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Experiment - 1

AIM: Lab 1: Study of different types of physical layer wired/wireless connections

As a part of study you must include following aspects of connection

- Specifications including range, modulation etc.
- Scalability showing their applicability in various network architecture e.g LAN, WAN, MAN, HAN etc.
- Provide Schematic view of physical connector

Introduction – [1],[2]

The physical layer in the OSI Model is the lowest layer and is used for transmitting data in its basic form: bit-level. The transmission medium can either be wired or wireless. Physical layer components in a wired model include cables and connectors that are implemented for carrying data from one place to another. Data is transmitted in the form of electromagnetic signals, which translates to a stream of bits. Over the past few years, there has been rapid growth in wireless data transmission as well. Due to the availability of internet, Wi-Fi and Bluetooth communications are becoming a norm.

The functions of the physical layer are -

1. **Bit synchronization:** The physical layer provides the synchronization of the bits by providing a clock. This clock controls both sender and receiver thus providing synchronization at bit level.
2. **Encoding and Signalling:** How are the bits encoded in the medium is also decided by this layer. For example, on the coppar wire medium, we can use differnet voltage levels for a certain time interval to represent '0' and '1'. We may use +5mV for 1nsec to represent '1' and -5mV for 1nsec to represent '0'. All the issues of modulation is dealt with in this layer.
3. **Bit rate control:** The Physical layer also defines the transmission rate i.e. the number of bits sent per second.

4. **Physical topologies:** Physical layer specifies the way in which the different, devices/nodes are arranged in a network i.e. bus, star or mesh topolgy.
5. **Transmission mode:** Physical layer also defines the way in which the data flows between the two connected devices. The various transmission modes possible are: Simplex, half-duplex and fullduplex.

Types of Physical Layers Connections (Wired) –

1) Fiber Optic Cable – [4]

Fiber optic cable, also called as optical fiber cable, is a type of Ethernet cable which consists of one or more optic fibers that are used to transmit data. Fiber optic cable transmits data as pulses of light go through tiny tubes of glass. The transmission capacity of optical fiber cable is 26,000 times higher than that of twisted pair cable.

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.

Range – Up to 80km.

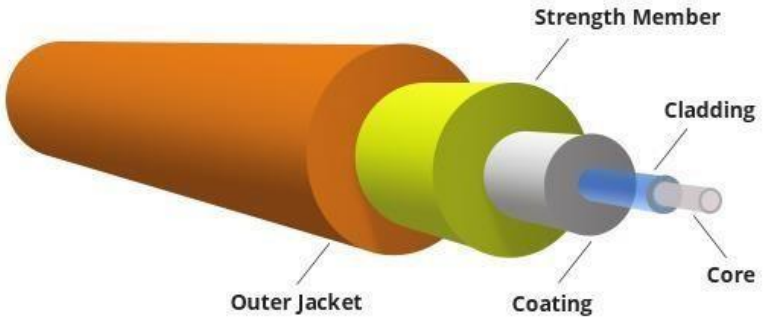
Modulation –

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 –



2) Coaxial cable – [4]

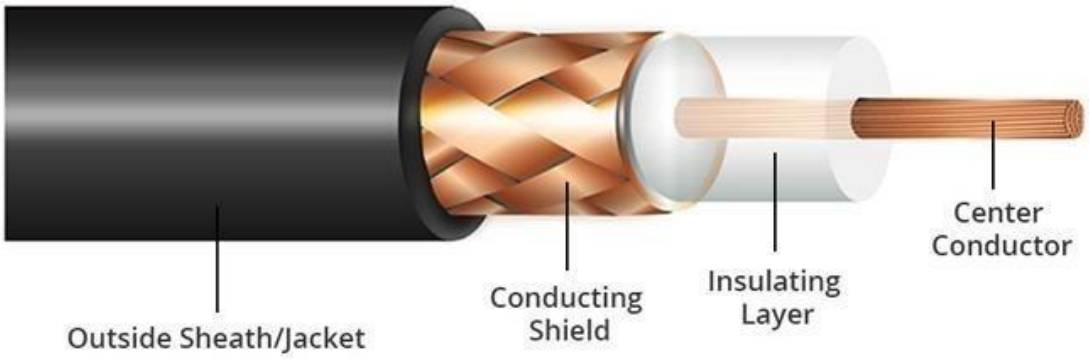
Coaxial cable, or coax cable, is designed to transmit high frequency signals. It's comprised of a round copper conductor and three layers of insulation and shielding which prevents crosstalk from motors, lighting and other sources of EMI. With the shield construction, the coaxial cable can support longer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

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 –



3) Twisted Pair copper cables – [3],[4]

Twisted pair cables are literally a pair of insulated wires that are twisted together. 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:

a) 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.

b) 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.

Range – Up to 100m

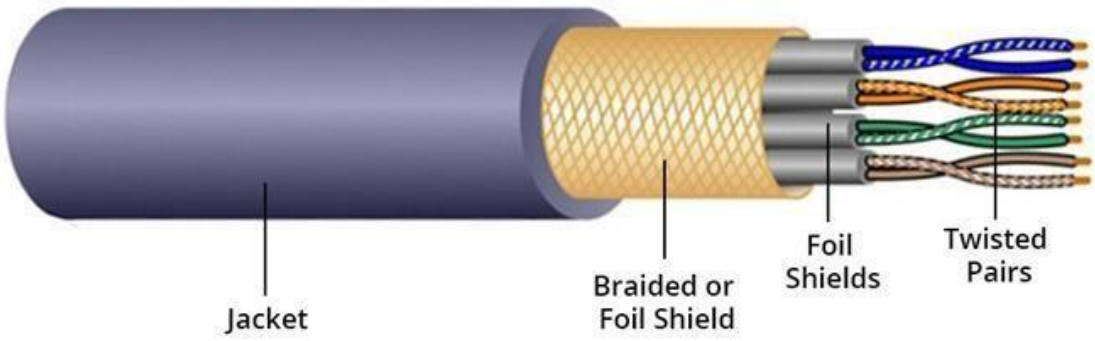
Bandwidth – Up to 750 MHz.

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 Connectivity –

A common wireless data implementation is enabling devices to wirelessly connect via a LAN. In general, a wireless LAN requires the following network devices:

- Wireless Access Point (AP) - Concentrates the wireless signals from users and connects, usually through a copper cable, to the existing copperbased network infrastructure such as Ethernet.
- Wireless NIC adapters - Provides wireless communication capability to each network host.

As the technology has developed, a number of WLAN Ethernet-based standards have emerged. Care needs to be taken in purchasing wireless devices to ensure compatibility and interoperability.

Types of Physical Layers Connections (Wireless) –

1) 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.

Range – Typically less than 10 m

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

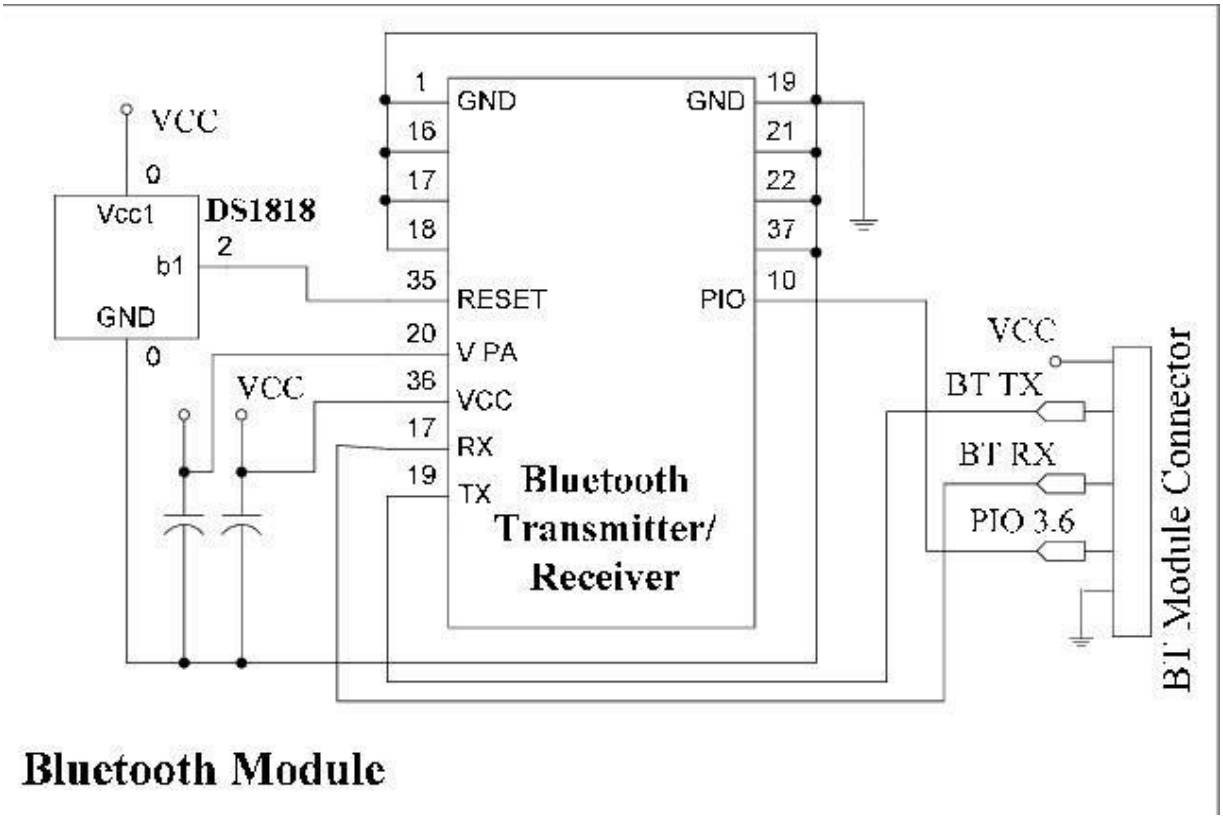
Modulation –

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.

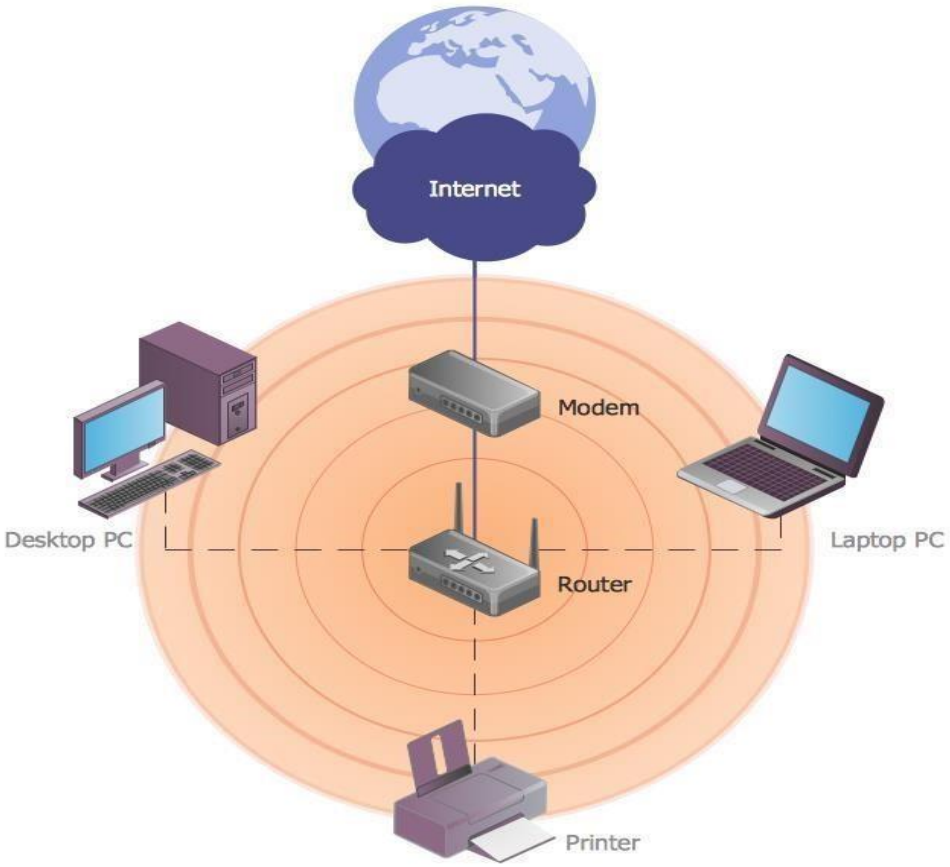
Schematic View –



Bluetooth Module

2) Standard IEEE 802.11 - Commonly referred to as Wi-Fi, is a Wireless LAN (WLAN) – [8]

WLANS allow users in a local area, such as a university campus or library, to form a network or gain access to the internet. A temporary network can be formed by a small number of users without the need of an access point; given that they do not need access to network resources.



Range –

Within a limited area such as a home, school, computer laboratory, campus, or office building.

Modulation –

Wi-Fi systems use two primary radio transmission techniques.

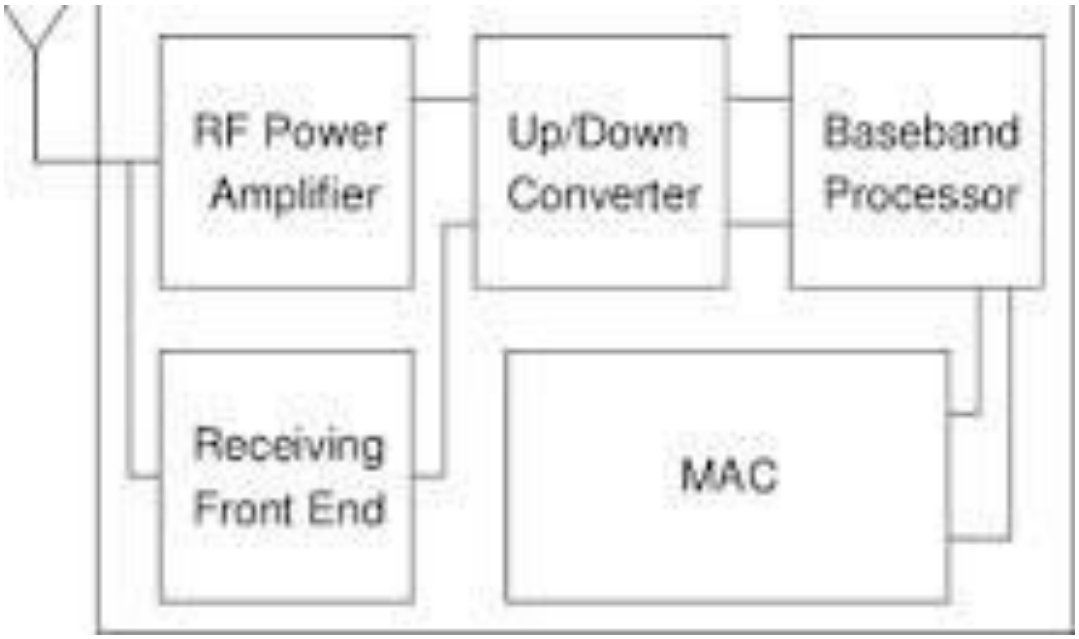
- 802.11b (<=11 Mbps) − The 802.11b radio link uses a direct sequence spread spectrum technique called complementary coded keying (CCK). The bit stream is processed with a special coding and then modulated using Quadrature Phase Shift Keying (QPSK).
- 802.11a and g (<=54 Mbps) − The 802.11a and g systems use 64channel 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.

Wi-Fi uses adaptive modulation and varying levels of forward error correction to optimize transmission rate and error performance.

As a radio signal loses power or encounters interference, the error rate will increase. Adaptive modulation means that the transmitter will automatically shift to a more robust, though less efficient, modulation technique in those adverse conditions.

Schematic View –



3) WMANS: Wireless Metropolitan Area Networks – [9]

This technology allows the connection of multiple networks in a metropolitan area such as different buildings in a city, which can be an alternative or backup to laying copper or fiber cabling.

Example –

WiMAX is a type of Wireless MAN and is described by the IEEE 802.16 standard.

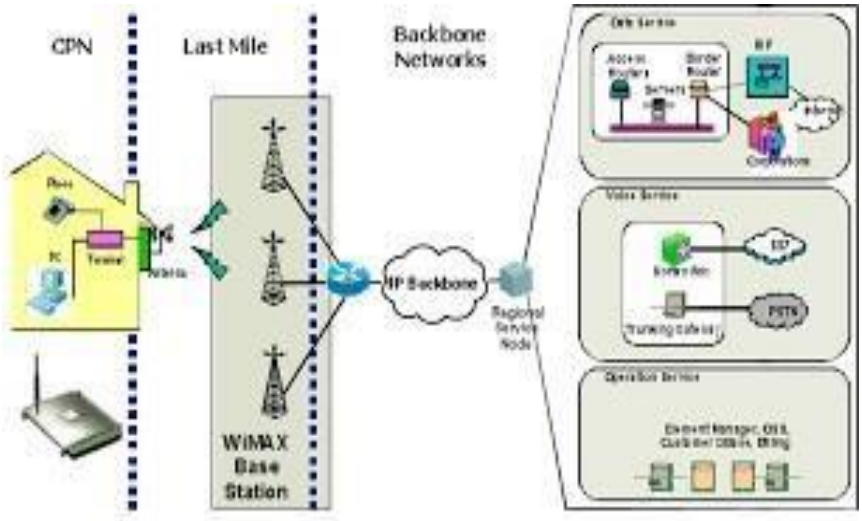
Range – This can extend up to the entire city or other related geographic area and can span up to 50 km.

Modulation –

Modulation is what wireless networks use to send data.

It enables the sending of encoded data using radio signals. Wireless networks use modulation as a carrier signal, which means that the modulated tones carry data.

Schematic View –



4) WWANS: Wireless Wide Area Networks – [7]

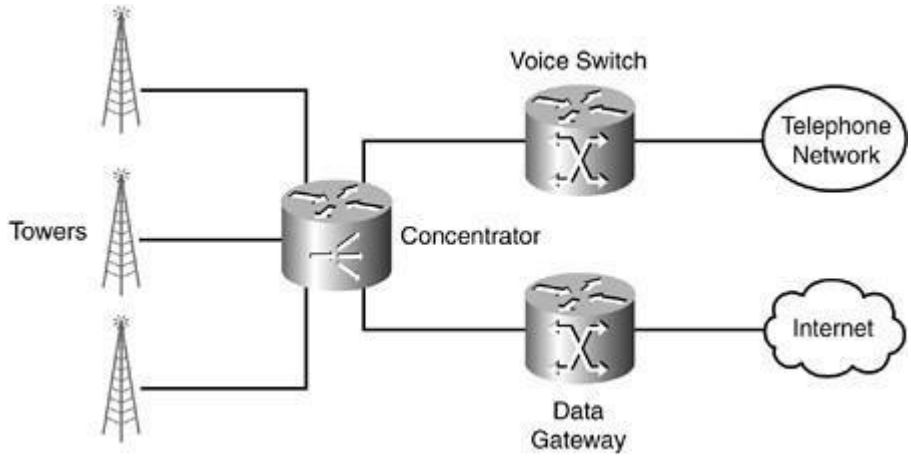
These types of networks can be maintained over large areas, such as cities or countries, via multiple satellite systems or antenna sites looked after by an ISP. These types of systems are referred to as 2G (2nd Generation) systems

Range – Like all wireless technologies, WiMAX can operate at higher bitrates or over longer distances but not both. Operating at the maximum range of 50 km (31 mi) increases bit error rate and thus results in a much lower bitrate.

Modulation –

Wireless WANs make use of technologies that focus on modulation of voice and data. Modulation converts digital signals that represent information inside a computer into either RF or light signals. Wireless WANs exclusively use RF signals designed to accommodate many users. Each user has a dedicated channel, and this is different from wireless LANs, where all users share one channel. This significantly reduces interference between wireless WAN user devices and base stations.

Schematic View –



Conclusion –

I got to know the different types of physical layers and what are they comprised of along with their advantages and disadvantages.

References –

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