Indoor DAS using CBRS N48 Signals for Private Network Coverage

*Vanlin Sathya, +Lyutianyang Zhang and *Mehmet Yavuz
*Celona. Inc, Cupertino, California, USA., +Chongqing University, Chongqing, China.
Email: vanlin@celona.io, zhanglyutianyang@cqu.edu.cn, mehmet@celona.io

***Abstract*—The deployment of Macro base station towers in outdoor environments ensures strong signal penetration in rural and urban areas. However, indoor environments face signal degradation due to structural barriers like thick walls and e-glass. Approximately 80% of traffic originates from indoors, necessitating solutions to boost indoor signal strength. This paper explores the use of passive Distributed Antenna Systems (DAS) to enhance indoor coverage. Passive DAS relies on coaxial cables, splitters, and antennas to relay RF signals from a central source to remote areas without active amplification. The integration of Citizens Broadband Radio Service (CBRS) into passive DAS introduces flexibility and control, allowing enterprises to deploy private LTE or 5G networks using shared spectrum. This study evaluates the performance of passive DAS in commercial indoor deployments, focusing on coverage, throughput, and latency, and highlights the technical considerations and benefits of using passive DAS to extend wireless coverage in challenging environments.**

***Index Terms*—DAS, CBRS, 5G, Private Network.**

I. INTRODUCTION

Due to large deployments of Macro base station towers in outdoor - rural and urban scenarios. The penetration of outdoor signal is strong everywhere, so users in the outdoor take advantage of good signal strength. But its not the same scenario indoors, due to thick wall bricks and e-glass, which generally blocks the signals indoor. Most of the traffic approximately 80% traffic comes from indoors with static and less mobility users with daily usage applications such as Voice call, SMS, Streaming, Zoom Call, etc. There are many ways one can boost the indoor MNO signal strength such as Neutral Host, Wi-Fi offloading, Repeator, and DAS system.

A neutral host network [1] is a shared cellular infrastructure model that enables multiple mobile network operators (MNOs) and private enterprises [2, 3] to deliver coverage and capacity using a common radio access network (RAN), while maintaining independent core networks and service control. In the context of 5G and Citizens Broadband Radio Service (CBRS) [4], neutral host architectures leverage spectrum sharing and network slicing to dynamically allocate resources among tenants, reducing capital expenditure and improving spectral efficiency. From a technical standpoint, this approach requires careful coordination of authentication, Quality of Service (QoS) enforcement, and roaming interfaces (e.g., 3GPP-defined N2/N3 connections), ensuring that each operator maintains secure isolation of subscriber traffic while benefiting from shared infrastructure. Such deployments are increasingly relevant in dense enterprise and indoor environments where traditional MNO coverage is limited, and they represent a convergence of multi-operator RAN, private wireless, and cloud-native core technologies within the IEEE and 3GPP frameworks.

Wi-Fi offloading [5] and Wi-Fi calling are mechanisms that enable mobile devices to maintain service continuity when the macro cellular signal from the MNO is weak. In Wi-Fi offloading, user data traffic is redirected from the cellular interface to IEEE 802.11-based Wi-Fi networks, typically via secure tunnels (e.g., IPSec) to the operator's core, reducing load on the RAN and improving spectral efficiency. Wi-Fi calling, standardized as Voice over Wi-Fi (VoWiFi) within the 3GPP IP Multimedia Subsystem (IMS), extends native voice and SMS services over Wi-Fi by encapsulating SIP signaling and RTP voice streams in secure IPSec tunnels between the device and the MNO's ePDG (Evolved Packet Data Gateway). Both methods require seamless handover mechanisms, authentication through SIM-based EAP-SIM/EAP-AKA protocols, and QoS management to ensure call quality. These techniques enhance coverage, particularly indoors, by leveraging IEEE 802.11 networks as complementary access to licensed cellular infrastructure.

A repeater system, often deployed with a donor antenna, is a cost-effective method to extend cellular coverage in areas where the MNO signal is weak, such as inside buildings or in rural environments. The donor antenna is typically mounted on the rooftop or an elevated structure to capture the strongest available macrocell signal from the MNO's base station. This signal is then amplified and re-radiated indoors via service antennas, effectively improving the received signal strength for user equipment (UE). Modern repeaters incorporate digital filtering, automatic gain control (AGC), and echo cancellation to mitigate interference, prevent oscillation, and maintain compliance with spectral emission masks. Unlike small cells, repeaters do not generate new radio resources but rather regenerate existing signals, making them spectrum-efficient yet dependent on donor signal quality. Proper system design must account for isolation between donor and service antennas, gain-versus-noise trade-offs, and uplink/downlink balance to ensure stable operation within 3GPP-defined performance limits.

A Distributed Antenna System (DAS [6–8]) is a network of spatially separated antenna nodes connected to a common source, designed to enhance cellular coverage in environments where the MNO signal is weak, such as high-rise buildings, stadiums, and underground facilities. In a passive DAS, the donor signal—typically captured via an outdoor donor antenna or base station feed—is distributed indoors using coaxial cables, splitters, and couplers without active electronic amplification, resulting in lower cost but limited coverage flexibility due to insertion losses and cable distance constraints. In contrast, an active DAS employs fiber-optic or Ethernet transport with active remote units that amplify and digitally process signals, enabling greater reach, dynamic power control, and support for multiple bands and operators simultaneously. Active DAS architectures often integrate with digital signal processing modules for filtering, delay compensation, and interference management, ensuring compliance with 3GPP performance requirements. Both approaches extend coverage but differ in scalability, cost, and spectral efficiency, with active DAS offering superior performance in large or complex deployments. In this work, we study the performance of the passive DAS system (using CBRS N48 sginals [2] as shown in Fig. 1) in terms of coverage, throughput, and latency in the commercial indoor deployment.

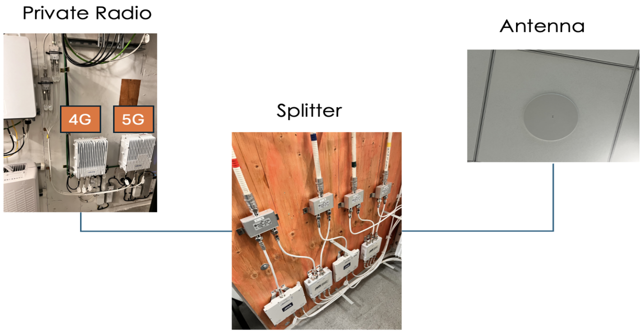


Fig. 1: Passive DAS Antenna Connected to PCN via CBRS

II. TYPES OF CBRS (N48) BASED DAS CONNECTIVITY

A. *Passive DAS Private Network Coverage (PCN)*

A passive DAS [9] extends wireless coverage by distributing radio frequency (RF) signals through coaxial cables, splitters, couplers, and antennas without relying on powered amplifiers. Unlike active DAS, which utilizes electronic components to amplify and transmit signals, passive DAS distributes signals directly from the source. This is particularly problematic in environments where dense construction materials block direct cellular signal penetration. When combined with the CBRS, operating in the 3550–3700 MHz band, passive DAS enables enterprises to deploy private LTE or 5G networks with improved flexibility and autonomy from traditional mobile operators.

The key element in a CBRS-enabled passive DAS is the Citizens Broadband Radio Service Device (CBSD), which functions as the system's base station. The CBSD transmits RF signals within the CBRS spectrum and must be both installed by certified professionals and registered with a Spectrum Access System (SAS)—a cloud-based service that dynamically manages frequency allocation and interference protection. The CBSD connects to the DAS through a headend unit that conditions the RF signal before distribution. Typical headend components include filters, combiners, and impedance-matching networks that help maintain signal strength and reduce loss before the signal is distributed throughout the passive network.

After processing, the RF signal travels through coaxial cables to passive components such as splitters and directional couplers. These devices divide and route the signal to multiple antennas positioned across the facility. Each antenna then radiates the signal to its nearby area, extending coverage without the need for powered amplification. Because a passive DAS cannot actively compensate for signal loss, system design must carefully consider attenuation caused by long cable lengths and multiple passive devices. This factor is especially important for CBRS, as its mid-band frequencies are more prone to propagation losses compared to traditional low-frequency cellular bands.

The CBRS spectrum is governed by a three-tier access structure that includes Incumbent Access, Priority Access Licenses (PALs), and General Authorized Access (GAA). All CBSDs deployed within a passive DAS must adhere to SAS coordination guidelines that regulate spectrum use and prevent interference. In setups with multiple CBSDs, all devices must operate under a single spectrum grant and must stop transmitting within 60 seconds if any unit loses authorization. These measures ensure adherence to FCC Part 96 and protect incumbent users such as naval radar systems.

Implementing CBRS over a passive DAS presents several engineering and operational challenges. Signal loss over long cable runs, limited interference management capability, and the need for accurate RF planning are key considerations during design. Moreover, CBSDs must be compatible with SAS protocols and support remote updates and configuration despite being integrated into a passive system. Even with these challenges, the combination of CBRS and passive DAS offers a cost-effective, secure, and scalable solution for enterprises seeking enhanced indoor wireless coverage. This setup enables organizations to operate private LTE or 5G networks tailored to their specific connectivity requirements, while maintaining independence from public operators.

Overall, combining CBRS with passive DAS merges traditional RF distribution techniques with modern spectrum-sharing technology. This integration enables enterprises to deliver reliable indoor coverage in areas where conventional cellular signals are weak. With proper design and regulatory compliance, CBRS-powered passive DAS networks can support a wide range of applications, including industrial automation, smart building systems, and enterprise communications.

B. *Active DAS PCN*

Active and hybrid DAS [10] integrated with the Citizens Broadband Radio Service (CBRS) represent a more advanced solution for extending wireless coverage in enterprise and industrial settings. Unlike passive DAS, which relies entirely on coaxial cables and unpowered components, active DAS uses powered hardware to convert, amplify, and transmit signals digitally over fiber or Ethernet connections. Hybrid DAS combines both passive and active elements, offering a balance between system performance, scalability, and cost efficiency. By utilizing the CBRS spectrum (3550–3700 MHz band), these architectures allow organizations to establish private LTE and 5G networks with enhanced control, security, and flexibility—providing a powerful alternative to conventional carrier-managed wireless infrastructures.

In an active DAS deployment that operates within the CBRS spectrum, the system begins with a Citizens Broadband Radio Service Device (CBSD) serving as the base station. The CBSD connects to a centralized headend or master unit, where the RF signal is digitized and converted for transmission over fiber-optic or Ethernet links. These digital signals are then delivered to distributed remote radio units (RRUs) or remote nodes located throughout the building or campus. Each RRU reconverts the digital signal into analog RF and transmits it through antennas to user devices. This architecture allows for fine-grained control of signal levels, adaptive power management, and real-time system monitoring—features that are vital for maintaining consistent, high-quality connectivity in large or complex indoor environments.

Hybrid Distributed Antenna System (DAS) deployments that utilize the CBRS spectrum employ a modular design combining both active and passive components. In this configuration, RF signals are transmitted from the headend to intermediate nodes—such as remote radio units (RRUs) or signal repeaters—using fiber or Ethernet connections. From these nodes, the signal is carried via coaxial cables to passive antennas for distribution throughout the facility. This hybrid approach reduces the number of powered elements, lowering deployment and maintenance costs while maintaining the signal quality and reach associated with digital transport. Hybrid DAS is well-suited for medium-sized enterprises or facilities where a fully active DAS may be financially impractical, yet a passive system alone would not deliver sufficient performance. As with passive DAS private cellular networks (PCNs), all CBRS deployments must comply with SAS coordination and regulatory requirements.

Signal propagation in the CBRS band poses distinct challenges due to its mid-band frequency range. Although this spectrum provides a favorable balance between coverage and capacity, it experiences slight increase in attenuation compared to lower-frequency bands. Active and hybrid DAS architectures address these limitations through digital signal transport and amplification, offering precise control over signal distribution and strength. Furthermore, advanced antenna designs and low-PIM (Passive Intermodulation) components are commonly employed to preserve signal integrity and minimize interference.

In summary, active and hybrid DAS architectures utilizing CBRS provide a robust framework for deploying private wireless networks in environments where conventional cellular coverage is limited or where greater control and security are necessary. These systems combine the flexibility of shared spectrum with the precision of digital signal transport and the scalability of modular design to deliver reliable connectivity across diverse applications. When implemented with careful engineering, regulatory compliance, and SAS integration, active and hybrid DAS offer a forward-looking solution for modern enterprise wireless infrastructure.

C. Repeater or Donor DAS

Repeater or donor antenna-based DAS leveraging CBRS provides a practical and scalable approach to extend wireless coverage in areas where direct signal penetration is challenging. This architecture is particularly suited for buildings with thick concrete walls, underground facilities, or remote locations where installing a full base station infrastructure may be cost-prohibitive. The fundamental concept involves a donor antenna that captures an existing CBRS signal—originating from a nearby CBSD or a macrocell—and redistributes it through a network of service antennas to cover the target area.

In a repeater-based DAS, the donor antenna is generally installed on a rooftop or other elevated location to ensure a clear line-of-sight to the source CBRS signal. The antenna captures the transmission and delivers it to a Bi-Directional Amplifier (BDA) or repeater unit, which amplifies both uplink and downlink signals to maintain robust communication between user devices and the network. From the repeater, the signal is routed via coaxial or fiber-optic cables to multiple indoor antennas, which then broadcast the signal throughout the facility. This configuration effectively extends the original CBRS coverage without requiring a direct connection to the core network.

Incorporating CBRS into repeater DAS deployments requires careful technical planning. The donor signal must originate from a CBSD that is registered and authorized with a SAS, which dynamically manages spectrum allocation in the 3550–3700 MHz band to protect incumbent users, such as naval radar systems, from interference. Since repeater DAS relies on off-air signal capture, the quality and stability of the donor signal are critical. Fluctuations or obstructions in the donor signal can degrade the performance of the entire DAS network. Consequently, site surveys and RF modeling are essential to determine optimal donor antenna placement and ensure consistent signal availability.

A key consideration in CBRS repeater DAS deployments is the use of low-PIM (Passive Intermodulation) components throughout the signal path. Operating in mid-band frequencies, CBRS signals are particularly sensitive to interference and degradation. To maintain signal integrity and reduce noise, high-quality coaxial cables, connectors, and antennas are essential. Additionally, the BDA must be configured to prevent oscillation, which can occur if the amplified signal couples back into the donor antenna. Adequate isolation between donor and service antennas, combined with proper gain control, is necessary to mitigate this risk and ensure stable network performance.

Repeater DAS systems provide a rapid and cost-effective method for extending coverage, but they are primarily intended for coverage enhancement rather than increasing network capacity. Since these systems simply relay an existing signal, they do not augment overall throughput. In environments with high user density or demanding data requirements, a hybrid solution that integrates repeater DAS with small cells or active DAS components may be more suitable. Nevertheless, for facilities aiming to expand CBRS coverage without deploying a full base station infrastructure, repeater or donor antenna DAS remains a practical and technically sound option.

III. PASSIVE DAS USING CBRS

A passive DAS offers a cost-efficient method for extending CBRS coverage within indoor environments. In this setup, the RF output from an indoor CBRS small cell or gNB (CBSD) is distributed through coaxial feeders, splitters, and taps to multiple service antennas located throughout the facility. Although this design is straightforward and economical, its performance is highly sensitive to losses in passive components, uplink signal aggregation, and precise TDD timing alignment.

A. Notation

Throughout this section, the following notation is adopted. The carrier frequency is denoted as f, with system bandwidth B, and speed of light c. The conducted transmit power of the CBSD is P_{TX}, and G_{H} represents the headend antenna gain. Passive losses due to coaxial feeder and components are expressed as L_{feed} and L_{comp}, respectively. On the device side, G_{UE} is the UE antenna gain, and NF is the receiver noise figure. The key performance metrics include the RSRP and SINR.

B. Passive Chain Loss and EIRP

The total downlink (DL) passive loss experienced in a DAS branch can be written as

$$L_{\mathrm{DAS}} = L_{\mathrm{feed}} + L_{\mathrm{split}} + L_{\mathrm{tap}} + L_{\mathrm{conn}}. \tag{1}$$

For an ideal $1 : N$ power splitter, the loss is

$$L_{\mathrm{split,\,ideal}} = 10\log_{10} N \text{ (dB)}, \tag{2}$$

and when considering insertion loss L_{ins},

$$L_{\mathrm{split}} = 10\log_{10} N + L_{\mathrm{ins}}. \tag{3}$$

The effective isotropic radiated power (EIRP) at the service antenna port is then

$$\mathrm{EIRP}_{\mathrm{ant}} = P_{\mathrm{TX}} + G_{\mathrm{H}} - L_{\mathrm{DAS}} + G_{\mathrm{ant}}. \tag{4}$$

Coaxial feeder loss is a significant factor at 3.5 GHz. It can be modeled approximately as

$$L_{\mathrm{feed}}(f,\ell) \approx a(f)\,\ell + b(f), \tag{5}$$

where ℓ is the cable length in meters, and $a(f)$ represents the frequency-dependent attenuation slope. For example, common "low-loss" cables exhibit 4–6 dB loss per 100 ft at 3.5 GHz.

C. Indoor Path Loss Model

Indoor signal propagation is captured by the close-in (CI) model:

$$PL(d) = FSPL(1 \text{ m}) + 10n\log_{10}(d) + X_{\sigma}, \tag{6}$$

where d is the UE distance in meters, n is the path loss exponent, and X_{σ} models log-normal shadowing. The free-space reference loss is given by

$$FSPL(1 \text{ m}) = 32.4 + 20\log_{10}(f_{\mathrm{GHz}}) \text{ (dB)}. \tag{7}$$

At 3.5 GHz, $FSPL(1 \text{ m}) \approx 43.3$ dB. For indoor office deployments, n typically ranges from 2.0 (LOS) to 3.5 (NLOS).

D. Downlink RSRP and SINR

The DL RSRP at the UE is expressed as

$$\mathrm{RSRP} \approx \mathrm{EIRP}_{\mathrm{ant}} - PL(d) + G_{\mathrm{UE}} - L_{\mathrm{misc}}, \tag{8}$$

where L_{misc} accounts for body and cable losses.

Thermal noise power over a bandwidth B with receiver noise figure NF is

$$N = -174 + 10\log_{10} B + NF \quad \text{(dBm)}. \tag{9}$$

The resulting DL SINR is

$$\mathrm{SINR} = \mathrm{RSRP} - 10\log_{10}\left(10^{I/10} + 10^{N/10}\right), \tag{10}$$

where I is the interference power in dBm. In noise-limited cases, I is negligible, and SINR is governed primarily by N.

E. Uplink Budget and Noise Aggregation

On the UL, the CBSD receives

$$P_{\mathrm{RX,CBSD}} = P_{\mathrm{UE}} + G_{\mathrm{UE}} - PL(d) + G_{\mathrm{H}} - L_{\mathrm{DAS,UL}}. \tag{11}$$

Since the DAS aggregates noise from K antennas, the UL noise floor is increased by

$$\Delta N_{\mathrm{UL}} \approx 10\log_{10}(K) + L_{\mathrm{comb}}. \tag{12}$$

The UL SINR is then

$$\mathrm{SINR}_{\mathrm{UL}} = P_{\mathrm{RX,CBSD}} - (N_{\mathrm{CBSD}} + \Delta N_{\mathrm{UL}} + I_{\mathrm{UL}}). \tag{13}$$

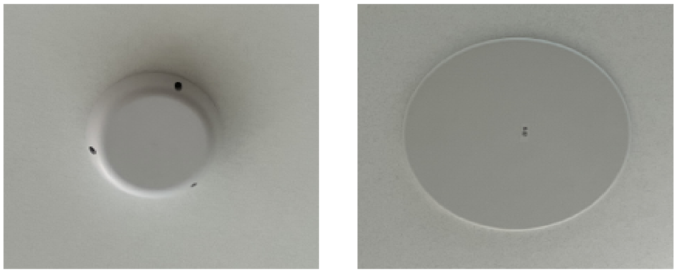
This highlights that uplink capacity degrades rapidly as more antennas are added to a sector without sufficient isolation.

F. TDD Timing Constraints

Because CBRS employs TDD, coax-induced delay must remain within guard periods. The group delay is given by

$$\tau_{\mathrm{coax}} = \frac{\ell}{VF \cdot c}, \tag{14}$$

where VF is the velocity factor of the coax (typically 0.8). For example, a 50 m run yields $\tau \approx 208$ ns, which is well within the 4–5 μs cyclic prefix used in NR/LTE.



(a) Antenna Model 1

(b) Antenna Model 2

Fig. 2: Passive DAS Antenna - PCN Deployment.

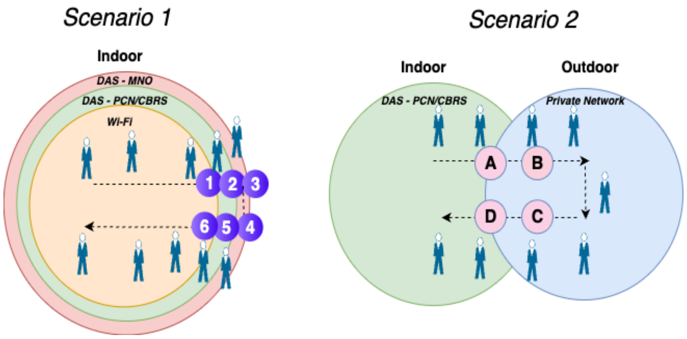


Fig. 3: DAS PCN Deployment Scenarios

G. *MIMO Symmetry*

For 2×2 MIMO to be effective, parallel DAS paths must be matched in loss:

$$\Delta L_{\mathrm{MIMO}} = |L_{\mathrm{path\,A}} - L_{\mathrm{path\,B}}| \leq 1\text{–}2\,\mathrm{dB}. \tag{15}$$

Additionally, polarization or spatial diversity must be preserved at the antenna level.

H. *Design Rules and Limits*

The maximum number of antennas per sector is constrained by the UL SINR requirement:

$$K \leq 10^{\frac{P_{\mathrm{RX,CBSD}} - N_{\mathrm{CBSD}} - I_{\mathrm{UL}} - \mathrm{SINR}^{\star}_{\mathrm{UL}} - L_{\mathrm{comb}}}{10}}. \tag{16}$$

Similarly, the maximum allowable DAS loss for a target RSRP is

$$L^{\max}_{\mathrm{DAS}} = P_{\mathrm{TX}} + G_{\mathrm{H}} + G_{\mathrm{ant}} - PL(d) + G_{\mathrm{UE}} - L_{\mathrm{misc}} - \mathrm{RSRP}^{\star}. \tag{17}$$

The above analysis highlights several key guidelines:

- Downlink coverage is constrained by total DAS loss, but uplink SINR typically sets the practical antenna-per-sector limit.
- Noise rise scales as $10\log_{10} K$, limiting the number of antennas that can be combined.
- Higher-value taps near the headend can balance losses and reduce near-end noise.
- Maintaining path symmetry is critical for MIMO effectiveness.
- Coax delays should be checked to ensure TDD guard intervals are not exceeded.

IV. DEPLOYMENT SCENARIOS

A. *Scenario 1 - Indoor Only*

In this scenario, we assume that a passive DAS is deployed in an indoor environment and that the user device is capable of operating on 3GPP Band n48 technology, as illustrated in Fig. 3. Under the default behavior, devices typically prefer Wi-Fi for data traffic when indoors. However, as the user moves outside the Wi-Fi coverage area (for example: the Wi-Fi connected user moves from ① to ② as shown in Fig. 3), the device tends to remain attached to Wi-Fi for an extended duration before the link eventually breaks, resulting in service disruption. In several deployments, customers have already implemented passive DAS infrastructure to support major MNOs in the indoors. The DAS infrastructure, including splitters and controllers, is often provisioned with additional ports that allow the insertion of PCN CBRS Band 48 signals. Since the cabling and passive infrastructure are already in place, operators can leverage this capability to provide an additional secure layer of connectivity for devices within the premises.

Each device configuration targets two primary applications: voice and data. These applications can be routed over either a primary or secondary line. By default, the primary line corresponds to the MNO network, while the secondary line corresponds to Wi-Fi or DAS PCN, and in some cases, both connections can remain active. When both Wi-Fi and DAS PCN are available simultaneously on the device, the cellular data path is preferentially routed through DAS PCN[1] to ensure reliable and consistent service continuity. Hence, we expect the device to roam on the three different coverage when they move from indoor to outdoor (for example: the user moves from ① to ② to ③ as shown in Fig. 3) and outdoor to indoor (for example: the user moves from ④ to ⑤ to ⑥ as shown in Fig. 3).

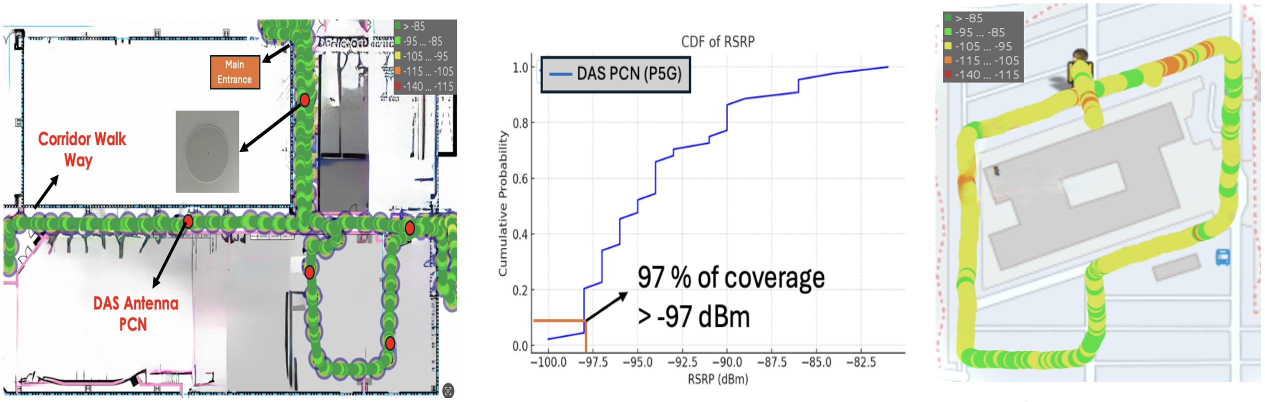
B. *Scenario 2 - Indoor and Outdoor*

In this scenario, we assume that Wi-Fi is available in the indoor environment while a private network (PCN[2]) is deployed outdoors. The user devices (e.g., tablets and iPhones) are capable of operating on both technologies, enabling mobility between indoor and outdoor coverage areas. Under default behavior, the device connects to Wi-Fi indoors and, upon moving outdoors, remains associated with Wi-Fi for an extended period before transitioning to the private network. This delayed handover results in disrupted service during Wi-Fi (Ⓐ) → private network (Ⓑ) roaming. Similarly, when transitioning from the private network to Wi-Fi (*i.e.,* private network (Ⓒ) → Wi-Fi (Ⓓ)), larger timeout values or higher latency can occur, leading to application logouts and degraded user

---

[1] For iPhones, the industrial configuration capability will help the device to prefer PCN than Wi-Fi

[2] The term Private Network and Private Coverage Network (PCN) used interchangeably throughout the manuscript.



(a) 5G DAS PCN Indoor

(b) 5G DAS PCN CDF Indoor

(c) Outdoor - No PCN Coverage so device Connected to MNO

Fig. 4: *Passive DAS PCN Coverage and Performance*

TABLE I: Passive DAS PCN Deployment Parameters

Parameter	Value
Experiment Environment	Indoor
Number of Floors	1
Number of 4G and 5G APs	2
Number of DAS PCN Antennas	5
4G BW Configured per AP	20 MHz
5G BW Configured per AP	40 MHz
TDD Config	DL and UL Heavy
Nature of Antenna	Omni
Mobile Device Used	iPhone 15 Pro, Pixel and CT 47
CBRS Operating Frequency	3.55 to 3.7 GHz
Coverage SW Tool Used	SigCap, and NSG

experience. Such interruptions are particularly problematic in mission-critical environments such as petrochemical plants, oil and gas facilities, and ruggedized distribution sites. The desired behavior, therefore, is for the device to seamlessly switch to the private network whenever CBRS coverage is available, ensuring service continuity.

In the indoor environment, some enterprises have already deployed passive DAS infrastructure to enhance indoor MNO signal coverage. These deployments can be extended by integrating CBRS signals into the same DAS infrastructure. This allows employee devices to maintain seamless roaming between indoor and outdoor areas while remaining connected to the same private network. As a result, critical applications remain uninterrupted, eliminating service dropouts and ensuring reliable performance in demanding operational environments.

V. EXPERIMENT ENVIRONMENT AND CONFIGURATION

This section discusses the experiment environment configuration parameters and system utilization for the DAS systems. In this scenario, we considered the enterprise deployment setup, where devices receive data in both directions in downlink and uplink.

A. *Passive DAS - CBRS Configuration*

The passive DAS deployment and corresponding connection setup are illustrated in Fig. 1 where its integrated with the existing DAS infrastructure. Frequency planning was executed using the Self-Organizing Network (SON) algorithm, which autonomously selects optimal EARFCNs and transmit power levels to minimize co-channel interference. The Physical Cell ID (PCI) assignment algorithm ensures unique PCI values for each DAS PCN AP, thereby eliminating the risk of PCI collisions or confusion problem.

For radio signal collection, a ROHDE & SCHWARZ autonomous mobile network scanner equipped with an external Single Input Single Output (SISO) antenna module was used. Key radio parameters—including PCI, EARFCN, Reference Signal Received Power (RSRP), and Throughput —were recorded during the measurement campaign.

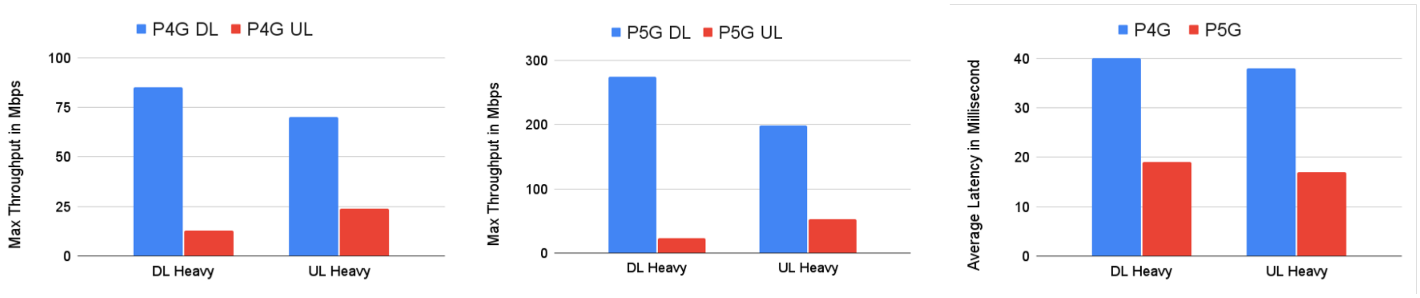
In addition, a Samsung Galaxy S23+ device was configured with QualiPoc to log detailed data across the PHY, MAC, and application layers. Walk test were performed, following a custom-designed route intended to replicate realistic user movement within the indoor enterprise facility. This methodology was consistent with the procedures followed in the 4G experiments. The collected radio metrics were analyzed using industry-standard post-processing tools. Deployment-specific configuration parameters are summarized in TableI.

B. *Coverage*

Fig. 4 (a) shows the coverage of the indoor 5G DAS PCN and Fig. 2 shows the DAS PCN antenna. In this scenario, single 5G AP is connected to five DAS antennas (as shown in red circle dot in Fig. 4 (a) for the location of the antenna) to provide coverage in the corridor region. All these antenna are connected to controller, where it control the power so its not exceeding the max FCC power limitation. We observed strong RF coverage foot-print in indoor and there is no coverage hole found throughout the corridor. Similarly, Fig. 4 (b) shows the CDF of the indoor data points, where we observed 97% of the user having better RSRP signals which is greater than -97 dBm. Fig. 4 (c) shows the outdoor coverage, where we observed no DAS PCN signals[3] so the device automatically

---

[3] No DAS PCN is deployed in outdoor so the device preference for data in outdoor is prioritized over MNO, primary carrier/line.



(a) 4G PCN Throughput

(b) 5G PCN Throughput

(c) 4G 5G PCN Latency

Fig. 5: *MAX or Peak Throughput and Latency Performance*

connected to the outdoor MNO carrier signal.

C. Throughput and Latency Performance

In this experiment, we used the speed test to record all the throughput performances. We validated the performance with two realistic slot configuration *i.e.,* Downlink (DL) heavy with more DL sub-frames and Uplink (UL) heavy with more UL sub-frames. Fig. 5 (a) shows the 4G DAS PCN performance in throughout for DL and UL heavy. Since, the 4G system operates on the 20 MHz bandwidth, we observed 80 Mbps in DL and 18 Mbps in UL for DL heavy slot configuration. Similarly for the UL heavy, we observed 74 Mbps in DL and 25 Mbps in UL. Fig. 5 (b) shows the 5G DAS PCN performance in throughout for DL and UL heavy. In this scenario, the 5G DAS PCN operates on the 40 MHz bandwidth configuration, we observed 275 Mbps in DL and 24 Mbps in UL for DL heavy slot configuration. Similarly for the UL heavy, we observed 198 Mbps in DL and 53 Mbps in UL.

Fig. 5 (c) shows the latency for the 4G and 5G DAS PCN system. We observed average of 40 ms latency on 4G and 19 ms latency on 5G. We observed 0% packet drop on both 4G and 5G DAS PCN system.

VI. CONCLUSION

In conclusion, the deployment of passive DAS using CBRS in PCN presents a viable solution for enhancing indoor wireless coverage. This approach leverages coaxial cables, splitters, and antennas to relay RF signals without active amplification, making it cost-effective and efficient. The integration of CBRS (in PCN) introduces flexibility and control, allowing for the deployment of private LTE or 5G networks using shared spectrum. Our study demonstrates that passive DAS can significantly improve coverage, throughput, and latency in commercial indoor environments. However, careful planning and high-quality components are essential to mitigate signal loss and ensure reliable performance. Overall, passive DAS with CBRS offers a promising method for addressing the challenges of indoor signal degradation and meeting the growing demand for robust wireless connectivity.

REFERENCES

[1] M. I. Rochman, J. R. Palathinkal, V. Sathya, M. Yavuz, and M. Ghosh, "Neutral-hosts in the shared mid-bands: Addressing indoor cellular performance," *arXiv preprint arXiv:2505.18360*, 2025.

[2] V. Sathya, M. Jimenez, O. Sahin, and M. Yavuz, "Private network-anywhere and everywhere," in *2025 International Conference on Computing, Networking and Communications (ICNC)*, pp. 43–49, IEEE, 2025.

[3] V. Sathya, O. Sahin, L. Zhang, and M. Yavuz, "A measurement campaign of commercial private network deployment in indoor and outdoor environments," in *2024 IEEE 100th Vehicular Technology Conference (VTC2024-Fall)*, pp. 1–7, IEEE, 2024.

[4] M. Grissa, A. A. Yavuz, B. Hamdaoui, and C. Tirupathi, "Anonymous dynamic spectrum access and sharing mechanisms for the cbrs band," *IEEE Access*, vol. 9, pp. 33860–33879, 2021.

[5] M. H. Cheung and J. Huang, "Dawn: Delay-aware wi-fi offloading and network selection," *IEEE Journal on Selected Areas in Communications*, vol. 33, no. 6, pp. 1214–1223, 2015.

[6] C. Bouras, S. Kokkalis, A. Kollia, and A. Papazois, "Techno-economic analysis of mimo & das in 5g," in *2018 11th IFIP Wireless and Mobile Networking Conference (WMNC)*, pp. 1–8, IEEE, 2018.

[7] T. Alade, H. Osman, and M. Ndula, "In-building das for high data rate indoor mobile communication," in *2012 IEEE 75th Vehicular Technology Conference (VTC Spring)*, pp. 1–5, IEEE, 2012.

[8] S. Elhoshy, M. Ibrahim, M. Ashour, T. Elshabrawy, H. Hammad, and M. M. Rizk, "A dimensioning framework for indoor das lte networks," in *2016 International Conference on Selected Topics in Mobile & Wireless Networking (MoWNeT)*, pp. 1–8, IEEE, 2016.

[9] N. Petrović and D. Savković, "Lte performance in a hybrid indoor das (active vs. passive)," in *2015 23rd Telecommunications Forum Telfor (TELFOR)*, pp. 141–144, IEEE, 2015.

[10] T. Mizuno and J. Le Calvez, "Real-time passive seismic monitoring using das—today's solutions and remaining challenges," *The Leading Edge*, vol. 43, no. 1, pp. 24–29, 2024.