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PREPARING THE INFRASTRUCTURE FOR NEXT-GEN Wi-Fi

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- Unexpected Challenges of Running Cloud-Native 5G Networks
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- Digital Building Solutions—The Future of Building Technology

PREPARING THE INFRASTRUCTURE FOR NEXT-GEN Wi-Fi

Today's installation platform will fund tomorrow's technologies.

COVER ARTICLE By Patti Fisher, RCDD, DCDC, OSP, RTPM, WD and Bree Murphy, RCDD

Often described as an essential and required utility in both enterprise and residential markets, Wi-Fi has become a necessity in many businesses. An unpredicted spike in network traffic, caused by an overabundance of new Wi-Fi-enabled client devices and applications, can wreak havoc on the network. As a result, the user experience suffers because of problems, such as repeated buffering, slow connection speeds, and web pages not loading, among other issues that ultimately hinder the availability and performance of the network.

This can be detrimental to businesses in the enterprise market where Wi-Fi is expected and also required for the operational use of the facility. Currently, the many emerging technologies and new devices under development that can operate across various types of wireless systems will soon find their way onto the Wi-Fi network.

High-use cases include high-bandwidth applications, high-resolution video streaming, the Internet of Things (IoT), the Internet of Medical Things (IoMT), machine-to-machine (M2M) communication, artificial intelligence (AI), virtual reality (VR), and augmented reality (AR). The devices and applications supporting these emerging technologies will no doubt exploit the availability of the Wi-Fi network, and for customers in the enterprise market, the challenge will be how to keep up with the increased bandwidth demands to provide seamless connection and communication.

Planning for a robust infrastructure that will support future generations of wireless now means considering new technologies that can improve performance capabilities, update the cabling infrastructure, and modernize wireless access point (WAP) installation methods.

Wi-Fi TECHNOLOGIES CONTINUE TO EVOLVE

As an information delivery method, Wi-Fi has been in existence for decades. The need for constant improvement is essential to providing the performance necessary for consumers and enterprise networks today and into the future. There have been eight iterations of the Wi-Fi network protocol, with the latest—IEEE 802.11ax—released in 2019. Each iteration has been faster and more reliable than its predecessor.

In October of 2018, the Wi-Fi Alliance™ adopted a more traditional naming approach to help eliminate confusion among the standards. This simpler identification method makes it easier to determine the generation of technology and product compatibility. Based on the new naming standards, IEEE 802.11n refers to Wi-Fi 4; IEEE 802.11ac refers to Wi-Fi 5; and IEEE 802.11ax refers to Wi-Fi 6. Furthermore, IEEE 802.11be *Extremely High Throughput* (EHT) is the forthcoming new amendment to the Wi-Fi standard, referred to as Wi-Fi 7.

IEEE 802.11ax (Wi-Fi 6)

Ever since the Wi-Fi Alliance provided certification for Wi-Fi 6 in 2019, it has recognized this iteration as the most widely adopted Wi-Fi standard to date, exceeding 50 percent market share in three years compared to four years for Wi-Fi 5 (IEEE 802.11ac.). In addition, Wi-Fi 6 provides improved performance, faster speeds, expanded coverage, and longer battery life compared to Wi-Fi 5. Advanced features of Wi-Fi 6 are offering new opportunities for the IoT and densification in public areas.

Whereas Wi-Fi 5 operates in the 5 GHz range only, Wi-Fi 6 operates in both the 2.4 GHz and 5 GHz ranges, creating more available channels. Additionally, Wi-Fi 6 offers increased throughput using a higher level of quadrature amplitude modulation (QAM), which allows for more data-per-packet transmission.

In terms of downloads from the WAP to the client, early Wi-Fi standards only supported one transmission at a time per WAP. The second wave of Wi-Fi 5 began using multi-user, multiple-input, multiple output (MU-MIMO), which allows WAPs to send up to four streams simultaneously. However, Wi-Fi 6 allows for eight simultaneous streams and makes use of specific beamforming technology that is capable of accurately aiming the streams at the receiver's antenna.

Additionally, an even more significant technology advancement developed for the Wi-Fi 6 standard is the use of MU-MIMO with an LTE cellular base station technology called orthogonal frequency division multiple access (OFDMA). This allows each MU-MIMO stream to be split into four additional streams, boosting the effective bandwidth per user by 4X. Basic service set (BSS) coloring is yet another Wi-Fi advancement that helps improve network congestion. Overlapping basic service set (OBSS) occurs when two or more unrelated WAPs are installed in close proximity and operating on the same transmission channel interfere with each other. This problem can significantly reduce the network's performance. The BSS coloring is a method used to differentiate between the BSS of WAPs and their clients on the same radio frequency (RF) channel. The result is mitigation of co-channel interference. Together, OFDMA and BSS coloring allow the network to handle large amounts of network traffic more efficiently. As more and more devices utilize the Wi-Fi network, this will help preserve the speed and stability of the network connections. Other technologies introduced in Wi-Fi 6, such as trigger-based random access and dynamic fragmentation coupled with spatial frequency reuse, provide for deterministic communication in congested environments, a necessity in time-critical applications.

Lastly, Wi-Fi 6 introduces a technology called target wake time (TWT), which allows for more efficient communication between the router and client device in terms of sleep and wake mode. It promises to make a significant improvement in battery life because the client device will spend less time and energy searching for a wireless signal.

Although Wi-Fi 6 offers many advantages over previous Wi-Fi iterations, the unpredicted, rapid release of more Wi-Fi enabled devices and bandwidth-hungry applications revealed that Wi-Fi 6 needed something more. As a result, the largest breakthrough in the history of Wi-Fi took place on April 23, 2020 when the FCC released 1,200 MHz of spectrum in the 6 GHz band (5.925-7.125 GHz) for unlicensed use. This takes Wi-Fi 6 technology and extends it into the 6 GHz band, known as Wi-Fi 6E (E = extended) for even greater performance.

FCC 5 GHz and 6 GHz Channel Plans

The 6 GHz band offers 1,200 MHz of spectrum supporting an additional 59 contiguous 20 MHz wide channels (Figure 1). In comparison, the 2.4 GHz band encompasses 3 channels that are each 20 MHz wide while the 5 GHz band has 25 non-contiguous 20 MHz channels (Figure 2).

The additional spectrum will result in less congestion, and the contiguous spectrum permits greater flexibility in channel bonding, which will support high-bandwidth consumers, such as AR, VR, and low-latency applications. Only certified Wi-Fi 6E equipment will offer the capability to operate within the 6 GHz band.

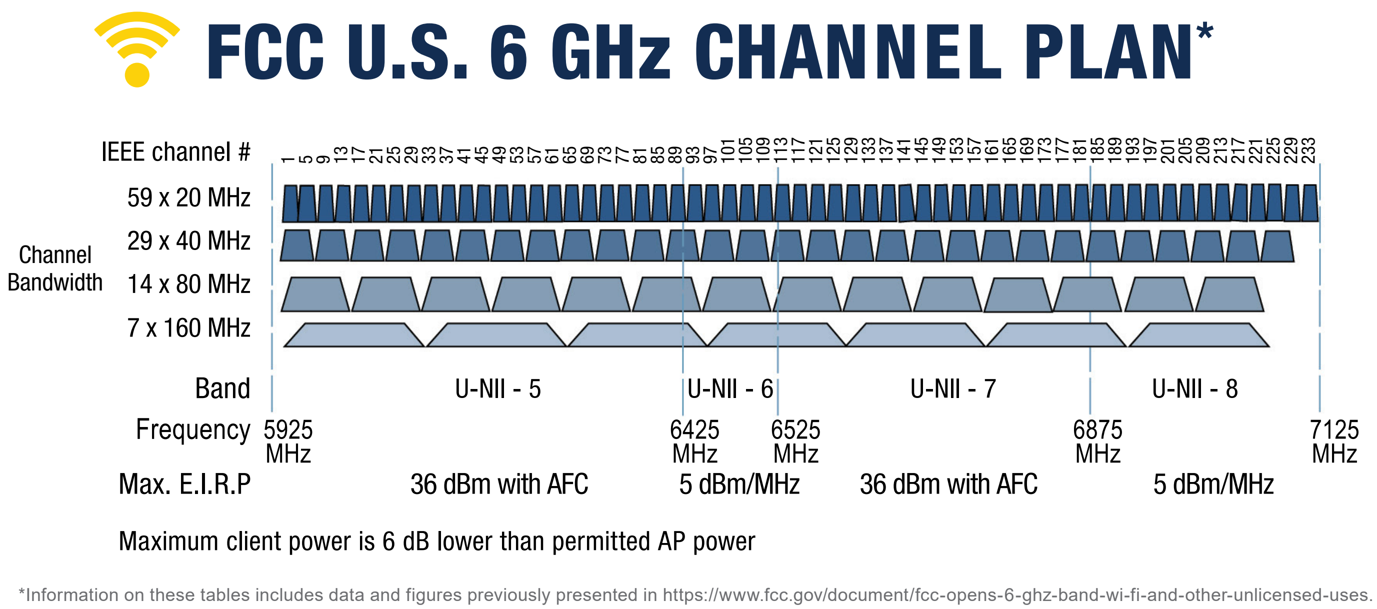

FIGURE 1: FCC U.S. 6 GHz channel plan.

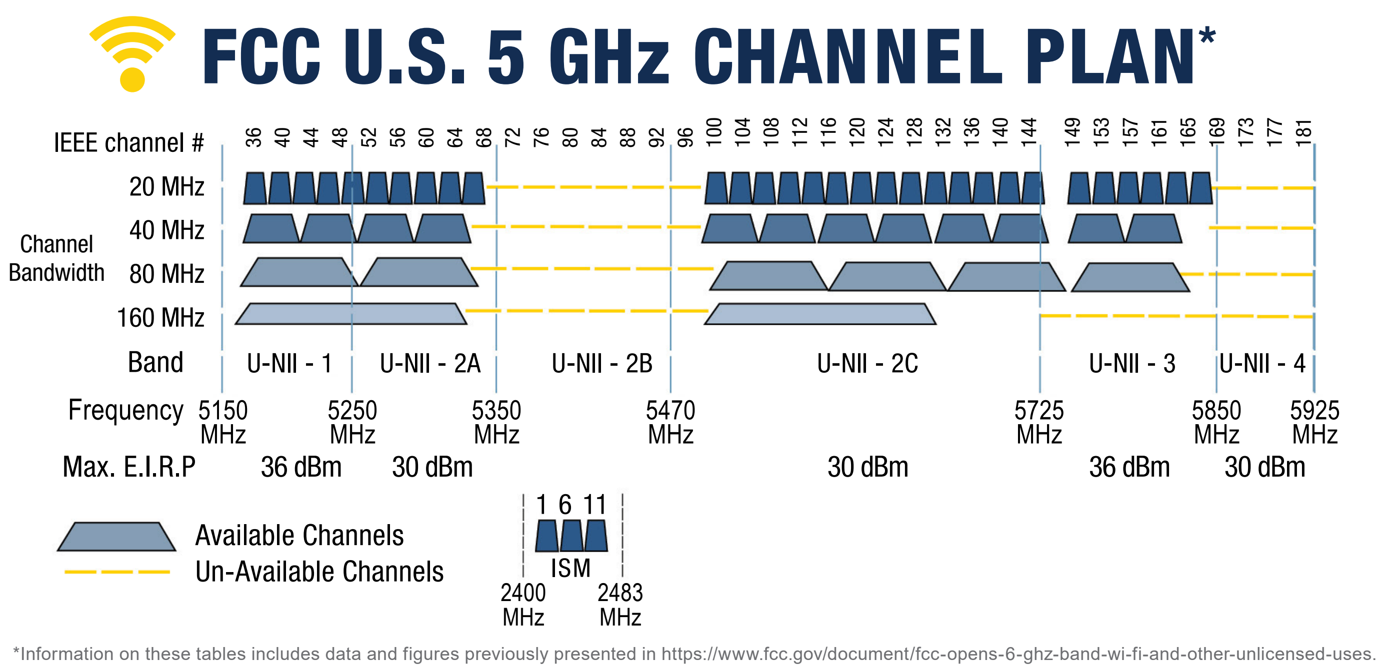

FIGURE 2: FCC U.S. 5 GHz channel plan.

Automated Frequency Coordination (AFC)

The 6 GHz band has long been used by incumbent operators, such as utility companies, public safety agencies, common carriers, and fixed satellite services (FSS) TV broadcasters. In an effort to not interfere with these existing users, a plan for spectrum use for outdoor deployments was put in place. The Wi-Fi Alliance, along with the U.S. FCC, developed a system known as automated frequency coordination (AFC), which manages spectrum usage requests for outdoor environments.

This achievement follows the publication of the *AFC System to AFC Device Interface Specification* by the Wi-Fi Alliance. The focus is to ensure that the incumbents do not experience unfavorable interference from other unlicensed systems. The key component to consider is the power radiated from WAPs and antennas. The FCC defines four types of device classifications with very different transmit power rules. These power rules are related to power emitted from WAPs defined as equivalent isotropic radiated power (EIRP). The EIRP is generally used to restrict the amount of radiation power from wireless devices and their antennas. Standard power for indoor/outdoor use (limited to UNII-5 and UNII-7 bands) are permitted without restrictions for indoor use. However, outdoor use requires AFC guidance. Low power indoor (LPI) mode for indoor use only (limited to UNII-6 and UNII-8 band), a very low power (VLP) mode to be further defined, and client power that is typically 6 dB lower than the WAP to which it is attached.

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The Wi-Fi Alliance recently added two additional elements necessary for AFC system implementation: The *AFC System Reference Model* and *AFC Device Compliance Test Plan*. This guidance helps enable unlicensed devices in the 6 GHz band to operate outdoors so that they do not interfere with existing equipment already operating in the 6 GHz spectrum. Facility owners and ICT professionals involved in the design and implementation of outdoor Wi-Fi networks are urged to monitor the development of AFC and similar systems to inform their decision on extending their Wi-Fi 6E network outdoors.

Wi-Fi 6/6E Industry Outlook

The industry is experiencing a rapid shift toward Wi-Fi 6 to support mission-critical data and help to alleviate network saturation. Wi-Fi 6 has become the preferred standard for most enterprise networks with Wi-Fi 6E gaining unprecedented momentum. The Wi-Fi Alliance has certified more than 400 Wi-Fi 6E devices ranging from laptops to consumer and enterprise WAPs, smart phones, and smart TVs. According to the Wi-Fi Alliance, supply constraints are anticipated to bounce back at the end of 2022, driving rapid deployment of both Wi-Fi 6 and 6E WAPs.[1]

Looking at the continuing evolution of Wi-Fi technologies, it is important to address the cabling infrastructure to support next-gen Wi-Fi's increased power and bandwidth. Today's installations fund tomorrow's technologies. As a result, a robust, reliable, and adaptable ICT infrastructure that will support the next generation of wireless and Wi-Fi-enabled devices is critical. With Wi-Fi evolving, ICT professionals need to reconceptualize their ICT infrastructure in preparation for emerging wireless bandwidth demands.

CONSIDER THE STRUCTURED CABLING

Pathways and spaces, power, cabling, and even network equipment upgrades may be required before this generation of WAPs can be fully implemented. The early releases of Wi-Fi 6 WAPs could operate over the existing category 5e or category 6 infrastructure. However, the current versions can operate at speeds up to 10 Gb/s. To fully use the Wi-Fi 6 and 6E capabilities, at a minimum, category 6A should be used. Moreover, Wi-Fi benefits from another advantage of category 6A cables; they better dissipate the heat generated by the higher wattage of power over Ethernet (PoE).

Pathways and Spaces

Although manufacturers have made great strides in reducing cable diameter since the category 6A ratification in 2009, most still have a greater outer diameter than category 6. This creates the need for careful calculations when sizing basket tray, conduits, and even outlet boxes. These larger cables and deeper jacks benefit from the use of deeper and wider boxes, such as two gang with a one gang mud ring, that help installation and even potentially reduce cable failure. Terminations within the outlet box can gain from jacks designed to reduce the sharp bend at the punch down.

While telecommunications rooms (TRs) are no longer the closets they once were, changes are still required. The increase in cable outer diameter impacts the size of sleeves, ladder tray, and vertical managers. Designs should address installation practices, such as cable routing within racks and slack storage, that can be challenging with category 6A cable having an average outer diameter of .275 in (≈7.0 mm). See Figure 3.

FIGURE 3: Managing category 6A at the rack.

The PoE switches generate more heat and often have different power requirements than their predecessors. While the power and cooling needs within the TR are easily addressed in greenfield deployment, they pose a unique challenge when one must overcome them in an existing TR.

As wireless is called upon to support more and more other systems, including building automation systems (BAS) or access control, there may be a need to provide wireless in areas of the building, such as mechanical penthouses and electrical rooms, where there can be greater radio frequency (RF) interference. As owners move away from wired connections and desire more robust wireless networks, deploying wireless infrastructure with the ability to scale up is beneficial.

The TRs are venturing out to the edge and may benefit from a zone cabling topology. The zone topology moves the heat and cable density from the TR into distributed telecommunications enclosures (TEs). Having a distributed zone approach, where the TE is near the WAPs, allows for rapid reconfiguration of the WAPs. It shortens the length of copper cables being installed and reduces the number of cables within pathways approaching the TE. It is important to reserve additional capacity within the TE so that cabling for extra WAPs can be installed to enhance wireless coverage (Figure 4).

FIGURE 4: Installing cables in a zone enclosure.

Power

The extra radios and processor capabilities means these new generations of WAPs require more power. At a minimum, 802.3at (PoE Plus) is required to enable all functionality. Where tri-frequency Wi-Fi 6E WAPs are deployed, 802.3bt power is necessary because 802.3at is no longer sufficient. Furthermore, 802.3bt is the most current PoE standard that defines per-port power-source capabilities of 45 watts (W), 60 W, 75 W, and even 90 W. When a WAP is not fully powered, its functionality may be downgraded. Different vendors approach down grading capabilities differently. Some may turn off 2.4 GHz radios while others disable other network interfaces, such as a Bluetooth low energy radio. It is important to research what will not be functioning when deploying WAPs with less than full power.

Cabling

Initially thought of as a way to future-proof cabling, the benefit of category 6A has been publicized for years. Some may not have adopted category 6A because of the increase in cost, perceived installation challenges, or because of not having a current use case for the increased transmission rate. If not making a wholesale move to category 6A, it has been advised to use the advanced cable, at a minimum, for the WAPs. These generations of WAPs benefit from two class EA/category 6A or higher horizontal cables to each Wi-Fi location. Two cables allow for increased bandwidth through link aggregation; they also could provide increased PoE if that becomes necessary.

Deploying Type 4 PoE Plus to remotely power WAPs can cause heat to build up in cable bundles. Select cables that are qualified for reliability up to 75°C (167°F), which enables support of the Type 4 PoE application over the entire operating temperature range of -20°C to 60°C (-4°F to 140°F). Shielded systems are more thermally stable and support longer channel lengths when deployed in high temperature environments (e.g., ceilings) and larger number of shielded cables may be bundled without concern for excessive heat build-up within the bundle. Use solid conductor cords that exhibit better thermal stability and lower insertion loss than stranded conductor cords for equipment connections in the ceiling where higher temperatures are likely to be encountered.

Look for jacks, patch panels, and patch cords that comply with IEC 60512-99-001, *Connectors for Electronic Equipment.* This includes testing of communications cabling being used for remote powering. This signifies the ability for these devices to be disconnected under Type 4 PoE without damaging the circuit boards. Before specifying direct connect terminations, verify the body of the plug fits within the space allowed at the WAP's Ethernet ports.

Backbone cabling should be a minimum of 25 Gb/s capable multimode optical fiber media to support Wi-Fi 6 and Wi-Fi 6E uplink capacity.

Network Equipment

The structured cabling systems described previously make up the passive components of the data network systems. The active data network electronics needed for Wi-Fi 6 and 6E may be different than those already installed. Since Wi-Fi 6 and 6E WAPs can accept more traffic compared to earlier generations of wireless, the current gigabit Ethernet backhaul may become a bottleneck. Typically, the network design will use multi-gig PoE switches. These provide the ability for each port to be 1, 2.5, 5, or 10 Gb/s. While all switches in a TR do not usually need to be this way, the WAPs are split between a couple of multi-gig switches to reduce the potential of a complete wireless outage by losing a single switch. Some network administrators may decide to delay a switch upgrade until more client devices, compatible with the 6GHz band, are available.

Calculate PoE loads carefully to ensure the network equipment can provide the power needed over the full number of ports supporting the Wi-Fi devices. Pay attention to power supplies so they do not cause a reduction in the available PoE. Most of these multi-gig PoE switches are using either 720 W or 1100 W power supplies. See Figure 5.

Industry Standards and Recommended Guidelines

For standards with recommendations and best practices for the cabling infrastructure, consult the following:

- ISO/IEC TR 24704, Information technology—*Customer Premises Cabling for Wireless Access Points.*
- ANSI/BICSI 008-2018, *Wireless Local Area Networks (WLAN) System Design and Implementations Best Practices.*
- ANSI/BICSI N2-17, *Practices for the Installation of Telecommunications and ICT Cabling Intended to Support Remote Power Applications.*
- While TIA TSB-162-B and ISO/IEC TR 24704 are not standards and can only recommend the use of two category 6A per WAP, the recently published ANSI/4966-A, *Telecommunications Infrastructure Standard for Educational Facilities* requires a minimum of two category 6A or higher performing cable runs for every WAP.

Consider the industry standards and best practices when evaluating the costs and benefits of the infrastructure required to support next generation technologies. There are potential impacts on both the passive and active components of the network. Increasing the performance of the structured cabling system is required for wireless communication and will also benefit other areas of the network. Since the cabling infrastructure often has a life span of 15 or more years, it makes sense to deploy the suggested industry recommendations that defer the need to replace the cabling infrastructure.

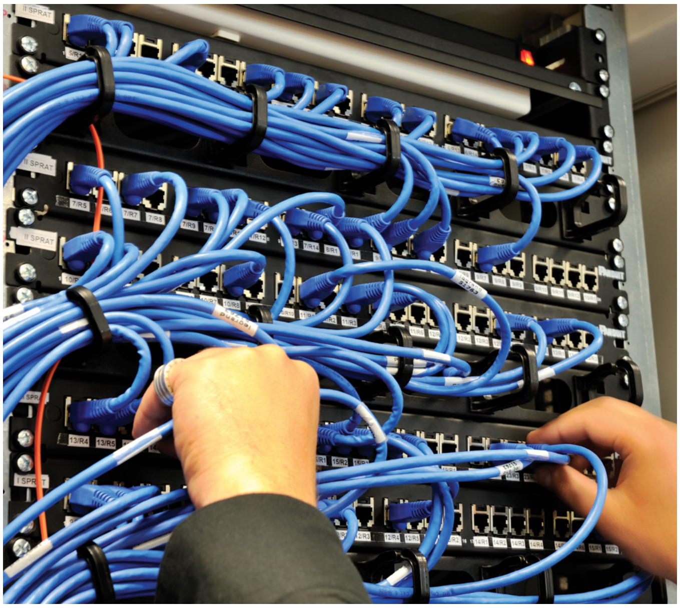

FIGURE 5: Patching at the switches.

MODERNIZE THE WAP'S PHYSICAL INSTALLATION METHODS TO PREPARE FOR THE FUTURE

Rethinking the cabling infrastructure has also shifted the industry to consider new and improved methods of installing wireless equipment. As technology evolves, physical installation methods must evolve as well. Traditional methods of WAP deployment have become less desirable and there is now an undeniable need to provide installation alternatives for seamless deployment, adequate functionality, and performance for the areas in which they serve.

Designers, architects, contractors, and building owners are seeking new ways to deploy wireless equipment with critical operational support and aesthetics suitable to architecturally sensitive areas. Network planners will, therefore, look for infrastructure options that enable scalability as requirements change and adaptability to different networking technologies.

Considerations before selecting a WAP's installation method:

- Eliminate the need for holes and gaps in the ceiling tiles for cable egress (Figures 6, 7).
- Simplify installation while concealing and protecting wireless equipment and cabling components without compromising performance of the wireless network (Figures 6, 7).
- Provide full access to wireless equipment and associated cabling and components for maintenance and serviceability without the need to enter the ceiling space (Figures 6, 7).
- Ceiling enclosures should provide all the proper performance and safety ratings for the intended purpose (Figures 6, 7).
- Consider an installation method with room to stow excess cable service loop and associated components while providing quick and easy access to all components (Figures 6,7).

FIGURE 6: Example of a 2 x 2 locking ceiling tile mount, offering physical security, performance, and aesthetics.

FIGURE 7: Example of a 2 x 2 ceiling mount opened, displaying properly stowed cabling and components for quick and easy authorized access without opening up the ceiling space. The quick-release interchangeable door provides a low-cost method of upgrading to future WAPs.

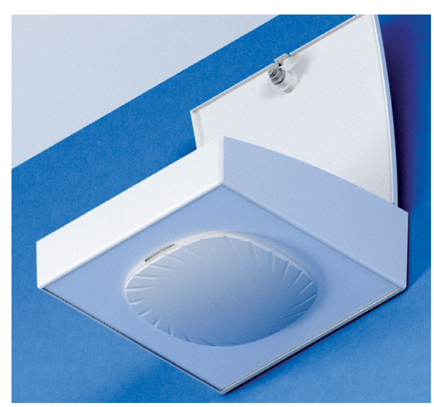

FIGURE 8: Example of a right-angle mount providing horizontal orientation of the WAP. The WAP is partially recessed into the mount, exposing only the antenna face of the WAP, providing for the ideal combination of aesthetics and wireless coverage. Interchangeable trims provide an affordable method for easy migration to new WAPs.

- Provide an installation that offers a built-in, easy migration path to future WAPs. The need will arise when the current wireless equipment is exchanged for newer advanced equipment (Figures 6, 7, 8).

- Choose a lockable installation method for the prevention of tampering (Figures 6, 7, 8).

- Simplify hospital ICRA procedures with a ceiling installation method permitting access to the installed equipment without opening the above ceiling space. Use a ceiling enclosure in the critical environments requiring a barrier between the work-space and the above ceiling space (Figures 6, 7, 8).

- Select an installation method that will satisfy aesthetic requirements, blending into the environment.

- Provide consistency in the look and function of the installation throughout the facility, as well as ease of operational support.

CONCLUSION

Future generations of Wi-Fi technology introduce a significant increase in throughput and bandwidth for wireless networks across all industry segments.

There have been eight iterations of the Wi-Fi network protocol, with the latest—IEEE 802.11ax—released in 2019. Each iteration has been faster and more reliable than its predecessor.

The need to reconceptualize the physical layer infrastructure is essential to supporting future Wi-Fi performance improvements. When the time comes to upgrade the Wi-Fi network, simply swapping out the existing WAPs may not be adequate enough to achieve the full performance of the upgraded Wi-Fi equipment.

Upgrading the cabling system and WAP installation methods should be considered during current design planning to ensure full WAP performance and ease of operational support of the Wi-Fi network. The cabling system design should incorporate all available industry recommended standards to ensure the longevity of the cabling installation. Additionally, it is recommended to adopt new and improved WAP installation methods that provide a consistent look and serviceability features throughout the building.

Furthermore, implementing modern WAP installation hardware that offers adaptability, security, aesthetic requirements, and optimal performance of the WAP will help to seamlessly deploy future upgrades. In conclusion, the physical layer infrastructure should be designed today to support effortlessly the technologies of the future.

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