Wi-Fi TRAINING - MODULE 5

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Qn 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)

ASPECT	Wi-Fi 6	Wi-Fi 6E	Wi-Fi 7
Frequency Band	Uses 2.4 GHz and 5 GHz bands	Adds 6 GHz band for more space	Supports 2.4, 5, and 6 GHz
Max Speed	Reaches up to 9.6 Gbps theoretically	Same as Wi-Fi 6 at 9.6 Gbps	Hits 46 Gbps in theory
Channel Width	Supports up to 160 MHz channels	Same 160 MHz but more channels	Doubles to 320 MHz for more data
Key Technology	OFDMA for better efficiency	OFDMA plus less interference	Multi-Link Operation for speed
Spatial Streams	Up to 8 streams for multiple devices	Same as Wi-Fi 6 with 8 streams	Up to 16 streams for capacity
Efficiency Boost	Reduces latency by 75%	Lower interference in 6 GHz	Lowest latency with MLO

Qn 2:

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

OFDMA:

- OFDMA - **Orthogonal Frequency Division Multiple Access**
- It splits a Wi-Fi channel into smaller sub-channels
- These sub-channels are called resource units
- Multiple devices can use these units at the same time

How it works:

- OFDMA stands for Orthogonal Frequency Division Multiple Access
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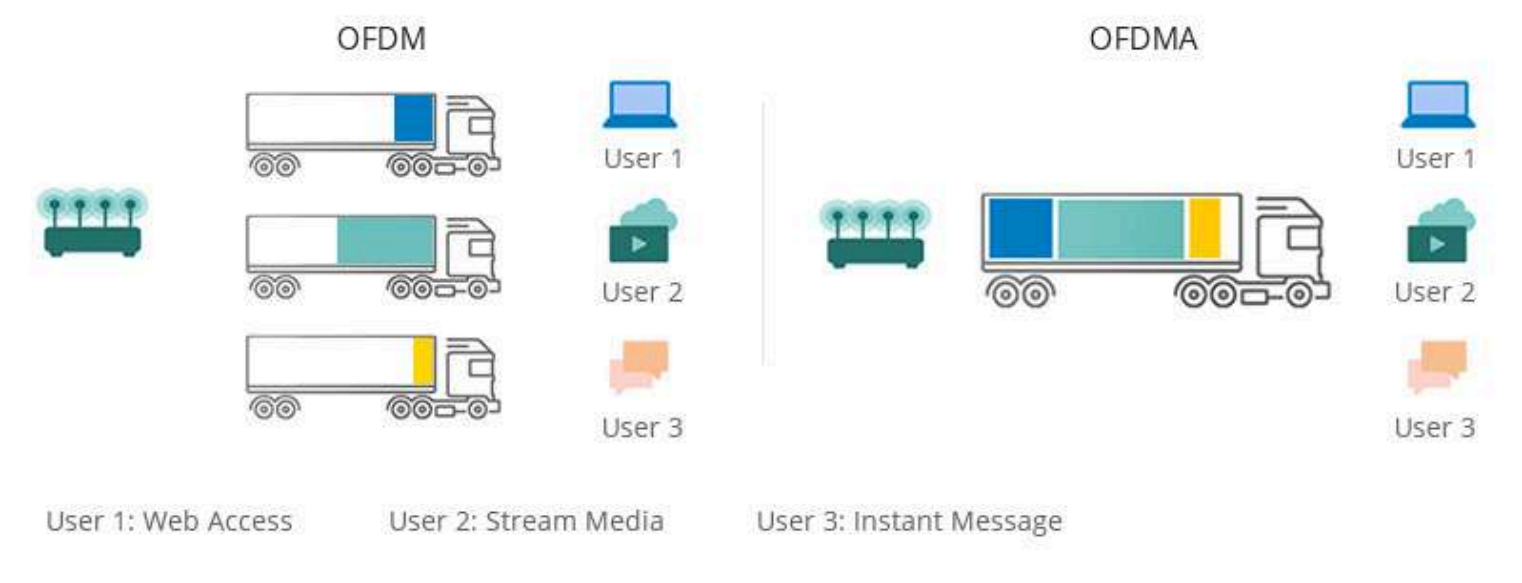
Benefits:

- OFDMA allows up to 9 devices to share a channel
- It reduces wait times for data transmission
- Smaller packets get their own resource units
- This cuts down on wasted channel space
- Overall throughput increases significantly



Qn 3:

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

TWT:

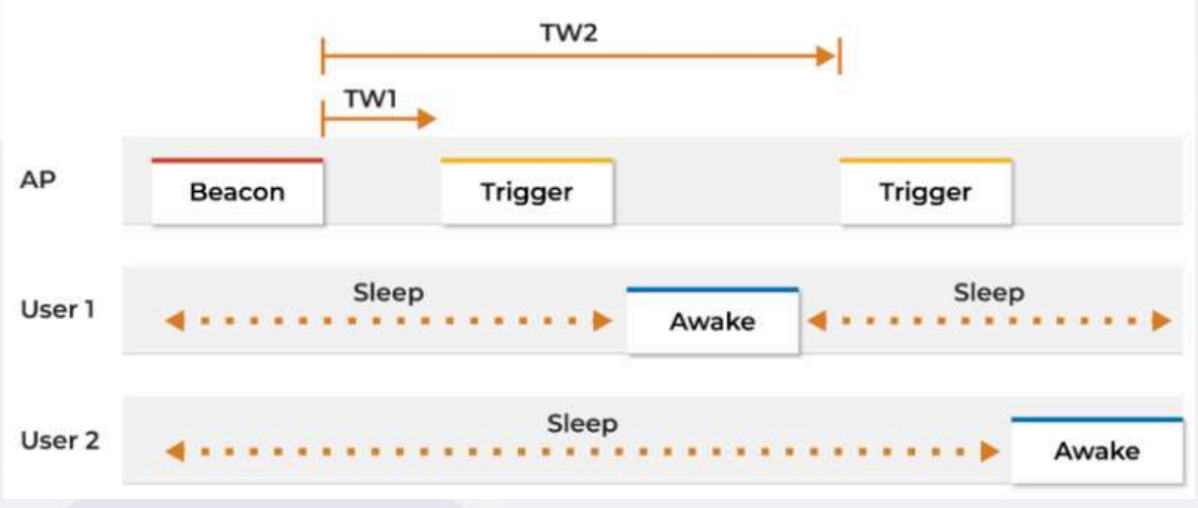
- Target Wake Time is a Wi-Fi 6 feature for power saving
- It schedules when IoT devices wake up to communicate
- Devices sleep longer between these scheduled times
- This extends battery life for small gadgets
- It’s perfect for IoT devices with low data needs

Power Efficiency Gains:

- IoT devices like sensors often run on tiny batteries
- TWT cuts power use by limiting wake-up frequency
- Devices can sleep for hours or days
- They only wake at set times to send updates
- This can double or triple battery lifespan

TWT in terms of Network Clutter:

- Many IoT devices send small, periodic data bursts
- TWT ensures they don’t all wake up at once
- Scheduled wake times reduce channel congestion
- It prevents collisions in networks with many devices
- Access points handle traffic more smoothly



Qn 4:

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

Expanded Spectrum:

- The 6 GHz band introduces a massive 1200 MHz of new spectrum for Wi-Fi 6E, offering much-needed space
- It provides 14 additional 80 MHz channels and 7 wider 160 MHz channels to minimize overlap and congestion
- More spectrum allows networks to handle increased traffic without slowing down in busy environments
- This expansion supports future growth as more devices join the network
- It enables better channel planning for large-scale deployments

Cleaner Signal:

- Unlike the crowded 2.4 GHz and 5 GHz bands, the 6 GHz band experiences far less interference from devices
- It avoids disruptions from microwaves, cordless phones, and neighboring networks, ensuring a stable connection
- This cleaner signal enables speeds up to 9.6 Gbps with reduced latency for smoother app performance
- It provides a quieter environment for sensitive applications like augmented reality
- The reduced noise enhances overall reliability in urban settings

Modern Needs - Support:

- The 6 GHz band supports more simultaneous connections, making it ideal for dense areas like offices or apartments
- Its wider channels enhance throughput, which is perfect for high-bandwidth apps like video streaming or gaming
- While the range is shorter than 2.4 GHz, it excels in setups with closely placed access points

Qn 5:

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

Comparison:

ASPECT	Wi-Fi 6	Wi-Fi 6E
Range	Operates on 2.4 GHz and 5 GHz bands	Adds 6 GHz band but has shorter range
	Covers larger areas like homes or offices	Better for close setups with nearby APs
	Longer range due to lower frequencies	Needs more APs for wide coverage
Bandwidth	Supports up to 160 MHz channels	Same 160 MHz but with 14 extra channels
	Decent capacity but limited in busy areas	More bandwidth in the 6 GHz spectrum
	Fewer channels lead to potential overlap	Higher throughput with additional space
Interference	Faces noise from devices in 2.4 GHz	Cleaner 6 GHz band with less noise
	5 GHz also crowded in dense environments	Avoids clashes with microwaves or phones

Qn 6:

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

Speed & Capacity:

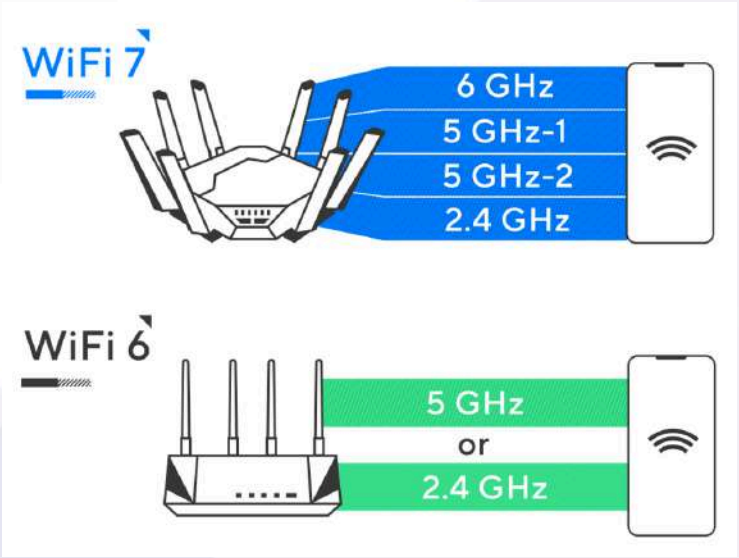
- Wi-Fi 7 targets speeds up to 46 Gbps for massive data handling
- It doubles channel width to 320 MHz for wider data pipes
- Supports up to 16 spatial streams for more device connections
- Uses 4096-QAM to cram more data into each signal
- This makes it ideal for future high-bandwidth needs

Multi Link Operation:

- Multi-Link Operation lets devices use multiple bands at once
- It switches or combines 2.4 GHz, 5 GHz, and 6 GHz seamlessly
- Improves throughput by balancing traffic across bands
- Reduces latency for real-time apps like gaming
- Enhances reliability in crowded network setups

Efficiency Features:

- Wi-Fi 7 refines OFDMA for even better resource sharing
- It introduces coordinated beamforming for precise signal targeting
- Supports Multi-User MIMO with more simultaneous users
- Includes enhanced TWT for smarter power management
- These features optimize performance in dense areas



Qn 7:

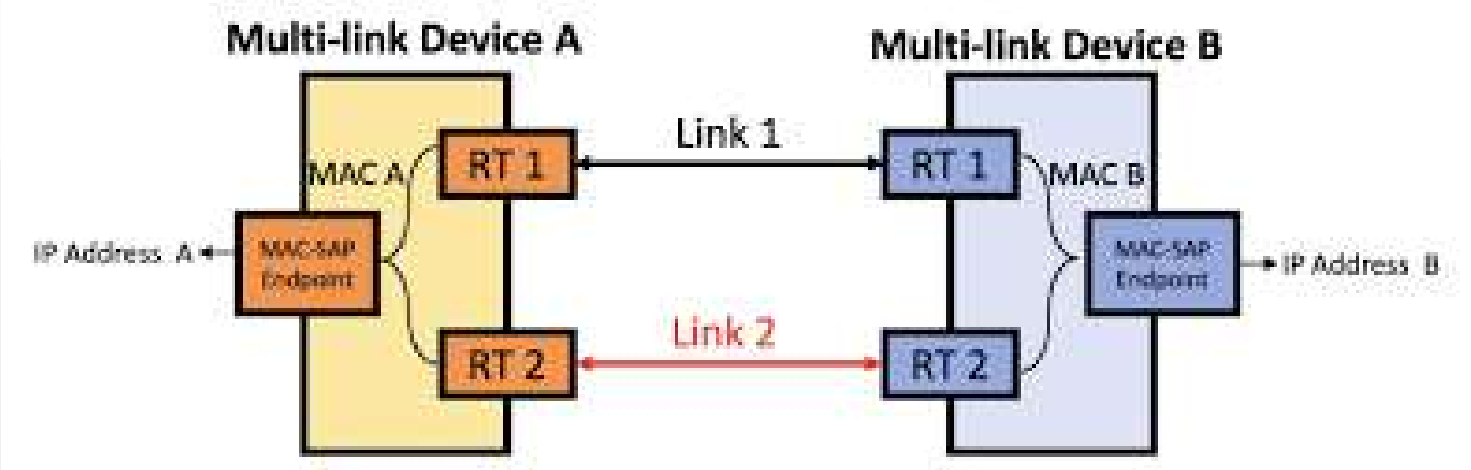
Explain the concept of Multi-Link Operation (MLO) and its impact on throughput and latency

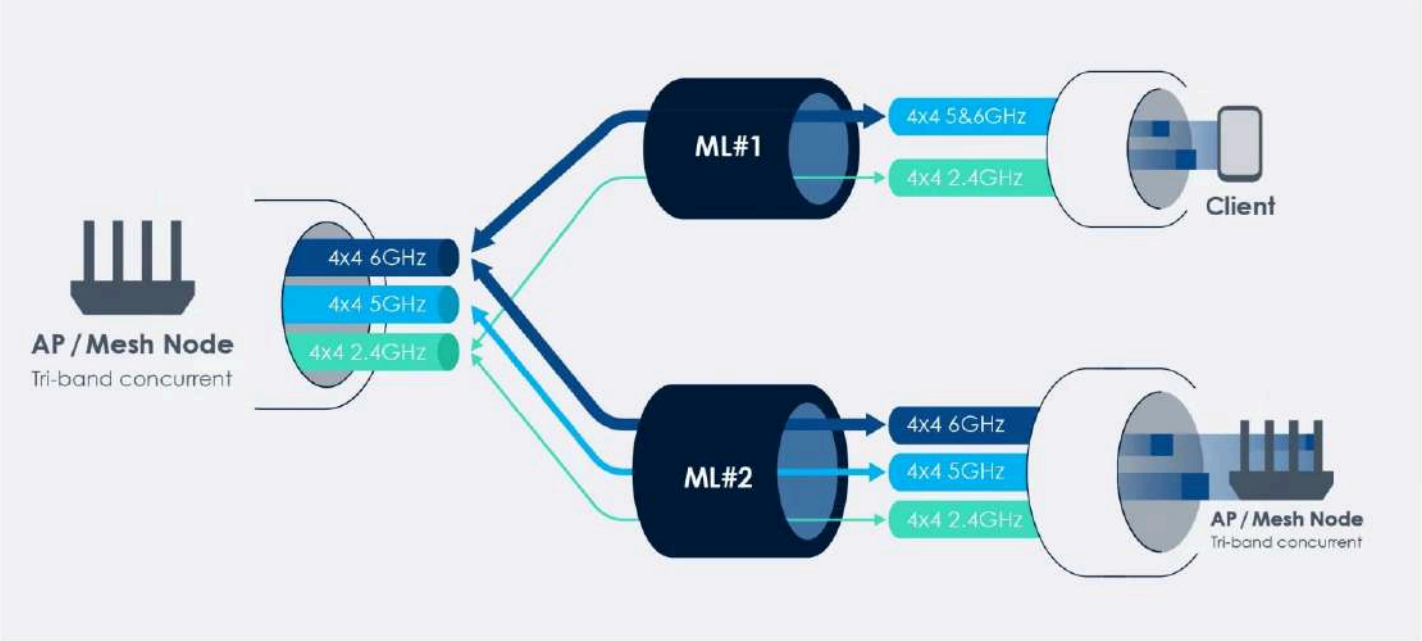
Multi Link Operation:

- Multi-Link Operation in Wi-Fi 7 enables devices to connect across 2.4 GHz, 5 GHz, and 6 GHz bands simultaneously
- It allows a device to transmit and receive data using multiple frequency bands at the same time
- This technology uses a single MAC layer to manage all links, ensuring seamless coordination
- MLO leverages the strengths of each band to optimize performance for various network conditions

Enhancing throughput:

- MLO significantly increases throughput by combining bandwidth from 2.4 GHz, 5 GHz, and 6 GHz bands
- It achieves speeds up to 46 Gbps by sending data across multiple bands in parallel
- High-bandwidth applications like 8K video streaming or virtual reality benefit from this increased capacity





Enhancing throughput:

- MLO lowers latency by smartly distributing traffic across multiple bands to avoid congested channels
- Real-time applications such as online gaming or video calls experience faster response times with this approach
- It enables devices to switch bands dynamically, ensuring minimal delays even in high-density networks

Qn 8:

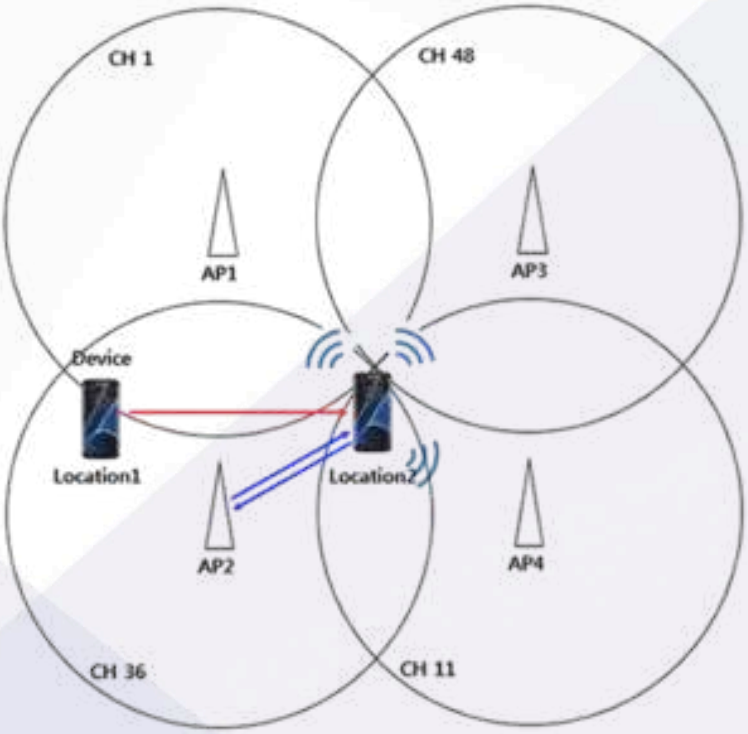
What is the purpose of 802.11k and v, and how does it aid in roaming

Purpose of 802.11k:

- 802.11k standard helps devices find the best access point by providing a neighbor report
- It gathers information about nearby APs, including signal strength and channel details
- This enables faster decision-making when switching between access points
- It reduces the time clients spend searching for a better connection

Purpose of 802.11v:

- 802.11v allows access points to suggest better connection options to devices
- It provides network-assisted roaming by sending BSS transition management frames
- This helps clients move to less congested or stronger APs seamlessly
- It enhances network management by optimizing device placement



Qn 9:

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

Fast BSS Transition:

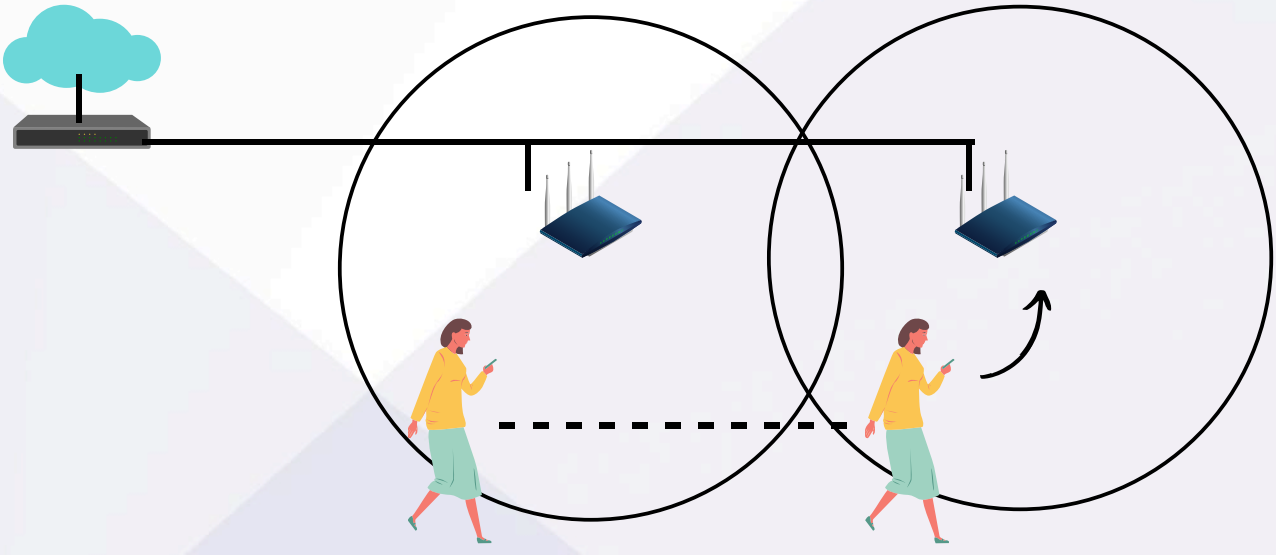
- Fast BSS Transition or 802.11r speeds up switching between access points
- It pre-authenticates devices with target APs before roaming occurs
- This process maintains security while moving across the network
- It ensures a seamless handoff without interrupting connections

802.11r:

- The client establishes a security context with multiple APs in advance
- It uses a Pairwise Master Key (PMK) to streamline authentication
- When roaming, it reuses this context for quick re-association
- The transition completes in milliseconds rather than seconds

802.11r:

- Fast BSS Transition reduces downtime during handoffs for mobile users
- It supports uninterrupted voice calls or video streams on the move
- Devices like phones or laptops stay connected in large venues



Qn 10:

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

802.11k in Roaming:

- 802.11k provides a neighbor report to help devices identify nearby access points
- It collects signal strength and channel data for faster AP selection
- This reduces the time spent scanning during handoffs
- It ensures clients quickly find the best connection option

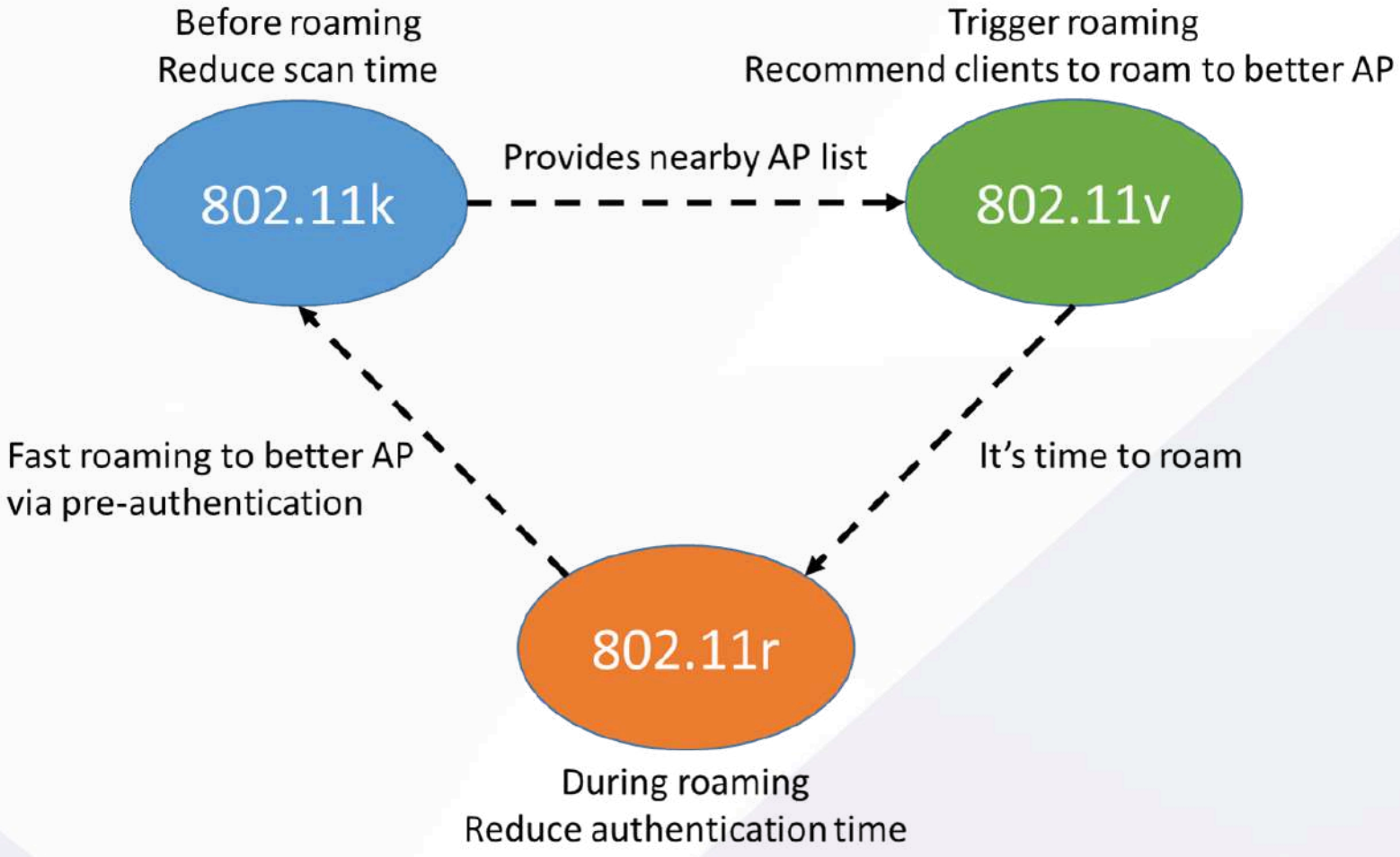
802.11v in Roaming:

- 802.11v sends BSS transition management frames to suggest better APs
- It assists devices in moving to less congested or stronger access points
- This optimizes network load and improves signal quality
- It guides clients smoothly through the roaming process

802.11r Integration with both:

- 802.11r pre-authenticates with target APs using a shared security context
- It reuses the Pairwise Master Key for rapid re-association
- Combined with k and v, it minimizes downtime during transitions
- This trio ensures uninterrupted connectivity across enterprise spaces

802.11k/v/e together in Roaming:



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