# MODULE 5 ASSIGNMENT

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)?**

## Wi-Fi 6 (802.11ax):

* + - OFDMA for better efficiency and lower latency.
    - MU-MIMO on uplink and downlink.
    - Target Wake Time (TWT) for improved power efficiency.
    - Higher performance in dense environments.
    - WPA3 for better security.

## Wi-Fi 6E:z

* + - Extends Wi-Fi 6 into the 6 GHz band.
    - Up to 1,200 MHz of extra bandwidth.
    - Less interference from legacy devices.
    - More available channels → better performance.

## Wi-Fi 7 (802.11be):

* + - Supports 320 MHz channels (double from Wi-Fi 6).
    - 4K QAM for higher data rates.
    - Multi-Link Operation (MLO) for better throughput and reliability.
    - Reduced latency for AR/VR and real-time use cases.

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

* + Divides a Wi-Fi channel into multiple smaller sub-channels (RUs).
  + Allows simultaneous data transfer for multiple devices.
  + Reduces latency by serving multiple users in one transmission.
  + Enhances performance in congested environments.
  + Improves spectrum utilization.

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

* + Allows scheduling when devices wake to send/receive data.
  + Minimizes power usage — ideal for battery-powered IoT.
  + Reduces contention and network congestion.
  + Extends battery life of devices.
  + Supports scalable and energy-efficient networks.

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

* + Offers a clean, uncongested spectrum.
  + Supports up to 59 new 20 MHz channels.
  + Reduces interference from legacy devices.
  + Enables wider channels (up to 160 MHz) for high throughput.
  + Ideal for high-bandwidth applications like 4K/8K streaming and VR.

# Compare and contrast Wi-Fi 6 and Wi-Fi 6E in terms of range, bandwidth, and interference

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| --- | --- | --- |
| **Feature** | **Wi-Fi 6** | **Wi-Fi 6E** |
| **Frequency Bands** | 2.4 GHz and 5 GHz | 6 GHz (new spectrum) |
| **Range** | Better range, especially on 2.4 GHz | Slightly reduced range due to higher frequency |
| **Bandwidth** | Limited by existing 5 GHz spectrum | Supports more channels and wider bandwidth |
| **Channel Availability** | Fewer non-overlapping channels | Up to 59 new 20 MHz channels |
| **Interference** | Higher interference from legacy devices | Very low interference (clean 6 GHz band) |
| **Use Case** | Suitable for general use and backward compatibility | Ideal for high-performance, low- latency applications |
| **Device Support** | Compatible with most modern Wi-Fi devices | Requires Wi-Fi 6E compatible devices |

1. **What are the major innovations introduced in Wi-Fi 7 (802.11be)?**
   * 320 MHz channel width.
   * 4K QAM for up to 20-30% more throughput.
   * Multi-Link Operation (MLO) across multiple bands.
   * Enhanced Channel Sounding and beamforming.
   * Lower latency and jitter for real-time applications.

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

* + Allows simultaneous use of multiple links (e.g., 5 GHz + 6 GHz).
  + Increases total throughput by combining bandwidth.
  + Improves link reliability and load balancing.
  + Reduces latency and supports seamless data flow.
  + Enhances performance for time-sensitive applications.

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

## 802.11k:

* + - Devices receive neighbor reports for nearby APs.
    - Speeds up scanning and selection of best AP.

## 802.11v:

* + - AP suggests optimal APs for roaming.
    - Devices can transition more intelligently.
  + Improves roaming experience and reduces disruptions.

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

* + Enables fast and secure handoff between APs.
  + Reduces latency during roaming.
  + Pre-authenticates client with nearby APs.
  + Ideal for applications like VoIP, video conferencing.
  + Supports smooth transitions without service interruption.

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

* + 802.11k: Helps client discover nearby APs.
  + 802.11v: Assists in choosing the best AP based on signal and load.
  + 802.11r: Speeds up authentication during handoff.
  + Together, they:
* Enhance roaming decisions.
* Reduce delay and packet loss.
* Improve user experience in enterprise and large networks.