5G and Wi-Fi: Charting a path toward superior indoor connectivity

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Meeting the market need for superior indoor connectivity technology

Having entered the market at a similar time, the two latest wireless standards 5G NR and Wi-Fi 6, both address the acute need for advanced connectivity. Each one boosts the bandwidth and capacity for both today's and tomorrow's networks, and both are faster than their predecessors (4G/LTE and Wi-Fi 5), more energy-efficient, and capable of supporting a greater number of devices simultaneously. How then can a service provider know which one to pick in favor of the other? The decision is not necessarily easy.

For any service provider in the process of comparing the advantages of each option, it is advisable to consider the following:

- ✓ Reliability requirements of the traffic.
- ✓ Critical low-latency requirements.
- ✓ The need for mobility and outdoor wide-area connectivity.
- ✓ A complete and future proof solution addressing current and future needs.

Wi-Fi 6 is suited to indoor or local area deployments and use cases requiring high speed, and best-effort traffic. But since Wi-Fi operates on unlicensed spectrum, its reliability and availability cannot be guaranteed. In critical use cases requiring highly reliable, low-latency connectivity and/or wide-area deployment, 5G is the best fit.

While both 5G NR and Wi-Fi 6 serve a specific purpose well, they share overlapping territory in which they are viable alternatives. That is, namely: in indoor use cases where reliable and predictable connectivity is not required.

5G and Wi-Fi: both have a role to play

With the arrival of every new generation of technology, the comparison of 3GPP and IEEE-based solutions have traditionally been a hot topic for discussion. And the advent of 5G NR and Wi-Fi 6 is no different. Both standards are technologically superior to their predecessors, and each has a role to play in today's and tomorrow's networks. Each technology has its strengths and selling points, so there is a solid case for using both as viable solutions. Rather than being regarded as competitors, we argue that the technologies should be viewed as co-existing solutions, each with plenty of benefits to offer, depending on the deployment situation.

The boost given to Wi-Fi 6 in terms of capacity, efficiency, and flexibility has aligned it with emerging 5G priorities. Unlike its predecessor, Wi-Fi 5 (IEEE802.11ac), the standard can support up to 12 simultaneous user streams from a single Wi-Fi access point, 8x8 multiuser MIMO for both uplink and downlink, and offers greater flexibility to deploy channel sizes from 20MHz to 160MHz, accommodating specific use-case requirements. The addition of OFDMA improves Wi-Fi performance, driving greater efficiency, and lower latencies in arenas, auditoriums, and other high-density environments. Wi-Fi is certain to remain popular, providing last-hop access to wireless devices in people's homes. It will also continue to serve enterprises' non-critical use cases effectively in mainly indoor deployments.

5G, on the other hand, is a complete solution for enhanced mobile broadband (eMBB), fixed wireless access (FWA), massive machine-type communication (M-MTC), and critical machine-type communication (C-MTC). It supports both the wide-area and indoor connectivity needs of consumers, enterprises and the public sector alike.

5G NR has given dramatic capability boost to cellular communication leveraging wide range of frequencies (sub-1 GHz to 100 GHz) with very large bandwidths, seamless carrier aggregation across multiple bands, massive number of steerable antenna elements, flexible and scalable physical layer for handling diverse scenarios, ultra-lean design for energy efficiency,advanced critical MTC features for ultra-reliability, ultra-low latency, interruption-free mobility, and Time-Sensitive Networking (TSN), and fully flexible end-to-end network slicing and QoS framework. With these capabilities, 5G NR is much more attractive technology for addressing demanding indoor connectivity requirements than the earlier generations of cellular systems.

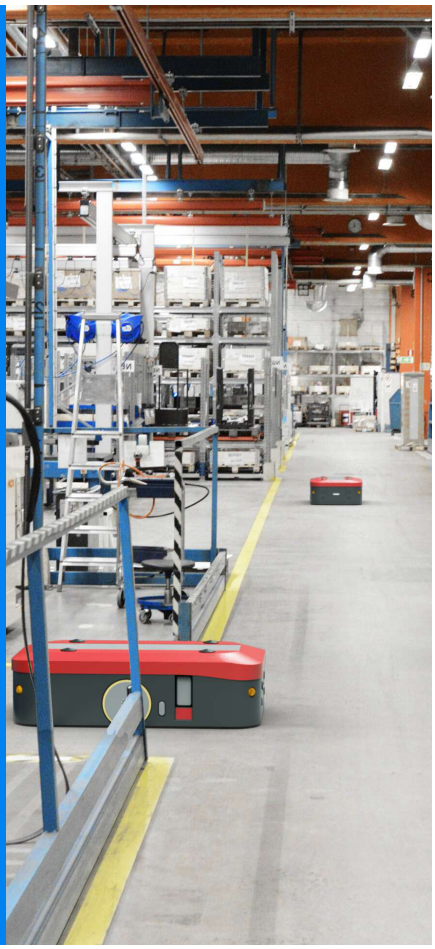
What about spectrum?

5G technology makes use of a wide range of licensed frequency bands around the world. A common technology platform across all the low, mid and high bands is a vital advantage in providing a broad range of highly available and reliable services. The unlicensed version of 5G, known as NR-U, will be able to additionally utilize the 5 and 6GHz unlicensed frequency bands, again leveraging the technology platform to opportunistically add capacity where needed.

Wi-Fi 6 uses the 2.4 and 5GHz unlicensed frequency bands, while Wi-Fi 6E will add the new 6GHz band.

The use of 6GHz spectrum is currently under study in different parts of the world. This spectrum is currently used by fixed links and other services. In the USA, the Federal Communications Commission published a Report and Order in April 2020 opening the 5925 – 7125 MHz band for unlicensed use. Doing so adds 1,200MHz of additional bandwidth for unlicensed technologies including Wi-Fi 6 and 5G NR-U. In Europe, technical analysis is ongoing for 5925 – 6425 MHz, regarding potential indoor use considering protection of incumbents and potential application of geo-location databases.

One additional big advantage of (4G and) 5G technology is its ability to use dedicated locally licensed spectrum for critical industrial digitalization and applications. Many countries are considering dedicating spectrum for private applications. Germany, for example, allocated local licensed spectrum in the 3700–3800 MHz range to industries for their applications in 2019, while Japan announced the allocation of the 28 GHz band. Other countries, including France and Italy, are looking at allocating spectrum to CSPs, who then ensure availability for industries.



The benefits of 5G NR and Wi-Fi 6

Both 5G and Wi-Fi 6 will have a role to play in the delivery of indoor networks now and into the future. The various advantages of each technology are outlined below.

The benefits of 5G

When operating on licensed spectrum, 5G offers superior reliability and better predictability to meet critical communication needs.

- 5G is designed to fulfill QoS requirements for a much broader range of use cases than Wi-Fi (5G has full support for massive MTC, eMBB, critical IoT, TSN).
- 5G supports fully flexible end-to-end QoS differentiation with a single network.
- Rigorous device interoperability testing and certification process.
- A 5G system can also use unlicensed spectrum to offload non-critical traffic. (Known as New Radio Unlicensed or NR-U, this version of NR is part of 3GPP Release 16.)
- 5G provides both wide-area and local coverage with full mobility, while Wi-Fi 6 is limited to local coverage and more basic mobility.
- 5G has end-to-end specifications covering a complete system architecture, whereas Wi-Fi specifies primarily layer 1 and layer 2.
- 5G offers the combined merits of the mid-band and low-band for good coverage, and highband in mmWave for extreme capacity, low predictive latency, and highly accurate positioning. Wi-Fi 6 is limited to the mid-band and finite bandwidth per access point or device.
- Unlike Wi-Fi 6, 5G provides end-to-end security and global identity management.

The benefits of Wi-Fi 6

As a technology option, Wi-Fi has been far more widely adopted by non-smartphone device manufacturers and is established in more ecosystems than 5G.

- Wi-Fi 6 modems are less expensive than their 5G counterparts.
- Deployment is often easy and requires limited technical competence (users can establish one or a few access points themselves).
- Some operating systems such as Apple iOS 13 prefer Wi-Fi over cellular, connecting the device to a nearby Wi-Fi network automatically.
- Available to all, Wi-Fi 6 (and NR-U) operates on unlicensed spectrum. Usage rights are limited with 5G NR, which operates on licensed spectrum.

Enterprise IT integrators and procurement departments prefer Wi-Fi because:

- Wi-Fi competence is common.
- Relationships with vendors are well established.
- Users with data-limited packages are accustomed to offloading to Wi-Fi.

Total cost of ownership (TCO)

In assessing previous generations of cellular and Wi-Fi technology, we see that while the former has been favorable for large-scale deployments, the latter has been preferable for small-scale deployments. When professionally installed and managed, a sizeable Wi-Fi 5 deployment is on a par with a 4G deployment in terms of TCO. But OPEX is typically higher for Wi-Fi and CAPEX higher for cellular.

An example of connectivity cost for a connected warehouse

Wi-Fi is 22% higher in total cost per square foot than cellular

Use case assumptions:

- Rectangular building 250,000ft², single floor, no significant walls or other signal impediments.
- 1000 connected devices (average throughput 80 Mbps) and low numbers of users.
- High bandwith/low latency use case based on connecting robots in a pick/pack logics warehouse.

Cost breakdown – Wi-Fi

Equipment and install (CAPEX)

43%

of total cost.

Product support, help desk, onsite IT (OPEX)

57%

of total cost.

Based on the following equipment:

160 Wi-Fi APs
10 PoE switches
Router
Wireless access controller
Server (network/user mgmt)
Install, cabling, racks, etc

Cost breakdown – Cellular

Equipment and install (CAPEX)

65%

of total cost.

Product support, help desk, onsite IT (OPEX)

35%

of total cost.

Based on the following equipment:

40 small cells
HSS, router
vEPC distributed LTE core
Install, cabling, racks, etc

Source: Ericsson Internal Studies, 2019

Besides assessing the monetary value of every new technology, it is also essential to compare the relative added value that each delivers. For example, 5G on licensed spectrum offers superior reliability, can cover both wide area and local connectivity and supports more use cases than Wi-Fi. Several segments should, therefore, gain more value from 5G than Wi-Fi 6 from a technology perspective.

With the reduced predictability of Wi-Fi 6, service interruptions are to be expected, and these, in turn, will lead to disturbances in production. Clearly, this should also be taken into account.

The security discussion

Wi-Fi is sufficiently secure for office and home use. But 5G addresses a much larger security issue, accounting for end-to-end security and global identity management. This can largely be explained by the specific way in which 5G is designed. 3GPP has always considered the communication system as a whole, making sure it works on a global scale for billions of users. Resilience, privacy regulation, data protection, encryption, interconnect, and access and core network security are all covered.

Users' demand for trustworthiness has increased over time, causing security requirements to evolve, and leading to the introduction of enhanced privacy protection features in 5G. 5G also employs strong security algorithms, traffic encryption, and protection of signaling and interfaces.

Based on well-proven algorithms and tightly coupled with a global identity management infrastructure, authentication is another of the mobile network's major strengths. Since the age of 3G, the mobile network has been able to authenticate the device, and the device, in turn, authenticates the mobile network. There have also been secure solutions for storage and distribution of keys, fulfilling regulatory requirements, and allowing international roaming.

A closer look at 5G and Wi-Fi security

5G security is the result of standardization, product security, deployment, operations and management, and incident-handling capabilities: a highly beneficial coordinated approach to security.

Wi-Fi 6 uses Wi-Fi protected access 3 (WPA3) for security, which is an improvement on earlier WPA2. However, it has certain design flaws and vulnerabilities, allowing for different kinds of attacks. Security flaws have also been identified for Wi-Fi protected setup (WPS).

5G can also interact securely with other network technologies such as Wi-Fi, being a more generic solution for authentication. This allows users to connect over cellular access and Wi-Fi within one framework in a secure way.

Conclusions

5G will play a larger role in future connectivity scenarios

5G NR supports more use cases than Wi-Fi 6, is more reliable, and provides both wide- and local-area coverage with mobility. So many service providers will benefit from the added value of 5G NR and the fact that ultimately, they get more for their money. 5G is also the best fit for addressing emerging new IoT use cases.

Always consider the use case when making a technology decision

Wi-Fi 6 is certainly good enough to use in cases where best effort eMBB traffic is required in indoor local areas. On the other hand, any use cases that require either outdoor deployments or are of a critical nature with high reliability and low latency requirements – or a combination of both – demand licensed spectrum and 5G.

Superior quality of service will be a game-changer

If there is a need for fine-grained service differentiation and superior quality of service levels, Wi-Fi might not be the right choice. When buying off-the-shelf, 5G is the better choice since device testing in this domain is more rigid, and protocol compliance is better than with Wi-Fi equipment.

This paper concludes that while Wi-Fi and cellular access technologies will continue to co-exist and work together to deliver indoor connectivity across the globe, the decision between one or the other will inevitably arise. In this case, we endeavor you to weigh the options and opinions in this paper and make a sound judgment based on your unique set of circumstances.

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