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EXPERIMENT 1

AIM: Study the different types of physical layer wired and wireless connections.

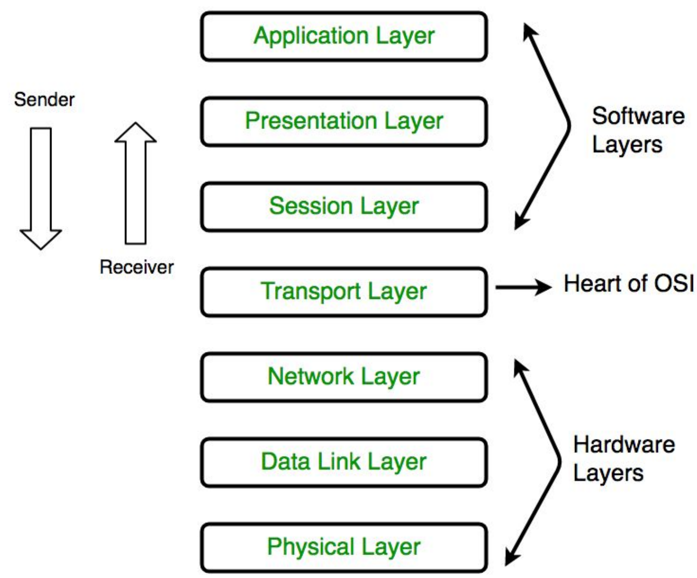
THEORY:

1. PHYSICAL LAYER

The **lowest layer** of the Open Systems Interconnection (OSI) reference model is the physical layer.

It is responsible for the **actual physical connection** between the devices. The physical layer contains information in the form of bits.

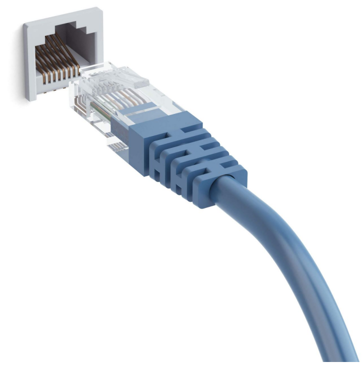
The physical layer is responsible for the **transmission of a raw bit-stream** over the physical medium. The transmission medium can either be wired or wireless.[1]



2. WIRED CONNECTIONS

Wired connections are by far the most common. The main media in use are **coaxial cable, twisted pairs, and fiber 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 (speed). It must also support **two-way or multiway** communications.[2]

2.1 Ethernet



An Ethernet cable is a common type of 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.[3]

- The Ethernet physical layer has evolved over its existence starting in 1980 and 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.[4]

- 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.[5]

A PAM signal

- A single Ethernet cable has an upper limit as to how long it can be before there is a signal loss called **attenuation**. This problem results because the electrical resistance of a long cable affects performance. However, this doesn't limit the size of a network, because hardware like **routers or hubs** can join multiple Ethernet cables together on the same network.[3]

- RJ45 is a type of **connector** commonly used for Ethernet networking. It looks similar to a telephone jack but is slightly wider. Since Ethernet cables have an RJ45 connector on each end, Ethernet cables are sometimes also called **RJ45 cables**. The "RJ" in RJ45 stands for "registered jack," since it is a standardized networking interface. The "45" simply refers to the number of the interface standard.[6]

2.2 Universal Serial Bus (USB)

The Universal Serial Bus 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.[7]

- USB System Design :
  - A USB system consists of a **host** with one or more downstream ports, and multiple peripherals, forming a **tiered-star topology**. Additional USB hubs may be included, allowing up to five tiers. A USB host may have multiple controllers, each with one or more ports. Up to **127 devices** may be connected to a single host controller. USB devices are linked in series through hubs. The hub built into the host controller is called the **root hub**.[7]

  - USB device communication is based on **pipes** (logical channels). A pipe is a connection from the host controller to a logical entity within a device, called an **endpoint**. Because pipes correspond to endpoints, the terms are sometimes used interchangeably. Each USB device can have up to **32 endpoints** (16 *in* and 16 *out*), though it is rare to have so many. Endpoints are defined and numbered by the device during initialization (the period after physical connection called "enumeration") and so are relatively permanent, whereas pipes may be opened and closed.[7]

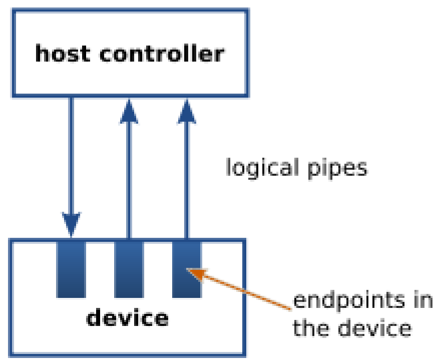


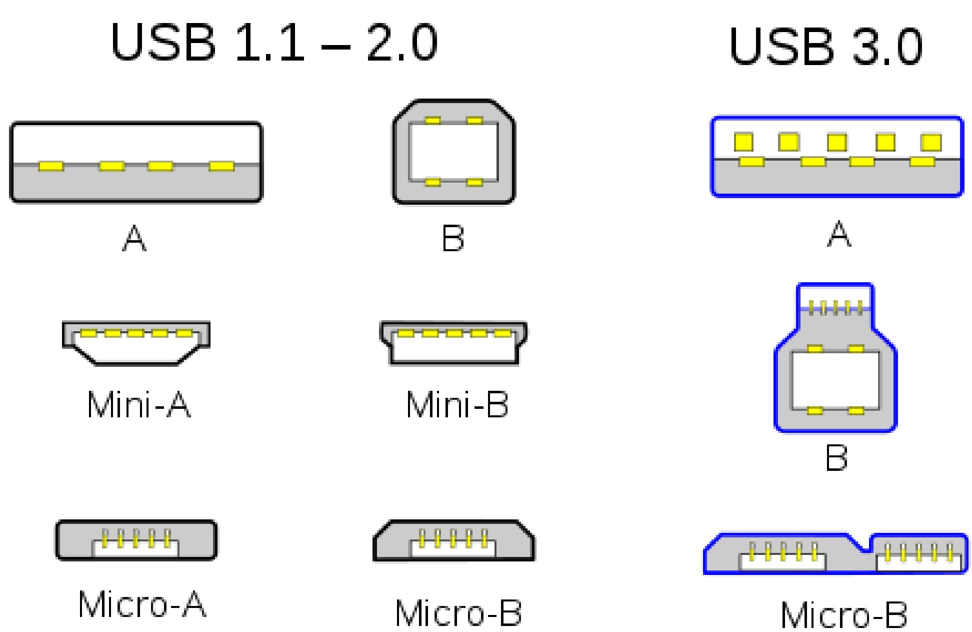
Figure : System Design

- When a host starts a data transfer, it sends a **TOKEN packet** containing an endpoint specified with a tuple of (device_address, endpoint_number). If the transfer is from the host to the endpoint, the host sends an **OUT packet** (a specialization of a TOKEN packet) with the desired device address and the endpoint number. If the data transfer is from the device to the host, the host sends an **IN packet** instead.[7]

- 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).[7]
  - 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).[7]
  - 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).[7]

- USB cables are **limited in length**, as the standard was intended for peripherals on the same table-top, not between rooms or buildings. However, a USB port can be connected to a **gateway** that accesses distant devices. USB has a strict tree network topology and **master/slave protocol** for addressing peripheral devices; those devices cannot interact with one another except via the host, and two hosts cannot communicate over their USB ports directly. Some extension to this limitation is possible through USB On-The-Go.[7]

- The **connectors** the USB committee specifies support a number of USB's underlying goals. The female connector mounted on the **host** or device is called the **receptacle**, and the male connector attached to the **cable** is called the **plug**. By design, it is difficult to insert a USB plug into its receptacle incorrectly. The USB specification requires that the cable plug and receptacle be marked so the user can recognize the proper orientation. The **USB-C plug** however is **reversible**. USB cables and small USB devices are held in place by the gripping force from the receptacle, with no screws, clips, or thumb-turns as other connectors use.[7]

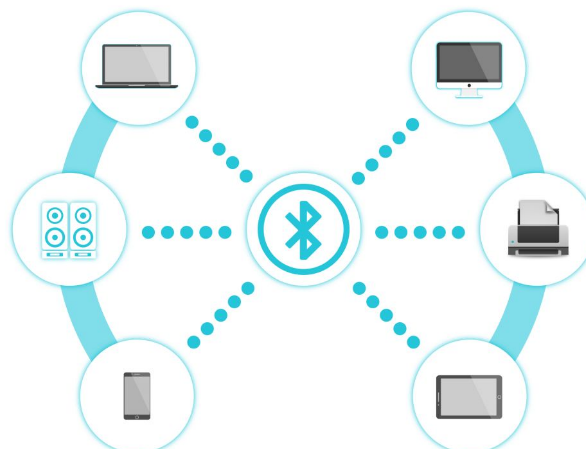


Comparison of USB connector plugs, excluding USB-C type plugs

3. WIRELESS CONNECTIONS

A 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**. Examples of wireless networks include cell phone networks, wireless local area networks (WLANs), wireless sensor networks, satellite communication networks, and terrestrial microwave networks.[8]

3.1 Bluetooth



Bluetooth is a **wireless technology** standard used for exchanging data between fixed and mobile devices over short distances using **short-wavelength UHF radio waves** in the industrial, scientific and medical radio bands, from 2.402 GHz to 2.480 GHz, and building **personal area networks (PANs)**. It was originally conceived as a wireless alternative to RS-232 data cables.[9]

- Range :
  Bluetooth is a standard wire-replacement communications protocol primarily designed for low power consumption, with a **short range** based on low-cost transceiver microchips in each device. Because the devices use a radio (broadcast) communications system, they **do not have to be in visual line of sight** of each other; however, a quasi optical wireless path must be viable. Range is power-class-dependent, but effective ranges vary in practice. The following table displays ranges of bluetooth devices by class.[9]

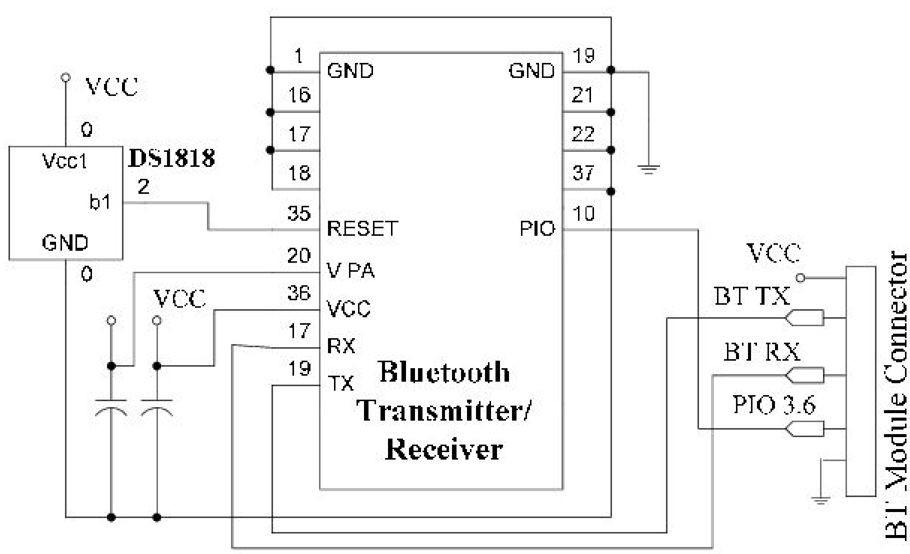
Ranges of Bluetooth devices by class

Class	Max. permitted power (mW)	Max. permitted power (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

Ranges of Bluetooth devices by class

- 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.[9]

- Bluetooth Schematic View[10]:



Bluetooth Module

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. Devices that can use Wi-Fi technologies include desktops and laptops, smartphones and tablets, smart TVs, printers, digital audio players, digital cameras, cars, and drones.[11]

- Equipment frequently support multiple versions of Wi-Fi. To communicate, devices must use a **common Wi-Fi version**. The versions differ between the **radio wavebands** they operate on, the **radio bandwidth** they occupy, the **maximum data** rates they can support and other details. Some versions permit the use of multiple antennas, which permits greater speeds as well as reduced interference. The full list of versions of Wi-Fi is[11]:

Wi-Fi generations

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

- Wi-Fi uses multiple parts of the **IEEE 802 protocol** family and is designed to interwork seamlessly with its wired sibling Ethernet. Compatible devices can network through wireless access points to each other as well as to wired devices and the Internet. Wi-Fi most commonly uses the **2.4 gigahertz** (120 mm) **UHF** and **5 gigahertz** (60 mm) **SHF** ISM **radio bands**; these bands are subdivided into multiple channels. Channels can be shared between networks but **only one transmitter** can locally transmit on a channel at any moment in time.[11]

- Wi-Fi's wavebands have relatively **high absorption** and work best for **line-of-sight** use. Many common obstructions such as walls, pillars, home appliances, etc. may greatly reduce range, but this also helps minimize interference between different networks in crowded environments. An access point (or hotspot) often has a range of about **20 metres** (66 feet) indoors while some modern access points claim up to a **150-metre** (490-foot) range outdoors. Hotspot coverage can be as small as a single room with walls that block radio waves, or as large as many square kilometres using many overlapping access points with roaming permitted between them. Over time the speed and spectral efficiency of Wi-Fi have increased. As of 2019, at close range, some versions of Wi-Fi, running on suitable hardware, can achieve speeds of over **1 Gbit/s**.[11]

- 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).[12]

    - 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.[12]

REFERENCES :

1. https://www.geeksforgeeks.org/layers-of-osi-model/
2. https://www.sciencedirect.com/topics/computer-science/wired-connection
3. https://www.lifewire.com/what-is-an-ethernet-cable-817548
4. https://en.wikipedia.org/wiki/Ethernet_physical_layer
5. https://www.edn.com/pam-ethernet-a-perfect-match/
6. https://techterms.com/definition/rj45
7. https://en.wikipedia.org/wiki/USB
8. https://en.wikipedia.org/wiki/Wireless_network#Underlying_technology
9. https://en.wikipedia.org/wiki/Bluetooth
10. https://www.researchgate.net/figure/Circuit-diagram-of-the-Bluetooth-Module_fig7_3183341
11. https://en.wikipedia.org/wiki/Wi-Fi
12. https://www.tutorialspoint.com/wi-fi/wifi_radio_modulation.htm

CONCLUSION:

From this experiment, I learned about the 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.