Echo 5G Brings Millimeter Wave to Indoor Commercial Venues

Melroy Machado
Technical Product Manager

Figure 1

For the first time, 5G allows mobile network operators to offer enterprises a compelling alternative to fiber, cable and DSL. That alternative is Fixed Wireless Access (FWA) for business, also known as 5G FWA service. Previous attempts at FWA failed because they required a completely new overlay network and expensive, proprietary equipment. 5G operators can now use their same mobile networks to deliver ultra-high-speed broadband services to residential subscribers and enterprise customers using 3GPP standard equipment and common mobile components.

The fastest version of 5G uses millimeter wave (mmWave) spectrum that can achieve speeds as fast as gigabit fiber internet – or faster. This is good news for the emerging cloud gaming industry which depends not only on high speed but also low latency, jitter, and packet loss. Cloud gaming smartphones are replacing PCs and consoles to allow gamers to go just about anywhere, such as for the retail outlets and stadiums where cloud gamers or augmented reality enthusiasts, respectively, congregate.

mmWave signals typically have difficulty penetrating buildings where 80% of these 5G connections, as with 4G, are expected to originate. Pivotal Commware solved this problem by developing the Echo 5G™, an on-window repeater that acts as a portal to facilitate in-building mmWave signal penetration to both customer premise equipment (CPE) and mmWave smartphone users. This paper will explain what propagation challenges the Echo was developed to solve. It will also provide a few examples of Echo-enabled in-building mmWave coverage – clothing store, hair salon, VIP suite in a stadium and media center at a racetrack -- and suggest some applications that users will enjoy at these venues in the future.

Echo 5G

Echo 5G is a customer-installed repeater for in-building mmWave penetration (Figure 1). The Echo in Figure 1 features an indoor-side puck whose sole function is to power the outdoor-side beamformer through the glass, from a wall-outlet. (The next generation Echo will be an all-indoor unit.)

By using Holographic Beam Forming®, the Echo consumes only 15W, giving it the unique

ability to leverage magnetic power coupling through glass. Low power consumption also confers uniquely small size and low weight.

Echo was designed to address the following mmWave propagation challenges:

1. Reflection off the glass when arriving at an angle,
2. Attenuation by the glass itself, and
3. Shadowing by exterior surfaces, limiting indoor coverage.

Echo captures the mmWave signal from the gNB, straightens it out, pushes it through the glass, and "gently floods" it into the interior. See Figure 2.

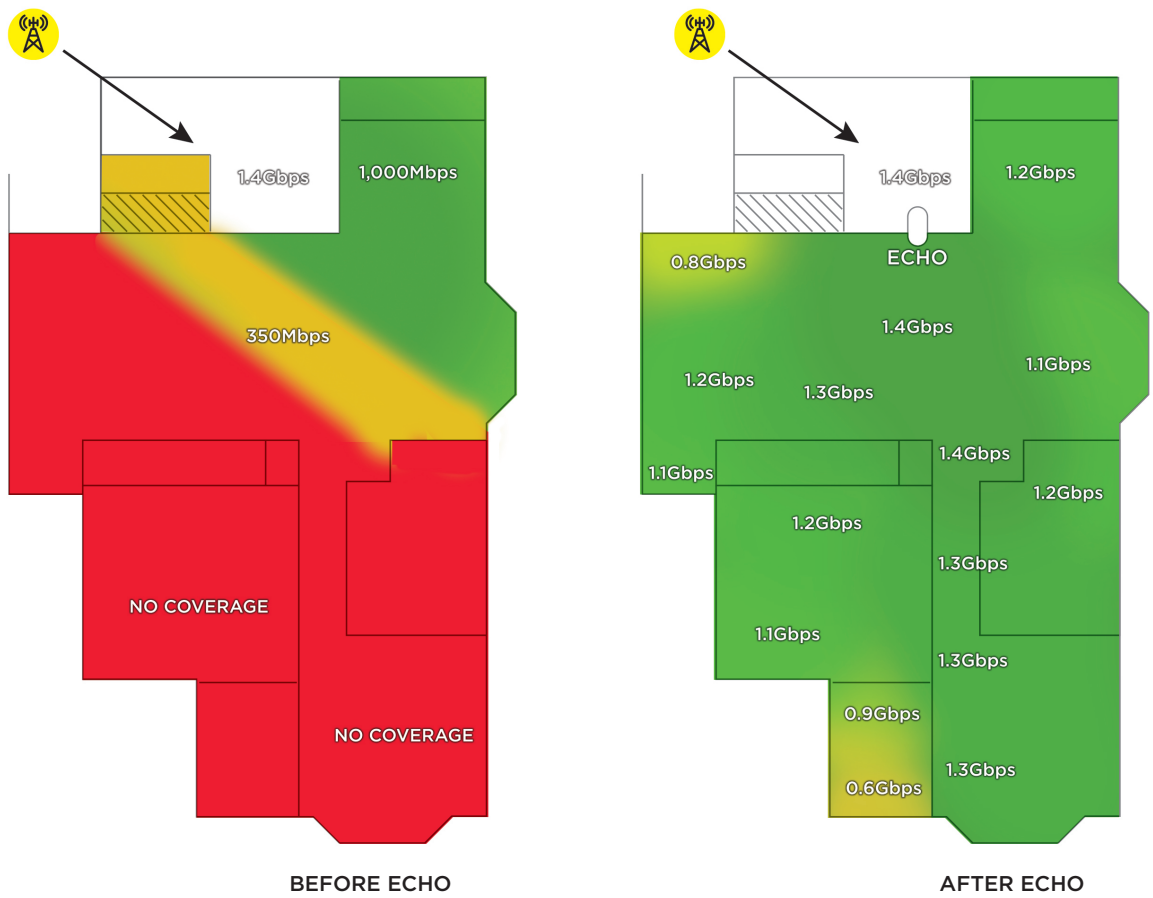


Figure 2

Clothing Store

The Echo has generated impressive indoor coverage improvement in a variety of retail settings. In each case, prior to installing an Echo on the glass, indoor 5G coverage is typically poor to non-existent. Figure 3 shows the exterior of Havana Nines which occupies over 2,000 sq. feet. A gNB resides outside the store in the distant background. In Figure 4, the Echo, as seen from inside the store, acquires the mmWave signal despite a 72-degree scan angle from the gNB.

Figure 3 | Exterior of Havana Nines with gNB in the distance

Figure 4 | Echo mounted on glass at a 72° angle from the gNB

Figure 5 compares coverage and throughput in Havana Nines before and after the installation of an Echo.

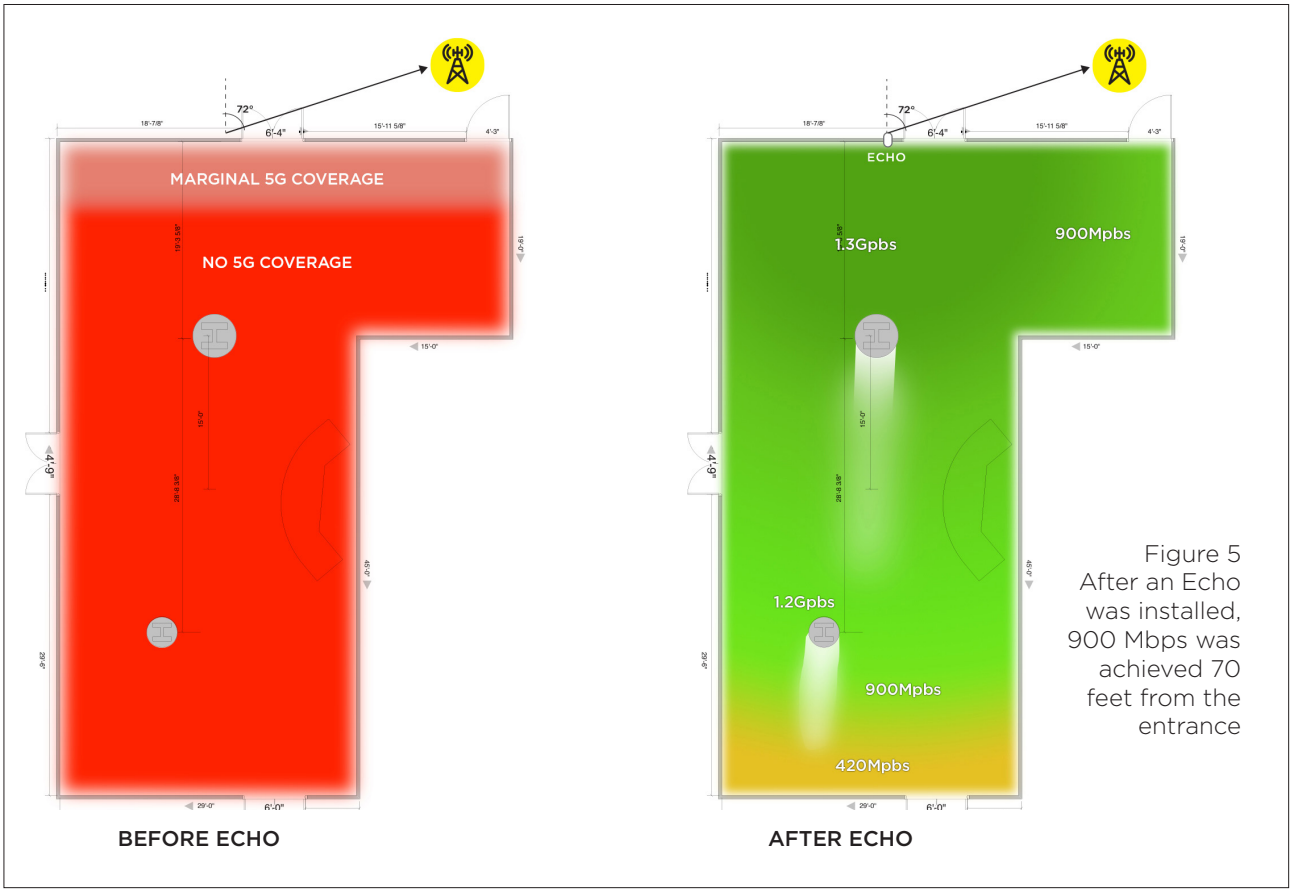


Figure 5
After an Echo was installed, 900 Mbps was achieved 70 feet from the entrance

One can imagine the Havana Nines space occupied by different types of retailers, e.g., coffee shops, grocery stores, etc. How might patrons use their mmWave smartphones in these establishments? Imagine standing in front of a mirror to try on different outfits without having to wear them. The "magic mirror" in Figure 6 allows users to customize a look by trying different clothes, shoes and accessories using hand gestures that are detected by the mirror.

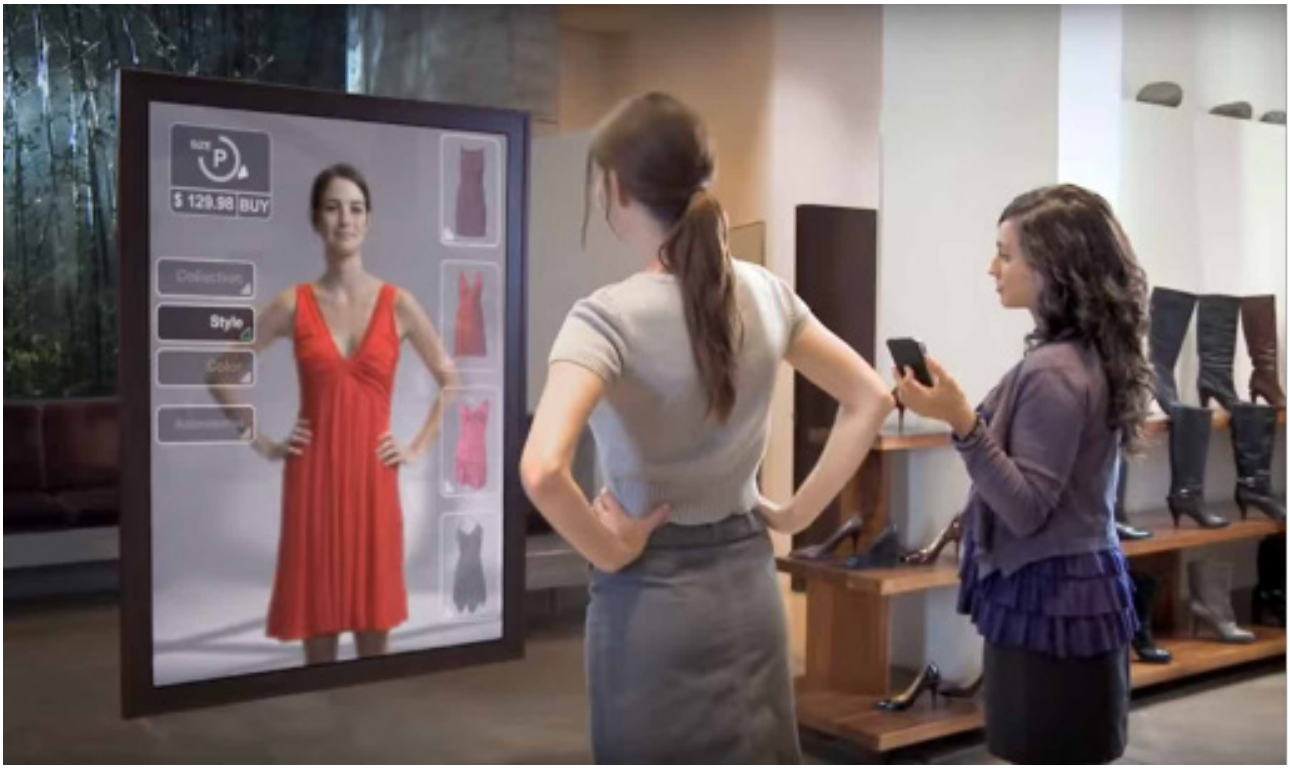


Figure 6

Or imagine 5G cloud gaming on your smartphone while waiting in lines at a restaurant, post-office, DMV, or anywhere you want time to fly by. A gigabyte, ultra-low latency pipe to every device will mean new and better immersive experiences than those experienced on PCs and consoles. In the future, you'll likely stream games to your end device just like you stream videos and music from Netflix, YouTube and Spotify today. See Figure 7.

Figure 7

Try to resist not using your smartphone to see, at a glance, what's on sale at your favorite grocery store (Figure 8). This capability would arise from 5G and mobile edge computing (MEC) creating real-time analytics for customer engagement and inventory management.

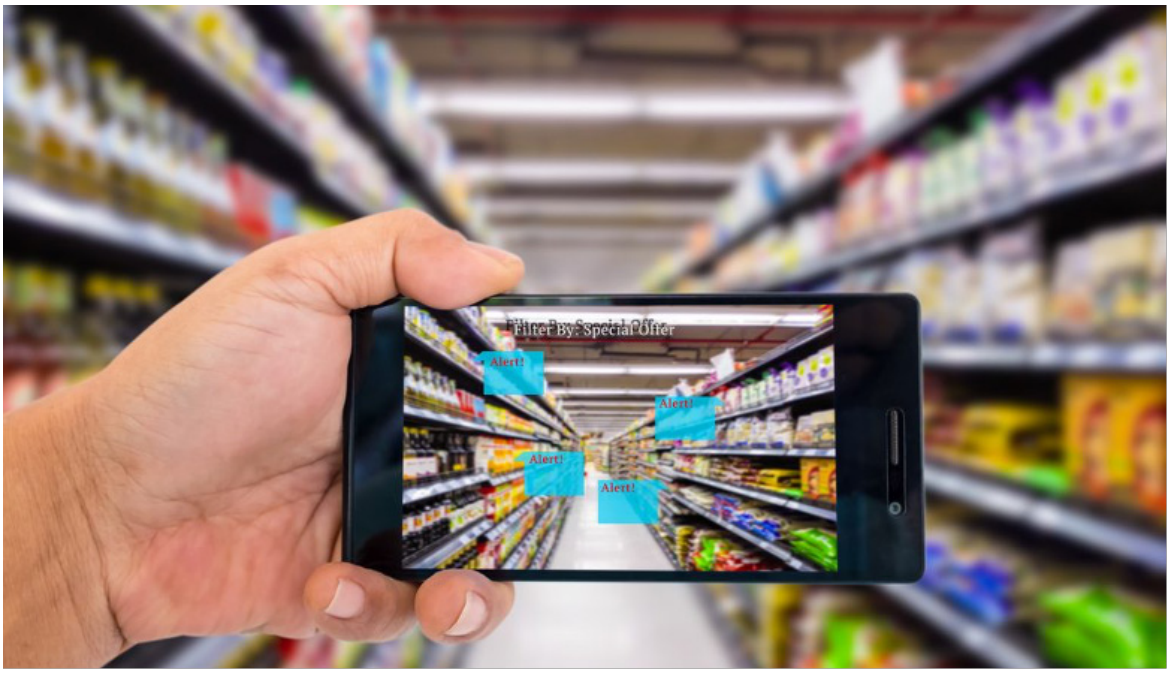


Figure 8

Hair Salon

Before an Echo was introduced to this Great Clips salon, indoor mmWave coverage from a distant gNB penetrated about 35 feet inside the salon mainly due to structural shadowing from its 35-foot-tall exterior wall (Figure 10). Figure 11 shows how the Echo counteracted this shadow to deliver hundreds of megabits inside the full salon to the salon chairs where, one day, magic mirrors will be able to show different hair styles to customers before the cuts begin.

Figure 9

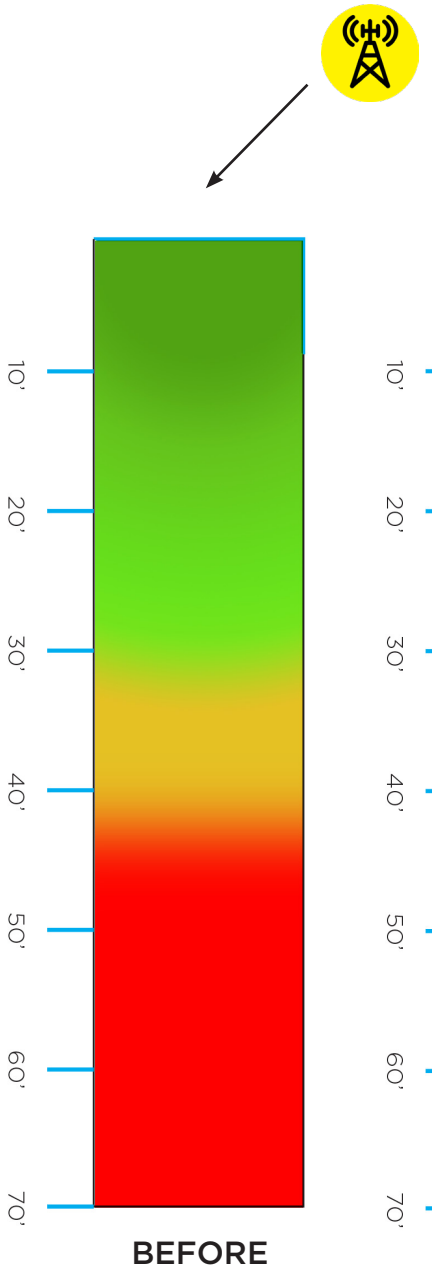


Figure 10

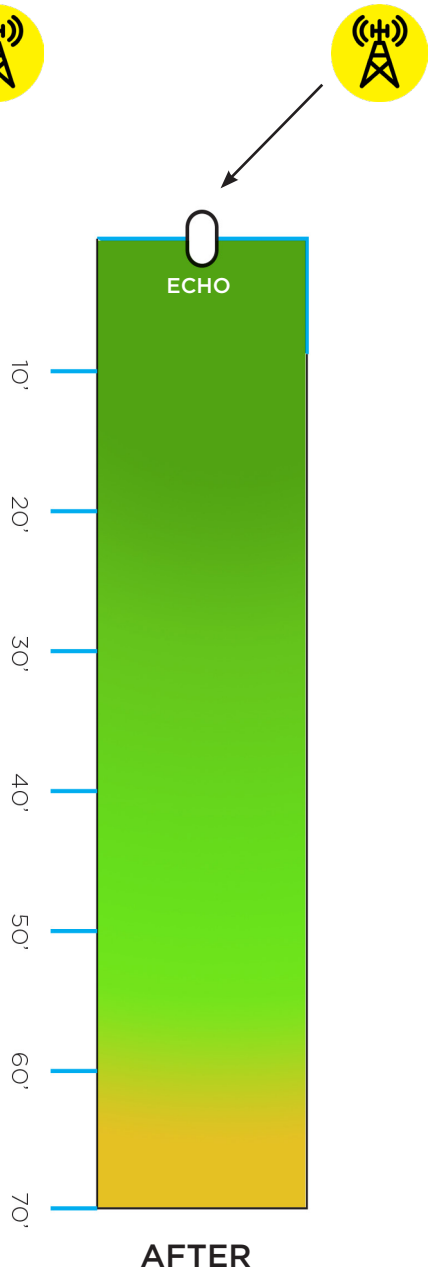


Figure 11

Figures 10 and 11 compare coverage and throughput in Great Clips before and after the installation of an Echo.

Stadiums

Echo has extended mmWave coverage indoors to deliver 5G to VIP patrons in stadiums. Without the Echo, 5G coverage in the VIP suite shown in Figure 12 extended only a few feet beyond the glass railing. This was due to structural shadowing from the floor above. An installed Echo (circled) provided 1.7 Gbits to the entire VIP suite and the concourse beyond. The inset of Figure 12 shows the overhang which typically shadows VIP suites from 5G mmWave at stadiums.

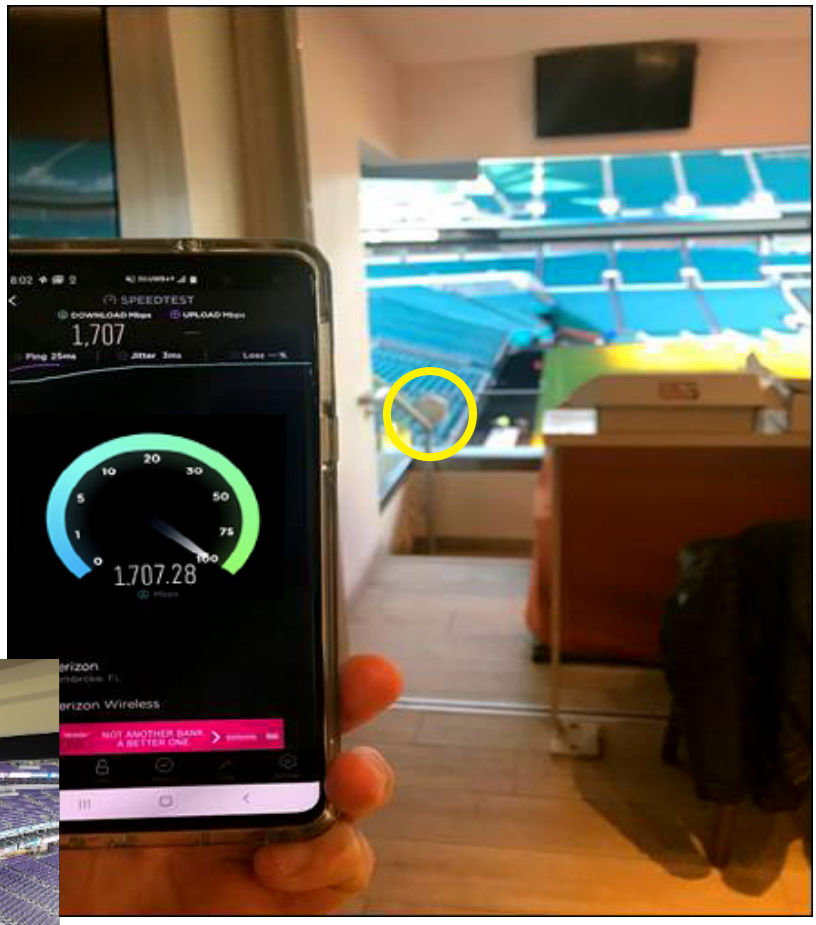
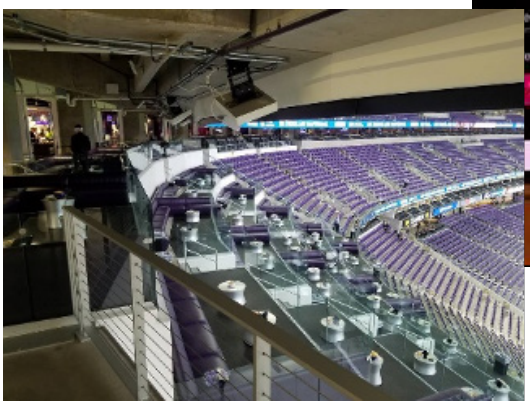


Figure 12 | Echo overcomes structural shadowing in a VIP suite.



Inset | Similar VIP suites structurally shadowed from above

As above, why might a patron want 5G mmWave coverage in the VIP suite? One possibility is to enjoy a real-time, augmented reality app, courtesy of 5G MEC, that reduces latency into the single-digit milliseconds—many times faster than the blink of an eye — ensuring a smooth viewing experience with no lag or jitter. Figure 13.

Figure 13 | Real-time augmented reality application in the VIP suite

Racetrack Media Center

Figure 14 shows two daisy-chained Echos after they were introduced to the media center at a motor speedway in Indiana. They are circled – one on each side of the tech room shown in Figure 15, which also shows the media room served by the distant Echo. The first Echo (pictured near the balcony in orange) acquired mmWave signal from the outside gNB and passed it to a second Echo attached to the tech room's interior glass wall which, in turn, lit up the entire, 200-foot-long media room with a median throughput of 900 Mbps. See figures 14 and 15.

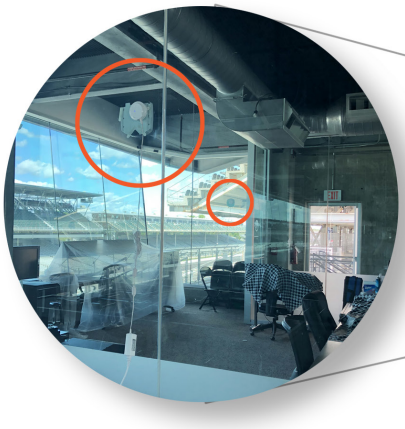


Figure 14 | Two Echos bridging one room to serve another

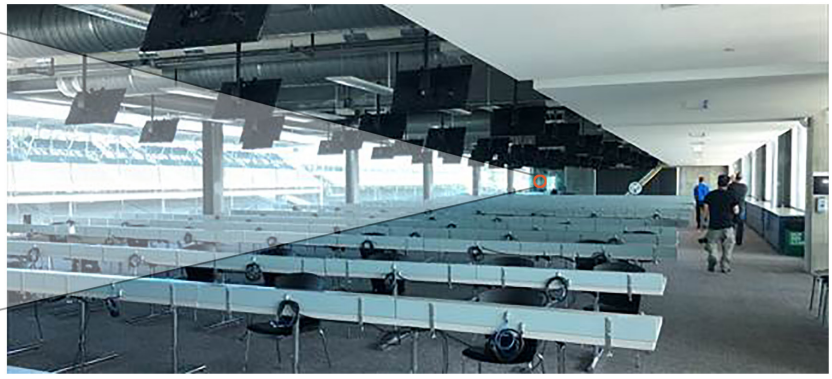


Figure 15 | 200' media room service by second Echo

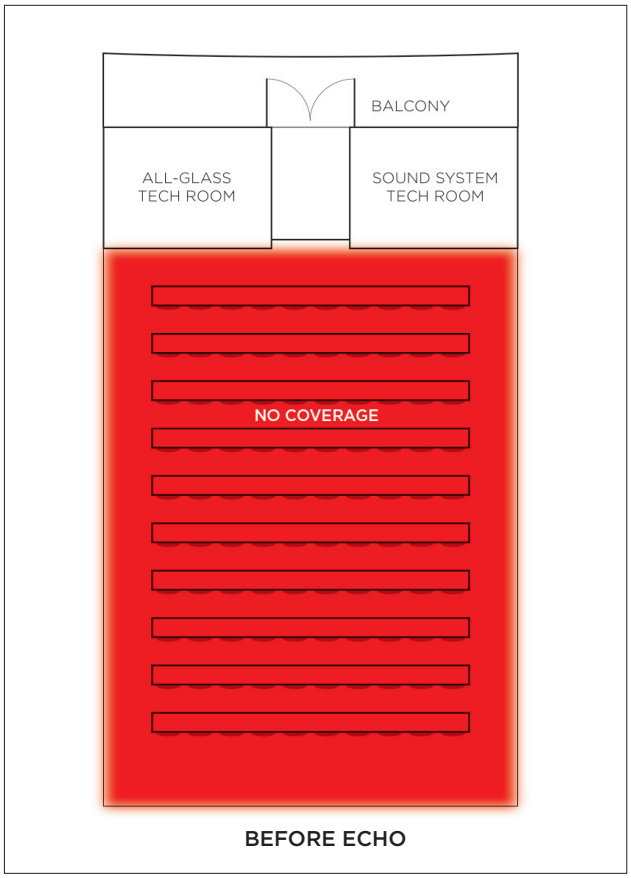


Figure 16 | No 5G coverage in media room

Figure 17 | Two daisy-chained Echos providing minimum 700 Mbps to the media room

Journalists in a media room like this will one day invoke instant race replay with the 5G network slicing function made possible with 5G due to the capacity and throughput performance of mmWave. With ultra-clear images taken by cameras throughout the stadium, these journalists – and fans -- will watch and replay each thrilling moment. Figure 18.

Figure 18 | Instant replay at the racetrack, courtesy of 5G mmWave

Conclusion

This paper showed how Echo 5G overcomes mmWave propagation challenges to bring high capacity/low latency 5G indoors. Before and after Echo scenarios included a retail establishment, hair salon, stadium VIP lounge and racetrack media room. In each scenario, one can speculate about what 5G applications will emerge to take advantage of native mmWave. For operators, deploying Echos and Pivots with gNBs provides a lower total cost of ownership alternative to deploying gNBs alone. But repeaters are just part of the Pivotal mmWave ecosystem. In addition to Echos and Pivots, the third member of the ecosystem, WaveScape, recommends placement and orientation of Echos, Pivots, and gNBs to reach a given target coverage level. The fourth member of the ecosystem, Intelligent Beam Management System, manages and optimizes Pivotal repeaters in real-time. To learn more about Pivotal's mmWave ecosystem, please visit https://pivotalcommware.com/products/.