EXPERIMENT 1

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CLASS: TE COMPS **BATCH: D**

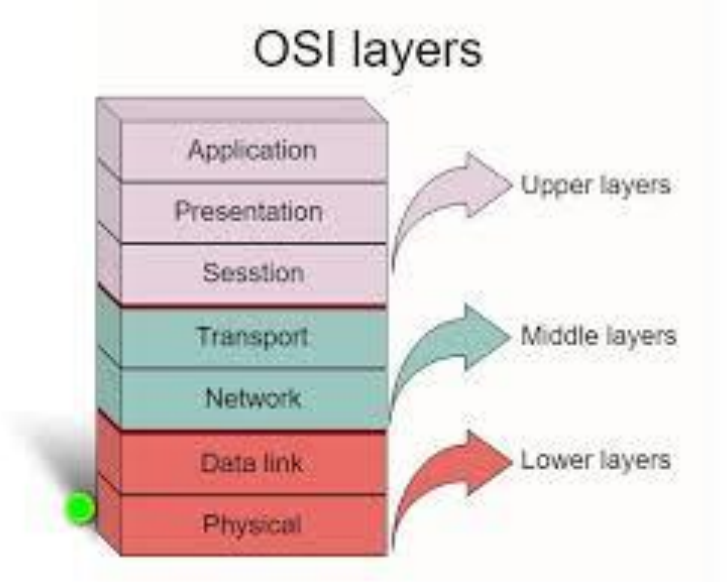
AIM- To study different types of physical layer wired/wireless connections.

THEORY-

Physical Layer

In the seven-layer OSI model of computer networking, the **physical layer** or **layer 1** is the first and lowest layer. This layer may be implemented by a PHY chip.

The physical layer defines the means of transmitting raw bits[1] over a physical data link connecting network nodes. It is responsible for actual physical connection between the devices.



Wired Network

A wired network connection is described as a configuration that involves cables which establish a connection to the Internet and other devices on the network. Most wired networks use Ethernet cables to transfer data between connected PCs. In a small wired network, a single router may be used to connect all the computers. Larger networks often involve multiple routers or switches that connect to each other.

1.DSL- DSL is a wired transmission that uses traditional copper telephone lines already installed to homes and businesses. Availability and speed of DSL service may depend on the distance from a home or business to the closest broadband-equipped telephone company central office or telephone exchange.[1]

1.1 Specifications:

- **Range-** The bit rate of consumer DSL services typically ranges from 256 kbit/s to over 100 Mbit/s in the direction to the customer (downstream), depending on DSL technology, line conditions, and service-level implementation. In general, the maximum **range** for **DSL** without a repeater is 5.5 km (18,000 feet). As distance decreases toward the telephone company office, the data rate increases. The **typical speed** for a **DSL** connection is 6 Mbps[2]

- **Modulation-** Modulation is the method the modem communicates with the DSLAM (server). **ADSL** or G. 992.1 or also G. DMT is the oldest form of **modulation**. It supports a maximum sync rate of 8Mbps. The next one is ADSL2 also referred to as G.992.3 supports a maximum of 12Mbps sync rate. The newest (if you can even call it new) is ADSL2+ or G.992.5 supports a maximum of 24Mbps sync rate.[2]

  Several Modulation techniques are used by various kinds of DSL, although these are being standardized by the International Telecommunication

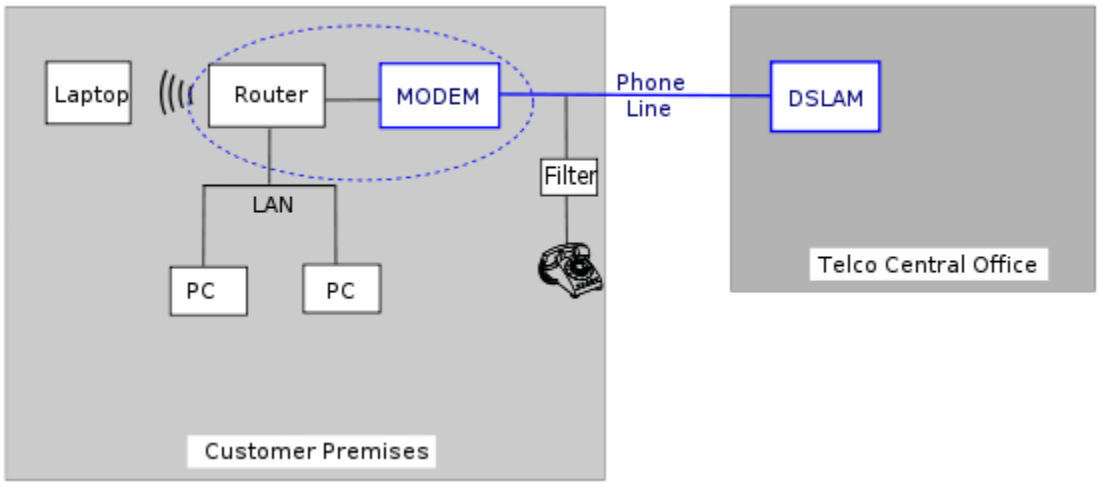
Union (ITU). Different DSL modem makers are using either Discrete Multitone Technology (DMT) or Carrierless Amplitude Modulation (CAP).

- **Signaling-** Voice signals travel over phone lines at frequencies ranging from 0 kHz to 4 kHz. Standard modems use the same frequencies, but DSL uses frequencies between 25 kHz and 1 MHz. These signals are then translated by a Digital Subscriber Line Access Multiplexer (DSLAM) located at the phone company's nearest central office.

1.2 Scalability

DSL Internet service only works over a limited physical distance and remains unavailable in many areas where the local telephone infrastructure does not support DSL technology. The service is not available everywhere. The connection is faster for receiving data than it is for sending data over the Internet.[3]

1.3 Schematic View



2.Ethernet- Ethernet is a system for connecting a number of computer systems to form a local area network, with protocols to control the passing of information and to avoid simultaneous transmission by two or more systems.[5]

2.1 Specifications:

- **Range-** There are a few different versions of ethernet cable, but they all have different ranges.[5]

    1. **10BASE5-** 10BASE5 uses a thick and stiff coaxial cable up to 500 meters (1,600 ft) in length. Up to 100 stations can be connected to the cable using vampire taps and share a single collision domain with 10 Mbit/s of bandwidth shared among them
    2. **10BASE2-** 10BASE2 coax cables have a maximum length of 185 metres (607 ft). The maximum practical number of nodes that can be connected to a 10BASE2 segment is limited to 30 with a minimum distance of 50 centimetres (20 in) between devices .It offers a 10 Mbit/s of bandwidth.
    3. **10BASET-** 10BASET have a maximum length of 100m and uses twisted pair of wires. Up to 1024 stations can be connected to it and it offers a bandwidth of 10 Mbit/s.

- **Modulation-** Most forms of Ethernet use pulse amplitude modulation (PAM) constellations. In PAM signal modulation, information is encoded in the amplitude of a series of signal pulses. For example, a two-bit modulator (PAM4) takes two bits and maps the signal amplitude to one of four possible voltage levels (perhaps –2V, -1V, 1V, 2V) over a specified period, *Tp* . Demodulation of the signal is accomplished by detecting the amplitude level of the carrier at each period Tp.

  The type of Ethernet determines which type of PAM is used. For example, 100BASE-T2 (running at 100Mb/s) Ethernet utilizes a five-level PAM modulation over two wire pairs. The IEEE 802.3an standard defines the wire-level modulation for 10GBASE-T,etc.[4]

- **Signaling-** Early Ethernet standards used Manchester coding so that the signal was self-clocking and not adversely affected by high-pass filters.

  The StarLAN 10 signaling was used as the basis of 10BASE-T, with the addition of *link beat* to quickly indicate connection status.[5]Using twisted pair cabling, in a star topology, for Ethernet addressed several weaknesses of the previous standards were overcome.

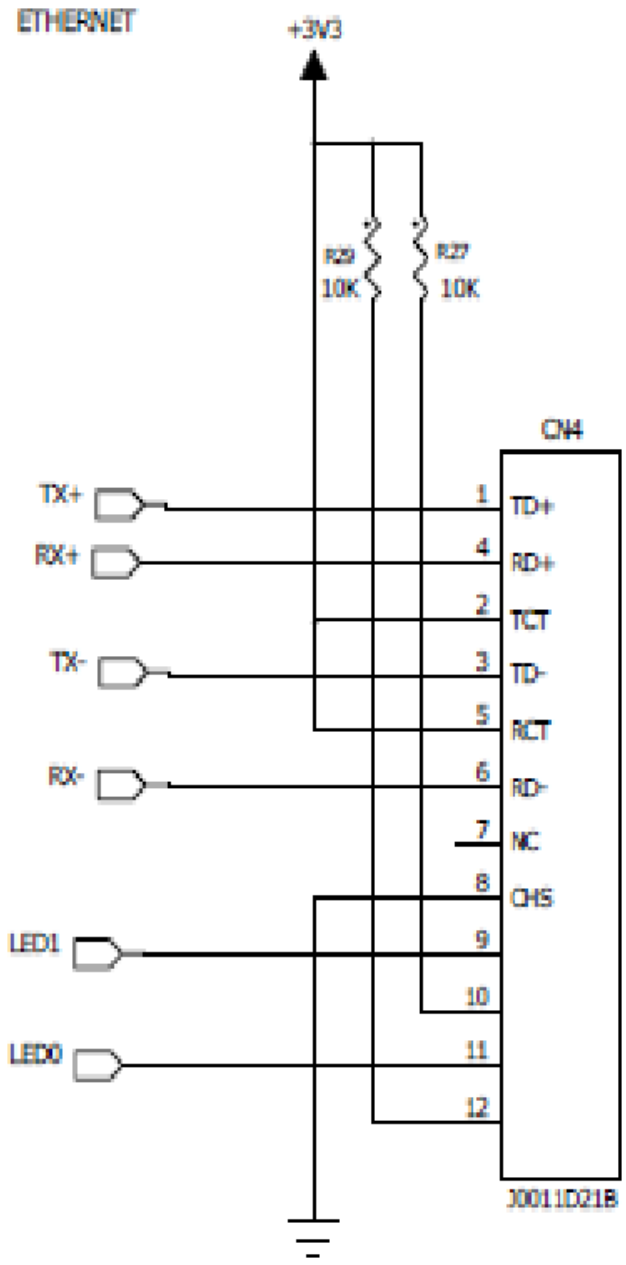
  Ethernet and IEEE 802.3 networks represent their data differently than do Token-Ring networks but they both use the same clocking scheme. The clock signal is a constant pulse. On an Ethernet or 802.3 network the signal is present only when a frame is being transmitted. Otherwise the cable is electrically '0'.

2.2 Scalability-

Ethernet is a family of computer networking technologies commonly used in local area networks (LAN).Ethernet is currently the most widely used technology in enterprise networking.

Unfortunately, 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.

2.3 Schematic Diagram



3. Fiber Distributed Data Interface (FDDI)

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.[15]

3.1 Specifications

- Transmission rate: 125 megabaud (100 Mb/s at the data link)
- Physical layer entities: 1000 (max)
- Total Ring length: 200 km (124 mi) (max)
- Transmission medium: Fiber optic or copper cable
- Network topology: Dual ring of trees
- Media access method: Timed-token passing

3.2 Scalability

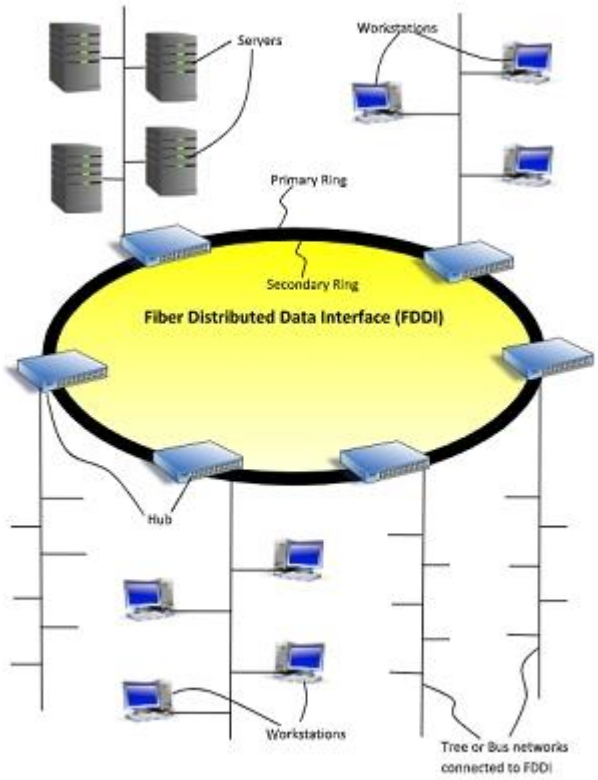
Fiber Distributed Data Interface (FDDI) is usually implemented as a dual token-passing ring within a ring topology (for campus networks) or star topology (within a building).[17]

It is applicable in large LANs that can extend up to 200 kilometers in diameter.

Designers normally constructed FDDI rings in a network topology such as a "dual ring of trees". A small number of devices, typically infrastructure devices such as routers and concentrators rather than host computers, were "dual-attached" to both rings. Host computers then connect as single-attached devices to the routers or concentrators. The dual ring in its most degenerate form simply collapses into a single device.

For these reasons, FDDI is not often used as a wide area network (WAN) solution, but is more often implemented in campus-wide networks as a network backbone. Typically, a computer-room contained the whole dual ring, although some implementations deployed FDDI as a metropolitan area network.

3.3 Schematic View[16]



4.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[18]. 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.

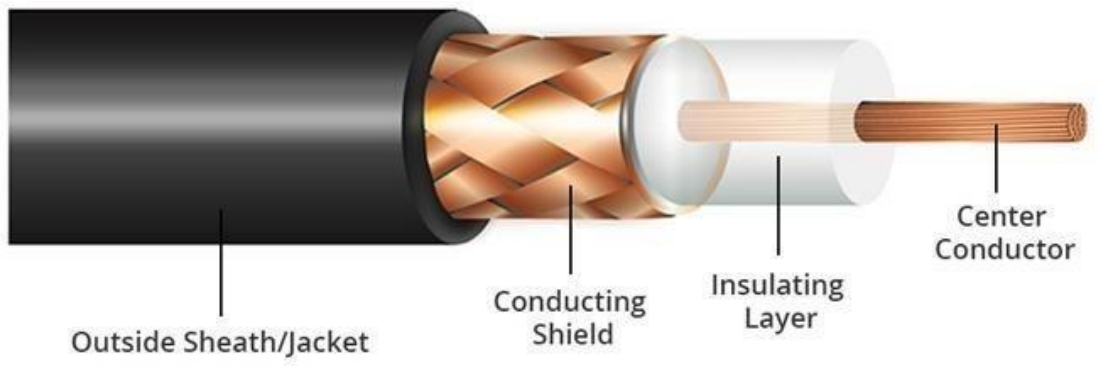
- **Range** – Up to 500m

- **Modulation** –
  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** –
  There are two types of coaxial cable
  1.RG8 used in LAN also known as thick Ethernet.
  2.RG-58 used for LAN and known as thin Ethernet.

- **Schematic View** –



5. **Twisted Pair copper cables** –

Twisted pair cables are literally a pair of insulated wires that are twisted together[19]. While this does help to reduce outside noise, these cables are still very susceptible to it. Twisted pair cables are the most cost-effective option of the three – mostly due to their lower bandwidth capacity and high attenuation. There are two types of twisted pair cables:

- Unshielded twisted pair (UTP) –

The Unshielded Twisted Pair (UTP) copper cables are the defacto standard for Ethernet cabling system. UTP cables are twisted in helical fashion like a strand of a DNA. Twisted are introduced for a special purpose. UTP cables are also used in telephone lines. Unlike older landline telephones, there are no incidents of crosstalk in current landline phones due to UTP cables twisted design. In networking, the twists help avoid data leakage. The commonly used UTP copper cable is Cat5, Cat5e, Cat6, Cat6a and Cat7.

- Shielded Twisted Pair (STP) –

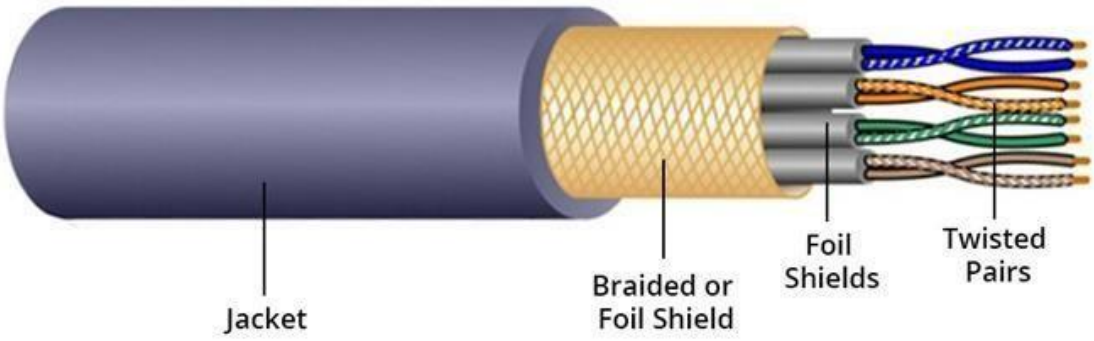
  Shielded' with a foil jacket to cancel any external interference. Used primarily for large-scale enterprises, high-end applications, and exterior cabling that will be exposed to environmental elements. [20]

  - Range – Up to 100m
  - Bandwidth – Up to 750 MHz.
  - Modulation – Line coding is used here.

    Line coding is the modulation of an electrical charge so that each side of a connection knows what is a one and what is a zero.
  - Scalability –

    It is scalable in LAN architecture.

- Schematic View –



The 10BASE-T is the legacy version and further generations of it specifying their speed, range are given below:
100BASE-T1: Speed of 100 Mbit/s and range of 15m.
100BASE-TX: Speed of 100 Mbit/s and range of 100m.
1000BASE-T: Speed of 1000 Mbit/s and range of 100m.
2.5GBASE-T: Speed of 2500 Mbit/s and range of 100m. 5GBASE-T: Speed of 5000 Mbit/s and range of 100m.
10GBASE-T: Speed of 10000 Mbit/s and range of 100m.
20GBASE-T: Speed of 20000 Mbit/s and range of 30m.
40GBASE-T: Speed of 40000 Mbit/s and range of 30m.

Wireless Networks

Wireless network is a computer network that uses wireless data connections between network nodes.

Wireless networking is a method by which homes, telecommunications networks and business installations avoid the costly process of introducing cables into a building, or as a connection between various equipment locations admin telecommunications networks are generally implemented and administered using radio communication. This implementation takes place at the physical level (layer) of the OSI model network structure.

Examples of wireless networks include cell phone networks, wireless local area networks (WLANs), wireless sensor networks, satellite communication networks, and terrestrial microwave networks.

1.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.

1.1 Specifications-

- **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. Data range is 250 kbps and the number of nodes that can be connected are around 64,000.[7]

- **Modulation-** Zigbee modulation is carried out through direct sequence spread spectrum (DSSS). The 2.4 GHz band, in which ZigBee transceivers are most commonly deployed, uses the OQPSK (offset quadrature phase-shift keying) modulation stream.

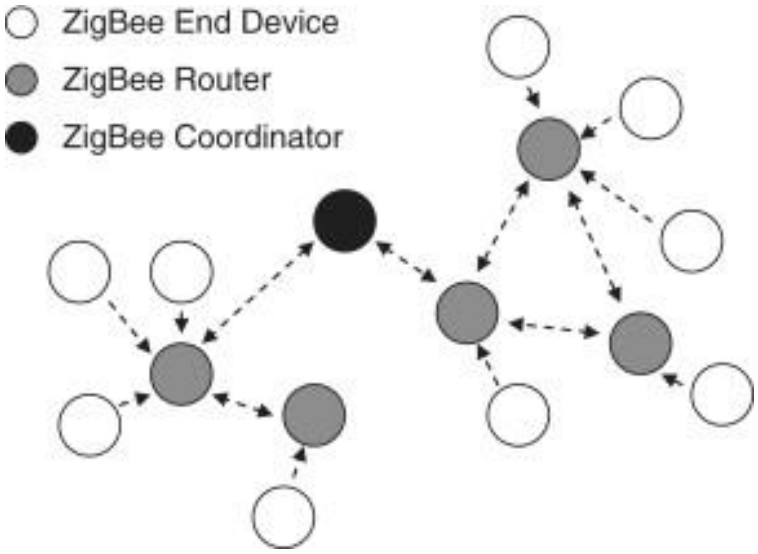
1.2 Scalability

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. IEEE 802.15.4/Zigbee standard constitutes a promising technology for the deployment of low-power and low rate Wireless Personal Area Networks.[8]

Our best networking topology choice is therefore a Zigbee mesh networking architecture. The Zigbee standard, as mentioned earlier, has been designed for

low power, low data rate networks and has been widely used in residential, building, and industrial automation/control applications.

1.3 Schematic Diagram



2. Wi-Fi-

Wi-Fi is a family of wireless network protocols, based on the IEEE 802.11 family of standards, which are commonly used for local area networking of devices and Internet access[10]. 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 completeinter operability certification testing.

2.1 Specifications

- **Range-** The most common, least expensive and first to become widespread is 802.11b, which provides data transfer rates of 11 Mbps (or, in an "enhanced" version, 22 Mbps) and a typical distance range of approximately 300 feet. It operates at the 2.4 GHz radio frequency.[9]

  802.11a was developed to provide higher speed communications, up to 54 Mbps. Unfortunately, you sacrifice range to get that speed because the signal typically only reaches about half as far. However, it has another advantage in that it suffers less from interference. That's because it operates at the 5.8 GHz frequency, which is used by fewer common household and office devices.

  802.11g in some ways gives you the "best of both worlds." You get the high speed of a 54 Mbps, with "enhanced" versions available that claim double that speed and a distance range closer to that of b. Since 802.11g is really an extension to its 802.11b cousin, it operates at the same frequency, 2.4 GHz

  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 can use different digital modulation schemes for data transmission. Environmental factors and protocol will define scheme selection. Below, we look at the principles behind modulation. [12]
  BPSK is used for lower bit rates with 802.11g clients. A low bit-rate would be negotiated for many reasons, those discussed later in the document. BPSK paired with half rate encoding, results in a bit-rate of 6Mbps. 9Mbps is achieved with BPSK and 3/4 code rate.

If the the signal strength exceeds the receiver sensitivity, a more complicated modulation scheme can be used. 802.11g can use up to 64QAM which uses both phase and amplitude modulation coherently, achieving 48Mbps and 54Mbps with a code rate of half and 3/4 respectively. An example constellation diagram for 64QAM is shown below.

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 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 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 bit streams 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.

802.11n and 802.11ac use the same modulation principles as 802.11g. 802.11ac can negotiate up to 256QAM if the receiver sensitivity permits. In addition to modulation schemes, 802.11n and 802.11ac pair the modulation scheme with other technologies that enable even faster bit-rates. The bit-rate for 802.11n and 802.11ac can be determined by the MCS value. The MCS value related to the receiver sensitivity is listed on the product data sheet.

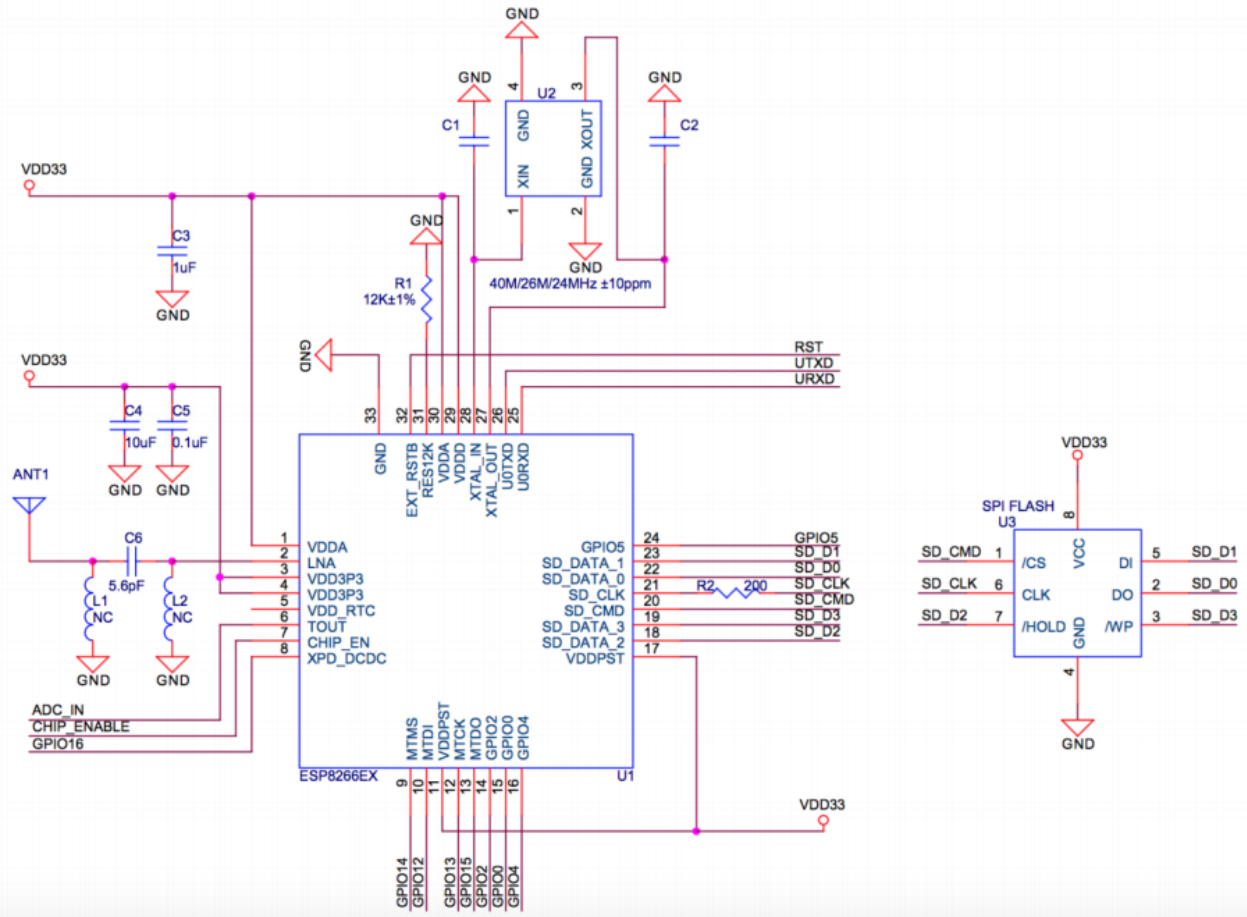
- **Signaling-** A WiFi network employs radio waves to establish communication between devices. ... The radio waves which comprise WiFi signals make use of the 2.4 GHz and 5 GHz frequency bands. These are higher than the frequencies used for televisions or cell phones and allow more data to be carried than do the lower frequencies.

2.2 Scalability-

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.[13]

Wi-fi can be used for various applications like mobile app,business application,browsing internet,computer application,video conference,etc.

2.3 Schematic Diagram[13]



3) Bluetooth Wireless Personal Area Network (WPAN) – [10]

The two current technologies for wireless personal area networks are InfraRed (IR) and Bluetooth (IEEE 802.15). These will allow the connectivity of personal devices within an area of about 30 feet. However, IR requires a direct line of site and the range is less.[14]

- Range – Typically less than 10 m

Ranges of Bluetooth devices by class

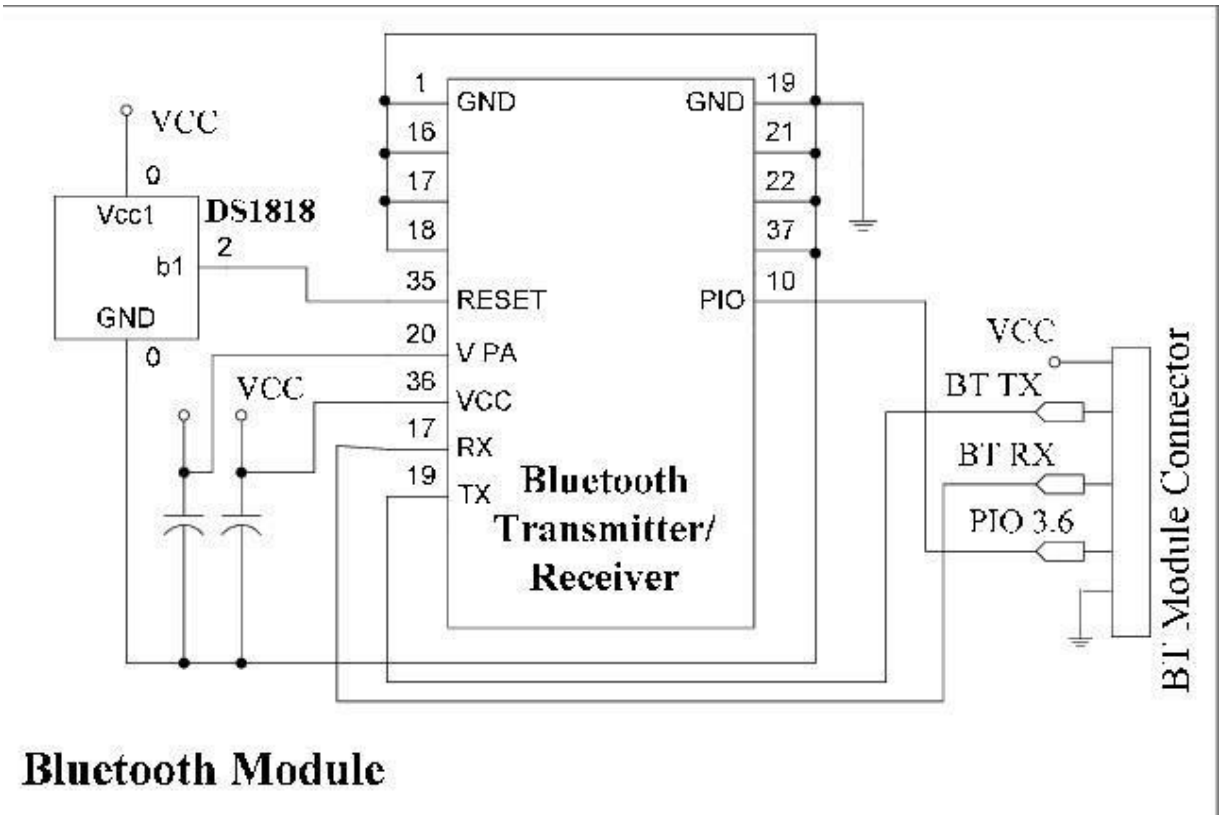
Class	Max. permitted power (mW)	(dBm)	Typ. range[2] (m)
1	100	20	~100
1.5 (BT 5 Vol 6 Part A Sect 3)	10	10	~20
2	2.5	4	~10
3	1	0	~1
4	0.5	−3	~0.5

- Modulation –

  Bluetooth uses Frequency Hopping Spread Spectrum technique which is used in spread spectrum signal transmission. During radio transmission, frequencies are switched repeatedly, to help reducing unlawful access to cross paths which causes interruptions. FHSS makes Bluetooth communication more robust and secure. The speed of interferences from other devices will be reduced, though it will not cause the transmission to stop.

  Adaptive modulation and coding methods, OFDM, GMSK, QAM, CDMA, DMT and similar methods are utilized in the areas of wireless, cellular and satellite communication systems. These modulations are used in wireless, cellular, wired line and satellite communication systems.

- Schematic View –



4.Cellular Networks

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 transciever, 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.[21]

When joined together, these cells provide radio coverage over a wide geographic area. This enables numerous portable transceivers 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

Specifications

• Range: In cities, each cell site may have a range of up to approximately 1⁄2 mile (0.80 km), while in rural areas, the range could be as much as 5 miles (8.0 km). It is possible that in clear open areas, a user may receive signals from a cell site 25 miles (40 km) away.

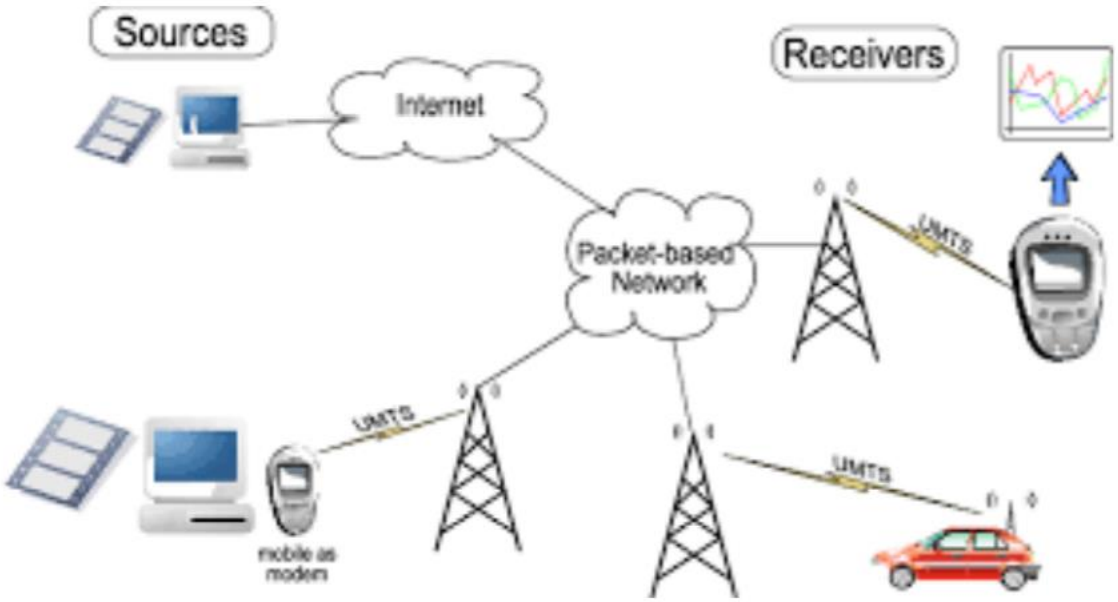
• Modulation: It uses QAM modulation technique. QAM (quadrature amplitude modulation) is a method of combining two amplitude-modulated (AM) signals into a single channel, thereby doubling the effective bandwidth. QAM is used with pulse amplitude modulation (PAM) in digital systems, especially in wireless applications

• Signaling: Cellular signalling networks are formed when different cell signalling pathways interact and are detected by a combination of experimental and computational methods. [23]

Scalability

Cellular systems use several radio communications technologies. The systems divide the region covered into multiple geographic areas. Each area has a lowpower transmitter or radio relay antenna device to relay calls from one area to the next area. The most common example of a cellular network is a mobile phone (cell phone) network. A mobile phone is a portable telephone which receives or makes calls through a cell site (base station) or transmitting tower. Radio waves are used to transfer signals to and from the cell phone. [22]

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 of the physical connector.

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