Telecommunications & Electronic Media

Allocating Radio Spectrum for the "Mobile Data Tsunami"

*By Thomas W. Hazlett**

I. A Mobile Data Tsunami?

The mobile sector is said to face a looming spectrum shortage. Policy-makers express great concern over a coming crisis.[1] But markets easily avoid shortages—with rising prices. This phenomenon discourages consumption while boosting production. Excess demand is eliminated and balance restored.

In mobile markets, price mechanisms operate, but regulators control the supply of a key resource input—radio spectrum. It is impossible, in fact illegal, for bandwidth under-utilized in one market to be bid into use for mobile networks starving for bandwidth. This situation forces demand to be more tightly rationed. Operators deter deployments, restrict new offerings, and delay new technologies. Network growth is stunted. It is the silent heart attack.

The shortages strike first at more than 55 million high-speed wireless data users.[2] Over 650,000 Apple App Store programs are available for iPhones, while Android, Blackberry, Symbian, and Microsoft users have hundreds of thousands of their own to choose from. Voice calls have been joined on the mobile platform by text or multi-media messages, e-mail, web surfing, and video streaming. New network overlays supply machine-to-machine ("M2M") applications, like the emergency phone call from an OnStar car installation, the book download from a Kindle, or the medical monitor running as a handset app. (See Figure 1.) The crowding pushes networks to split cells, upgrade technologies, offload data to fixed networks, and to access any newly available frequency spaces. Keeping productive spectrum bottled up in allocations determined by regulators decades ago imposes a tax that deters growth in perhaps the most dynamic sector of our economy.

Additional bandwidth loosens constraints. Whatever level of service might be supplied when a minute of network access costs five cents can now be supplemented by a range of new outputs when that cost drops to, say, three cents. A price shift signals the existence of more abundant capacity. Volumes increase, and quality of service improves. More applications launch. Video clips that streamed to a subscriber's handset in one minute might now do so in five seconds. Whole new business models become viable. Unforeseen innovation occurs.

Asking *"How much bandwidth does the mobile sector need?"* misses the point. This question cannot be fruitfully answered by dispassionate observers, whether or not they are government experts. Competitive markets, wherein rival networks seek to profit from efficiently combining network investments, services, and spectrum, form a process that best supplies an ever-changing answer. Putting as much bandwidth as possible into the market—via liberal licenses that permit any use within the specified frequency space—is the pro-consumer policy. Yet, vast bandwidth (in the TV band and elsewhere) is substantially under-employed and off-limits for market reallocation.

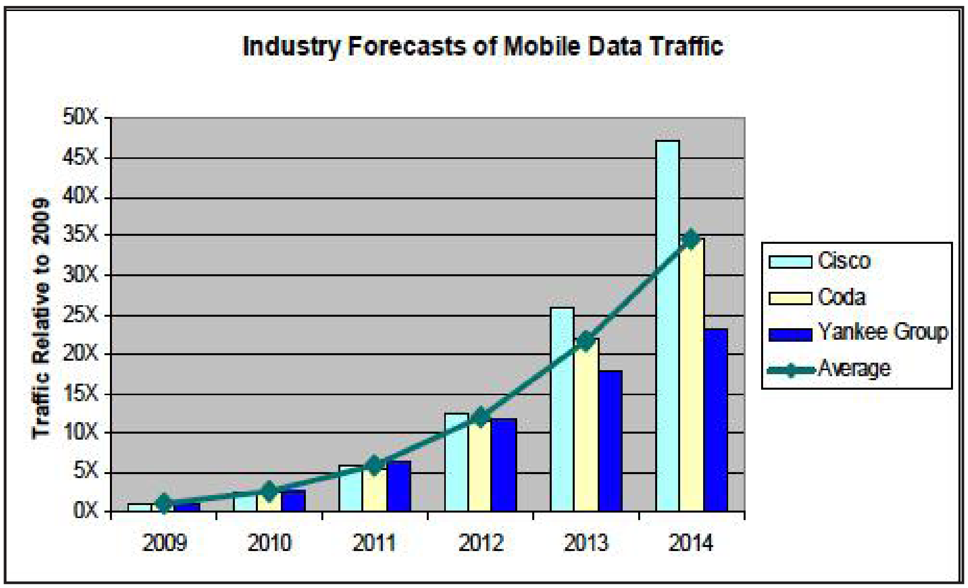

Fig. 1. Mobile Broadband Data Demand, Industry Forecasts[3]

Growth in mobile markets is seemingly inevitable, but at what pace? It is widely feared that new pricing structures will curtail the consumer's mobile experience. One pundit recently wrote in *Bloomberg Businessweek*:

> The era of unlimited plans does have to end. The best way to allocate finite goods is through transparent, efficient markets. As traffic increases on mobile networks—it nearly tripled this year, and Cisco expects it to grow twenty-six fold by 2015—consumers will be forced to make smarter choices about how they use mobile data. Perhaps parents will be forced to download the toddler-pacifying Elmo videos at home rather than on-demand in the car. That's not a tragedy; it's what markets do.[4]

Mobile carriers generate more than $160 billion in annual revenues. Each pricing rule has costs and benefits. Sometimes

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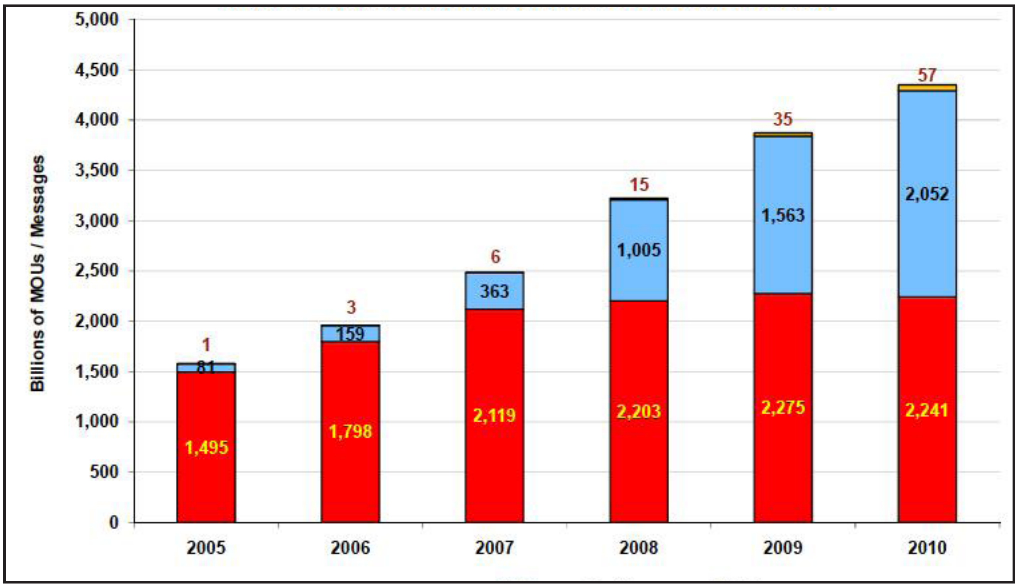

Fig. 2. U.S. Mobile Voice Minutes (Red), SMS (Blue), and MMS (Yellow)[5]

the bother of charging for minutes of talk time is not worth the trouble, particularly as customers do not like having to worry about how much a given minute of use is costing them. Buckets of minutes, available for a fixed monthly fee, are extremely popular, as are "free unlimited" off-peak or on-net minutes. Where the marginal cost of usage is low, the trick is to entice customers to support network costs via a monthly subscription fee.

How far this offer extends, and how much opportunity for consumption exists, is complicated. It requires billions of dollars in network construction, maintenance, and management dollars to answer. One thing is clearly known: the more spectrum that is available for the network to deploy, the lower the costs to customers will be.

Mobile systems are being transformed from voice-only platforms to multi-media, multi-network platforms. (See Figure 2.) The rise of SMS (short messaging service, or "texts") is one major trend, but these services claim little network capacity. But more bandwidth-intensive applications are also on a steep trajectory. (See Figure 3.) Wireless networks incur heavy capital costs to bring the new capacity to customers, and current trends suggest that for Canadian and U.S. carriers, revenue per gigabyte will fall below total cost per gigabyte sometime in 2013.

Leveraging existing assets is expensive and risky for operators, who are themselves constrained by capital markets. To the degree that additional spectrum resources are not available to help expand network capacity, such investments become even riskier. Enthusiasm for capital expenditures will

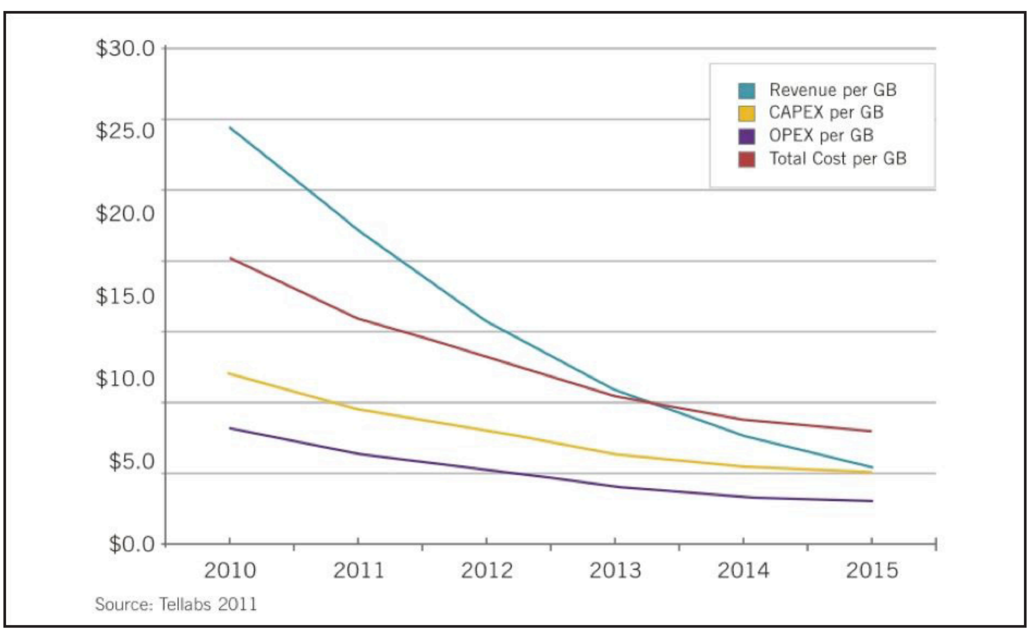

Fig. 3. North American Mobile Data Carriers: Costs, revenues, 2010-2015[6]

wane. Yet, by permitting additional bandwidth to be bid into its most productive use, the mobile data tsunami can be not only accommodated, but also promoted.

II. Proliferating Mobile Networks

A. 6 Billion Subscribers, 50 Billion Devices

Most people think of mobile networks as consisting of cell-phone carriers like Verizon Wireless, AT&T, Sprint, T-Mobile, MetroPCS, or Leap. Others see the emergence of a new wireless broadband competitor Clearwire as part of the mix. But the vertical growth in wireless services is sometimes less obvious.

Vertical services are those applications hosted by a given network that go beyond traditional, carrier-supplied voice calls. Mobile virtual network operators ("MVNOs") have formed, for example, buying wholesale access to physical networks. TracFone and Consumer Cellular, among several others, are MVNOs that sell retail services without operating their own infrastructure. This business model allows multiple systems (and their subscribers) to access spectrum and network resources on shared platforms.

Sharing intensifies when new services are added to the product menu. SMS, MMS (multimedia messaging service—texting with pictures or videos), and high-speed data are the most popular mass-market services. When a carrier upgrades its network from first-generation analog voice ("1G"), to second-generation digital ("2G"), to third-generation broadband data ("3G"), the platform becomes capable of hosting a new range of possible applications. Upgrades to fourth-generation ("4G") standards are now underway. With the improved speeds and capacities they bring, still more options become feasible.

Yet we have not even scratched the surface of what lies ahead. The emergence of M2M devices is already proceeding at breakneck pace. Truck fleets use them to monitor available transport slots, to track merchandise, and to optimize logistics. Vending machines report sales to computer servers, reducing inventory costs. Power meters do not have to be read by meter readers trekking from door-to-door, but automatically report to headquarters via wireless links. Automobiles, guidance-assisted, can be steered clear of traffic accidents. Electronic-payment systems have already become mass-market successes in developing economies, where banking infrastructure is relatively under-developed.

Industry experts predict that by 2020, six billion cellular phone subscribers will co-exist in a world of 50 billion connected mobile devices. They imagine everything from heart sensors monitoring vital signs 24/7 to location finders implanted in the family dog.

B. Emerging M2M Apps

When calculating the value of wireless services, economists generally focus on the consumer surplus received from making voice calls.[7] The numbers derived from these calculations are very large. Yet there are other impressive innovations taking place all through the "mobile ecosystem." It is as if we are measuring the importance of the transcontinental railroad by examining how many people ride the trains, leaving out the economic development of the American West made possible by the new infrastructure.

It is extraordinarily difficult to measure the gains in markets that are only now emerging. Moreover, it is unclear how we attribute those gains; radio spectrum is one of many inputs. That issue is quite vexing for statisticians and economists. But in a broader sense, there is not much scope for confusion. The simple fact is that such markets will be stunted if additional spectrum is not made available. The following examples are illustrative.

i. Vehicle Tracking and Collision Avoidance

One of the best-developed families of mobile applications rides the road. Among the earliest such devices are from OmniTRACS by Qualcomm. Launched in 1988, the system relies on satellite-radio links to communicate the location of vehicles. Truck fleets use the service, with on-board radio devices connected to computers with keyboards adjacent to the driver's seat. "The system consists of wireless devices installed on semi-trailer trucks that 'talk' to computers located in a network operations center (NOC), enabling transportation carriers to monitor driver performance; schedule and plan vehicle maintenance more effectively; and improve customer service."[8] In addition, trucks are efficiently routed via information generated about local conditions and last-minute variations in pick-ups or deliveries, saving time and fuel, while reducing traffic.

The service became a "killer app" for trucking firms not only in the U.S. but around the world. In 1993 Irwin Jacobs, the co-founder and CEO of Qualcomm, was deemed "The Man Who Changed Trucking" by *Fleet Magazine*.[9]

Passenger vehicles also benefit from M2M applications. OnStar, developed by General Motors, has been available as a factory-installed feature on GM cars for several years. Using both satellite and terrestrial wireless networks, it not only notifies public safety authorities in the event of an accident emergency, it provides vehicle location and other services to subscribers. Competing vehicle-M2M devices have been developed by ATX and SYNC. Given new opportunities with faster 4G networks, services are able to extend coverage and features. A new "stand-alone" OnStar service is newly available to all cars in an after-market appliance sold at retail store Best Buy. The device, which is installed as a rear-view-mirror replacement, gives the customer "automatic crash response, turn-by-turn navigation, stolen vehicle location assistance, one-button access to emergency and roadside services and hands-free calling."[10]

Since 1986 the LoJack (opposite of "hijack") vehicle location tool has been sold to vehicle owners who wish to recover their property in the event of a theft. The wireless device, which uses a police band frequency, is small (about the size of a cigarette box) and emits a tracking signal when activated by remote-radio communication. The company boasts a 90% recovery rate for stolen cars. Such wireless applications have reduced criminal activity: "The fact that fewer vehicles were stolen in 2008 than 1980, despite the doubling in the number of vehicles on the road, is at least partly the result of the great improvement in locking devices built into modern vehicles."[11]

The crime-preventing equipment deters car thefts generally. Because criminals do not know which vehicles are equipped with tracking devices and which are not, they attempt to steal fewer cars. This spreads the benefits of such wireless innovations far beyond those households that purchase the technology.[12]

Vehicle-based M2M apps under development could enhance collision avoidance. Advanced radio sensors are being tested using devices that monitor the environment surrounding a vehicle as it travels.

Computers can respond to a situation in approximately 0.3 seconds, as opposed to the human reaction time of one-half to one full second. . . . If these sorts of telematics can be integrated into automobile systems to not only keep people connected, but to also help them avoid deadly traffic accidents, then society may be well on its way to living up to science-fiction standards.[13]

ii. Energy Conservation

Another M2M development involves coming up with optimized truck routes that can save energy by creating the most efficient truck-delivery routes, which save fuel and cut pollution:

> Many M2M fleet management solutions . . . help reduce emissions. Fleet management solutions can issue alerts when a vehicle exceeds predetermined limits for idle time or speed. . . . M2M solutions help devise the best routes for truck deliveries to avoid unnecessary idling and to cut down on left-hand turns. According to UPS[,] . . . between 2004 and 2008 this simple technique shaved nearly 30 million miles off delivery routes, saved three million gallons of gas and reduced emissions by 32,000 metric tons of CO2—the equivalent of removing 5,300 passenger cars from the road for an entire year![14]

Electric utilities can also promote energy efficiency through M2M devices on meters. Vodafone, the largest international mobile carrier, notes that wireless SIM cards installed inside electrical outlets can both monitor consumption and communicate price changes in real time, incentivizing efficiencies. "During times when energy prices fluctuate rapidly, customers will transparently know what prices they are paying, precisely how much energy and utilities they are using, and where specifically it is being used."[15] M2M devices are also being used in Smart Grids to redirect power consumption from expensive peak periods to lower-cost off-peak periods. The electric-power industry also uses M2M technology to monitor energy extraction and production. Energy production increases, while carbon emissions fall.[16]

iii. Public Sector

Myriad M2M applications have emerged in the public sector. For instance, in New Hampshire, fifty school districts contract with a bus company to transport some 1500 special-needs children daily. Prior to M2M devices, essential coordination was often lacking: "Dispatching the company's 178 buses was tedious and cumbersome, requiring the use of a radio and constant manual checks to ensure buses with wheelchair lifts" were available where needed.[17] Combining mobile-network-connected devices with GPS services aided efforts. KORE Telematics reported the following in a case study,

- $400,000 annual savings reported by reducing driver overtime
- 50% less time in routing the right bus to the appropriate location
- improved on-time performance through more efficient routing
- increased child safety achieved by monitoring driver speeds and rapid response to bus breakdown.[18]

Police departments use M2M applications to obtain criminal records, and to keep up with the constant stream of various alerts, bulletins, or "wanted" notices. M2M applications transfer such data over cellular networks.

In San Jose, California, each police patrol car is a broadband-connected office. Officers in the field have instant access to police databases via high-speed internet connections. The system, developed by Feeney Wireless and run over the Sprint mobile network, has such benefits as "cost and times savings[,] . . . on-demand access to real-time information[,] . . . [and] enhanced emergency response."[19]

In Austin, Texas, the police department acquired, in early 2011, 100 mobile devices that scan fingerprints. The radios then automatically identify the prints, and check for any outstanding arrest warrants. In just three months, the devices were used 340 times, resulting in the arrest of forty suspects. Not only do the devices deter the use of fake names and phony IDs, they keep officers in the field rather than in the station verifying suspects' identities.[20]

Other services greatly improve police surveillance. Cameras used to record potential criminal activity had to be manned and located within a few hundred yards of a backhaul link. This limitation exposed surveillance operatives to potential discovery and consumed vast amounts of police officers' time. New systems developed for a Southern California police department, however, have produced remote, cellular-network-connected cameras that are movement-activated (eliminating data flows when there is nothing suspicious to observe) and controlled by police officers in a command center—or traveling with a notebook computer—miles away.[21]

C. Mobile Health

Perhaps the most exciting of all M2M opportunities lies in "mobile health" (also known as "wireless healthcare," "connected health," or "mHealth"). This burgeoning field holds tremendous promise in its potential to help improve health while reducing health-care costs. From securely delivering a critical patient's cardiac information to a doctor's smart-phone—wherever he is—to pill bottles that remind you to take your medication with an SMS message, innovative mHealth applications are almost without bounds.

The demand for wireless medical services is projected to increase by 58 percent annually over the next five years.[22] The digital health market (which includes mobile applications) is estimated to have been $1.7 billion in 2010, and is expected to grow to $5.7 billion by 2015.[23] More than 200 million downloads of mHealth applications are in use.[24] Currently, U.S. mHealth revenues are approximately $100 million annually, but the rapid evolution in mobile devices coupled with physician demand and the need to improve quality while reducing health-care costs is forecast to result in a $1.7 billion market by 2014.[25]

The top ten medical conditions being targeted for wireless health applications are breast cancer, heart failure, Alzheimer's, COPD, sleep disorders, depression, asthma, diabetes, hypertension, and obesity.[26] Mobile health devices monitor patient behavior, patient symptoms, or device performance (keeping heart pacemakers running properly). Using mHealth can lower costs and increase quality of life. Some developing applications give a sense of what is possible.

i. Biometric Sensors

Biometric sensors placed in mobile handsets transmit data to remote medical teams, generally at hospitals. These may be neighborhood facilities, or hospitals hundreds of miles away. Multiple wireless technologies convey data from small sensors such as glucose meters or blood pressure monitors to servers located in data centers. These data are monitored and recorded for further analysis.

In a typical pathway, a body sensor collects key biometric data. The sensor may be implanted in the body or embedded in the handset. Using a mobile broadband network, the portable device transmits the data for analysis wherever such monitoring can best be done, anywhere in the world. In effect, the patient's biometric data telecommutes, saving transport costs for patients and doctors. The new applications can be integrated with existing monitoring and diagnostic equipment. Two examples:

Obstetrics Airstrip Technologies' AirStrip OB™ service[27] sends critical patient information (such as fetal heartbeat and maternal contraction patterns) directly from monitoring systems in the delivery ward to a clinician's smart-phone or tablet. Data are transmitted securely in real time.

Radiology/Neurology Calgary Scientific's "ResolutionMD Mobil" service[28] provides remote access to CT and MR images through the clinician's smartphone. This information permits clinicians to closely observe and diagnose, 24/7, while attending other patients. One compelling application is for acute stroke, when doctors can immediately access brain scans for clinical assessments, no matter where they are located. This can markedly improve the quality of critical care.

ii. Medication Monitoring

Wireless applications are being used that remind patients to take their medicine. One such app[29] is a wirelessly embedded pill bottle that generates refill alerts and also reminds patients to take their medications via light or sound pulses, phone calls, or text messages. Progress reports are issued for patients, family members, and caregivers.[30]

III. Spectrum Allocation and Consumer Welfare

Economists have found that adding spectrum to mobile markets leads to lower prices for consumers. In a study published in the *RAND Journal of Economics* in 2009, Roberto Muñoz and I compared twenty-eight markets around the world to find out how different spectrum allocations ultimately impacted consumers.[31] We found that additional allocations of radio spectrum strongly influenced economic efficiency, both because of better performance by carriers and the effect of the extra bandwidth in enhancing competition between them.

In one particular simulation, we tried to forecast the impact that an additional 30 MHz of spectrum would have on the mobile market in the U.S. We chose this range because of the delays in auctioning off PCS licenses, which were announced in 1989-92, but the auction was not completed until 1996. The Federal Communications Commission ("FCC") gave preference to heavily subsidized "designated entities" ("DEs").[32]

These subsidies allowed DEs to launch artificially high bids knowing that they would be bailed out if they went bankrupt.[33] Many DEs that won bids found that bankruptcy courts let them keep their licenses in bankruptcy even as they slashed[34] payments they owed to the U.S. Treasury.[35] The result was that most of the C-block licenses did not become available to the market until 2005, when the FCC held a re-auction.

Our model projected the value that an extra 30 MHz of spectrum in the U.S. mobile market would have yielded if deployed in 1997-2003. The extra bandwidth would have lowered prices and expanded volumes, producing consumer welfare gains of about $66 billion over the seven-year period (in total). This magnitude is very large, but it was not a surprise. Annual consumer surplus gains from the use of mobile phones—just for voice and texting—have been conservatively estimated at about $200 billion.[36]

IV. How the U.S. Fell Behind the E.U.—and Then Caught Up

The problem of expediting the delays in spectrum allocation was studied by the FCC's National Broadband Plan Task Force, which issued its report in March 2010. It concluded, "The process of revisiting or revising spectrum allocations has historically taken 6-13 years."[37] The statement is based on an analysis of key allocation episodes, summarized in Table 1.

The summary is forgiving in its measurements. The cellular-telephone spectrum allocation, which it lists as beginning in 1970 and ending in 1981, took far longer. AT&T filed an application for cellular bandwidth in 1958;[38] the FCC opened the official proceeding to do this in 1968. Licenses were assigned, not in 1981, but in multiple rounds (most using lotteries) between 1983 and 1989. The process could well be defined as lasting not eleven years, but thirty-two.

The FCC accurately presents the basic problem: "Historically, the FCC's approach to allocating spectrum has been to formulate policy on a band-by-band, service-by-service basis . . . ." [39] The Report describes this framework as being "criticized for being ad hoc, overly prescriptive and unresponsive to changing market needs."[40]

Table 1. NBP Summary of Key Spectrum Allocation Lags[41]			
Band	*First Step*	*Available for Use*	*Approximate Time Lag*
Cellular (AMPS)	1970	1981	11 years
PCS	1989	1995	6 years
Educational Broadband Service (EBS)/Broadband Radio Service (BRS)	1996	2006	10 years
700 MHz	1996	2009	13 years
AWS-1	2000	2006	6 years

A. How the U.S. Fell Behind the E.U. in 2G

One way to see the problem with regulatory lag is to compare spectrum allocation in the U.S. to that of the European Union ("E.U."). No other nation was faster in getting cellular-analog-voice-telephone services—1G ("first generation")—to market than the U.S. Not only did the U.S., via Bell Labs, develop the underlying technology, but AT&T was far more innovative than the state monopolies over post, telephone, and telegraph—the European PTTs.

The privatization wave of the 1980s swept away Europe's PTTs and replaced them, in part, with private telephone carriers. European regulators then looked to license additional wireless rivals. For next-generation, digital-voice ("2G") services, they pursued a policy designed to favor European producers by issuing mobile licenses that mandated deployment of a technical standard—"GSM"—developed by Nokia (Finland), Ericsson (Sweden), Alcatel (France), and Siemens (Germany). By establishing a large GSM market, both in handsets and network equipment, economies of scale would kick in and allow local manufacturers to compete successfully in the global electronics market.

The industrial policy pursued in Europe motivated policy-makers to move quickly, and they did, relative to the U.S. While the FCC stalled in issuing so-called personal communications services ("PCS") licenses for 2G, the Europeans took an early lead in spectrum allocation. By 1992, twelve European countries had licensed GSM networks,[42] and services were launched—with over one million GSM subscribers.[43] In contrast, American PCS licenses were delayed for over five years until regulators could determine how to deal with 4500 point-to-point microwave stations already using the 1.9 GHz band.[44,45] The logjam was broken in 1994 when the FCC auctioned overlays, in which the bands were authorized for use by new PCS networks, but incumbent microwave licensees were allowed continued use of the frequencies. The (new) overlay licensees could then bargain with the (old) incumbents, arranging deals in which the incumbents were paid to relocate. To reduce bargaining costs, the FCC imposed an arbitration structure and mandated time limits. Soon, the incumbents relocated and new cellular competition—accessing 120 MHz of PCS spectrum—was made available to the public.[46]

Due to these FCC moves, mobile operators could by then select virtually any service to offer, any technology to deploy, and any business model to operate. Power levels were similarly left for the mobile operator to optimize; where radios needed high power to jump long distances to the network, they could do so. Today, cellular handsets search continuously for the lowest power levels they can use while still maintaining transmissions. They adjust power hundreds of times per second to minimize emissions, conserving battery life and bandwidth, helpfully accommodating other network users.

B. 3G Services Without 3G Licenses

While the E.U. was again licensing carriers with 3G authorizations in 2000-01, the U.S. was still mired in its 2G (PCS) licensing process. Not until 2006 and 2008 would new license auctions (for AWS and 700 MHz allocations) bring substantial new CMRS spectrum to market. This regulatory lag was a serious problem.

The offsetting factor was that the U.S. benefited from license liberalization. Flexible spectrum-use rights[47] meant that carriers did not have to wait for 3G licenses in order to deploy 3G networks. Canadian technology firm RIM, for example, introduced a pager, the "Inter@ctive," in 1998, by contracting with mobile carriers.[48] This innovation presaged the smart-phone revolution a decade later. The smart-phone, the paradigmatic device of the 3G network, was launched on U.S. networks having access to liberal licenses long before regulators got around to awarding "3G" licenses.

Of course, 3G and 4G devices deliver data services in addition to voice calls. Today, high-speed wireless services in the U.S. compare favorably with deployments in the EU. (See Figure 4.) As recently as 2006, the U.S. mobile allocation of less than 200 MHz paled in comparison to the average EU allocation of 266 MHz.[50] But flexible spectrum-usage rules enabled a competitive advantage for the U.S. market.

The U.S. system has, despite too-tight bandwidth constraints, been free to deploy efficient technologies. Prices, appropriately measured as mean revenue per minute of voice use, are lower in the U.S. than in any other high-income country. (See Figure 5.) The result is that mobile voice usage is easily the highest per capita anywhere. (See Figure 6.)

Yet we can do much better.[53] Vast bandwidth continues to lie virtually idle, representing a world of wasted opportunity. The intense growth in mobile services we have seen so far—Americans use over 2 trillion voice minutes per year, and send more than 2 trillion text messages—is simply the tip of the consumer-welfare iceberg. Demand is already observed for

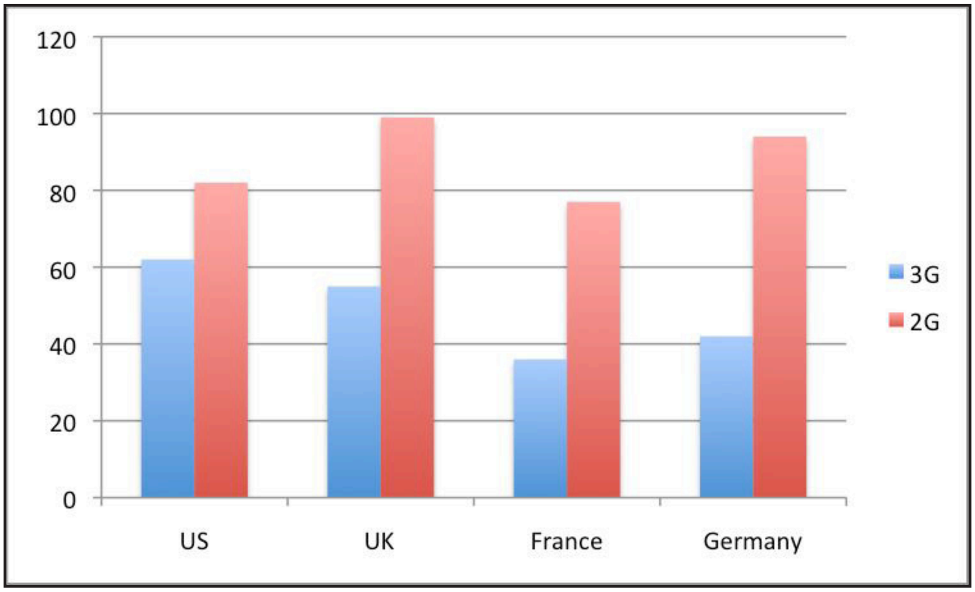

Fig. 4. 2G, 3G Subscribers per 100 Population, 2010[49]

far-faster speeds, far-greater capacities, and far more bandwidth-consuming applications. Emerging networks, including those hosting M2M applications, represent the future of mobile communications. Continued spectrum liberalization is the key to generously accommodating that future.

V. Lessons Learned

> [E]normous economic value [will be] created by releasing 300 MHz of additional spectrum to meet growing demand for mobile data.
>
> —FCC, *Mobile Broadband: The Benefits of Additional Spectrum,* OBI Technical Paper Series No. 6 (2010).

Everyone—including the economic experts at the FCC and the U.S. Department of Justice Antitrust Division[54]—realizes that the central question of the wireless industry is radio spectrum. With many of the regulatory hurdles overcome, U.S. commercial networks have about 450 MHz of radio spectrum to deploy, using licenses that grant broad rights to use airwaves flexibly, without rigid rules or restrictions.

We can now productively use (at least) all of the 450 MHz of spectrum available. The FCC projects that upwards of another 300 MHz would also be efficiently utilized by U.S. mobile carriers as of 2014.[55] In contrast, the International Telecommunications Union (an arm of the United Nations) forecasts market demand in countries like the U.S. for a total of

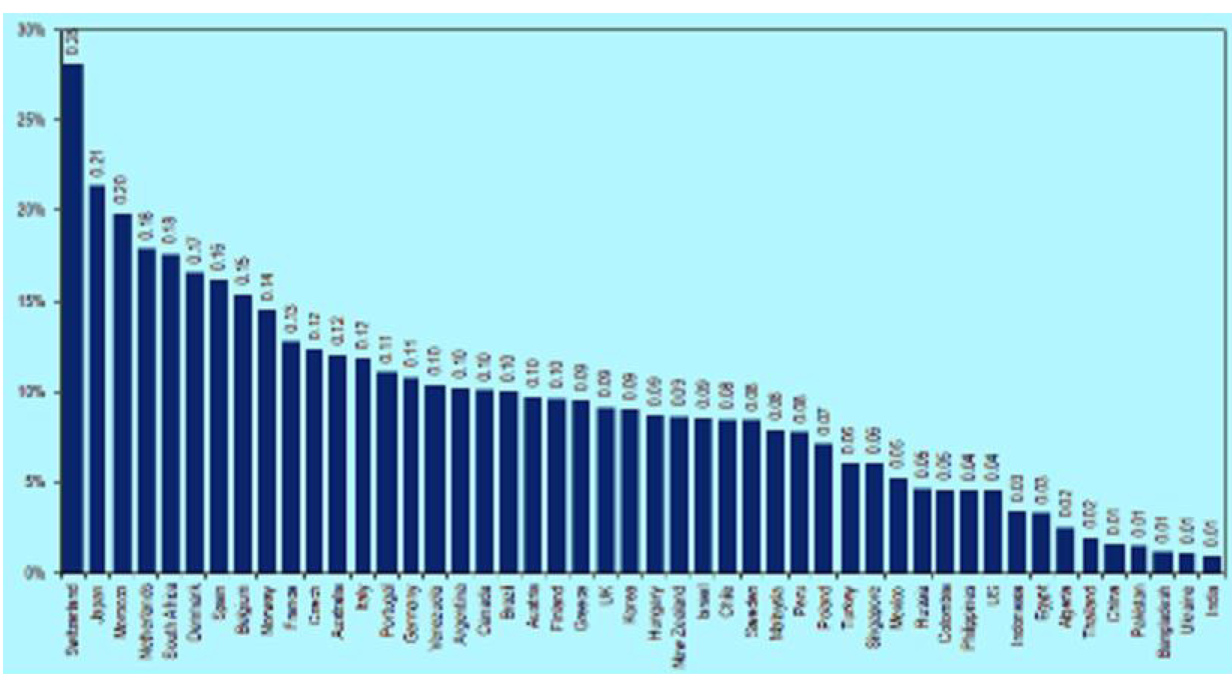

Fig. 5. Average Price per Voice Minute Across Countries, 2Q2010 ($US)[51]

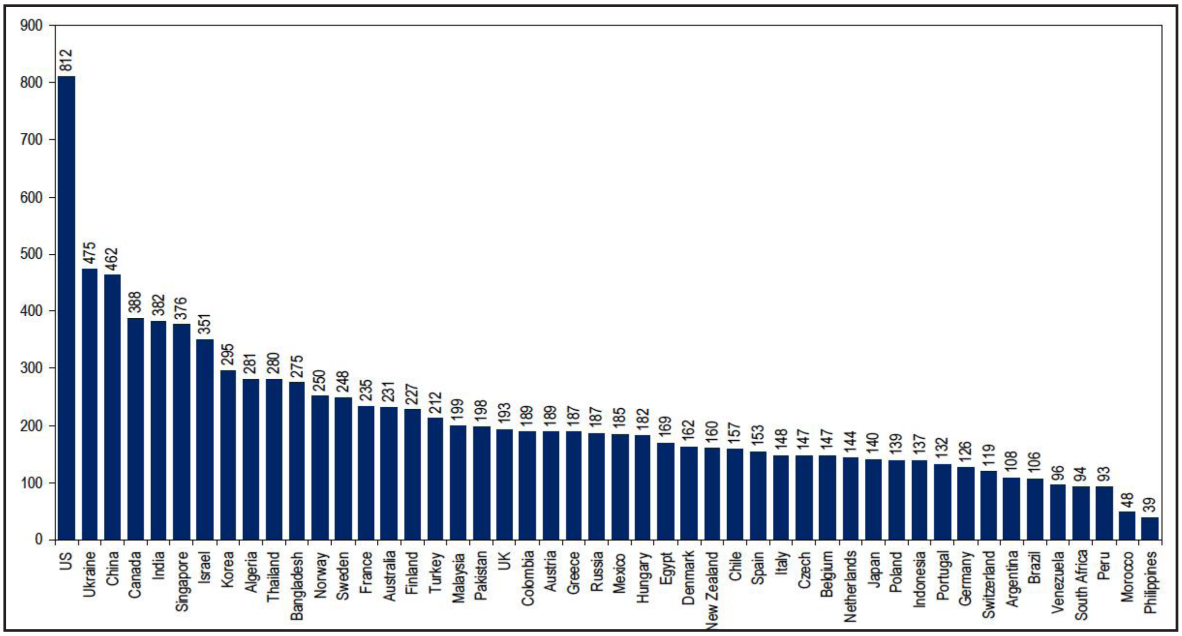

Fig. 6. Minutes of Use per Capita per Month Across Countries, 2Q2010[52]

over *1,700 MHz* by 2020.[56] In truth, there is no magic number for "demand." How much networks, and their subscribers, will gobble up depends on the price they must pay for access. But mobile markets will create far more value should input prices be lower. And the reliable way to lower those prices is for regulators to allow more spectrum to flow to the marketplace.

It is time for bold steps and fundamental reforms. These measures should capture the lessons we have learned.

• *Spectrum creates its own wireless demand*. Policy-makers need not worry about the precise amounts of bandwidth mobile carriers are going to utilize; they need simply to make copious amounts of bandwidth available to the marketplace. A more generous flow of spectrum will itself send the signal that technologists, carriers, and application innovators can profitably invest in developing the networks of tomorrow. Relieving spectrum bottlenecks by allocating substantially more frequency space will lower costs for consumers and entrepreneurs alike, encouraging competition and robust wireless growth.

• *Spectrum markets prosper with permissive licenses*. When bandwidth is allocated via licenses that permit operators to choose technologies, services, or business models, competitive markets replace administrative fiat. Licensees, given flexibility, have powerful incentives to build the most useful and popular networks, providing platforms that generate maximum economic value. Moreover, secondary markets are free to shift spectrum inputs from outmoded employments to more productive wireless applications. As technology options change, so do efficiencies—and networks evolve. Restrictions on spectrum use disrupt market forces, over-protecting the past and freezing out the future.

• *Case-by-case spectrum allocation system is a barrier to progress*. Fundamental reform calls for moving to a more liberal regime with spectrum-use rights that are flexible, not fixed. The market should not have to wait for regulators to make specific determinations about the use of each frequency band, but be able to bid spectrum from one employment to another. Companies—wireless carriers, device makers, media producers, technology vendors, or daring upstarts—should be able to deploy new services, buying spectrum rights in markets without waiting for a six- to thirteen-year FCC proceeding.

The approach to airwave liberalization suggested in a formal letter to the FCC by "37 Concerned Economists" (Feb. 7, 2001) should be revived.[57] The letter read, in part:

> Constraints on the use of spectrum cause both static and dynamic inefficiencies. At any moment, unnecessary restrictions prevent beneficial uses of spectrum. Over time, these regulatory rigidities can discourage innovation altogether. . . . Better rules would be permissive, allowing wireless licensees flexibility to use spectrum subject only to limits on out-of-band emissions and anti-competitive concentration.

Some of this policy vision has indeed permeated the FCC. The 2010 National Broadband Plan includes a chapter on the importance of additional spectrum allocations, and focuses attention on the prospect of allowing TV-band airwaves to be bid into the mobile market.[58] This thinking might be stretched further, and greater strategic attention given to the process of allocation reform. Beyond Five-Year Plans that target specific bands for reallocation, provoking FCC turf wars, our emerging information economy would be best supported by a systemic liberalization. This does not and cannot happen under top-down administrative allocation. It requires economically motivated asset owners facing competitive constraints. Using formats already tried and tested by regulators, such as the overlay rights used to move PCS spectrum out of historic uses and into vastly more productive employments, the process of spectrum repurposing can be moved to the market. Such policy options offer hope for greater speed and efficiency in the quest to supply the radio-spectrum inputs demanded by wireless users.

Endnotes

1 Federal Communications Commission ("FCC") Chair Julius Genachowski, for instance, has taken on the issue, calling repeated attention to "unsustainable demands on our invisible infrastructure—spectrum." Julius Genachowski, *More Spectrum, Please,* Wall St. J. (Mar. 23, 2011).

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54 Mobile Wireless Services Industry

> Mobile wireless services allow customers to make and receive telephone calls and use data services using radio transmissions without being confined to a small area during the call or data session, and without the need for unobstructed line-of-sight to the radio tower. This mobility is highly prized by customers. . . . To provide these services, mobile wireless services providers must acquire adequate and appropriate spectrum . . . .

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