Wi-Fi 6: Advanced uses for a new era of connectivity

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Contributions to this paper were provided by the following member companies:

Wi-Fi 6 brings a new era of connectivity for Wi-Fi® networks

Wi-Fi 6, based on the IEEE 802.11ax standard, provides the capabilities required to turn once unimaginable initiatives into practical solutions. The era of Wi-Fi 6 officially began with the launch of the Wi-Fi CERTIFIED 6™ certification program by Wi-Fi Alliance®, continuing the Wi-Fi® tradition of interoperability regardless of vendor, backward compatibility with legacy devices, and the latest in security protections. Wi-Fi 6 is the latest generation of Wi-Fi and addresses the opportunities and challenges of today and tomorrow. Chief among these are high bandwidth, low latency applications and highly congested environments utilizing multiple wireless local area network (WLAN) technologies. The addition of enhanced security protocols and energy efficient features makes Wi-Fi 6 a key technology to meet the evolving applications and demands on WLAN networks today.

The feature set for Wi-Fi 6 has been extensively reviewed in various industry publications. Those discussed in this paper include the following key features implemented in Wi-Fi CERTIFIED 6 (Figure 1):

- **Orthogonal frequency division multiple access (OFDMA):** Subdivides a channel into smaller frequency allocations to increase network efficiency and lower latency for both uplink and downlink traffic; ideal for dense and Internet of Things (IoT) environments
- **Downlink multi-user multiple input, multiple output (MU-MIMO):** Increases user access and capacity using different spatial streams; allows more downlink data to be transferred simultaneously on the same channel, enabling several high bandwidth applications to run concurrently
- **Target wake time (TWT):** Establishes scheduled sleep and wake times for longer device battery life, providing network determinism through improved network efficiency; benefits all Wi-Fi 6 devices and excellent for IoT

Other enhancements, such as 1024-QAM, BSS coloring, beamforming, and eight spatial streams contribute to enabling Wi-Fi 6 to accommodate extensive uses at home and in the enterprise, including uses targeted by 5G in the coming years. The advantages of Wi-Fi 6 in such instances relate to the ubiquity of Wi-Fi networks, ease of deployment, and the use of unlicensed spectrum.

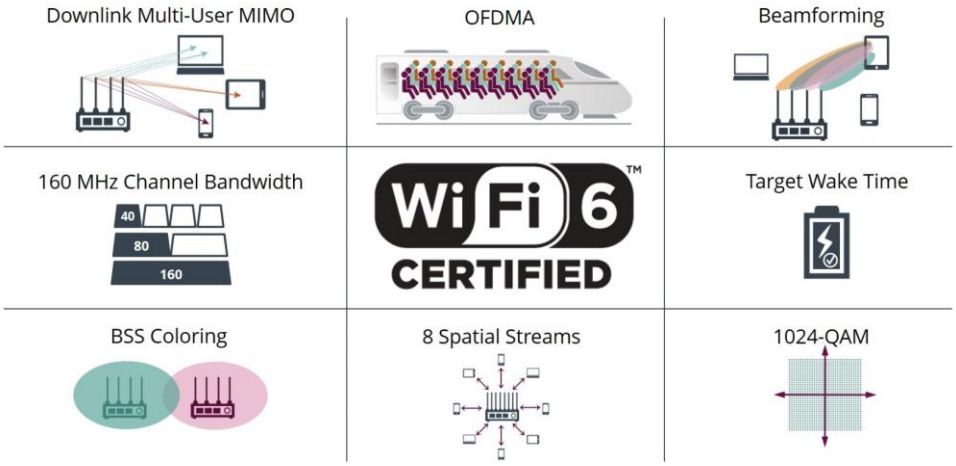

Figure 1. Key features implemented in Wi-Fi CERTIFIED 6 devices

While prior Wi-Fi generations have successfully focused on data rates, the goals for Wi-Fi 6 are grounded in increasing overall network capacity and throughput. Wi-Fi 6 presents faster speeds compared to prior versions, supporting up to 10 gigabits per second (Gbps), and has been engineered to more efficiently use spectrum resources to enable good performance in even the most demanding Wi-Fi environments. Wi-Fi 6 advancements enable Wi-Fi networks to handle many more devices performing a wide variety of tasks *and* provide a better user experience in high bandwidth applications—all while increasing power efficiency for Wi-Fi 6 devices connected to Wi-Fi 6 networks.

Wi-Fi 6 utilizes unlicensed spectrum and comes with a robust ecosystem to provide users with high performance, lower cost technology that complements other technologies. Wi-Fi 6 enables many advanced connectivity use cases such as smart home, smart building, and smart city efforts, as well as industrial automation, cloud-based collaboration, and high resolution, bandwidth intense entertainment. Because Wi-Fi CERTIFIED 6 devices continue the Wi-Fi Alliance tradition of backwards compatibility, upgrading Wi-Fi networks to Wi-Fi 6 brings only positive benefits, enabling the implementation of new and emerging uses while efficiently serving existing devices and infrastructure. For home broadband networks or private enterprise networks in large campuses, healthcare environments, manufacturing environments and more, Wi-Fi 6 empowers network administrators to provide the latest in seamless connectivity to customers, guests, and employees alike.

Expanding Wi-Fi capabilities for a new era of applications

Over the past 20 years, Wi-Fi has evolved and developed to become faster and handle more devices and applications using nearly the same amount of unlicensed spectrum allocation from decades ago. The industry has proven to be truly innovative with each major generation of Wi-Fi, resulting in increasing usage year over year and giving rise to massive growth in the types of devices accessing Wi-Fi networks. Expectations for Wi-Fi go beyond delivering data, voice, and video. Consumer institutions and large conglomerations use Wi-Fi to reliably perform mission critical functions and provide high quality experiences. Ultra high-definition (Ultra HD) content is no longer limited to use by a few niche industries—any user can stream 4K and 8K movies to a device, even while mobile. With annual Wi-Fi device shipments reaching nearly 4.5 billion by end of 2020, 1.6 billion of which will be Wi-Fi 6 devices[1], the world is doing amazing things with Wi-Fi and doing them so well that consumers and businesses continue to expect more from Wi-Fi devices and networks.

Wi-Fi networks everywhere must successfully handle multiple devices per person, as well as IoT devices used to help people run their lives and businesses more efficiently. This paper covers a variety of uses enabled by Wi-Fi 6 in two key areas:

Environments with high client density where massive numbers of devices compete for access to the same network. This includes public spaces such as airports, hotels, and stadiums where thousands of people connect to a managed Wi-Fi network, as well as environments with a lot of IoT devices, such as connected sensors that help run building climate control systems, manufacturing lines, and security systems.

Bandwidth intensive environments where low latency may also be required are characterized by a large number of devices performing applications that require vast amounts of data. Such applications include Ultra HD video streaming, telepresence, videoconferencing, remote robotics and maintenance, and augmented, virtual, and mixed reality (AR, VR, MR).

Wi-Fi 6 was developed with these environments in mind, to provide better user experiences keeping pace with the growth in advanced connectivity uses of Wi-Fi.

Environments with high client density

The world is moving toward connecting nearly everyone and everything, everywhere. There is great growth in the number and types of devices connected to the internet. Wi-Fi is the main connectivity technology for a multitude of these devices, ranging from health monitors to smart building sensors.

IoT deployment presents the challenge of how to securely and easily connect hundreds or thousands of electronic devices to networks, congruent with their operational and engineering needs. In contrast with user controlled devices such as laptops, many IoT devices have varied requirements related to data rate use, reliability, power

[1] *IDC, 2019*

constraints, quality of service (QoS), and determinism. For example, an IoT device may require polling every five milliseconds (ms) or it will shut down, while another might not communicate regularly at all. Traditionally, these needs have been met with proprietary, niche, or service provider-specific technology. However, Wi-Fi has been increasingly chosen as the indoor IoT platform because of its significant economies of scale, ease of control, manageability, and direct access to the cloud for tools and analytics. To address evolving IoT operational needs, Wi-Fi 6 has increased its IoT capabilities to make it superb at handling many low data rate devices and high data rate client devices simultaneously. These abilities are expected to accelerate Wi-Fi 6 adoption in IoT environments.

There are three key areas where Wi-Fi 6 advances IoT in many segments and verticals: determinism, power savings, and reliability.

Determinism

OFDMA provides the ability for the access point (AP) to control and schedule both downlink and uplink transmissions between multiple client devices in the same transmit opportunity, allocating each client to its own contention-free frequency block or resource unit. Figure 2 illustrates how OFDMA allows different types of traffic from different devices to transmit in a single channel. The effect in Wi-Fi 6 networks is reduced channel contention, greater reliability, and determinism. A key metric of determinism is 99th percentile latency, which suits a very large percentage of IoT applications, including industrial IoT (IIoT) uses. Wi-Fi 6 exhibits very linear and well bounded latency with increasing demand, or numbers of clients. This allows network designers to plan for and deliver consistent, deterministic quality in increasingly dense IoT networks.

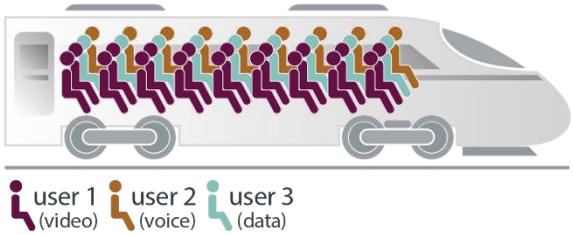

Figure 2. OFDMA enables parallel transmission and receipt of data to multiple users simultaneously

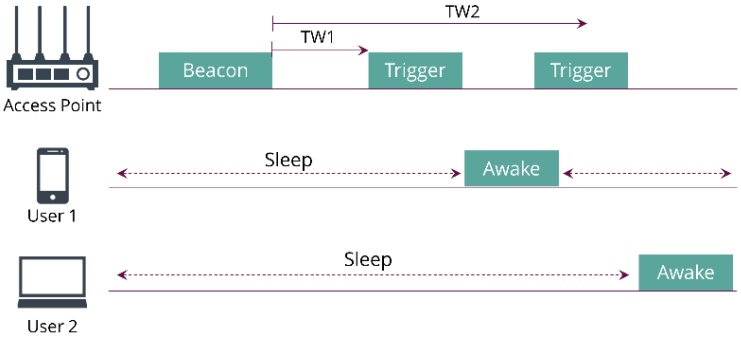

Figure 3. Scheduled network access helps TWT deliver device power savings and network efficiency

Power savings

Building upon OFDMA, Wi-Fi 6 adds individual target wake time (TWT), a significant evolution over power saving efforts of prior generations. Utilizing TWT, the AP and client device agree to a precise wake time, enabling the AP to aggregate large groups of client requests into fewer triggered transmit opportunities. This results in more efficient, contention-free channel access and significant client device power savings, making it ideal for battery powered IoT devices (Figure 3).

Reliability

Wi-Fi 6 also incorporates new spatial reuse techniques such as overlapping basic service set (BSS) packet detection. This mechanism allows APs and client devices alike to ignore transmissions from other co-located BSSs identified by "color," whose signal strength is lower than an AP-governed threshold. This keeps the channel free for concurrent transmission or other transmission opportunities. Network managers should determine the best threshold that will ensure signal quality and concurrency.

The mass rollout of IoT devices in high density environments can be hindered by redundant overlay networks and limited physical space for these different networks. Building new, separate networks for multiple wireless protocols can be cost prohibitive. Each new IoT technology may require its own gateway and dedicated firewall, along with separate switching, power, and cable infrastructure. Wi-Fi 6 offers increased determinism, power savings, less contention, and direct access to the cloud. Equipment vendors are beginning to offer new "converged" Wi-Fi 6 APs, which can provide more IoT capabilities without multiple types of infrastructure, while also simplifying network

management. Upgrading the existing network to Wi-Fi CERTIFIED 6 infrastructure is the best solution for to providing higher speeds and capacity with the latest security.

Wi-Fi 6 usage examples in dense environments

The features of Wi-Fi 6 aggregate to provide the next step for IT departments to scale solutions to meet the growing connectivity needs of IoT. Described below are a few examples, which apply across enterprise and other market segments.

Smarter, more efficient buildings

Wi-Fi 6 can help optimize the operations in building infrastructure through a variety of IoT applications. Whether a network setup is vertical, horizontal or distributed over multiple geographies, Wi-Fi 6 can be leveraged to engineer intelligent facilities that contribute both efficiency and user experience advantages.

Modernized utilities and equipment management: There are efforts being made across industries to improve utilization and consumption of electricity, gas and water. For example, modernization initiatives throughout the U.S. Department of Defense have the potential to save hundreds of millions, or billions, of dollars in combined savings on water, gas, and electricity consumption, as well as improved response time in the case of equipment failure. Such modernizations are finding their way to state, local, and enterprise use cases as well.

Wi-Fi 6 and IoT security

When employing IoT devices from a variety of manufacturers, utilizing Wi-Fi CERTIFIED 6 equipment which includes Wi-Fi CERTIFIED WPA3™ security is recommended. To further mitigate risks, network administrators should explore strategies before deployment such as:

Secure onboarding: Purchase products that provide secure onboarding, such as those supporting Wi-Fi CERTIFIED Easy Connect™ and WPA3™.

Policy and profiling: Establish system-wide policies for the network that clarify what devices are allowed and what information those devices can access. Open networks can benefit from additional protections of Wi-Fi CERTIFIED Enhanced Open™.

Security framework: Consider a device-to-cloud security framework that leverages common security policies and network elements.

Continual monitoring: Use platforms on that support supervised and unsupervised machine learning to automatically baseline user and device behavior while actively looking for anomalous activity.

Regardless of segment or vertical, advanced smart building system deployments will speed incident responses by integrating data from multiple IoT devices. For example, food-grade storage warehouses containing millions of cubic feet of refrigerated and freezer units are fine-tuned to the temperature required for specific items. Should an ice cream freezer located in Arizona suddenly lose power, it can have significant consequences for the company and supply chain. An advanced smart building system powered by Wi-Fi 6 will detect the cooler malfunction and set off a chain of communications that enable faster response time to solve the problem, reducing risk and product loss. Some actions these systems could take include:

- Notifying the building management and an appropriate repair person of the issue
- Sending the part number of the malfunctioning part that needs replacing to the responsible vendor with specific instructions
- Providing a list of tools needed for the fix
- Alerting the company's security and operations managers to ensure access to the site and equipment in need of repair
- Transmitting incident video for real-time repair assistance and follow-up analysis

Similar scenarios apply to reducing such incidents by enhancing preventative maintenance, made possible by more precise, usage-based practices that Wi-Fi 6 IoT sensors provide.

Efficient building maintenance and sanitation: Large enterprises frequently maintain hundreds of public restrooms as well as indoor and outdoor receptacles for waste and recycling. These organizations can integrate Wi-Fi 6, IoT, and location services with reporting and analytics systems to create a usage-based sanitation model instead of the current, pre-defined cleaning and waste collection schedules. In addition to ensuring the most used facilities are serviced when needed instead of when dictated by an employee schedule, the resulting more efficient routing of waste removal vehicles can contribute to the institution's sustainability goals.

In addition to sanitation improvements throughout a large campus or location, Wi-Fi 6 can help with maintenance of the physical structures. Labor is the primary cost for cleaning many surfaces, such as floors, ducts and windows.

Future investments will include IoT robots for keeping environments tidy and meeting health codes. Such deployments will also reduce accidents in hazardous locations and mistakes due to human error. More sophisticated robotic solutions will also incorporate real-time video streaming for on-demand viewing of spaces and structures, and even labor costs for simple functions like replacing batteries in sensor devices will be reduced because Wi-Fi 6 features facilitate very long battery life for Wi-Fi 6 sensors.

Real-time asset tracking: Other technologies working in parallel with Wi-Fi 6 can provide enterprises with cost-effective, low overhead, mobile IoT device tracking using a single streamlined system. Previously, such tracking required multiple separate systems. Whether robots, people, or equipment, Wi-Fi 6 low power devices can be placed on almost anything for locating, tracking, inventorying and redirecting in real time. The benefits of asset tracking span multiple segments, from healthcare to retail to manufacturing environments.

Streamlined industrial and manufacturing environments

In addition to the aforementioned asset tracking use, industrial and manufacturing companies are keenly interested in utilizing IoT devices to manage physical buildings as well as the operations and processes that occur in these buildings. Figure 4 provides examples of industrial IoT uses requiring different levels of assurance and determinism. As more and more types of goods include various forms of intelligence, manufacturers are routinely expected to load and update an increasing array of firmware and software into their products during the production process. This proliferation only adds to the density and bandwidth demands already generated by IoT enabled assembly tools and robotics. Such increasingly complex manufacturing sites require a combination of high performance and low latency connectivity to keep assembly lines moving without costly disruptions or delays.

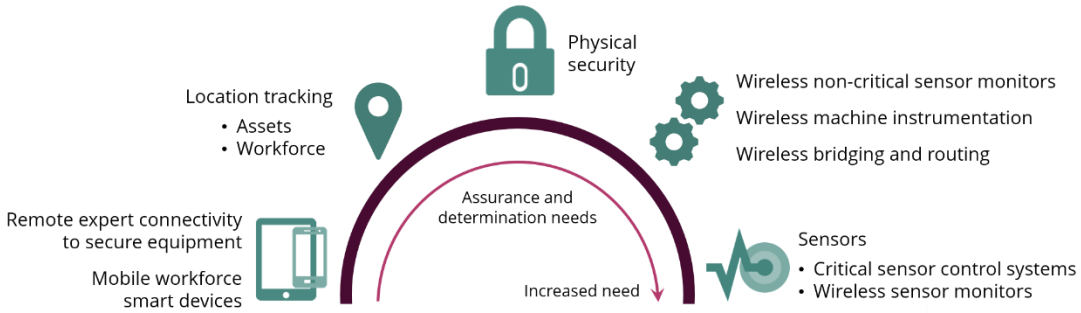

Figure 4. Industrial IoT uses increasingly require determinism now supported by Wi-Fi 6

Upgrading to Wi-Fi 6 networks can provide the low latency needed to successfully manage critical processes within a factory or processing center. Beyond that, it provides the added benefits of longer range, ability to access the cloud to feed analytics and diagnostics tools, and determinism that increases efficiency. Companies that use Wi-Fi CERTIFIED 6 equipment also receive the latest in Wi-Fi security with Wi-Fi CERTIFIED WPA3™.

Efficient transportation hubs, stadiums, and venues

Along with transportation hubs such as airports and train stations, stadiums and convention centers are some of the most demanding environments for Wi-Fi deployments. Specific challenges include extremely high numbers of client devices, device diversity that includes wearables, tablets, and smartphones, and unique physical, radio frequency deployment obstacles such as bowl architecture styles of stadiums and amphitheaters, places with concrete and rock walls, and mid-to-upper-level seating.

Despite these challenges, Wi-Fi 6 also supports a wide range of critical operations such as wayfinding, ticketing, concessions, merchandise, and parking systems through connected IoT devices. These devices and systems are designed to automate processes, capture new insights, and keep people and property safe. Examples include staff alert safety buttons, connected door locks, smart thermostats, room occupancy sensors, window blind controls, and closed-circuit television systems. Wi-Fi 6 can simultaneously support thousands of high bandwidth clients such as smartphones, plus low data rate IoT sensors, on a robust network.

Bandwidth intensive environments

Video traffic is surging. Whether in the home, at work, or on-the-go, users demand smooth, high definition video experiences that Wi-Fi 6 delivers. The emergence of live and produced video streaming services and augmented, virtual, and mixed reality (AR, VR, and MR, respectively) have created network environments where extremely high volumes of traffic involving images, video, and data are transferred simultaneously. By 2022, it is expected that 82 percent of all IP traffic will be video based, more than half of which will be handled by Wi-Fi[2]. Some of these uses also require extremely low latency. While prior generations of Wi-Fi have delivered these capabilities, the features in Wi-Fi 6 bring entertainment, AR/VR/MR, and telepresence experiences to new levels.

Varying requirements of video-based uses

Video technology can be used to entertain, educate, and even remotely conduct tasks such as building inspections after a fire. There are differences in video requirements depending upon the use: video security surveillance in a residential smart home may not need to be as clear or constant as video surveillance in a museum or government facility. Streaming movies in student housing will not require the same data rates and latency as remote surgery. A typical family with a moderate number of smart home devices such as video surveillance, a smart speaker, and home automation require at least 200 megabits per second (Mbps) bandwidth and latency within 20 to 40 ms[3]. Add to that family members who are serious video game players, who work from home and do a lot of video conferencing and cloud collaboration, or who are taking virtual college classes from the home, and the bandwidth and latency requirements increase.

The emergence and rapid adoption of Ultra HD video and AR, VR, and MR has redefined video experiences. Moving from static, standard definition video displays into Ultra HD and three-dimensional (3D) immersion enhances the user experience and dramatically places more demands on the Wi-Fi network environment. These trends will pick up in the coming years: AR/VR traffic is expected to increase 12 times from 2017 to 2022, and internet video to TV will increase threefold during the same timeframe[4].

AR/VR equipment advancements being made now will result in better user experiences and increased accessibility to these devices. This trajectory begins with Wi-Fi 6 networks. To help advance the capabilities and expand use of VR devices, some companies have begun to migrate complex rendering tasks onto the cloud. Cloud VR services represent a new opportunity that will help reduce the computing requirements for VR devices.

Wi-Fi 6 features such as OFDMA apply to the high bandwidth applications of Ultra HD streaming, HD video conferencing, and AR/VR/MR. In addition, downlink MU-MIMO (Figure 5), BSS coloring, and transmit beamforming help deliver performance and latency enhancements that allow Wi-Fi 6 networks to provide operational efficiencies, immersive entertainment and training, and tactile internet experiences.

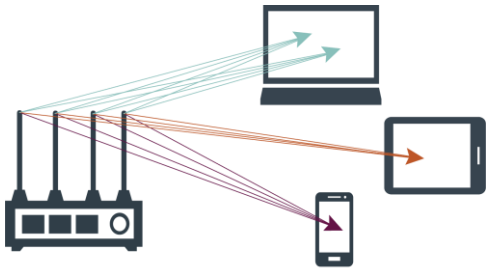

Figure 5. Downlink MU-MIMO enables several high bandwidth applications to run concurrently

Most implementations of Wi-Fi 6 are likely targeted to meet the needs of high definition imaging and video uses such as the examples listed below.

[2] *Cisco VNI, 2019*
[3] *Huawei. 2019*
[4] *Cisco VNI, 2019*

Estimated use case needs for quality video services		
	Bandwidth	**Latency**
Streaming Ultra HD (4K) video	15 - 30 Mbps	20 ms
Streaming Ultra HD (8K) video	40 - 100 Mbps	20 ms
Real-time imaging (healthcare)	≥ 30 – 100+ Mbps	≤ 200 ms
Online gaming	3 – 6 Mbps	20-40 ms
HD video conferencing	5 - 7.2 Mbps	20 ms
Standard AR/VR (entertainment)	≥ 130 Mbps	≤ 20 ms
Advanced AR/VR (training)	> 80 Mbps	15 ms
Perfect AR/VR (remote surgery)	≥ 1.5 Gbps	≤ 8 ms

Sources: Huawei iLab, Cisco, Microsoft, Frontier Communications, HealthIT.gov

Wi-Fi 6 usage examples for bandwidth intensive, low latency applications

Networks across many market segments and verticals experience increased density through use of bandwidth intensive applications. The following section describes examples of uses that Wi-Fi 6 has the capacity, efficiency, and performance to provide.

Remote walkthroughs

AR/VR through Wi-Fi 6 can streamline operations. Retailers with stores and warehouses nationwide will no longer need to fly corporate teams to each physical location for in-person inspections. Instead, a location manager can "walk through" a remote facility by wearing an AR/VR device that streams video and audio, enabling the corporate operations team to "see" the remote facility while also interacting with the location manager. Similarly, commercial real estate companies can offer AR/VR experiences to leasing teams who are investigating options for branch locations, individual clients, and movie set scouting from hundreds or thousands of miles away.

Telepresence

Healthcare: The advantages of leveraging Wi-Fi 6 to move away from traditional in-person and wired healthcare solutions are particularly apparent in rural areas, during natural disasters, and in conflict zones. With Wi-Fi 6 providing the ability to push telepresence and other video-intensive solutions to the edge, healthcare organizations can deploy robotics and AR/VR for distant surgical procedures, along with enabling Ultra HD video for real-time assistance from remote medical specialists or high speed transfers of 3D images for real-time analysis. These solutions will save and enhance lives in ways that were simply unavailable before.

VR video enables surgical operations to be broadcast globally, and medical students can use VR glasses to practice surgery. Additionally, high definition 3D video systems can allow visitors from far away to virtually visit a family member in the hospital. For instance, in remotely visiting someone that just had a baby, family members can be fully immersed as if they were in the hospital ward, including attending physician meetings.

Education and training: Immersive experiences in education can increase student interest in learning, shifting education from textbook-based to visualized content. VR helps build a virtual learning environment where students can experience virtual labs, celestial bodies in the universe, microcosms in biology, among other uses. In this way, education and training is more realistic and inspirational. Students are presented with knowledge in a vivid and intuitive manner, helping trainers get pupils more engaged and motivated in virtual classrooms.

Maintenance and repairs: From air conditioners to conveyer belts in an assembly plant, finding repair assistance by consulting written information and video instructions only goes so far. Moving forward, enterprise solutions will supply onsite technicians with real-time, high resolution, hands-free video interactivity. With remote technicians able to "see" what's happening onsite, they can collaborate effectively with local service personnel or, depending upon the complexity of a product or solution, even guide non-technical individuals through troubleshooting tasks.

Applying Wi-Fi 6 enabled AR to the industrial manufacturing environment can improve the work efficiency of engineering personnel to complete various complex tasks. For example, in mechanical maintenance, when a machine is faulty, maintenance personnel can transmit onsite video to experts at the headquarters through AR glasses in real time. The experts can then remotely locate mechanical faults based on information and real-time images sent by the wearer and instruct onsite engineers to rectify faults or replace parts. It is also possible to send system installation manuals to onsite personnel through AR. The personnel can then carry out operations according to the guide displayed via the AR glasses. Therefore, smart glasses can improve work efficiency and help streamline the entire maintenance process.

Enhanced living environments

Lodging enhancements: The ubiquity of personal device streaming to home TVs is driving hotels to shift from wired screens to large format 4K displays, adding significantly to demands for more bandwidth that is high performance and low latency. In addition, the advent of Ultra HD digital signage enables delivering compelling visual communications into guest rooms for in-room services, marketing, promotions, real-time travel information, emergency notices, and even personalized wall art.

Dense residential capabilities: Today's application-centric students expect residence halls to provide smart building controls and they are also on the frontlines for supporting every new consumer technology as soon as it hits the market. They live in dense environments with multiple dormitory rooms, often with multiple people per room, and are online concurrently. Consumer AR/MR and VR, digital assistants, gaming devices, 4K TVs and the exploding wearables category all increase density, bandwidth and latency demands. Further, these environments present high potential for radio interference, which Wi-Fi 6 BSS coloring technology can reduce.

Smooth streaming: In any residential environment, from single-family homes to multi-dwelling units such as apartment and condominium complexes, bandwidth demand is growing with the increase in video traffic. Many home environments include multiple Ultra HD televisions which increase bandwidth consumption. By 2022, 62 percent of the installed flat-panel TV sets will be Ultra HD[5], prompting users to expect more bandwidth from their service providers. It is not uncommon for multiple residents to stream Ultra HD content simultaneously, especially during peak hours. Wi-Fi 6 features bring more throughput so the network can transmit clearer image files, smoothly playback online 4K and 8K video, without buffering or delay.

Quality gaming: Online gaming has become an important consumer service, with millions of players joining virtual worlds through gaming consoles, tablets, smartphones, and computers. Real-time online games require higher bandwidth and latency requirements if they are to deliver a positive user experience. For example, a massively multiplayer online (MMO) game will likely freeze when the network latency exceeds 100 ms. When network latency exceeds 250 ms, player operations are seriously affected, and the game cannot be played fairly[6]. Wi-Fi 6 easily accommodates the growing requirements for gaming.

Effective home offices: Many companies allow employees to work from home to reduce physical building space overhead. Wi-Fi 6 enhancements enable home offices to operate similarly to their corporate offices through quick file sharing, cloud collaboration, peer-to-peer communication, smooth video conferencing, screen sharing, and live video streaming which can also be used for online presentations. Wi-Fi 6 features enable new levels of flexibility for home offices.

Immersive stadium and venue experiences

Mentioned earlier, stadiums are one of the most demanding environments for Wi-Fi deployments. Fan expectations for a truly interactive and immersive experience are at an all-time high. Venue owners are compelled to meet these expectations by providing a reliable and smooth streaming experience for Ultra HD video and bandwidth heavy AR/VR content. In these scenarios, AR/VR glasses and headsets and high bandwidth-per-client data consumption are becoming normal network characteristics.

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[5] *Cisco VNI, 2019*

[6] *Huawei, 2019*

Every seat is a good seat: Branded stadium applications supporting 4K-ready video replays captured by multiple cameras with comprehensive viewing angles can be supported by in-venue, stadium-grade networks. These include on-field cameras such as referee cameras and cameras showing the player's perspective that stream, multicast and unicast live feeds to fans. Those in upper level seating may now have a virtual view from the front row that provides a richer experience and enables the venue and teams to more effectively sell those seats. This virtual experience offers the best of both worlds to fans by allowing them to feel like they are in the middle of the action with panoramic, front row views.

Visitor experiences: To enhance eSports events and visitor or facility tour experiences, venues are also providing both real-time and static content to fans with sophisticated AR/VR headsets. For example, an empty stadium does not offer a compelling or realistic feel for what a game day experience feels like. Venues such as the Mercedes-Benz arena in Stuttgart uses AR headsets to simulate the game day experience for schoolchildren and others touring the stadium. With the headsets, visitors can see cheering fans and virtually greet the players as they run through the tunnel.

Summary

The role and value of Wi-Fi is always expanding. Functions thought impossible 20 years ago are commonly achieved through Wi-Fi today. Constant evolution and enhancements have solidified Wi-Fi as the preferred connectivity technology for users everywhere. Widescale adoption of Wi-Fi CERTIFIED 6 networks stands to deepen user reliance on this technology through standardization of key features focused on providing more reliability and determinism, as well as increased efficiency and performance while providing multi-gigabit speeds.

Wi-Fi 6 ushers in a new era of connectivity, improving the user experience for the traditional functions that Wi-Fi performs today while enabling a host of new and emerging uses and opportunities. Key capabilities of Wi-Fi 6 deliver performance gains at lower latencies, even in high density environments. Wi-Fi 6 is a platform for innovation, enabling the industry to address more uses, introduce more devices, and invent new ways to revolutionize home, enterprise, and industry. Upgrading networks and devices to Wi-Fi CERTIFIED 6 provides assurances of product interoperability, backward compatibility, and the latest security protections, regardless of product vendor or brand.

About Wi-Fi Alliance®

www.wi-fi.org

Wi-Fi Alliance® is the worldwide network of companies that brings you Wi-Fi®. Members of our collaboration forum come together from across the Wi-Fi ecosystem with the shared vision to connect everyone and everything, everywhere, while providing the best possible user experience. Since 2000, Wi-Fi Alliance has completed more than 50,000 Wi-Fi certifications. The Wi-Fi CERTIFIED™ seal of approval designates products with proven interoperability, backward compatibility, and the highest industry-standard security protections in place. Today, Wi-Fi carries more than half of the internet's traffic in an ever-expanding variety of applications. Wi-Fi Alliance continues to drive the adoption and evolution of Wi-Fi, which billions of people rely on every day.