The Myth of Spectrum Scarcity

Why Shuffling Existing Spectrum Among Users Will Not Solve America's Wireless Broadband Challenge

A Martin Cooper Position Paper

March 2010

Executive Summary

America urgently needs to satisfy its exploding demand for radio spectrum. Proposed solutions suggest that reallocating spectrum from existing users to those with more urgent requirements can solve the problem. While reallocation may offer some relief, the technical and political obstacles associated with spectrum reallocations will deliver too little too late; such solutions simply cannot fulfill the country's exploding need for radio spectrum. Keeping America's telecommunications infrastructure robust, competitive and expanding requires *multiples* of the existing 250 MHz of telecom spectrum—two or three times that much in the short term and much more in the long term. This need will not be satisfied by trying to reassign inadequate segments of spectrum among licensees. Instead, it will be the actualization of existing and new technologies that, in effect, create additional spectrum by using current allocations more efficiently and offer America its best and most economic solution. Though the physical band of radio spectrum is finite, technological advances have made spectrum capacity grow exponentially for more than a century: Technological progress has doubled the amount of available radio spectrum for telecommunications every 30 months since 1897 with a concomitant reduction in the cost of information delivery. History must instruct us. The government should adopt policies that encourage the use of more efficient telecommunications technologies.

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The History of Spectrum Allocation and Today's "Lack" of Spectrum

The availability of spectrum has been a challenge since the beginning of radio. When Guglielmo Marconi conducted the first radio transmissions in 1895, the energy from his spark-gap transmitter occupied the *entire* usable radio spectrum. In 1901, his first transatlantic transmission blanketed an area of more than 100 million square miles. Yet it sent only about one bit every six seconds—and the earth's surface could accommodate only few such transmissions at a time.

While Marconi had a virtual monopoly on radio spectrum in the early 20th century, competitors soon appeared and the concept of radio interference in shared spectrum was born. But from the beginning, improved technology has increased spectral capacity so that the available spectrum has always been able to carry the ever-expanding telecommunications traffic.

Since 1901, for instance, spectral efficiency in telephone communications has improved by a factor of about one trillion. Since 1948, it has improved a million times over. And when introduced in 1983, cellular communications immediately offered a ten-fold increase in spectrum capacity—by transmitting in 30 MHz of spectrum what would have taken 300 MHz to transmit with the previous generation of technology. Today's cellular systems are better than 100 times more efficient than the mobile telephones of the 1980s.

And yet today's headlines are filled with talk of a shortage of mobile-phone spectrum, particularly as broadband traffic from smart-phones has exploded. Last year, for example, 312 million mobile-broadband connections generated an average of 273 megabytes of traffic monthly, according to a report earlier this year in *The Economist*. That is 158% more than at the end of 2008[1]. And as Apple readies itself to begin iPad sales, its telco partner AT&T has already experienced a 5,000% increase in mobile broadband traffic in the past three years[2].

No one is expecting such growth to stop any time soon. According to a

[1] http://www.economist.com/businessfinance/displaystory.cfm?story_id=15498399
[2] http://www.att.com/Investor/Financial/Earning_Info/docs/4Q_09_slide_bw.pdf, page 10

February prediction from Cisco Systems Inc., for instance, the world's mobile-data traffic will double every year through 2014, increasing 39 times between 2009 and 2014 at a compound annual growth rate of 108%. By 2014, 3.6 exabytes (or 3.6 billion gigabytes) will be transmitted over mobile-data networks on a monthly basis, Cisco predicts.[3]

Currently Proposed Solutions

Because there are no available segments of unused spectrum to help carriers meet these growing needs, some in Congress are suggesting that the government conduct an inventory of the radio frequency spectrum to identify unused, or lightly used spectrum. The implication is that, like a host serving pie to a hungry crowd, the less needy will willingly give up some of their dessert to alleviate the hunger of the less fortunate.

Such a solution can be cumbersome—imagine the difficulties that will arise in trying to get licensees to give up their spectrum to a competitor even if they are paid for it. And even if successful, it will only address a small part of the spectrum need as mobile-data traffic continues to explode and as other desirable services arise.

The only reasonable approach is to trust our history and adopt policies that foster the trend that radio spectrum has experienced for more than a century: to expand the availability of spectrum with smarter technology. Rather than cutting smaller servings of spectrum, the government should champion the use of improved technologies in order to make a bigger pie—with ample helpings of spectrum for everyone.

The March of Spectral Efficiency

Until recently, spectrum capacity has been expanded by:

- Increasing the practical useable frequency range;
- Introducing more efficient transmission and receiving technology;
- Sharing spectrum by dividing it in frequency, time and geography.

Geographic sharing—or the ability of two entities to use the same segments of spectrum at the same time when they are geographically separated sufficiently to avoid interference[4]—has driven most of the capacity improvements to date. While the capability to increase spectrum capacity by means other than geographic sharing has been largely exhausted,

[3] http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-520862.html

[4] Historically separation was measured in miles. Modern technology allows re-use with separation measured in feet.

geographic sharing, in its many forms has provided—and has the potential to continue to provide—important improvements.

We must not ignore the fact that, as a result of geographic sharing and other technological advances, there has never been a meaningful shortage of spectrum. Whenever new services have come into being—be that broadcast radio, television or cellular phone service—users have scrambled to accumulate rights to that service's spectrum and to vigorously exercise those spectrum rights. But it has always been technology that has made a sufficient amount of spectrum available to meet market demand. Even as isolated traffic congestion occurs (such as the iPhone's impact on service quality in New York City[5]), carriers are using existing tools to resolve the congestion and improve quality.

Some of the newest tools—including smart antennas, microcells, femtocells, techniques for content compression, and off-loading of traffic to Wi-Fi—are increasingly being used to significantly expand radio spectrum availability. Over the next 10 to 20 years, these and other new technologies have the capacity to multiply cellular-communications spectrum by at least an additional ten times—or the equivalent of 2500 MHz of new spectrum for telecommunications carriers.

To encourage a continued improvement in spectral efficiency, a superior and long-lasting solution is to oblige licensees to use advanced techniques for getting more out of the spectrum that they already have. The use of emerging technologies will not only increase the amount of available spectrum, but may also lead to new services being introduced, based on emerging technologies. Additional spectrum may also mean new market entrants, more competitive markets, and better products for the country. If smarter technologies are encouraged to flourish, cellular technology will continue to improve our productivity, to educate us, entertain us, make us safer, and revolutionize the health care industry.

A policy of reallocation is rational only if the resource, spectrum, is viewed as inadequate to demand. Our history, along with an understanding of the potential of *known* technologies, demonstrates that spectrum is an asset that cannot be separated from the technology assets that enable it; that these technology assets are not finite; and that, in our robust society, they always scale to demand. That is the genius of our society; our policies should exploit that.

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[5] http://online.wsj.com/article/SB10001424052748704878904575030834144717418.html and http://gizmodo.com/5370493/apple-genius-bar-iphones-30-call-drop-is-normal-in-new-york

About Martin Cooper

Five decades ago, the only place a commercial wireless phone could be found was in the dashboard of an automobile, attached to a trunk full of equipment that the car had to lug around. Marty Cooper, who at that time was in charge of Motorola's mobile division, led the effort that changed all of that. Mr. Cooper and his team revolutionized telecommunications forever by marrying the idea of portability with cellular technology, unveiling a hand-held cellular phone in 1973. After a decade of development, tenacity and vision, they put the world's first commercial mobile-cellular phone on the market in 1984. From the spark of that 1-pound DynaTAC phone, an industry of 4 billion mobile phones has flourished.

But inventing the mobile phone is hardly Mr. Cooper's only significant accomplishment. For example, he also kick-started the market for quartz watches in the 1960s. In the 1970s, he led the Motorola team that transformed paging from a technology used in single buildings into one that could stretch across cities and, working with the FCC introduced the concept of trunked radio that revolutionized the land-mobile industry. In the 1980s, he launched a billing-software company for the new cellular industry (which he later sold it to Cincinnati Bell for $23 million). And in the 1990s, Mr. Cooper co-founded ArrayComm in order to make mobile-communications spectrum more efficient with smart antennas. Today, he advises the government on a wide variety of telecommunications issues.

Contact info:
Martin Cooper
DYNA llc
mcooper@dynallc.com
Phone: 858 481 2700
Mobile: 619 787 0500
Twitter: MartyMobile