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How to Deliver Pervasive In-Building Connectivity

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Today's mobile subscribers demand quality service everywhere, all the time – from commercial buildings and event venues to college campuses, manufacturing plants, and subways. Yet delivery of pervasive in-building connectivity presents myriad challenges, particularly as mobile network technologies continue to evolve. How can network operators and system integrator ensure quality in-building service?

Tackle RF Challenges

Although mobile networks provide pervasive wide-area coverage in most cities and suburbs worldwide, many legacy radio frequency (RF) bands do not penetrate building materials very well. This means that energy-efficient windows, neighboring buildings, and other nearby obstacles easily block outdoor network signals. As a result, mobile device users typically experience poor quality of service (QoS) indoors — where roughly 80 percent of all mobile voice and data traffic occurs.

Traditionally, many building owners, system integrators, and third-party network operators have addressed this in-building connectivity challenge by deploying neutral host distributed antenna system (DAS) equipment. Yet, each deployment is unique, and a number of factors need to be evaluated to determine the type of DAS platform best suited to the job and the way in which it's deployed. The building size, materials, and layout all play an important role, as well as the intended in-building use cases. Is it a commercial property with retail tenants, a hospital campus, or a multi- story office building? Perhaps a sports stadium or music venue is in need of expanded capacity to support a multimedia fan experience.

More importantly, proper DAS configuration and deployment will require knowledge of which spectrum is in use in the nearby mobile network cell sites, and the signal propagation characteristics of each RF band. For example, the recently available 5G mid-band frequencies, such as the C-band spectrum, are even more easily attenuated than legacy mobile frequencies, so these transmissions are even more readily impeded by interior walls, cubicles, furniture, and other clutter than frequencies used for legacy 3G and 4G transmissions. As more mobile network operators (MNOs) build out 5G networks using mid-band frequencies, legacy DAS equipment requires upgrades to support the new frequency bands, and additional DAS modifications may be needed to maintain seamless in- building 5G coverage.

Tailor DAS Deployments

Because the mid-band spectrum provides access to larger channels than legacy bands, the C-band and other mid-band 5G frequencies offer significantly greater capacity for wide-area network deployments. However, these wider channels also consume more radio output power, reducing the effective coverage area. Therefore, to achieve the same in-building coverage footprint using the mid-band spectrum, existing DAS installations will require upgrades, such as antenna replacements and increased output power. (see Figure 1)

Challenges	Legacy 2GHz Band	C-Band	Difference
Pilot Power	LTE 20 MHz -30.8dB	NR 100 MHz -35.2dB	4.4dB
Pathloss	58dB at 30 Feet	63dB at 30 Feet	5dB
Cable Loss	100' ½" Superflex 3.1dB	100' ½" Superflex 4.4dB	1.3dB/100'

Figure 1. C-Band Challenges

Likewise, the C-band provides a shorter signal propagation range as well. In fact, C-band coverage per antenna is a small percent of the in-building coverage provided by some legacy frequencies at the same power level. That means that in an office environment with sheet rock walls, an antenna providing a little more than 10,000 square feet of coverage with a 4G 20 MHz-wide channel may only cover around 3,000 square feet with a 5G 100 MHz-wide channel in the C-band. In this scenario, the upgraded DAS equipment would require amplifiers that provide 4 to 10 times more output power to match the existing footprint (see Figure 2 on next page). Similarly, a growing number of network operators are turning to mid-band Citizens Broadband Radio Service (CBRS) spectrum for private in- building and campus networks, due to the relative speed and lower cost of deploying unlicensed spectrum. In this way, network operators and enterprises can realize the promise of the Internet of Things (IoT), enabling a variety of secure Industry 4.0 use cases, including predictive maintenance, real-time asset tracking, manufacturing automation, and occupational health and safety. Yet, the ability to reliably implement this type of private 5G network requires careful in-building network planning to ensure mission-critical connectivity.

Match Network Transformation

As mobile network infrastructure evolves from 4G to 5G and 6G, increasing network densification is making site build-out ever more difficult. In fact, there were more than 450,000 outdoor small cell nodes already operating across the U.S. at the end of 2022. At the same time, greater economic pressures and coverage mandates are compelling MNOs to find new ways to reduce costs even as they densify coverage.

These challenges are giving rise to new approaches to network deployment and management, including active radio access network (RAN) sharing. These deployment models allow multiple MNOs to share

RAN equipment and/or CBRS spectrum allocations to reduce costs and avoid potential performance and maintenance problems caused by over-building their networks. These shared RAN infrastructure approaches help MNOs increase cost efficiency as they reduce site footprint and environmental impacts, especially for those buildings that, in size or capacity needs, do not require a full multi-operator DAS.

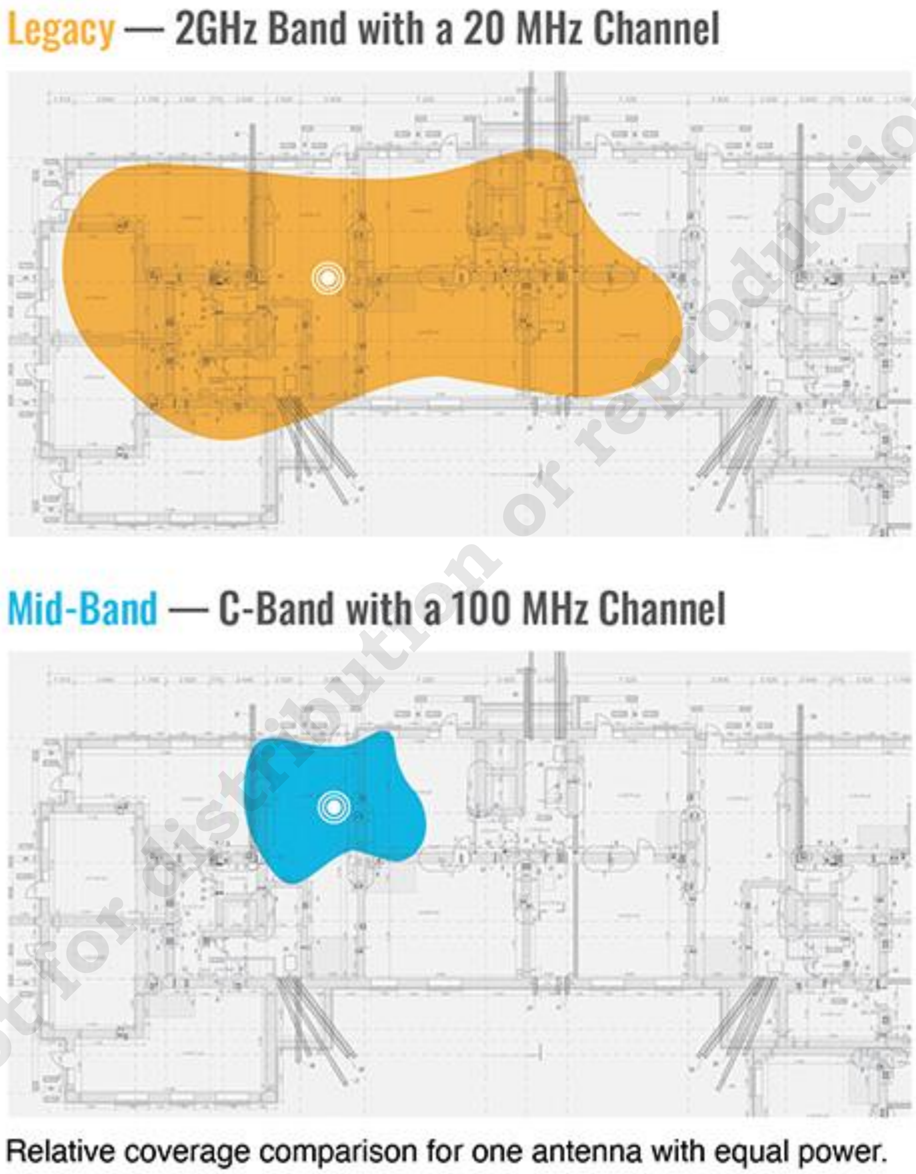

Figure 2. Legacy vs. Mid-band

MORAN

With a multi-operator RAN (MORAN) model, each MNO has dedicated baseband units (BBUs) despite sharing radios, antennas, and power with other MNOs. These shared MORAN deployments can be used with licensed spectrum, in a public network, or with CBRS spectrum for private networks. And when deploying an Open RAN network, a "shared O-RU" feature might be a cost-effective option. This configuration allows full visibility and control of BBU equipment, although it will require changes to front haul switches to enable multiple interfaces. (Figure 3 on next page)

Evolve DAS Models

With the traditional in-building coverage model, multiple operators share neutral host DAS infrastructure that interfaces with signal sources from each MNO’s RAN independently to provide capacity. The DAS platform then distributes that capacity from multiple MNOs to multiple antenna points throughout the building, venue, or campus. This universally accepted model provides the MNOs full visibility and control of their own RAN infrastructure and has been a de facto preferred solution for larger buildings where MNOs need most of their frequency bands.

Yet, as tomorrow’s indoor networks evolve to progressively greater RAN sharing, a model like MOCN is the type of solution that provides better efficiencies for smaller buildings with no capacity constraints. As MNOs transition to an active RAN sharing model, next-generation DAS architectures will enable sharing of the distribution and intermediate layers, while core connections to the MNO networks will exist as today. The MOCN shared spectrum model may be a more efficient solution for smaller enterprise networks and venues below 200,000 square feet, where seamless coverage is more critical than high capacity.

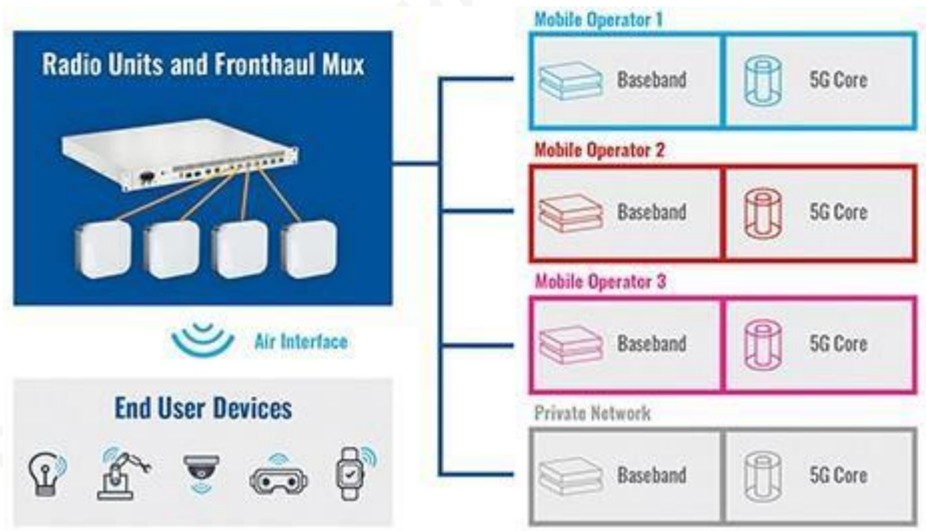

Figure 3. MORAN

MOCN

The full evolution of RAN sharing results in multi-operator core network (MOCN) architecture, in which multiple MNOs share one or more CBRS channels, as well as the baseband. By pooling spectrum allocations, MNOs maximize RAN sharing and resource efficiency for greater cost efficiency, while giving up a certain amount of visibility, flexibility, and control. (Figure 4 on next page)

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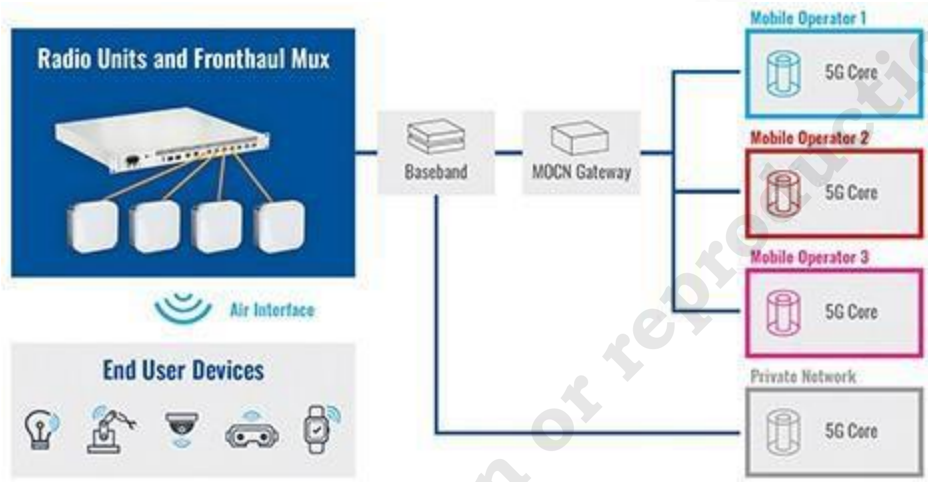

Figure 4. MOCN

In the cases of extreme capacity requirements, it's expected that neutral host DAS infrastructure will continue acting as a more cost-effective in-building solution, particularly with an O-RAN-based DAS interface to MNO networks.

Prepare for Tomorrow

Mobile networks are continually evolving. It's no secret that 5G adoption is accelerating faster than any previous generation, and 5G connections are now expected to reach [6.8 billion] by the end of 2027. With a growing number of enterprises and commercial building owners looking to 5G and the IoT to automatically control building systems such as security cameras, lighting, and smart thermostats, DAS upgrades and deployment configuration changes are needed to ensure seamless in- building 5G coverage and capacity.

Looking forward, preparing for future network transformation will be critical as the FCC releases additional spectrum allocations, MNOs turn off previous mobile generations, and active RAN sharing becomes the norm. Open RAN and advancements in DAS infrastructure are paving the way to meeting these challenges with scalability, reliability, and efficiency. Every deployment project is unique, however, and a robust approach to planning goes a long way toward ensuring QoS and always-on, everywhere, in-building connectivity.