# Wi-Fi 6
## and Enterprise Networking Convergence

Covering the evolution of Wi-Fi 6 and the impact of its adoption in business environments.

iBwave

# Table of Contents

# Wi-Fi 6 is one of the most important technology upgrades for enterprise wireless in many years.

It will improve the quality and performance of Wi-Fi, making it more fit-for-purpose in high-density environments, or ones with tighter demands on reliable and predictable connectivity. It should help CIOs enhance network security, add new use-cases and ease future automation and fault-management.

It fits with the vision of a wireless-primary environment, whether that is in a corporate HQ office, a hospital, a factory or a sports stadium. It has been designed for an era in which users expect high-performance wireless connections from their computing and communications platforms, indoors and outdoors, at home and at work – not just for convenience, but as the primary means of accessing corporate resources and the public Internet alike.

In coming years, we can expect a continued explosion of device numbers, carried both by humans (such as AR headsets), and as part of infrastructure (4K & 8K screens everywhere). We will see more fixed IoT devices such as environmental sensors and smart-lighting, and mobile ones such as drones and robots, often visiting parts of a building where humans rarely go. Many – or most – of these devices will be Wi-Fi connected. Wi-Fi 6 should enable more devices to be supported simultaneously, with higher reliability.

However, Wi-Fi 6 will not exist in a vacuum. It will coexist with older Wi-Fi technologies on both client- and network-side for many years. Its arrival also occurs in parallel with numerous other adjacent technology and business trends:

- **Indoor cellular networks**, whether these are oriented towards making existing 4G coverage better, or are future-proofing for 5G. This includes private and neutral-host deployments.
- **IoT deployment**, as numerous new classes of device and connectivity technology are increasing loads on indoor networks, while adding new sets of requirements. This will drive a mix of Wi-Fi and other technologies, from fiber to Bluetooth.
- **Smart building functionality** adding incremental use-cases (and ROI justification) for in-building fiber, ethernet and wireless infrastructure.
- **Optical LAN** connections for high-performance computing is important in a number of markets.
- **Vertical-specific networks**, such as industrial control systems or broadcast connectivity, can overlap with Wi-Fi upgrades and installations.

Taken together, Wi-Fi 6 and these other convergent developments will mean enterprises require careful analysis and potential upgrade of the uplink/aggregation capacity of the campus core, with deep fiber penetration through the building. For property developers and landlords, overall "connectivity" of buildings will be an essential part of attracting and retaining tenants, and maintaining rental prices.

In other words, Wi-Fi 6 is an important part of wider story about in-building and on-campus network convergence. It makes sense for enterprises to think about as many of these angles together as possible. Some are happening now in concrete fashion, but others are less-clear in terms of adoption scale, exact timing, architecture and use-cases.

To mitigate this unpredictability, Disruptive Analysis advises flexibility and as much future-proofing as possible, so that any further additions and upgrades can be done incrementally and cost-effectively as possible. While this does not mean doing "everything" immediately, it means thinking through enough likely or possible scenarios methodically, and making sensible investments to reduce long-term costs of ownership.

Central to this story of "evolving convergence" is deploying enough fiber, enough power, and wherever possible a unified and extensible design upfront.

## Purpose and Structure of This Document

This report covers the evolution of Wi-Fi 6, and the likely impact of its adoption in business environments. In particular, it covers the fit of this new Wi-Fi standard with other in-building network infrastructure, especially fiber and various classes of indoor cellular systems such as small-cells. A future iBwave white paper will consider more technical details on Wi-Fi 6 planning and design; this document looks at the wider picture and justification for investment and convergence.

The document has been prepared by independent research firm Disruptive Analysis, and commissioned by iBwave, for distribution to its customers, partners and a wider audience. It is based on Disruptive Analysis' continuous research program covering wireless technologies, IoT networking, service-provider dynamics and enterprise communications.

It should be read by CIOs, strategy executives, CTOs, CMOs, facilities management & planning/operational staff at major enterprises, property firms, communications service providers, information providers, software vendors, IoT firms, cable operators, ISPs, integrators, developers, XaaS providers, investors and similar organisations. It is also aimed at policymakers, regulators and others in public administration, who intersect with telecoms and broader infrastructure-development concerns.

Mentions of companies and products in this document are intended as illustrations of market evolution and are not intended as endorsements or product/service recommendations. For more details, please contact information@disruptive-analysis.com

# What is Wi-Fi 6?

## What's in a name? 802.11ax vs. Wi-Fi 6

There are two core industry bodies involved with Wi-Fi. The IEEE (Institute of Electrical and Electronics Engineers ) sets the underlying technical specifications for a wide range of networking technologies, notably including Ethernet and Wireless Ethernet, the latter being the basis for Wi-Fi and having the designation 802.11, plus its numerous enhancements and extensions such as 11b, 11n, 11ac, 11ad and so on.

Meanwhile the Wi-Fi Alliance (WFA) is the body concerned with the overall branding, interoperability and certification of the products that use 802.11 standards. As well as the radio technology standards and protocols from IEEE, it also considers adjacent elements needed for a complete solution, such as security mechanisms. It owns and promotes the Wi-Fi brand and the various logos used to depict certified products. It engages with regulators to advocate for access to suitable spectrum, and end-users, integrators and the media to highlight solutions and value from the technology. It also works to help create higher-level specifications and certifications, such as for mesh-networks based on Wi-Fi, or deployment guidelines for property developers.

However, over the last few years, it has become increasingly clear that the arcane standardisation names – 802.11ax, 802.11ay and so forth – mean little to consumers, and not much more to many businesses, outside of specialist IT and network personnel. In particular, it is not obvious to the untrained eye why 802.11ax is an important upgrade for 802.11ac Wave 2, but why .11ah or .11ay are very different types of enhancement

The obvious contrast is with cellular technology, where the progression from 3G to 4G to 5G is instantly understandable (even if there is a lot of internal industry debate about exactly how 5G is defined). In reality, each generation of mobile technology involves a whole set of separate refinements and enhancements – some mandatory, some optional. Insiders talk about different 3GPP releases, with 5G being introduced in Rel-15 and enhanced with Rel-16 and Rel-17, but that is largely invisible to the wider world.

As a result, in October 2018 Wi-Fi Alliance announced a shift to a simpler naming scheme. The current version would be rebranded as Wi-Fi 5, and the new update, based around 802.11ax and other features, would become Wi-Fi 6, complete with numerical logos. The implied one-upmanship vs. the mobile community's 5G transition is amusingly blatant.

Disruptive Analysis recognises that the naming shift annoys some of the industry's purists, but feels it is an important step to combat the almost-overwhelming noise around 5G, especially within enterprises and policy/government realms. It is important for the Wi-Fi industry (and its main end-user groups) to amplify its messaging and branding, especially when debates around new spectrum and deployment of next-generation industrial networks are taking place. A clear reminder that Wi-Fi is the default option for private wireless connectivity – and is not standing still – is valuable.

**Simplified Wi-Fi naming convention should help mass-market visibility vs 5G**

| Old Name | New Name | Logo |
|---|---|---|
| **802.11ax** | **Wi-Fi 6** | |
| **802.11ac** | **Wi-Fi 5** | |
| **802.11n** | **Wi-Fi 4** | |

Source: Wi-Fi Alliance

## Key Features

Wi-Fi 6 is largely based around the new radio specification, 802.11ax, plus additional features such as mandatory WPA3 security. Unlike previous upgrades to Wi-Fi the main focus is not on ever higher peak speeds, but instead on better efficiency, predictability and reliability of the connections. This reflects the requirements of the modern enterprise and consumer wireless marketplace, and expected mid-term trends.

Remember that Wi-Fi 5, previously known as 802.11ac, was first launched in 2013, with the requirements and standards work having been done over the previous 3 years. At that point of conception in 2010, iPhones and Androids were still something of a novelty, especially in enterprises. The iPad had only just been introduced. The Wi-Fi world still revolved around laptops – which were themselves often just seen as more convenient alternatives to desktop PCs, rather than the default computing device for most workers.

By contrast, Wi-Fi 6 has been born into the era of wireless-first users, IoT transforming business processes, and an array of new mobile/cloud computing and data-access paradigms. Its core features and improvements reflect that.

Without delving too deeply into the underlying technology, the key aspects to be aware of include:

- **OFDMA** (Orthogonal Frequency Division Multiple Access) is a change from older Wi-Fi versions' OFDM (M=multiplexing), which in essence allows radio channels to be split into sub-units. This improves the management of traffic, increasing both overall network capacity and allowing for much more "deterministic" connectivity. Particular devices or applications can receive more reliable QoS (quality of service) than in the past. There is less risk of contention, congestion or delay. This makes the technology much better-optimised for demanding use-cases such as VoIP or time-sensitive industrial automation. This is very important for the Wi-Fi community at the present time, as the growing interest in private/enterprise 5G otherwise poses a competitive threat.
- **MU-MIMO & Transmit Beamforming:** (Multiple-User, Multiple-In, Multiple-Out). MIMO refers to a technique of using multiple antennas to form radio signals into "beams". This has been around in several previous versions of Wi-Fi, but is now standardised in a form that allows multiple simultaneous beams to be supported by an AP, connecting to several devices concurrently for both down- and up-link. Up to 8 streams can be supported.
- **1024-QAM** (quadrature amplitude modulation mode), which is a new RF modulation enhancement, which increases throughput speeds by up to 25%.
- **BSS Colouring:** This is a technique for dense deployments, which allows multiple APs and devices to use the same RF channels, but with less interference and thus higher effective capacity.
- **Target Wait Time:** This is a mechanism by which Wi-Fi clients and APs can pre-negotiate to schedule future connection timings, allowing the devices' radios to remain idle most of the time, and thus saving battery life. It should be particularly important for IoT use-cases such as sensors, where permanent connectivity is not essential – they can send/receive data in batches, rather than keeping the radio alive for continuous transmission.

One other important development is around spectrum used by Wi-Fi 6. At the moment the world's Wi-Fi works in two main bands – 2.4GHz and 5GHz – both available on an unlicensed basis. While there are minor differences in some geographies, because of certain channels being occupied by other applications, there is strong global consistency. This harmonisation has been key to Wi-Fi's past growth.

In future it will be desirable to add new bands, to improve capacity further. However, as is also the case with the cellular industry (and also broadcasting and satellite), finding new global bands is tricky. The Wi-Fi industry may have to deal with regional variations, either in the width of the band, or precise regulations on power and coexistence with other users. Fortunately, the silicon industry (and regulatory spectrum management) is becoming more sophisticated, so various approaches should emerge. We may see more spectrum-sharing and dynamic allocation mechanisms.

The most promising band for Wi-Fi in the near future is in the 6GHz range. Especially in the US, it seems likely that 1GHz or more may become available in this band in the next 2 years, coinciding with many Wi-Fi 6 deployments. Europe is also looking at 6GHz, but probably with less overall capacity and perhaps some form of sharing with 5G cellular. The exact shape of this band is one of the "unknowns" at present, but for which deployments can be future-proofed.

In any case, it seems very likely that any new 6GHz band will only be certified for Wi-Fi 6 and OFDMA, in order to maximise the benefits of the new standard. Older variants of Wi-Fi will be confined to 2.4GHz and 5GHz.

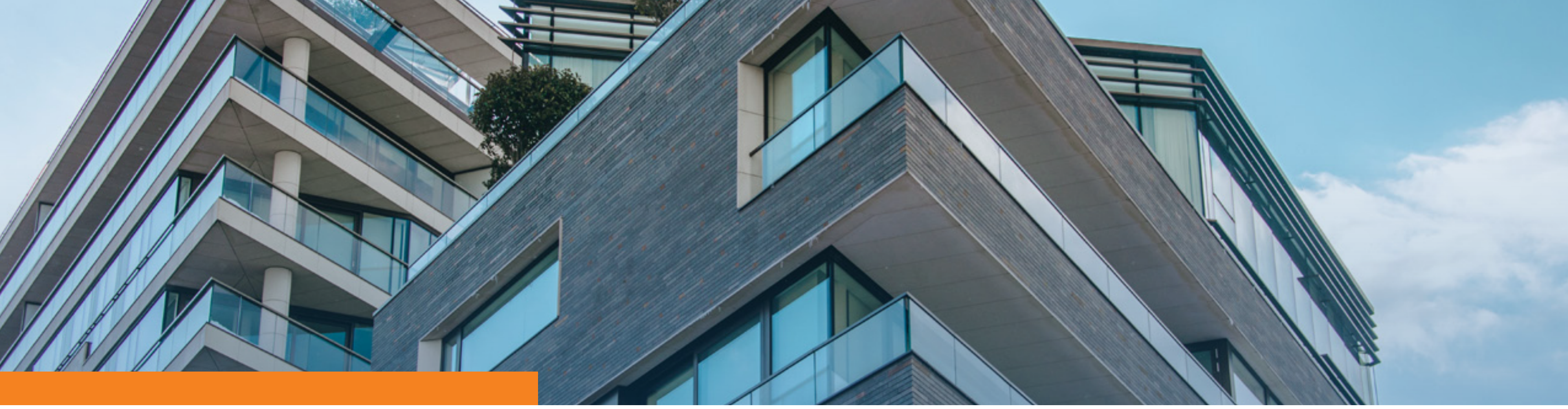

## Status & Roadmap of Wi-Fi 6

The core technology standard underpinning Wi-Fi 6, the IEEE's 802.11ax standard, is essentially complete, with final ratification expected in late 2019. However, numerous companies are already shipping products on both network and client sides, since any final modifications are expected to be minor, with software/firmware updates made remotely in the field. Various enterprise-grade APs have been announced, and there is a steady adoption of Wi-Fi 6 in flagship smartphones and PCs.

Mainstream availability on a wider number of devices should occur during 2020, and by 2021 Disruptive Analysis expects Wi-Fi 6 to be supported almost ubiquitously on the types of computing product bought by enterprises. That said, lower-cost IoT products may take longer to support the technology, as will consumer-grade APs. And, of course, there will be a long legacy of existing networks and devices in-market.

At the moment, few people are talking about what happens after Wi-Fi 6 is widespread, but it can be safely assumed that a Wi-Fi 7 will follow in 5 years or so. Perhaps more importantly, in the meantime we will also see continued innovation around the mmWave-range 802.11ad/ay standards (formerly called WiGig), low-power 11ah, and the mesh-network approaches which are already commonplace on high-end residential systems.

In addition, as discussed in the convergence section below, we can also expect to see Wi-Fi 6 become increasingly integrated with cellular technologies and other low-power IoT systems.



# Expected Use-Cases and Applications

Wi-Fi 6 is expected to be adopted broadly, across many industries and building types. Each will have its own profile of users, and changing and newly-developed applications. Overall, we can expect more video, more IoT, more cloud connectivity and more industrial applications. Businesses increasingly have workers who are nomadic or using hot-desk facilities, and a mix of laptops, tablets and smartphones. Wireless is often the default, especially as many modern devices now lack wired ethernet ports.

However, against the general "rising tide" of connectivity needs, it is possible to pick out some especially important sectors or groups, for which Wi-Fi 6 will confer particular benefits:

- **Technology Leaders:** Some sectors generally adopt leading-edge technologies more rapidly, even if it is still somewhat immature. We can expect Wi-Fi 6 infrastructure to gain rapid adoption in the technology industry itself, universities and research institutes, and others with engineering groups keen to deploy the latest-and-greatest, even if it is just at a pilot stage initially.
- **High-Density Venues:** Conference centres, entertainment venues, education / lecture halls, train stations and airports are all examples of locations with high densities of users and devices, often with demanding requirements for downloads, video/media consumption and upload, and multiple devices per person. Many already see pressure on existing Wi-Fi networks, as well as extremely high cellular usage as well. Such sites are likely to push for early adoption of Wi-Fi 6 and multi-band 5G. They will also likely be at the forefront of demand for new spectrum bands such as 6GHz and 28GHz / 60GHz mmWave as well. As well as scaling existing use-cases, the highest-performing wireless networks may well also enable new revenue streams or improve customer/visitor experience (for instance, via immersive video).
- **Multi-Dwelling Units:** Given the likely adoption of Wi-Fi 6 in consumer smartphones and other devices, it will be important for the network-side capability to be added to systems covering apartment blocks and hotels relatively rapidly. This applies particularly to new-build sites with central ISP provisioning (such as university student residences), and similar shared locations.
- **Integrated Solutions:** Increasingly, wireless networks are "baked-in" to complete solutions, whether these are geared towards industrial automation, retail systems, IoT, medical or many other technology domains. When implemented at scale, this can also drive demand for suitably-capable infrastructure on the network side. High-bandwidth or low-latency systems such as AR/VR, HD videoconferencing, process-control systems and the like may well nudge some companies to upgrade their Wi-Fi networks in tandem. Such advanced systems are likely to be central to broader improvements in business-process, with budgets and time-horizons to match.
- **Smart Cities and Buildings:** The increased client-side power efficiency of Wi-Fi 6 (because of Target Wait Time) should make it more suitable for battery-powered IoT uses. While it is unlikely to have the range and massive-density capabilities of true low-power WAN technologies (such as 4G NB-IoT or LoRA) or the still-emergent Wi-Fi HaLOW version, it should still improve on today's performance. It will also be better-positioned against Bluetooth Low Energy and other short-range wireless alternatives. We may also see something of a resurgence of city/campus-wide networks for visitor and employee use, including in limited outdoor contexts like a hospital's grounds.
- **Uplink / Mesh:** While this paper firmly advocates the use of deep fiber and power-over-ethernet for Wi-Fi access points in enterprise, we may also see Wi-Fi 6 first being used for uplink or meshing between APs itself, especially if "clean" 6GHz spectrum becomes available soon.

## Key Early Venue Types for Wi-Fi 6 Deployments

Transport Hubs

Hotels & Offices

Tech & Education

Sports / Entertainments

Smart Buildings

MDUs

Wi-Fi will also be widely adopted beyond the enterprise, including in homes, small businesses and public venues. This will catalyse the arrival of both smartphones and new client types, some of which will be brought into businesses by consumers, especially for travel, hospitality and entertainment venues.

One use-case that parallels the emergence of Wi-Fi 6 is the growth of federation approaches such as PassPoint and Cisco's new OpenRoaming. The latter in particular will enable nomadic users to gain access to Wi-Fi across multiple sites and locations, with businesses associations, consortia or other groups (such as academic institutions) acting as new classes of federated service provider. These will make it easier for users to access many Wi-Fi networks with greater ease, and should reduce user-support overheads, and limit the switch to unlimited-plan cellular in some cases.

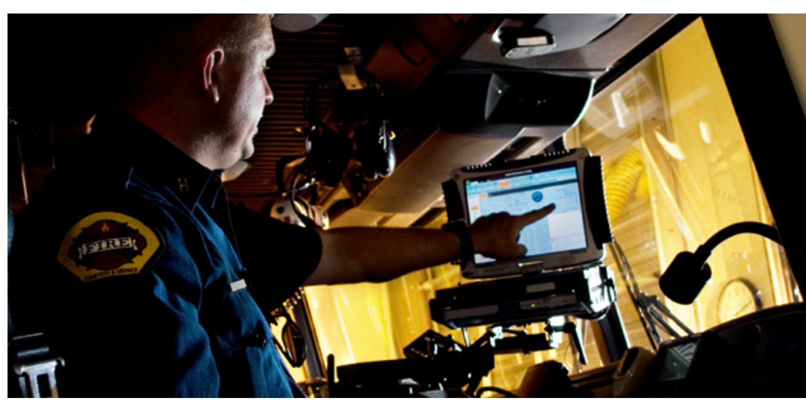
# Implementing Wi-Fi 6: The Path to Convergence

As mentioned in the introduction, Wi-Fi 6 is an important innovation, but it does not exist in a bubble. It is important not to view its commercialisation and adoption in isolation. Its introduction is occurring at the same time as many other trends in enterprise technology, and in many ways the technology, use-cases and integration efforts will "converge".

This does not mean that different networks will all be used simultaneously, by the same devices and applications, but rather they can benefit from holistic planning, design and management to avoid duplication of effort, or constraints on space and power.

Other aspects that are "adjacent" to Wi-Fi 6, but which should be considered as parts of the same, larger puzzle, include:

- Growing demand for 4G mobile broadband, especially in visitor-heavy venues like airports, sports stadia and shopping malls. This is stretching the abilities of traditional DAS systems – as well as they ways they are built and financed.
- Introduction of 5G, which brings huge indoor-coverage complications, especially for mmWave bands above 20GHz. (Please see the previous iBwave eBook on 5G and in-building convergence for more details)
- Upswing in interest in private and neutral-host wireless cellular (using 4G or 5G), with building-owners and new providers aiming to build their own networks in unlicensed and shared spectrum, such as the US CBRS band.
- Growth of all sectors of IoT, meaning greater numbers of devices, and a diversity of network connection technologies (Wi-Fi, cellular networks LTE-M and NB-IoT, short-range systems such as Bluetooth and ZigBee, LPWA options such as LoRa and SigFox; and proprietary systems of various types)
- Various forms of smart-building technology, such as LED lighting integrated with wired LANs (and using PoE power-over-Ethernet as an electricity source).
- High-performance computing, embedded/industrial and building systems reliant on fiber connections and optical LAN.
- External fiber connections from all premises, for Internet access, and WAN / SD-WAN / cloud connectivity.
- Evolving standards for public safety coverage in-building, which may still be based on two-way radio, but could be transitioning to 4G or other technologies.
- Edge-computing and edge-cloud access, perhaps with new data-centre technology on premise (such as Amazon Outposts)
- Various sector-specific technology trends, in domains such as broadcast, medical systems and so on.

## Future Wi-Fi 6 evolution is paralleled by advances in private 4G / 5G indoors

| | Wi-Fi 5 > 6 | Public 4G/5G | Private 4G/5G | Other |
|---|---|---|---|---|
| **MNO indoor coverage / offload (esp. phones)** | | | Neutral Host model gaining awareness | |
| **Local IT / Internet LAN (laptop, phones, etc.** | Performance improved by Wi-Fi 6 | | Major focus of CBRS & similar | Fiber, Ethernet |
| **Local IoT (static)** | Performance improved by Wi-Fi 6 | | | BLE, Zigbee, Enternet |
| **Local IoT (moving)** | | | | Niche Wireless |
| **Local OT (industrial)** | Improved by Wi-Fi 6 | | Becoming more common | Fiber, Nice Wireless |
| **Local voice radio** | | | | P25, TETRA, DECT |
| **Sector-specific uses** | Improved by Wi-Fi 6 | | | Declining |

Source: Disruptive Analysis

UBIQUITOUS | COMMON | RARE | VERY RARE

In other words, businesses of all types (and also buildings / venues of all types) are demanding ever greater connectivity, wired and wireless, for a constantly-evolving set of use cases. Facilities managers have to try to ensure infrastructure can deal with the demands of employees, visitors, production systems, onsite and offsite compute, and regulatory requirements such as public safety access.

They cannot easily predict which will use Wi-Fi, which will use (multiple networks') cellular connectivity, and even which spectrum bands may be relevant in future. That in turn means that additional access points and antennas may need to be added at later points. Third-party organisations are starting to rate buildings based on their overall connectivity – including wireless coverage. That in turn may feed through to occupancy rates, whether that is for shared office-space, retail tenants, or hotel guests.

Manufacturing or other industrial facilities will increasingly want flexible, re-configurable layouts and automated systems, so they can move machinery around, add new sensors, exploit AI-based machine vision, or a myriad of other innovations.

Some of this will be driven by Wi-Fi 6's capabilities. But they should also anticipate a very heterogenous technology environment, where certain aspects are shared, notably fiber and LAN wiring. The latter may well be oriented more towards delivering higher-specification Power over Ethernet POE+ for more demanding end-points.

## Design Considerations

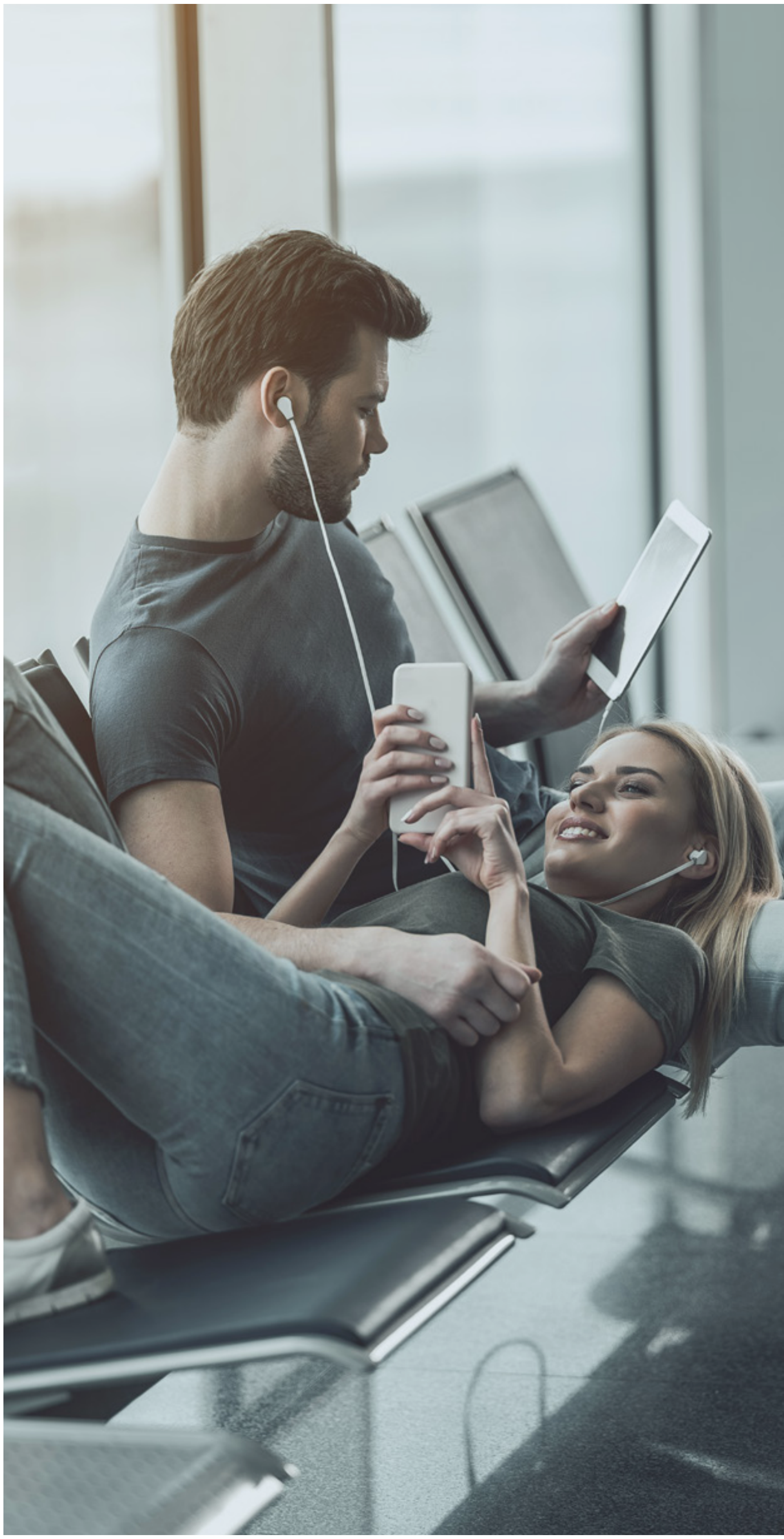
As discussed above, Wi-Fi 6 will enable greater numbers of simultaneous connections to each AP. However, this is offset by the expected increases in overall device numbers, especially as IoT products and screens/ audio-visual systems proliferate within most enterprise locations. In other words, unless there are specific company/industry-related trends, the density of APs is likely to remain roughly consistent with legacy Wi-Fi deployments.

While Wi-Fi 6 brings considerable benefits to wireless connectivity and performance, there are certain implications in terms of network design and implementation. Firstly, the power consumption of the most sophisticated new APs may be quite high, given the number of antennas and RF chains used to support the multi-user capabilities. This might mean that APs go beyond the 30W that can be delivered with one PoE+ connection.

Secondly, the aggregate throughput from each uplink – especially in busy venues – could well exceed 1Gbps and even reach as much as 5Gbps. This implies a relatively high density of switches, and deep reach of fiber through the core of the building to each floor, or cluster of APs. The need for deep fiber will also be driven by the other convergence aspects discussed in the previous section, such as 5G and small-cell support for wireless coverage. The building/campus core switches may well need upgrading as well, plus the WAN/SD-WAN links to the public Internet and cloud.

This convergence process will be highly specific to a given industry and company. In some cases, these other technology domains may be able to use Wi-Fi as a transport layer. In others, it may be that the fiber or ethernet wiring can be shared. But sometimes, the benefits may just result from two projects being conducted in sync, to minimise disruption and improve efficiency of the installation.

We are also likely to see an increasing focus on cloud- and AI-based management of Wi-Fi systems, whether for operations management or security reasons. While this is not specific to Wi-Fi 6, it will become mainstream roughly at the same time, so it is reasonable to consider them together.



# Conclusions

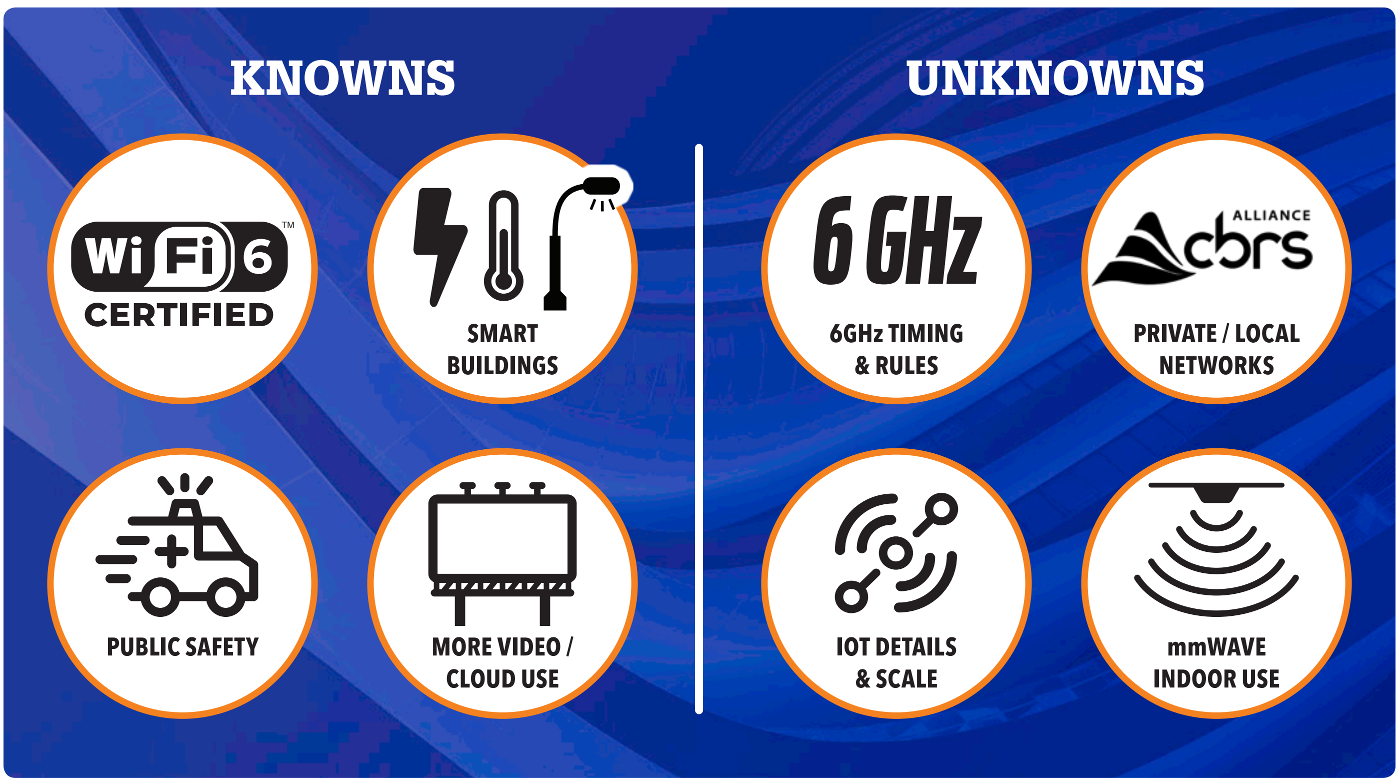
Wi-Fi 6 is a very important evolution for enterprises. It will extend the utility and applicability of Wi-Fi, at exactly the right time – just as new IoT devices and wirelessly-accessed cloud applications go through a period of exponential growth. It should give greater capacity and efficiency for indoor wireless, across venues of multiple types.

While we are still just at the earliest stages of commercialisation of both network and client products, it seems inevitable that Wi-Fi 6 will become mainstream in the next 2-3 years, and will be in wide use for another 5-10 years beyond that. Those making deployment decisions today may hesitate, given its immaturity, but by mid-2020 its momentum will be much greater.

However, it would be wrong to view Wi-Fi 6 in isolation. It will coexist with a number of other technological innovations, especially indoor cellular and IoT connectivity. 5G will have some important indoor use-cases (for instance, in industrial control, or for guest-access in convention centres), but it will not replace or diminish the case for Wi-Fi.

It is also important to recognise that many of these convergence trends still have "unknowns" – which spectrum bands, how far 5G will get adopted in-building, the rapidity of deployment of private/neutral cellular, exact IoT solutions and so forth. There may be new stakeholders involved as well, from vertical systems-providers, to telcos, to new IT organisations targeted at smart buildings or managed wireless.

### Future Wi-Fi 6 & converged in-building infrastructure must be future-proofed




Source: Disruptive Analysis

Overall, this broad and converged infrastructure shift – with both known and still-undefined elements - will demand more robust and flexible uplink/backhaul connectivity, which may be shared by several in-building systems being deployed. A holistic view of connectivity infrastructure has the potential to reduce total ownership costs, and limit the number of times the building fabric needs to be changed. Wi-Fi specialists should work more closely with their indoor cellular & IoT counterparts, and look for greater synergies in hardware, software and integration domains.

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