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Wifi Training Module 5 Assessment

Q1) What are the key features of wifi 6, 6e and 7 and how do they differ from previous gen?

Feature	Wifi 6	Wifi 6e	Wifi 7
DataRate	9.6Gbps	9.6Gbps	46Gbps
Spectrum	2.4GHz+5GHz	6GHz	2.4+5+6Ghz
Channel Width	20-160MHz	20-160MHz	Upto 320MHz
Spatial Streams	Upto 8	Upto 8	Upto 16
Modulation	1024QAM	1024QAM	4096QAM
MU-MIMO	UP+DL	UP+DL	Enhanced
Latency	10-15ms	10ms	<5ms (target)

Additionally, all the generations now have OFDMA support unlike wifi 5

Q2) Explain the role of OFDMA in wifi 6 and how it improves network efficiency?

OFDMA – Orthogonal Frequency Division Multiple Access is multi user. This allows single AP to simultaneously communicate with multiple clients. It divides the channel into smaller sub-channels called resource units and these units can be divided among multiple users. This ensures less traffic, especially in denser networks with many clients connected. And also, because the channel is divided, many user data can be processed at a time, reducing idle time, waiting and improving throughput.

Q3) Discuss the benefits of Target Wake Time (TWT) in WIFI 6 for iot devices.

TWT is a power saving mechanism introduced in WIFI 6. In traditional wifi, stations (STA) stay awake fully and keep listening for new incoming traffic. This leads to wastage of power, which is not good for battery operated STA like IoT devices and mobile phones. In TWT, the STA and AP negotiate and agree upon time intervals where the STA would be awake and transmit or receive data. This makes sure that in most of the time, the STA would be asleep, conserving power and longer battery life for battery operated STA.

It also means that since there is a scheduled time slots, larger and denser networks can efficiently allocate time slots to avoid network traffic and so is scalable in nature.

Q4) Explain the significance of 6GHz band in WIFI 6E.

1. Much More Spectrum

6 GHz has an additional 1.2 GHz of spectrum (5.925 GHz to 7.125 GHz, varying by country).

More than twice as much spectrum as 2.4 GHz and 5 GHz together in previous Wi-Fi.

Result: More space for more channels means less congestion.

2. Wider, Cleaner Channels

With 6 GHz, you can have:

7 additional 160 MHz channels (perfect for VR, 8K video, gaming).

14 additional 80 MHz channels.

Wider channels = lower latency and higher speeds.

Because 6 GHz is new to Wi-Fi, there is no prior interference from legacy Wi-Fi devices, Bluetooth, or microwaves.

3. Reduced Latency and Improved Performance

Equipment running on 6 GHz does not have to contend with older Wi-Fi 4/5 equipment.

Only Wi-Fi 6E devices can use this band, so more consistent, faster, and smoother performance.

4. Improved Experience in Congested Environments

In crowded areas like stadiums, airports, or offices where 5 GHz is congested, 6 GHz offers clean air for performance-heavy use cases.

It makes a huge difference for video calls, streaming, AR/VR, and cloud games.

5. Advanced Features Only

Only Wi-Fi 6 features (such as OFDMA, MU-MIMO, TWT, BSS Coloring) are permitted in 6 GHz.

Legacy protocols (Wi-Fi 4/5) can't run in 6 GHz.

Result: Ensured modern efficiency — no bringing old tech to the new band.

Q5) Compare WIFI 6 and 6E in terms of range, bandwidth and interference.

Feature	**Wi-Fi 6 (2.4 GHz / 5 GHz)**	**Wi-Fi 6E (6 GHz)**
Range	- **2.4 GHz**: Longest range, but slower. - **5 GHz**: Medium range, faster but more easily blocked by walls.	- **6 GHz**: Shorter range than 5 GHz. - Walls and obstacles weaken signals faster.
Bandwidth (available spectrum)	- 2.4 GHz: Very limited. - 5 GHz: More than 2.4 GHz, but fragmented. - Only a few 80/160 MHz channels available.	- Huge new spectrum (up to **1.2 GHz**). - Multiple **160 MHz** wide channels possible. - Much higher potential speeds.
Interference	- 2.4 GHz: Very high (Bluetooth, microwaves, etc.). - 5 GHz: Less interference, but still crowded (Wi-Fi 5, radar, etc.).	- **Very low interference**. - Only modern Wi-Fi 6E devices operate here. - No legacy Wi-Fi, no Bluetooth overlaps.

Q6) What are the major innovations introduced in WIFI 7? (802.11be)

1) Operates at multiple frequency bands: 2.4GHz, 5GHz, 6GHz.
2) Maximum theoretical datarate: upto 46Gbps
3) Introduced 4096 QAM
4) MU-MIMO now supports 16 spatial streams
5) Wider Channel Bandwidth – upto 320MHz.
6) MLO – Multi-Link Operation – Allows devices to connect to multiple frequency bands at once.
7) Lower latency with shorter guard intervals

Q7) Explain the concept of MultiLink Operation and its impact on throughput and latency.

In older wifi generations, clients (STA) can only connect to a single frequency band, either 2.4GHz, 5GHz or 6GHz at a single time. This means the other bands go unused, and we might limit speed in the connected band

Wifi 7 introduces MLO, which enables devices to connect to all the bands at the same time. Multi Link Operation supports establishing multiple links to the different frequency bands at the same time. This means that data traffic can be distributed across the bands and this increases throughput, reduces latency and improves reliability.

There are two modes of operation in MLO:
a) STR – Simultaneous Transmit Receive (Asynchronous mode): This means that all the links can send and receive data independently without interfering with each other.

b) NSTR – Nonsimultaneous Transmit Receive (Synchronous Mode): this means that all the links work with each other at the same time. This means that either all link transmit data or receive data at the same time.

Q8) What is the purpose of 802.11k and v and how does it aid roaming?

802.11k: This protocol allows the STA to find the best AP to roam to without scanning blindly.

a) The STA requests a neighbour report from the AP, this report tells the STA the details of all the nearest AP, their BSSID, signal strength, etc.

b) The AP replies with the report

c) When signal strength drops, the STA can now connect to the neighbouring AP with strongest signal without scanning blindly.

802.11v: Network Assisted client management

This allows an AP to guide STA on which AP to roam to, power and load management.

a) Network assisted roaming: AP will tell STAs the nearest AP to roam to when the signal becomes weak real time, without the STA even notices the drop in signal quality.
b) BSS Transition Management: AP will tell STA which AP to roam to, without the client making that decision.
c) Idle Mode Notification: Clients will notify AP when they enter sleep mode. This helps in resource management.
d) Traffic Management: AP can filter traffic to not go to sleeping clients.

Q9) Explain the concept of Fast BSS Transition (802.11r) and its benefit in mobile environments.

802.11r reduces the handoff time when STA move from one AP to another.

a) Pre-authentication before handoff: The Client gets authenticated to the nearest AP without leaving the current AP.

b) Fast Transition Key: Key derivation and exchange happen in advance, so handoff is seamless.

c) FT OTA and ODS:
OTA: STA directly exchanges FT messages with target AP

ODS: The current AP shares the FT messages to the target AP.

802.11r ensures seamless handoff. This is particularly useful in real time applications like voice/video calls and ar/vr. It also reduces latency and enhances user experience in public and enterprise wifi.

Q10) How does 802.11k/v/r work together to provide seamless roaming in enterprise networks?

802.11k ensures that the STA connects to the best AP.

802.11v makes the AP connect to the next best AP if the signal strength weakens. This is done automatically.

802.11r makes handoff seamless. Client automatically gets authenticated to the next target AP while still connected to the current AP to ensure seamless handoff. The FT messages are either shared to the target AP by the STA (OTA) or by the current AP itself (ODS).

In an enterprise network, laptops will be taken from one floor to another, from one place to another. This means that the signal strength has to be strong in order for the employee to work properly on the laptop. This can be possible due to the 3 protocols mentioned above.