Blueprint for a Federal Spectrum Service: A Very Rough Draft

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Overview

This draft presents some preliminary ideas on the use of a federally chartered corporation to transfer excess spectrum to the private sector. The spectrum in question is currently assigned by the federal government to itself and is used for federal purposes. Primarily, the plan calls for a mandatory redesign of federal systems in order to reduce their spectrum footprint, but also for the use of corporate funds to advanced research and development of spectrum-based systems and technologies. The corporation, the Federal Spectrum Service, would have a limited lifespan and a clear mandate to reduce the federal spectrum footprint by 75% over ten years.

Background

In previous papers[1], I've analyzed spectrum allocation from the standpoint of achieving spectrum efficiency, which is best measured in terms of bits per second per hertz per user. I've found the following:

- Licensed systems generally outperform unlicensed ones by a factor of 1.5:1 or more.

- Licensing is effective because a single spectrum manager can employ packet scheduling, which is able to allocate spectrum on demand up to 99% utilization, while unlicensed systems must rely on contention protocols that seldom allocate at more than 50% efficiency.

- The efficiency gap grows larger as the network service area increases: the contention protocols used by unlicensed networks work best when small numbers of devices share a time, space, and frequency slice, and work worst when a large number of contenders must compete for spectrum access. Unlicensed system cooperate poorly.

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[1] Chiefly in: Richard Bennett, "Technical Principles of Spectrum Allocation", 2013. *TPRC 41: The 41st Research Conference on Communication, Information and Internet Policy*. Available at SSRN: http://ssrn.com/abstract=2240625 or http://dx.doi.org/10.2139/ssrn.2240625 and Richard Bennett, *Powering the Mobile Revolution: Principles of Spectrum Allocation* (Washington, DC: Information Technology and Innovation Foundation, July 31, 2012), http://itif.org/events/powering-mobile-revolution-principles-spectrum-allocation.

- Latency aggravates the inefficiency of unlicensed networks: contention protocols all use some variation on "listen before talk," where the listening time is a function of edge-to-edge propagation time and therefore become less efficient in high latency conditions.

- It's generally known that wireless coverage is a function of power and frequency, where higher frequencies require more power to achieve coverage of a broad area than would lower frequencies.

- Frequencies lower than 3 GHz are preferable for battery powered mobile devices, while frequencies higher than 6 GHz are more suitable for long distance, stationary, point-to-point systems; intermediate frequencies are suitable for a variety of other uses, such as small mobile cells, nomadic, and low bandwidth machine-to-machine applications.

- 2.4 GHz spectrum has a special feature: because 2.4 GHz is resonant frequency of water, and water vapor is everywhere, this spectrum is only suitable for limited coverage systems such as Bluetooth, Wi-Fi, Garmin's ANT+, and medical body sensor systems. On the positive side, the limited propagation of 2.4 GHz signals enables easy re-use of the spectrum over short distances, the trick that makes unlicensed Wi-Fi and Bluetooth effective.

- Because water resonance does not exist across the full spectrum, unlicensed allocation is not a candidate for the general-purpose spectrum utilization model of the future: until coding systems advance to the point that they enable collision-free multiple access, scheduling must remain the norm. Consequently, we have many tools to meet the needs of stationary and nomadic systems, but only one for mobile: licensed spectrum with scheduling.

- Mobile networks are constrained by two primary factors: the growing demand for mobile data capacity and the cost of increasing capacity. Data capacity is function of gross spectrum and efficiency; if demand increases faster than technology increases efficiency, there's not way to satisfy it without throwing more spectrum at the problem.

- While a great deal of spectrum use by mobile devices is more nomadic than mobile – watching TV programs on an iPad – much demand is truly mobile, such as Mobile Augmented Reality. MAR applications cannot, as a general rule, be off-loaded to Wi-Fi.

- The least expensive way to increase mobile data capacity is the "sectorization" of existing antenna masts. When an antenna mast that once was divided into three sectors is divided into six sectors, capacity roughly

doubles, but only when the sectors don't interfere with each other. Non-interference generally requires more spectrum.

- Federal spectrum is over-allocated compared to commercial spectrum, and federal systems do not show increased efficiency over time the way that commercial ones do.

- A number of federal spectrum allocations are inappropriate or inefficient. The Defense Department and other agencies, for example, use spectrum for backhaul purposes that can be accomplished with wire, and other agencies use their authorizations for video surveillance that could easily be accommodated by public unlicensed or public licensed frequencies with greater security.

A number of analysts, such as Eisenach[2], Hazlett[3], and Lenard, White, and Riso[4], have observed that government's use of spectrum is insensitive to the positive effects of market forces. Government allocates more spectrum to itself than it does to commercial and other public uses, it allocates larger swathes, it requires less sharing, and it often uses spectrum to accomplish purposes that it could easily accomplish by other means. While spectrum-based systems in the private sector experience Moore's Law improvements in efficiency, power, and price, government systems stagnate and as a result the economy suffers.

The spectrum *status quo* is irrational. It's inconsistent, at best, for agencies of the federal government to harm the economy that serves the people they're chartered to protect.

The Federal Spectrum Service

There are at least three elements to this problem. Firstly, the government's use of spectrum needs to become motivated by incentives to use spectrum more efficiently, effectively, and rationally. This is an economic problem.

Secondly, and perhaps more importantly, government needs to be better informed regarding the means of using spectrum well in the present and near future. It's quite possible that government's reliance on obsolete systems has less to do with

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[2] Jeffrey Eisenach, "Spectrum Reallocation and the National Broadband Plan," *Federal Communications Law Journal* 64, no. 1 (December 2011), http://www.repository.law.indiana.edu/fclj/vol64/iss1/4/.

[3] Thomas Hazlett, "Tragedy TV: Rights Fragmentation and the Junk Band Problem," *Arizona Law Review*, 2011, http://www.arizonalawreview.org/pdf/53-1/53arizlrev83.pdf.

[4] Thomas M. Lenard, Lawrence J. White, and James L. Riso, "Increasing Spectrum for Broadband: What Are The Options?" (Technology Policy Institute, February 2010), https://www.techpolicyinstitute.org/files/increasing_spectrum_for_broadband1.pdf.

incentives than with ignorance. Incentives are important, but knowledge about the best means of serving the people with smart spectrum systems is also important. Government agencies are staffed by well-meaning people who may very well be performing poorly because they lack the knowledge to carry out their missions effectively.

Thirdly, government spectrum policy lacks clear goals and directions. Responsibility for spectrum use is dispersed across many agencies, each of which operates according to its own mission and mandate. While there have been opportunities to unite the discrete spectrum policies of the diverse federal agencies to a common set of goals, action has been scant. The National Broadband Plan called for the federal government to surrender a significant portion of its spectrum authorization, and the response from the White House was a timid plan for "sharing" between public and government spectrum systems that lacked detail, commitment, and practicality.

I propose the creation of a *Federal Spectrum Service* to address these three issues. The FSS could be chartered as a corporate entity distinct from the government with a specific mandate, similar in concept to the Postal Service. The FSS's charter whould focus on the overriding goal of reducing the federal spectrum footprint by 50% over a five-year period, and then reducing it a further 50% over another five-year period. At that point, it would be appropriate to evaluate its performance and either extend it, terminate it, or direct it toward a new goal.

Thus, the FSSs would be a profit-oriented organization with a special relationship with government agencies. Rather than having each government agency maintain its own group of spectrum experts with limited knowledge and experience and no power to re-allocate spectrum, as we do now, the FSS would be a consolidated pool of experts. It would be able to advise and direct each agency regarding the options that exist in terms of spectrum-based and non-spectrum-based communication systems, consolidate government systems, and make spectrum available for public use by improving the efficiency of government systems.

Where the FSS were to find gaps between agency needs and current capabilities, it could recommend the application of research funding to such problems if solutions are not in the horizon. Where if found that applied research has already been done but products have not yet reached the market, it could speed up the product development and release cycle by placing orders and advising developers of agency requirements. And where it found agencies under-performing their mandates by relying on obsolete equipment, it could require agencies to upgrade.

Perhaps most importantly, the FSS would be able to intervene in ill-fated agency boondoggles such as the DARPA Joint Tactical Radio System that cost the taxpayers

$6B and failed to deliver useful systems, by setting more realistic goals and terminating failing projects.[5]

The FSS would also need to oversee public allocations of spectrum currently made by the FCC. Its overriding concern should be the correction of imbalances in the allocation of spectrum to government systems, increasing the rate of progress in better government systems, and redesigning obsolete systems such as radar by replacing them with less resource-intensive and more powerful systems. Where public allocations are concerned, it would critically evaluate the need for special-purpose allocations such as those for Medical Body Area Networks and specialized automotive networks and determine whether general-purpose networks are up to the task.

FSS Mission and Methods

The mission of the FSS would be very broad, combining roles played by portions of today's FCC, NTIA, DARPA, National Science Foundation, Department of Transportation, and other agencies. It needs considerable power over agency use of spectrum if it's to overcome current patterns of conduct by the agencies. With respect to the nation as a whole, the FSS needs to be guided by a clear directive to promote economic growth and the public interest in constant, rapid improvement in the quality and performance of spectrum-based systems.

The overall mandate for the FSS is not substantially different from that envisioned by the framers of the Constitution for the 18th century postal system, both a source of revenue for the treasury and a vital stimulant to democracy and the private sector, but its goals would be much more specific.

Functions

The FSS would have a statutory charter to perform the following functions:

1. Assume default ownership of all radio frequency spectrum: licensed and unlicensed, public and private.
2. The power to grant and sell licenses to the use of spectrum and to issue regulations for both transmitters and receivers.
3. The power to operate spectrum-based equipment used by government agencies and to sub-contract network operations.
4. The power to monitor, audit, and catalog the use of spectrum by government agencies.
5. The power to unilaterally replace spectrum-related equipment used by government agencies.
6. The ability to direct research funding for spectrum and related subjects by research topic but not by designee.

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[5] Sean Gallagher, "How to Blow $6 Billion on a Tech Project," tech blog, *Ars Technica*, June 18, 2012, http://arstechnica.com/information-technology/2012/06/how-to-blow-6-billion-on-a-tech-project/2/.

7. The ability to purchase wired and wireless network equipment for use by government.
8. The ability to invest in firms developing wireless network equipment.

These functions and powers will be described in greater detail in an upcoming paper. Some additional detail is offered in the portions following.

Limits

In the normal course of operations, when an agency has an application to run that requires a spectrum allocation, it shall present a specification for the application to the FSS. The FSS shall respond with a proposal for running the application consisting of its specification of a method of meeting the application's needs while reducing its spectrum footprint.

Typically, the FSS specification would consider equipment, networks, and spectrum, including opportunities to share spectrum with the commercial sector, other agencies, or unlicensed systems. Sharing spectrum in this connection includes operating a virtual network over general-purpose facilities

If the agency wishes to use spectrum assigned to the federal government, it shall follow the FSS recommendation. If it does not agree with the FSS recommendation, it can contract with a commercial provider who has its own spectrum license and it may use unlicensed spectrum; but it may not operate equipment on a government frequency in a manner inconsistent with the FSS recommendation.

This provides the FSS with authority and also creates checks and balances on its power with the commercial/unlicensed escape clause. The funding for a commercial option comes from the agency's budget. The FSS is free to sub-license unused federal spectrum to commercial operators. When the FSS sub-licenses, the revenue it receives goes into its budget, and revenues in excess of expenses are returned to the treasury.

Guidelines and Financing

The FSS will operate under a guideline of reducing the federal spectrum footprint by 50% every five years, with freed spectrum going to the private sector as licensed or unlicensed assignments. After the first five-year period, the FSS's budget will come from spectrum licenses it sells at auction, the gains it makes from investments, license fees it collects by sub-licensing government spectrum, and license fees from intellectual property it finances.

Unresolved Issues

This is a very preliminary plan, which by its nature leaves a number of questions unanswered for the time being. These include the following:

1. **Expanding the federal mission:** While the overall goal of reducing the federal footprint is understandable, it does not address the desire of federal

agencies to implement new systems and applications that use spectrum to serve the people. If the goal of moving spectrum from government bands to commercial ones is rational because it enables more intense application development by the commercial sector, isn't it also rational to permit the development of new systems by the government? One partial answer is that the five-year goal is looser than commercial performance, where efficiency is doubled every 30 months. This leaves room for expanded missions and feeds the auction system at the same time, but it's not a total answer. Government needs to use spectrum with an eye toward utility as well as efficiency.

2. **Conflicts of interest:** A profit-motivated authority with the power to monetize federal spectrum will surely operate in its own interests where they conflict with those of government. If incentives are properly aligned, this is not necessarily a problem; otherwise it is.
3. **The insatiable appetite for unlicensed spectrum:** Advocates for unlicensed spectrum have proven themselves more adept at seeking and winning allocations from the FCC than at actually building and operating networks. How will the FSS assess the demand for additional licensed spectrum with the apparently insatiable appetite for additional unlicensed spectrum? What utility models address this trade-off?
4. **What becomes of the FSS at the end of its ten-year mandate?** It could effectively declare bankruptcy, be converted into a federal agency, or operate as an unrestricted commercial entity. Its consulting and rule-making functions would still be valuable even if it didn't have spectrum to license.
5. **How much government ownership, if any, should the FSS have?** It would certainly be desirable for taxpayers to enjoy some of the benefit of the FSS's profit-oriented activities.