Can Spectrum Policy Match Speed of Mobile Expansion?

> *Mobile devices, data traffic roar ahead . . . but spectrum lags*
> *The fundamental computer market shift – from PC to mobile + cloud*
> *Can secondary spectrum markets fill the near term capacity gap?*

BRET SWANSON > July 27, 2012

At the beginning of 2011, Cisco projected mobile data traffic for the year would grow at a sizzling 131%. It was wrong. Mobile traffic last year grew 133%.

Just a decade ago, cell phones were for talking; there was hardly such a thing as "mobile data." At 597 petabytes per month, however, *mobile* data traffic in 2011 was roughly equal to the entire global Internet of 2004.

The rapid expansion of our mobile ecosystem is a boon to consumers and the economy. But it is a daunting challenge for infrastructure providers – and for policymakers. Any market changing so fast exhibits growing pains. New capacity (i.e., more bandwidth) fuels innovation in devices and multimedia content, which in turn hunger for more capacity. Massive private investment in new network capacity has driven and (mostly) accommodated bandwidth demand, which has been more than doubling each year. No business or industry, however, can function smoothly if one of its chief inputs is unavailable. In the case of mobile, that crucial input is wireless spectrum.

"Spectrum" refers to bands of electromagnetic radiation, defined by frequency (and wavelength), ranging from radio waves to visible light to gamma rays. Because of the supreme regularity of electromagnetic radiation, it is highly useful for sensing our world (radar, our eyes, and x-ray machines each "see" different spectrum bands). It is also the most effective means we have found to transmit information – TV, radio, satellite, mobile, Wi-Fi, and much more.

There is no shortage of spectrum, *per se*. It is a fact of nature, revealed by science and harnessed by technology. Yet there is only a relatively small range of spectrum that is useful for mobile communications – and within that range only small portions that the government makes available for commercial use. Today, we don't have the optimal spectrum allocation to encourage continued growth of the Internet economy.

Capacity

When we first started building 3G mobile networks in the mid-2000s, many thought it a silly and wasteful exercise. How would we ever use this capacity? Too much bandwidth at too much expense, not nearly enough applications and services. Mobile device screens were thought too small and too lifeless to watch video, surf the Web, or read, not to mention play games or video chat. There were no mobile "apps" as we know them today.

Just a few short years later, a 2011 Credit Suisse survey of U.S. wireless carriers found their networks running at 80% of capacity, meaning many network nodes are tapped out. The projected unusable surplus of 3G wireless capacity had, thanks to the iPhone and its smartphone cousins, turned into a severe shortage in many big cities.

Fortunately, we can invest in more capacity by building more cell towers and upgrading to

faster wireless networks, such as the new fourth generation (4G) technology known as LTE.

Spectrum, however, is still the foundational resource. And one might say there is a man-made shortage of it. Of the best airwaves between 174 MHz and 4 GHz – the spectrum most useful for mobile communications – the U.S. government claims around 61%. Broadcasters from the over-the-air TV era control around 29%, leaving just about 10% for mobile service providers.

Many policymakers understand this mismatch between our old-world spectrum allocation and the growing needs of our modern mobile ecosystem. Yet there is much evidence that policy is not moving fast enough to sustain investment and innovation. Powerful forces in technology are demanding swifter action.

The New Computers

Mobile phones have been with us since the 1980s. Smartphones and tablets, however, are a fundamental shift in the computer market. This transformation can be seen most vividly in a now-famous chart produced by Asymco (see next page). Using data initially compiled by Jeremy Reimer, Asymco shows annual unit volumes of computing devices since 1975. After lots of new products and jostling in the early and mid-1980s, the market condensed around two basic platforms – PCs and Macs. By the early 1990s, most of the competing devices had died, leaving PCs as the totally dominant computing platform, with Macs a distant second. This duo continued its virtual 100% share through the late 80s, all of the 90s, and most of the 2000s.

Then, in the late 2000s, came the first genuinely new consumer computing platforms in a generation. General purpose in nature, smartphones and, later, tablets had real computer power, broadband connectivity, high end graphics, and supported a wide array of software apps.

The unit volumes achieved by these wireless devices in just a few short years are astounding:

- Smartphones outsold PCs for the first time in 2011 – 488 million versus 415 million units, respectively.
- Sales of tablet computers in 2011 grew 256% to nearly 73 million.
- Non-handset mobile devices, such as tablets and other form-factors, are expected to grow at a 40% compound rate through 2014.

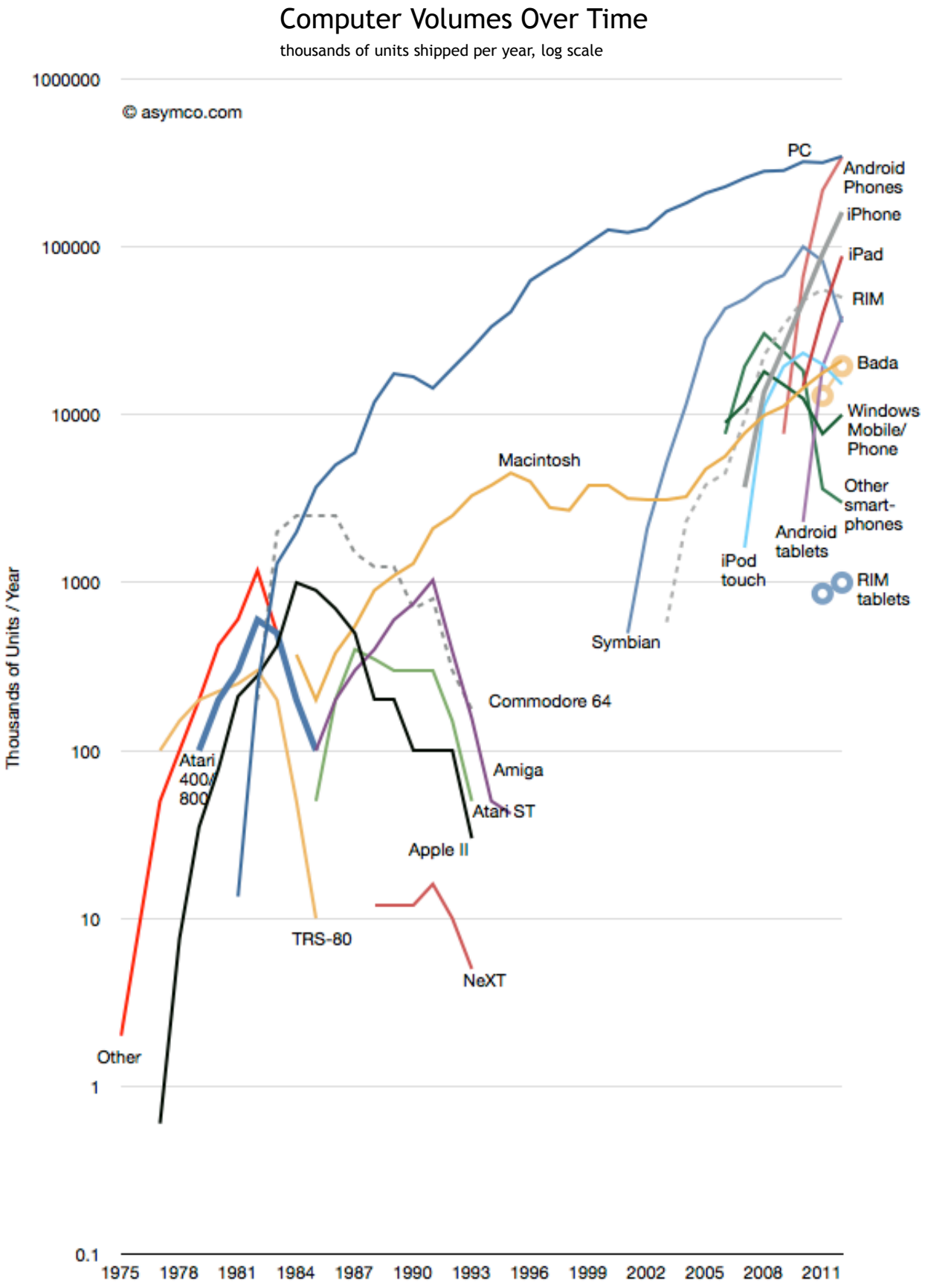
These new form factors add diversity to what was an already burgeoning market for mobile phones. In 2011, the U.S. passed the 100% mobile penetration mark – more subscribers than people – reaching a total of 327.6 million subscriptions.

Mobile + Cloud + Apps

The new mobile computers and new broadband wireless networks also revolutionized the software market.

More computer power and broadband connectivity – combined with a larger, more user-friendly interface – allowed Apple to develop and popularize the mobile software "app." The previous generation of consumers had known software chiefly as the Microsoft operating system Windows, office productivity applications like Office, and maybe boxed games or specialty programs. The World Wide Web introduced new kinds of software and content, often based on Java or Flash, but the Web was not a compelling experience on mobile devices.

The iPhone brought both an attractive Web experience and a wide variety of useful software to mobile devices for the first time. The ability to acquire new apps quickly from the cloud, first via Wi-Fi and then over 3G networks, probably changed the relationship between consumers and software forever.


Computer Volumes Over Time
thousands of units shipped per year, log scale
© asymco.com
Thousands of Units / Year
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Atari 400/ 800
Apple II
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Other

Apple launched its App Store in mid-2008, and in just four years the number of available apps has grown to nearly 700,000. Users of Apple's mobile iOS have downloaded 30 billion apps. Apple says it has paid app developers $5 billion. On a related note, Apple says it has reached 400 million iTunes accounts (with consumer credit cards attached).

Google, meanwhile, launched its Android mobile OS and its own app marketplace after Apple, but both are growing even faster.

Google estimates 900,000 Android activations per day, for a total of 400 million Android devices. Choosing among more than 600,000 available apps, Android users have now downloaded more than 20 billion apps.

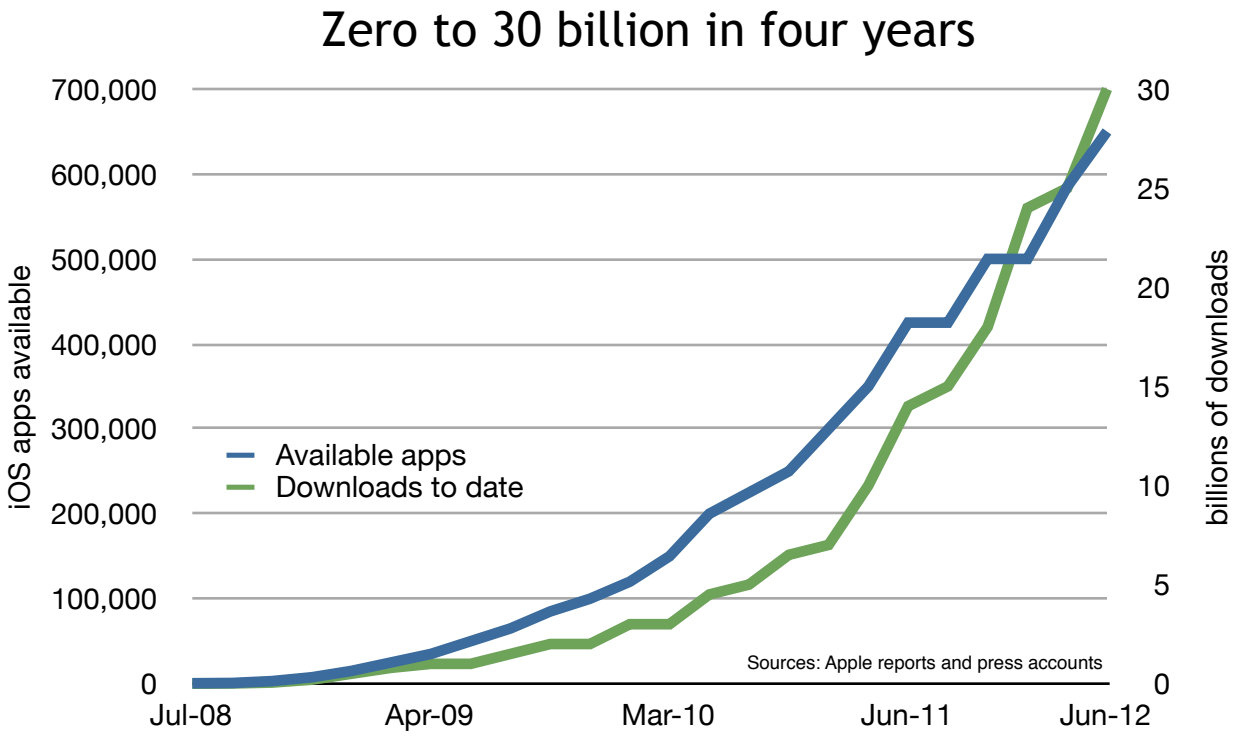
The reliance of mobile devices on the cloud will only grow. Increasingly, phones, tablets, and a host of thin clients, sensors, and other wireless nodes (Google glasses?) will depend on resources in the cloud – computing, storage, content, services, and real-time updates from apps that push (and pull) information to (and from) the network.

Features like Apple's Siri voice command-and-search will require always-on real-time access to cloud networks that can find and deliver accurate results without delay. Other device-based apps (or new HTML5 Web apps) will be closely integrated with computing, storage, and databases in the cloud – think real-time updates from social networks, sports events, or financial markets.

Video of all types will be the largest bulk traffic driver – entertainment, news, sports, video clip sharing, etc. Netflix, for example, is now streaming more than a billion hours of video per month.

Real-time communications – especially video chat – will of course impose growing burdens on a network originally conceived for the much less bandwidth-intensive needs of voice transmission.

So a combination of powerful factors is driving rapid mobile traffic growth. Mobile devices are the chief new personal computing paradigm. The volumes of these devices are reaching into the many billions worldwide. An



explosion of software, available instantaneously and in small chunks, being developed by thousands of creative coders, is driving new consumer demand and use. Consumers themselves are creating content with, for example, cameras and social networks. And broadband networks are enabling rich multimedia and video content in diverse incarnations.

In its latest network traffic report, Cisco projects North American mobile data will grow at a compound annual rate of 75% through 2016, when mobile traffic could reach nearly two exabytes per month.

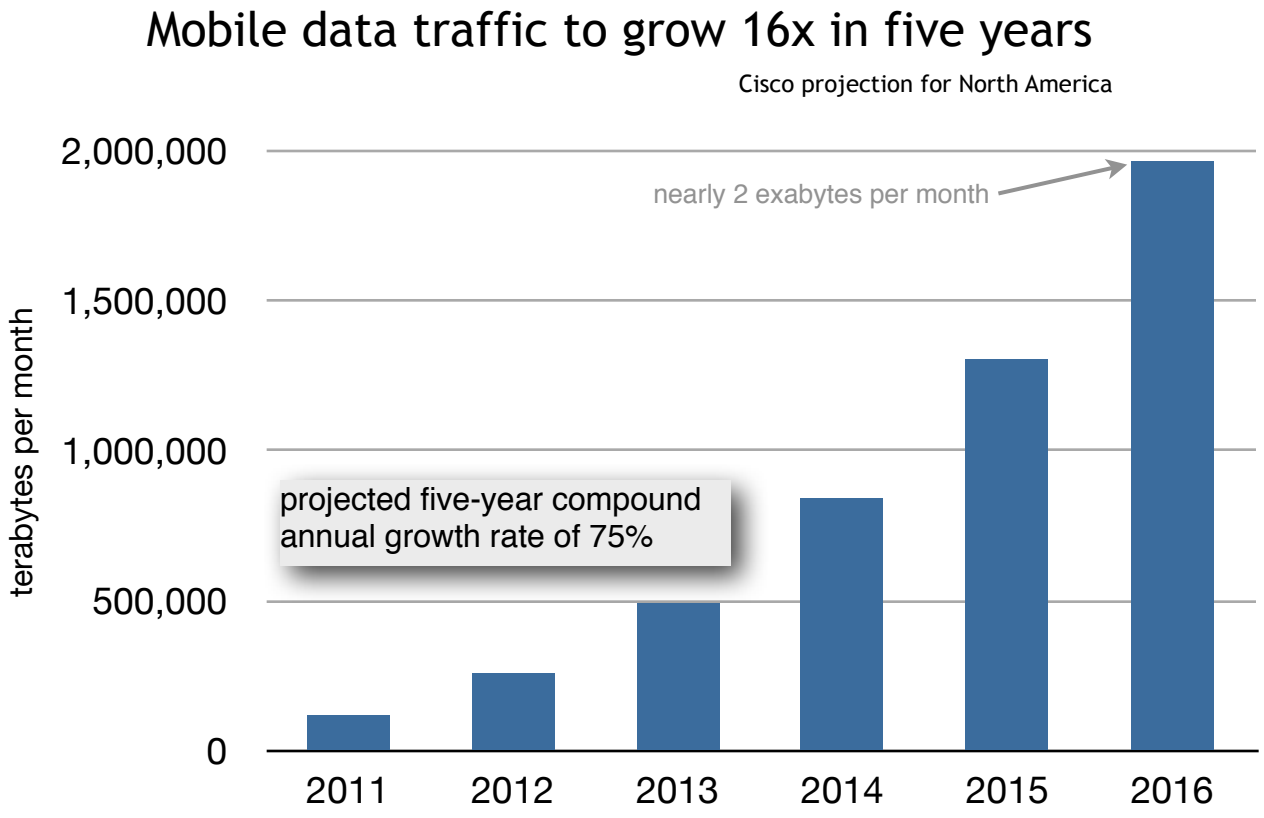
Competition

Opponents of open spectrum auctions and flexible secondary markets often ignore falling prices, expanding choices, and new features available to consumers. Instead they sometimes seek to limit new spectrum availability, or micromanage its allocation or deployment characteristics, charging that a few companies are set to dominate the market. Although the FCC found that 77% of the U.S. population has access to three or more 3G wireless providers, charges of a coming "duopoly" are now common.

This view, however, relies on the old analysis of static utility or commodity markets and ignores the new realities of broadband communications. The new landscape is one of overlapping competitors with overlapping products and services, multi-sided markets, network effects, rapid innovation, falling prices, and unpredictability.

It is, for example, worth emphasizing: *Google and Apple were not in this business just a few short years ago.*

Yet by the fourth quarter of 2011 Apple could boast an amazing 75% of the handset market's profits. Apple's iPhone business, it was widely noted after Apple's historic 2011, is larger than all of Microsoft. In fact, Apple's



non-iPhone products are also larger than Microsoft.

Android, the mobile operating system of Google, has been growing even faster than Apple's iOS. In December 2011, Google was activating 700,000 Android devices a day, and now, in the summer of 2012, it estimates 900,000 activations per day. From a nearly zero share at the beginning of 2009, Android today boasts roughly a 55% share of the global smartphone OS market.

In 2009, Gartner projected market shares for mobile operating systems in 2012. Below are the projected shares for full-year 2012 and the rough actual shares for the first quarter of 2012:

Mobile OS	Projection 2012	Actual 1Q 2012
Symbian	39%	8%
Android	14.5%	55%
iPhone	13.7%	23%
Windows	12.8%	3%
Blackberry	12.5%	7%
Linux	5.4%	4%
WebOS	2.1%	–

The projections missed the mark of actual shares by wide margins. This testifies less to Gartner's forecasting abilities than to the dynamism of the mobile marketplace. We doubt anyone could have accurately forecast this outcome, nor that projections of these markets going forward will be much better.

Apple's iPhone changed the structure of the industry in several ways, not least the relationships between mobile service providers and handset makers. Mobile operators used to tell handset makers what to make, how to make it, and what software and firmware could be loaded on it. They would then slap their own brand label on someone else's phone.

Apple's quick rise to mobile dominance has been matched by Blackberry maker Research In Motion's fall. RIM dominated the 2000s with its email software, its qwerty keyboard, and its popularity with enterprise IT departments. But it couldn't match Apple's or Android's general purpose computing platforms, with user-friendly operating systems, large, bright touch-screens, and creative and diverse app communities.

Sprinkled among these developments were the rise, fall, and resurgence of Motorola, and then its sale to Google; the rise and fall of Palm; the rise of HTC; and the decline of once dominant Nokia.

Apple, Google, Amazon, Microsoft, and others are building cloud ecosystems, sometimes complemented with consumer devices, often tied to Web apps and services, multimedia content, and retail stores. Many of these products and services compete with each other, but they also compete with broadband service providers. Some of these business models rely primarily on hardware, some software, some subscriptions, some advertising. Each of the companies listed above – a computer company, a search company, an ecommerce company, and a software company – are now major *Internet infrastructure* companies.

As Jeffrey Eisenach concluded in a pathbreaking analysis of the digital ecosystem ("Theories of Broadband Competition"), there may be market concentration in one (or more) layer(s) of the industry (broadly considered), yet prices are falling, access is expanding, products are proliferating, and innovation is as rapid as in any market we know.

The Spectrum Question

Large capital investments in wireless and backhaul networks have driven American

mobile innovation and, for the most part, accommodated traffic demand. U.S. service providers invested $26 billion in wireless infrastructure in 2010 and another $26 billion in 2011. For the period 2001-11, U.S. wireless investment was around $258 billion.

Spectrum, however, is becoming a limiting factor. More cell towers (with antennas, base station equipment, and backhaul links) are sometimes but not always the best way to boost capacity. They are expensive and often difficult to "site" given local politics and appropriate geographic availability. The new technologies, such as 4G, are also better suited to wider spectrum bands, which aren't always available in the older allocations.

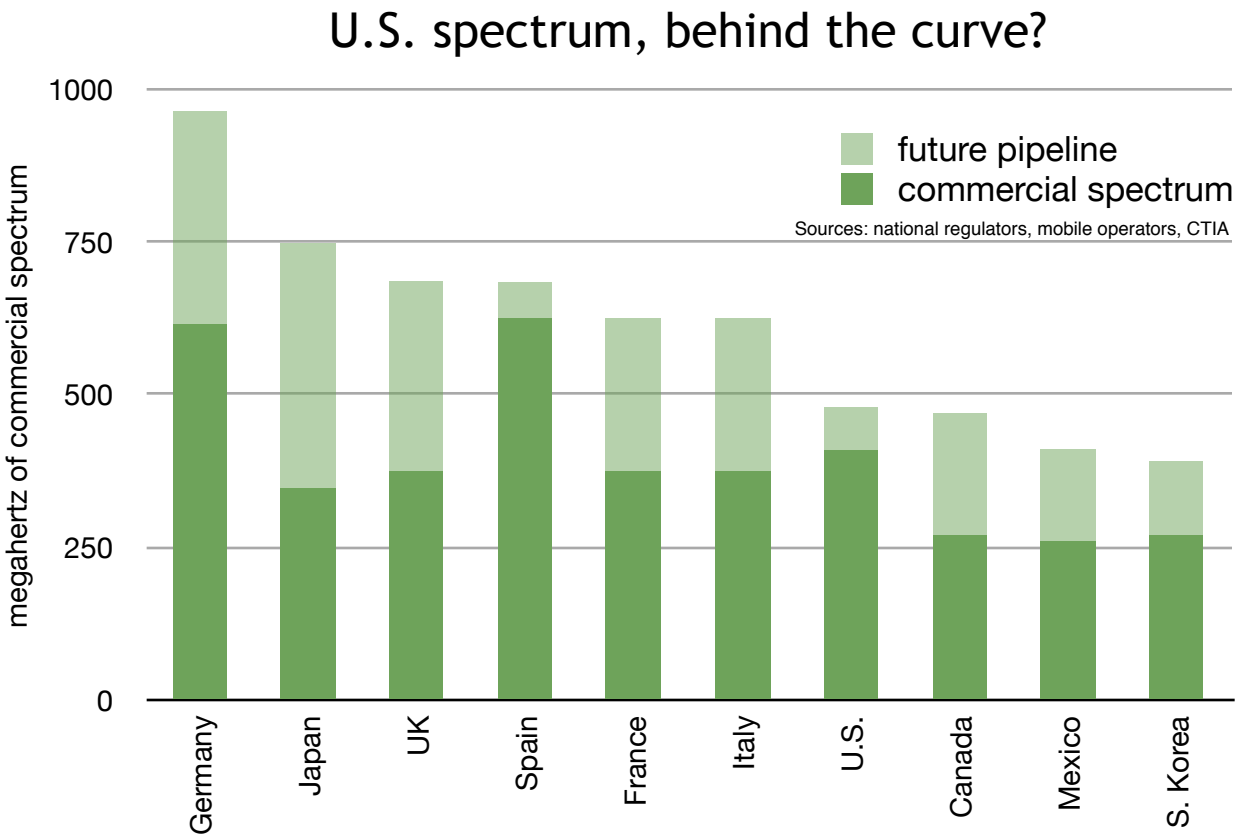
Most mobile operators in the U.S. today control between 50 and 90 MHz of spectrum. Wireless engineering consultant Peter Rysavy estimates that by 2016 they might need more than 200 MHz to serve the busiest markets.

The U.S. appropriately established a goal to unleash 500 MHz of spectrum by the end of the decade and 300 MHz by mid-decade. But its actual spectrum policies are falling far behind this objective.

As the chart below shows, the U.S. lags many other advanced economies in the total amount of spectrum likely to be available in the next several years.

On only four occasions has the U.S. opened large new spectrum bands for mobile use – cellular in the 1980s, PCS in the 1990s, and AWS and 700 MHz in the mid- and late-2000s, respectively. Moreover, it often takes five to 10 years between the decision to release new spectrum and its eventual arrival in the marketplace (via auctions and other means).

For these reasons and more, secondary markets for spectrum are crucial. They provide a modest amount of flexibility and "liquidity" to a sometimes inflexible market. (For



example, AT&T and Sirius XM last month proposed a swap of WCS spectrum that would allow AT&T to more quickly deploy 4G capacity; and Verizon and T-Mobile proposed a swap of AWS spectrum that would enlarge T-Mobile's net spectrum position but give Verizon a better contiguous allocation.)

Unleashing spectrum through auctions and allowing greater flexibility to use, buy, and sell existing private spectrum is important to accommodate existing demand for new data services and to drive future wireless innovation. Spectrum policy and politics, however, has been deteriorating.

- The FCC and Justice Department vetoed AT&T's merger with T-Mobile, which, through an expansion of cell sites and addition of spectrum, would have improved AT&T's 3G network now and accelerated AT&T's 4G roll-out by several years.

- The FCC battled with Congress over a spectrum auction bill that could unleash hundreds of megahertz of unused and underused spectrum. The FCC wanted broad authority to restrict and massage the auctions in various ways and to manage the technical and business models of the wireless arena. The House wanted open auctions that would not predetermine who can bid, how much companies can buy, and how buyers use the spectrum. The proposal finally became law early this year, but arguments persist over how the FCC will conduct the auctions. Even in the best of circumstances, the process will take years.

- LightSquared, a venture of Harbinger Capital, sought approval of its nationwide 4G wholesale network but ran into a wall of technical opposition from the GPS community, which claimed LightSquared interfered with GPS signals, situated in spectrum next door. LightSquared lost its bid, and so for now its 50 MHz of spectrum is dark.

- The government is now reviewing Verizon's announced purchase of SpectrumCo., the large spectrum holdings of several U.S. cable TV companies. Several times the government delayed its decision and asked for more information from the parties, leading many observers to doubt the transaction would be approved. More recently, it became known the FCC was likely to approve the transaction. But now the Department of Justice is reviewing a distinct but related proposal in which Verizon and the cable companies would engage in some joint-marketing of products. DoJ's hesitation to approve the marketing agreement is now delaying the spectrum transaction.

These events threaten to slow the innovation and hypergrowth the mobile industry has recently enjoyed.

Not only do these actions keep spectrum from being used most efficiently or off the market entirely, but they impose further opportunity costs on the ecosystem. For example, SpectrumCo.'s spectrum remains offline because the cable companies decided not to go ahead with their own mobile network build. But if SpectrumCo. cannot sell its spectrum, it's not just the spectrum that goes unused. SpectrumCo.'s owners, the cable companies, are also deprived of several billion dollars in capital they might use to enhance their wireline broadband networks.

Building and Operating Networks

There are essentially three ways to increase wireless capacity – more spectrum, more cells, and faster technology. We need all three.

We can multiply the same bands, or "reuse" spectrum, with a larger number of smaller cells transmitting signals a shorter distance. Deploying more small cells will be a major part of the wireless expansion for many years to come. Yet more cells mean more expense – and more complexity.

We can push more bits through a given band of spectrum – better spectral efficiency. This,

too, is important. It is true, with LTE, we are closing in on Shannon's theoretical limit of how many bits can be transmitted over a channel per unit time. It is also true that we keep finding ingenious new ways to create more channels – e.g., MIMO antenna technologies.

Nevertheless, without the third leg of the wireless stool – spectrum – the mobile equation collapses. We mix and match these three resources, based on cost and network architecture, to produce the most capacity at the lowest cost. Take away spectrum, and we can do a lot to compensate – more cells, more investment, more technology, and, yes, more cost and more complexity. And thus higher prices and other problems.

One crucial consideration is that as we deploy new network technologies and nodes, we must continue operating existing networks serving older generations of devices. As Rysavy notes, mobile operators until the year 2020 "will have to allocate separate spectrum for 2G, 3G, and 4G, a strain on their spectrum holdings beyond the pressure from escalating mobile broadband demand."

The simpler solution if we want to encourage continued innovation at its fastest possible clip is to allow ecosystem companies to build networks and deliver services using the best mix of resources. This means not artificially limiting the use of spectrum but allowing it to flow to its highest value uses.

If and when the incentive auctions championed by FCC Chairman Genachowski are successfully completed, it will be a major achievement that will help fuel another round of mobile innovation. It should also be noted that in recent days FCC Commissioners Rosenworcel and Pai have urged greater speed in regulatory decisions and a more concrete timeline for the spectrum auctions.

Unless and until the FCC's 500 MHz wireless big bang becomes a reality, however, an active, flexible secondary market for spectrum will have to fill the gap. EE