**Wi-Fi Training Program**

**Assignment Solutions – 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)?**

| **Feature** | **Wi-Fi 5 (802.11ac)** | **Wi-Fi 6 (802.11ax)** | **Wi-Fi 6E** | **Wi-Fi 7 (802.11be)** |
| --- | --- | --- | --- | --- |
| Frequency Bands | 5 GHz | 2.4 GHz & 5 GHz | 2.4 GHz, 5 GHz, 6 GHz | 2.4 GHz, 5 GHz, 6 GHz |
| Max Data Rate | ~3.5 Gbps | ~9.6 Gbps | ~9.6 Gbps | ~46 Gbps |
| Channel Width | 80/160 MHz | Up to 160 MHz | Up to 160 MHz | Up to 320 MHz |
| MU-MIMO | Downlink only | Uplink + Downlink | Same as Wi-Fi 6 | Improved with 16 streams |
| OFDMA | No | Yes | Yes | Enhanced |
| Latency | Higher | Lower | Lower | Extremely low |
| Target Wake Time (TWT) | No | Yes | Yes | Yes |

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

**OFDMA (Orthogonal Frequency Division Multiple Access)** divides a Wi-Fi channel into smaller sub-channels called **Resource Units (RUs)**. This allows multiple devices to transmit or receive simultaneously.

**Benefits:**

* Reduces contention and overhead.
* Improves efficiency in dense environments.
* Supports simultaneous uplink/downlink communication.

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

**TWT** allows devices to negotiate specific wake/sleep schedules with the Access Point.

**Key benefits:**

* **Power saving**: Devices stay in sleep mode until their scheduled time.
* **Improved battery life**: Ideal for IoT sensors and battery-operated gadgets.
* **Reduced contention**: Fewer devices competing at the same time.

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

The **6 GHz band** (5925–7125 MHz) adds:

* **More spectrum (up to 1200 MHz)** for wider channels (160 MHz or even multiple 80 MHz).
* **Less interference**, as it’s exclusive to Wi-Fi 6E devices.
* **Faster data rates and low latency**, especially in high-density environments.

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

| **Aspect** | **Wi-Fi 6** | **Wi-Fi 6E** |
| --- | --- | --- |
| Range | Better indoor coverage | Slightly reduced (higher freq) |
| Bandwidth | Up to 160 MHz channels | Same, but with more clean channels |
| Interference | May overlap with legacy devices | Minimal (dedicated 6 GHz band) |

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

* **320 MHz channels**: Doubles bandwidth.
* **Multi-Link Operation (MLO)**: Uses multiple bands/links simultaneously.
* **16×16 MU-MIMO**: More simultaneous data streams.
* **1024-QAM → 4096-QAM**: Higher data rates.
* **Enhanced OFDMA**: More flexible resource allocation.
* **CMU-MIMO (Coordinated Multi-User MIMO)**: Better coordination between APs.

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

**MLO** enables devices to use multiple channels (like 5 GHz + 6 GHz) at once for both upload and download.

**Impact:**

* **Higher throughput**: Combines bandwidth from multiple links.
* **Lower latency**: Transmits over the least congested path.
* **Greater reliability**: Can switch links if one has interference.

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

* **802.11k**: Helps clients scan more efficiently by providing a list of nearby APs — improves handover speed.
* **802.11v**: Allows the AP to suggest better APs for the client — supports intelligent roaming and network load balancing.

Both help devices **roam faster and smarter** without disrupting active connections.

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

**802.11r** allows fast handoff between APs by **pre-authenticating** with nearby APs.

**Benefits:**

* **Seamless handoff** during VoIP or video calls.
* Reduces roaming delay to under 50ms.
* Ideal for **mobile clients** like phones or roaming sensors.

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

* **802.11k**: Helps device find nearby APs quickly.
* **802.11v**: Suggests the best AP based on signal/load.
* **802.11r**: Allows quick authentication with target AP.

**Together**, they provide **fast, intelligent, and secure roaming** — essential in enterprise Wi-Fi setups with multiple APs and real-time applications.