COMMSCOPE®

Unlocking the potential of in-building wireless service

The role of neutral hosts and multi-operator small cells

Contents

Building owners and managers consistently rate connectivity as important but are not satisfied with current options.

Sources: CommScope, Coleman Parkes, WiredScore.

Executive Summary

The delivery of robust, multi-operator in-building wireless coverage continues to lag behind the demand. In a 2016 survey of 600 building managers by CommScope and Coleman Parkes Research, 84 percent responded that good in-building cellular coverage improved employee productivity, but 43 percent were unhappy with their coverage. A survey of leasing decision makers by WiredScore found that connectivity was nearly as important as location in the leasing decision; but, still, 80 percent reported experiencing regular connectivity issues.

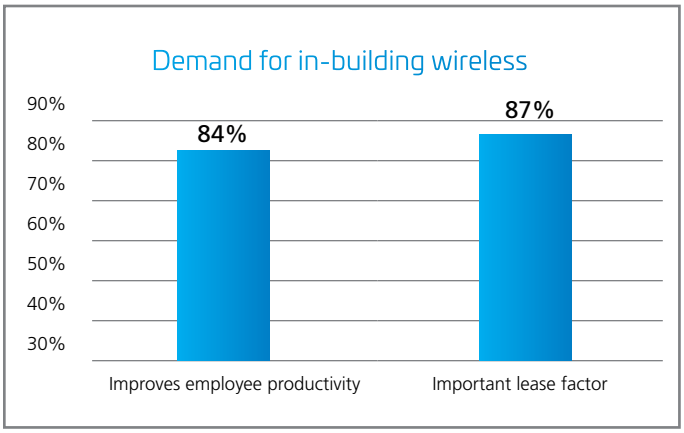
This gap persists despite major operator investments in their radio access networks, and significant advances in in-building wireless technologies.

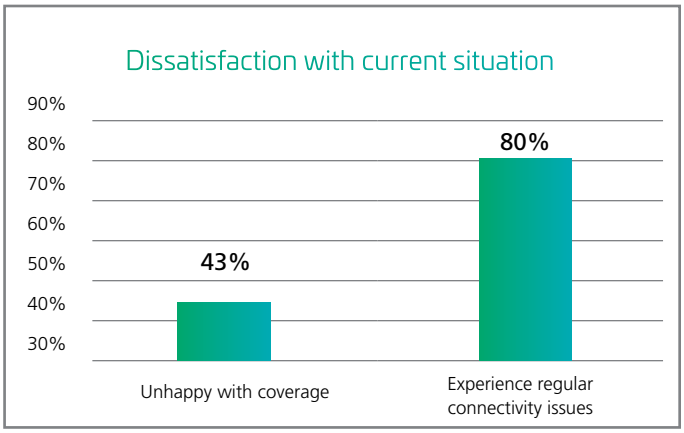
The traditional best-efforts "outside-in" approach, in which operators attempt to serve building inhabitants from outdoor macro cells sites, has never worked satisfactorily indoors. Trends in energy-efficient building construction, combined with the evolution of mobile technologies, only worsen this situation. Low-emission ("low-e") glass has been shown to reduce radio signal strength by as much as 15 dB, meaning the signal is only 1/32 its original strength after it passes through the glass. This is roughly equivalent to passing through a 1-inch-thick sheet of concrete.

Meanwhile, emerging 5G radio technology relies on higher frequency bands that propagate through obstructions even less. Furthermore, the core promise of 5G is that of enhanced performance: high bandwidth, low latency, and high reliability. A degraded "best-efforts" 5G is not an option for operators—or for application developers and enterprises hoping to build internet of things (IoT) and smart building infrastructures.

[1] CommScope and Coleman Parkes Research, In-Building Wireless Survey Report, 2016

[2] WiredScore, The Value of Connectivity, 2016





What has kept operators from addressing the indoor use case more comprehensively? Broad support of indoor spaces is, for operators, a "boil-the-ocean" exercise involving many thousands of individual systems, each having its own requirements in terms of coverage, capacity, interior cabling infrastructure, and access rights.

Enterprises and building owners, for their part, have exhibited an increased willingness to invest in systems that will benefit them, if those systems deliver high-quality wireless service and support more than just a single operator. Few enterprise IT departments have the skill set to properly evaluate, install or operate a licensed cellular infrastructure.

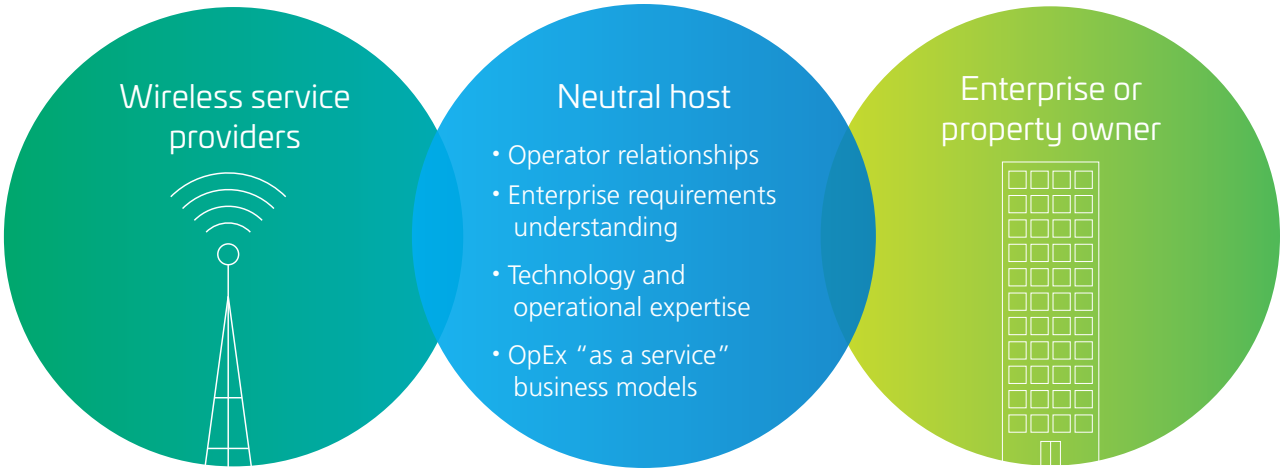
In Europe, neutral hosts are emerging to provide a vital link in the ecosystem to bridge this gap. Neutral hosts have several technology options to choose from: distributed antenna systems, CPRI-based remote radio head systems, standalone small cells, and C-RAN small cells. C-RAN small cells are evolving to push new possibilities by uniquely meeting both the technical and business model requirements of neutral hosts.

Filling a need in the ecosystem: neutral hosts

Neutral hosting is a familiar concept in mobile communications but may not be well known to enterprise readers. Tech UK states "Neutral host infrastructure comprises a single, shared network solution provided on an open access basis to all [mobile network operators] MNOs and is used to resolve poor wireless coverage and capacity inside large venues or other busy locations." The commercial entity that provides this infrastructure is likewise typically called a "neutral host."

Neutral hosting originated with outdoor macro cell towers. Acquiring the needed real estate, siting permission and physical tower construction are all costly, specialized endeavors. Therefore, it made economic sense for a single company to invest in this infrastructure and offer it to all operators rather than forcing each operator to build their own dedicated infrastructure. Having established this business model and the associated expertise, neutral host companies expanded into distributed antenna systems (DAS) for large venues such as airports and stadiums. In doing so, these companies have developed expertise in designing, deploying and operating complex in-building wireless systems, in close cooperation with mobile network operators, building owners, and enterprises.

Moving from large venues to mid-size office buildings is a natural progression and, in fact, we are already seeing neutral host companies in Europe move in this direction. From the end-user organization's perspective, neutral hosting aligns well with the "as a service" business model that allows enterprises to take advantage of third-party infrastructure and specialized expertise outside their core business domain.



Neutral hosts provide a valuable link between service providers and end-user organizations

Enterprise in-building wireless system requirements

For multi-operator in-building deployments, neutral hosts have typically relied on DAS. Recent advances, including digital and C-RAN architectures, have driven down the cost of these solutions. Meanwhile, indoor small cells have a lower entry cost point, and can be simpler to design and install. However, most small cells support only a single operator. Supporting multiple operators requires multiple parallel small-cell systems, quickly negating their cost and simplicity advantage. What's needed is a simpler multi-operator infrastructure. What does this look like?

The ideal neutral host in-building small cell solution must have the following characteristics:

- Support multiple operators in a single radio access point
- Leverage a shared IT-like transport infrastructure
- Allow per-operator capacity allocation and full control of subscriber quality of experience
- Enable independent per-operator network management
- Guarantee a smooth migration from 4G to 5G

Let us look at each of these requirements in more detail.

A **single radio supporting multiple operators** (ideally all major operators in a given country) is critical to minimize equipment and installation costs. It also optimizes the aesthetic of the radio solution installed throughout the building, which is vital for acceptance from the venue owner. Finally, a single radio greatly simplifies the system deployment, maintenance and inventory management for the neutral host.

Similarly, a single **IT-like transport infrastructure,** ideally based upon standard Ethernet LAN, reduces the equipment and installation costs. The use of PoE and VLAN configuration on standard switches simplifies the installation and commissioning of the system. It also broadens the ecosystem of system integrators and business partners on which the neutral host can rely. All this is important to make in-building cellular deployments as scalable as Wi-Fi.

While shared radio and transport infrastructure provides great efficiencies and reduces equipment and installation costs for the neutral host, an operator will still need **dedicated network capacity and end-to-end control of the subscriber's quality of experience.** An operator wants to manage its network as if the same infrastructure were not shared with others. Therefore, it is critical for the multi-operator small cell solution to be able to allocate network capacity and allow performance management on a per-operator basis. This also allows the neutral host to meet service-level agreements (SLAs) they have with each operator.

Another critical aspect of a neutral host in-building small cell solution is the ability to offer **configuration and fault management on a per-operator basis.** Each operator requires specific network parameters to be configured for each site, based upon factors such as macro environment, spectrum assets and subscriber share in a given market. Giving each operator the ability to provision the system with its set of "gold parameters" at commissioning and to adjust the network parameters during system operation are key enablers for neutral host deployments. The neutral host must also be able to offer the operators full visibility into their own system operation, including alarms and access to logs for fault management.

While the four characteristics mentioned above are more related to the CapEx and OpEx to deploy an in-building system for a neutral host, the last one is critical to guarantee its investment protection. 4G/LTE is still going to be the predominant radio access technology by number of connections for years to come. However, operators have recently started to deploy 5G on their macro networks. Given that many 5G use cases are applicable indoors, it is imperative for an in-building small cell solution to enable a smooth migration path to 5G, ideally via software upgrade—avoiding a costly replacement of radio equipment throughout the building.

Can in-building wireless technology meet neutral host needs?

Historically, mobile network technology for in-building has been used to address two different scenarios.

On one hand, DAS has been deployed in high-profile public venues, including stadiums, airports, and convention and entertainment centers. These deployments typically consist of a multi-carrier, multi-band RF signal distribution network including active head/remote end components, fiber and coaxial cabling. Macro base stations supporting different technologies from different operators are used as signal sources for the DAS, typically requiring a dedicated high-bandwidth transmission link to the site from each operator's core network.

On the other hand, femtocell technology has been introduced as a low-cost solution to address residential scenarios. A femtocell represents a standalone, scaled-down, lower-cost base station that connects to the public internet via a home router. As it needs to cover only a small area, it doesn't require professional installation and can be fully auto-provisioned and managed by the operator. Femtocells have been deployed by operators primarily for coverage extension and subscriber retention.

Neutral hosting for mid-size to large enterprises has been an under-served segment of in-building wireless for many years. Currently some of this segment is served by DAS. Meanwhile, femtocells cannot scale to support larger multi-operator enterprise deployments. More recently two solutions were introduced as result of the evolution of macro and femtocell technologies.

Distributed radio systems (DRS) derive from macro C-RAN solutions. DRS are based on macro BBUs, CPRI fiber front-haul and low-transmit-power radio heads. The fundamental limitation of these solutions is the cost associated with baseband and fronthaul equipment. As macro derivatives these solutions cannot leverage commercial off-the-shelf (COTS) Ethernet infrastructure. This typically entails higher cost and more complex commissioning, making these solutions not scalable for neutral host deployments.

Derivatives of femtocells, also called "pico cells" or "standalone small cells," have higher capacity and transmit power than those used for residential scenarios. The fundamental limitation of these solutions is the high number of cell borders and interference they introduce into the network when deployed in large clusters, as each radio radiates its own PCI. This makes commissioning and optimization time-consuming and unscalable. These solutions are not suitable for multi-operator deployments, as they have self-contained, non-shared radio, scheduling and processing resources. Therefore, they require one-for-one replication for each operator in the deployment. In addition, these products are typically built on cost-optimized system-on-chip (SoC) platforms that cannot be software-upgraded to 5G NR.

More recently, C-RAN small cells have emerged as a new approach to address the neutral host enterprise market. In these solutions the bulk of baseband processing is centralized in a baseband controller that provides capacity, while radio points are distributed throughout the building and provide coverage. A standard Ethernet LAN is used as a fronthaul network between the baseband controller and the radio points. C-RAN small cells support a single PCI architecture that eliminates interference within the building, while intelligent radio points interacting with a centralized scheduler enable advanced features like cell virtualization to maximize spectral efficiency while eliminating interference.

These solutions are suitable for neutral host deployments, as they support a DAS-like multi-operator sharing model but with the economics and ease of deployment of Wi-Fi. They support the following:

- Shared radio for lower deployment cost
- IT-based infrastructure and Wi-Fi-like deployment models for lower-cost, simple and scalable deployments
- Operator friendly with dedicated capacity per operator
- Per-operator infrastructure configuration, performance and fault management
- Smooth upgrade path to 5G with programmable radios, modular RF front end and Ethernet fronthaul

	OUTSIDE-IN	STANDALONE SMALL CELLS	DISTRIBUTED ANTENNA SYSTEMS	DISTRIBUTED RADIO SYSTEMS	C-RAN SMALL CELLS
Description	Serve indoor space through nearby macro towers or outdoor small cells	Self-contained mini-base stations; one physical cell ID per access point	Macro BBU/BTS with RF or CPRI interface to signal distribution	Macro BBUs with CPRI fronthaul to low-power radio heads	Baseband controller with IP/Ethernet fronthaul to intelligent radio points
Match to neutral host requirements					
Shared radio for multiple operators	-	-	Yes	Sometimes	Yes
Dedicated capacity for each operator	Yes	Yes	Yes	Sometimes	Yes
IT-based infrastructure	-	Yes	-	-	Yes
Software upgrade to 5G NR	Sometimes	-	Function of BBU/BTS	Function of BBU/BTS	Yes

Comparison of in-building wireless architectures for neutral host needs

Case studies illustrate the benefits

As described earlier, neutral host, in-building solutions have been traditionally served by DAS solutions with the associated macro components, and CommScope has long been a leading supplier of this technology. CommScope is now seeing the market expand to include many buildings more suited to the simplified deployment and cost model of C-RAN small cells, such as its OneCell solution. This model is being embraced, with many European neutral hosts now actively deploying or planning neutrally hosted small cell deployments using OneCell. Three such examples help illustrate the role of the neutral host and C-RAN small cell technology:

Large financial services provider

Set in a high-profile, central London location, this end customer's cellular requirement typifies the current trend toward corporate reliance on cellular service and the move away from the traditional "chained to the desk" approach. Deployed across 13 floors with two UK mobile network operators, the OneCell solution uses just three or four unobtrusive radio points per floor to provide high-quality 4G service to 2,400 corporate users.

One key requirement of a modern building is the space, power and cooling requirements of the main equipment room (MER). In this deployment the total OneCell equipment in the MER consumes just two U's of 19-in. rack space for the centralized controller elements, and requires just 800 watts of power—much less than traditional in-building deployments and more in line with the space availability and power consumption expectations of today.

Connectivity between the equipment room and the associated radio points is managed over standard LAN switching infrastructure—further reducing complexity and specialized deployment practices. OneCell's centralized capacity management, ultra-low interference characteristics and cell virtualization (spectrum reuse) features ensure maximum throughput capacity is available to all users, always.

The neutral host provider was key to the end-to-end service provision. The neutral host front-end sales team secured the relationship with the end customer, which was then backed up by a complete turnkey deployment service including backhaul, radio point and controller installation and full commissioning. The neutral host also secured service from the required operators via existing relationships—which traditional end customers do not have.

Multi-tenanted office space

The modern, more millennial approach to office working is moving toward multi-tenanted flexible working spaces as opposed to large, costly, inflexible corporate offices. In this deployment OneCell meets the growing need by said millennials for high-capacity cellular service that BYOD models demand.

OneCell meets these requirements perfectly, providing high-quality 4G service to a transient tenant base of around 3,000 people. The open ceiling design and more industrial approach to cabling meant OneCell was deployed in a day or two with minimal disruption. The workforce is—along with many unregistered visitors—served perfectly by offering operator service without a login process such as would be required by guest Wi-Fi. CommScope sees huge growth in this type of working and the associated deployment model of cellular services.

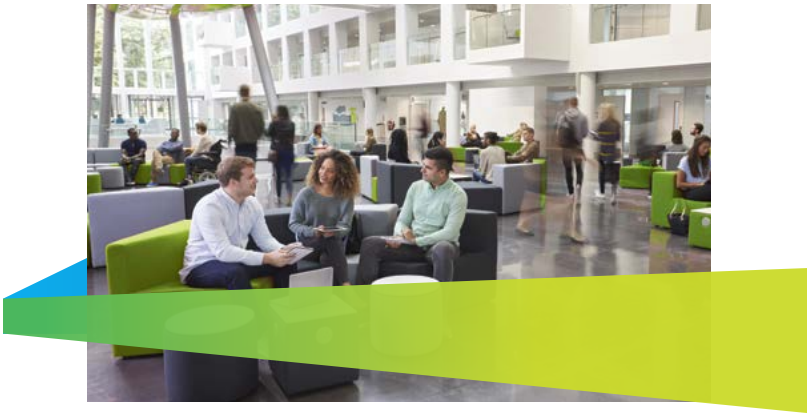
The neutral host leveraged existing relationships with the end customer to overlay the current 3G deployment with enhanced 4G service. Through strong relationships with the operators, they were able to gain the necessary approvals to proceed with the deployment and further prove the model through significant traffic offload from the macro network. The neutral host offers enhanced levels of operational monitoring services with local, dedicated staff to ensure continued good service from their investment.

Large education establishment

Again, OneCell can deliver against their key requirements, and working in conjunction with an IT-centric neutral host has delivered a solution that capitalizes on the expected strong educational IT infrastructure.

Currently deployed in a single building, the scope of the deployment is set to grow to other areas using the university's own fiber backbone—allowing for a centralized MER with a single backhaul connection to the MNOs via the neutral host's data center. The speed of deployment and flexible growth options look set to suit the technical and budgeting requirements of such establishments extremely well. In this instance the OneCell deployment is a logical extension to the already comprehensive list of IT-centric services the neutral host provides for the end customer.

Handling simple details such as site access and health and safety inductions, typical of onsite work, is made easier through the existing work that is already completed by the neutral host. The strong relationships and high level of trust mean this type of deployment can proceed with minimal disruption.



Case study	Financial services provider	Multi-tenant office space	Large education establishment
Industry vertical	Financial services	Shared workspace	Higher education
Number of users	2,400	3,000	25,000 (includes buildings not yet deployed)
Business benefits	Worker productivity, especially for highly-compensated specialists	Supports millennial/ BYOD workforce expectations; no login required (as for Wi-Fi) for transient work population	Faculty and student productivity; attractive learning and research environment
Neutral host role	Service provider relationship; turnkey deployment and commissioning	Overlay existing 3G deployment for 4G; gain operator approvals; ongoing monitoring and support	Existing relationship; strong understanding of university needs and IT infrastructure.
OneCell advantages	Low power and space footprint; standard LAN switching infrastructure	Rapid installation; demonstrable macro network offload	Extend across campus, using university's fiber backbone

C-RAN small cells provide flexibility to support a wide range of use cases.

All three use case examples to prove that, with the right neutral host team, deploying cellular services can be lower cost, be less disruptive, and can be accomplished in significantly reduced timescales. The traditional face of systems integrators needs to change into a more IT-centric nature, but these skills are readily available in the market for those integrators that do not have such skills in-house. These examples demonstrate that end customers are willing to fund deployments that bring tangible business value, and that there is a strong ecosystem ready to support them.

Shared and dynamically-licensed spectrum models

Thus far this paper has focused on traditional spectrum use models in which each operator delivers in-building service in their own licensed frequency bands, but other models exist in which multiple operators share common spectrum. These obviously have implications for multi-operator solutions.

RAN sharing

3GPP Release 8 defined two approaches to RAN sharing for LTE: multi-operator core network (MOCN) and gateway core network (GWCN). In MOCN, operators share base station equipment and spectrum. In GWCN, operators share base station equipment, spectrum, and elements of the core network—notably, the mobility management entity (MME) that manages the connection between the subscriber and the network.

A third approach, multi-operator radio access network (MORAN), shares base station equipment only. MORAN is not standardized in 3GPP and therefore is not implemented in a uniform way by RAN OEMs.

RAN sharing received a lot of attention back in 2013-2014 after MOCN and GWCN were first standardized. However, adoption has been limited, due largely to operators' desire for end-to-end control of all the network elements that affect subscriber experience.

Unlicensed and dynamically-licensed spectrum

More recently a new model has emerged in the form of the U.S. Citizen's Broadband Radio Service, or CBRS. With CBRS, the U.S. telecoms regulator FCC has opened 150 MHz of spectrum in the 3.5 GHz band for LTE use via a dynamic sharing model controlled by an entity known as a spectrum access server (SAS). More than half of this range (80 MHz minimum), known as general authorized access (GAA), can be used free of charge if it's done according to FCC rules manifested in the SAS. As of this writing, CBRS is about to commence commercial deployments. CBRS is limited to the U.S., but regulators in other countries are known to be considering similar models, watching the U.S. example.

Neutral host in-building wireless service is a promising use case for CBRS. Here, the neutral host would operate a local in-building wireless network and connect subscribers to their respective MNOs via roaming agreements. As with traditional spectrum models, neutral hosts are ideally suited to this role due to their expertise in designing and operating the networks, and their scale with which to make the needed roaming agreements feasible.

For this approach to gain wide adoption, two prerequisites must be met. First, subscriber devices must support the necessary CBRS band 48. Industry analyst Mobile Experts, Inc., predicts CBRS will be supported in 30 percent of U.S. handsets in 2021 or later.[3]

The second prerequisite is the willingness of mobile operators to enter into the needed roaming agreements. It's arguably in their interest to do so—it gains them wider in-building coverage with little to no incremental investment. In-building CBRS presents a new roaming use case, so the form and terms of such agreements would need to be worked out.

[3] Mobile Experts, CBRS Infrastructure and Devices, November 2018

CommScope in Neutral Host Small Cell Solutions

CommScope has delivered solutions for both macro and in-building wireless networks for decades, and, as such, has developed a deep understanding of neutral host needs through longstanding relationships with neutral hosting leaders globally. Our device management system (DMS) and OneCell C-RAN small cell are designed to support neutral host partners for wide-scale enterprise in-building wireless deployments.

The solution consists of the following key components:

- Device management system (DMS)
- OneCell baseband controller (BC)
- Ethernet fronthaul
- OneCell radio point (RP)

DMS is a fully FCAPS-compliant network management system that supports the following functions:

- Configuration management
- Fault management
- Performance management
- Zero-touch auto provisioning
- Software management

DMS is expressly designed to support neutral host deployments. It greatly simplifies system commissioning through a zero-touch auto-provisioning in which hundreds of parameters are configured without manual intervention. DMS also provides flexibility to neutral hosts and operators in the ways multi-operator deployments can be managed.

Fault, configuration and performance management can be assigned differently between the neutral host and the operators. For instance, the neutral host can monitor alarms only, or also manage the configuration of the whole system through DMS, while each operator can receive performance operational measurements (OMs) for its serving cells from the baseband controllers without the need to access the DMS. Alternatively, the operator can manage the configuration of its serving cells through its own DMS. Within a deployment, the functions performed by the operator and neutral host can differ by operator. Finally, the neutral host can provide a fully managed service to the operators by leveraging all the capabilities of the DMS.

The OneCell baseband controller provides macro-grade capacity and performance. The baseband controller is highly scalable and upgradable via software to support advanced features, including cell virtualization—a capability that allows spectrum to be dynamically reused without introducing interference. Each baseband controller is dedicated to a single operator with an S1 connection to its core network. Thus, in a neutral host deployment, the operators need not share baseband processing and capacity. Each operator has full end-to-end control of the quality of experience delivered to its subscribers. Moreover, the footprint of a single BC is extremely small. Only two rack units of head-end space are needed to support a deployment with four operators.

OneCell fronthaul can run over standard Ethernet LAN, including COTS fiber and PoE switches and Category 6A cabling. A single multi-gigabit Ethernet transport infrastructure is shared across multiple operators. This reduces equipment and installation costs, simplifies the installation and commissioning of the system, and makes in-building neutral host deployments more scalable. Ethernet fronthaul also makes OneCell compatible with 5G in-building networks, so OneCell LTE neutral host deployments can be upgraded to support 5G NR in the future.

The table below summarizes how the various components of the system are shared among operators or dedicated to a single operator, within a neutral host deployment.

Item	Sharing	Comments
Baseband controller	Dedicated	BBU-equivalent element; each operator fully controls its own capacity and baseband operation
Fronthaul Ethernet switches and cabling	Shared	Cost saving through single shared infrastructure; VLAN configuration provides logical separation
Radio points	Shared	Shared physical resource on a single Ethernet/PoE connection creates per-operator virtualized radio instances (VRIs).
RF modules	Dedicated	Each operator controls transmit power within own frequency band

Network elements are shared when it is possible to do so without sacrificing operator control of its network

The RP5000 Series is the OneCell radio platform to support LTE and 5G NR evolution. It is characterized by the following attributes:

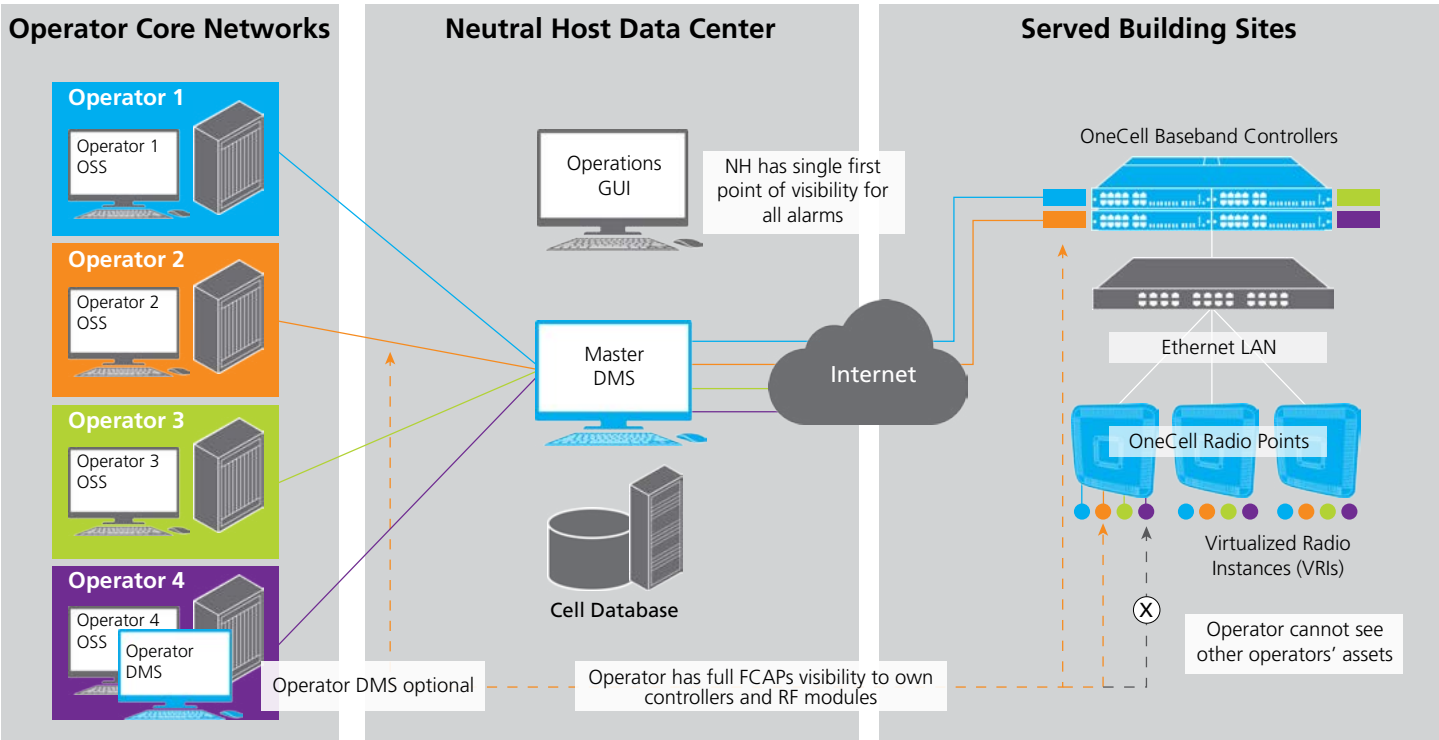
- Programmable baseband processing
- Multi-carrier/multi-band capability
- Modular radio front end
- Multi-gigabit Ethernet interface

Within the OneCell RP5000 Series, the RP5100 line can support up to four radio modules on up to four different bands. Each radio module supports a single carrier/operator in a given band in 2x2 MIMO mode; therefore, up to four operators can be supported in a single unit. Through the creation of virtualized radio instances (VRIs), each operator "sees" a dedicated radio at each access point. The operators don't share spectrum or radio transmit power, and the radio modules are field upgradable, so operators can be added over time without impacting the initial radio design. Moreover, multiple radio modules can be allocated to a single operator to support higher MIMO orders or carrier aggregation.

RP5000 Series feature	Benefit for neutral host deployments
Multiple virtualized radio instances (VRIs)	Single access point supports up to four service providers or frequency bands. Eliminates need for duplicate devices at each access point location
Modular/programmable radio front ends	Radios can be provisioned for operator frequency bands Software-upgradable from LTE to 5G NR within the same band
Multi-gigabit Ethernet interface	Single cable run provides network connection and PoE power for up to four operators
Compact, elegant design	Pleasing aesthetics suitable for commercial and multi-dwelling residential spaces
Indoor and ruggedized versions	Ability to serve adjacent outdoor spaces: courtyards, parking garages, entryways

OneCell RP5000 Series radio point is designed to meet neutral host requirements

The diagram below shows the end-to-end architecture of a OneCell neutral host deployment, with one of the many possible scenarios for dividing management responsibilities between the neutral host and the network operators.



OneCell and DMS provide flexibility for the neutral host to manage the site deployment while operators continue to see and manage their networks.

Conclusion

The need for in-building wireless connectivity is increasingly a strategic requirement for enterprise communications and business applications. These are already in heavy use due to the advent of smartphones and LTE, and they will become even more critical with 5G.

Operators, however, do not have the resources to "light up" every major commercial building. Neutral hosts have the expertise and business model flexibility to play a critical role in broadening the reach of in-building wireless services. We are already seeing this model emerge in Europe.

To be truly successful, neutral hosts need technology platforms that deliver excellent LTE performance, provide an economical upgrade path to 5G, and allow the flexibility to support multiple stakeholders and business models.

CommScope is committed to serving and expanding the in-building wireless market, in partnership with neutral hosts and mobile operators. Our OneCell C-RAN small cell system and DMS management system are designed specifically to meet the needs of multi-operator, neutral hosted deployments. Together, we are making the in-building wireless future possible.

Together, we are making the in-building wireless future possible

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We collaborate with our customers and partners to design, create and build the world's most advanced networks. It is our passion and commitment to identify the next opportunity and realize a better tomorrow. Discover more at commscope.com.

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