

Whitepaper

Wi-Fi 7 – WHAT IS IT ALL ABOUT?

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Executive Summary

2023 sees the latest version of Wi-Fi enter production – Wi-Fi 7. It maintains its historic strengths and adds major new capabilities. These ensure it is ready for the new and demanding AR, VR, & metaverse services; and also, firmly pushing back on mobile's drive for wider adoption in traditional Wi-Fi markets.

Wi-Fi 7 now supports such advanced capabilities as link aggregation, multi-band communications, multi-Access Points communications, Access Point hand-offs when on the move, and targeted wait time for broadcast.

These capabilities increase the maximum connection speed to 46Gbps, reduce the communications latency, and enhance the connection reliability. Additionally, they improve mobility with automatic Access Point handovers as users move, and increased IoT device battery life by lowering communications demands.

Wi-Fi 7 also maintains its strong record of backwards compatibility for user devices and Access Points. This will ensure that it will be rapidly adopted by the market, that Wi-Fi module costs will remain low, and that the massive ecosystem of equipment will continue. These are attributes that the mobile G's have struggled to achieve.

Looking at the competitive evolution of the cellular and Wi-Fi markets.

- Wi-Fi 7 will secure its dominant position in its main markets of home, office, and enterprise.
- Mobile will continue to dominate in the big geographic spaces and those with significant interference issues. Like national mobile networks, ports, and mines.
- There will be strong competition between Wi-Fi and mobile in the mid-sized spaces like airports, venues, and factories. These are markets where Wi-Fi has historically dominated. Mobile private networks vendors are suggesting that this is a new and big opportunity, but they will need to address operations and costs to increase their market share.



Wi-Fi evolution

There are two main international bodies that control the evolution of Wi-Fi:

- IEEE defines the Wi-Fi standards (www.ieee.org)
- Wi-Fi Alliance tests compliance (www.wi-fi.org)

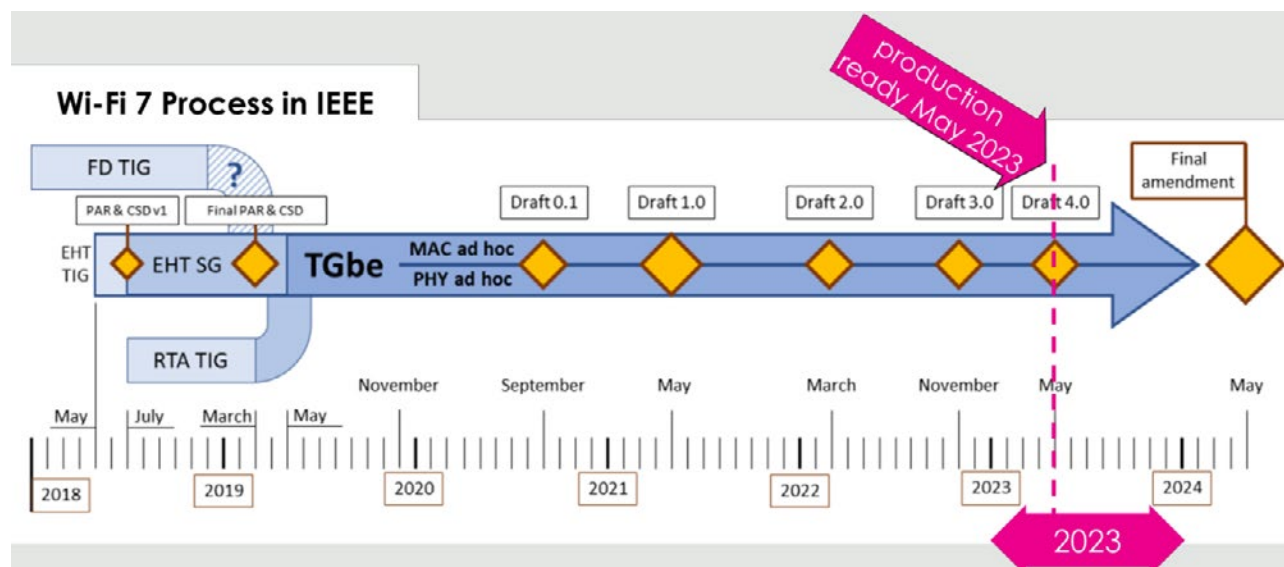


Wi-Fi Generation	IEEE standard	Maximum Link Rate	Deployed	Radio Frequency (Ghz)
Wi-Fi 7	802.11 be	46 Gbs	2023	2.4 + 5 + 6
Wi-Fi 6E	802.11 ax	9 Gbs	2021	2.4 + 5 + 6
Wi-Fi 6	802.11 ax	9 Gbs	2019	2.4 + 5
(Wi-Fi 5)	802.11 ac	7 Gbs	2014	2.4 + 5
(Wi-Fi 4)	802.11 n	0.6 Gbs	2008	2.4 + 5
...				
(Wi-Fi 1)	802.11 b	0.01 Gbs	1999	2.4

In general, each new version of the Wi-Fi standard is backward compatible with all previous versions. So, any new end-user device supporting the latest standard will be able to communicate with any version of Access Point. Though to get the highest speeds you may have to disable some of the older generations.

New Wi-Fi generations are generally well adopted by industry. For example, for 6/6E: the Wi-Fi Alliance predicts an 80% market share of sold Wi-Fi enabled products by early 2025, and IDC predicts 5.2 billion Wi-Fi 7 enabled product shipments in 2025 (for 5G Ericsson predicts 0.6 billion product shipments).

The current Wi-Fi 7 standardization process is nearing an end. The specification will be ready for production in May 2023, with a final version (with minimal change expected) in May 2024. The start of 2023 has already seen the release of Wi-Fi 7 compatible devices.



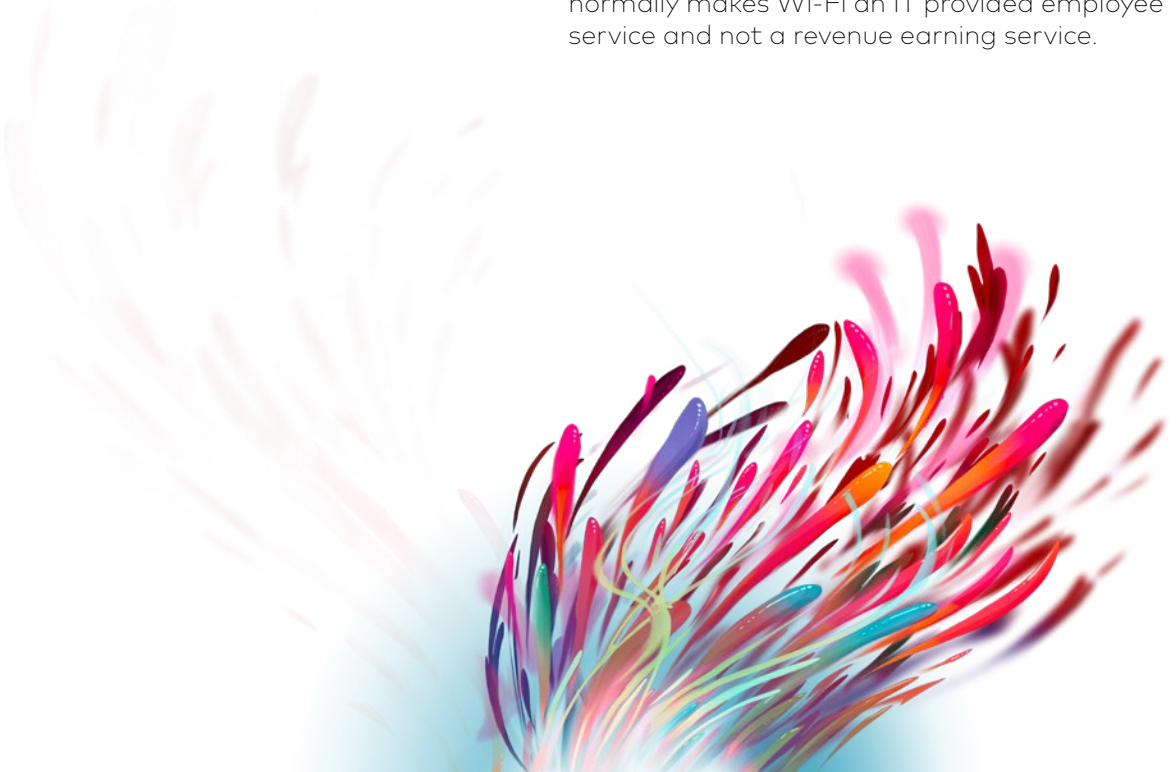
Wi-Fi 7's key feature set

Wi-Fi 7 brings many new features. This section highlights some features that are significant improvements and ones that close perceived gaps between the capabilities of mobile and Wi-Fi.

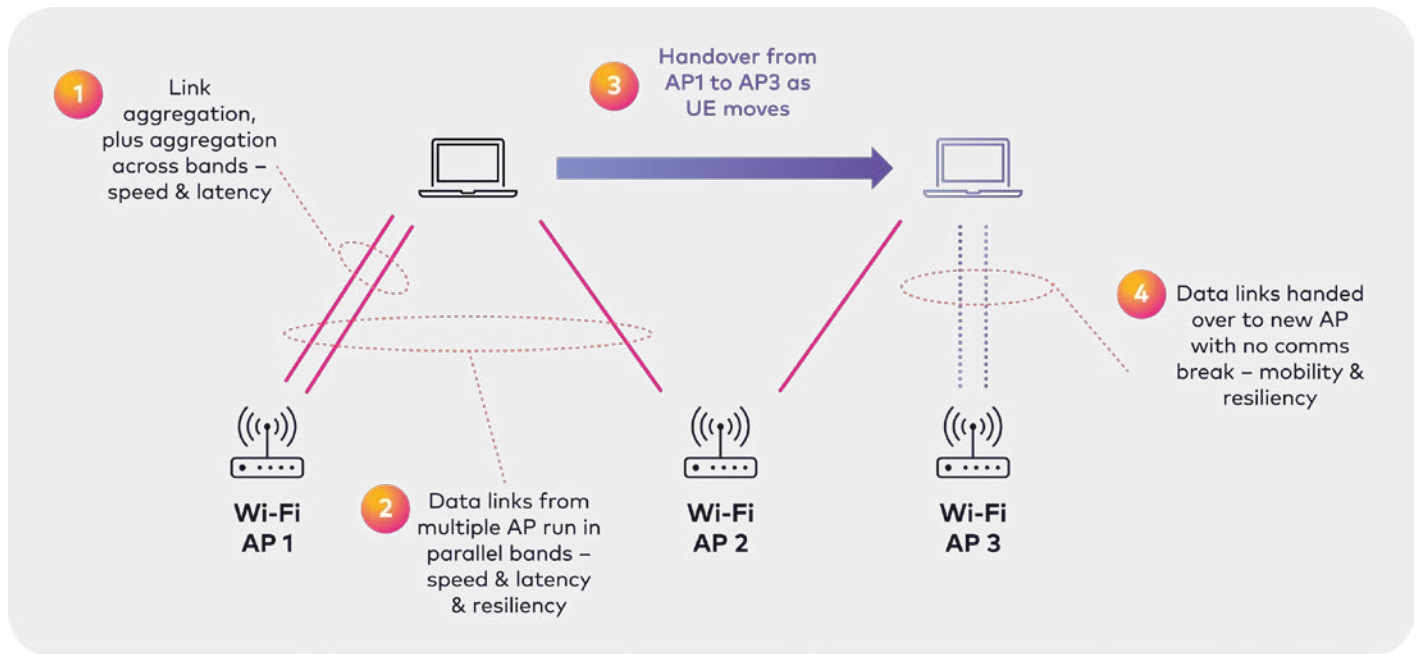
Highlighted features are:

- **Multi-link aggregation:** brings faster speed & lower latency; data transmission can use multiple links from the same AP in parallel.
- **Bigger channels:** brings faster data rates; bigger channel widths at the higher 6GHz frequencies (up to 320MHz).
- **Multi-band congestion avoidance:** brings less congested connections; end-user devices can connect on multiple radio bands and search for the least congested channels.
- **Multi-AP data transfer:** brings faster speeds and more resiliency; end-user devices can send & receive data from multiple APs in parallel.
- **Multi-AP mobility:** maintains a good connection when on the move; end-user devices can connect to multiple AP and can handoff smoothly between each AP.
- **Roaming compatibility:** frictionless end-user device movement between multiple Wi-Fi networks with different providers; OpenRoaming Alliance is enabling global Wi-Fi roaming (also on Wi-Fi 6).
- **Enhanced sensing:** brings more accurate motion sensing; bigger channels make sensing less affected by noise; a location accuracy of approximately 30cm is possible.
- **Restricted Targeted Wait Time (RTWT):** allows low power devices (say IoT) to sleep for extended periods when not transmitting, enhancing battery life.

Unlike mobility, there is less focus on what new paid-for services could be offered to end users. This is for a number of reasons. Backward compatibility of Wi-Fi network generations means that full network upgrades are needed less often as network users can always connect. Most Wi-Fi networks are of smaller scale than national mobile networks so require less investment to change. Most Wi-Fi networks are owned by enterprises to provide connectivity for their employees; so, it normally makes Wi-Fi an IT provided employee service and not a revenue earning service.



Multi-Link and Multi-AP in more detail



Link aggregation (1) enables a device to combine multiple communications channels to an AP. This creates a virtual single channel of a higher bandwidth. Channel aggregation not only is possible within a single band (say the 2.4GHz band) but also across multiple bands (say 2.4GHz + 5GHz + 6GHz). By combining multiple parallel channels in this manner, this effectively reduces latency and increases resiliency.

Further to the simpler link aggregation in (1), it is also possible to aggregate links across multiple APs (2). In this scenario the end user device communicates with multiple APs in parallel in the same or different bands. This effectively reduces latency and, in particular it increases communications resiliency.

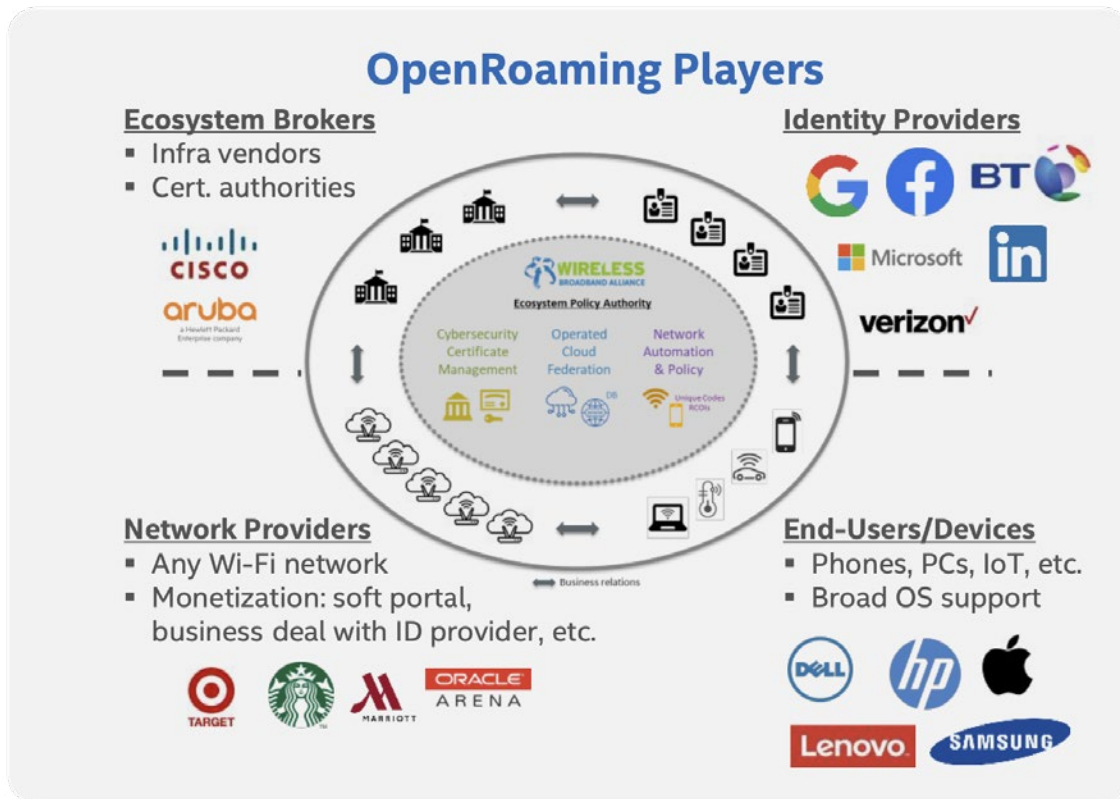
Wi-Fi 7 also improves the handoff (3 & 4) of communications channels from one AP to another AP. Communications links running from one end-user device to an AP can be moved/handed over to a different AP. When this is combined with parallel communications to multiple APs, this means that is much easier for demanding communications (say an AR / VR experience) to be unaffected as

the device moves around a space between APs. This hand-off was poor in previous Wi-Fi versions and resulted in poor user experiences when moving around. Proprietary mesh Wi-Fi solutions had been developed to address this problem.

Wi-Fi roaming – OpenRoaming in more detail

Unlike mobile, Wi-Fi end-user device roaming from one network to another was historically not smooth. It typically involves selecting the new network provider and entering in the credentials for the new network provider before you were permitted access.

OpenRoaming was established (May 2020) to make frictionless roaming on Wi-Fi possible. It is administered by the Wireless Broadband Alliance (WBA). OpenRoaming aims to provide true roaming across Wi-Fi 7 & Wi-Fi 6 network providers with no extra end-user sign-ins. As of May 2022, there were more than 1 million OpenRoaming hotspots.



Typical OpenRoaming network providers could include: CSPs, hospitality & convention centers, airports, transportation hubs, education institutes, cities, governments, retail, restaurants, coffee shops, sports stadiums, arenas, corporate offices, and other public guest Wi-Fi venues.

Many Wi-Fi equipment vendors and device OEMs support OpenRoaming including: Adentro, Airties, Boingo, Broadcom, Cisco (original owner), Cityroam, Cloud4Wi, Commscope, eduroam, Enea, Extreme Networks, GlobalReach, Intel, Kyrio, Samsung, Single Digits.

How it works:

- End-users roam from one OpenRoaming network to another
- As an end-user moves, the device identifies a new OpenRoaming network and it attempts to automatically establish a connection using its OpenRoaming credentials.
- The network owners can set policies that define which OpenRoaming end-users can access their networks and on what basis.
- Network owners can establish payment terms, often with the other network, for paid access to their network. WRIX is the basis for this interconnection and settlement.
- Network owners can present a captive portal and send messages to interact with users. This is a common feature of Wi-Fi networks where new users are provided with landing pages to get T&Cs confirmed, credentials entered, advertising presented, other services offered, and so on.
- The end-users may not be aware of the roaming from one network to another.
- The Wireless Broadband Alliance authority (WBA) is the centralised policy authority for all of the networks.
- OpenRoaming uses technology from Hotspot2.0, Passpoint, and WRIX.

Wi-Fi 7's impact on mobile

With the new Wi-Fi 7 capabilities it is highly likely that Wi-Fi will maintain its consumer home & indoor enterprise business advantage over Mobile technologies.

Wi-Fi 7 is defending its existing leadership in the consumer home & enterprise business indoor markets from mobile technology by

- keeping deployment simple
- keeping the costs incorporating Wi-Fi modules in devices low
- offering an improved networking feature set for demanding applications (key features are higher speeds, multi-AP communications, link aggregation, AP handover)
- having a huge ecosystem of compatible devices (laptops, smart-sensors, smartphones, ...)
- access to free and globally available spectrum in 3 separate bands

Mobile is very unlikely to replace Wi-Fi in the carpeted enterprise (indoor) business and home consumer markets.

In the small factory, retail, & smaller outdoor areas it is likely that there will be strong competition between Wi-Fi & Mobile based solutions.

In the larger outdoor areas (ports, mines, ...) it is expected that mobile will dominate. This is particularly due to its excellent large space coverage capabilities (larger cell sizes), and it has better operations in environments that are complex, dense, and congested.



Conclusion

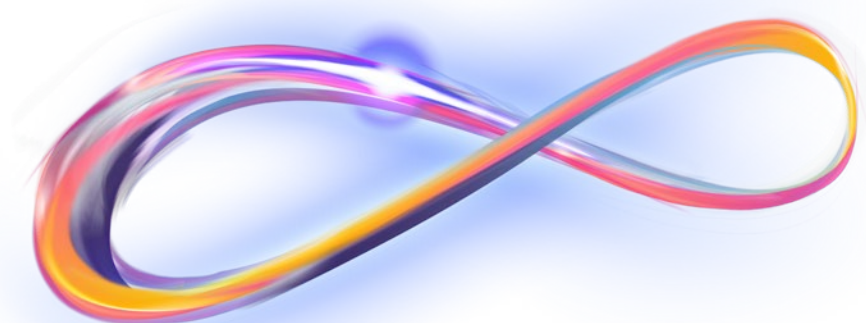
Wi-Fi 7 is formally released in May 2023 by the IEEE and the Wi-Fi Alliance will be ready to do device compliance testing. Backwards compatibility for Wi-Fi versions has been a great enabler for the adoption of each new version and Wi-Fi 7 continues with this approach.

The new Wi-Fi version is a big step forward in capability. It addresses several perceived weaknesses in previous versions and prepares it for next generation services like AR or VR or Metaverse, which are expected to require higher up and down link streaming bandwidths with reduced tolerances for communications delays.

To address these needs Wi-Fi 7 now supports such capabilities as link aggregation, multi-band communications, multi-AP (access point) communications, and AP hand- off. These increase the maximum speed to 46Gbps, reduce the communications latency, enhance the connection reliability, and improve mobility with AP handovers. The multi-AP capability effectively rolls the highly appreciated, but proprietary, mesh Wi-Fi products into the core Wi-Fi standard.

The continued low cost of Wi-Fi modules means that we will likely see the rapid adoption of Wi-Fi 7 in new products during 2023. The availability of the huge Wi-Fi ecosystem is set to continue with Wi-Fi 7.

Wi-Fi 7 is set to secure Wi-Fi's dominant position in its current main markets of home and office. It is likely we will see strong competition with mobile in larger spaces like factories. However, mobile will continue to dominate in the big outdoor spaces like ports and mines due to its better coverage and interference handling.



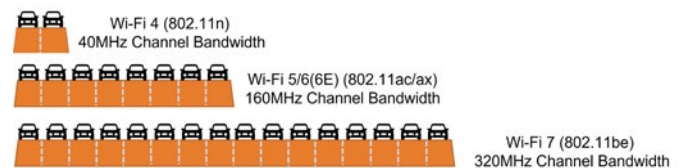
Annex: Further information

Glossary

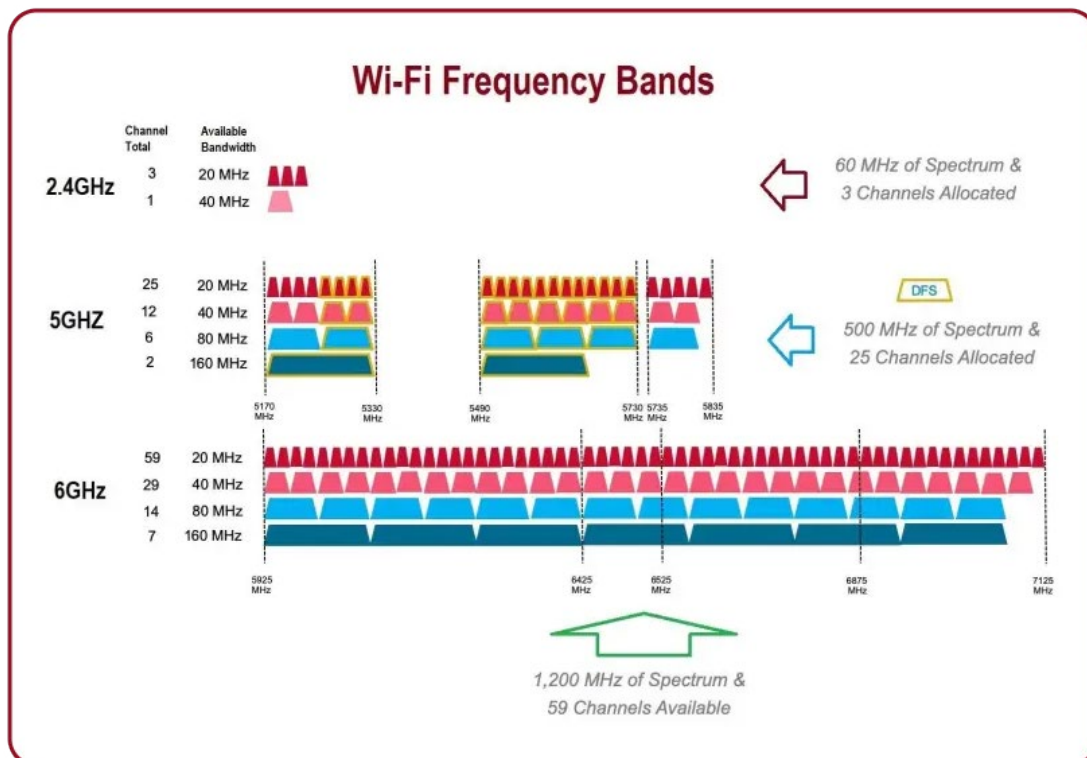
Term	Description
Carpeted business space	It is used to differentiate the factory floor part of an enterprise's premises from administration/office space.
Wi-Fi	Wireless-Fidelity, a common wireless networking technology
QAM	Quadrature Amplitude Modulation – a type of RF modulation
Access Point	Or AP. An AP is a device that creates a wireless local area network, or WLAN, usually in an office or large building. An AP connects to a wired router, switch, or hub via an Ethernet cable, and projects a Wi-Fi signal to a designated area.
WRIX	Set of standards defined by the WBA, designed to facilitate commercial Wi-Fi roaming between operators. Covering: interconnection, data clearing, financial settlement.
WBA	Wireless Broadband Alliance
Wi-Fi Alliance	A non-profit organization that owns the Wi-Fi trademark. Manufacturers may use the trademark to brand products certified for Wi-Fi interoperability.

Wi-Fi Channelization

The 6GHz band has now been opened to Wi-Fi applications, Wi-Fi 7 supports a 320MHz channel bandwidth on this new band while supporting, 20/40/80/160MHz channel bandwidth on both 5GHz and 6GHz bands, and 20/40MHz on the 2.4GHz band. The introduction of 320MHz channel in Wi-Fi 7 can double the maximal nominal throughput when comparing to existing Wi-Fi 6/6E.



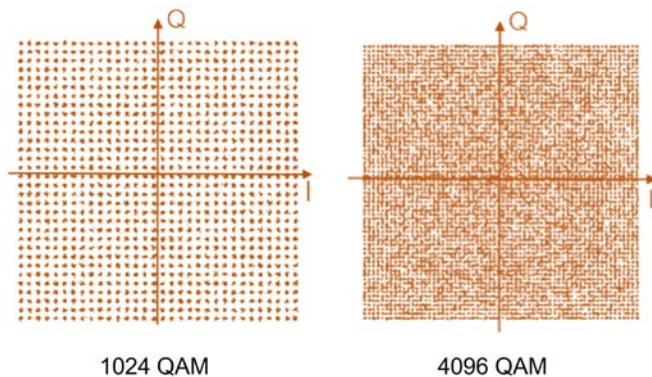
The following diagram shows a more complete view of the channel mapping.



RF modulation

One of the most common Wi-Fi modulation approaches is quadrature amplitude modulation (QAM) – this mixes both amplitude and phase variations in a carrier.

While Wi-Fi 6 supports up to 1024-QAM with 10-bit constellations, Wi-Fi 7 supports 4K- QAM with 12-bit constellations. The two-bit increase in information carried represents a 20% increase in speed.



Multi-Link Operation

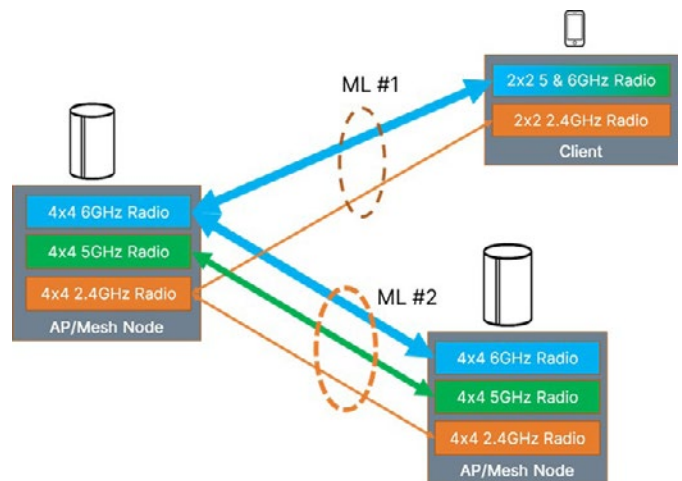
Multi-Link Operation: Multi-link Operation (MLO) allows network devices to communicate across multiple bands and channels at the same time.

Like the link aggregation / trunking features of wired Ethernet, it offers greater sophistication and flexibility by creating bundling or bonding of several radio links to work as a high bandwidth (virtual) link between network devices.

The individual radio links can work both independently and simultaneously, as well as coordinating to enhance aggregate speeds, latency, range (coverage), or power saving.

MLO within Wi-Fi 7 is a MAC layer solution for concurrently using multiple links and is transparent to the higher-layer protocols and services.

It is highly useful in improving throughput, link robustness, roaming, interference mitigation, and reducing latency.



Sources

- <https://www.electronicsspecifier.com/industries/wireless/wi-fi-7-a-huge-step-forward-for-networking>
- www.wi-fi.org
- www.ieee.org
- www.wballiance.com/openroaming/

Why Amdocs

Amdocs leverages a deep understanding of existing capabilities and strategies to create tailored solutions that combine our assets with those of the service providers' enterprise customers. Our holistic solution design approach considers enterprise requirements, use cases, future vision, as well as the degree to which the enterprise wishes to manage its network operations.

Leveraging our vendor experience, flexible solution blueprints, and mobile private network deployment experience, we provide a single point of accountability for committed SLAs, while minimizing risks associated with mobile private network implementations. Meanwhile, our global delivery and support organization – spanning RAN, core, cloud, IT, system integration, transport, security, and software domains – enables us to manage all the complexities of an end-to-end mobile private network solution.

With our combination of deployment and automation, mobile private network management portal, and AI-enabled operations services, we lead the industry in enhancing the customer experience, while improving overall operational efficiencies.

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