Wi-Fi 7: The next generation in the evolution of Wi-Fi

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Wi-Fi 6 has just been launched, but Wi-Fi 7 is already on the horizon as the next generation of Wi-Fi, continuing an impressive evolution of a technology that was launched over 20 years ago. What new features and capabilities will Wi-Fi 7 deliver? Who will need Wi-Fi 7? When will it be available? In the next pages we present an overview of Wi-Fi 7 and the anticipated benefits that it will bring to Wi-Fi users.

Successful technologies evolve continuously – the evolution never stops. The more successful the technology, the greater the need to keep improving the user experience. Wi-Fi is one of the most successful wireless technologies. And with success comes the need to innovate.

Wi-Fi must continue to improve performance, increase spectrum efficiency, reduce costs, and, most importantly, and make the user experience better to retain its prominence. Together with 5G, Wi-Fi will keep us connected and extend its reach to those among us who are still unconnected.

This is why, even as Wi-Fi 6 was just becoming commercially available in 2019, work was already underway on the next generation, Wi-Fi 7, within the IEEE 802.11be Extremely High Throughput (EHT) working group.

Wi-Fi 7 has ambitious goals and must meet tight requirements to meet our increasing connectivity needs. The IEEE has still a lot of work ahead, and plans to approve and publish the 802.11be amendment by mid-2024, and we expect to see commercial equipment by that same time, along with a certification program by the Wi-Fi Alliance to ensure interoperability.

What to expect from Wi-Fi 7

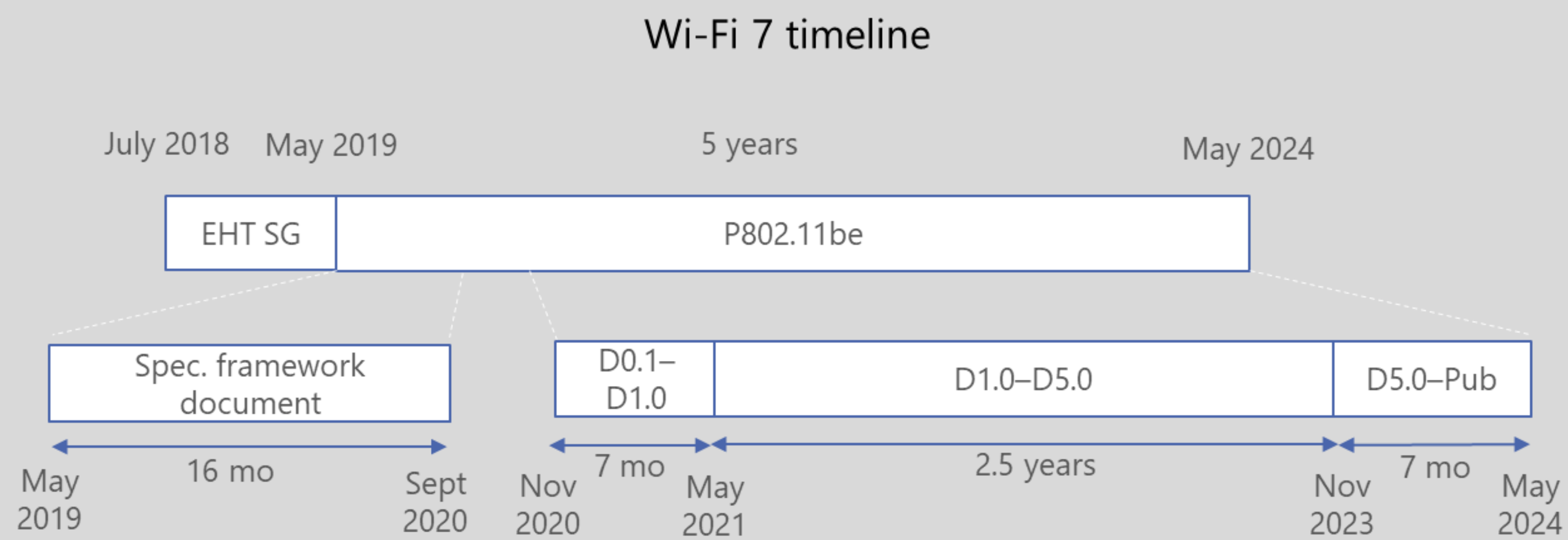
- Higher data rates
- Lower latency
- Higher spectrum efficiency
- Higher power efficiency
- Better interference mitigation
- Higher capacity density
- More connected devices
- Higher cost efficiency

Wi-Fi 7 Timeline

The IEEE 802.11be Enhancements for Extremely High Throughput amendment will define the next generation of Wi-Fi. It is scheduled to be completed by May 2024.

It is expected that the Wi-Fi Alliance will base Wi-Fi 7 on 802.11be and launch a certification program as soon as the standardization process is sufficiently mature.

As with previous Wi-Fi generations, pre-certified products may be available even before the publication of the IEEE amendment. We expect a gradual deployment of Wi-Fi 7 networks to follow the enterprise refresh cycles and home AP updates. Wi-Fi's backwards compatibility ensures a smooth transition to Wi-Fi 7, enabling devices to connect to networks using previous Wi-Fi generations.



Source: Intel Corporation

While Wi-Fi 7 is not yet here and many of the new features are still being defined, the progress toward the new standard shows us the trajectory of Wi-Fi's technological evolution – where Wi-Fi is heading, what we can expect from it, and what the pace of change will be. Wi-Fi 6 marked a great step forward from Wi-Fi 5. The table below shows the pattern of Wi-Fi evolution. Wi-Fi 6 improvements went well beyond the increase in throughput. It fundamentally changes how Wi-Fi transmits and manages traffic and this improves the overall quality, reliability and security of the technology.

Wi-Fi 7 will take Wi-Fi further ahead in the same direction. It will still use OFDMA, but it will enhance it to make it more flexible and efficient, and with the added option to use 4096-QAM. MU-MIMO will support 16 spatial streams, up from 8 in Wi-Fi 6. The maximum channel size (320 MHz) is doubled and makes Wi-Fi 7 ideally suited to benefiting from access to the 6 GHz band, the most recent band added for unlicensed use and supported by Wi-Fi 6E. The new features of Wi-Fi 7 bring a huge increase in the maximum data rate – 46 Gbps, although higher data rates may be achieved in some environments and configurations. Wi-Fi 7 will also bring lower latency, as well as increased flexibility in using network and spectrum resources.

Wi-Fi generations

	Wi-Fi 4	Wi-Fi 5	Wi-Fi 6	Wi-Fi 6E	Wi-Fi 7 (expected)
Launch date	2007	2013	2019	2021	2024
IEEE standard	802.11n	802.11ac	802.11ax		802.11be
Max data rate	1.2 Gbps	3.5 Gbps	9.6 Gbps		46 Gbps
Bands	2.4 GHz and 5 GHz	5 GHz	2.4 GHz and 5 GHz	6 GHz	1–7.25 GHz (including 2.4 GHz, 5 GHz, 6 GHz bands)
Security	WPA 2	WPA 2	WPA 3		WPA3
Channel size	20, 40 MHz	20, 40, 80, 80+80, 160 MHz	20, 40, 80, 80+80, 160 MHz	20, 40, 80, 80+80, 160 MHz	Up to 320 MHz
Modulation	64-QAM OFDM	256-QAM OFDM	1024-QAM OFDMA		4096-QAM OFDMA (with extensions)
MIMO	4x4 MIMO	4x4 MIMO, DL MU-MIMO	8x8 UL/DL MU-MIMO		16x16 MU-MIMO

Source: IEEE, Intel Corporation, Wi-Fi Alliance

Today’s leading edge in Wi-Fi: Wi-Fi 6

Launched in 2019, Wi-Fi 6 is the latest Wi-Fi generation, and it is a big step forward from Wi-Fi 5. Technological progress is the foundation for Wi-Fi 6, but the drivers for adoption are the increased reliance on Wi-Fi for connectivity and the demand for higher data rates, lower latency, higher reliability and better security, in both the enterprise and consumer markets. Wi-Fi 6 is well suited to supporting the applications of smart homes and the services and IoT and industrial IoT (IIoT) applications in the enterprise. Key features in Wi-Fi 6 include:

- Increased data speeds up to 9.6 Gbps, compared to 3.5 Gbps in Wi-Fi 5.
- Up to 160 MHz bandwidth channels.
- Wi-Fi 6E adds support for the 6 GHz band, where available, in addition to the global 2.4 GHz and 5 GHz unlicensed bands supported by Wi-Fi 4 and Wi-Fi 5.
- Better network efficiency, lower latency, increased range with OFDMA, UL and DL MU-MIMO, 1024-QAM subcarrier modulation and transmit beamforming (BF).
- Improved spectrum efficiency and resource allocation, better service level agreement (SLA) compliance with transmission scheduling.
- Higher spatial reuse (SR) and color coding to support high-density deployments.
- Introduction of target wake time (TWT) to improve network efficiency and to prolong device battery life.

Wi-Fi 7 technology	
EHT preamble and packet format	Universal signal field (U-SIG) will provide forward compatibility for future changes in frame formats (e.g., for version, uplink/downlink [UL/DL], transmission opportunity [TXOP] and duration) and will facilitate support for multiple PHY frame formats within the same network.
320 MHz max channel size	Doubling the max channel size from Wi-Fi 6 can double the throughput. Wi-Fi 7 also supports 160+160 MHz, 240+180 MHz, and 160+80 MHz channels to combine non-adjacent spectrum blocks.
4096-QAM	4096-QAM can increase throughput by 20%, but its use is optional and lower modulation schemes continue to be supported. Because it needs a high signal-to-noise ratio, BF may have to be used in conjunction with 4096-QAM.
Enhanced OFDMA	With Wi-Fi 6, Wi-Fi moved to OFDMA. Wi-Fi 7 will increase OFDMA's flexibility, by allowing the allocation of punctured resource units (RUs) to a single station (STA) (see below) and by allowing direct link transmission. The enhancements to OFDMA will increase spectrum efficiency, reduce latency, and improve user experience and support for more demanding use cases.
16 spatial streams MU-MIMO	The doubling of spatial streams – from 8 to 16 – in Wi-Fi 7 can double the network throughput in certain scenarios. MU-MIMO increases flexibility and spectrum efficiency by independently handling the connection from antennas at the AP and at the STA.
Multi-link operation (MLO)	With MLO, devices can simultaneously transmit and/or receive across different bands and channels, with separation of data and control planes. The parallel links increase the throughput to the device, lower the latency and improve reliability. Data flows can be assigned to specific links based on application or device requirement, leading to increased reliability and performance for IoT/IIoT and other enterprise applications.
Multi-AP operation	Coordination among neighboring APs improves resource and spectrum utilization, reliability, throughput, and latency. A set of APs can form a system in which channel access and transmission schedule are tightly coordinated. Coordination may include OFDMA, SR, TDMA, BF and joint processing (JP). With coordinated OFDMA, APs transmit to STAs on different RUs. With coordinated SR, APs transmit to STAs on the same RU. With coordinated TDMA, different APs take turns in transmitting to STAs on the same RU. With coordinated BF, the initiating AP can transmit to its own STAs using the same RUs, while the recipient AP transmits to its own STAs, eliminating interference. Coordinated JP establishes a distributed MU-MIMO system that allows multiple APs to connect the same STA.
Deterministic low latency	MLO, multi-AP, wider channels, and support for 802.1 time-sensitive networking (TSN) will further decrease latency, especially in congested environments, to support real-time applications with tight requirements such as gaming, AR/VR and some IIoT applications. Not only will latency be lower, it will also be more deterministic – the latency over the Wi-Fi link will be less variable and more predictable. Deterministic latency is valuable in applications that can tolerate consistent latency, and in URLLC applications (for instance, in some industrial automation applications) that do not tolerate variance in latency.
Multi-RU (puncturing)	OFDMA enhancements increase spectrum efficiency and flexibility by assigning punctured resource units (RU) per STA. With this feature, Wi-Fi 7 can use puncturing to eliminate transmission in parts of the channel (up to 20 MHz) to accommodate spectrum restrictions that may prohibit the use of part of the band. Puncturing also makes it possible to use wide channels in environments where there is insufficient contiguous spectrum available.

The performance and efficiency improvements that Wi-Fi 7 promises are impressive, but do we need them? Isn't Wi-Fi 6 good enough? The specifications for Wi-Fi 7 are based on the anticipation of an increased adoption of use cases with strict latency and reliability requirements. Wi-Fi 6 meets the demand for these use cases today, but Wi-Fi 7 enhancements will allow Wi-Fi to scale as adoption – and hence traffic density – grows and as requirements become more stringent. Wi-Fi 7 provides a forward path to ensure that Wi-Fi retains the scalability to carry increasing traffic loads and continues to meet users' requirements.

Wi-Fi 7 brings more flexibility and capabilities to enterprises as they embark in the digital transformation. Wi-Fi 7 and 3GPP-based 5G will work together to introduce edge computing, distributed and cloud architectures, virtualization and digitalization in the emerging private wireless networks (PWN).

More specifically, Wi-Fi 7 will improve support for applications that require deterministic latency, high reliability and quality of service (QoS).

In the enterprise, this will benefit IoT and IIoT applications, such as industrial automation, surveillance, remote control, AV/VR and other video-based applications. Consumer users can benefit from Wi-Fi 7 for gaming, AV/VR and video applications, and for smart-home services.

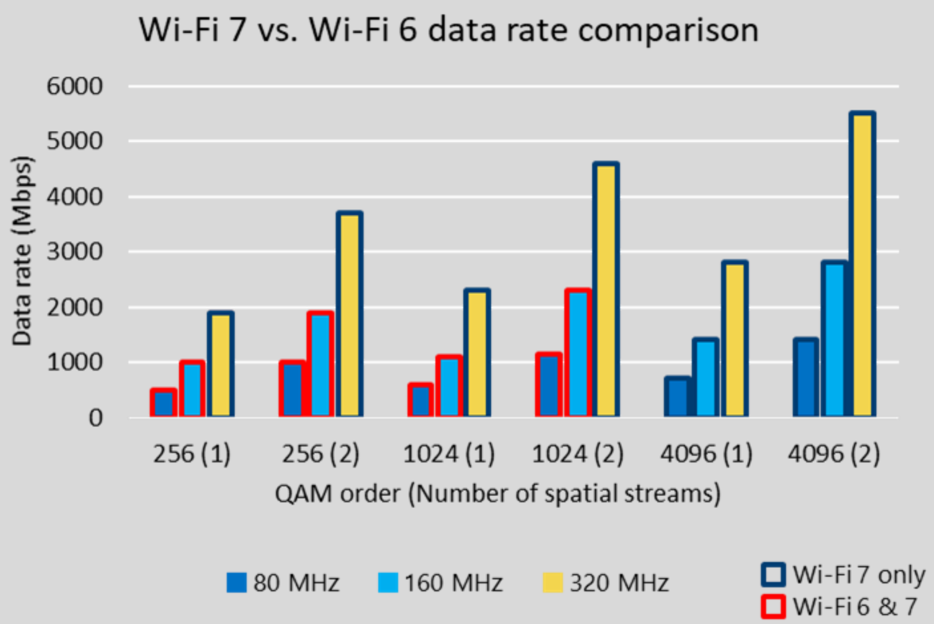
Beyond specific use cases, Wi-Fi 7 will continue to expand the availability of Wi-Fi and to transport most of the wireless traffic in enterprise, public and residential environments, in a cost-effective way and further improving the efficiency in using precious spectrum resources.

Data rates in Wi-Fi 6 and Wi-Fi 7

One of the main goals of Wi-Fi 7 is to increase capacity and data rates above the 9.6 Gbps of Wi-Fi 6 in three 160 MHz channels with 1024-QAM and 8 spatial streams. In Wi-Fi 7, the maximum data rate is 46 Gbps in a 320 MHz channel in 6 GHz and one 160 MHz channel in 5 GHz, with 4096-QAM and 16 spatial streams. The doubling of spatial streams and the doubling of channel bandwidths results in an increase of 4.8 times in throughput from Wi-Fi 6 to Wi-Fi 7.

The figure below shows how the data rate of Wi-Fi 7 increases with a combination of wider channels, higher QAM and more spatial streams. Data rates for channels up to 160 MHz and for 256 and 1024 QAM are comparable for Wi-Fi 6 and Wi-Fi 7. Moving to 4096-QAM improves the data rate, but the major impact comes from doubling the size of the channel to 320 MHz and increasing the number of spatial streams.

Increased spectrum availability will be key to benefit from the increase in data rates due to the wider channels. The availability of large swaths of so far largely unused spectrum in the 6 GHz band in the US and in the UK – and soon in other countries – for unlicensed use will facilitate the use of wide channels. The 320 MHz channels, however, can also be used in the 5 GHz band in countries where enough spectrum is available. Where spectrum availability is constrained, puncturing with multi-RU makes it possible to establish wide channels using non-contiguous spectrum blocks.



Source: Intel Corporation

Managing Wi-Fi integration and migration in the enterprise private wireless networks (PWN)

PWNs have recently gained traction in telecoms as enterprises have deepened their commitment to deploying and controlling the on-prem network infrastructure. But PWNs are nothing new: Wi-Fi enterprise networks are the most successful example of PWNs. Moving forward, Wi-Fi will continue to play a central role, as PWNs expand their scope.

No longer restricted to Wi-Fi, PWNs will increasingly include cellular and low-power access technologies and new network architectures to accommodate edge computing and network slicing. They will also have to support a wider range of use cases, including IoT and IIoT. As wireless connectivity becomes more central to the operations of the enterprise, the complexity of PWNs will increase in step with the increased capabilities.

Enterprises have to make many choices. Which technologies should they deploy? When and where should they deploy them? Which access technologies are best positioned to support specific services and applications? Can the same service or application be supported by more than one access technology? How well-integrated should access technologies be?

Backward compatibility in Wi-Fi ensures a smooth transition to Wi-Fi 6 today, and Wi-Fi 7 a few years from now. Any new generation of Wi-Fi APs and devices operates with previous Wi-Fi generations. This means that network upgrades can be gradual, following an enterprise's refresh cycle or its growing capacity, coverage or performance requirements. Enterprises will be able to set their own pace in the migration path to Wi-Fi 7, and can also trust that they will continue to benefit from their investments in Wi-Fi 6.

Enterprises that want to add cellular – 4G or 5G in licensed or unlicensed bands, or in shared bands such as CBRS in the US – have the option to integrate Wi-Fi in the cellular core through the trusted WLAN Gateway Function (TNGF) and the Non-3GPP Interworking Function (N3IWF), which enable the cellular core to connect to Wi-Fi. TNGF and N3IWF will continue to work with Wi-Fi 7, making the upgrade from Wi-Fi 6 seamless within the overall PWN.

Software-defined networking (SDN) will further simplify and reduce the cost of network evolution to Wi-Fi 7, by increasing flexibility in the use of network resources – for instance, with configurable air interfaces.

The new approach to a more gradual network evolution that does not require drastic upgrades within 3GPP will allow enterprises to take a holistic approach to the evolution of their PWNs.

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About Monica Paolini

Monica Paolini, PhD, founded Senza Fili in 2003. She is an expert in wireless technologies and has helped clients worldwide to understand technology and customer requirements, evaluate business plan opportunities, market their services and products, and estimate the market size and revenue opportunity of new and established wireless technologies. She frequently gives presentations at conferences, and she has written many reports and articles on wireless technologies and services. She has a PhD in cognitive science from the University of California, San Diego (US), an MBA from the University of Oxford (UK), and a BA/MA in philosophy from the University of Bologna (Italy).