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Industry Voices: Dynamic spectrum sharing realities

by Peter Rysavy | May 24, 2024

The U.S. government's National Spectrum Strategy, released in November 2023, heavily emphasizes dynamic spectrum sharing (DSS) to solve the problem of not enough spectrum for all the entities that need it. The idea of making an underused resource available to other entities sounds efficient, but the realities of implementation are complex; development will take years, and the resulting solution could be suboptimal unless participants agree on key principles.

Proponents of the Citizens Broadband Radio Service (CBRS) are pushing for DSS to be built on CBRS, but CBRS has many limitations, including that it is anything but dynamic. For example, the CBRS spectrum access system (SAS) calculates channel assignments only once a day. The shutdown time if CBRS detects a military system is 300 seconds, and once CBRS removes a channel, lower-priority users cannot use the channel again for two hours.

In contrast, a truly dynamic system such as 3GPP's standard for 5G dynamic spectrum sharing, in which the base station scheduler shares a radio channel for both 4G and 5G operation, operates on a msec-by-msec basis, millions of times faster than CBRS. 3GPP speeds are not necessary for the NSS DSS, but a quick response to changing needs is a critical DSS design element, and current CBRS speeds are not necessarily optimal for future DSS deployments. Detection and mitigation times are critical variables, with shorter values making the DSS solution more complex.

One fundamental spectrum sharing problem with higher-priority incumbents — and in CBRS, the Department of Defense (DoD) is the primary user and everyone else is a secondary or a tertiary user — is that non-primary users can only use the radio channel when the incumbent doesn't need it. This type of sharing differs from other approaches such as Wi-Fi spectrum sharing, in which everyone has equal access to the radio resource. Because the government can take the CBRS band away at any time, the radio resource is not dependable.

What is a factory with a 5G private network based on CBRS supposed to do when it suddenly loses the radio resource? Send everyone home for two hours?

CBRS suitability

Ironically, this undependability actually makes CBRS more suitable for existing wireless network operators, such as cellular operators or cable companies, because these companies have other radio resources they can use, leaving CBRS as an auxiliary resource. However, the undependability undermines the notion that CBRS is an innovation band available to everyone.

Beyond the limitations of inequitable sharing, CBRS was designed for sharing with very specific Navy radar systems. A new DSS system for other bands will have to cope with other types of incumbent systems with completely different characteristics, such as airborne radar.

The existing CBRS Environmental Sensing Capability (ESC), which detects Navy radar operation and informs the SAS to relinquish radio channels, is completely inadequate for the 3.1 - 3.45 GHz band, one of the bands targeted by the NSS.

In a recently released DoD report, Emerging Mid-Band Radar Spectrum Sharing (EMBRSS) Feasibility Assessment Report, DoD acknowledges the sensing challenge, saying the "band poses unique challenges for sensing that have not been previously encountered in spectrum sharing implementations." CBRS as currently defined is simply not scalable for nationwide sensing deployment. Additionally, its sensing requirements are so restrictive that whisper zones are needed around each sensing facility, thus restricting 5G deployments.

This EMBRSS report, written by DoD, is the culmination of two years of study, whereas the NSS calls for an additional two years of study of the same 3.1–3.45 GHz band. The probability of our adversaries in commercial and military spectrum technology, such as China, taking a four-year timeout to study a band before acting on it is unlikely.

The National Telecommunications and Information Administration (NTIA) has contemplated a system to replace or possibly augment ESC called the Incumbent Informing Capability (IIC), with which DoD could inform the SAS or network operators directly about its spectrum needs. The downside of this approach is that incumbents could reserve more spectrum than they actually need, creating fallow periods and inefficiencies. Regardless, it is one more complex system that would have to be developed.

The EMBRSS report also calls into question what entity would manage the spectrum database, which it calls a dynamic spectrum management system (DSMS). In CBRS, commercial entities, including Federated Wireless and Google, manage those databases. But the EMBRSS report recommends that the DSMS be "operated by and within the DoD." This completely upends the current industry/government spectrum sharing architecture.

The number of entities involved makes the DSS effort even more complex. The National Spectrum Consortium (NSC) will be coordinating the effort through the Partnering to Advance Trusted and Holistic Spectrum Solutions (PATHSS) working group, a prior iteration of which provided industry input to DoD's EMBRSS study. Participants include multiple government organizations, industry and academia. Further complicating the process is that much information is needed to design the DSS, such as military system waveforms and interference tolerance, is classified, and only provided in limited form through strict confidentiality procedures.

Another concern relates to the overly conservative assumptions about interference and propagation that DoD employed during CBRS development, one reason CBRS can only operate at low power levels. The hope is that moving forward, more realistic assumptions will prevail.

Active 5G RAN to the rescue?

Given the multiple limitations of CBRS, the NSS indicates that even if the DSS solution retains elements of CBRS, the overall system will need to be evolved. One such improvement, analyzed in the EMBRSS report, is Active 5G RAN. Instead of completely ceasing operation in a protection area when a military system needs to operate, an active RAN avoids interference by minimizing radio energy in the direction of the military radar system.

5G can accomplish this using existing capabilities, such as beam forming, null steering, and radio physical resource block (PRB) muting, or reselection to another band. Sensing could also occur at base stations rather than via the current ESC network.

Active 5G RAN adds to DSS complexity, but the EMBRSS report states it would "improve efficiency and effectiveness of the spectrum use." Active 5G RAN also mitigates one of the main concerns of sharing with the higher priority government incumbent — complete loss of the radio resource across a large area — because the network can keep using the radio resource, albeit in diminished form.

No wonder then that DoD considers DSS a moonshot — it is. And it will take years to develop. Despite the focus on 3.1 - 3.45 GHz, the objective is applying the system to other bands in the future. But the inadequacy of CBRS, designed for 3.55 - 3.70 GHz and now not readily supporting the nearby 3.1 - 3.45 GHz without significant changes, is instructive. Every sharing solution ever developed has been unique to the specific systems that must interoperate in that band. Look also at the new 6 GHz Wi-Fi automatic frequency control, another spectrum sharing approach which too is unique to that band. No one has ever invented a general-purpose spectrum sharing system. Such a design might even be inherently impossible. But the goal of the moonshot is to see what might be possible.

In an ideal world, the entire 3.3 - 4 GHz band would be available for high power 5G networks. Actually, that is exactly what the rest of the world is doing, except the U.S., which is struggling to open up below 3.45 GHz and has put 150 MHz of low-power CBRS in the middle of this critical 5G band. 3GPP has designated band n77 to extend from 3.3 - 4.2 GHz, and many countries around the world are now benefiting from mobile broadband networks operating at full power in this range of frequencies.

In this ideal world, sharing based on experimental new technologies would occur in 3.1 - 3.3 GHz, 3.55 - 3.70 GHz could operate at higher power, and 3.3 - 3.45 GHz would be made available using simplified sharing mechanisms. The U.S. would then achieve global harmonization, resulting in lower prices for consumers, as well as hugely capable 5G networks.

Given that some of the incumbent radar systems in 3.1 - 3.7 GHz are obsolete and being replaced by improved technologies, some of which will operate in different bands, an opportunity is presenting itself to simplify spectrum sharing and expedite DSS deployment. The DoD could accelerate the transition of some of the airborne systems operating in 3.3 - 3.45 GHz, design its systems to better co-exist with 5G systems, which will have the added benefit of making them more resilient globally, and the industry could then implement simplified sharing mechanisms.

For all this to happen, however, DSS developers will have to hammer out a myriad of details, beginning with defining DSS requirements. With sensing, for example, does the system have to detect a particular radar waveform or respond to interference thresholds?

The U.S. should experiment with new spectrum technologies, and over time, spectrum sharing may become more effective. Until then, the country should maintain proven approaches, including simpler forms of sharing such as geographical coordination, and wherever possible, exclusively licensing full-power, wide radio channels. For bands in which sharing is the only option, designs must be practical and effective.

Peter Rysavy, president of Rysavy Research, has been analyzing and reporting on wireless technologies since 1994. See https://www.rysavy.com.

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