

Wi-Fi 8 under the hood: The technologies powering ultra-high reliability

PART 2: A technical look at the innovations making Wi-Fi 8 a game changer for real-world connectivity

Wi-Fi
8

Qualcomm

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What you should know:

- With Wi-Fi 8, users benefit from consistently reliable connections, overcoming the limitations of previous Wi-Fi generations in demanding scenarios.
- Breakthrough innovations at the PHY and MAC layers enable robust connectivity, seamless roaming, higher throughput and extended coverage for devices across diverse environments.
- Qualcomm Technologies is helping shape the future of Wi-Fi 8, bringing advanced wireless technologies and AI-driven connectivity to support next-generation intelligent systems and user experiences.

[Previously](#), we explored how Wi-Fi 8 is being developed to meet the demands of a new era shaped by AI-driven systems, personal device ecosystems and mission-critical applications. Designed to deliver ultra-high reliability, Wi-Fi 8 aims to provide consistent, low-latency and near-lossless performance in real-life environments where congestion, interference, mobility and coverage boundaries challenge legacy Wi-Fi.

Here, we'll take a closer look at the technologies making Wi-Fi 8 uniquely capable of solving these challenges. We'll also explore how these innovations translate into tangible benefits across key environments: enterprise and industrial settings, connected homes and public venues — where seamless, intelligent connectivity is becoming more and more essential.



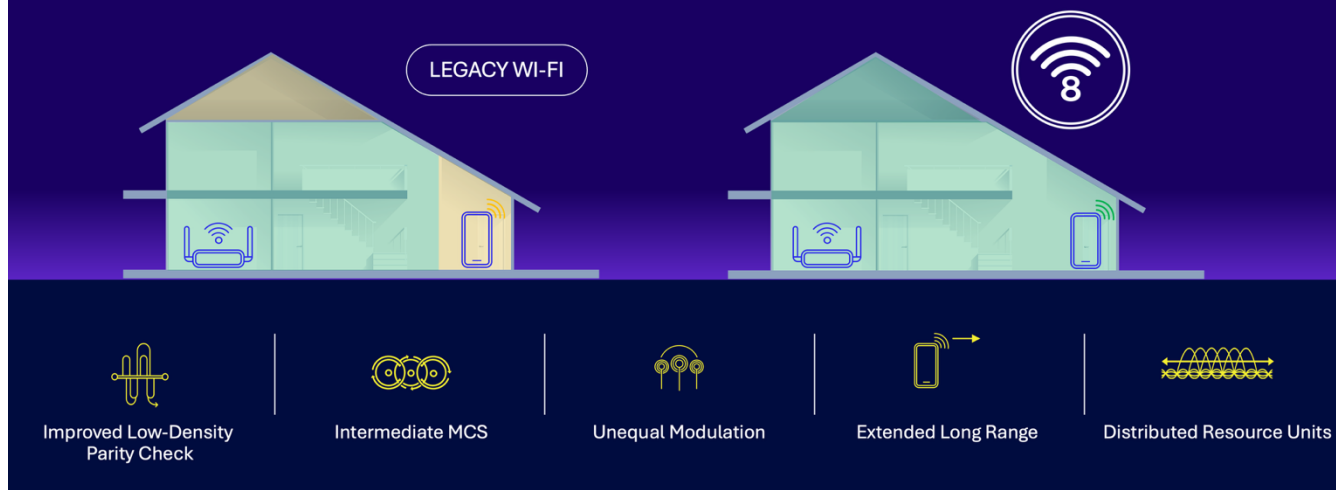
1. The technology behind ultra-high reliability

Wi-Fi technology, like all wireless communication systems, is built on a layered architecture that organizes how data is transmitted and received. Two of the most critical layers in this architecture are the physical (PHY) layer and the medium access control (MAC) layer. The PHY layer is responsible for the actual transmission of data over the air. It defines how bits are converted into radio frequency signals and vice versa, including aspects like modulation, coding and signal strength. The MAC layer, on the other hand, governs how devices access the shared wireless medium, coordinating when and how data packets are sent to avoid collisions and ensure efficient use of the spectrum.

The IEEE 802.11bn standard, which serves as the base for Wi-Fi 8, introduces a suite of innovations at these foundational layers to improve reliability, throughput and responsiveness, especially in challenging conditions. Wi-Fi 8 tackles long-standing limitations in signal handling and spectrum coordination, setting the stage for a new generation of ultra-resilient and high-performance wireless connectivity.

Edge Performance

PHY enhancements for challenging signal environment



Enhancing the physical layer

Wi-Fi 8 brings a wave of targeted PHY layer enhancements to address connectivity challenges like weak uplink signals, inefficient MIMO modulation and signal degradation at the network edge. These enhancements are designed to deliver more robust performance and higher effective throughput in non-ideal signal conditions than any previous generation of Wi-Fi.

- **Improved Low Density Parity Check (LDPC) Coding:** Packet loss and retransmissions can cripple performance in high-throughput or impaired signal conditions. Wi-Fi 8 offers longer block lengths for low-density parity check (LDPC) coding, significantly improving error correction and decoding. This results in fewer dropped packets and more reliable connections, even in noisy or congested environments.
- **Unequal Modulation Across Spatial Streams (UEQM):** Legacy MIMO systems are only as strong as their weakest link, forcing all spatial streams to use the same modulation level. Wi-Fi 8 eliminates this constraint by allowing each stream to adapt its modulation based on individual signal quality. This unlocks higher throughput and greater resilience in environments with uneven signal propagation.
- **Additional Modulation and Coding Schemes (MCS):** MCS defines the combination of modulation formats and coding rates that set how data is encoded for transmission over the air, thereby determining the achievable data rate. For legacy Wi-Fi, the coarse granularity of available MCS levels limited optimal rate adaptation in fluctuating signal environments, leading to suboptimal performance. Wi-Fi 8 introduces intermediate MCS levels, enabling finer-grained rate adaptation. This allows for smoother transitions and more stable performance in scenarios where signal quality varies rapidly, like in mobile or high-density public settings.

- **Enhanced Long Range (ELR):** Devices at the edge of a network, such as outdoor cameras, garage sensors or mobile robots, can suffer from weak uplink signals due to power limitations. This can create an uplink-downlink power imbalance where APs transmit at higher power than clients. ELR addresses this imbalance by improving the link budget, effectively extending network reach and helping maintain reliable connectivity for low-power and distant clients.
- **Distributed Resource Units (DRU):** In the 6 GHz band, regulatory limits on power spectral density (PSD), which cap the transmit power per MHz, restrict the total transmit power. For devices using small Resource Units in an OFDMA transmission, such as 26- or 52-tone RUs, this limitation translates into reduced range and reliability. Wi-Fi 8 addresses this challenge through DRU, which allows to spread tones across a wider frequency range, effectively increasing the total transmit power while staying within PSD limits. In regions with stricter PSD limits, this technique can yield power gains, significantly enhancing signal robustness. The result is extended coverage, improved link reliability, and better performance for clients.

Together, these PHY layer innovations form the foundation of Wi-Fi 8's ultra-high reliability promise, ensuring performance remains consistent, robust and efficient, while also increasing range and boosting throughput in challenging wireless conditions.

Seamless Roaming

Single Mobility Domain: Seamless handoffs between access points

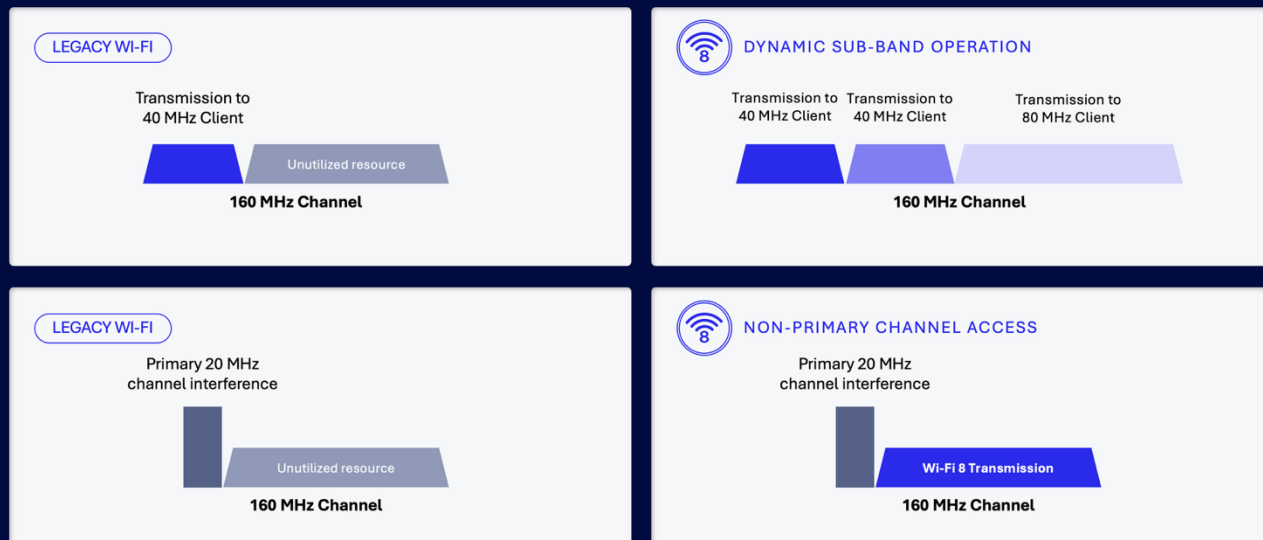


MAC layer innovations

- **SMD Roaming:** The **single mobility domain (SMD)** is a key feature of Wi-Fi 8, designed to deliver seamless roaming across multiple access points without handoff interruptions which can cause packet loss, latency spikes or dropped connections. Legacy Wi-Fi roaming involves disconnecting from one AP and re-connecting (including reassociation and security setup) with another, which introduces delays and data discontinuity. This break-before-make roaming can cause latency spikes, packet loss resulting in audio/video glitches during movement and a poor user experience. In a single mobility domain, multiple APs are logically grouped into a unified domain. A client device maintains its association and security context across multiple APs and remains continuously connected as it moves between APs. SMD roaming is handled via a make-before-break mechanism, meaning the device establishes a new connection before releasing the old one. These innovations are designed to enable Wi-Fi 8 to deliver virtually seamless connectivity and consistent performance as users and devices move through coverage zones.
- **Spectrum Efficiency:** Wi-Fi 8 introduces several mechanisms to improve how spectrum is utilized, especially in dense environments and where devices with varying capabilities must coexist efficiently.

Spectrum Efficiency

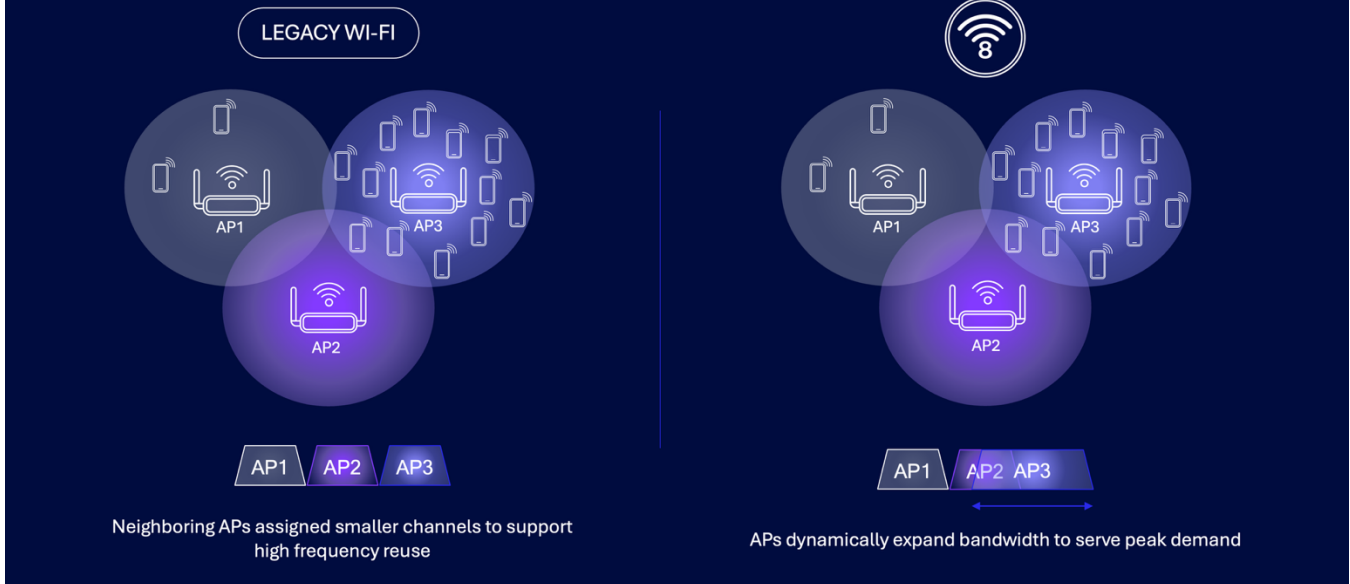
Dynamic Sub-Band Operation (DSO), Non-Primary Channel Access (NPCA)



- **Dynamic Sub-Band Operation (DSO):** Today, typically only premium clients support the full 320 MHz, or 160 MHz bandwidth offered by APs, leading to portions of the spectrum being unused and inefficiently allocated. DSO allows multiple narrowband devices to simultaneously operate within different portions of the wideband channel, maximizing spectrum utilization and increasing throughput in mixed-device environments.
- **Non-Primary Channel Access (NPCA):** When the primary channel is busy due to overlapping BSS (OBSS) traffic or other conditions, NPCA allows Wi-Fi devices to opportunistically access a secondary channel. The key benefit is that it enables stations to continue transmitting data by switching to a designated NPCA channel rather than waiting for the primary channel to become free, which improves overall network efficiency and reduces transmission delays in dense environments. Specifically, NPCA helps mitigate the impact of channel congestion caused by neighboring networks by allowing devices to dynamically switch and contend for access on less congested channel frequencies. This can lead to higher throughput, lower latency and better spectrum utilization, especially in scenarios where multiple networks overlap and compete for airtime on the same primary channel.

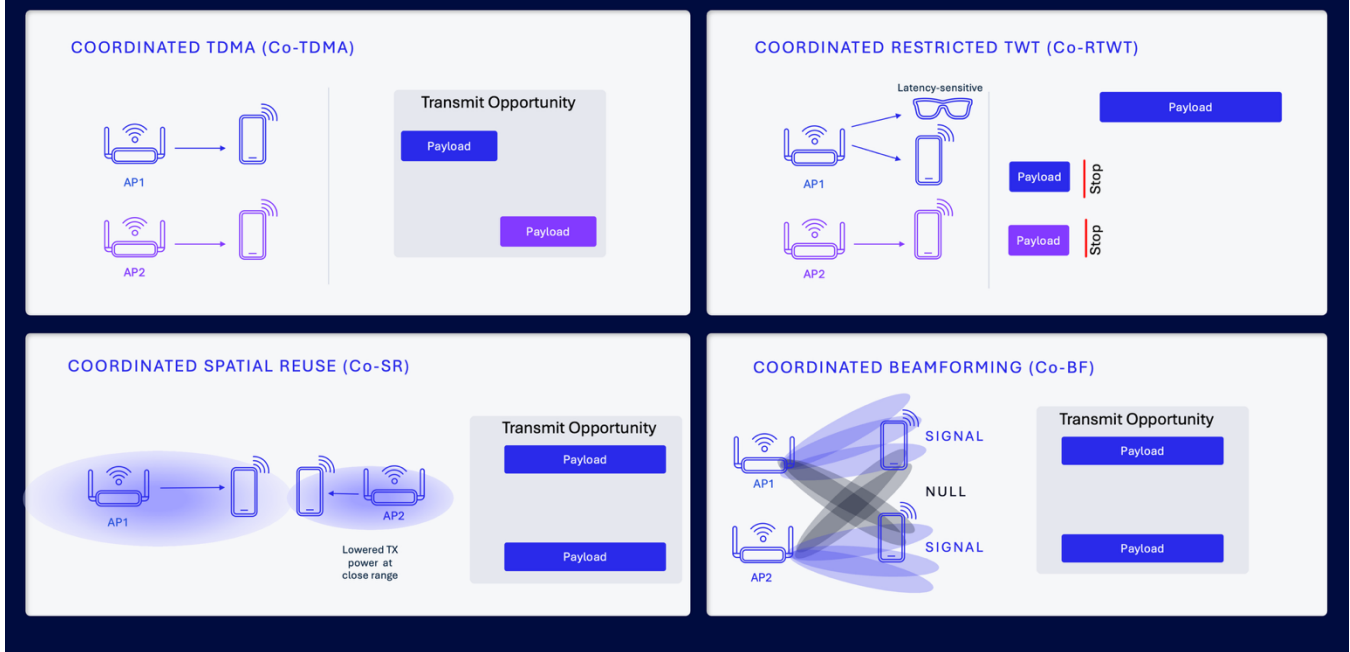
Spectrum Efficiency

Dynamic Bandwidth Expansion



- **Dynamic Bandwidth Expansion (DBE):** Enterprise deployments often avoid wide channels due to frequency reuse constraints. DBE allows APs experiencing high traffic to temporarily expand their operating channel bandwidth to serve high traffic loads, improving throughput without disrupting legacy clients when other channels are not highly utilized. This is especially useful in enterprise deployments where frequency reuse limits the use of wide channels like 160 or 320 MHz.

Multi-AP Coordination



- **Multi-AP Coordination:** In dense environments with overlapping networks, unmanaged interference and contention can severely degrade performance. Wi-Fi 8 addresses this by introducing coordinated mechanisms that enable APs to operate as a unified system, reducing collisions and improving spectrum efficiency.
 - **Coordinated TDMA (Co-TDMA):** Enables APs to share transmission opportunities in a time-sliced manner, reducing contention and latency. By distributing airtime across coordinated APs, Co-TDMA enables more predictable access and improved performance for latency-sensitive applications.
 - **Coordinated Restricted Target Wake Time (Co-rTWT):** APs coordinate the times of access windows to facilitate priority access for latency-sensitive traffic, enabling more deterministic performance even in congested environments.
 - **Coordinated Beamforming (Co-BF):** APs use advanced antenna steering to focus signals on clients and null interference toward neighboring APs. This improves signal quality, reduces contention, and allows more efficient spectrum reuse in dense deployments.
 - **Coordinated Spatial Reuse (Co-SR):** Allows access points to dynamically adjust transmit power based on the link conditions between the AP and a given client. This enables simultaneous transmissions on the same channel in dense multi-AP deployment scenarios. The feature improves overall throughput and efficiency in dense environments.

These coordination mechanisms allow Wi-Fi 8 to deliver consistent, high-throughput, low-latency connectivity in environments with high device density and overlapping coverage.



2. Mapping Wi-Fi 8 features to real-world environments

Wi-Fi 8 is designed not just for theoretical gains, but for impact; its innovations are tuned to the realities of modern connectivity, where reliability, responsiveness and efficiency are mission-critical. Let's explore how the technical breakthroughs, many spearheaded by Qualcomm Technologies, connect to the environments where they'll reshape expectations and redefine what wireless performance feels like.

Enterprise & Industrial IoT: Enabling intelligent and autonomous operations

Enterprise and industrial environments have long relied on wired Ethernet to meet the stringent demands for operations like robotic assembly, real-time monitoring, high-quality conferencing and increasingly AI-driven automation that require ultra-reliable, low-latency connectivity. Wi-Fi 8 introduces the opportunity to deliver that same level of reliability over wireless, unlocking new flexibility for intelligent operations.

- For example, **single mobility domains** allow autonomous mobile robots to roam across large factory floors without experiencing reduced throughput or latency spikes. A technician using an XR headset can move between APs while maintaining a seamless video feed without buffering or interruptions.
- In dense deployments, typical of enterprise campuses and factory settings, multi-AP coordination technologies, such as **coordinated TDMA (Co-TDMA)** and **restricted target wake time (Co-rTWT)** allow APs to collaboratively manage transmissions. In a factory setting, where autonomous robots depend on real-time control updates, these technologies can reduce contention and mitigate interference by sharing transmission opportunities and enforcing exclusive access windows for latency-sensitive traffic, thus enabling deterministic operation of these time-critical industrial systems.

- At the network edge, **enhanced long range (ELR) and improved LDPC coding** extend coverage and improve reliability for devices like surveillance cameras and IoT sensors, which often operate in challenging RF conditions.

Residential: Consistent, high-throughput, low-latency coverage

While earlier Wi-Fi generations delivered their strongest performance closest to the access point, Wi-Fi 8 is designed to extend that experience, delivering consistently higher throughput and lower latency throughout the home.

- To help maintain strong connections in areas farther from the router, **enhanced long range (ELR) and distributed resource units (DRU)** improve uplink reliability for distant devices and IoT endpoints such as cameras and sensors.
- **Additional modulation and coding schemes (MCS)** provide finer-grained rate adaptation, smoothing out performance in dynamic conditions and supporting bandwidth-intensive applications like streaming and gaming.
- For homes with multi-AP mesh networks, **multi-AP coordination** features enable nodes to manage fronthaul and backhaul traffic more efficiently. The Single Mobility Domain (SMD) featureset has the potential to significantly improve the overall user experience for users that are moving throughout their homes while being connected.
- Finally, **power efficiency** features for both clients and APs help reduce energy consumption in always-on residential gateways, supporting sustainability goals without compromising responsiveness.

Public spaces: Virtually seamless connectivity in high-density venues

In public venues like airports, stadiums and transit hubs, Wi-Fi 8 tackles the dual challenge of high user density and constant mobility.

- Key features such as **multi-AP coordination, dynamic sub-band operation (DSO) and non-primary channel access (NPCA)** work in concert to dramatically boost capacity and manage interference in these crowded environments. By coordinating transmissions across multiple access points, they reduce collisions and maximize throughput with low latency, even when thousands of devices are competing for bandwidth.
- Meanwhile **dynamic bandwidth expansion (DBE)** allows APs to temporarily widen their operating channels to handle traffic surges. For instance, during a halftime show or a busy airport rush, when large crowds simultaneously stream high-definition video or upload content, Wi-Fi 8 APs can momentarily open wider channels to accommodate the spike in demand. This can ensure that no one experiences a slowdown, even during peak usage.
- The **single mobility domain** feature further enhances user experience by enabling seamless roaming across APs. As people move through a venue, their devices hand off between APs without dropping connections, eliminating audio/video glitches during calls or streaming sessions.

In summary, Wi-Fi 8 introduces a suite of innovations designed to meet the demands of modern connectivity, where mobility, density and responsiveness are critical. Together, these innovations enable systems to operate with the precision, responsiveness and reliability traditionally reserved for wired infrastructure, while also delivering significantly faster wireless connectivity in scenarios where legacy Wi-Fi struggled.

As a leader in wireless innovation, Qualcomm Technologies is driving the development of Wi-Fi 8, delivering advanced connectivity solutions that empower enterprises, public spaces and homes worldwide. With our deep expertise in wireless technologies, we are uniquely positioned to unlock the full potential of Wi-Fi 8 for intelligent computing at the edge.

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Rolf De Vegt is currently VP of Technical Standards at Qualcomm Technologies, Inc. With over 30 years of telecommunication and semiconductor industry experience, he leads technology standard development for key technologies in the connectivity semiconductor business unit and leads Qualcomm participation in IEEE802.11 standardization.

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