TE COMPS

Batch A

Data Communication and Computer Networks Lab

Experiment 1

Aim: To study different types of physical layer wired/wireless connections.

Physical Layer:

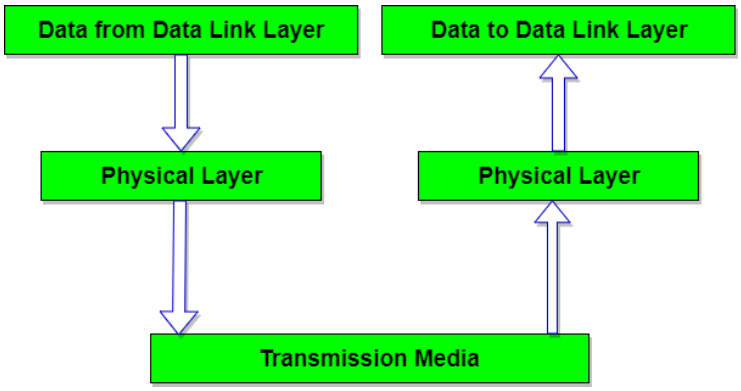
- Physical layer is the **lowest layer** of the OSI reference model.
- It is responsible for sending bits from one computer to another.
- This layer is not concerned with the meaning of the bits and deals with the setup of **physical connection to the network** and with transmission and reception of signals.

Functions of Physical Layer:

Following are the various functions performed by the Physical layer of the OSI model.

1. **Representation of Bits:** Data in this layer consists of stream of bits. The bits must be encoded into signals for transmission. It defines the type of encoding i.e. how 0's and 1's are changed to signal.
2. **Data Rate:** This layer defines the rate of transmission which is the number of bits per second.
3. **Synchronization:** It deals with the synchronization of the transmitter and receiver. The sender and receiver are synchronized at bit level.
4. **Interface:** The physical layer defines the transmission interface between devices and transmission medium.
5. **Line Configuration:** This layer connects devices with the medium: Point to Point configuration and Multipoint configuration.

6. **Topologies:** Devices must be connected using the following topologies: Mesh, Star, Ring and Bus.
7. **Transmission Modes:** Physical Layer defines the direction of transmission between two devices: Simplex, Half Duplex, Full Duplex.
8. Deals with baseband and broadband transmission.



Physical Layer: Operation

The media does not carry the frame as a single entity. The media carries signals, one at a time, to represent the bits that make up the frame.

There are three basic forms of network media on which data is represented:

- Copper cable
- Fibre
- Wireless

The representation of the bits - that is, the type of signal - depends on the type of media. For copper cable media, the signals are patterns of electrical pulses. For fibre, the signals are patterns of light. For wireless media, the signals are patterns of radio transmissions.

Wired Physical Layer Connections

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.

1. Ethernet

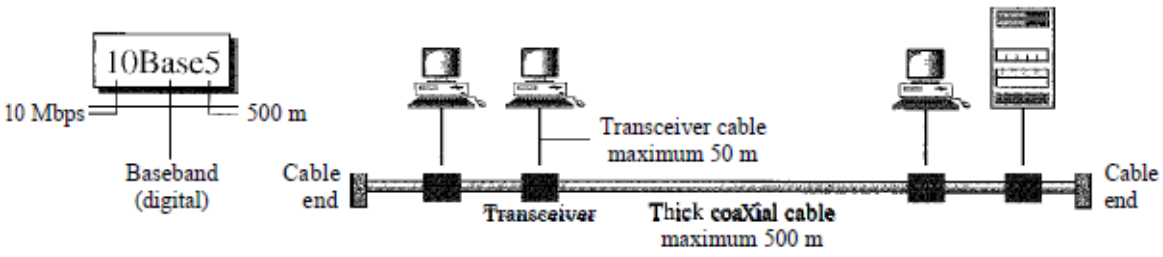
- Ethernet is the technology that is commonly used in wired **local area networks (LANs).**
- Ethernet is a network protocol that controls how data is transmitted over a LAN and is referred to as the IEEE 802.3 protocol. The protocol has evolved and improved over time to transfer data at the speed of more than a gigabit per second.

Categories of Ethernet:

Characteristics	10Base5	10Base2	10Base-T	10ase-F
Media	Thick coaxial cable	Thin coaxial cable	UTP	Fibre
Range	500 m	185 m	100 m	2000 m
Topology	Bus	Bus	Star	Star
Line encoding	Manchester	Manchester	Manchester	Manchester
Nodes	100	30	1024	1024
Speed	10Mbps	10Mbps	10Mbps	10Mbps
Scalability	LAN	LAN	LAN	LAN
Modulation	PAM	PAM	PAM	PAM

❖ 10Base5: Thick Ethernet

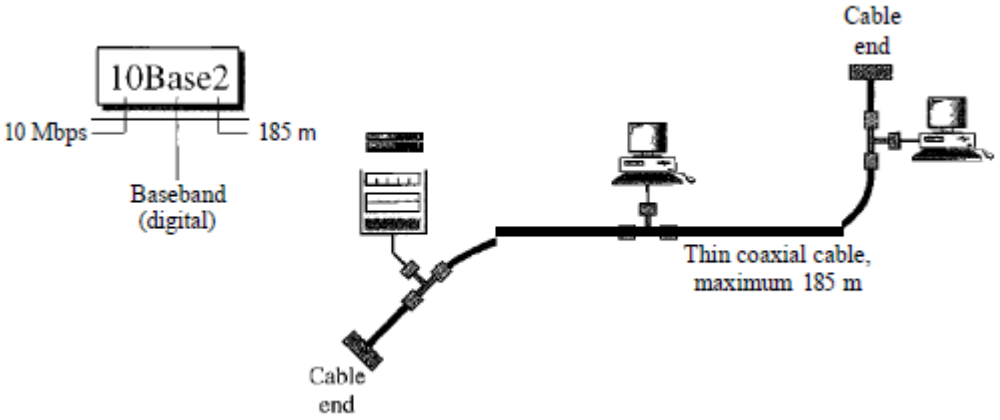
- The first implementation is called 10Base5, thick Ethernet, or Thicknet.
- The nickname derives from the size of the cable, which is roughly the size of a garden hose and too stiff to bend with your hands.
- 105Base5 was the first Ethernet specification to use a **bus topology** with an external transceiver (transmitter/receiver) connected via a tap to a thick coaxial cable.
- 10Base5 Implementation:



❖ 10Base2: Thin Ethernet

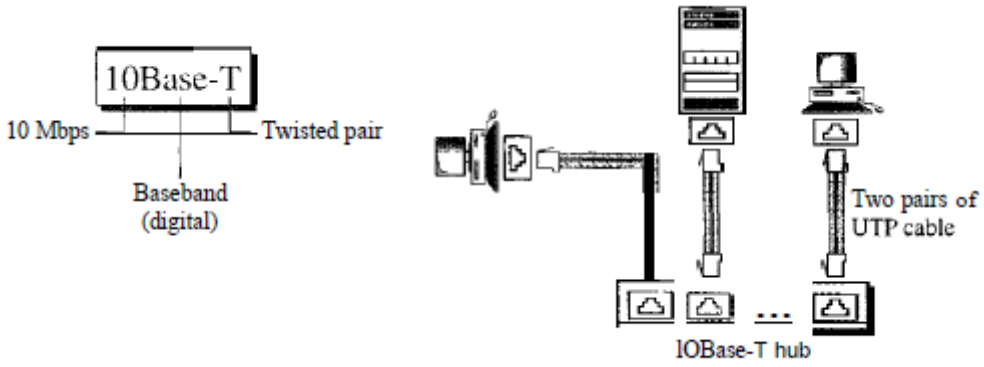
- The second implementation is called 10Base2, thin Ethernet, or Cheapernet.
- 1OBase2 also uses a **bus topology**, but the cable is much thinner and more flexible.

- The cable can be bent to pass very close to the stations. In this case, the transceiver is normally part of the network interface card (NIC), which is installed inside the station.
- 10Base2 Implementation



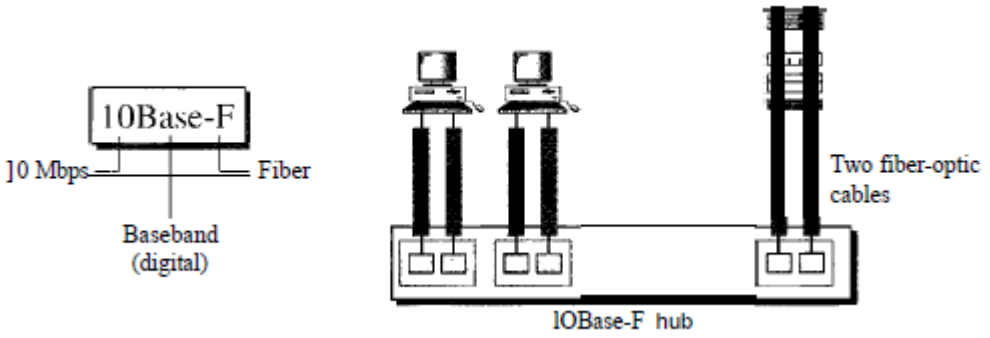
❖ **10BaseT: Twisted -Pair Ethernet**

- The third implementation is called 10Base-T or twisted-pair Ethernet.
- 10Base-T uses a **physical star topology**. The stations are connected to a hub via two pairs of twisted cable.
- Note that two pairs of twisted cable create two paths (one for sending and one for receiving) between the station and the hub. Any collision here happens in the hub.
- The maximum length of the twisted cable here is defined as **100 m**, to minimize the effect of attenuation in the twisted cable.
- 10BaseT Implementation

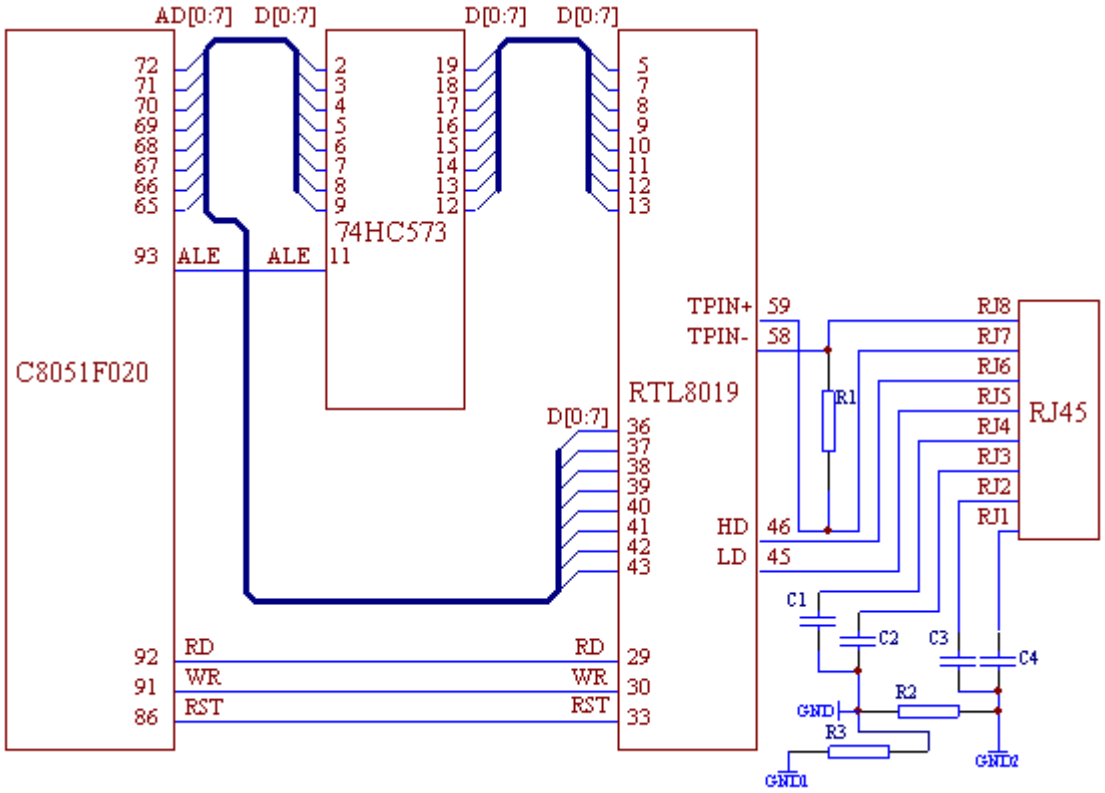


❖ **10Base-F: Fiber Ethernet**

- Although there are several types of optical fiber 10-Mbps Ethernet, the most common is called 10Base-F.
- 10Base-F uses a **star topology** to connect stations to a hub. The stations are connected to the hub using two fiber-optic cables.
- 10BaseF Implementation



Schematic diagram of Ethernet



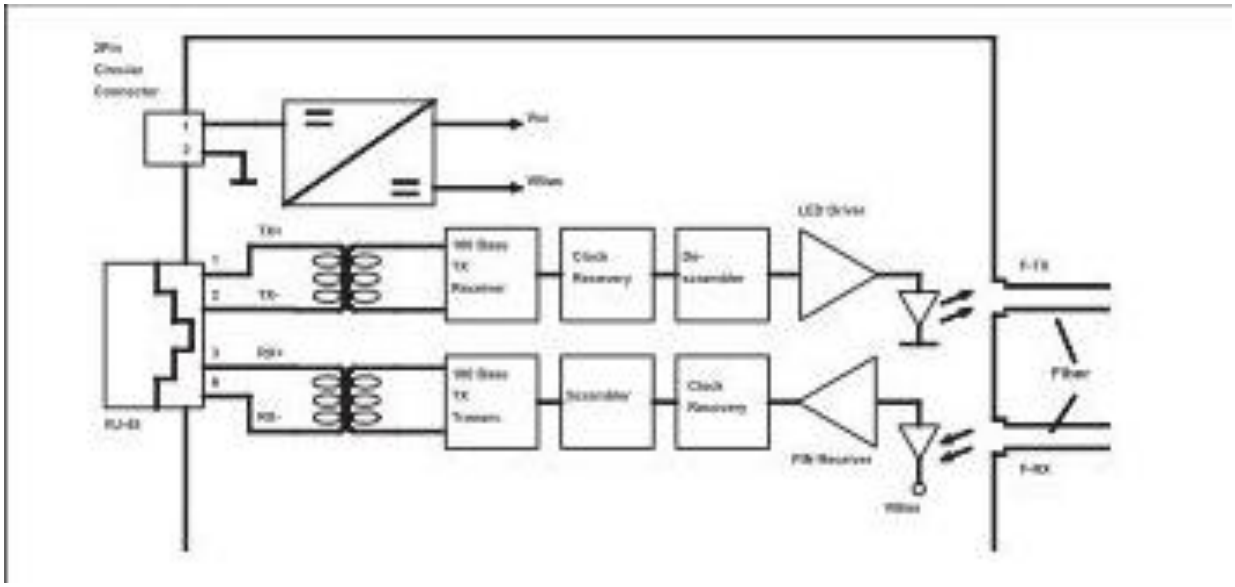
2. Fast Ethernet

- Fast Ethernet was designed to compete with LAN protocols such as FDDI or Fiber Channel (or Fiber Channel, as it is sometimes spelled).
- IEEE created Fast Ethernet under the name **802.3u.** Fast Ethernet is backward-compatible with Standard Ethernet, but it can transmit data 10 times faster at a rate of **100 Mbps.**

Fast Ethernet Implementations

Characteristics	100Base-TX	100Base-FX	100Base-T4
Media	Cat 5 UTP or STP	Fiber	Cat 3 UTP
Range	100 m	100 m	100 m
Topology	Star	Star	Star
Line encoding	MLT-3	NRZ-I	8B/6T
Block encoding	4B/5B	4B/5B	
Number of wires	2	2	4
Speed	100 Mbps	100 Mbps	100 Mbps
Scalability	LAN	LAN	LAN
Modulation	PAM-5	PAM-5	PAM-5

Schematic View of Fast Ethernet



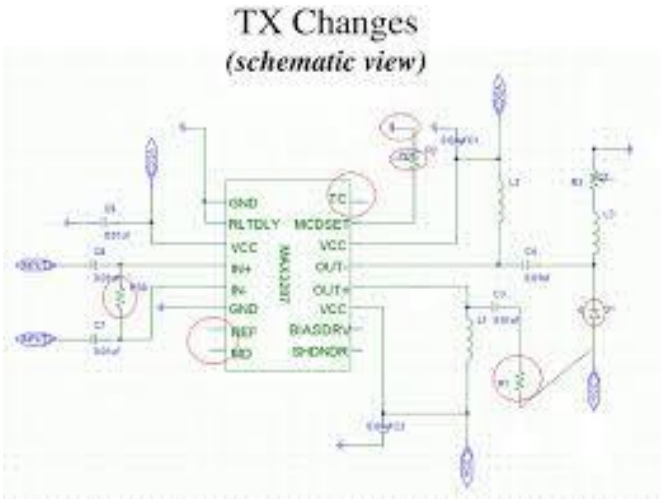
3. Gigabit Ethernet

- The need for an even higher data rate resulted in the design of the Gigabit Ethernet protocol (**1000 Mbps**).
- The IEEE committee calls the Standard **802.3z**.

Gigabit Ethernet Implementation

Characteristics	1000Base-SX	1000Base-LX	1000Base-CX	1000Base-T
Media	Short wave fiber	Long wave fiber	Copper STP	UTP
Range	550 m	5000 m	25 m	100 m
Topology	Star	Star	Star	Star
Line encoding	NRZ	NRZ	NRZ	4D-PAM5
Block encoding	8B/10B	8B/10B	8B/10B	
Number of wires	2	2	2	4
Speed	1000 Mbps	1000 Mbps	1000 Mbps	1000 Mbps
Scalability	LAN	LAN, MAN, WAN	LAN	LAN
Modulation	PAM-5	PAM-5	PAM-5	PAM-5

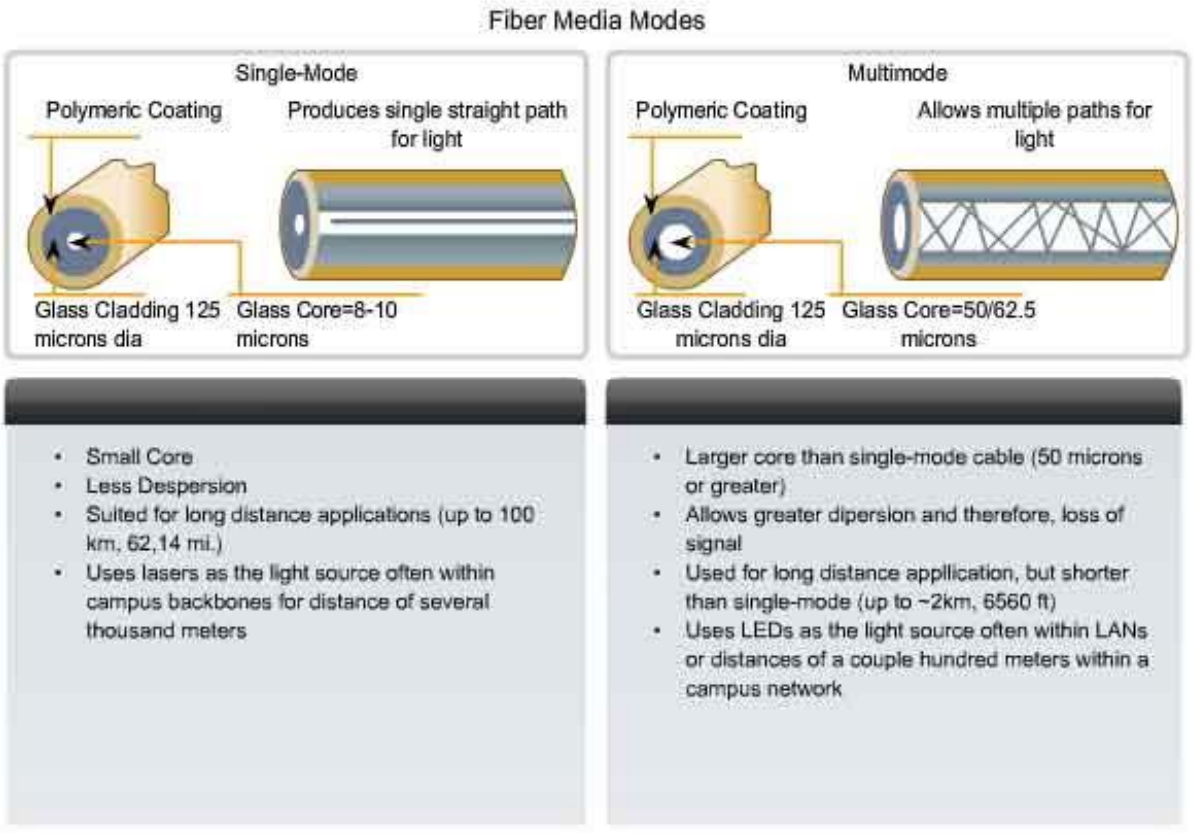
Schematic view of Gigabit Ethernet



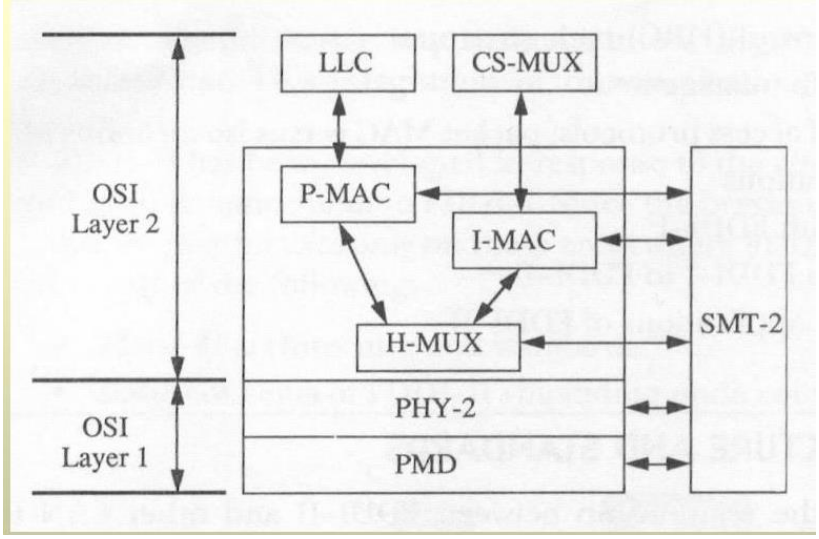
4. Fiber Distributed Data Interface (FDDI)

- FDDI uses optical **fiber** as its physical medium.
- It provides high data rate of **100 Mbps** and can support **thousands of users.**
- It is used in **LAN**s up **to 200 kilometers** for long distance voice and multimedia communication.
- It uses ring based token passing mechanism and is derived from IEEE 802.4 token bus standard.
- FDDI technology can also be used as a backbone for a wide area network **(WAN)**

Single-mode and Multimode Fiber

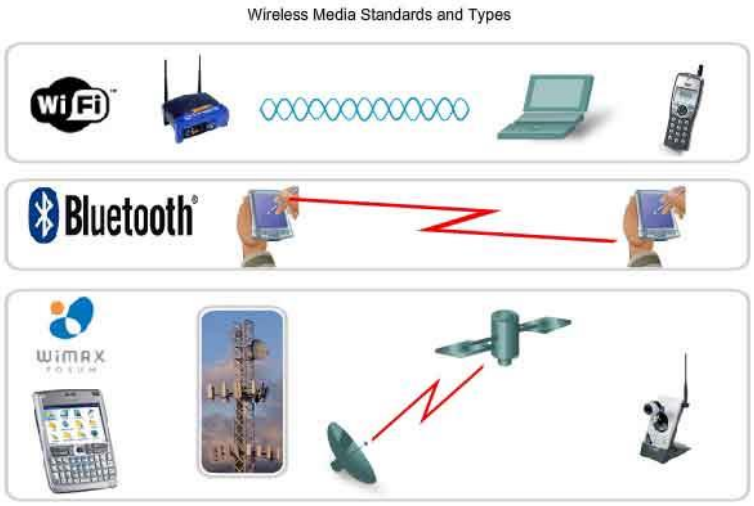


Schematic view:



Wireless Physical Layer Connections

- Standard **IEEE 802.11** - Commonly referred to as **Wi-Fi**, is a **Wireless LAN (WLAN)** technology that uses a contention or non-deterministic system with a Carrier Sense Multiple Access/Collision Avoidance (CSMA/CA) media access process.
- Standard **IEEE 802.15** - **Wireless Personal Area Network (WPAN)** standard, commonly known as "**Bluetooth**", uses a device pairing process to communicate over distances from **1 to 100 meters**.
- Standard **IEEE 802.16** - Commonly known as **WiMAX** (Worldwide Interoperability for Microwave Access), uses a point-to-multipoint topology to provide wireless broadband access.
- Global System for Mobile Communications (**GSM**) - Includes Physical layer specifications that enable the implementation of the Layer 2 General Packet Radio Service (**GPRS)** protocol to provide data transfer over mobile cellular telephony networks.



1. IEEE 802.1 Wi-fi

Characteristics	802.11a	802.11b	802.11g	802.11n
Data rate	54 Mbps	11 Mbps	54 Mbps	248 Mbps
Throughput	23 Mbps	4.3 Mbps	19 Mbps	74 Mbps
Frequency	5 GHz	2.4 GHz	2.4 GHz	2.4/5 GHz
Range	35-120 m	38-140 m	38-140 m	70-250 m
Scalability	WLAN	WLAN	WLAN	WLAN
Number of channels	3	Upto 23	3	14
Transmission	OFDM	DSSS	DSSS/OFDM	MIMO

IEEE 802.11 Infrared

- Two capacities **1 Mbps or 2 Mbps**
- Range is **10 to 20 meters** and cannot penetrate walls
- Does not work outdoors

IEEE 802.11 Frequency Hopping Spread Spectrum (FHSS)

- Multipath fading
- 79 non-overlapping channel, each 1 MHz wide at low end of 2.4Ghz ISM band.
- Dwell time: Minimum time on channel before hopping(400 msec)

IEEE 802.11a

- Devices operating under this standard are not interoperable with the 802.11b and 802.11g standards described below.

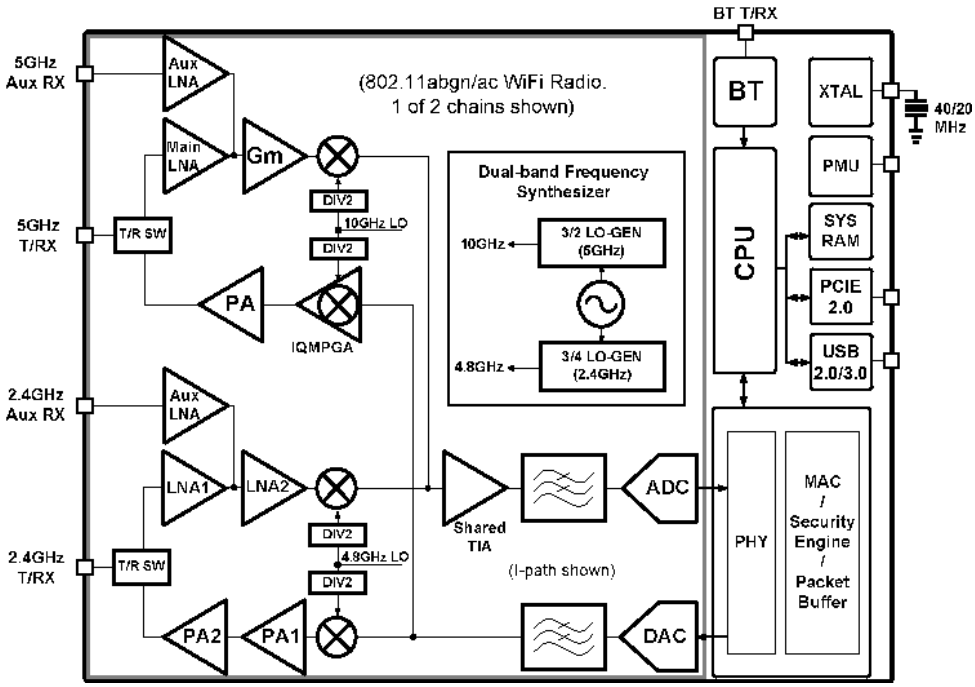
IEEE 802.11b

- Devices implementing this standard have a longer range and are better able to penetrate building structures than devices based on 802.11a.

IEEE 802.11g

- Devices implementing this standard therefore operate at the same radio frequency and range as 802.11b but with the bandwidth of 802.11a.

Schematic View:



2. IEEE 802.15 Bluetooth

The need for personal devices to communicate wirelessly with one another without an established infrastructure has led to the emergence of **Personal Area Networks (PANs)**.

- Ericsson's Bluetooth project in 1994 defines the standard for PANs to enable communication between mobile phones using low power and low cost radio interfaces.
- IEEE has approved a Bluetooth based standard named IEEE 802.15.1 for Wireless Personal Area Networks (WPANs). IEEE standard covers MAC and Physical layer applications.

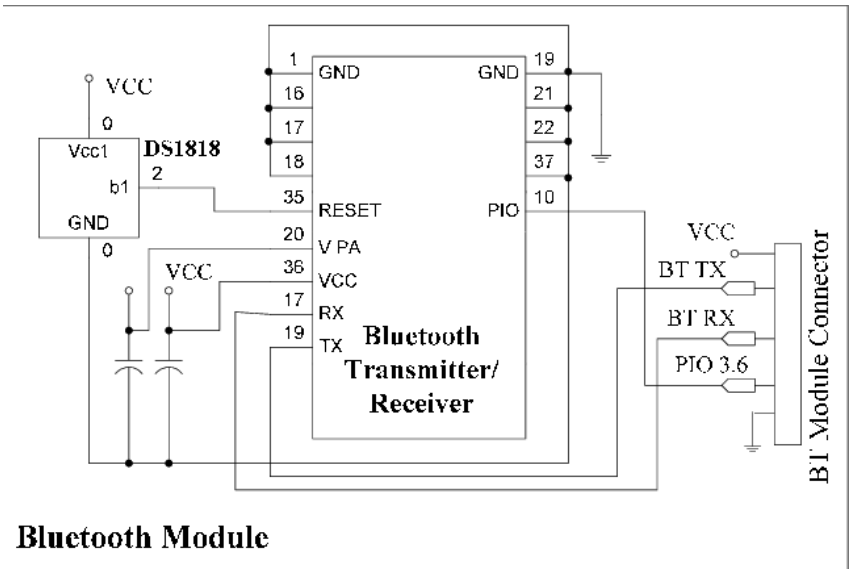
- **Bluetooth** specification details the entire protocol stack. Bluetooth employs **Radio Frequency (RF)** for communication. It makes use of **frequency modulation** to generate radio waves in the **ISM** band.

Scalability: PAN

Data rate: 250 kbps

Modulation: Frequency modulation

Schematic View:



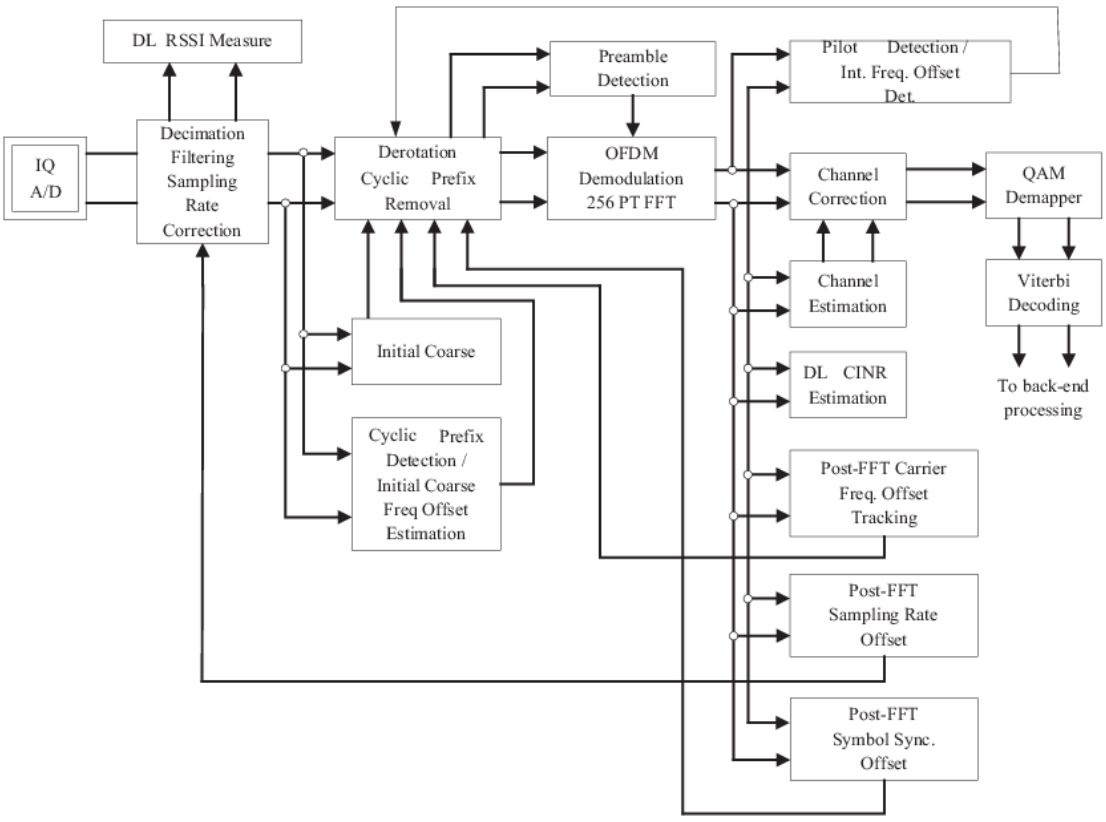
Bluetooth Module

3. IEEE 802.16 WiMAX

- The IEEE 802.16, the **Air Interface for Fixed Broadband Wireless Access Systems**, also known as the **IEEE WirelessMAN** air interface, is an emerging suite of standards for fixed, portable and mobile BWA in **MAN**.
- These standards are issued by IEEE 802.16 work group that originally covered the wireless local loop (WLL) technologies in the 10.66 GHz radio spectrum, which were later extended through amendment projects to include both licensed and unlicensed spectra from 2 to 11 GHz.

Characteristics	802.16	802.16a	802.16e
Spectrum	10 -66 GHz	2-11 GHz	< 6 GHz
Configuration	Line of sight	Non-line of sight	Non-line of sight
Bit rate	32 to 134 Mbps	< 70 or 100Mbps	Upto 15 Mbps
Modulation	QPSK, 16-QAM, 64-QAM	256 Sub-Carrier OFDM using QPSK, 16-QAM, 64-QAM, 256-QAM	256 Sub-Carrier OFDM using QPSK, 16-QAM, 64-QAM, 256-QAM
Mobility	Fixed	Fixed	< 75 MPH
Channel Bandwidth	20, 25, 28 MHz	Selectable 1.25-20 MHz	5 MHz (Planned)
Typical Cell Radius	1-3 Miles	1-3 Miles	1-3 Miles
Scalability	WAN	WAN	WAN

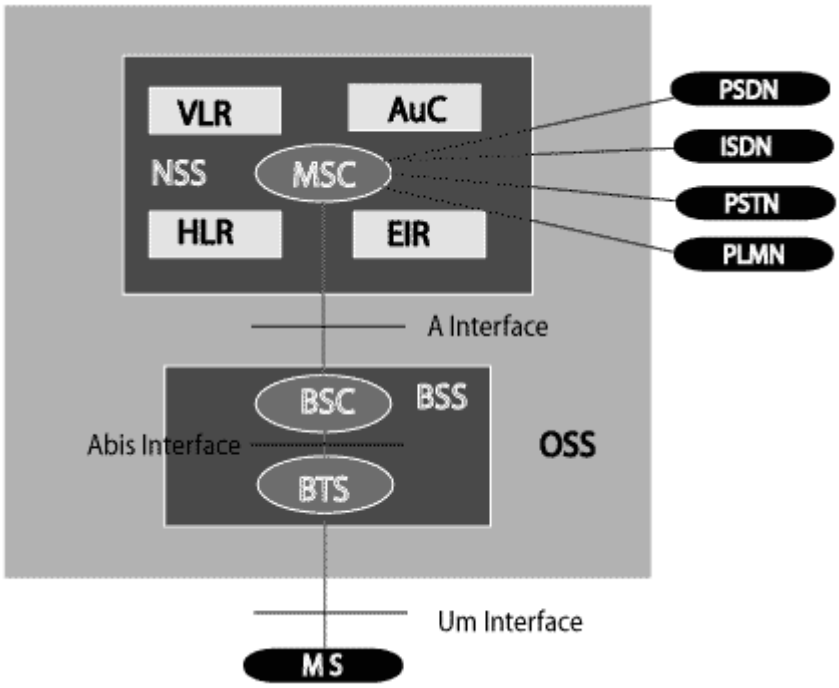
Schematic view:



4. GSM

- GSM is a globally accepted standard for digital cellular communications.
- GSM uses narrowband Time Division Multiple Access (TDMA) for providing voice and text based services over mobile phone networks.
- GSM stands for Global System for Mobile Communication. It is a digital cellular technology used for transmitting mobile voice and data services.
- GSM is a **circuit-switched** system that divides each 200 kHz channel into eight 25 kHz time-slots. GSM operates on the mobile communication bands 900 MHz and 1800 MHz in most parts of the world. In the US, GSM operates in the bands 850 MHz and 1900 MHz.
- GSM was developed using digital technology. It has an ability to carry 64 kbps to 120 Mbps of data rates.

GSM Architecture



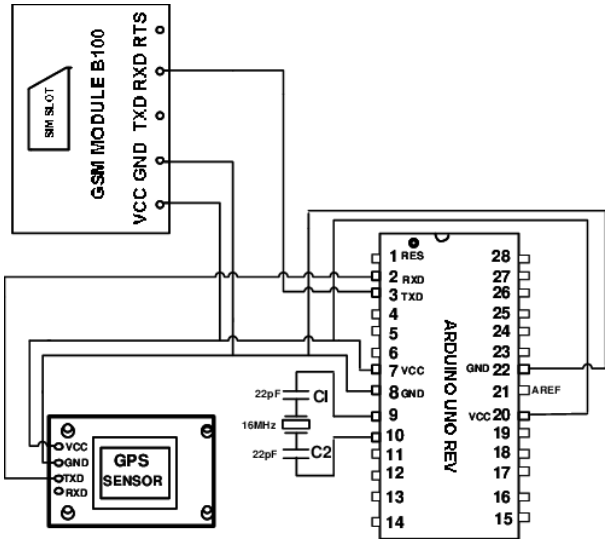
Modulation: The GSM uses **Gaussian Minimum Shift Keying (GMSK)** modulation method.

Transmission Rate: The total symbol rate for GSM at 1 bit per symbol in GMSK produces 270.833 K symbols/second. The gross transmission rate of a timeslot is 22.8 Kbps. GSM is a digital system with an over-the-air bit rate of 270 kbps.

Frequency Band: The **uplink frequency range** specified for GSM is 933 - 960 MHz (basic 900 MHz band only). The **downlink frequency band** 890 - 915 MHz (basic 900 MHz band only).

Scalability: WAN

Schematic View:



Comparison between generations:

Characteristics	2G	3G	4G	5G
Introduced in year	1993	2001	2009	2018
Frequency	1.8 GHz	1.6-2.0 GHz	2-8 GHz	3-300 GHz
Data rate	64 kbps	144 kbps-2 Mbps	100 Mbps-1Gbps	> 1Gbps
Technology	GSM	WCDMA	LTE, WiMAX	MIMO, mm Waves
Access system	TDMA, CDMA	CDMA	CDMA	OFDM, BDMA
Switching type	Circuit	Packet	Packet	Packet
Internet service	Narrowband	Broadband	Ultra broadband	Wireless world wide web
Bandwidth	25 MHz	25 MHz	100 MHz	30 -300 GHz
Advantage	SMS, MMS, internet access and SIM introduced	High security, international roaming	Speed, global mobility	Extremely high speed, low latency

Applications	Voice calls, short messages	Video conferencing, mobile TV, GPS	High speed applications, wearable devices	High resolution video streaming, remote control of vehicles, robots and medical procedures

Conclusion:

1. In this experiment, I learned about various wired and wireless connections in physical layer of OSI reference model.
2. I understood difference between them regarding parameters as range, data rate, modulation, etc.