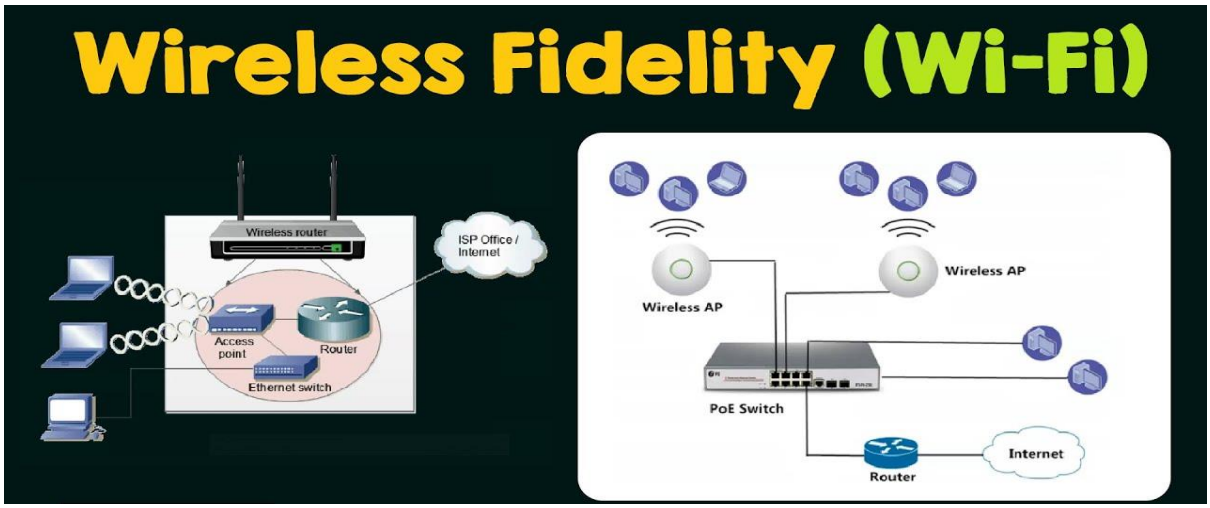
Unit-06
Wireless and Mobile Networks

6.1. Wi-Fi: 802.11 Wireless LANs

- Wi-Fi stands for Wireless Fidelity, is a technology that allows devices to connect to the internet and communicate with each other wirelessly within a local area network.
- Wireless LANs are those Local Area Networks that use high frequency radio waves instead of cables for connecting the devices in LAN. Users connected by WLANs can move around within the area of network coverage. Most WLANs are based upon the standard IEEE 802.11 or Wi-Fi.
- The term 802.11 refers to a family of IEEE (Institute of Electrical and Electronics Engineers) standards for WLANs
- IEEE 802.11 also known as Wi-Fi, is designed for using limited geographical area (different office buildings, homes).
- Wi-Fi networks use radio waves in the 2.4 GHz and 5 GHz bands to provide wireless connectivity within a limited range, indoor 100-300 ft, outdoor 300-900ft.
- IEEE 802.11 is basically standard define for wireless LANs technology.
- Some additional features of 802.11 Wi-Fi:

– Security mechanisms
– Power management



6.1.1 The 802.11 Wireless LAN Architecture

The 802.11 Wireless LAN Architecture is the framework that defines how wireless local area networks (WLANs) operate using the IEEE 802.11 standard, commonly known as Wi-Fi. This architecture enables wireless devices to communicate with each other and connect to wired networks.

The 802.11 Wireless LAN Architecture provides a flexible and scalable framework for building and managing wireless networks. It supports different operational modes, ensures secure communication, and allows seamless connectivity across large areas through the use of APs, BSSs, and ESSs.

6.1.2 The 802.11 MAC Protocol

The 802.11 MAC (Media Access Control) Protocol is a key component of the IEEE 802.11 standard for wireless LANs (Wi-Fi). It governs how data is transmitted over the shared wireless medium, ensuring efficient, reliable communication between devices while minimizing collisions and interference.

It uses mechanisms like CSMA/CA, ACK frames, and RTS/CTS to prevent collisions, ensure data integrity, and support both basic and time-sensitive communication needs.

6.1.3 The IEEE 802.11 Frame

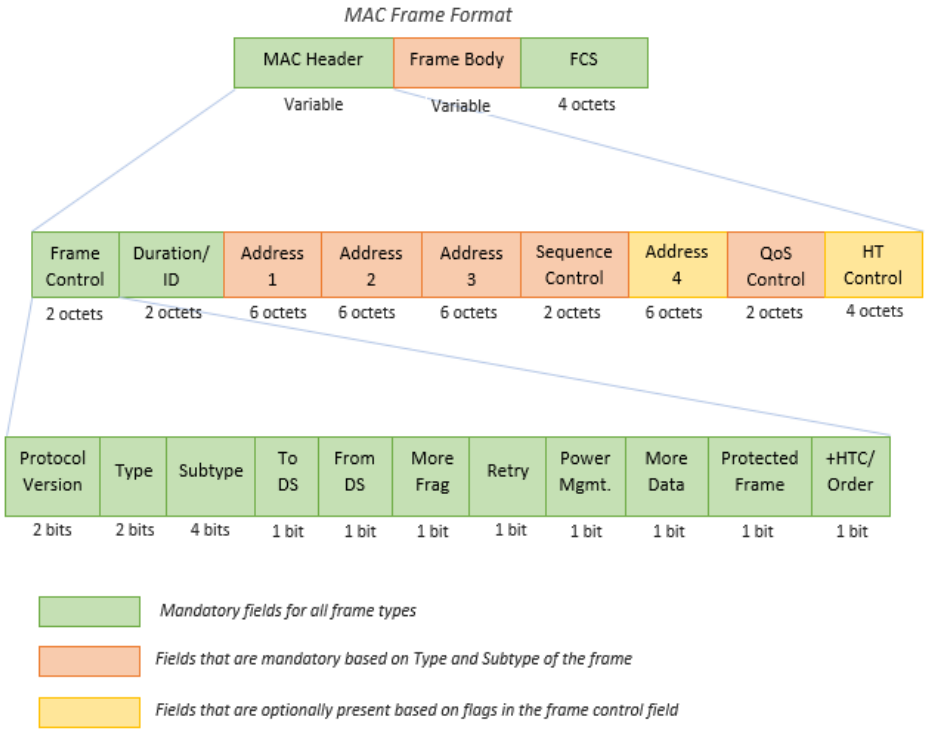
The IEEE 802.11 Frame is the fundamental unit of communication in a wireless LAN (Wi-Fi) based on the IEEE 802.11 standard. It encapsulates data and control information for transmission over the wireless network. The frame structure is designed to ensure reliable data delivery, manage access to the wireless medium, and support network management tasks.

Frame Types:

1. **Management Frames**:
    - Used for network management tasks like authentication, association, and beaconing. Examples include Beacon, Probe Request, and Association Request frames.
2. **Control Frames**:
    - Help in controlling access to the wireless medium. Examples include RTS (Request to Send), CTS (Clear to Send), and ACK (Acknowledgment) frames.
3. **Data Frames**:

- Carry the actual data being transmitted between devices. They also include the necessary control information to ensure proper delivery.

IEEE 802.11 MAC Frame Format



6.1.4 Mobility in the Same IP Subnet

Mobility in the Same IP Subnet refers to the ability of a wireless device (such as a laptop or smartphone) to move from one access point (AP) to another within the same IP subnet without losing its connection or requiring a change in its IP address. This ensures seamless connectivity, enabling uninterrupted communication even as the device moves throughout the coverage area.

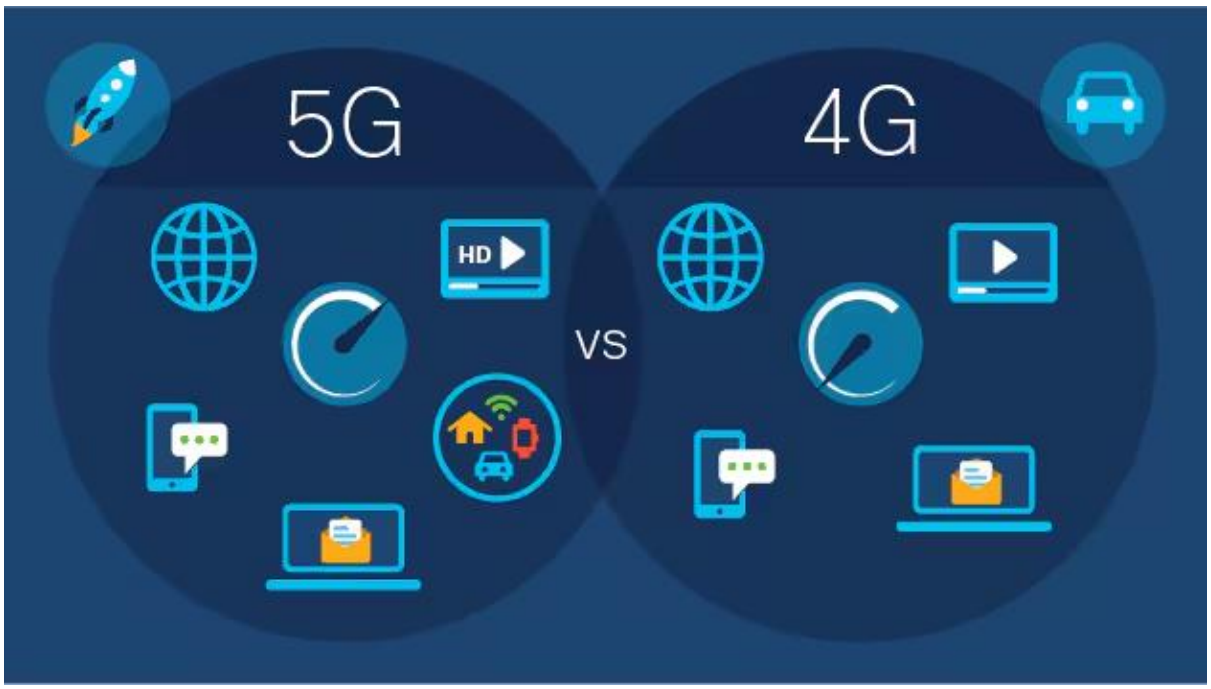
6.1.5 Personal Area Networks: Bluetooth

Personal Area Networks (PANs) using Bluetooth refer to short-range wireless networks designed for connecting devices within a small area, typically within a range of about 10 meters. Bluetooth is a widely used technology for creating PANs, allowing devices like smartphones, tablets, laptops, headphones, and other peripherals to communicate wirelessly.

Bluetooth supports simple network structures like piconets and more complex ones like scatternets, enabling a wide range of applications from wireless peripherals to audio streaming and home automation.

6.2. Cellular Networks: 4G and 5G

Cellular Networks: 4G and 5G represent the fourth and fifth generations of mobile communication technologies, each bringing significant advancements in speed, latency, capacity, and network architecture. These technologies enable a wide range of applications, from basic mobile communication to advanced Internet of Things (IoT) and real-time data services.



4G (Fourth Generation) Networks:

4G, also known as LTE (Long-Term Evolution), was introduced to provide faster data speeds and improved network efficiency compared to 3G. It supports high-speed internet access, HD video streaming, and other data-intensive applications.

Features:

- **Data Speed**: 4G offers download speeds up to 100 Mbps (mobile) and 1 Gbps (stationary).
- **Low Latency**: Around 50 milliseconds, suitable for real-time applications like video conferencing.

- **OFDM (Orthogonal Frequency Division Multiplexing)**: A modulation technique that reduces interference and improves data transmission.
- **All-IP Network**: 4G uses an all-IP (Internet Protocol) infrastructure for both voice (VoIP) and data services, enabling more efficient use of network resources.

5G (Fifth Generation) Networks:

5G is the latest generation of mobile networks, offering significantly higher speeds, lower latency, and greater capacity than 4G. It is designed to support a wide range of new use cases, including massive IoT deployments, autonomous vehicles, and smart cities.

Features:

- **Data Speed**: Theoretically up to 20 Gbps, with real-world speeds ranging from 100 Mbps to 10 Gbps.
- **Ultra-Low Latency**: As low as 1 millisecond, enabling real-time applications like remote surgery and autonomous driving.
- **Massive Connectivity**: Supports a vast number of connected devices per square kilometer, crucial for IoT.
- **Network Slicing**: Allows the creation of multiple virtual networks on a single physical 5G network, tailored to specific application needs.
- **mmWave (Millimeter Wave)**: Uses higher frequency bands for faster data rates, though with shorter range, complemented by low- and mid-band frequencies for broader coverage.

4G and 5G cellular networks are the backbone of modern mobile communication, with 4G providing high-speed internet access and 5G ushering in a new era of ultra-fast, low-latency, and highly connected networks.

Comparison between 4G and 5G

Item	4G	5G
Peak Data Rate	1 Gbps (DL)	20 Gbps (DL)
User Experienced Data Rate	10 Mbps	100 Mbps
Spectrum Efficency	-	X3
Areal Traffic Capacity	0.1 Mbps/m^2	10 Mbps/m^2
Latency	10ms	1ms
Connection Density	100,000/km^2	1,000,000/km^2
Network Energy Efficency	-	X100
Mobility	350km/h	500km/h
Bandwidth	Up to 20 MHz	Up to 1 GHz