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Experiment 1

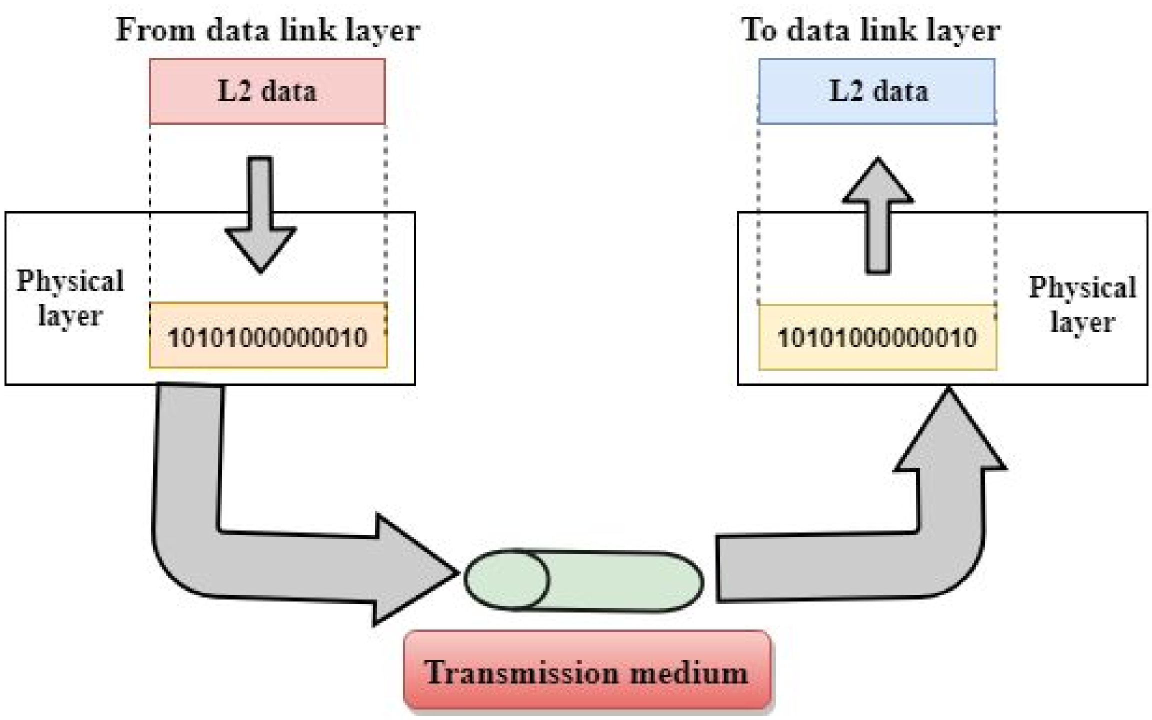
Aim: To study the different types of physical layers wired and wireless connections

Theory:

1. Physical Layers

Physical layer is the **lowest layer** of the OSI reference model. Physical layer in the OSI model plays the role of interacting with actual hardware and signaling mechanism. Physical layer is the only layer of OSI network model which actually deals with the physical connectivity of two different stations. This layer defines the hardware equipment, cabling, wiring, frequencies, pulses used to represent binary signals etc.

Physical layer provides its services to Data-link layer. Data-link layer hands over frames to physical layer. Physical layer converts them to electrical pulses, which represent binary data.The binary data is then sent over the wired or wireless media.

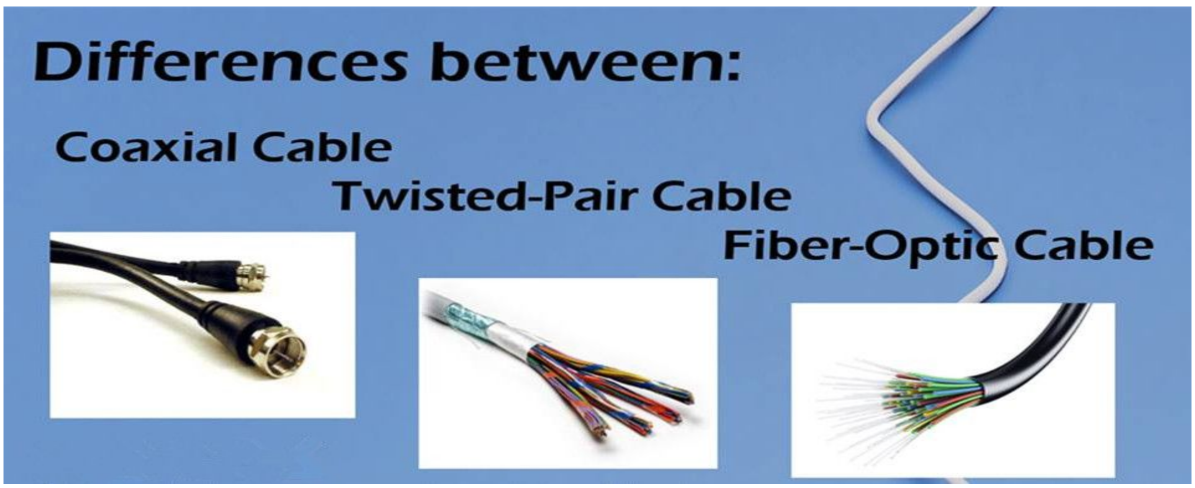


2. WIred Connections

Wired connections are by far the most common. The main media in use are:

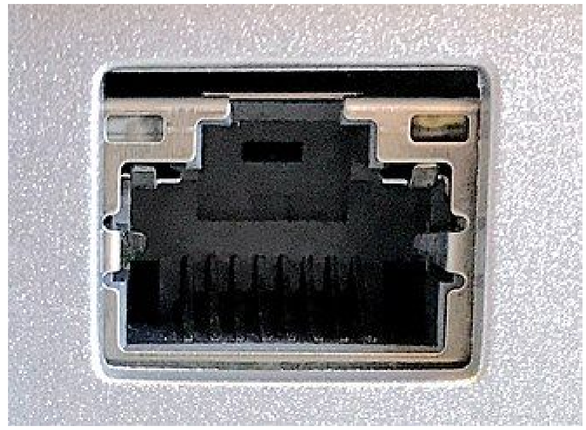
- **a. Coaxial cable,**
- **b. Twisted pairs**
- **c. Fibre optics**

For each of these, specific network technologies or specifications have been designed. The medium must have properties that will ensure a reasonable error performance for a guaranteed distance and rate of date delivery (i.e. speed). It must also support two-way or multiway communications.



Twisted pair cable	Co-axial cable	Optical fiber
1. Transmission of signals takes place in the electrical form over the metallic conducting wires.	1. Transmission of signals takes place in the electrical form over the inner conductor of the cable.	1. Signal transmission takes place in an optical forms over a glass fiber.
2. In this medium the noise immunity is low.	2. Coaxial having higher noise immunity than twisted pair cable.	2. Optical fiber has highest noise immunity as the light rays are unaffected by the electrical noise.
3. Twisted pair cable can be affected due to external magnetic field.	3. Coaxial cable is less affected due to external magnetic field.	3. Not affected by the external magnetic field.
4. Cheapest medium.	4. Moderate Expensive.	4. Expensive
5. Low Bandwidth.	5. Moderately high bandwidth.	5. Very high bandwidth
6. Attenuation is very high.	6. Attenuation is low.	6. Attenuation is very low.
7. Installation is easy.	7. Installation is fairly easy.	7. Installation is difficult.

2.1 Ethernet

An ethernet cable is a common type network cable used with wired networks.Ethernet cables connect devices such as PCs, routers, and switches within a **local area network.** These physical cables are limited by length and durability.

It was commercially introduced in **1980** and first standardized in **1983** as **IEEE 802.3**. Ethernet has since been refined to support higher bit rates, a greater number of nodes, and longer link distances, but retains much backward compatibility. Over time, Ethernet has largely replaced competing wired LAN technologies such as **Token Ring** etc. The Ethernet physical layer encompasses multiple physical media interfaces and several orders of magnitude of speed from **1 Mbit/s to 400 Gbit/s**. The physical medium ranges from **bulky coaxial cable** to **twisted pair** and **optical fiber** with a standardized reach of up to 40 km. In general, network protocol stack software will work similarly on all physical layers.

<u>Ethernet Specifications</u> :

- Range
  Over deployed multi-mode cabling ethernet supports ranges of between 240 m and 300 m with 400/500 MHz·km modal bandwidth. It also supports 10 km over single-mode fiber.
- Modulation
  Ethernet uses biphase modulation to transmit data bits, this is accomplished by using a Manchester encoded bit-stream. Ethernet does not use IQ modulation because it is not bandwidth limited by the FCC.

Ethernet Scalability :

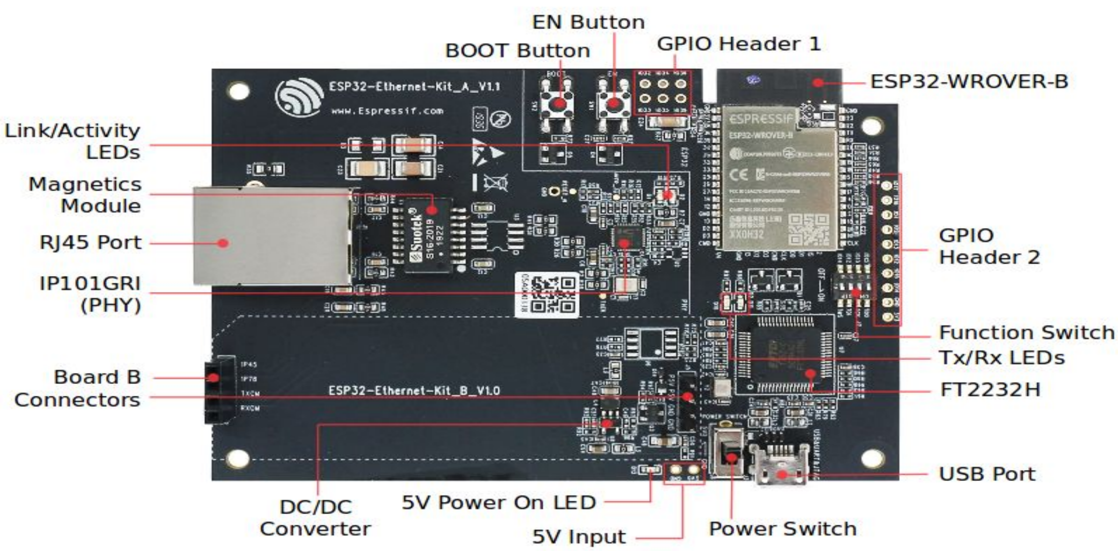
Ethernet is a family of computer networking technologies commonly used in local area networks (**LAN**), metropolitan area networks (**MAN**), and wide area networks(**WAN**). Ethernet is currently the most widely used technology in enterprise networking.

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.

Ethernet Schematic View :

The ESP32 Ethernet PHY interface is shown in the schematic below. It mainly consists of three sections:

- The PHY chip or interface
- The 50 MHz oscillator
- Jack and magnetics



The main sections of ESP32 Ethernet PHY interface are:

- Pull-up resistors on the ESP32 side of the PHY chip.
- Series termination resistors for reducing signal reflection and ringing.
- The 50-ohm pullups on the ethernet jack side of the PHY chip.
- Proper magnetic jack. Most ethernet jacks are low cost and do not contain any magnetics… you cannot use those directly. You will need external inductive components for using plain old **RJ-45 connectors**.

2.2 Universal Serial Bus (USB)

USB was designed to standardize the connection of peripherals like pointing devices, keyboards, digital still and video cameras. But soon devices such as printers, portable media players, disk drives and network adaptors to personal computers used USB to communicate and to supply electric power. It is a commonplace to many devices and has largely replaced interfaces such as serial ports and parallel ports.

USB Specifications :

- **Range**:
  - The USB 1.1 standard specifies that a standard cable can have a maximum length of 5 meters (16 ft 5 in) with devices operating at full speed (12 Mbit/s), and a maximum length of 3 meters (9 ft 10 in) with devices operating at low speed (1.5 Mbit/s).

- USB 2.0 provides for a maximum cable length of 5 meters (16 ft 5 in) for devices running at high speed (480 Mbit/s).
- The USB 3.0 standard does not directly specify a maximum cable length, requiring only that all cables meet an electrical specification: for copper cabling with AWG 26 wires, the maximum practical length is 3 meters (9 ft 10 in).

- **Modulation** :
  - At the input, the device communicates via MIDI and USB protocols. At the output is tension. Its value is managing by pulse-width modulation.
  - Pulse-width modulation (PWM) is used for controlling the amplitude of digital signals in order to control devices and applications requiring power or electricity. It essentially controls the amount of power, from the perspective of the voltage component, that is given to a device by cycling the on-and-off phases of a digital signal quickly.
- **Other specifications :**
  - Two important aspects of USB are its support capability and total bandwidth. It is capable of supporting 127 devices and has a total bandwidth of 12 Mbit per second which is equal to 1.5 MB per second. Working of a 12 Mbit (full speed device) or a 1.5 Mbit (low-speed device) depends on the total bandwidth of the USB.
  - USB 2.0 has a maximum signaling rate of 480 Mbit/s and USB 3.0 has a usable data rate of up to 4 Gbit/s (500 MB/s).

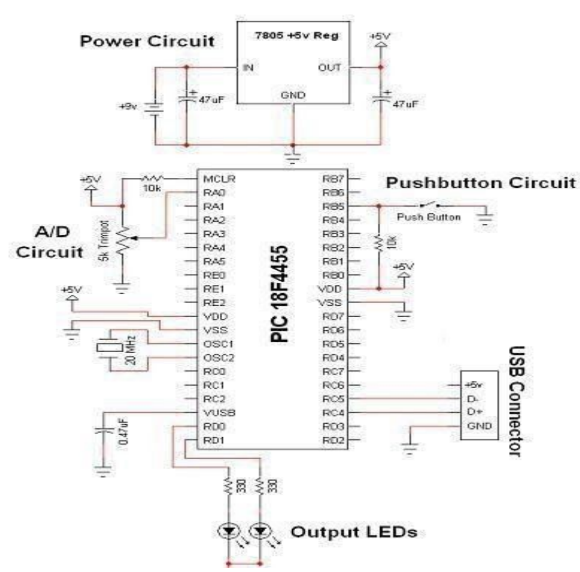
<u>USB Schematic View :</u>

Hardware design for USB is actually quite minimal, which is a big plus for us. However, what you quickly find out with USB is that the easy hardware design means the communication and control software is very complex. The main devices used in the circuit are the PIC 18F4455, USB Connector, and LM7805.

Schematic Specifics:

a. <u>Power Circuit</u>

The +5v output from the power circuit comes from the LM7805 regulator. Notice



the 47uF capacitors on the input and output. These are meant to be DC filtering capacitors, which smooth out the constant DC voltage being fed to the microcontroller from the 7805 regulators.

b. <u>USB Connection and Output LEDs</u>

Make sure you double-check your USB pinout. A common mistake when wiring the PIC to the USB connector is getting the D+ and D- signals backward. So if you're sure that the PIC is running your perfect code, but the USB device isn't coming up properly, switch D+ and D-, it might just magically fix your problem! The output LEDs will be simple 'toggle' LEDs. The program running on our laptop will be able to toggle them on and off with the push of a button.

c. <u>A/D and Push Button Circuits</u> :

The A/D circuit is a standard 3 pin, Connected to Power, Signal Out, and Ground circuit. The signal output goes into RA0 which is the Analog to Digital converter. After the PIC converts this signal it should send the data to the laptop via USB. The laptop will visually display the trimpot's value. The push-button will do a similar thing when the button is pushed, the laptop application should update with a notification that it has been pressed.

2.3 Power Lines

Power Line communication (PLC) is Layer-1 (Physical Layer) technology which uses power cables to transmit data signals. In PLC, modulated data is sent over the cables. The receiver on the other end de-modulates and interprets the data. Because power lines are widely deployed, PLC can make all powered devices controlled and monitored. PLC works in half-duplex. There are two types of PLC:
○ **Narrow band PLC**
○ **Broadband PLC**

Narrow band PLC provides lower data rates up to 100s of kbps, as they work at lower frequencies (3-5000 kHz).They can be spread over several kilometers.
Broadband PLC provides higher data rates up to 100s of Mbps and works at higher frequencies (1.8 – 250 MHz).They cannot be as much extended as Narrowband PLC.

2.4 Optical Fiber

- An optical fiber is a flexible, transparent fiber made by drawing glass (silica) or plastic to a diameter slightly thicker than that of a human hair.
- Optical fibers are used most often as a means to transmit light between the two ends of the fiber and find wide usage in fiber-optic communications, where they permit transmission over longer distances and at higher bandwidths (data transfer rates) than electrical cables.
- Fibers are used instead of metal wires because signals travel along them with less loss, in addition, fibers are immune to electromagnetic interference, a problem from which metal wires suffer.
- Fiber optic cable can be divided into single mode fiber (**SMF**) and multimode fiber (**MMF**).
- Single mode optical fiber has a small core, and only allows one mode of light to propagate at a time. While multimode fiber cable comes with a larger core and is designed to carry multiple light rays or modes at the same time.

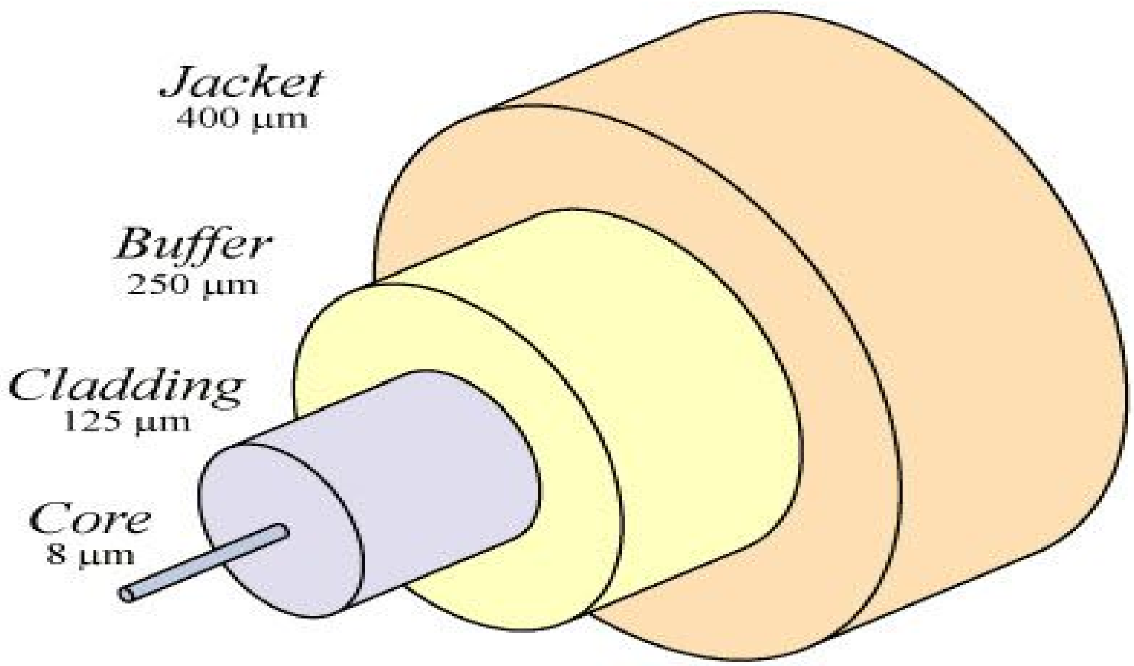
Specifications

- **Range**: Up to 80km.
- **Bandwidth** up to 4700MHz. Available for home use in speeds up to 2 Gbps (2000Mbps). Business Internet available in much faster speeds.
- **Modulation**
  An optical modulator is a device which is used to modulate a beam of light. Depending on the parameter of a light beam which is manipulated, modulators

may be categorized into amplitude modulators, phase modulators, polarization modulators etc.
Often the easiest way to obtain modulation of intensity of a light beam, is to modulate the current driving the light source, e.g. a laser diode. This sort of modulation is called direct modulation, as opposed to the external modulation performed by a light modulator. For this reason light modulators are, e.g. in fiber optic communications, called external light modulators.

Scalability
It is scalable in CAN architecture.

Schematic View



3. WIRELESS CONNECTIONS

- 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. This implementation takes place at the physical level (layer) of the OSI model network structure.
- Advances in MOSFET technology, and the wide adoption of RF CMOS (radio frequency CMOS), power MOSFET and LDMOS (lateral diffused MOS) devices led to the increase of digital wireless networks by the 1990s, and further advances led to increased bandwidth in the 2000s.

Most of the essential elements of wireless networks are built from MOSFETs, including the mobile transceivers, base station modules,routers, RF power amplifiers, telecommunication circuits, RF circuits,and radio transceivers, in networks such as 2G, 3G, and 4G.

3.1 Bluetooth

Bluetooth wireless technology is a short range communications technology intended to replace the cables connecting portable unit and maintaining high levels of security. Bluetooth technology is based on **Ad-hoc technology** also known as **Ad-hoc Pico nets**, which is a local area network with a very limited coverage.

Symbol of Bluetooth

An example of a Bluetooth device

The usage of Bluetooth has widely increased for its special features.

- Bluetooth offers a uniform structure for a wide range of devices to connect and communicate with each other.
- Bluetooth technology has achieved global acceptance such that any Bluetooth enabled device, almost everywhere in the world, can be connected with Bluetooth enabled devices.
- Low power consumption of Bluetooth technology and an offered range of up to ten meters has paved the way for several usage models.

- Bluetooth offers interactive conference by establishing an adhoc network of laptops.
- Bluetooth usage model includes cordless computer, intercom, cordless phone and mobile phone.

<u>Bluetooth Specifications</u> :

- **Range**

  The Bluetooth Core Specification mandates a range of not less than 10 meters (33 ft), but there is no upper limit on the actual range.

	Bluetooth v2.1	Bluetooth Low Energy (BLE)
Range	up to 100 meters	up to 100 meters
Max Range (free field)	Around 100 m (class 2 outdoors)	Around 100 m (outdoors)
Frequency	2.402 – 2.481 GHz	2.402 – 2.481 GHz
Max data rate	1-3 Mbit/s	1 Mbit/s
Application throughput	0.7-2.1 Mbit/s	Up to 305 kbit/s
Topologies	Point-to-point, scatternet	Point-to-point, mesh network
Network Standard	IEEE 802.15.1	IEEE 802.15.1

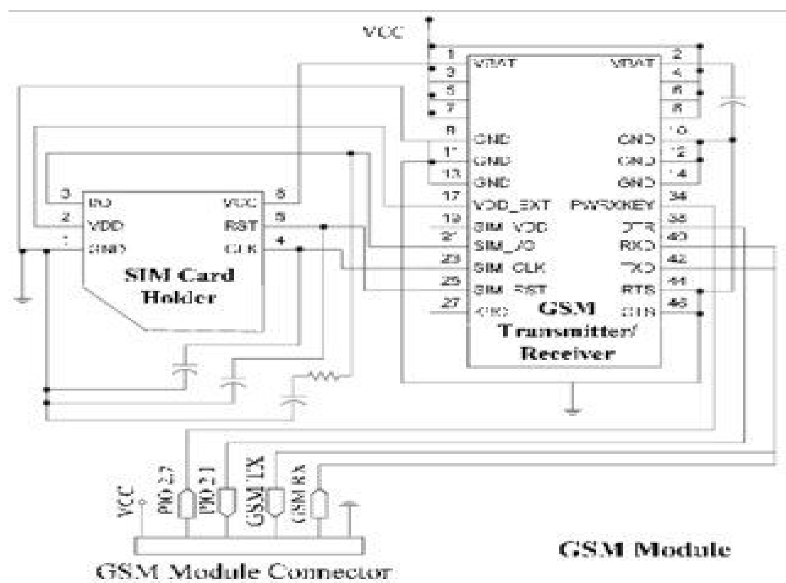
- **Modulation**
  - Originally, Gaussian frequency-shift keying (GFSK) modulation was the only modulation scheme available.
  - Since the introduction of Bluetooth 2.0+EDR, π/4-DQPSK (differential quadrature phase-shift keying) and 8-DPSK modulation may also be used between compatible devices.

- Devices functioning with GFSK are said to be operating in basic rate (BR) mode where an instantaneous bit rate of 1 Mbit/s is possible. The term Enhanced Data Rate (EDR) is used to describe π/4-DPSK and 8-DPSK schemes, each giving 2 and 3 Mbit/s respectively.

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 mobile terminals can communicate and exchange data - even on the move or when there is no line-of-sight between the terminals.

Bluetooth Schematic View :



The Bluetooth Module is a low-power embedded Bluetooth v2.0+EDR module with a built-in high-output antenna. The module is a fully Bluetooth compliant device for data communication with a transmission power of up to +8dBm and receiver sensibility of down to -83dBm combined with low power consumption. The Bluetooth Module delivers opportunities for rapid ad-hoc connections and the possibility of automatic, unconscious, connections between WPCOMs. The complete circuit diagram of the Bluetooth Module is given in the figure.

3.2 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. 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.

<u>Wi-Fi Specifications</u> :

The full list of versions of Wi-Fi is:

IEEE Standard	802.11a	802.11b	802.11g	802.11n	802.11ac	802.11ax
Year Released	1999	1999	2003	2009	2014	2019
Frequency	5 GHz	2.4 GHz	2.4 GHz	2.4 GHz & 5 GHz	2.4 GHz & 5 GHz	2.4 GHz & 5 GHz
Maximum Data Rate	54 Mbps	11Mbps	54 Mbps	600 Mbps	1.3 Gbps	10-12 Gbps

- **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.

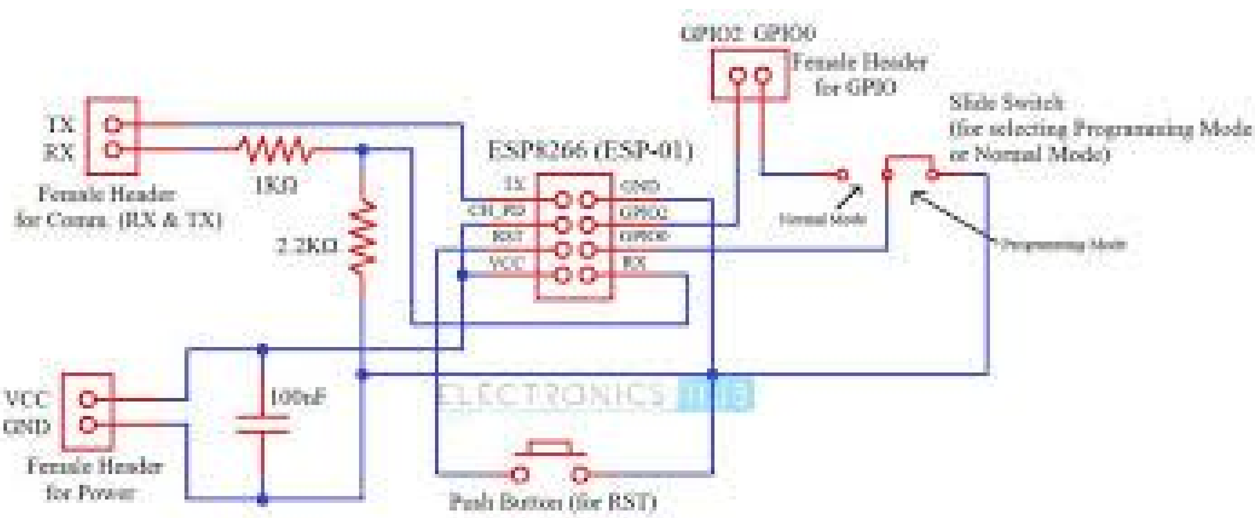
Wi-Fi Scalability :

- 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.

Wi-Fi Schematic View :

ESP8266 is a UART-WiFi transparent transmission module with ultralow power consumption, specially designed for the needs of a new connected world. It offers a complete and self-contained Wi-Fi networking solution, allowing it to either host the application or to offload all Wi-Fi networking functions from another application processor.



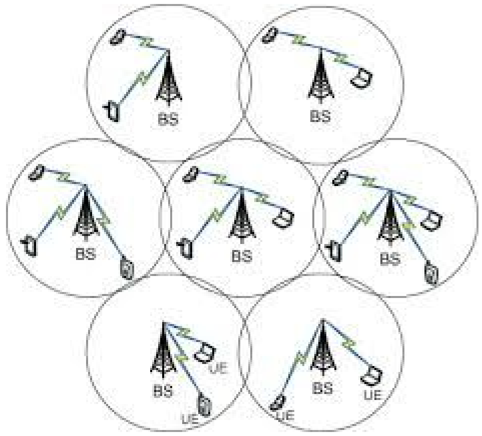
Schematic View ESP8266 - WiFi Module

ESP8266 has powerful on-board processing and storage capabilities that allow it to be integrated with the sensors and other application-specific devices through its GPIOs with minimal development up-front and minimal loading during runtime. Its high degree of on-chip integration allows for minimal external circuitry, and the entire solution, including the front-end module, is designed to occupy minimal PCB area. ESP8266 Serial Wifi Wireless Transceiver Module is suitable for Uno, Mega 2560, and Nano.

3.3. Near Field Communication (NFC)

- Near-Field-Communication (NFC) is a set of communication protocols for communication between two electronic devices over a distance of 4 cm or less. NFC offers a low-speed connection with simple setup that can be used to bootstrap more-capable wireless connections.
- NFC devices can act as electronic identity documents and keycards. They are used in contactless payment systems and allow mobile payment replacing or supplementing systems such as credit cards and electronic ticket smart cards. NFC tags are passive data stores which can be read, and under some circumstances written to, by an NFC device. They typically contain data (as of 2015 between 96 and 8,192 bytes) and are read-only in normal use, but may be rewritable.
- Like other "proximity card" technologies, NFC is based on inductive coupling between two so-called antennas present on NFC-enabled devices—for example a smartphone and a printer—communicating in one or both directions, using a frequency of 13.56 MHz in the globally available unlicensed radio frequency ISM band using the ISO/IEC 18000-3 air interface standard at data rates ranging from 106 to 424 kbit/s.

3.4 Cellular Networks



A cellular network or mobile network is a radio network distributed over land areas called cells, each served by at least one fixed-location transceiver, known as a cell site or base station. In a cellular network, each cell characteristically uses a different set of radio frequencies from all their immediate neighbouring cells to avoid any interference.

- When joined together these cells provide radio coverage over a wide geographic area. This enables a large number of portable transceivers (e.g., mobile phones, pagers, etc.) to communicate with each other and with fixed transceivers and telephones anywhere in the network, via base stations, even if some of the transceivers are moving through more than one cell during transmission.
- Although originally intended for cell phones, with thedevelopment of smartphones, cellular telephone networks routinely carry data in addition to telephone conversations:

○ Personal Communications Service (PCS): PCS is a radio band that can be used by mobile phones in North America and South Asia. Sprint happened to be the first service to set up a PCS.

○ D-AMPS: Digital Advanced Mobile Phone Service, an upgraded version of AMPS, is being phased out due to advancement in technology. The newer GSM networks are replacing the older system.

○ In telecommunications, **Long-Term Evolution** (LTE) is a standard for wireless broadband communication for mobile devices and data terminals, based on the **GSM/EDGE** and **UMTS/HSPA** technologies.

○ It increases the capacity and speed using a different radio interface together with core network improvements.

○ LTE is sometimes known as **3.95G** and has been marketed both as "4G LTE" and as "**Advanced 4G**”

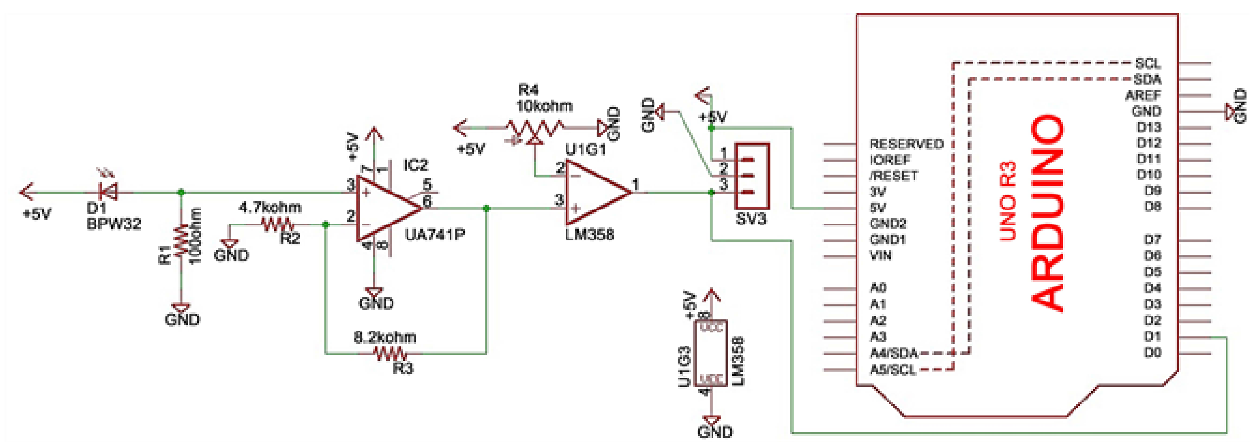
○ **5G** is the fifth generation technology standard for cellular networks, which cellular phone companies began deploying worldwide in 2019, the planned successor to the 4G networks which provide connectivity to most current cellphones.
○ Like its predecessors, 5G networks are cellular networks, in which the service area is divided into small geographical areas called **cells**. All 5G wireless devices in a cell are connected to the Internet and telephone network by radio waves through a local antenna in the cell.
○ 5G speeds will range from **~50 Mbit/s** to over a gigabit/s. The fastest 5G is known as **mmWave**. As of July 3, 2019, mmWave had a top speed of 1.8 Gbit/s on AT&T's 5G network.

○ **Frequency range 1 (< 6 GHz)**
The maximum channel bandwidth defined for FR1 is 100 MHz, due to the scarcity of continuous spectrum in this crowded frequency range. The band most widely being used for 5G in this range is 3.3–4.2 GHz. The Korean carriers are using 3.5 GHz although some millimeter wave spectrum has also been allocated.

○ **Frequency range 2 (> 24 GHz)**

The minimum channel bandwidth defined for FR2 is 50 MHz and the maximum is 400 MHz, with two-channel aggregation supported in 3GPP Release 15. In the U.S., Verizon is using 28 GHz and AT&T is using 39 GHz. The higher the frequency, the greater the ability to support high data-transfer speeds.

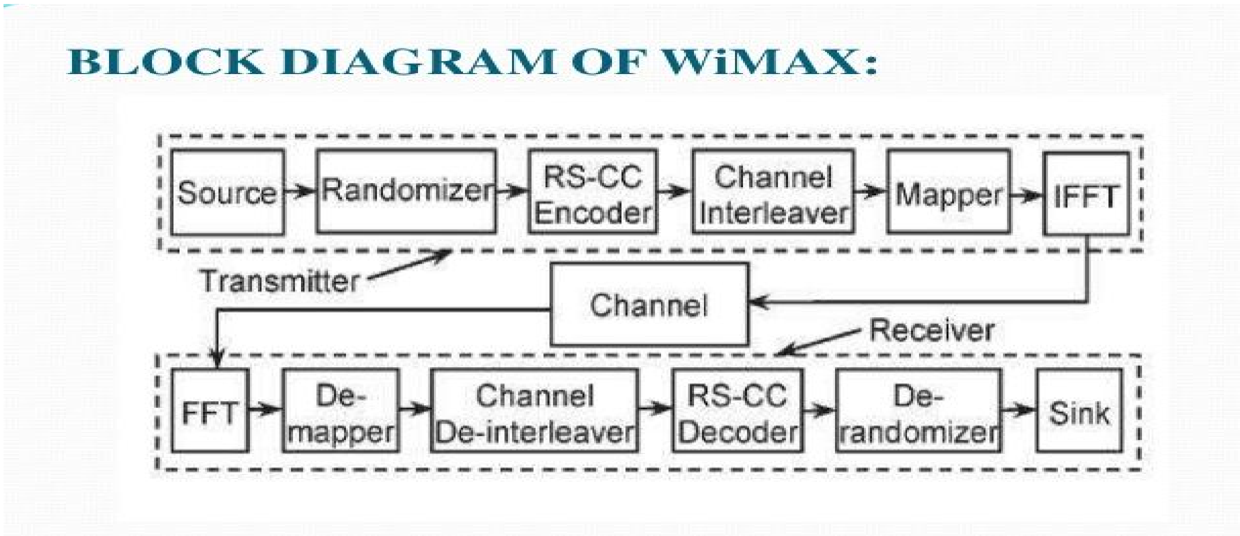
3.5 Li-Fi



- Li-Fi (short for light fidelity) is wireless communication technology which utilizes light to transmit data and position between devices. The term was first introduced by Harald Haas during a 2011 TEDGlobal talk in Edinburgh.

- In technical terms, 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.
- In terms of its end use, the technology is similar to Wi-Fi -- the key technical difference being that Wi-Fi uses radio frequency to induce a voltage in an antenna to transmit data. Whereas Li-Fi uses the modulation of light intensity to transmit data.
- Li-Fi can theoretically transmit at speeds of up to 100 Gbit/s. Li-Fi's ability to safely function in areas otherwise susceptible to electromagnetic interference (e.g. aircraft cabins, hospitals, military) is an advantage.The technology is being developed by several organizations across the globe.
- Li-Fi has the advantage of being useful in electromagnetic sensitive areas such as in aircraft cabins, hospitals and nuclear power plants without causing electromagnetic interference.
- Both Wi-Fi and Li-Fi transmit data over the electromagnetic spectrum, but whereas Wi-Fi utilizes radio waves, Li-Fi uses visible, ultraviolet, and infrared light.
- While the US Federal Communications Commission has warned of a potential spectrum crisis because Wi-Fi is close to full capacity, Li-Fi has almost no limitations on capacity.
- The visible light spectrum is 10,000 times larger than the entire radio frequency spectrum.
- Researchers have reached data rates of over 224 Gbit/s, which was much faster than typical fast broadband in 2013.
- Li-Fi is expected to be ten times cheaper than Wi-Fi.

3.6 WiMAX



- **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.
- WiMAX was initially designed to provide 30 to 40 megabit-per-second data rates, with the 2011 update providing up to 1 Gbit/s for fixed stations.
- The latest version of WiMAX, WiMAX release 2.1, popularly branded as/known as **WiMAX 2+**, is a backwards-compatible transition from previous WiMAX generations.

Physical layer:

- The original version of the standard on which WiMAX is based (IEEE 802.16) specified a physical layer operating in the 10 to 66 GHz range. 802.16a, updated in 2004 to 802.16-2004, added specifications for the **2 to 11 GHz** range.
- 802.16-2004 was updated by 802.16e-2005 in 2005 and uses scalable orthogonal frequency-division multiple access[18] (SOFDMA), as opposed to the

fixed orthogonal frequency-division multiplexing (OFDM) version with 256 sub-carriers (of which 200 are used) in 802.16d.

- More advanced versions, including 802.16e, also bring multiple antenna support through MIMO. (See WiMAX MIMO) This brings potential benefits in terms of coverage, self installation, power consumption, frequency reuse and bandwidth efficiency. WiMax is the most energy-efficient pre-4G technique among LTE and HSPA+.

3.7 Zigbee

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

- Its low power consumption limits transmission distances to 10–100 meters line-of-sight, depending on power output and environmental characteristics. Zigbee devices can transmit data over long distances by passing data through a mesh network of intermediate devices to reach more distant ones. Zigbee is typically used in low data rate applications that require long battery life and secure networking (Zigbee networks are secured by 128 bit symmetric encryption keys.) Zigbee has a defined rate of 250 kbit/s, best suited for intermittent data transmissions from a sensor or input device.
- The ZigBee Smart Energy 2.0 specifications define an Internet Protocol-based communication protocol to monitor, control,inform, and automate the delivery and use of energy and water. It is an enhancement of the ZigBee Smart Energy version 1 specifications. It adds services for plug-in electric vehicle charging, installation, configuration and firmware download, prepay services, user information and messaging, load control,demand response and common information and application.

CONCLUSION:

From this experiment, I learned about the OSI Model,Physical Layer, the types of Wired and Wireless Connections. For each of these connections, I studied their specification, their scalability in the various network architecture, and their schematic view.

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