WT Question bank IAT-1-MOD 1,3

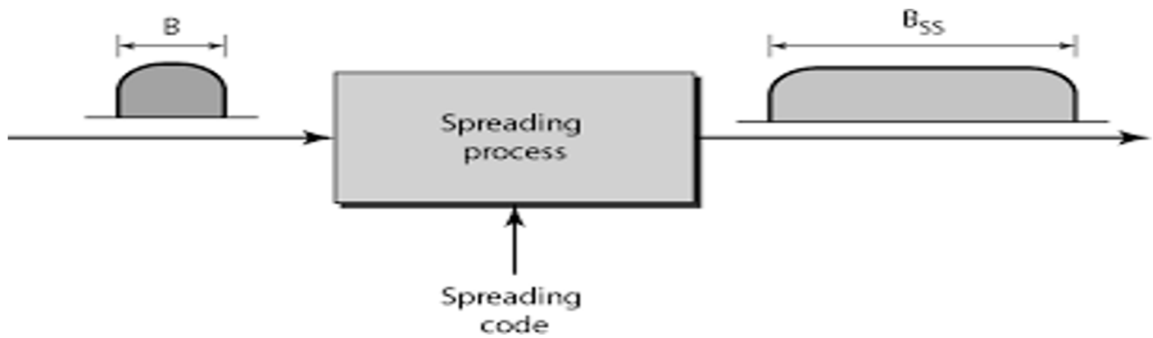
Q.1) Distinguish between 1G/2G/3G/4G

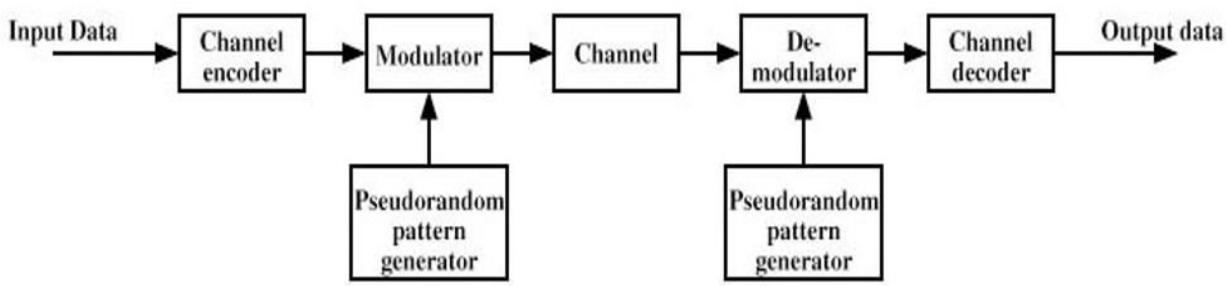
Feature	1G (First Generation)	2G (Second Generation)	3G (Third Generation)	4G (Fourth Generation)
Technology	Analog Communication	Digital Communication	Packet Switching + Circuit Switching	Fully IP-based, Packet Switching
Speed	~2.4 kbps	~64 kbps (GPRS), up to 384 kbps (EDGE)	Up to 2 Mbps (3G), up to 42 Mbps (HSPA+)	100 Mbps - 1 Gbps (LTE-Advanced)
Frequency Band	800 MHz	900 MHz, 1800 MHz	850 MHz, 1900 MHz, 2100 MHz	700 MHz, 1800 MHz, 2600 MHz
Data Services	No data services	SMS, MMS, WAP	Mobile internet, GPS, video calling	High-speed internet, HD video streaming, cloud computing
Call Quality	Poor (high noise, low clarity)	Improved clarity, encryption	Better clarity with less interference	HD voice quality (VoLTE)
Security	Low (easily intercepted)	Encrypted voice calls, better security	Enhanced security (authentication, encryption)	Strong security (IPSec, AES encryption)
Power Consumption	High battery usage	Low power consumption	Moderate power consumption	Optimized power efficiency
Latency	High	Moderate	Lower (~100 ms)	Very Low (~10-50 ms)
Devices	Analog mobile phones	Feature phones (basic mobile phones)	Smartphones, tablets, modems	Smartphones, smartwatches, IoT devices
Major Drawback	Poor quality, no security	Slow internet, limited multimedia	High latency, slower speeds than 4G	High infrastructure cost

Q.2) Explain Spread spectrum techniques and illustrate FHSS and DHSS.

Spread Spectrum

- As the name implies, **spread spectrum techniques involve spreading the bandwidth** needed to transmit data.





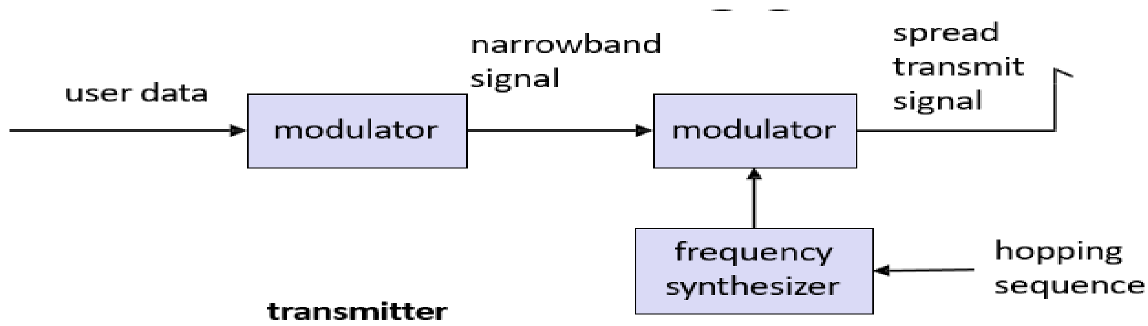
Frequency Hopping Spread Spectrum (FHSS)

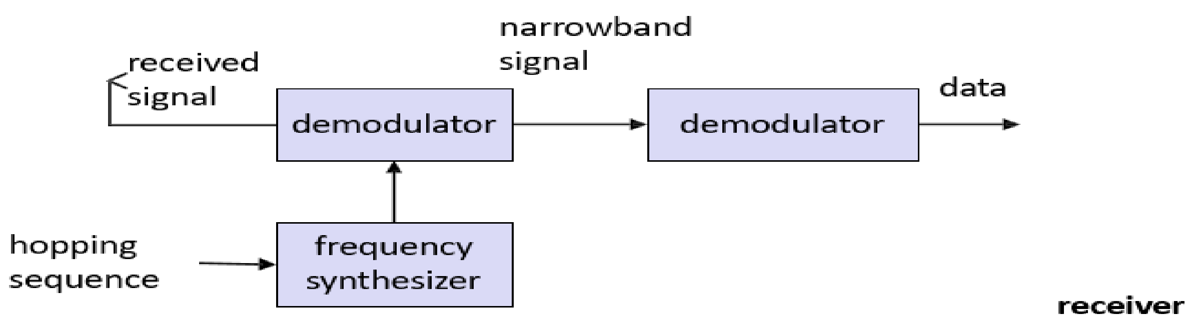
- For **frequency hopping spread spectrum (FHSS) systems, the total available** bandwidth is split into many channels of smaller bandwidth plus guard spaces between the channels.

- Transmitter and receiver stay on one of these channels for a certain time and then hop to another channel. This system implements FDM and TDM.

- The pattern of channel usage is called the **hopping sequence, the time spend on a** channel with a certain frequency is called the **dwell time.**

- FHSS comes in two variants, slow and fast hopping





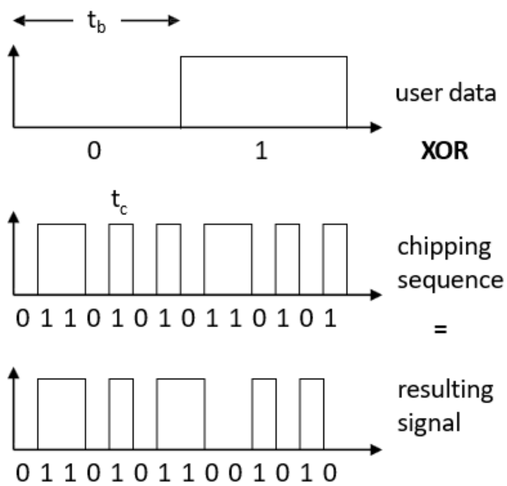
Direct Sequence Spread Spectrum (DSSS)

- In this scheme, the user signal is spread by performing an XOR with a fixed sequence called as a chipping sequence.
- As shown in figure 1.6, a user signal 01, is XORed with the chipping sequence

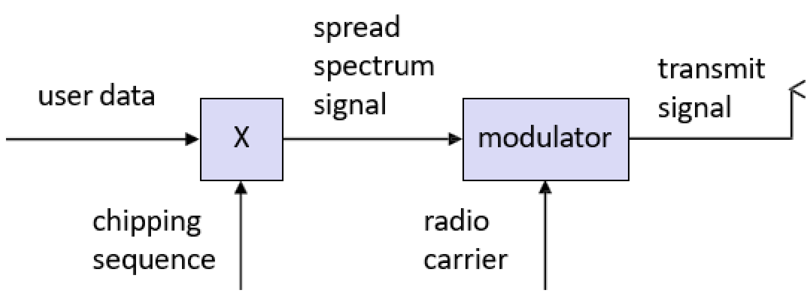
0110101, the resulting signal is either 0110101 (if the user bit is 0) or its complement

1001010 (if the user bit is 1).

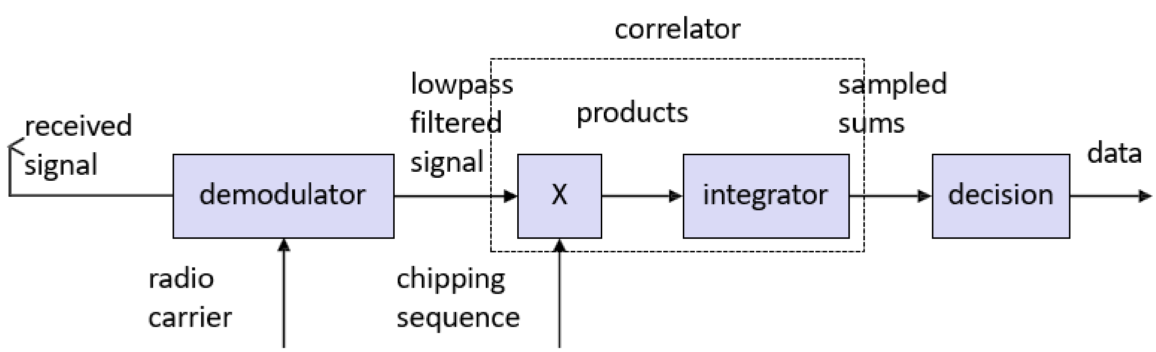
- XOR of the signal with pseudo-random number (chipping sequence)
  - many chips per bit (e.g., 128) result in higher bandwidth of the signal
- Advantages
  - reduces frequency selective fading
  - in cellular networks
    - base stations can use the same frequency range
    - several base stations can detect and recover the signal
      - soft handover
- Disadvantages
  - precise power control necessary
  - The overall system is complex to implement.



t_b: bit period
t_c: chip period



transmitter



receiver

Q.3) Draw the basic arrangement of Orthogonal frequency division Multiplexing Transceivers and discuss its overall operation.

→ **Basic Arrangement of OFDM Transceivers:**

An **OFDM (Orthogonal Frequency Division Multiplexing)** transceiver consists of a **transmitter** and a **receiver** that work together to transmit data over multiple orthogonal subcarriers.

Operation of OFDM Transceiver:

1. **Transmitter Side:**
   - **Input Data**: The data is first received in serial format.
   - **Serial-to-Parallel Conversion**: The data is split into multiple parallel data streams.
   - **Modulation**: Each data stream is modulated using **QAM (Quadrature Amplitude Modulation)** or **PSK (Phase Shift Keying)**.
   - **IFFT (Inverse Fast Fourier Transform)**: Converts frequency-domain signals into time-domain signals.
   - **Cyclic Prefix Addition**: A cyclic prefix is added to prevent **Inter-Symbol Interference (ISI)**.
   - **Digital-to-Analog Conversion (DAC)**: Converts the signal into an analog form for transmission.
2. **Transmission Channel:**
   - The modulated signal is transmitted over a **multipath fading channel**, where it may face interference and noise.
3. **Receiver Side:**
   - **Analog-to-Digital Conversion (ADC)**: Converts the received analog signal back into a digital form.
   - **Remove Cyclic Prefix**: Eliminates the cyclic prefix to recover the original signal.
   - **FFT (Fast Fourier Transform)**: Converts the time-domain signal back to the frequency domain.
   - **Demodulation**: Extracts the original data using **QAM/PSK**.
   - **Parallel-to-Serial Conversion**: Converts parallel data streams back into a serial data format.
   - **Output Data**: The final recovered data is sent to the destination.

Q.4) (i) Illustrate multiple access techniques (a) TDMA, (b) FDMA, (c) CDMA, …….------- PPT-Multiple Access Techniques

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Q.5) Identify the drawbacks in the 4G technology and Determine the use of Massive MIMO in 5G for increasing user capacity

→ Drawbacks of 4G Technology:

Despite its high speed and efficiency, **4G technology** has some limitations:

1. **High Infrastructure Cost** – Deployment of 4G networks requires expensive infrastructure upgrades.
2. **Limited User Capacity** – 4G can face congestion issues when a large number of users connect simultaneously.
3. **High Power Consumption** – 4G devices consume more power due to continuous data transmission.
4. **Latency Issues** – Although lower than 3G, 4G still has a latency of around **30-50 ms**, which is not ideal for ultra-low latency applications like autonomous vehicles.
5. **Inefficient Spectrum Utilization** – The spectral efficiency of 4G is lower compared to **5G**, leading to bandwidth limitations.
6. **Interference in Dense Networks** – In crowded areas, 4G networks experience interference, reducing performance.
7. **Not Ideal for IoT** – 4G lacks optimized support for **massive IoT (Internet of Things)** applications requiring low power and long battery life.
8. **Limited Connectivity in Rural Areas** – Due to high deployment costs, 4G coverage is often weaker in remote locations.
9. **No Native Support for Network Slicing** – 4G cannot provide customized network slices for different applications like **smart cities, healthcare, and gaming**.
10. **Limited Support for Advanced Applications** – Emerging technologies like **AR/VR, autonomous vehicles, and remote surgery** require **higher speeds, lower latency, and better reliability**, which 4G struggles to provide.

Massive MIMO in 5G for Increasing User Capacity

Massive MIMO (Multiple-Input Multiple-Output) is a key technology in **5G networks** to enhance **user capacity and network performance**.

How Massive MIMO Works?

- **Traditional MIMO** (used in 4G) employs **2 to 8 antennas** at the base station.
- **Massive MIMO** in 5G uses **64 to 256 antennas**, significantly increasing the number of simultaneous connections.
- It allows multiple users to share the same frequency band **without interference** by using **beamforming**.

Benefits of Massive MIMO in 5G:

✅ **Increases User Capacity** – More antennas mean more users can be served at the same time.
✅ **Improves Spectral Efficiency** – Efficient use of frequency spectrum allows more data transmission.
✅ **Enhances Signal Quality** – Uses **beamforming** to focus signals on specific users, reducing interference.
✅ **Boosts Network Coverage** – Stronger and more focused signals extend coverage, especially in urban areas.
✅ **Reduces Latency** – Faster communication reduces delays, making 5G ideal for real-time applications.

4G faces challenges like **limited user capacity, high latency, and network congestion**. **Massive MIMO** in **5G** solves these issues by **increasing network capacity, improving signal quality, and optimizing spectral efficiency**, making 5G more reliable for future applications.

Q.18) Draw and Explain the Architecture of IEEE 802.11

→

IEEE 802.11 WLAN (Wi-Fi)

- **IEEE 802.11 is a set of media access control (MAC) and physical layer (PHY)** specifications for implementing wireless local area network (WLAN) computer communication in the 2.4, 3.6, 5, and 60 GHz frequency bands.
- They are created and maintained by the IEEE LAN/MAN Standards Committee (IEEE 802).

IEEE 802.11 WLAN Protocol Architecture

<table>
<tr><td rowspan="2">ISO/OSI
Data Link Layer</td><td colspan="3">802.2 Logical Link Control (LLC)</td></tr>
<tr><td colspan="3">802.11 Media Access Control (MAC)</td></tr>
<tr><td rowspan="2">ISO/OSI
Physical Layer
(PHY)</td><td colspan="3">802.11 Physical Layer Convergence Protocol
(PLCP)</td></tr>
<tr><td>PMD 802.11
Infrared</td><td>PMD 802.11 FHSS
Frequency Hopping
Spread Spectrum</td><td>PMD 802.11 DSSS
Direct Sequence
Spread Spectrum</td></tr>
</table>

- Figure above shows that the physical layer of 802.11 is divided into two different layers: PMD (Physical Medium Dependent) and PLCP (Physical Layer Convergence Protocol).
- The PMD layer **offers physical medium-dependent access** for infrared, FHSS(Frequency Hopping Spread Spectrum) and DSSS (Direct Sequence Spread Spectrum) communication.
- **PLCP provides a medium-independent interface** for the MAC (Medium Access Control) layer, which manages the package transport from one network interface to another through a shared transmission channel.
- **FHSS uses the frequency hopping mechanism to avoid collisions with other WLAN** devices. The baseband is divided into 79 channels, which are changed in a random order.
- **DSSS uses the CDMA (Code Division Multiple Access) mechanism, which enables** multiple transmissions on the same frequency channel for more than one transmitting device. The different signals are multiplexed with the help of device-unique codes and are de-multiplexed at the receiver‘s side.

IEEE 802.11 Physical Layer

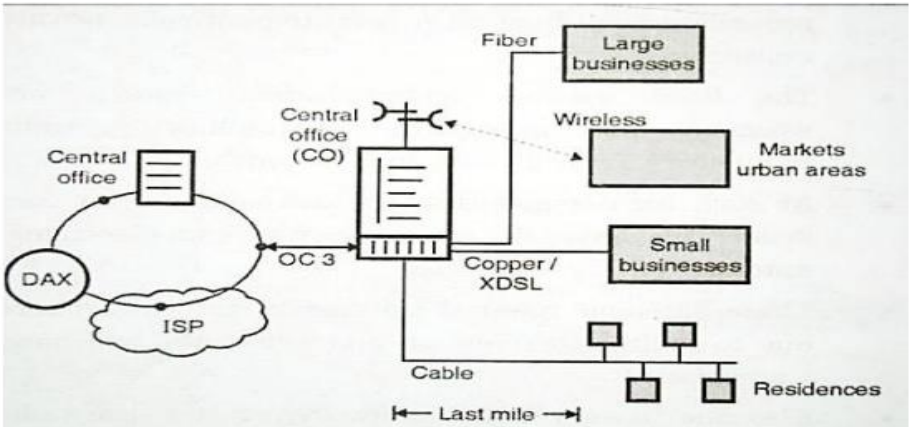
- IEEE 802.11 supports three different physical layers: one layer based on infra red and two layers based on radio transmission (primarily in the ISM band at 2.4 GHz, which is available worldwide).
- All PHY variants include the provision of the **clear channel assessment signal (CCA). This is needed for the MAC mechanisms controlling medium access and indicates if** the medium is currently idle.
- The PHY layer offers a service access point (SAP) with 1 or 2 Mbit/s transfer rate to the MAC layer (basic version of the standard).

IEEE 802.11 MAC Layer

- The data link layer within 802.11 consists of two sublayers: logical link control (LLC) and media access control (MAC). 802.11 uses the same 802.2 LLC and 48-bit addressing as the other 802 LAN, allowing for simple bridging from wireless to IEEE wired networks, but the MAC is unique to WLAN.
- The sublayer above MAC is the LLC, where the framing takes place. The LLC inserts certain fields in the frame such as the source address and destination address at the head end of the frame and error handling bits at the end of the frame.
- The 802.11 MAC is similar in concept to 802.3, in that it is designed to support multiple users on a shared medium by having the sender sense the medium before accessing it.
- In an 802.11 WLAN, collision detection is not possible due to the *near/far problem.*
- *To detect a collision, a station must be able to transmit and listen at the* same time, but in radio systems the transmission drowns out the ability of a station to hear a collision.

Q.19) Define WLL. Illustrate MMDS and LMDS working in WLL based Technology.

WLL stands for **Wireless Local Loop**. Microwave wireless links can be used to create a wireless local loop such as shown in figure below.



Working of MMDS in WLL based Technology

MMDS: Multichannel multipoint distribution service. It is known as wireless cable or multichannel multipoint distribution service, used for general purpose broadband networking or as an alternative method of cable television programming reception.

- ICC has assigned five bands of frequency in US in range from 2.15 GHz to 2.68 GHz for MMDS

Advantages

- Larger wavelength of signal
- Base station cost is lower

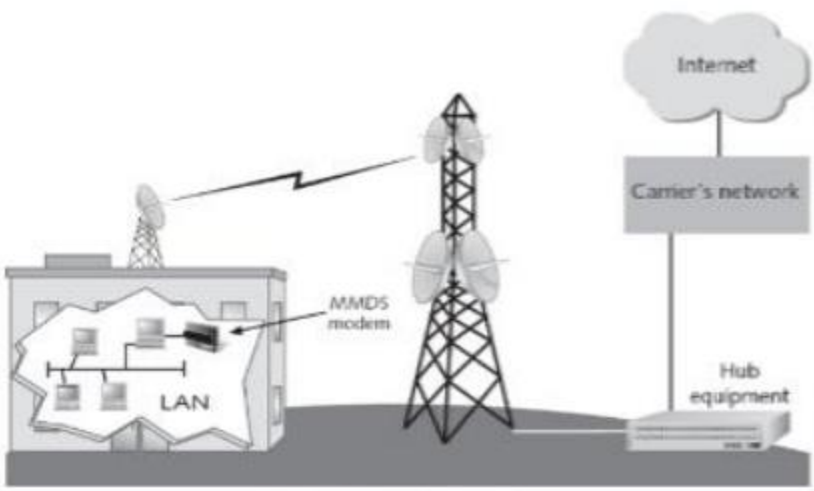


Fig: MMDS System

Working of LMDS in WLL based Technology

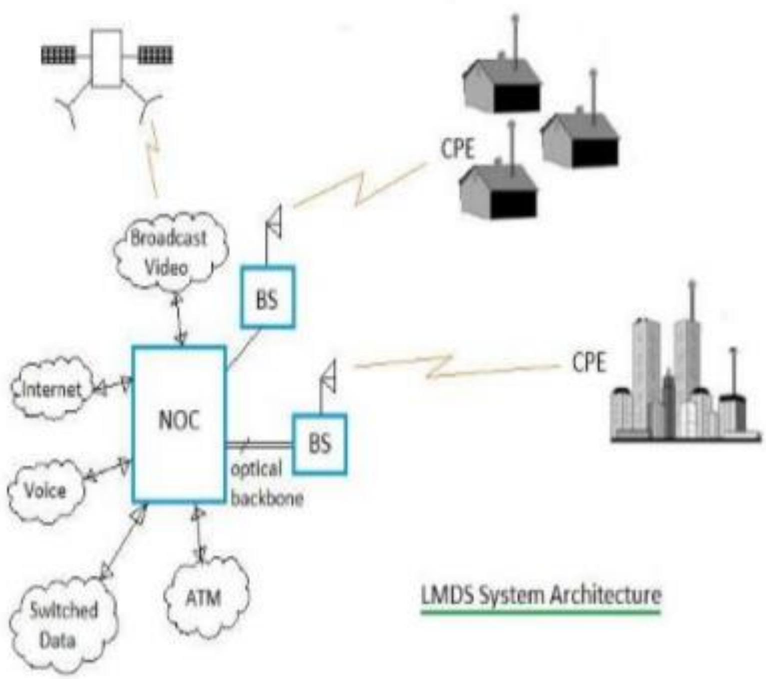
- LMDS: Local multi-point distribution system.
- It is a broadband wireless point to multipoint communication system that provides reliable digital two-way voice, data and Internet services. The term "Local" indicates that the signals range limit. "Multipoint" indicates a broadcast signal from the subscribers, the term "distribution" defines the wide range of data that can be transmitted, data ranging anywhere from voice, or video to Internet and video traffic.
- It provides high capacity point to multipoint data access that is less investment intensive.

Advantages:

- Lower entry and deployment cost
- Ease and speed of deployment
- Fast realization of revenue
- Uses low powered, high frequency (25-31 GHz) signals over a short distance.

Four parts in LMDS are:

1. NOC (network operation center)
2. Fiber based infrastructure
3. Base station
4. Customer premise equipment



LMDS System Architecture

Q.20, 21) Explain in Detail Wi-Max technology

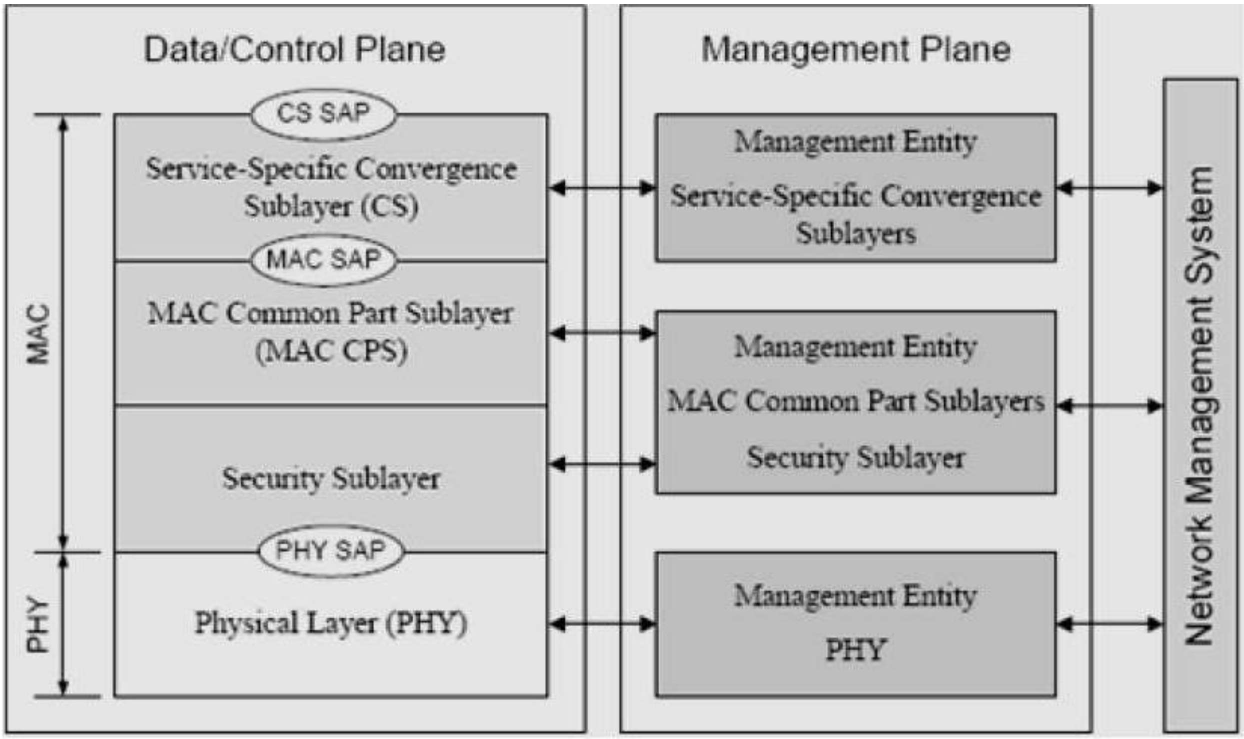
→ IEEE 802.16 (WiMAX)

- **IEEE 802.16 is a series of wireless broadband standards written by the Institute of Electrical and Electronics Engineers (IEEE)**.
- Although the 802.16 family of standards is officially called Wireless MAN in IEEE, it has been commercialized under the name "WiMAX" (from "Worldwide Interoperability for Microwave Access") by the WiMAX Forum industry alliance.

Key Features of IEEE 802.16

1. Broadband Wireless Access
2. Coverage area up to 50 km.
3. Data rate up to 70 Mbps.
4. Modulation technique used is BPSK, 64-QAM.
5. Offers non-line of site (NLOS) operation.
6. 1.5 to 28 MHz channel support.
7. Hundreds of simultaneous sessions can be carried per channel.
8. Delivers >1Mbps data throughput per user.
9. Supports both licensed and unlicensed spectrum.
10. QoS for voice, video, and T1/E1(Digital Signal), continuous and bursty traffic.
11. Support Point-to-Multipoint (PMP) and Mesh network models.

IEEE 802.16 is a broadband wireless access network standard that describes two layers, PHYand MAC to provide services for Point-to-Multipoint (PMP) broadband wireless access.



The IEEE 802.16 MAC layer is categorized into the following three sublayers:

- **Service Specific Convergence Sublayer (CS):**
- The service specific convergence sublayer (CS) provides any **transformation or mapping of external network data, received** through the CS service access point (SAP) **into MAC SDUs** received by the MAC CPS through the MAC SAP.
- Accepts higher layer protocol data units (PDUs) from the higher layer.
- Perform classification of higher layer PDUs and associates them to the proper service flow identified by the connection identifier (CID).
- Delivering CS PDUs to the appropriate MAC SAP.

MAC Common part sublayer

- Defines multiple-access mechanism
- Bandwidth allocation
- Connection establishment
- Connection maintenance
- Connection-oriented protocol

- Assign connection ID to each service flow.

Security sublayer

- Deals with privacy and security.
- The security sublayer provides subscribers with privacy or confidentiality across the broadband wireless network.

It manages :

- Authentication
- Secure key exchange
- Encryption

PHY Layer

- 802.16 uses scalable OFDMA to carry data, supporting channel bandwidths of between 1.25 MHz and 20 MHz, with up to 2048 subcarriers.
- It supports adaptive modulation and coding, so that in conditions of good signal, a highly efficient 64 QAM coding scheme is used, whereas when the signal is poorer, a more robust BPSK coding mechanism is used.
- In intermediate conditions, 16 QAM(quadrature amplitude modulation) and QPSK can also be employed.
- Other PHY features include support for multiple-input multiple- output (MIMO) antennas in order to provide good non-line-of- sight propagation (NLOS) characteristics (or higher bandwidth) and hybrid automatic repeat request (HARQ) for good error correction performance.
- Although the standards allow operation in any band from 2 to 66 GHz, mobile operation is best in the lower bands which are also the most crowded, and therefore most expensive.