Understanding CBRS Capacity

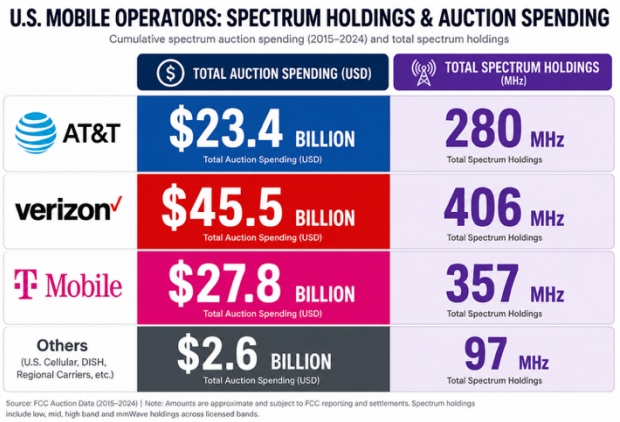
InfiniG provides reliable mobile coverage in commercial buildings at a significantly lower cost than alternatives. Its Mobile Coverage as-a-Service (MCaaS) Cloud-based solution uses small radio nodes that share cellular airwaves, radio infrastructure, and the building's existing Internet to connect users to their mobile network operator's service. InfiniG's solution leverages MOCN (Multi-Operator Core Network), a 3GPP-standardized telecom architecture that allows multiple mobile network operators to share the same Radio Access Network (RAN) and spectrum, while maintaining separate, independent core networks

This application note addresses a common misconception that the shared-licensed CBRS band can't provide as much capacity as exclusively-licensed bands for in-building mobile coverage. It demonstrates that because radio channels in the CBRS band are freely available inside a building they enable massive in-building reuse, delivering much more capacity than spectrum owned and controlled by the mobile network operators (MNOs).

Spectrum 101

The term "spectrum" refers to the part of the electromagnetic wave spectrum that is usable for radio communications. Spectrum is usually broken into "bands" based on their technical characteristics and licensing framework. Common cellular bands include 600, 700 and 800 MHz ("low band"); 1700, 1900, and 2100 ("mid band"); 2500, 3400 and 3700 MHz ("high band"); and 24000, 28000 and 39000 MHz ("millimeter wave"). In general, lower-frequency bands travel farther, providing greater geographical coverage. However, they offer lower capacity because they are more desirable (thus command a higher licensing cost) and their longer reach means less opportunities for geographical reuse. Conversely, higher frequency bands don't travel as far but offer much greater capacity.

Spectrum bands are divided into "channels," which in the US are typically awarded at auction for the exclusive use of mobile network operators. The ultimate cost of Spectrum at these auctions is roughly proportional to the population of the geographic area of exclusivity, the technical characteristics of the band, and the total number and size (in MHz) of the channels within the band obtained. Simply put, more MHz in a desirable band covering more people will cost more. The following chart shows how much has each mobile network operator has spent so far on spectrum and for how many MHz.



More Spectrum = More Capacity

An important correlation in radio communications is that the amount of voice and data you can transmit, otherwise known as “capacity,” is directly proportional to the spectrum available. This means that the more spectrum a mobile operator owns (MHz), the more users they can serve with higher speeds.

Thia basic relationship comes from the Shannon theorem in communications theory:

$$C = B \times Log_2(1 + SNR)$$

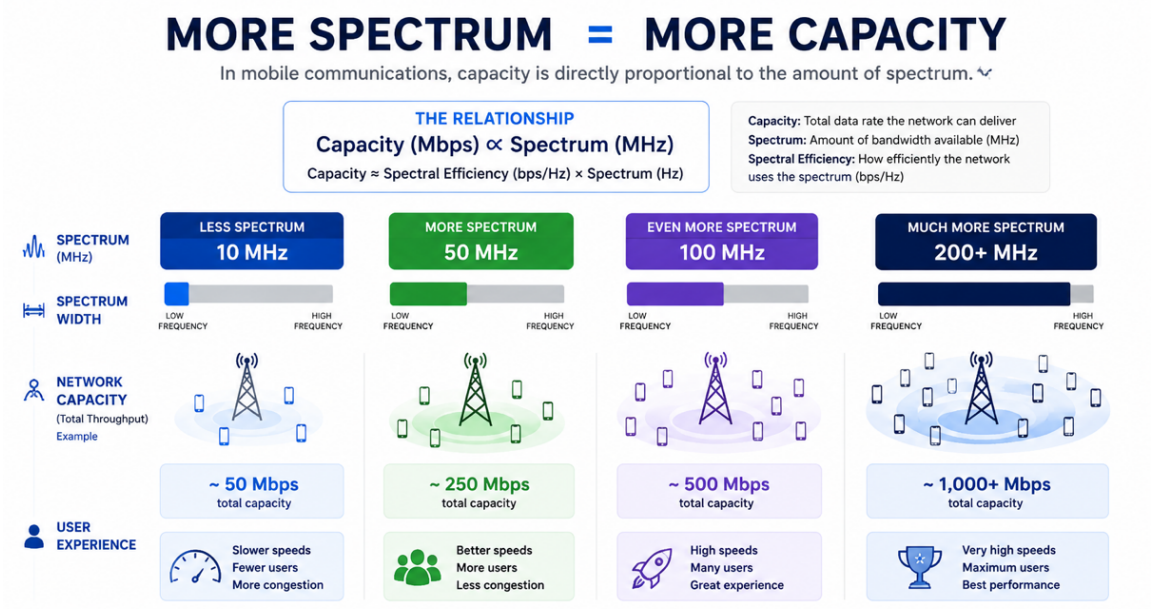
Where:
* *C = channel capacity (maximum data rate, in bits/sec)*
* *B = bandwidth or spectrum width (Hz or MHz)*
* *SNR = signal-to-noise ratio*

For wireless networks, this is often simplified into the practical engineering approximation:

$$Throughput\ (Mbps) \cong Spectral\ Efficiency\ (bits/s/Hz) \times Spectrum\ (MHz)$$

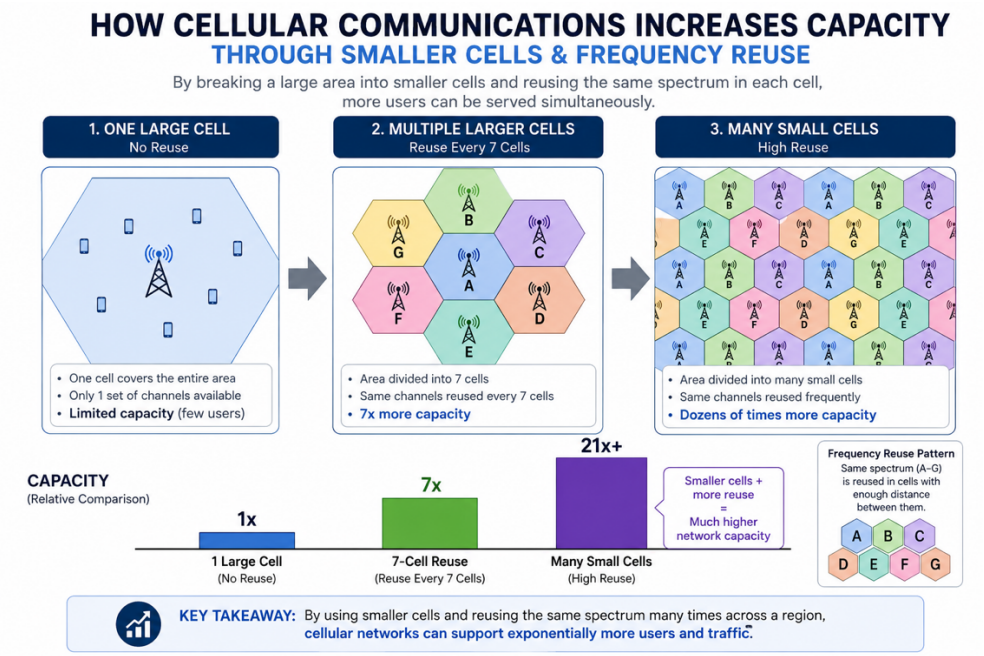
This shows that data throughput (Capacity) is approximately proportional to available Spectrum, regardless of technology (Spectral Efficiency).

The misconception about CBRS spectrum capacity arises when comparing the total 1,140 MHz of Spectrum the US mobile operators collectively have to the 150 MHz available to CBRS. This simple comparison neglects two very important facts: (1) CBRS spectrum is essentially free and (2) CBRS spectrum can be freely reused within a building without permission (license) from the mobile network operators.



More Reuse = More Capacity

Just like light and other forms of electromagnetic radiation, radio waves get weaker over distance. This means that spectrum can be re-used if it is used far enough that the original radio waves are too weak to cause interference. Wireless engineers have known this fact and have used it to their advantage for decades. In fact, the term "cellular" in mobile communications originated from breaking up radio towers into smaller cells that can reuse spectrum, thus increasing capacity and making those old bulky car phones finally affordable.



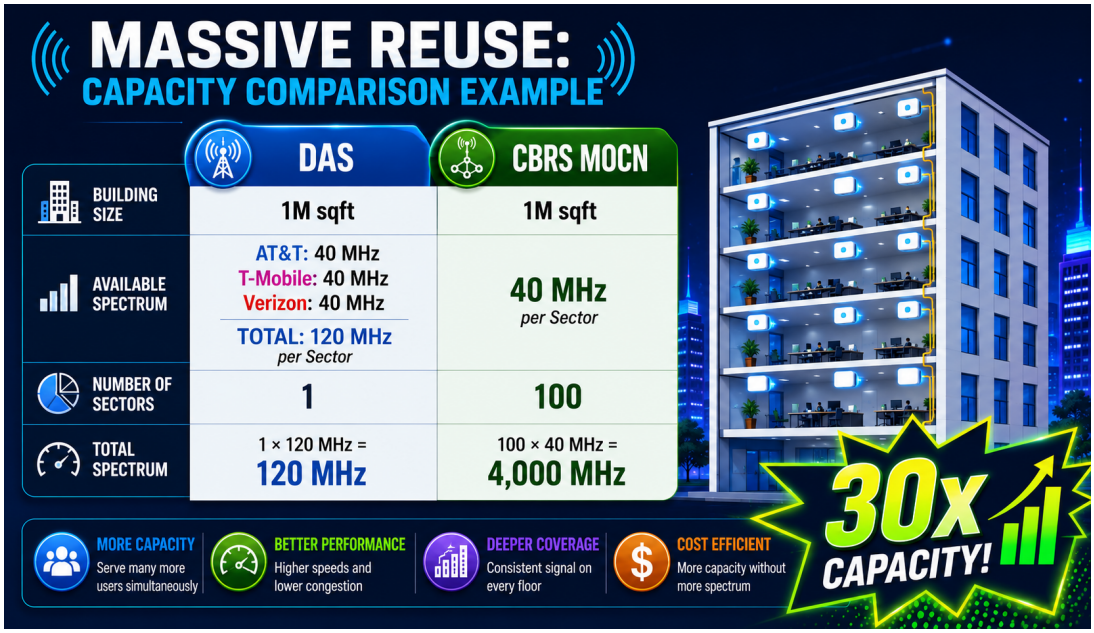
The separation distance required for this type of spatial reuse depends on various factors, including spectrum band and transmit power. Outdoors, that distance tends to be in the range of half a mile in dense urban locations to 2-3 miles in rural areas. For in-building, it's only a few hundred feet. Furthermore, each cell gets subdivided into "sectors" using directional antennas that don't interfere with each other, further increasing capacity.

In-Building Cellular = Massive CBRS Reuse

The final piece of the puzzle of CBRS capacity is the fact that CBRS spectrum can be massively re-used indoors. Traditional indoor mobile coverage deployments, such as Distributed Antenna Systems (DAS), use exclusively-licensed spectrum. This spectrum is "donated" by the mobile network operators that own the spectrum for use as the signal-source of the DAS. Because exclusively-licensed spectrum is valuable and expensive, MNOs will donate the absolute minimum for these in-building systems. A typical DAS may have 40 MHz for each mobile operator, for a total of 120 MHz. Although DAS can also be subdivided into sectors for more capacity, each new sector requires a new signal source from the MNOs, making the proposition costly and complex.

In contrast, CBRS can be freely reused throughout the building at minimal cost. Most InfiniG CBRS MOCN deployments consist of small cells where **each** transmits 40 MHz of CBRS spectrum shared among all the participating MNOs and perhaps private network applications. This may not seem like much until one realizes that this 40 MHz may only be covering one floor or even part of a floor in a building. Users in the floor above and below get an **additional** 40 MHz each, etc. Essentially, every time you add a cell, you get a new sector and a **new** 40 MHz of capacity for the building. This massive reuse leads to massive capacity, even when it's shared among subscribers of all MNOs and private applications.

The following example illustrates this point. This building's DAS gets a total of 120 MHz donated by the mobile network operators, which must be shared among all users in the building. However, if they used InfiniG's CBRS MOCN they would get 40 MHz per each of the 100 small cell antennas, for a total 4,000 MHz of Capacity. That's 30x more capacity for the users of that building!



Conclusion

This Application Note demonstrated how, despite the common misconception, freely available CBRS spectrum combined with time-honored spectrum reuse techniques lead to a much greater mobile capacity than DAS and other in-building alternatives. As people increasingly use their mobile phones to do everything from everyday business to financial transactions to entertainment, having adequate mobile network capacity becomes essential.

About InfiniG

InfiniG delivers mobile phone coverage as a service to building owners and enterprises. The company leverages CBRS spectrum, the latest MOCN and Cloud technologies, and close relationships with the major US mobile operators to provide high-quality mobile service to offices, hotels, hospitals, schools, warehouses, campuses and any other location with poor mobile coverage.