NEW AMERICA FOUNDATION

SPECTRUM POLICY PROGRAM

Spectrum Series Issue Brief #8 October 2002

ISSUE BRIEF

Open Spectrum
THE NEW WIRELESS PARADIGM

By Kevin Werbach*

Almost everything you think you know about spectrum is wrong.

For nearly a century, radio frequency spectrum has been treated as a scarce resource that the government must parcel out through exclusive licenses. We simply can't imagine doing anything else. Yet the assumptions underlying the dominant paradigm for spectrum management no longer hold. Today's digital technologies are smart enough to distinguish between signals, allowing users to share the airwaves without exclusive licensing.

Instead of treating spectrum as a scarce physical resource, we could make it available to all as a commons, an approach known as "open spectrum." Open spectrum would allow for more efficient and creative use of the precious resource of the airwaves. It could enable innovative services, reduce prices, foster competition, create business opportunities and bring our communications policies in line with our democratic ideals. Despite its radical implications, open spectrum can coexist with traditional exclusive licensing, through both designated unlicensed wireless "parks" and "underlay" of non-intrusive communications in licensed bands. Both approaches should be encouraged. The risks are minimal, while the potential benefits are extraordinary.

If the US Government wants to put in place the most pro-innovation, pro-investment, deregulatory and democratic spectrum policy regime, it should do everything possible to promote open spectrum. Congress and the FCC should:

- Develop rules to foster more effective cooperation among unlicensed users
- Set aside more spectrum for unlicensed uses
- Eliminate restrictions on non-intrusive underlay techniques across licensed bands
- Promote experimentation and research in unlicensed wireless technology

We can glimpse the possibilities of open spectrum in existing unlicensed bands. These bands are limited, congested, and devoid of any interference protection. Yet they are the sites of the most explosive phenomenon in the wireless world: WiFi. WiFi (IEEE 802.11) is a protocol for unlicensed wireless local area networks, allowing high-speed data connections anywhere within a few hundred feet of an access point. WiFi deployments are growing at fantastic rates. A market that did not exist three years ago now generates well over a billion dollars annually, continuing to expand despite a severe technology recession. Investment and innovation are running rampant.

WiFi shows only a fraction of open spectrum's potential. If the US government took steps to facilitate the full realization of open spectrum, it would achieve several vitally important policy goals. Moreover, it would do so by moving away from heavy-handed regulation towards a free-market environment in which innovation and service quality matter more than government-granted privileges.

Thinking Different About Wireless

Exclusive spectrum licensing is considered necessary because the alternative would be a "tragedy of the commons": a chaotic cacophony in which no one could communicate reliably. The tragedy of the commons idea resonates with our intuitions. After all, too many sheep grazing in the same meadow will use up all the grass. Too many cars on a highway at the same time will cause traffic jams and collisions. Why should spectrum be any different?

Spectrum *is* different. Technologies developed in recent decades make it practical to avoid the tragedy of the commons. "Open spectrum" is an umbrella term for such approaches.[1] There are two ways to implement open spectrum technologies. The first is to designate specific bands for unlicensed devices. This is the approach that allowed WiFi to flourish in the 2.4 GHz and 5 GHz bands. The second mechanism is to "underlay" unlicensed technologies in existing bands without disturbing licensed uses. This approach, epitomized by the ultra-wideband technology the FCC authorized earlier this year, effectively manufactures new capacity by increasing spectrum efficiency. Underlay can be achieved either by using an extremely weak signal or by employing agile radios able to identify and move around competing transmissions.

The Spectrum Mirage

We are accustomed to thinking of the radio spectrum as a scarce physical entity, like land. Charts showing the partitioning of the spectrum and auctions for geographically defined rights to slices of the airwaves reinforce the physicality of spectrum. This is a mirage. There is no "aether" over which wireless signals travel. Moreover, the spectrum isn't nearly as congested as we imagine. Run a

*Kevin Werbach is a technology consultant, author, and founder of the Supernova Group. He has served as the Editor of *Release 1.0: Esther Dyson's Monthly Report*, and as Counsel for New Technology Policy at the Federal Communications Commission. While at the FCC, he authored *Digital Tornado*, the first comprehensive analysis of the Internet's implications for telecommunications.

spectrum analyzer across the range of usable radio frequencies and the vast majority of what you'll hear is silence. Even in bands licensed for popular applications such as cellular telephones and broadcast television, most frequencies are unused most of the time in any given location. This is the case because spectrum allocations assume dumb devices that have a hard time distinguishing among signals, thus requiring bands with large separation.

With today's technology, the better metaphor for wireless is not land, but oceans.[2] The oceans are huge relative to the volume of shipping traffic and the pilots of each boat will maneuver to avoid any impending collision (*i.e.*, ships "look and listen" before setting course). To ensure safe navigation, we have general rules defining shipping lanes and a combination of laws and etiquette defining how boats should behave relative to one another. A regulatory regime that parceled out the oceans to different companies, so as to facilitate safe shipping, would be overkill. It would sharply reduce the number of boats that could use the seas simultaneously, raising prices in the process.

The same is true with spectrum. Allowing users to share spectrum, subject to rules that ensure they do so efficiently, would be far more effective than turning more spectrum over to private owners.

The Myth of Scarcity

When you think about it, our approach to spectrum is the exception rather than the rule. We shrug at intense government regulation of communications over the airwaves that would be unconstitutional in other media. After all, wireless communication is speech. Under the First Amendment, the government faces a high burden in justifying any law that defines who may communicate and who may not. Yet Congress and the FCC routinely determine who may broadcast on certain frequencies, and they regularly shut down those, such as pirate radio broadcasters, who fail to observe those rules.

The rationale for limiting speech over the airwaves is that there is no alternative. Spectrum is scarce, so the argument goes, so either some may speak or none will be able to get their message across amid the cacophony of interfering voices.[3] As discussed above, though, that scarcity is a historically and technologically contingent judgment.

Capacity-magnifying techniques such as spread spectrum, software-defined radio and cooperative networking make it possible to see spectrum as something other than a physical resource to be licensed. These technologies use smart transmitters and receivers to differentiate among signals. Just as many people in a crowded room can talk simultaneously by modulating their voices and using their intelligence to distinguish speakers, many users can coexist in the same frequency bands. Portions of the radio spectrum could be treated as a commons.

A commons, like the air we breathe and the language we speak, is a shared, renewable resource. It is open to all. It is not completely free or inexhaustible, but it can seem that way if individuals follow rules to prevent over-grazing. A commons is entirely compatible with competitive capitalism. The marketplace occurs among users of the commons; the commons itself cannot be bought or sold.

The beauty of a spectrum commons is that is creates good incentives. Exclusive licensing and property rights create spectrum monopolies, which seek to maximize the rents they can collect. Licensing spectrum at auction ensures it goes to those who value it highly, but winners must recoup their investments. This biases their actions. As noted above, exclusive licensing also encourages manufacturers to make devices as dumb as possible, while a spectrum commons has the opposite effect. In a commons environment, companies can respond to marketplace demands by tailoring new services, since the costs of entry are minimal.

OPEN SPECTRUM IN THE REAL WORLD

The WiFi Explosion

There is real-world validation of the open spectrum argument in the form of WiFi and related technologies. WiFi refers to the 802.11b and 802.11a wireless Ethernet standards defined by the Institute for Electrical and Electronic Engineers (IEEE). The first mass-market commercial implementation became available in 1999. Since then, the market has grown rapidly, with expected sales of some 10 million PC/laptop adapter cards this year. Vendors such as Cisco, Linksys, D-Link, Netgear and Proxim are doing a brisk business selling access points for home networks, adding value to residential broadband connections. On the enterprise side, wireless LAN deployments doubled last year, with more than one million access points now in use in 700,000 companies, according to the Yankee Group.[4] Cahners In-Stat sees the WiFi hardware market generating over $5 billion in 2005, and that doesn't even include service revenues.[5]

Though originally developed for corporate local area networks (LANs), WiFi has garnered attention for two applications: hotspots and community access points. Hotspots are wireless nodes in high-traffic locations such as hotels, airports and cafes. Over 4,000 have been deployed in the US, and many more in Europe and Asia. Community access points are similar, but they are freely available to anyone in the area. An increasing number are funded by governments, universities and non-profits who see a benefit in providing widespread wireless Internet access.

WiFi is not alone. Several companies are trying to marry the cost economies of standards-based 2.4 GHz radios with proprietary software and hardware to support additional capabilities. Others are developing ultra-wideband (UWB) devices, which use such low power that they can underlay beneath existing licensed spectrum bands. After a long and bitter fight, the FCC authorized UWB underlay for the first time in February.[6] The FCC put strict limits on UWB systems, but committed to reviewing them if interference fears do not materialize. For applications that need only a range of a few feet, such as sending data between a phone

and a personal digital assistant or printing from a laptop to a printer, there are personal-area network technologies, including Bluetooth. At the other extreme are metropolitan-area networks that cover entire neighborhoods or cities, embodied in the IEEE's 802.16 standard.

The success of WiFi shows that spectrum sharing works in the real world. Without heavy-handed control by government or by service providers, an entire industry has emerged. Despite repeated warnings of a "meltdown," only isolated anecdotal cases of congestion among WiFi users have been reported. Companies such as Intel and Microsoft are devoting substantial resources to these technologies, which they would be unlikely to do if they were seriously concerned about a tragedy of the commons.

Moreover, wireless LAN technology is evolving and diversifying rapidly. WiFi devices become cheaper and more sophisticated every year, just like personal computers (but unlike most telecommunications services). They are standards-based components sold in a competitive market, at volumes that allow for economies of scale. Those new devices become part of the network as soon as users purchase and install them. Capital investment is spread among users, rather than shouldered upfront by a network operator, as with 3G and other traditional wireless services.

Open Spectrum and the Last-Mile Bottleneck

The fundamental problems in the residential broadband market are the same as in wireless. Cable modem and DSL providers market their services as providing faster Web surfing than dial-up access. Many end-user simply don't find this compelling, especially at $50 per month. Unlike the open WiFi market, there is no room for innovators to roll out new service offerings or better technology because everything must go through the network owner.

Standard WiFi technology provides only short-range connections, within approximately 300 feet. Despite this limitation, several approaches could allow unlicensed devices to deliver last-mile broadband service. Companies such as Nokia, MeshNetworks and SkyPilot have created systems that use a meshed architecture. Rather than connect to a central hub, each device can send information to every other device it can see. Information can be routed through the network using many different paths, depending on capacity, line of sight and other characteristics. The mesh approach gets around limitations that hobbled previous fixed-wireless systems in the last mile.

Other companies such as Etherlinx and Motorola have created proprietary technologies on top of WiFi radios to allow significantly increased range in traditional point-to-multipoint deployments. Operating in the unlicensed 5 Ghz band, Motorola claims its Canopy technology can serve up to 1,200 subscribers from a single access point at a range of up to two miles. Unlicensed wireless connections could also serve as "tails" at the end of existing phone, cable or fiber infrastructure in residential neighborhoods.

POLICY RECOMMENDATIONS

Despite the promise of open spectrum, there are many threats to the continued growth of unlicensed wireless. For example, Sirius Satellite Radio filed a petition with the FCC earlier this year seeking restrictions on WiFi based on trumped-up concerns about interference. The Sirius petition was withdrawn after it provoked serious objections. Nonetheless, it gives a sense of how licensed users could seek to hamstring unlicensed alternatives. Wireless operators facing new competition from unlicensed devices may similarly rely on scare tactics and legal maneuvers.

Another threat is "propertization" of spectrum. If the FCC were to give spectrum licensees full ownership rights, as some economists advocate, it would significantly decrease the likelihood that spectrum would be available for unlicensed uses. Companies that pay for control over frequencies will want to recoup their investments, which means excluding competing users. Once spectrum becomes private property, converting some of it to unlicensed "parks" or even eliminating restrictions on band sharing could require costly eminent domain proceedings.

Finally, because unlicensed wireless data devices must at some point connect into the public Internet, they depend on "backhaul" facilities of incumbent local exchange carriers. Until meshed networking or other technologies provide sufficient alternatives, the government should be wary of efforts by those carriers to discriminate in the provision of backhaul to unlicensed wireless operators.

At the same time, policymakers should take affirmative steps to facilitate open spectrum. By announcing a comprehensive open spectrum agenda, the US government would give investors and technologists the confidence to devote resources to new ventures.

1) Fostering Effective Cooperation

The first step is to enhance existing unlicensed bands, which were not designed with open spectrum in mind. The FCC should work with the private sector and the technical community to identify minimal requirements to facilitate efficient spectrum sharing. In the near term, this could include service rules for the 5 GHz band to allow for continued growth of wireless data networking applications. These should not pre-determine technology or applications, but could include general requirements such as mandating that devices be capable of two-way packet-switched communications. The FCC should also remove restrictions in its existing rules, such as outmoded prohibitions on repeaters, to allow for greater spectrum sharing.

In the future, the FCC could define additional "rules of the road," either as requirements or as advisory "best practices." For example, companies could be encouraged to build devices that modulate their output based on actual conditions, or that repeat traffic for other users, allowing for meshed architectures.

2) Expanded Unlicensed Spectrum
Improving existing unlicensed bands isn't enough. Most are so narrow and congested that their utility is limited. Furthermore, the high frequency of the most prominent unlicensed bands limits signal propagation. Lower-frequency spectrum that penetrates weather, tree cover, and walls would provide significant advantages for services such as last-mile broadband connectivity.

The FCC should identify additional spectrum that could be designated for use as unlicensed "parks," with a particular focus on frequencies below 2 GHz. The FCC will need to consult with other agencies, technical and scientific organizations and the private sector. Furthermore, the US government should work through the international fora to create global unlicensed bands wherever possible.

3) Remove Constraints on Underlay
The FCC took a major step forward with its approval of ultra-wideband. The Commission wisely rejected overblown fears about interference, relying on technical data and prudent restrictions on UWB deployment. However, the Commission's initial rules still put severe limits on where and how UWB can be used. Assuming that experience shows the fears about interference ungrounded, the FCC should loosen its restrictions without delay.

The FCC should look at other ways to facilitate underlay of unlicensed communications in existing spectrum bands. As technology advances, the FCC could consider a rule allowing underlay in certain bands, so long as devices check the local environment before transmitting and vacate a frequency within a certain time if a licensed service appears there. Underlay could also be used as a transition mechanism in bands with limited numbers of incumbents.

4) Drive Technology Development and Adoption
The government should seek out additional mechanisms to encourage the development and deployment of unlicensed devices. These could include liberalizing rules for experimental licenses, funding research projects, and using government procurement power to drive adoption of WiFi or other technologies. The FCC and other agencies should also review their existing programs. For example, the FCC doesn't allow the use of Schools and Libraries subsidies for unlicensed networking devices, because they do not involve a communications "service."

The FCC and Congress should continue their broader efforts to foster investment and competition in communications: open spectrum will flourish in a growing market.

A Near-Term Opportunity in 700 MHz
The forthcoming return of analog television spectrum provides an opportunity to put some of these policies into practice. Congress has directed the FCC to auction the 700 MHz spectrum now occupied by broadcast channels 60-69, though the auction has been delayed. Congress should take advantage of the opportunity and designate some or all of the spectrum for unlicensed devices. As a transitional mechanism, the FCC could allow only underlay uses that do not intrude on incumbent licensees.

Conclusion
We are living under faulty assumptions about spectrum. Licensing may have been the only approach in the 1920s, but it certainly isn't in the first years of the 21st century. We take it for granted that companies must pay for exclusive rights to spectrum, and that once they do, they must invest in significant infrastructure build-out to deliver services. We also take for granted pervasive regulation of spectrum usage, which would be intolerable for any other medium so connected to speech. We assume that market forces, if introduced at all, must apply to choices among monopolists rather than free competition. We make these assumptions because we can't imagine the world being otherwise.

Open spectrum forces us to rethink all of our assumptions about wireless communication. By making more efficient use of the spectrum we have, the capacity constraints that limit current wireless voice and data services can effectively be removed. By opening up space for innovation, open spectrum would lead to development of new applications and services. It could provide an alternative pipe into the home for broadband connectivity. And it could allow many more speakers access to the public resource of the airwaves.

We stand at a crucial point. Our policies could fritter away open spectrum's historic opportunity, either through inaction or harmful limits on new technologies. Or we could listen to what the market and technology are telling us. Computers have made wireless devices vastly smarter than they were in the past. It's time for our policies to become smarter as well. Promoting open spectrum is the most democratic, deregulatory, pro-investment and innovation-friendly move the US Government could make.

Endnotes

[1] *See, e.g.*, Kevin Werbach, "Open Spectrum: The Paradise of the Commons," *Release 1.0*, November 2001, available from the author or at http://www.release1-0.com; Yochai Benkler, "Open Spectrum Policy: Building the Commons in Physical Infrastructure," from New America Foundation conference "Saving the Information Commons," May 10, 2002, http://www.newamerica.net/Download_Docs/pdfs/Doc_File_122_1.pdf); Yochai Benkler, "Overcoming Agoraphobia: Building the Commons of the Digitally Networked Environment," 11 *Harvard Journal of Law and Technology* 287 (1998), http://www.law.nyu.edu/benklery/agoraphobia.pdf.
[2] Futurist George Gilder made a similar analogy. *See* George Gilder, "Auctioning the Airways," *Forbes ASAP*, April 11, 1994. *See also* Rich Karlgaard, "2002 Hangs on These," *Forbes*, January 21, 2002.
[3] *See* Red Lion Broadcasting Co., Inc. v. Federal Communications Commission, 395 U.S. 367 (1969).
[4] *See* Stephen Lawson, "Wireless LAN Use Growing Fast," *InfoWorld*, August 1, 2002.
[5] *See* "Wi-Fi: It's Fast, It's Here—and It Works," *BusinessWeek*, April 1, 2002.
[6] *See* Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems, ET Docket No. 98-153, First Report and Order, FCC 02-48, February 14, 2002.