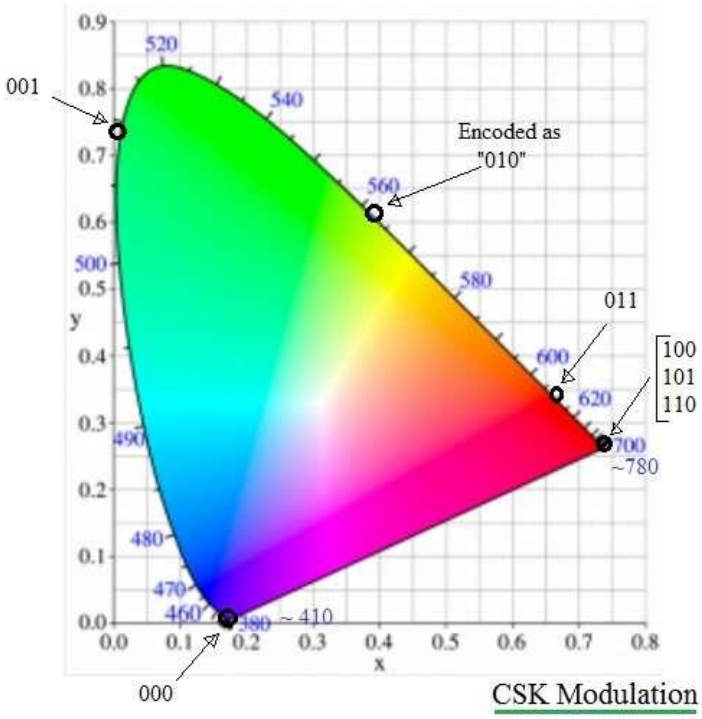
It utilizes OOK – On off keying, VPPM – Variable pulse position modulation and CSK - Colour shift Keying modulation.

On Off keying OOK:

In this modulation, data is represented by on and off of the LED. In simple terms, light 'ON state' represents logic '1' and light 'OFF state' represents logic '0'. OOK uses **Manchester codes** to represent digital information in the form of 1's and 0's.

Colour Shift Keying CSK:

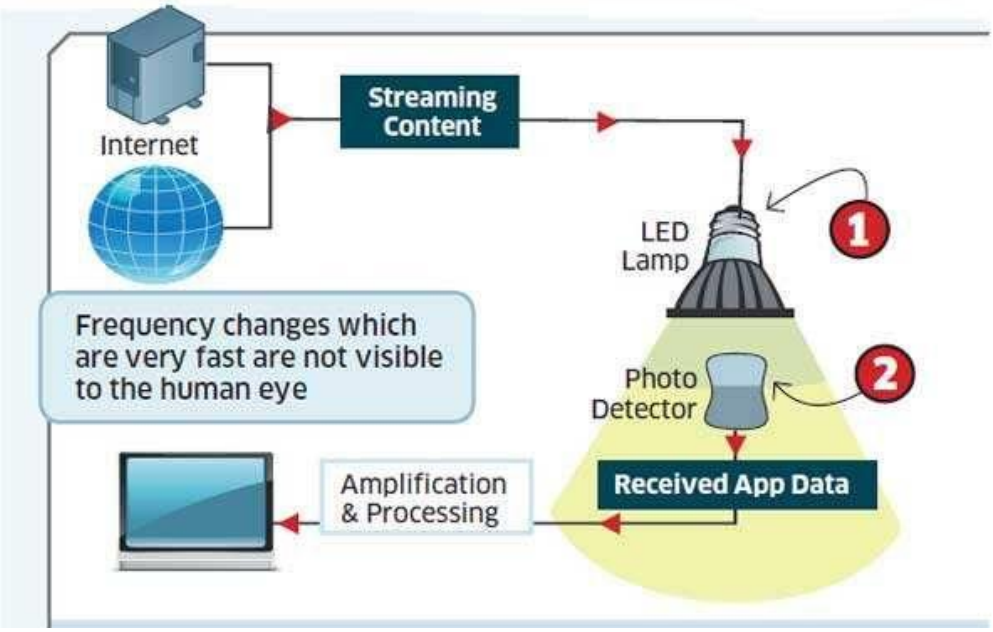
The CSK modulation scheme is used to represent information bits in the form of different colour wavelengths. Red LED, Green LED and Blue LED are used at the transmit end to produce different colours of different wavelengths to code the information bits.



- Scalability[19]:

  The applications of LiFi are endless because light is available everywhere. It can be used in a meeting room environment (LAN). Since the light cannot pass through walls, the data is secure. It can also be used in intelligent transportation systems. Car headlights and tail lights offer the prospect of car-to-car communication over LiFi, allowing development of anti-collision systems and exchange of information on driving conditions between vehicles. Traffic lights already use LED lighting, so that there is also the prospect offered of city-wide traffic management systems (MAN).

- Schematic diagram:



4.Wi-Fi

Wi-Fi is a wireless networking technology that allows devices such as computers (laptops and desktops), mobile devices (smart phones and wearables), and other equipment (printers and video cameras) to interface with the Internet.

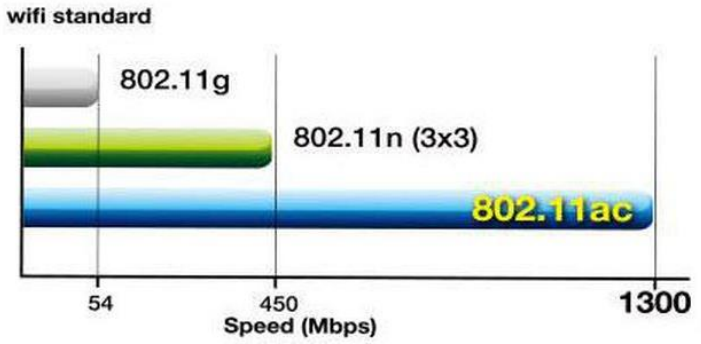
- Specifications:

  a. Range:

The range varies according to the hardware used but it typically is limited to a home, office or campus.

b. Speed:

The speed varies according to the standard used.



c. Medium access technique [25]:

IEEE 802.11 wireless LANs use a media access control protocol called Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA).

The algorithm of CSMA/CA is:

I. When a frame is ready, the transmitting station checks whether the channel is idle or busy.
II. If the channel is busy, the station waits until the channel becomes idle.
III. If the channel is idle, the station waits for an Inter-frame gap (IFG) amount of time and then sends the frame.
IV. After sending the frame, it sets a timer.
V. The station then waits for acknowledgement from the receiver. If it receives the acknowledgement before expiry of timer, it marks a successful transmission.
VI. Otherwise, it waits for a back-off time period and restarts the algorithm.

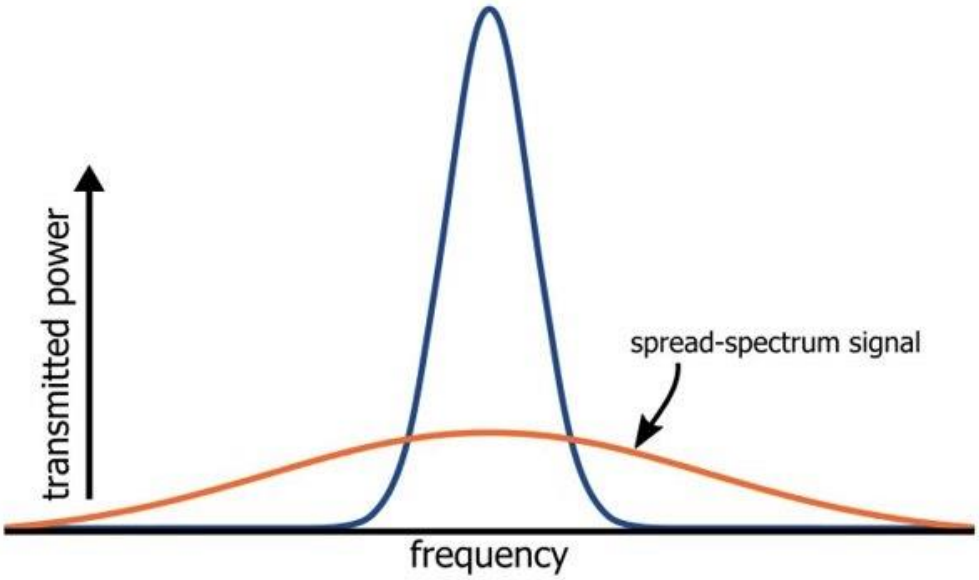
d. Modulation and coding [22]:

802.11b (<=11 Mbps) – The 802.11b radio link uses a **DSSS** technique called **complementary coded keying (CCK)**. The bit stream is processed with a special coding and then modulated using **Quadrature Phase Shift Keying (QPSK).**

802.11a and g (<=54 Mbps) − The transmitter encodes the bit streams 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.

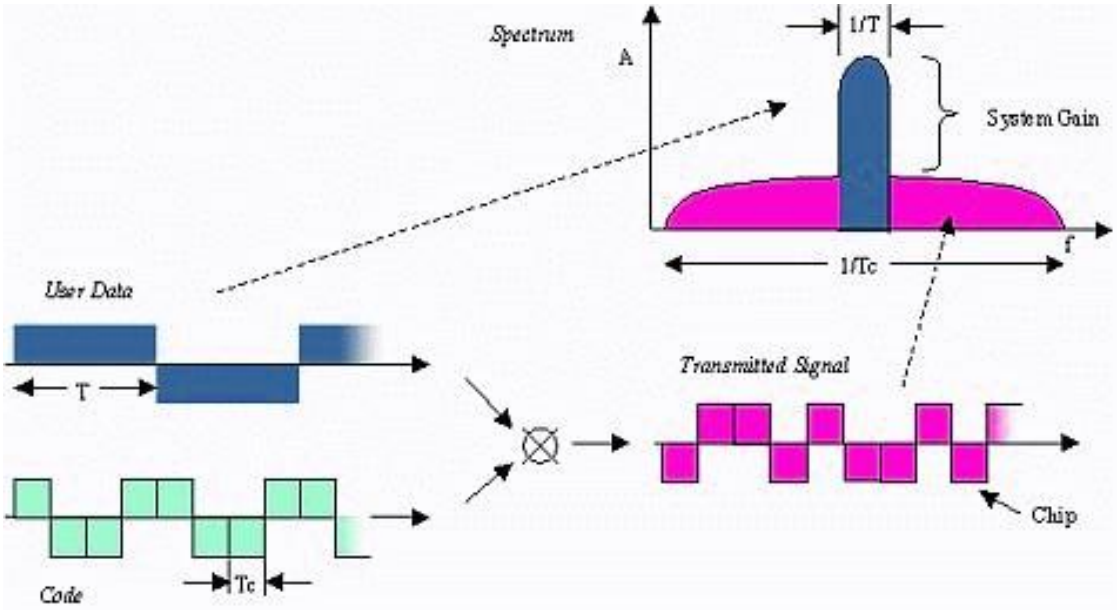
Spread-spectrum

In telecommunication and radio communication, spread-spectrum techniques are methods by which a signal generated with a particular bandwidth is deliberately spread in the frequency domain, resulting in a signal with a wider bandwidth.[23]



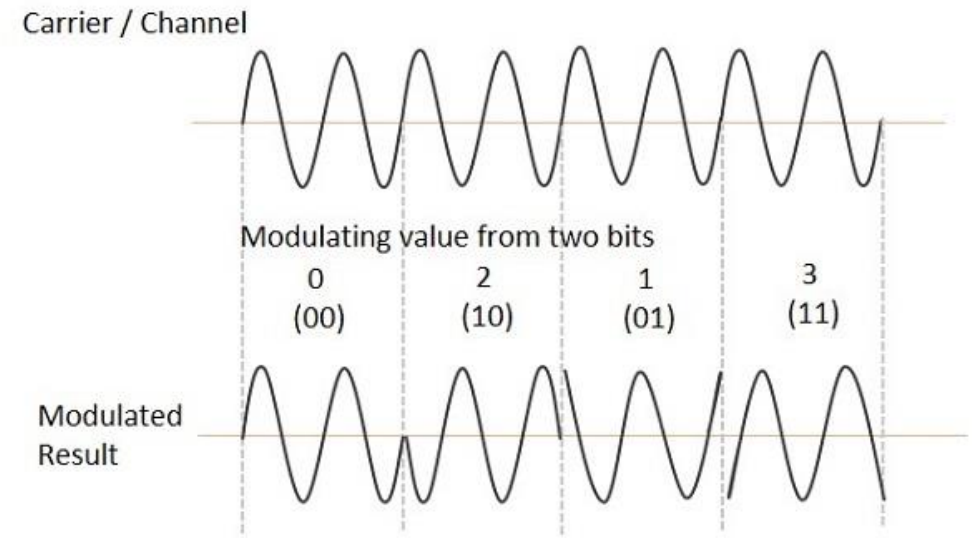
Direct Sequence Spread Spectrum

In telecommunications, direct-sequence spread spectrum (DSSS) is a spread-spectrum modulation technique primarily used to reduce overall signal interference. The direct-sequence modulation makes the transmitted signal wider in bandwidth than the information bandwidth.[24]



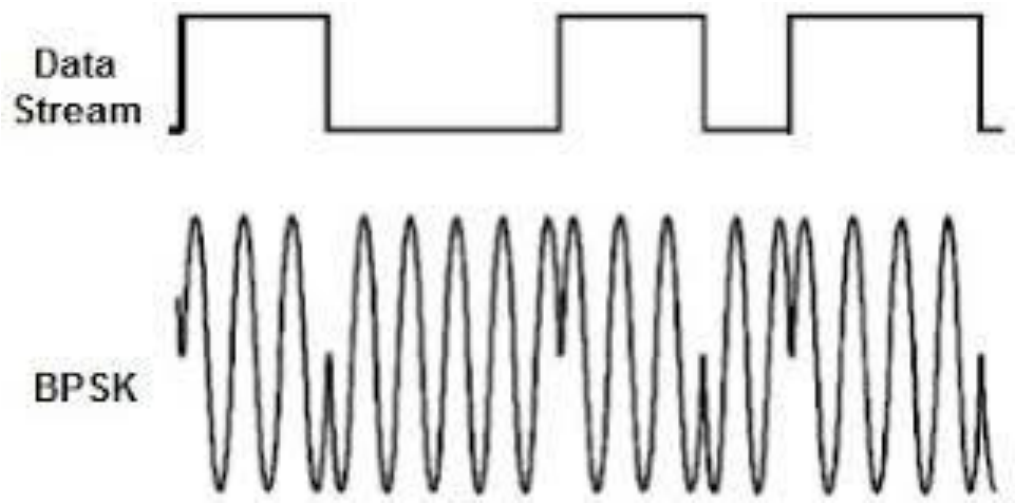
Quadrature Phase Shift Keying[26]

Quadrature Phase Shift Keying (QPSK) is a form of Phase Shift Keying in which two bits are modulated at once, selecting one of four possible carrier phase shifts (0, 90, 180, or 270 degrees). QPSK allows the signal to carry twice as much information as ordinary PSK using the same bandwidth.



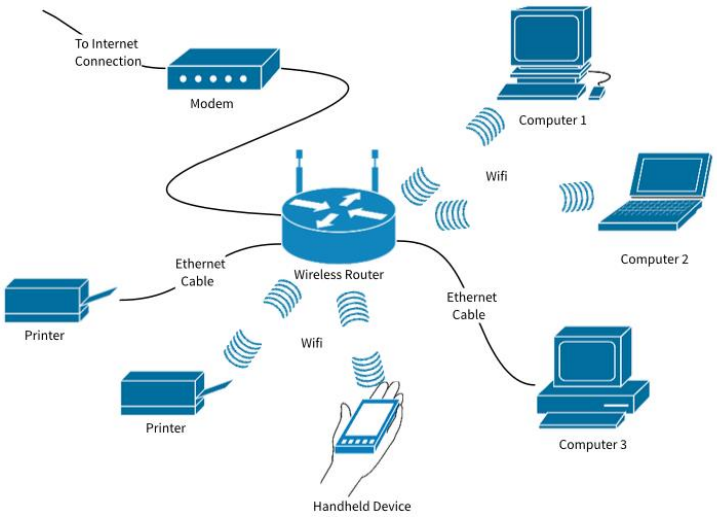
Binary Phase Shift Keying[27]

BPSK (also sometimes called PRK, phase reversal keying, or 2PSK) is the simplest form of phase shift keying (PSK). It uses two phases which are separated by 180° and so can also be termed 2-PSK.



- Scalability [28]:
  Speed and distance:
  802.11a and 802.11g provide more scalability in this regard than 802.11b, and with 802.11a channels can be combined to get even higher throughput.
  To reach farther areas, more access points are needed for 802.11a than for 802.11b or g.
  Compatibility
  802.11a variants are not backward compatible with 802.11b. However, g variants are backwards compatible with b.

- Schematic diagram



5.Ethernet

Ethernet is a family of computer networking technologies commonly used in local area networks, metropolitan area networks and wide area networks. It was commercially introduced in 1980 and first standardized in 1983 as IEEE 802.3.[34]

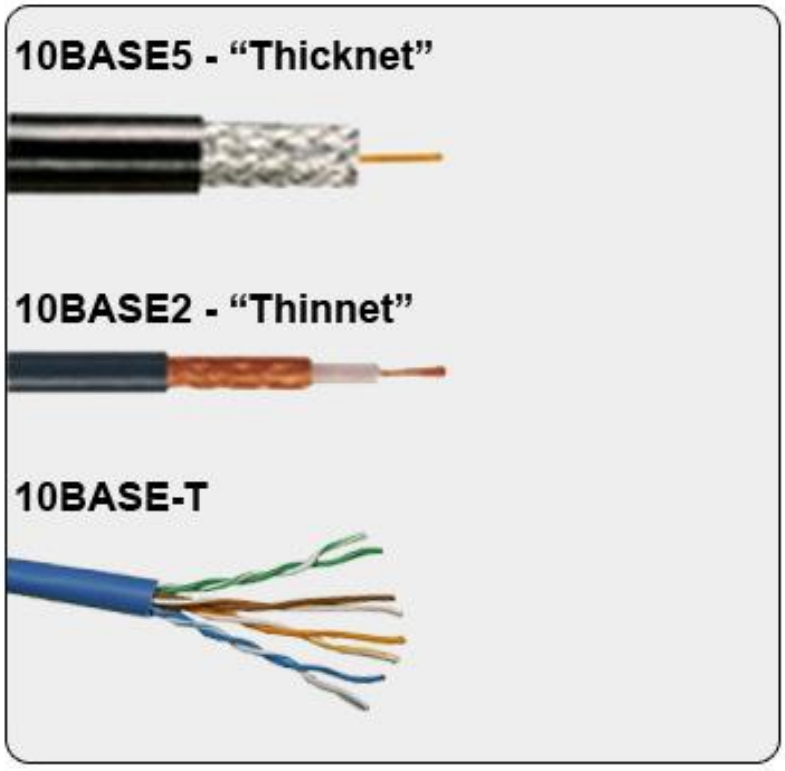
- Specifications:

a. Range & Speed [36]:

10BASE5 thick and stiff coaxial cable up to 500 meters (1,600 ft) in length. Up to 100 nodes can be connected to the cable. The data rate is 10 Mbps.

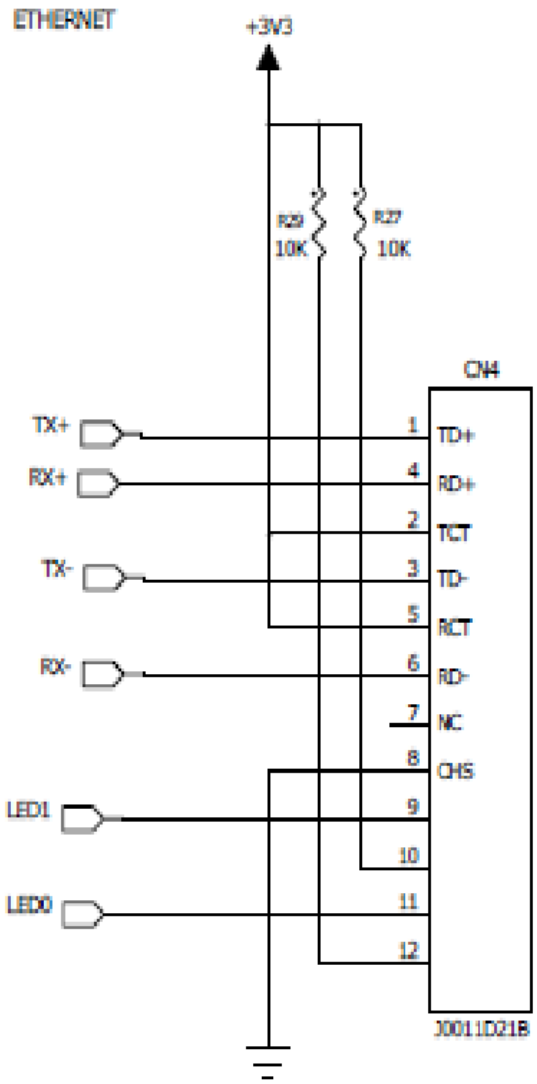
10BASE2 thin coax cables have a maximum length of 200 metres. The maximum number of nodes that can be connected to it is 30. It offers a 10 Mbps of bandwidth.

10BASET twisted pair of wires and have a maximum length of 100m. Up to 1024 nodes can be connected to it and it offers a bandwidth of 10 Mbps.



- Scalability [37]
  Ethernet has lasted well since its inception in the 1970s with Ethernet frame-structure and addressing remaining ubiquitous in the data centre environment as in many others. However, Ethernet exhibits scalability issues when used to build broadcast domains of more than a few thousand devices, such as costly and energy-dense address table logic and storms of broadcast traffic. The traditional method of avoiding such problems is the artificial subdivision of a network, but this introduces an administrative burden, requires significant routing equipment and with current protocols also precludes live migration.

- Schematic Diagram



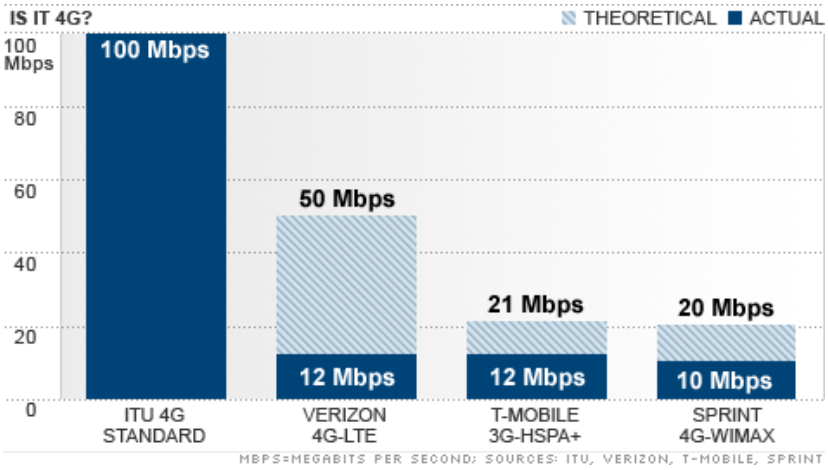
6.4G LTE

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. [38]

- Specifications:

a. Speed

The ITU standard stipulated a minimum specification of 100 Mbps download speed, which, was extremely hypothetical.



b. Range

LTE is required to support communication with terminals moving at speeds of up to 350 km/h, or even up to 500 km/h depending on the frequency band.[39]

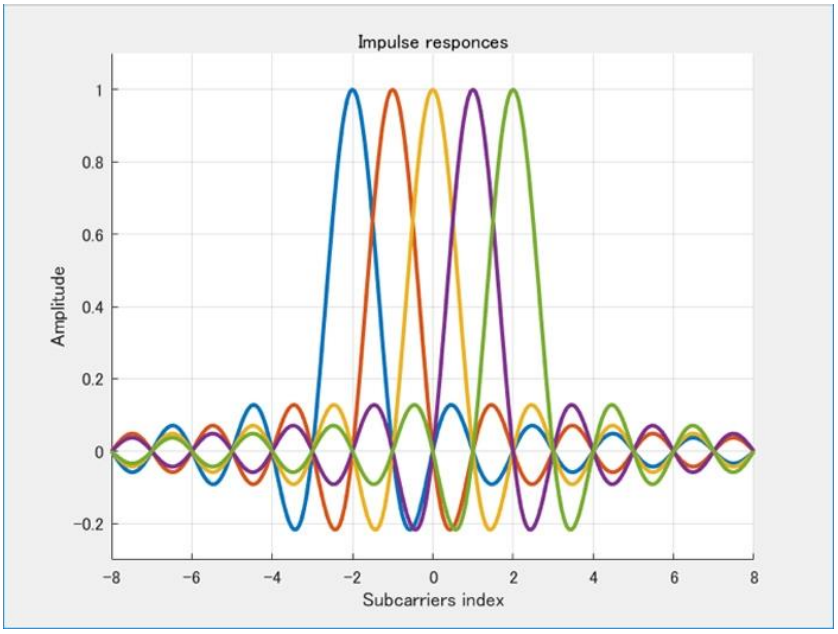
c. Modulation

LTE uses Orthogonal Frequency Division Multiplexing (OFDM) for the downlink - that is, from the base station to the terminal to transmit the data over many narrow band careers of 180 KHz each instead of spreading one signal over the complete 5MHz career bandwidth.[41]

Orthogonal Frequency Division Multiplexing

OFDM is a form of multicarrier modulation. An OFDM signal consists of a number of closely spaced modulated carriers. When modulation of any form - voice, data, etc. is applied to

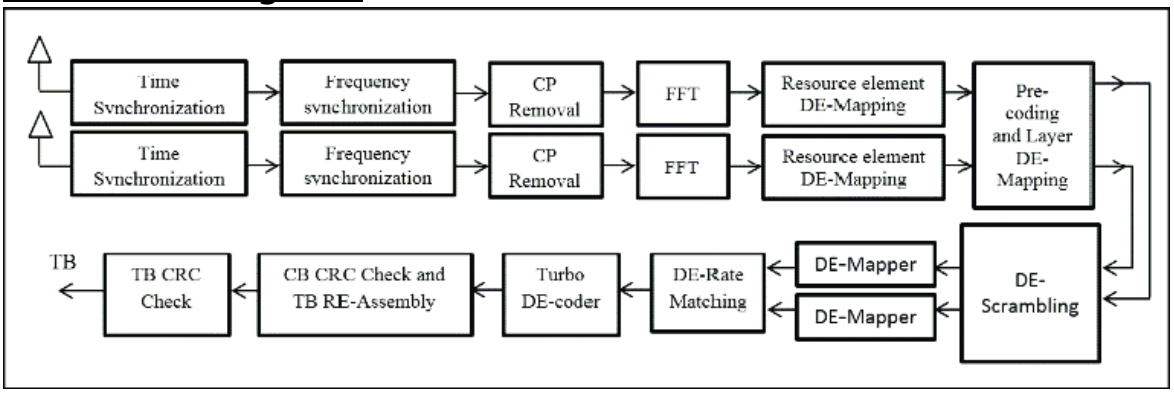
a carrier, then sidebands spread out either side. It is necessary for a receiver to be able to receive the whole signal to be able to successfully demodulate the data.[40]



- Scalability:

LTE has the ability to manage fast-moving mobiles and supports multi-cast and broadcast streams. LTE supports **scalable** carrier bandwidths, from 1.4 MHz to 20 MHz and supports both frequency division duplexing (FDD) and time-division duplexing (TDD). The IP-based network architecture, called the Evolved Packet Core (EPC) designed to replace the GPRS Core Network, supports seamless handovers for both voice and data to cell towers with older network technology such as GSM, UMTS and CDMA2000.[38]

- Schematic Diagram:



7.FDDI (Fiber distributed data interface)

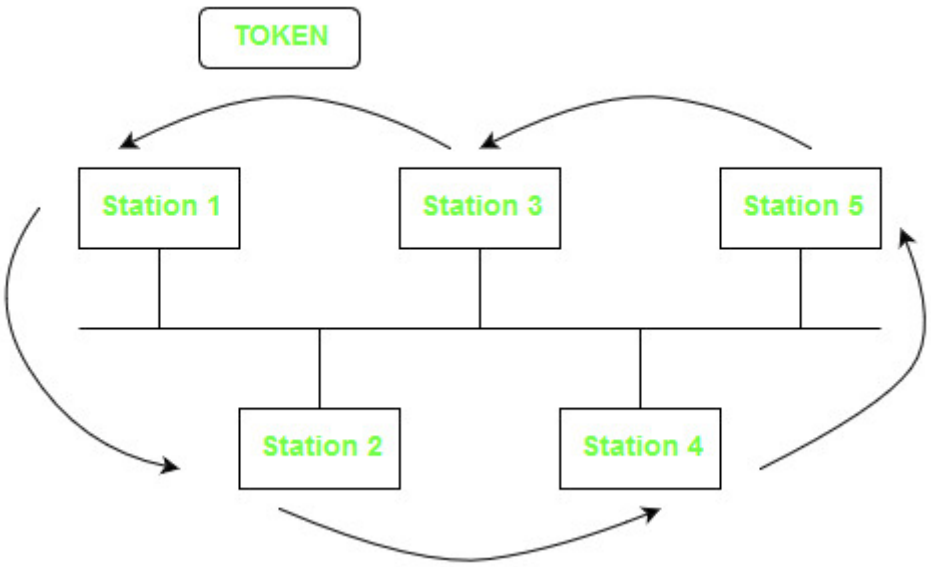
Fiber Distributed Data Interface (FDDI) is a set of ANSI and ISO standards for transmission of data in local area network (LAN) over fiber optic cables. [38]

- Specifications [39][38]:
  - **a. Speed:**
    It provides high data rate of 100 Mbps and can support thousands of users.

  - **b. Medium access technique:**
    It uses ring-based token passing mechanism and is derived from IEEE 802.4 token bus standard.

    Token Bus (IEEE 802.4) [37]:

    Token Bus (IEEE 802.4) is a popular standard for the token passing LANs. In a token bus LAN, the physical media is a bus or a tree and a logical ring is created using coaxial cable. The token is passed from one user to other in a sequence (clockwise or anticlockwise). Each station knows the address of the station to its “left” and “right” as per the sequence in the logical ring. A station can only transmit data when it has the token. The working of token bus is somewhat similar to Token Ring.



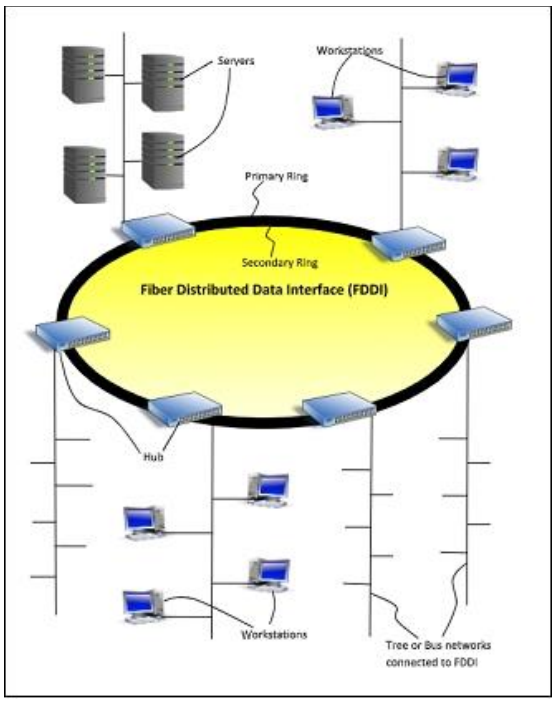
c. **Range:**
   It is used in LANs up to 200 kilometres for long distance voice and multimedia communication.

- Scalability [39][40]

  Fiber Distributed Data Interface, or FDDI, is a high-speed network technology which runs at 100 Mbps over fiber-optic cabling, often used for network backbones in a local area network (LAN) or metropolitan area network (MAN).

  Fiber Distributed Data Interface (FDDI) is usually implemented as a dual token-passing ring within a ring topology (for campus networks) or star topology (within a building). The dual ring consists of a primary and secondary ring. The primary ring carries data. The counter-rotating secondary ring can carry data in the opposite direction, but is more commonly reserved as a backup in case the primary ring goes down. This provides FDDI with the degree of fault tolerance necessary for network backbones.

- Schematic Diagram



8.ZigBee

Zigbee is a wireless technology developed as an open global standard to address the unique needs of low-cost, low-power wireless IoT networks. The Zigbee standard operates on the IEEE 802.15.4 physical radio specification and operates in unlicensed bands including 2.4 GHz, 900 MHz and 868 MHz [41]

- Specifications [42]:
    a. **Range:**
    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.

    b. **Speed:**
    ZigBee's data transfer **speed** is lower than Wi-Fis'. Its maximu m **speed** is just 250kbps, much lower than the lowest **speed** Wi-Fi offers.

    c. **Modulation:**
    The radios use direct-sequence spread spectrum coding, which is managed by the digital stream into the modulator. **Binary phase-shift keying (BPSK)** is used in the 868 and 915 MHz bands, and **offset quadrature phase-shift keying (OQPSK)** that transmits two bits per symbol is used in the 2.4 GHz band.

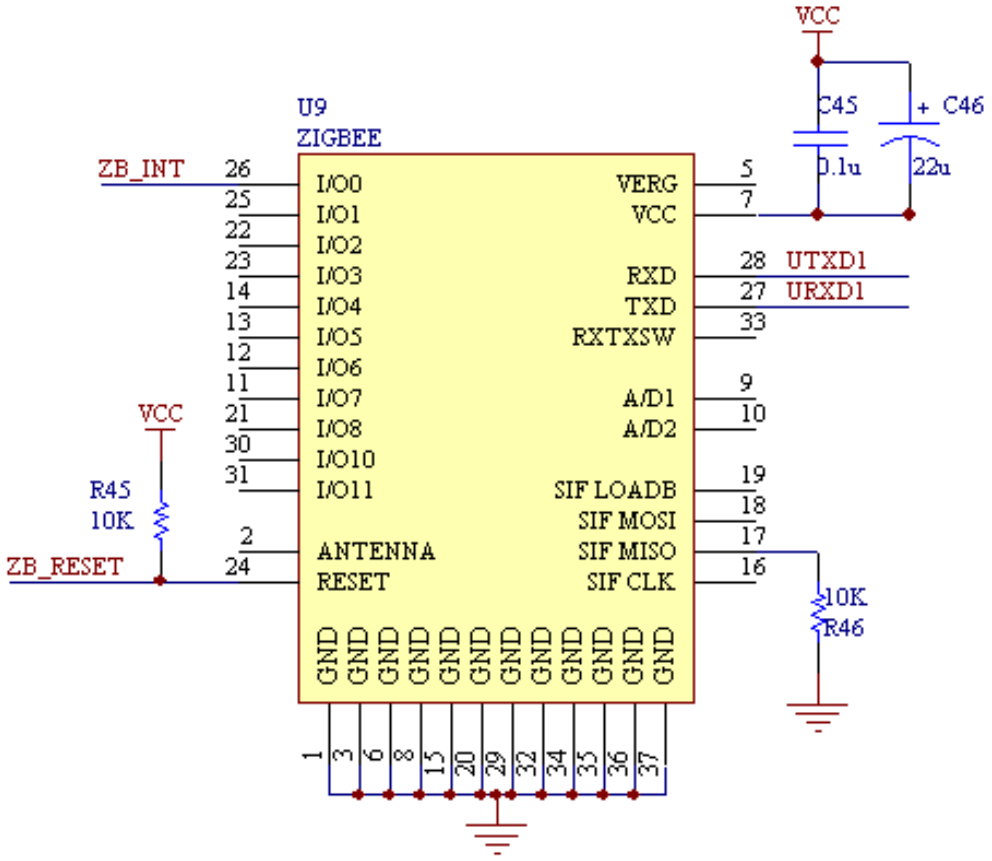
- Scalability [41][43]

    A key component of the Zigbee protocol is the ability to support mesh networking. In a mesh network, nodes are interconnected with other nodes so that multiple pathways connect each node. Connections between nodes are dynamically updated and optimized through sophisticated, built-in mesh routing table.

Mesh networks are decentralized in nature; each node is capable of self-discovery on the network. Also, as nodes leave the network, the mesh topology allows the nodes to reconfigure routing paths based on the new network structure. The characteristics of mesh topology and ad-hoc routing provide greater stability in changing conditions or failure at single nodes.

The Zigbee network specification states that networks can theoretically scale to thousands of nodes per network. However, realistically, and in practice, Zigbee networks can scale to hundreds of nodes in a single network. Our point-to-point/Bluetooth option is limited to two nodes and Wi-Fi to 15 devices per access point.

- Schematic Diagram



9.Coaxial Cable

Coaxial cable, or coax cable, is designed to transmit high frequency signals. It's comprised of a round copper conductor and three layers of insulation and shielding which prevents crosstalk from motors, lighting and other sources of EMI. With the shield construction, the coaxial cable can support longer cable lengths between two devices. Coax has 80X more transmission capacity than twisted pair cables. [46]

- Specifications [44][45]:
    a. **Range:**
    Ethernet can run approximately 100 meters using twisted-pair cabling. Using coaxial cable increases this distance to 500m.

    b. **Speed:**
    The transmission **speed** of **coaxial** cable is 10Mbps

    c. **Modulation and coding:**

    10 Mbit/s Ethernet uses Manchester coding. A binary zero is indicated by a low-to-high transition in the middle of the bit period and a binary one is indicated by a high-to-low transition in the middle of the bit period. Manchester coding allows the clock to be recovered from the signal. However, the additional transitions associated with it double the signal bandwidth.

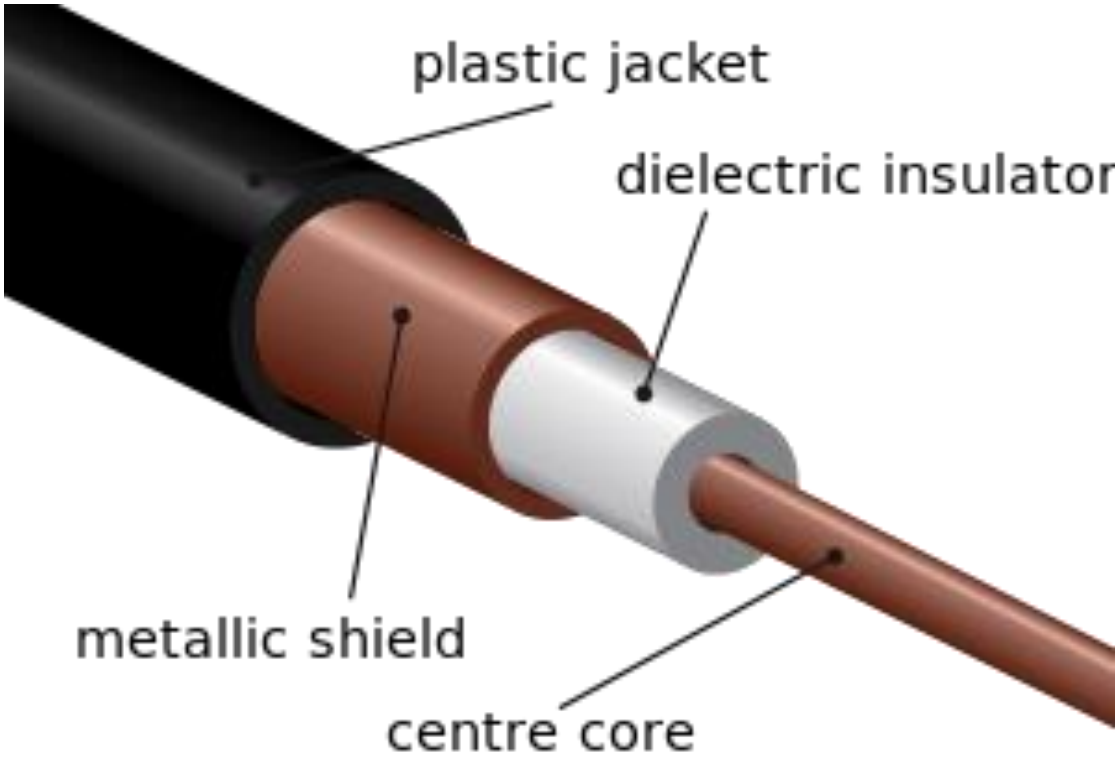
- Scalability [45]

    For **LANs**, coaxial cable offers several advantages. It can be run with fewer boosts from repeaters for longer distances between network nodes than either STP or UTP cable. Repeaters regenerate the signals in a network so that they can cover greater distances. Coaxial cable is less expensive than fiber-optic cable, and the technology is well known; it has been used for many years for all types of data communication.

    A connection device known as a **vampire tap** was used to connect network devices to Thicknet. The vampire tap then was

connected to the computers via a more flexible cable called the attachment unit interface (AUI). Although this 15-pin cable was still thick and tricky to terminate, it was much easier to work with than Thicknet.

- Schematic Diagram



10. Twisted pair Cable

Twisted-pair cable is the most common type of cabling you can see in today's Local Area Networks (LAN) networks. A pair of wires forms a circuit that can transmit data. The pairs are twisted to provide protection against crosstalk. Crosstalk is the undesired signal noise generated by the electromagnetic fields of the adjacent wires. When a wire is carrying a current, the current creates a magnetic field around the wire. This field can interfere with signals on nearby wires. To eliminate this, pairs of wires carry

signals in opposite directions, so that the two magnetic fields also occur in opposite directions and cancel each other out. This process is known as cancellation [47].

- Specifications [47]:
    a. **Range:**
       Generally, a distance of 100m without signal distortion.

    b. **Speed:**
       Depending upon the category the speed varies from a few Mbps to several Gbps.

    c. **Modulation and coding:**
       It uses a form of line coding. It is a pattern of voltage, current, or photons used to represent digital data transmitted down a transmission line.

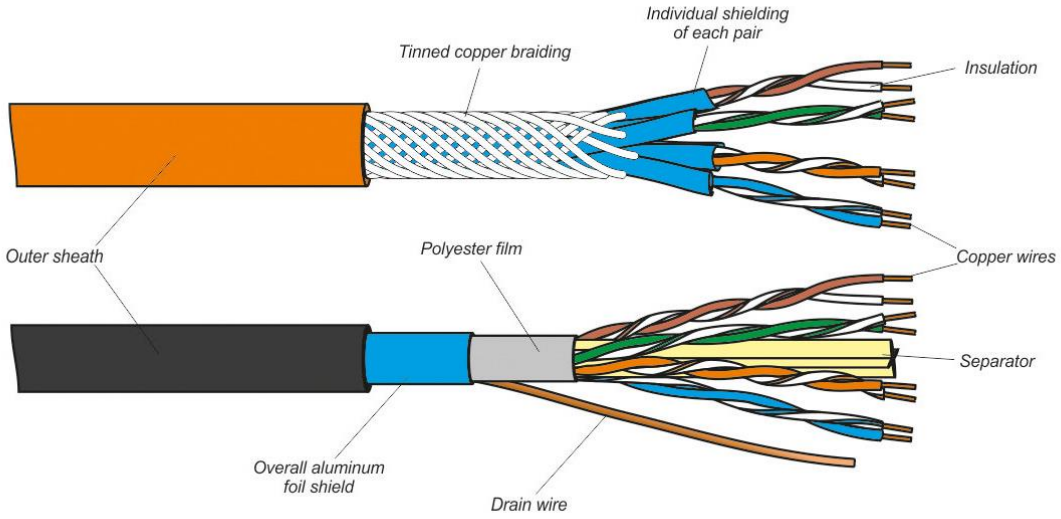
Unshielded Twisted Pair (UTP) cable is the most common networking media. Unshielded Twisted Pair (UTP) consists of four pairs of thin, copper wires covered in color-coded plastic insulation that are twisted together. The wire pairs are then covered with a plastic outer jacket. UTP cables are of small diameter and it doesn't need grounding. Since there is no shielding for UTP cabling, it relies only on "cancellation" to avoid noise.

Shielded Twisted Pair (STP) cables additionally have an overall conducting metallic shields covering four twisted pair wires. There may be another conducting metallic shields covering individual twisted pairs also. These metallic shields blocks out electromagnetic interference to prevent unwanted noise from the communication circuit. Drain wires are also used in Shielded Twisted Pair (STP) cables together with metallic shields for grounding purpose. The drain wire provides a low-resistance connection to shield for better grounding. The main purpose of drain wire is to carry away unwanted interference noise to ground.

- Scalability [48]

  Twisted pair cables are used in **LANs.** The earliest telephones used telegraph lines which were single-wire earth return circuits. In the 1880s electric trams were installed in many cities, which induced noise into these circuits. 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.

- Schematic Diagram



11. WiMAX (IEEE 802.16)

WiMAX (**Worldwide Interoperability for Microwave Access**) is a family of wireless broadband communication standards based on the IEEE 802.16 set of standards, which provide multiple physical layer (PHY) and Media Access Control (MAC) options.

The name "WiMAX" was created by the WiMAX Forum, which was formed in June 2001 to promote conformity and interoperability of the standard, including the definition of predefined system profiles for commercial vendors. The forum describes WiMAX as "a standards-based technology enabling the delivery of last mile wireless broadband access as an alternative to cable and DSL". IEEE 802.16m or WirelessMAN-Advanced was a candidate for the 4G, in competition with the LTE Advanced standard. [49]

- Specifications [50][51][52]:
    a. **Range:**
       WiMAX will blanket a radius of **30 miles** (50 km) with wireless access. The increased range is due to the frequencies used and the power of the transmitter.

    b. **Speed:**
       WiMAX can deliver theoretical download speeds to individual users around **10 Mbps to 20 Mbps.**

    c. **Modulation:**
       WiMAX supports a variety of modulation and coding schemes and allows for the scheme to change on a burst-by-burst basis per link, depending on channel conditions.
       Downlink: BPSK, QPSK, 16 QAM, 64 QAM; BPSK optional for OFDMA-PHY.
       Uplink: BPSK, QPSK, 16 QAM; 64 QAM optional.

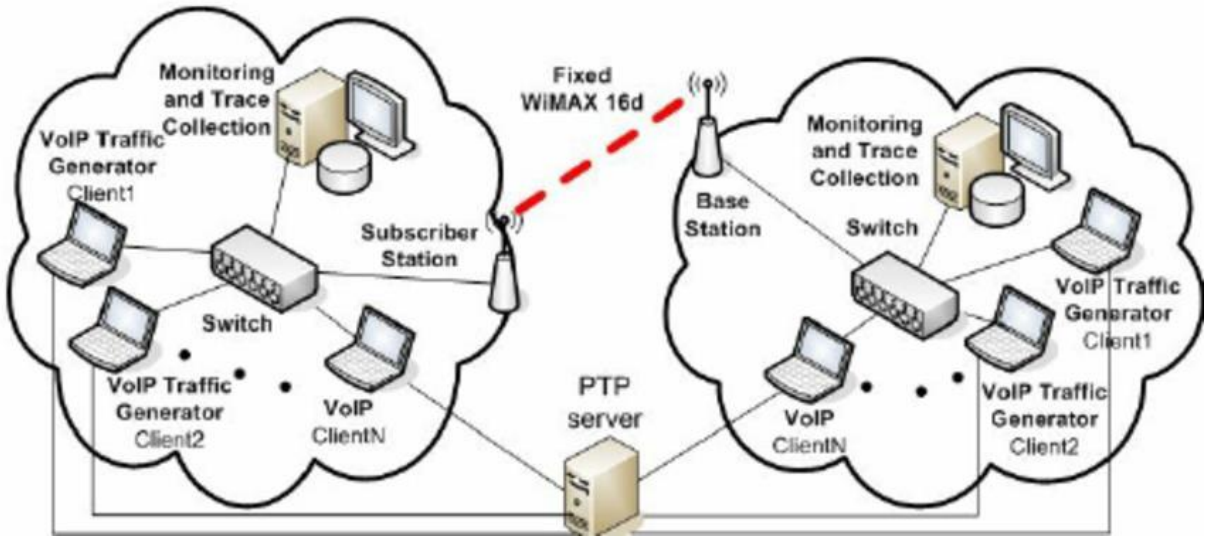
- Scalability [49]

It is scalable to **LAN** and **WMAN**

The scalable physical layer architecture that allows for data rate to scale easily with available channel bandwidth and range of WiMAX make it suitable for the following potential applications:

- Providing portable mobile broadband connectivity across cities and countries through various devices.
- Providing a wireless alternative to cable and digital subscriber line (DSL) for "last mile" broadband access.
- Providing data, telecommunications (VoIP) and IPTV services (triple play).
- Providing Internet connectivity as part of a business continuity plan.
- Smart grids and metering.

- Schematic Diagram



12. USB (Universal Serial Bus)

Universal Serial Bus is an industry standard that establishes specifications for cables and connectors and protocols for connection, communication and power supply between computers, peripherals and other computers. USB was designed to standardize the connection of peripherals to personal computers, both to communicate with and to supply electric power. It has largely replaced interfaces such as serial ports and parallel ports, and has become commonplace on a wide range of devices. Examples of peripherals that are connected via USB include computer keyboards and mice, video cameras, printers, portable media players, disk drives and network adapters. USB connectors have been increasingly replacing other types as charging cables of portable devices. [53]

- Specifications [54][55][56]:
    a. **Range:**
    The 2.0 specification limits the length of a cable between USB 2.0 devices to **5 meters**. The 3.0/3.1 specification does not specify a maximum cable length between USB 3.0/3.1 devices (SuperSpeed or SuperSpeed+), but there is a recommended length of **3 meters** (or about 9 feet and 10 inches). The length can be extended using repeater cables.

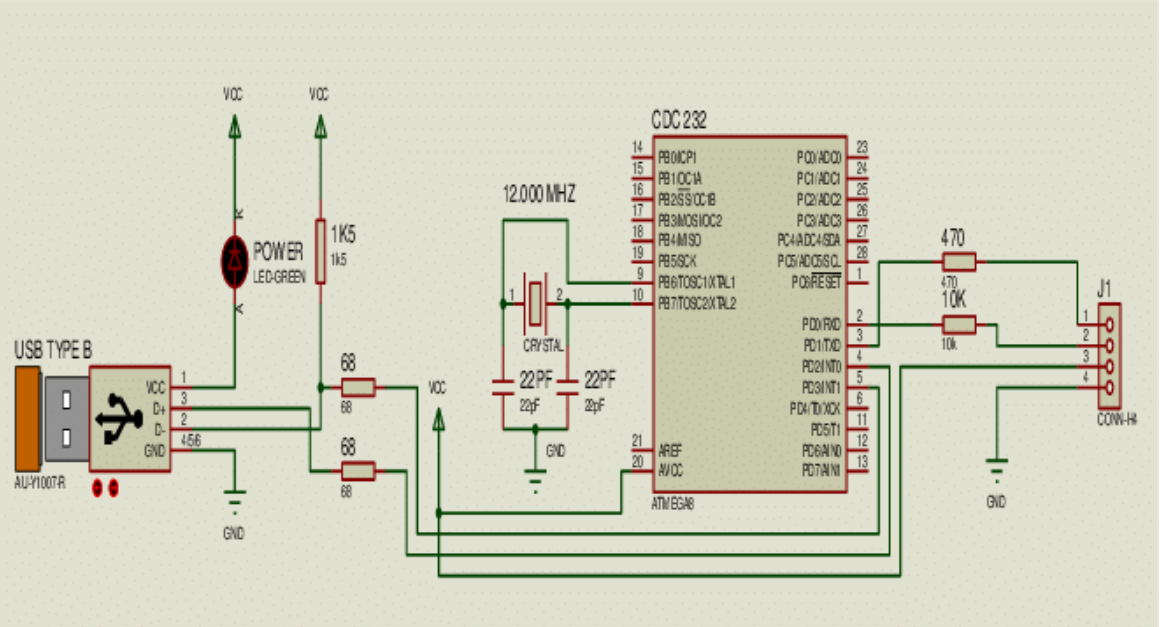
    b. **Speed:**
        - **USB** 1.0/Low-**Speed**: 1.5 Mbps
        - **USB** 1.1/Full-**Speed**: 12 Mbps
        - **USB** 2.0/Hi-**Speed**: 480 Mbps
        - **USB** 3.0/SuperSpeed: 5 Gbps
        - **USB** 3.1/SuperSpeed: 10 Gbps

    c. **Modulation and coding:**
    The clock is transmitted, encoded along with the differential data. The clock-encoding scheme is NRZI (Non-Return to Zero Invert).

- Scalability [57]

  The USB is controlled by a host; there can be multiple peripherals but only one host per bus. The host can be taken as master and peripheral as slaves, whereby the former is responsible for managing the connection, transactions, and scheduling bandwidth. The USB system uses tiered start topology. It consists of 7-bit addressing; this means it can support up to 127 devices at once. They are used in **PAN** and **LAN.**

- Schematic Diagram



CONCLUSION

In this experiment I learned various types of physical layer wired and wireless connections in terms of their specifications, scalability and schematic view.

REFERENCES

Physical layer

[1] http://www.tcpipguide.com/free/t_PhysicalLayerLayer1.htm
[2] Data communications and Networking by B. Farouzan.

Bluetooth

[3] https://en.wikipedia.org/wiki/Bluetooth#Bluetooth_5.
[4] Mario Collotta, Giovanni Pau, Timothy Talty, Ozan K. Tonguz. Bluetooth 5: a concrete step forward towards the IoT
[5] https://en.wikipedia.org/wiki/Frequency-hopping_spread_spectrum.
[6] https://en.wikipedia.org/wiki/Frequency-shift_keying.
[7] https://flylib.com/books/en/2.519.1/gaussian_frequency_shift_keying_gfsk_.html
[8] https://www.bluetooth.com/learn-about-bluetooth/bluetooth-technology/topology-options/#mesh
[9] https://www.digitaltrends.com/computing/bluetooth-mesh-networks/
[10] https://www.novelbits.io/bluetooth-mesh-tutorial-part-2/

NFC

[11] www.electronics-notes.com/articles/connectivity/nfc-near-field-communication/physical-layer-rf-signal-modulation.php
[12] www.electronics-notes.com/articles/connectivity/nfc-near-field-communication/technology.php.
[13] https://en.wikipedia.org/wiki/Near-field_communication
[14] https://electronics.howstuffworks.com/near-field-communication.htm
[15] https://www.slideshare.net/DilumBandara/other-types-of-networks-2015-3

LIFI

[16] https://www.sciencealert.com/li-fi-tested-in-the-real-world-for-the-first-time-is-100-times-faster-than-wi-fi
[17] https://en.wikipedia.org/wiki/Li-Fi
[18] https://www.rfwireless-world.com/Tutorials/LiFi-OOK-VPPM-CSK-modulation-types.html
[19] https://www.lifi-centre.com/about-li-fi/applications/.

Wifi

[20] https://www.forbes.com/sites/gordonkelly/2014/12/30/802-11ac-vs-802-11n-wifi-whats-the-difference/#49e3be1e3957
[21] https://www.tutorialspoint.com/csma-with-collision-avoidance-csma-ca
[22] https://www.tutorialspoint.com/wi-fi/wifi_radio_modulation.htm
[23] https://en.wikipedia.org/wiki/Spread_spectrum
[24] https://en.wikipedia.org/wiki/Direct-sequence_spread_spectrum
[25] https://www.tutorialspoint.com/csma-with-collision-avoidance-csma-ca

[26] https://www.maximintegrated.com/en/glossary/definitions.mvp/term/QPSK/gpk/244
[27] https://en.wikipedia.org/wiki/Phase-shift_keying#Binary_phase-shift_keying_(BPSK)
[28] https://www.techrepublic.com/article/factors-to-consider-when-building-a-scalable-wlan/

Ethernet

[29] https://en.wikipedia.org/wiki/Ethernet
[30] https://www.edn.com/pam-ethernet-a-perfect-match
[31] CNL-3
[32] Network Scalability in the Data Centre CPGS Report Malcolm Scott

LTE

[33] https://en.wikipedia.org/wiki/LTE_(telecommunication)
[34] https://www.slideshare.net/yihsuehtsai/long-range-cell-coverage-for-lte
[35] https://www.electronics-notes.com/articles/radio/multicarrier-modulation/ofdm-orthogonal-frequency-division-multiplexing-what-is-tutorial-basics.php
[36] https://www.tutorialspoint.com/lte/lte_ofdm_technology.htm

FDDI

[37] https://www.tutorialspoint.com/fiber-distributed-data-interface-fddi
[38] https://en.wikipedia.org/wiki/Fiber_Distributed_Data_Interface
[39] https://networkencyclopedia.com/fiber-distributed-data-interface-fddi/
[40] https://www.geeksforgeeks.org/token-bus-ieee-802-4/

Zigbee

[41] https://www.digi.com/solutions/by-technology/zigbee-wireless-standard
[42] https://en.wikipedia.org/wiki/Zigbee
[43] http://radar.oreilly.com/2014/08/how-to-identify-a-scalable-iot-network-topology.html

Coaxial

[44] https://uk.rs-online.com/web/generalDisplay.html?id=ideas-and-advice/coaxial-cable-guide
[45] https://www.ciscopress.com/articles/article.asp?p=31276&seqNum=2
[46] https://en.wikipedia.org/wiki/Coaxial_cable

Twisted pair

[47] https://www.omnisecu.com/basic-networking/common-network-cable-types.php
[48] https://en.wikipedia.org/wiki/Twisted_pair

WiMAX

[49] https://en.wikipedia.org/wiki/WiMAX
[50] https://www.cnet.com/news/whats-the-big-deal-about-wimax/
[51] https://www.tutorialspoint.com/wimax/wimax_physical_layer.htm
[52] https://computer.howstuffworks.com/wimax.htm

USB

[53] https://en.wikipedia.org/wiki/USB
[54] http://www.yourcablestore.com/USB-Cable-Length-Limitations-And-How-To-Break-Them_ep_42-1.html
[55] https://www.sony.com/electronics/support/articles/00024571
[56] http://www.ece.ualberta.ca/~elliott/ee552/studentAppNotes/2001f/interfacing/usb/appl_note.html
[57] https://www.engineersgarage.com/tutorials/introduction-to-usb-advantages-disadvantages-and-architecture-part-1-6/