TARANA

BROADBAND REINVENTED

Understanding CBRS Spectrum Availability

Abstract

Citizens Band Radio Service (CBRS), and its wide swath of spectrum (150 MHz) is a boon to anyone looking to deploy wireless broadband where other spectrum bands are increasingly crowded and, in many cases, unusable for reliable communications.

CBRS operation does come with some caveats however; one of the most important to understand is spectrum allocation and availability. Specifically, if an operator needs multiple channels to operate and loses one or more due to CBRS restrictions, the results can be catastrophic and create widespread service outages.

One way to ensure reliable CBRS operations is to minimize the number of CBRS channels (spectrum) required. This is not easily done by most systems which will introduce unacceptable levels of self-interference with high frequency reuse.

Tarana has pioneered an innovative solution that takes a ground up fresh approach to broadband wireless access (BWA). Tarana's Gigabit 1 (G1) platform is uniquely suited to take full advantage of CBRS while minimizing potential service interruptions.

This document offers insight into key issues around CBRS operation and how Tarana helps service providers create reliable, high-speed wireless broadband using CBRS.

The CBRS Spectrum

The CBRS band ranges from 3550-3700 MHz and was identified by the FCC as a candidate for spectrum sharing. What this means is that the band (otherwise known as band 48), although lightly used, still has incumbents that must be protected. Once those incumbents' needs are satisfied, the unused portion of the spectrum is made available for other users.

CBRS users are divided into three tiers: incumbents, priority access license (PAL), and General Authorized Access (GAA). Incumbents include the US Navy, fixed satellite service, and existing wireless broadband services (WiMAX). Priority for spectrum allocation is granted based on the tier a user is categorized as, i.e., incumbents are the highest priority, then PAL, and finally GAA.

Users who wish to operate on a portion of the CBRS band must register with a Spectrum Access Service (SAS), which dynamically grants access based on the category of user. Grants include specific spectrum allocation and transmission power levels. SAS uses specialized sensors to detect incumbent activity in protected areas, in particular the US coast line where the Navy could be an active incumbent.

A PAL user is one who has paid a license to operate on a specific portion of the CBRS band, assuming it is not in use by an incumbent. A portion of CBRS is designated GAA and may be used by anyone approved by the SAS for operation.

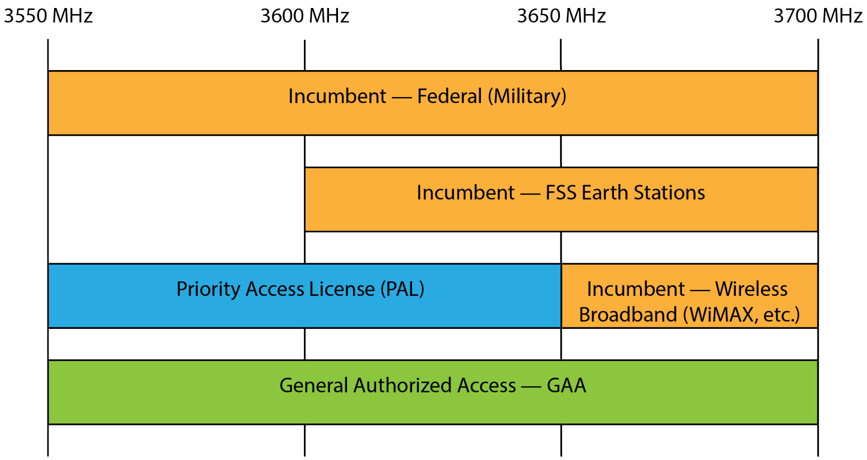

Figure 1: CBRS spectrum allocation and tiers of access

Spectrum Availability Challenges

Unless you are an incumbent, access to CBRS spectrum is not guaranteed. Even if the operator paid for a PAL, they **must** vacate the spectrum when an incumbent needs it. This will adversely affect links that previously worked fine and now must switch or even potentially have no other channel to use.

Operators working with equipment that requires multiple frequencies for reuse (k=2, 3, etc.) are especially hampered. In the case of PALs, they're paying twice or three times the cost or more and service stability is especially at risk if they lose even part of that spectrum due to incumbent need.

This can be especially vexing for operators near coast lines. Whenever Navy radar is deployed a dynamic protection area (DPA) is activated. A DPA is a pre-defined area where an incumbent could have operations and must be protected if activated. As a general rule of thumb, residential Category A CBRS devices (CBSD) are up to 150 km. Category B CBSDs (mounted on towers) range from 150 km – 450 km depending on location.

Activation mandates grant suspension and changes as dictated by the SAS. With over 95,000 miles of US coast line, this is not a minor issue.

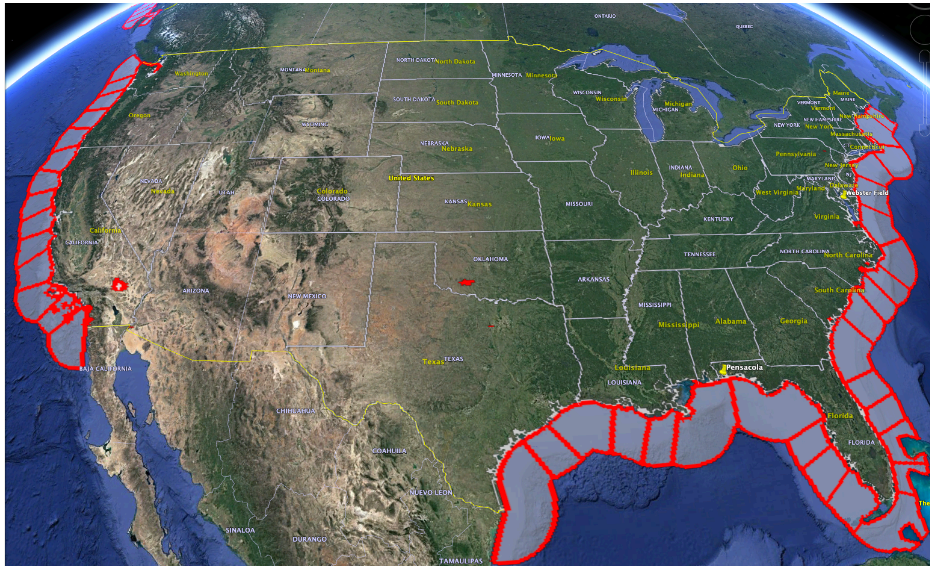

Figure 2: ESC-monitored DPAs for contiguous U.S.

Frequency Reuse and CBRS

Frequency reuse (often referred to as k) is the number of times a specific frequency is reused in a multi-sector and multi-tower topology. Operators must typically perform careful radio planning to ensure sectors on the same or nearby towers, don't interfere with each other. For most equipment vendors, this means using multiple RF channels. The number of frequencies (channels) used is then referred to, for example, as k=2 (two different channels), k=3, etc.

CBRS operators are allowed to purchase up to four 10 MHz-wide channels in any geographic area. This allows them to either operate towers with 4 sectors that each use 10 MHz, or a fewer number with wider channels. Operators may also seek to use part of the GAA channels as permitted by the SAS.

But what happens if the sectors are located in a DPA area that gets activated? Assuming there is overlap between the incumbent's desired frequencies and those in use by the operator, the SAS will suspend the channel grant to the operator for all impacted channels.

A Real World Example

Channel grant suspension can dramatically affect link availability. We recently spoke with an operator using CBRS in a DPA. They use 3 channel reuse (k=3) which means each tower has three sectors, each using a different CBRS channel.

When the DPA these sectors were located nearby got activated, two out of the three channels were suspended. This meant either the sectors had to find another channel or suspend operation.

As it happened, there was no other spectrum available, this meant two thirds of their radios had to shut down until the incumbent had left the area. This was a severe outage that caused downtime for the majority of subscribers connected to their towers.

The graphic below shows the 3 sector (k=3) tower on the left operating normally. On the right is the resulting activate channels (1) after the DPA was activated and no available alternative GAA was found.

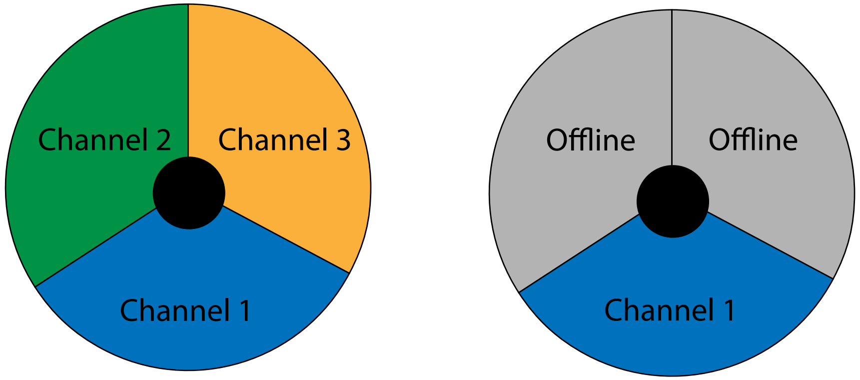

Figure 3: 3 channel sectors before and after DPA outage

The Value of Universal Frequency Reuse (k=1)

While spectrum access is not 100% guaranteed for PAL and GAA users, operators can reduce overall risk with smart radio planning. Equipment that can do universal frequency reuse (k=1) also has the following advantages:

- Simpler radio planning with no need to worry about channel overlap and self-interference
- Less exposure to service outages in the case of DPAs – less spectrum is required which makes it easier to find and another channel (only need to find space for one channel, versus two or three)

Tarana: Broadband Perfected

Tarana Gigabit 1 (G1) is a ground-up, fresh approach to wireless broadband with patented technology designed to solve the most challenging aspects of wireless operation. G1 features a number of ground breaking innovations that make possible what was otherwise deemed infeasible and has direct impact on operators looking to take advantage of CBRS spectrum.

A significant feature of G1 is its ability to reduce the impact of interference: both self-interference and that from third-party devices. It does this with a multi-faceted approach involved custom hardware and algorithms.

The use of distributed massive MIMO (DM-MIMO) means the RF signal is sent only in the direction needed from both ends of the link. A constant feedback loop is used to dynamically adjust the beam in real time to ensure optimal performance. This is critical in cases where there could be motion in the channel that would change link characteristics and the ideal direction of the beam, e.g., tree foliage movement, vehicles, or even new construction.

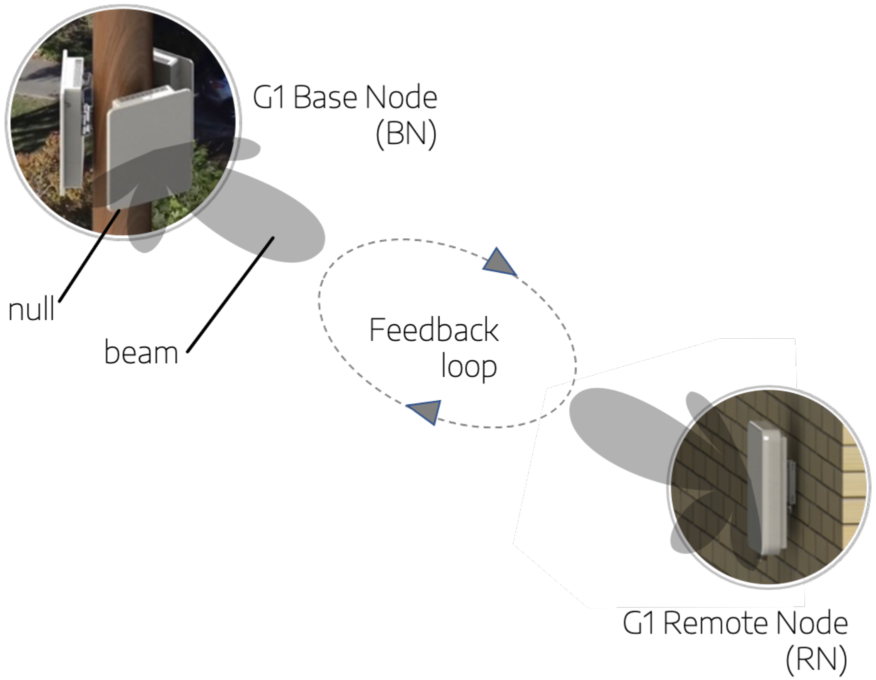

Figure 4: G1 reciprocal dynamic beamforming

Another G1 innovation is the use of dynamic, deep RF nulling. With this technique, RF nulls are used to eliminate outside interference from whatever direction it might occur. These nulls are established as needed and for as long as the outside interference occurs. G1 creates RF nulls on both sides of a link using Rx and Tx nulls. These nulls are up to 50 dB deep and can cancel up to 40 dB of interference.

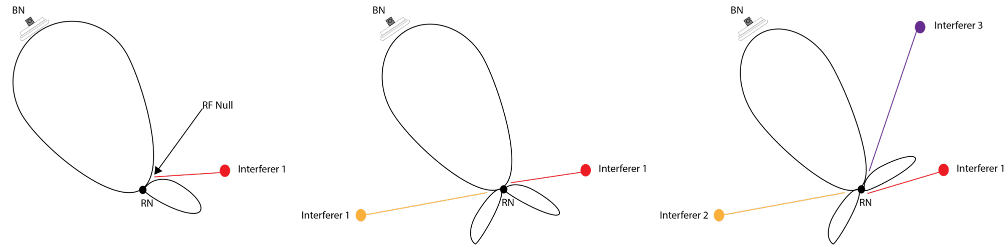

Figure 5: RF nulls with multiple interferers

The use of beamforming, RF nulls, and sophisticated algorithms eliminates interference and leads directly to universal frequency reuse. With G1, a three or even four-sector site can use a single channel without impacting performance. This is very different than the typical fixed wireless access system that uses more frequency to cover the same area (k=3 for example).

This characteristic of the G1 platform is key for operators considering the use of the CBRS spectrum, in particular if they are operating in DPAs.

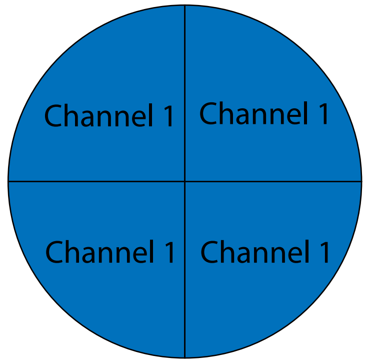

Figure 6: Frequency reuse with Tarana G1

Summary

CBRS is an exciting new area for wireless broadband use that offers up to 150 MHz of lightly used spectrum. It establishes three tiers of access with decreasing levels of priority. Because all operators must register with (and get channel grants) from a SAS, multiple operators can share the spectrum with less chance of interference.

One major caveat of CBRS is the requirement to vacate a channel due to the activation of a dynamic protection area (DPA) in the case where it is required by an incumbent. In the case of some incumbents (US Navy) this can occur at unpredictable times and places.

DPAs can be particularly difficult for operators to work around when they require a broad swath of spectrum, in particular due to the need for multiple channels to avoid self-interference (k=2, 3, etc.). The requirement for more channels can make it difficult to vacate and find a large enough portion of spectrum available elsewhere to maintain consistent performance and reliable operation. When it comes to broadband, reliability is a key performance metric that impacts the operator (in terms of SLAs) and the consumer in terms of experience and satisfaction.

Universal spectrum reuse (k=1) can be a critical advantage and alleviate some of the pain that can occur due to a DPA. Because only one channel is required per site, the operator can be more agile – if it becomes necessary to move/change channels, it's easier to find a smaller chunk of available spectrum (one channel) than a larger one (multiple channels). This has other advantages, including lower costs for PALs (less spectrum to buy) and simpler radio planning and design.

With G1, operators can quickly and easily deploy reliable, high-performance wireless broadband access in any environment, regardless of link obstructions and interference from existing or future equipment. The end result is a highly resilient, agile network that can better handle changes in the environment both physical and due to incumbent activity.

G1 is designed to offer:

- Connection speeds of 500+ Mbps, including symmetrical 100/100 Mbps.
- Patented interference elimination that provides unbeatable reliability and performance in the most challenging RF environments.
- Easy densification for further capacity or subscriber support.
- Future-proof expansion that requires minimal to no CPE adjustments or upgrades.

About Tarana

Tarana Wireless, Inc. is the performance leader in broadband wireless access network solutions, powered by a number of industry-first and well-proven breakthroughs in perfect, multidimensional optimization of radio signals. Its Gigabit 1 fixed access system overcomes previously insurmountable network economics challenges for service providers in both mainstream broadband and underserved markets, using free unlicensed spectrum. The company is headquartered in Milpitas, California, with additional research and development in Pune, India. For more information, visit taranawireless.com.