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Cel-Fi™ QUATRA In-Building Enterprise Cellular System

Usage and Configurations: Off-Air and Supercell

By Joe Schmelzer, Senior Director of Products at Nextivity

With the continued increase of cellular data consumption, mobile operators are supplementing network capacity and coverage where needed using various small cell platforms to meet local demand (i.e., densification). Similarly, consumers and businesses that increasingly rely on cellular service often take it upon themselves to source and deploy their own systems. Yet, in many environments, available indoor coverage options are either too complex or too costly for enterprises or service providers to consider.

Nextivity has worked directly with global operators to create the **Cel-Fi QUATRA In-Building Enterprise Cellular System**, an addition to the Cel-Fi family of products that addresses the growing need for affordable and flexible in-building cellular coverage solutions in the mid-sized enterprise environment. Cel-Fi systems have thus far been approved for use by nearly 200 carriers in 100 countries.

Purpose and Intended Audience

This paper details the Cel-Fi QUATRA In-Building Enterprise Cellular System for commercial in-building cellular coverage, how it works, and different use-case configurations. The paper is intended for mobile operators, installers, and interested business or IT professionals that want to better understand this hybrid solution that combines the best of active DAS with the digital architecture of smart, carrier-class indoor coverage solutions that have been widely adopted by carriers around the world.

A New “Smart” Approach to Coverage

In developing Cel-Fi QUATRA, Nextivity leveraged the processor and digital architecture that powers its family of Cel-Fi cellular coverage solutions. Unlike any other products in the market today, the digital architecture that underlies these proven solutions provides both the intelligence and scalability required to deliver and optimize indoor cellular coverage for venues up to 200,000 sq. ft.

“Smart” refers to the intelligent architecture that is designed to deploy quickly, is easy to use, self-configures and continuously optimizes and maintains itself, and in so doing, provides much better cellular service while remaining unconditionally network safe.

These smart systems have been designed with operator involvement to improve indoor coverage, without the network interference problems and installation complexity associated with other types of systems, like common bi-directional amplifiers, repeaters, or traditional DAS. The systems are highly programmable and can be controlled by the network it serves, and are unconditionally network safe (no network interference). Cel-Fi QUATRA can be installed by anyone with IT skills, at the lowest cost per sq. ft. of any enterprise-grade, in-building cellular coverage solution available on the market.

The smart digital architecture includes many features such as: automatic gain control to maximize system power, uplink power control to the macro network, advanced digital echo-cancellation and feedback control, uplink gating, and signal qualification (channels are individually qualified for boosting, so noise or very poor signals won't be amplified and won't degrade the network).

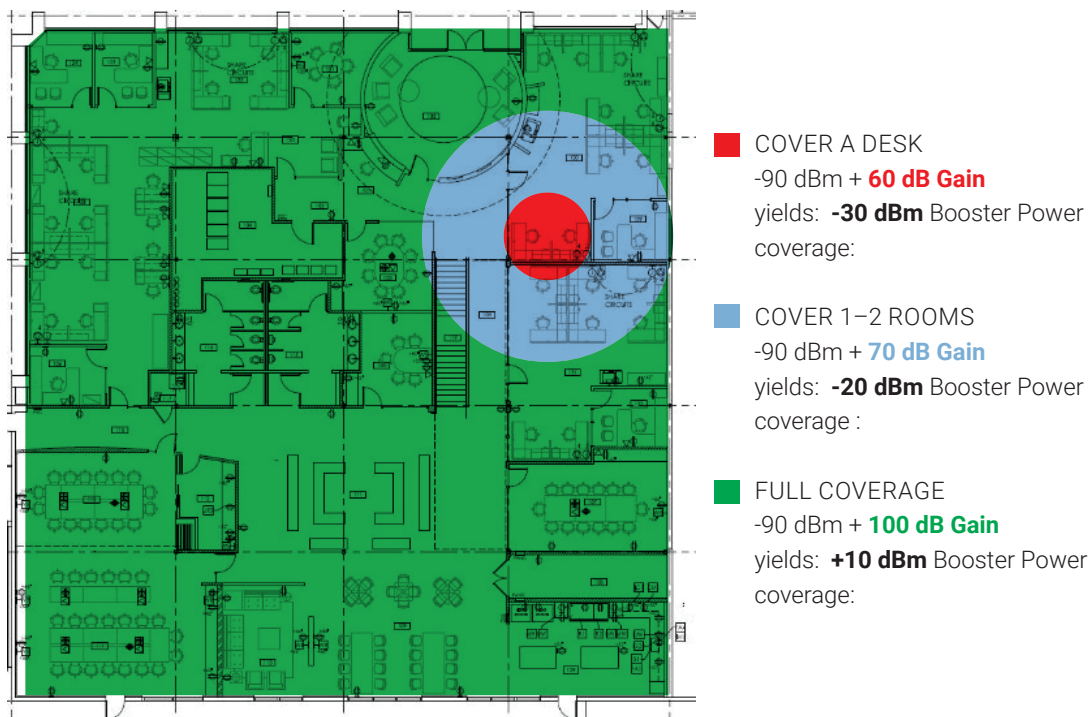


Figure 1: A typical Off-Air Gain “per-channel” power example.

Cel-Fi QUATRA In-Building Enterprise Cellular System

Cel-Fi QUATRA is an active DAS hybrid. A single system can be installed off air and configured to provide coverage up to 50,000 sq. ft. It is comprised of one Network Unit (NU), which is the hub of the system; and one to four Coverage Units (CU), which are the remote radio units of the system that rebroadcast the donor signal.

Cel-Fi QUATRA can also be deployed within larger venues using a small cell donor signal, combining up to four systems. In this scenario, by synchronizing the outputs from multiple CUs, the coverage area of each CU is stitched together to form one large cell that can provide coverage across an entire building of up to 200,000 sq. ft.

Cel-Fi QUATRA installation and commissioning is designed to require only typical IT skills. As a result, it can be installed faster than other available solutions. Once the system is mounted appropriately, standard Cat 5e (or better) cable is used to connect the NU with each CU. When powered-on, all network and system optimizations are performed automatically.

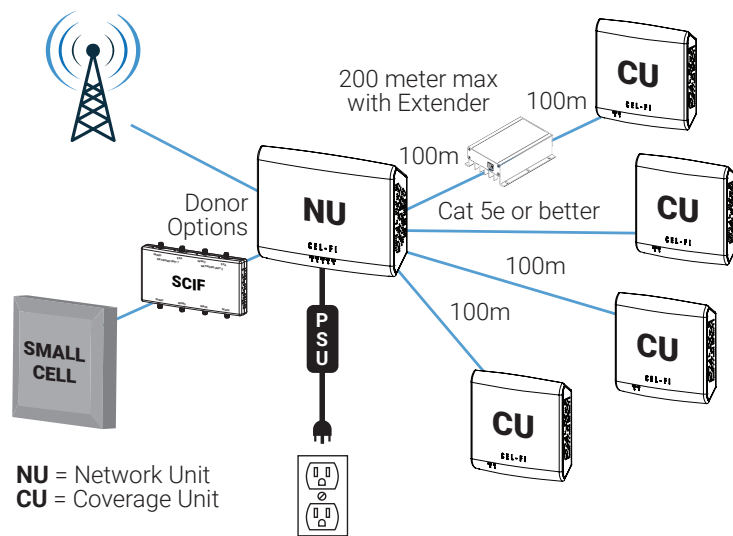


Figure 2: Cel-Fi QUATRA Elements

COVERAGE UNITS (CU)

- Up to four (4) per NU
- Power over Ethernet
- Built-in or external antennas
- Horizontal ceiling or vertical wall mountable
- Mounting Kit included

NETWORK UNIT (NU)

- Built-in or external donor antennas
- Accepts Small Cell donor inputs (to one or more QUATRA systems)
- Powers entire system
- Self-configuring
- Mounting Kit included
- Enterprise management

Why A Hybrid Solution is Better

The combined capabilities of active DAS and the digital architecture of Nextivity's smart, carrier-class, indoor coverage solutions eliminate problems associated with existing indoor cellular coverage technologies, and offers the following advantages:

- Much higher gain without overloading the network with amplified noise (capacity-killing interference)
- Larger coverage footprint per server antenna
- Simple, fast, hassle-free installation
- Obviates the need for site engineering and tuning, as with other DAS products
- Lower cost per sq. ft. of coverage
- Set and forget: Cel-Fi QUATRA dynamically tunes to operator network frequencies
- Makes the network more efficient (a better signal means the same amount of data may be transmitted in less time with less energy, freeing up network resources for other users)
- Simple to add future capacity without re-engineering

- System management options available for enterprises who want to implement alarms and alerts
 - Programmable and upgradable
-

Driving Down Cost and Complexity for Small and Medium Enterprise (SME)

A large enterprise may be able to support the ROI and associated costs of a traditional DAS solution that requires extensive planning, RF design, engineering, and highly skilled technical installation and maintenance, as well as extensive budget and contract negotiations with multiple vendors, integrators, and the carriers themselves.

But the cost of a traditional DAS solution typically puts them out of range of the SMB/SME. Simpler solutions such as femtocells and Wi-Fi calling are available but do not have the reliability, quality of service, or management capabilities that a business requires. Venues that range in size from 10,000 to 200,000 sq. ft. are particularly challenged with the price/performance gap, as they are too large for affordable consumer-grade solutions and too small for high-performance DAS.

Cel-Fi QUATRA addresses this gap by eliminating the need for RF engineering, using Cat 5e (or better) cabling to connect the NU with up to four CUs, and powering the entire system via Ethernet (PoE) from a single power supply at the NU. This also means the CUs can be mounted just about anywhere.

Nextivity chose to standardize on dedicated Cat 5e cabling to simplify IT requirements. (Better cable can be used, but is not required.) Simply put, if IT staff can run LAN cable, and plug the NU power supply into an AC outlet, they are qualified to install the system and Cel-Fi QUATRA does the rest.

As the CUs are powered antennas, they have full transmit power available (no coaxial distribution power loss). The NU and CU may be separated by as much as 200 meters when the optional QUATRA RANGE EXTENDER (QRE) is placed inline. The QRE is plug and play, and doesn't require independent power as it also is a POE device.

Cel-Fi QUATRA also includes support for MIMO, and up to 75 MHz of combined channel bandwidth across four (4) independent cellular bands. This provides flexibility for supporting mixed 3G and 4G networks on location.

All of this translates into a lower cost of coverage per sq. ft., and faster, hassle-free deployment times. Multiple Cel-Fi QUATRA systems may be installed and will self-organize to support larger spaces.

Cel-Fi QUATRA In-Building Enterprise Cellular System Configurations

Cel-Fi QUATRA is flexible and scalable. The optimum donor signal configuration is determined by applying some basic use-case principles.

Off-Air Configurations

Off-Air configurations use capacity from the operator's existing macro network, extending it indoors where it is needed. This can be the fastest and easiest way to provide indoor coverage, not requiring any fixed backhaul (small cell or femto), contracts, or lengthy permit processes.

This system can take advantage of the NU's internal antennas, or it can be connected to an external antenna. (Nextivity offers a Wideband MIMO Antenna that is perfect for this.) Using a high-gain external directional donor antenna can also

be a good way to improve signal quality. IT staff simply attach the antenna and run through the setup procedure. Nextivity also offers mounting solutions, an outdoor pole mount, and an indoor/outdoor wall mount. Guided by Nextivity's Antenna Positioning software, in minutes the antenna can be mounted, positioned, and aimed properly for best donor signal input by a single installer (other systems require two installers). Quality of the donor signal provided to the system is perhaps the most important factor in the installation outcome for an Off-Air configuration.

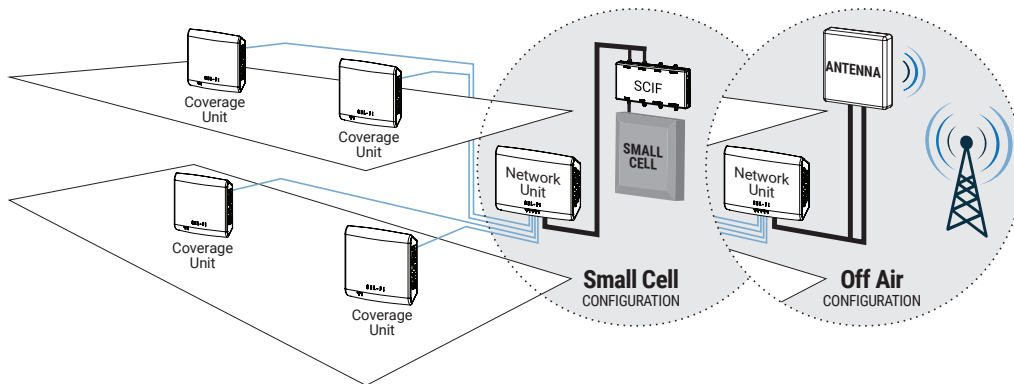


Figure 3: In-Building Enterprise Cellular System

Another advantage of the Off-Air configuration is that CUs only need to be placed where coverage problems exist in the building. In this configuration the existing macro signal is only being boosted where it is lacking, and a handset that migrates between Cel-Fi and macro-covered areas is simply seeing a better macro signal everywhere.

Supercell Configurations

In the Supercell™ configuration, a small cell is used as the donor for Cel-Fi QUATRA. (Any small cell can be used with Cel-Fi QUATRA, as long as the frequencies match.) The Supercell created by the small cell/active DAS hybrid provides uniform access to the capacity introduced by the small cell. Supercells are inherently uncomplicated from a planning and deployment point of view, and are far more resilient to the potential of interference.

This method facilitates a uniform signal distribution throughout a larger area. Additional Cel-Fi QUATRA systems may be used to expand coverage up to 200,000 sq. ft. per (typical) small cell.

Supercell Advantages

The Supercell configuration – i.e., Cel-Fi QUATRA connected to a small cell – has three key advantages over a small cell installed alone. These are:

1. Small cell dominance
2. Elimination of problems related to potential multiple small cell interference
3. Reduced small cell overhead and OPEX resource requirements.

Supercell Dominance

Advantage 1

Larger or more densely populated installation sites can often benefit from the network capacity delivered by a dedicated small cell. This means three things to the operator (and the customer):

1. The installation should provide enough signal dominance (power) over the outside macro network so (in-building) calls stay on the (in-building) small cell where they belong.
2. The local small cell also off-loads local traffic from the macro network, freeing up capacity for other macro network subscribers.
3. If the site suffers from network interference problems, such as pilot pollution in a high-rise building where too many cell sites are visible and interfering with each other, small cell dominance must be able to overcome the interference signal energy that is present.

In the typical example below, the building suffers from a lack of signal at its interior, while the perimeter areas of the building are being adequately served by competing macro cells.

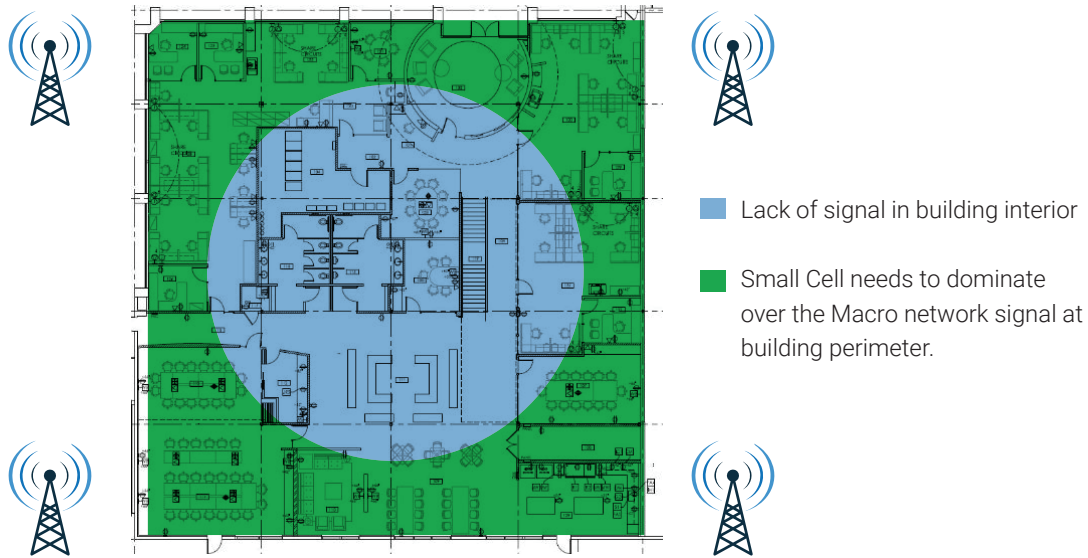


Figure 4: Small Cell competes with the Macro network.

If a small cell is installed in the center of the building, its signal power falls off as callers get closer to the perimeter. This results in service being handed-off to the outdoor network, which defeats the purpose of adding small cell capacity.

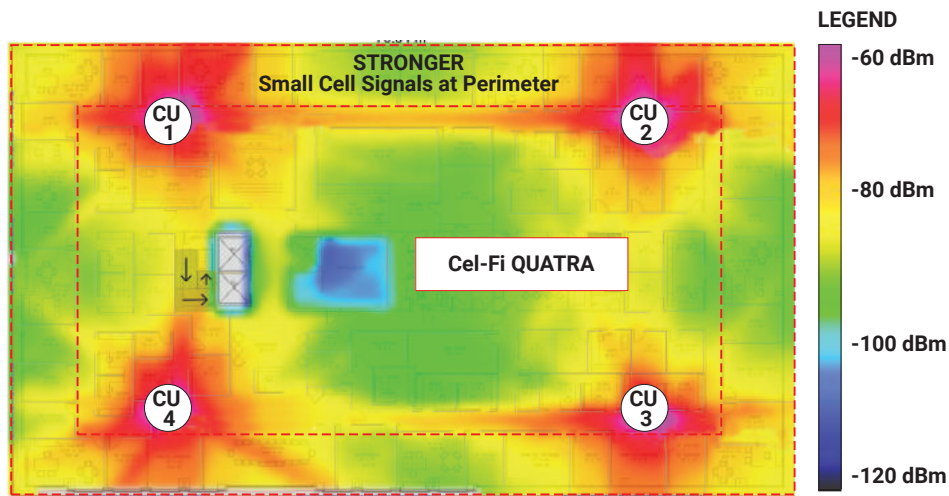


Figure 5: STRONGER Small Cell signal at perimeter.

Now consider the Supercell case which distributes local capacity in a more uniform fashion. The result is that more areas are covered, and power density (small cell dominance) is improved at the building perimeter.

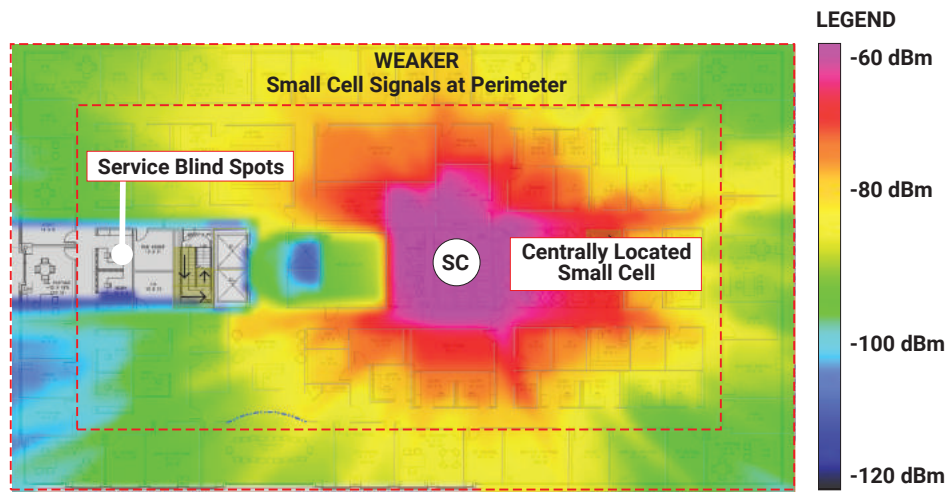


Figure 6: WEAKER Small Cell signal at perimeter.

In this case, the result is a 14 dB improvement for the perimeter offices, plus better coverage overall throughout the venue. This helps to ensure that local cell phones will be properly served by the local system, and that the macro network will be properly off-loaded as the operator intends.

Potential Interference From Multiple Small Cells

Advantage 2

Similar to macro network cells, small cells may interfere with each other where they overlap, causing reduced performance. The Supercell configuration resolves this problem by creating a large single composite cell and eliminating handoff regions between multiple small cells.

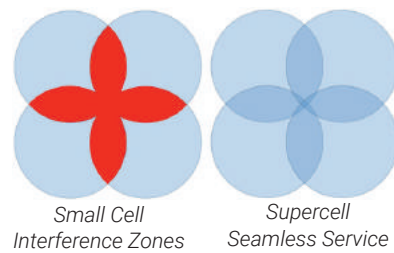


Figure 7: The Supercell Advantage

Small Cell Overhead and Opex

Advantage 3

Each small cell must have its own high bandwidth backhaul that connects it to the operator's gateway/core network. Therefore, additional small cells result in an increase in cumulative backhaul requirements and OPEX that must be considered. Some enterprises will have plenty of overhead bandwidth and can draw from that with small cells, but some will need to increase bandwidth, which comes at a cost. Each small cell comes with guidance on the bandwidth consumption, so the enterprise can easily determine if current bandwidth is sufficient.

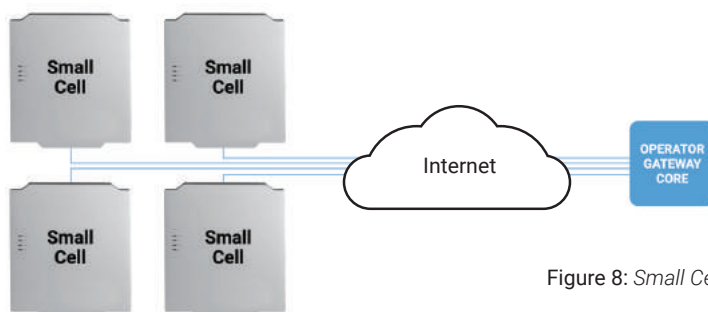


Figure 8: Small Cells require backhaul.

Conclusion

The industry has struggled to provide affordable cellular coverage solutions to small- and medium-sized businesses – until now. Existing consumer-grade solutions have been limited in performance, while active DAS has been too complex and costly. The Cel-Fi QUATRA In-Building Enterprise Cellular Solution is the first to meaningfully address the indoor cellular service needs of this market by improving indoor cellular performance, eliminating black holes, dropped calls, and poor voice quality.

Cel-Fi QUATRA builds on the digital architecture of Nextivity's proven carrier-class indoor coverage solutions to improve indoor cellular service in small- to medium-sized enterprises with the lowest cost per square foot of coverage.

Configurations are flexible and can be scaled to the unique needs of each venue. Off-Air configurations are designed to quickly bring outdoor coverage indoors, with minimum effort. Supercell configurations are designed to improve the effectiveness of local small cell capacity and coverage while offloading the macro network effectively.

With self-configuring and optimization capabilities, Cel-Fi QUATRA installation can be done with CAT 5e cabling by internal IT staff, without the need for RF engineers or sophisticated tools. Cel-Fi QUATRA was specifically designed to provide small- and mid-size enterprises with a carrier-grade and carrier-friendly in-building cellular coverage solution, at an exceptional TCO.

About the Author



Joe Schmelzer is Senior Director of Products at Nextivity. He has developed a variety of products and industrial devices for chipset vendors, OEMs, and service providers, including products for Sony, Qualcomm, Google, Verizon Wireless, AT&T, Dell and HP. He enjoys speaking opportunities and writing.

For more information, contact sales@cel-fi.com or visit www.cel-fi.com.