Spectrum Sharing: Are Databases and Small Cells the Future of Spectrum Licensing?

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The U.S. spectrum policy was born out of the tragic sinking of the Titanic 100 years ago. Concerned about the role that radio interference might have played in the effort by some to notify the Titanic of dangerous icebergs in the area, the U.S. government adopted the Radio Act of 1912, giving it the power to license wireless spectrum in the U.S. Despite the rapid evolution of wireless technology, that spectrum policy – which took into account the need for heavy noise mitigation – remains in effect today.

The Obama Administration and the FCC, however, have recognized that the current spectrum policy has led to an artificial scarcity and inefficient use of U.S. airwaves. Back in June 2010, President Obama issued a presidential memorandum requiring 500 MHz of spectrum to be made available for commercial use within 10 years, kicking off a plan to enable more efficient use of spectrum – centered on enabling disparate users of wireless services to share spectrum.

In July 2012, the President’s Council of Advisors on Science and Technology (PCAST), an advisory group appointed by the president, issued its recommendations for a new spectrum policy going forward. It concluded that the traditional practice of clearing government-held spectrum of federal users and auctioning it for commercial use is not sustainable. PCAST, instead, recommends that President Obama issue a new memorandum that states it is the policy of the U.S. government to share underutilized spectrum and require NTIA to identify 1,000 MHz of federal spectrum in which to implement shared-use spectrum pilot projects. These key recommendations have the blessing of the FCC, NTIA, and the Department of Defense. Central to kicking off this government spectrum-sharing policy will be the use of database-driven spectrum allocation and small cells.

In this report (the second installment; see White Space Technology: The Gateway to Spectrum Management, July 13, 2012), we focus on the concept of spectrum sharing: what it means, what plans the FCC and NTIA have for it, how equipment is evolving to enable it, and how business models must evolve to accommodate it.

PCAST Envisions a Spectrum Superhighway

The idea brought forth by PCAST in its recommendations centers around viewing spectrum as a superhighway – one that can be optimized for not just for coverage, but also for capacity based on factors such as frequency, geography, time, and modulation. This notion will be tested out on a rather fast-tracked basis if the President immediately enacts these key PCAST recommendations:

• Spell out spectrum sharing as a policy and direct the Secretary of Commerce to identify 1,000 MHz of federal spectrum immediately for sharing. PCAST identified the following list of bands as potentially being suitable for shared use:
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Mobile Ecosystem

- Direct the Secretary of Commerce, in collaboration the FCC, to establish a mechanism to provide the federal government with the ability to manage the sharing of federal spectrum. The vision is to have federal spectrum divided into frequency blocks with common characteristics, rather than the current narrowband service-specific static allocation scheme, to facilitate a dynamic sharing model. PCAST also recommends that the spectrum should be governed according to a three-tier hierarchy: Federal primary systems would receive the highest priority followed by exclusive secondary users (i.e., commercial LTE providers) that must register deployments and utilize a database for access while receiving some quality of service protections, likely in exchange for fees. Lastly, ‘general authorized access’ users would be allowed opportunistic access to unoccupied spectrum to the extent that no federal primary or secondary access users are actually using a given frequency band in a specific geographical area or time period.

- Create a group of industry executives called the Spectrum Sharing Partnership Steering Committee to recommend a policy framework, centered on a public-private partnership for sharing federally held spectrum.

- Require that NTIA and the National Institute of Standards and Technology (NIST) create an urban test city in a major U.S. city along with a mobile test service that can relocate to urban, rural, and federal facilities as needed to support rapid experimentation in spectrum management technology and practice.

- The FCC should work with the NTIA and federal agencies to begin immediately the process to modify its existing rules to allow ‘general authorized access’ devices to operate in two bands in the NTIA fast-track list, specifically the 3550-3560 MHz band and another to be determined by the NTIA and the FCC. PCAST suggests that a feasible way to operate this system would be as an extension of the white space system being developed and deployed by the FCC and various third-party vendors in the TV bands, but NTIA and FCC should determine the most appropriate management technology. The rules for this use will require the general authorized access devices to be both registered and frequency agile.

**What the FCC Is Doing to Further Spectrum Sharing**

While PCAST has been aggressively driving the notion of spectrum sharing, the FCC is not sitting idle on the issue. The agency is already moving ahead with the NTIA and other government agencies,
such as the Department of Defense, to create a proving ground for spectrum sharing. These initiatives include:

- Authorizing spectrum between the 2360 MHz and 2400 MHz band for medical body area networks (electronic health monitoring). The spectrum will be shared with federal users, and the FCC will develop rules for registration and frequency coordination.

- Moving ahead in partnership with NTIA to test LTE sharing in the 1755-1780 MHz band. The FCC has accepted an experimental license filed by T-Mobile USA to test the spectrum-sharing concept in this band. The FCC believes that if a number of tests prove successful, it could auction paired spectrum in the next three years. By pairing the 1755-1780 MHz band with the 2155-2180 MHz band, the FCC could extend the existing AWS band by an additional 50 MHz.

- Initiating a Notice of Proposed Rulemaking (NPRM) later this year to enable small cells in the 3.5 GHz that will share spectrum with federal radar users.

### Databases and Small Cells: The Technical Keys to Spectrum Sharing?

#### Database Spectrum Management

The FCC and regulators from other countries see white space deployments as the proving ground for spectrum sharing. White space spectrum in the U.S. became available with the transition of TV broadcasting from analog to digital in 2009. Spectrum that was previously allocated for analog VHF and UHF TV channels and their inter-channel spacing (guard bands) was freed up to become TV white space. The frequency range is in the 54 to 862 MHz band, with potentially more than 300 MHz in total bandwidth and a typical channel width of 6 MHz. The FCC approved rules for white space in 2010, and the plan is to allow white space to flourish as unlicensed spectrum serving as a platform for innovation.

To operate a white space system in the U.S., the FCC requires the use of databases that serve as clearinghouses for frequency reuse. Databases are needed to avoid interference with the incumbent users. White space devices are required to query databases to ensure that the frequencies are clear or can switch to clear frequencies before transmission. Functions of the databases are to maintain daily updated information on registered cable TV head-ends, TV translator station receive sites, operating sites of wireless microphones, and other low-power auxiliary stations as well as fixed white space devices.

At the heart of white space communications is the requirement that signals hop from one frequency to another to avoid bands used by other signals. As any system is likely to be given access to any spectrum on a secondary basis where no undue interference is caused to the primary user, it is essential that the system is effectively able to adapt itself around the primary users. To achieve this, a cognitive radio networking is required to provide the spectrum sensing and adaptation (see Standards Watch: White Space--The Answer to Spectrum Shortages?, July 24, 2012).

White space deployments will give database managers experience with more granular ways to manage spectrum, based on combinations of location, frequency, time, and device type. Interference, QoS, and priority access – factors important for spectrum sharing between commercial and government users – can eventually be managed with a database. Proving these concepts out is likely why the FCC is allowing 10 different database providers to operate in the white space market.

White space deployments offer a commercial lab of sorts in areas around regional spectrum servers, base stations, and clients with frequency-agile capabilities and real-time spectrum leasing and configuration protocols. These technologies will pave the way for commercial deployments of services in shared spectrum.
Small Cells

One of the more surprising pieces of the FCC’s move toward spectrum sharing is the utilization of small cells. Digging deeper, however, it is evident that small cells can fit into the vision of spectrum sharing given the fact that they are designed to play well with macro networks in a heterogeneous network (hetnet). The ultimate vision of small cells, which has yet to be reached and is under debate among some vendors, is for operators to be able to buy small cells from different vendors and install them on a plug-and-play basis since the equipment incorporates self-organizing network (SON) features that avoid interference.

The idea of tying spectrum sharing with small cells, then, makes sense on a number of fronts:

• The propagation characteristics of the 3.5 GHz band are limited, mitigating interference and making deployments in shopping malls, train stations, retail parks, and campuses ideal.

• Since small cells deliver targeted coverage, their chances of interfering with other services in shared spectrum are limited.

• The 3.5 GHz band is available on a nearly global basis, offering a potential for a global LTE band.

• It offers new opportunities for mobile competition. UK telecom regulator Ofcom was the first to propose the idea of auctioning off spectrum for small cells on a shared-spectrum basis last year. Its proposal included making 2 x 20 MHz available on a number of low-power licenses that would share spectrum at 2.6 GHz, with priority given to new entrants. The thought is that one entity builds a wholesale small cell network and sells access to others. Vendors such as Alcatel-Lucent argue that small cells should be deployed with a dedicated carrier if possible to eliminate concerns around interference between small cells and macro networks. Ofcom’s entire 4G auction plans are still under debate.

• The use of small cells represents a highly efficient use of the spectrum because of the greater capacity that can be provided with the intensive frequency re-use that can be achieved across a given area.

• Small cells will almost always be backed up by a macro cell layer of coverage. If a small cell is shut down in the 3.5 GHz shared band, operators can pick up coverage again in the macro network.

Certainly, a number of questions still need to be answered when it comes to the deployments of small cells in general, particularly around backhaul and network planning. A neutral-host concept in deploying small cells could eliminate concerns over multiple small cell deployments in a particular area from a regulatory and technical standpoint, but it also could reduce some of the efficiency gains if small cells are not tightly coordinated with a macro network, a point AT&T has highlighted in its criticisms of the PCAST report.

Other technical challenges include:

• The ability for small cells to support the high data rates operators desire without interfering with adjacent services

• Setting power limits within the cells

• Developing database and sensing algorithms that are scalable to a large number of small cells while also ensuring fairness regarding access

The Business Model Needs to Change for Mobile Ecosystem Players in a New Spectrum Sharing World

The road to spectrum sharing will be an evolutionary one – in terms of both technology and business model changes. White space database spectrum sharing and small cells are still in their infancy, as is
the concept of not having exclusive rights to spectrum.

Already, we are seeing that this ‘newness’ will face some key opposition. AT&T, for example, while not totally eschewing spectrum sharing, rang the alarm around the PCAST report in early August, declaring that regulators cannot ignore what it calls a proven model around exclusive licensing when it comes to investment, innovation, and jobs. Spectrum, after all, is the lifeblood of mobile operator businesses. Per AT&T’s VP of Federal Regulatory, “The over-eager pursuit of unlicensed sharing models cannot turn a blind eye on the model proven to deliver investment, innovation, and jobs – exclusive licensing. Industry and government alike must continue with the hard work of clearing and licensing under-utilized government spectrum where feasible.”

Even if operators manage to agree that spectrum sharing is feasible and in the best interest of all parties, the issue of the business model around access to spectrum will remain. By proposing a three-tier hierarchy of spectrum access (federal primary, exclusive secondary, and general authorized access), the suggestion is that the government would extract fees from one class of spectrum users – exclusive secondary. Still, it is unclear how this would be priced. Would it be done at auction? What level of assurances would need to be given to make any such auction work? What type of operator would take part without being fully confident of the technical feasibility and without knowing the exact nature of the access they would receive?

To be sure, the details on allocation will evolve as trials prove out (or disprove) spectrum sharing regimes. These proof points, in turn, will impact the prices established both by the government and the market. A bigger question, then, may be for operators to determine how they would expect to use this spectrum. Given spectrum access that may not be stable in terms of coverage or capacity over short periods of time, certain use cases may be more appropriate targets – use cases where immediate, on-demand, access is not critical. This might include non-real-time M2M applications or multicast applications where content is pushed to users in the background.

At any rate, the FCC will play a significant role in increasing the mobile ecosystem’s confidence in spectrum sharing through activities such as experimental licensing and technology trials.

**Recommended Actions**

**Vendor Actions**

- To gain valuable early insight into spectrum sharing, infrastructure and device vendors should seek to ally themselves with T-Mobile USA to test out spectrum sharing in the 1755 MHz band. This would be a boon to T-Mobile’s current network vendors (Ericsson and NSN), but would also prove a way for new vendors to get closer to operators.

- While PCAST did not call out cognitive radio as a specific requirement for spectrum sharing, it is an essential part in enabling devices to hop from one frequency to another to avoid interference in white space networks. There is also a major acknowledgement in the PCAST report that receiver technology is a key part of spectrum sharing, as the report speaks of defining interference limits when it comes to protecting the various users of spectrum. Device vendors should begin identifying opportunities around self-awareness/cognitive radio opportunities in this area.

- Vendors need to monitor the standards developments in cognitive radio capabilities in accordance with IEEE 802.22, the white space standards working group, for applicability to overall spectrum sharing. The group plans to release further specifications over the next two years, while White Space Alliance is in the process of rolling out conformance and compliance testing to ensure that the base station products and devices interoperate well with the geolocation databases.
• If they are not already, small cell vendors need to prioritize product development in the 3.5 GHz band.

• Database management suppliers such as Spectrum Bridge and Ericsson/Telcordia need to begin demonstrating that databases can play nice with small cells and effectively scale to their mass deployment.

User Actions

• Operators should investigate the benefits of multi-vendor hetnets, especially given the emergence of not only non-incumbent small cell base station vendors, but also independent suppliers of self-organizing and self-optimizing network (SON) solutions (e.g., Intucell, AirHop, and others). Multi-vendor networks, while potentially more complex, may give operators greater control over their suppliers and thus better cost structures, while also preparing them for the inevitable around spectrum sharing. It will take a mix of vendors and spectrum bands to make spectrum sharing work.

• Operators need to consider new business models around spectrum sharing. What services best fit in spectrum that is shared by others (e.g., M2M; lower-paying subscribers who do not need complete service reliability; offloading applications)? Until operators understand how they would make use of shared spectrum, any discussions around using it will be fruitless.

• Operators interested in leveraging shared spectrum opportunities need to engage actively with device vendors to get specific spectrum bands supported. Device vendors will not be able to support the entire array of potentially shared bands in a single device. As these vendors form their own plans around how to support shared spectrum bands, input from operators (customers) will be key.

• Whether or not spectrum sharing becomes the ‘norm,’ more operators need to follow AT&T’s lead and voice their preference for exclusive licensing. Spectrum sharing could introduce more competition in the U.S. wireless landscape. It could also waste time as the government finds a way to make it work. Where operators have built business models around the current licensing regime, keeping it intact is critical.