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Key Considerations to Solve the Challenges in Bringing 5G Indoors

Overview

Wireless connectivity in the workplace is no longer a convenience or option; it is critical. With significant advances in technology, 5G promises to provide unprecedented speeds, massive connectivity and immersive experiences needed in today's and tomorrow's enterprise communications networks.

While the tenants of 5G sound promising, many variables and unknowns remain about how 5G can meet the needs of indoor solutions. This short paper discusses some of the challenges such as spectrum choices and indoor infrastructure, and how service providers and user communities can leverage different solutions to provide indoor environments with the high-speed, low-latency connectivity that 5G promises.

5G Indoors Will Require a Use-Case Focused Spectrum Strategy

A wide range of legacy and new spectrum choices are being leveraged to support 5G. Each spectrum band brings different benefits and challenges to an operator's deployment strategy. 5G will warrant a careful look at the characteristics of the spectrum to support the desired indoor 5G application.

Low-band frequencies, also known as Sub-1 GHz spectrum, have excellent propagation characteristics, but the longer wavelengths in this band have a direct impact on speed. The low-bands do not provide the capacity to support high-bandwidth 5G applications. Operators will use the Sub-1 GHz spectrum to provide blanket-like indoor and outdoor coverage to enterprises that deploy highly scalable IoT applications, and to residential and business consumers where ultra-high throughput and low latency requirements are not as critical.

On the other hand, the **high-band frequencies**, often referred to as millimeter-wave (mmWave), can offer exceptionally high data rates, approaching or exceeding one Gbps. However, this spectrum's shorter waves mean the coverage range is smaller and does not consistently penetrate walls and windows. One of the challenges in today's buildings is that building materials, insulation, and UV windows can impede the mmWave signals generated by outdoor sites. Operators can mitigate this challenge by using mmWave radios with beamforming technologies to provide coverage for specialized inbuilding deployments that support line of sight connectivity with few obstructions.

Many carriers in the US and worldwide plan to utilize mmWave spectrum for select indoor use cases such as enabling new experiences at high- density venues, automating smart manufacturing facilities, and for providing fixed wireless access services to business locations.

The **mid-band spectrum** offers a nice balance of speed and propagation, which makes it a good choice for most indoor deployments. However, the legacy mid-band spectrum (< 3 GHz, where most 2G, 3G, and 4G networks are deployed) is scarce and limiting in support of the higher bandwidth and low latency needs of indoor 5G applications. FCC is pursuing newer (3-6 GHz) mid-band spectrums (including 3.7 to 4.2 GHz Band and 3.5 GHz CBRS Band for shared consumption) to provide additional capacity for indoor and outdoor 5G deployments[1]. Additionally, incorporating a strategy that uses shared and unlicensed spectrum will provide the flexibility that will allow operators to meet the low-cost and high-quality needs of public and enterprise in-building deployments, like those needed in hospitals and security-focused businesses.

As new spectrum bands become available, 5G indoor networks are expected to utilize a mix of low, mid, and high-frequency bands to enable the full coverage, high-speed, and low-latency connectivity needed by businesses and consumers.

[1] https://www.fcc.gov/5G

5G Applications and Spectrum Choices Will Drive New In-Building Deployment Options

To ensure good indoor experiences, carriers and building owners employ different options for delivering in-building cellular coverage and capacity. Today's coverage options start with leveraging propagation capabilities from the outdoor 3G/4G macro networks. When necessary, operators supplement these 3G/4G signals with additional solutions like active and passive distributed antenna systems (DAS), repeaters, and small cells. But with new spectrum choices and 5G's capabilities to support new higher speed and lower latency applications, in-building infrastructure requirements are changing significantly.

5G-ready DAS will be viable for only very large buildings and limited applications

DAS is the most common solution used by carriers and building owners to improve indoor coverage and capacity for multi-carrier multi-technology applications. However, the newer mid-band (> 3GHz) and high-band (> 6GHz) frequencies pose challenges in leveraging existing in-building DAS systems. Most active and passive DAS solutions are typically designed to work using frequencies below 2.6 GHz, so, to support 5G, these solutions will require significant upgrades that are cost prohibitive. In very large buildings with good availability of fiber, active DAS solutions can continue to provide effective 5G coverage depending on how DAS solutions evolve to support new mid-band and mmWave spectrum. At this point, even with support for newer bands, it is uncertain how DAS will be able to support the more advanced 5G services that require very high-speed, high-bandwidth, and ultra-low latency traffic.

Small Cells will dominate the in-building 5G deployments for small to large size buildings

The need for hyper-densification to achieve high capacity will become even more critical with 5G. While mmWave spectrum poses lower coverage and propagation, 5G small cells using mmWave spectrum are an excellent option for high-density scenarios with significantly reduced concern for interference between adjacent cells.

According to a Small Cell Forum / Rethink Wireless forecast – the indoor 5G small cell in high-band spectrum (> 6 GHz) will represent the largest number of connections over the 2019-2025 period. It will be followed by the mid-band indoor small cells, where both licensed and shared/ unlicensed deployments will flourish.[2] As per FCC, mid-band spectrum presents wireless providers with the opportunity to deploy base stations using smaller cells to achieve higher spectrum reuse than the lower frequency bands while still providing indoor coverage.[3,4] 5G small cells will offer operators a more cost-effective and flexible solution to provide the necessary capacity, coverage, and dynamic scalability in venues where capacity can change without notice, such as airports, subway terminals, or arenas. Network operators can also deploy 5G small cells to ensure localized connectivity for applications that require very high bandwidth and/ or ultra-low response times.

Virtualization and distributed radio architecture will bring new efficiencies to in-building deployments

Virtualized and disaggregated Radio Access Network (RAN) architecture that is being adopted by many network operators in macro networks can play a critical role in the evolution of indoor 5G networks as well. It will be essential in supporting the operator business case for in-building deployment by reducing the overall TCO.

Operators traditionally deploy small cells as standalone units with baseband functionality, radio, and antenna integrated in a single device, where each require dedicated power source and cables to backhaul traffic to the core network. In hyper-dense 5G deployments, integrated small cells can pose scalability challenges, while a disaggregated small cell network can reduce the operational and deployment concerns. These distributed solutions consist of centralized baseband control units located at a remote or edge data center that use IT-standard copper or fiber front haul to connect to distributed light-weight radio units with integrated antennas. This RAN architecture option will allow cost savings, ease of deployment, better planning for indoor coverage, and facilitate dynamic allocation of network capacity - positively impacting the overall quality of service indoors. Operators can use distributed small cell solutions wherever cell density and capacity requirements are high – like stadiums or public transit locations, such as airports and train stations.

The Disaggregated Small Cell architecture will allow cost savings, ease of deployment, better planning for indoor coverage, and improve quality of experience in high density indoor environments.

[2] https://www.5gamericas.org/wp-content/uploads/2019/07/Small_Cell_Siting_Challenges__Recommendations_Whitepaper_final.pdf
[3] https://www.fcc.gov/document/fcc-expands-flexible-use-mid-band-spectrum
[4] https://docs.fcc.gov/public/attachments/FCC-18-91A1.pdf

Samsung Solutions Are Paving the Path for Ubiquitous 5G Experience

Samsung is a critical contributor in the early commercial 5G launches in the U.S. By collaborating with many carriers and ecosystem partners, Samsung is demonstrating how 5G can drive the next wave of innovation in multiple industry verticals such as manufacturing, healthcare, and public venues, as well as deliver better indoor experiences for residential consumers and small businesses. Radio access and core network solutions from Samsung support the growth of service providers, business owners, and multi-tenant environments. Samsung's portfolio of indoor solutions includes 5G CPE routers and multiple small cell solutions supporting mmWave and sub-6 GHz spectrum. These innovative solutions from Samsung are paving the path to enable ubiquitous 5G experiences for businesses and consumers.

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