Wi-Fi Module 5

1. What are the key features of Wi-Fi 6, 6E and 7 and how do they differ from previous standards like Wi-Fi 5 (802.11ac)?

WIFI - 6

1. It uses 1024-QAM OFDMA Modulation scheme
2. Target Wake Time based power saving method was introduced
3. BSS coloring was introduced to avoid unnecessary transmission deferring.
4. Improvises MU-MIMO by supporting around 16 users
5. Offers enhanced security using WPA3

WIFI - 6E

1. Along with wifi-6 , it introduces 6 GHz frequency in use
2. Thereby offers congestion less high bandwidth and lower latency services.
3. Used channel bandwidth around 160 MHz

WIFI-7

1. It follows IEEE 802.11be
2. It uses 2.4,5,6 GHz frequencies
3. Channel bandwidth is extended upto 320 MHz.
4. It uses 4096 QAM with OFDMA
5. It introduced MLO (Multi Link Operation - to transmit using multiple frequencies, channels sequentially based on decisions or actively on multiple channels or handling multi radio multi link operations)

6. Maximum theoretical speed of around 9.6 Gbps is expected.

2. Explain the role of OFDMA in Wi-Fi 6 and how it improves network efficiency.

OFDMA is a **multi-user version** of OFDM (used in Wi-Fi 5 and earlier), where the **available channel is divided into smaller sub-channels** called **Resource Units (RUs)**.
Each RU can be assigned to a different user, enabling **simultaneous communication** with multiple clients.

By enabling Multi User access,

It improves efficiency and latency.

3. Discuss the benefits of Target Wake Time (TWT) in Wi-Fi 6 for IoT devices.

TWT allows a client and an access point (AP) to agree on specific **scheduled wake times** for communication. The device **sleeps** the rest of the time, dramatically reducing power consumption.

1. Extended Battery Life

- IoT devices like sensors, cameras, and meters can sleep for **long, predictable durations**.
- Since the radio is off most of the time, **battery usage drops sharply**.

2. Scheduled Access = Less Contention

- Devices don't have to **compete for airtime** with others.
- TWT eliminates random access and **reduces collisions**, improving reliability and efficiency.

4. Explain the significance of the 6 GHz frequency band in Wi-Fi 6E.

- More spectrum. Therefore, higher bandwidth
- Less traffic, therefore, less contention

5. Compare and contrast Wi-Fi 6 and Wi-Fi 6E in terms of range, bandwidth, and

interference.

Range:

WiFi 6 higher than Wifi 6E

Bandwidth:

Wifi 6E higher than WiFi 6 because of higher channel width

Interference:

WiFi 6 E has low interference as legacy devices won't be operating in 6Ghz frequency.

6. What are the major innovations introduced in Wi-Fi 7 (802.11be)?

- 320 Mhz channel
- 4096 QAM
- Preamble Puncturing
- Multi Link Operation
- Enhanced MU MIMO.

7. Explain the concept of Multi-Link Operation (MLO) and its impact on throughput and latency.

In MLO, Multiple frequency bands can be used at a time to transmit data to a particular STA.

This improves throughput because of parallel transmission

Latency is also greatly reduced as traffic can be routed through least congested route.

8. What is the purpose of 802.11k and v, and how does it aid in roaming?

IEEE 802.11k – Radio Resource Management (RRM)

Helps the client **discover better nearby APs** faster and more efficiently.

When the client starts to experience weak signal or performance drops, it normally has to **scan all channels** to find a better AP.

With **802.11k**, the current AP sends a **Neighbor Report** — a list of nearby APs and their channels.

Reduces **roaming time** by allowing the client to **scan only relevant channels**, not all of them.

Improves **handoff speed and accuracy**, especially in dense environments.

IEEE 802.11v – BSS Transition Management

The AP monitors the client's connection quality.

If another AP can offer better service, it sends a **BSS Transition Management Request** suggesting which AP the client should roam to.

9. Explain the concept of Fast BSS Transition (802.11r) and its benefit in mobile

environments.

Usually when a client roams from one AP to another. It has to perform authentication again. This make the calls to get cut and introduces latency of 300 to 500ms

In 802.11r,

The client **pre-negotiates encryption keys** with multiple APs **before roaming**.

This enables a **handshake to complete in less than 50 ms**, fast enough to be **imperceptible**.

10. How do 802.11k/v/r work together to provide seamless roaming in enterprise networks?

802.11k makes sure the AP gives the neighbour AP's with better signal

802.11v gives the BSS transition best AP to roam into

802.11r makes sure the keys are prenegotiated to ensure efficient handoff