April 21, 2010

Chairman Julius Genachowski
Commissioner Michael J. Copps
Commissioner Robert M. McDowell
Commissioner Mignon Clyburn
Commissioner Meredith Attwell Baker
Federal Communications Commission
445 12th Street, SW
12th Street Lobby, TW-A325
Washington, D.C. 20554

Re: ***Written Ex Parte Communication,*** GN Docket No. 09-51.

Dear Chairman Genachowski, and Commissioners Copps, McDowell, Clyburn, and Baker:

With the Commission turning from development of the National Broadband Plan to implementation, CTIA – The Wireless Association® ("CTIA") writes to reiterate its support for the Plan's commitment to identify 500 MHz of additional spectrum for wireless broadband and to supplement the record on the need for additional spectrum. Specifically, CTIA is submitting for the Commission's consideration the attached recent report, *Spectrum Shortfall Consequences*, developed by Rysavy Research, which describes the technical, service, and market consequences of not bringing sufficient spectrum to market for mobile wireless broadband services. As described in the attached, at stake is our country's continued leadership in mobile broadband and mobile innovation.

In prior filings, CTIA has documented the confluence of market trends driving the explosion of mobile wireless usage. Those market forces − including increasing mass market adoption, surging use of smartphones, development of high-bandwidth intensive applications, innovative pricing, and fixed-mobile substitution and convergence – are combining to produce a virtuous cycle of innovation throughout the wireless ecosystem, benefitting U.S. consumers, businesses, and developers of innovative applications and services.

Although mobile broadband is increasingly being harness to meet our national economic and policy objectives, the FCC has appropriately recognized the need for additional spectrum to facilitate this growth, our global competitiveness, and U.S. leadership in mobile wireless innovation. CTIA fully aggress with the FCC's conclusion and files this paper to further clarify the consequences of a spectrum shortfall. While it is impossible to identify with precision all of the potential harms of not bringing sufficient spectrum to market, the Rysavy paper explains that:

> Not being able to augment capacity through additional spectrum will have multiple adverse consequences: networks will perform at lower levels and be less reliable; service plans will change; and the vibrant cycle of innovation in the wireless ecosystem will stall. This spectrum drought could lead to the U.S. ceding global leadership in mobile communications and computing to other countries. This outcome could impact not only wireless innovation in the United States but

could also impact investment, job growth, and improvement in our health care, education, and energy sectors.

These conclusions reaffirm the importance of identifying additional spectrum as quickly as possible to meet the rapidly accelerating demand for mobile broadband services.

We believe the facts and analyses included in this filing provide further support for the Commission's much-needed national commitment toward continued global mobile broadband leadership made in the National Broadband Plan. Pursuant to Section 1.1206 of the Commission's rules, a copy of this letter is being filed via ECFS with the FCC Secretary's Office. If you have any questions, please do not hesitate to contact me.

Sincerely,

/s/ Christopher Guttman-McCabe
Christopher Guttman-McCabe
Vice President, Regulatory Affairs
CTIA – The Wireless Association®

Attachments
1. *Spectrum Shortfall Consequences*, Rysavy Research (Apr. 2010)

Spectrum Shortfall Consequences

April 21, 2010

Table of Contents

Introduction

The wireless industry is in the midst of tremendous growth and success. Not only has mobile voice become ubiquitous, but people are now beginning to use wireless-data services on a huge scale. The most visible aspect is the surging demand for smartphones. Additionally, the incorporation of advanced wireless networks with other devices like notebooks and netbooks is becoming common and will grow quickly as these new devices take hold. The U.S. today is the world leader for developing and deploying the most evolved wireless technologies, mobile device chipsets, powerful phones, mobile operating systems, and wireless applications.

What makes these mobile devices so compelling is wireless broadband connectivity that provides both instant "wherever, whenever" access to the Internet, applications and services, and the ability to consume increasingly vast amounts of media. The result is rapidly escalating data usage. Current trends in mobile-broadband traffic usage point to inevitable exhaustion of available spectrum in the relatively near term. This paper, sponsored by CTIA – The Wireless Association®, discusses the problems that will arise as demand begins to reach and then exceed network capacity. Not being able to augment capacity through additional spectrum will have multiple adverse consequences: networks will perform at lower levels and be less reliable; service plans will change; and the vibrant cycle of innovation in the wireless ecosystem will stall. This spectrum drought could lead to the U.S. ceding global leadership in mobile communications and computing to other countries. This outcome could impact not only wireless innovation in the United States but could also impact investment, job growth, and improvement in our health care, education, and energy sectors.

Innovation

The degree of innovation in the U.S. mobile wireless industry is simply remarkable, spanning computing, communications and semiconductors. North America is expected to become the leading smartphone market in 2010 with a forecasted 22% market share.[1] The U.S. edge in the wireless device market extends not simply to adoption of smartphones but also to the capabilities of the devices being deployed, with the U.S. becoming the launching-spot of choice for the most innovative devices, many of which are being developed in the United States. This includes products using technology from U.S.-based companies such as Apple (with the iPhone and now iPad), Google (with Android-based devices like the Google Nexus One), Motorola (with Android handsets and more), Palm (with the Pre, Pre Plus and more), and Microsoft (with the HD2 from HTC, and Kin One and Two from Sharp). Quite simply, the U.S. is the market of choice for the world's hottest phones.

These platforms now power more than two hundred thousand software applications written for smartphones alone. Here too, the U.S. leads the world in the creation and adoption of wireless applications, app stores, and open application development.

[1] Source: Forward Concepts, "New Smartphone and Chip Study Announced," February 10, 2010.

On the wireless networks side, broadband technologies such as Evolved Data Optimized (EV-DO), High Speed Packet Access (HSPA), WiMAX, and 3GPP Long Term Evolution (LTE) deliver throughputs of more than 1 Mbps, and with the newest versions of these technologies, rates are ten times higher. The U.S. is in a leadership position in deployment of these networks as well. Clearwire's WiMAX network provides services in 27 markets across the U.S. covering 34 million people, with plans to expand its network to cover up to 120 million people by the end of 2010. Clearwire's network also supports the deployments of Sprint, Comcast and Time Warner Cable. Similarly, Verizon's LTE network will be one of the world's largest next-generation wireless technology deployments, with plans to provide service in 30 cities by the end of 2010. These aren't the only significant deployments. AT&T launched the world's largest HSPA network in 2006, and will start deploying LTE in 2011. In addition, T-Mobile is rolling out HSPA+ (technology that not only can deliver peak download speeds of 21 Mbps, but is backward compatible with 3G devices currently on the market) in major markets throughout 2010. Numerous other regional and smaller wireless providers are also deploying 3G technology throughout their service areas.

With respect to chipsets, U.S.-led chipset-level innovations such as Intel's Atom processor, Qualcomm's Snapdragon processor, and NVidia's graphical processors are powering entirely new mobile-computing platforms such as netbooks and smartbooks. In parallel with smartphone adoption, these new platforms with their high-bandwidth connections will be the next wave of always-connected devices. Due to their larger screens, netbooks and smartbooks will be able to consume even more mobile-broadband data. Last year, netbook shipments surged 79 percent to 30.2 million units.[2]

This innovation is creating a virtuous cycle where attractive applications and devices drive demand and usage, spurring network investment (allowing for increased capacity and coverage) and further application development, lowering prices as the market becomes more efficient and more competitive, further stimulating usage. It is essential that this cycle be maintained.

The biggest threat to the maintenance of this cycle is insufficient capacity to support the applications that users desire. There are multiple means of augmenting capacity, but the most important single item is sufficient spectrum. Current indications are that we are rapidly approaching a spectrum shortfall for commercial mobile radio service. This is because many popular applications are highly bandwidth-intensive.[3] A failure to provide sufficient capacity in the wireless ecosystem will ultimately suppress the continued development of these applications, which has the potential to severely damage the rapid market growth we have recently experienced.

Bandwidth-Consuming Applications and Platforms

Providing sufficient capacity for mobile broadband networks requires planning considerations that are entirely different from the network planning required for voice networks. For example, whereas a voice codec operates at approximately ten thousand bits per second (10 kbps), there is almost no limit to the

[2] Source: Strategy Analytics, February 3, 2010.

[3] For further discussion of application bandwidth requirements, refer to the Rysavy Research report "Mobile Broadband Spectrum Demand," December 2008.

amount of data that applications can consume. For example, a YouTube video can consume one hundred times the amount of data bandwidth of a voice call.

The following table summarizes some of the popular emerging applications that are particularly bandwidth-intensive.

Table 1: Examples of Bandwidth-Intensive Applications

Application	Comments
Mapping and Navigation	This is bandwidth-intensive because image data is continuously updated.
Video Telephony	An increasing number of consumers are taking advantage of the video capabilities available in applications such as Skype, Yahoo Messenger, AOL Instant Messenger, MSN Messenger. The video component greatly exceeds the bandwidth of the voice component.
Cloud Computing	The ability to host applications on the Internet is gaining significant momentum, but demands constant high-bandwidth connectivity.
Social Networking	This is one of the leading growth areas on the Internet for both personal (e.g., Facebook) and business (e.g., LinkedIn) usages. An increasing amount of content includes video applications.
Telemedicine	Doctors can provide patients with crucial services remotely through transmission of high-resolution medical images and video.
Training and Education	An increasing amount of training and teaching is Web-based with video becoming an essential element.
News and Sports	More and more Internet-based news and sports pages contain video-based information ranging from excerpts to complete events.[4]
Entertainment	Gaming and video both consume significant bandwidth. Internet TV and movie options are becoming commonplace with sites such as Amazon Video on Demand, Hulu, Netflix, and YouTube. Many TV stations are now streaming their content over the Internet.
Machine-to-Machine	Previously M2M applications communicated only small amounts of data, but there will be an increasing number that can consume much larger amounts. There are many millions of machines that will benefit from broadband connectivity.

[4] For example, NBC made events viewable online during the 2010 Winter Olympics.

The bandwidth requirements for these applications vary, but, in general, many applications that involve human interaction function best when users have at least 500 kbps of throughput, and preferably more than 1 Mbps. On small-screen devices such as phones, video streaming can be accomplished at lower rates such as 200 kbps. Even at this lower rate, however, an hour consumes 90 Mbytes of data, and viewing two hours per day exceeds five Gbytes of data in a month. With new larger mobile devices and an ever-increasing array of data-intensive applications becoming popular, the trend will be for far greater data consumption.

Meanwhile, browsing today's popular Web pages in the absence of video content means downloading a megabyte or more of information at a time. Anything less than 1 Mbps of throughput can translate to waiting more than ten seconds for a page to load.

Now consider the capacity of today's network. HSPA deployed in one radio carrier has, at most, a sector throughput of 3.75 Mbps based on current technologies. How many high-bandwidth users does it take to consume the entire radio channel? Fewer than five. Even LTE will have finite capacity. With a spectral efficiency of 1.5 bps/Hz[5], LTE will have a sector capacity of about 15 Mbps. This is significantly higher than HSPA, but is still a finite quantity relative to typical trends in data consumption.

It is not just applications alone that enable data usage, but the underlying platforms on which they operate. Today's mobile computers are compact, have greater computing power than desktop-computers of ten years ago, contain vast amounts of solid-state memory that can store tens of thousands of songs or hours of video, employ intuitive touch-screen interfaces, and have bright, high-resolution screens suitable for multimedia applications.

While many applications run as clients on these systems, there is a move towards accessing all content and applications from the Internet. Google's Chrome OS, which will run on netbooks, smartbooks and tablets, is an example. New advances in Web technology, such as HTML 5, make this possible.[6] But this only works if the devices have consistent, high-speed connections to the Internet. As these mobile Internet devices gain market traction, they are poised to consume even more mobile-broadband data than smartphones.

Spectrum Demand Model

Cisco anticipates in their latest mobile traffic forecast[7] that mobile data traffic will double every year through 2014, representing a 39 times increase between 2009 and 2014. Whereas the amount of network capacity required to support voice communication is both predictable and bounded, the amount of bandwidth required to support data users is much more complex to predict. Rysavy Research

[5] Source: Rysavy Research, "HSPA to LTE-Advanced, 3GPP Broadband Evolution to IMT-Advanced (4G)," September 2009.

[6] For more information on mobile Web technologies, refer to the article by Peter Rysavy, "The Mobile Web Imperative," Dec 7, 2009, Information Week, http://www.rysavy.com/Articles/2009_12_Mobile_Web.pdf.

[7] Source: "Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2009-2014," Feb 9, 2010.

developed a spectrum demand model that uses the following variables to determine spectrum requirements: network spectral efficiency, data usage per subscriber per month, network busy hour, subscribers per cell site, protocol overhead, and network overload protection. In assuming traffic growth consistent with the Cisco forecast, this analysis predicts that a typical operator could consume all of its spectrum within three to five years. This situation will vary depending on the market, and capacity issues are likely to occur in a subset of coverage areas before then.[8]

Operators are pursuing multiple means of increasing network capacity including increasing the number of cell sites, offloading traffic onto femto cells and Wi-Fi, and deploying more efficient technologies. All of these will be part of the overall solution. But by themselves, they are insufficient.

To illustrate, consider that a new cell site costs roughly $200,000 to $300,000 to deploy plus the base station electronics cost of $50,000. Adding a radio carrier across three sectors, however, costs just the base station electronics of $50,000. In other words, it is five times less expensive to augment capacity with additional spectrum than by adding a new cell site. That is assuming the spectrum is available. Moreover, a critical problem is that in most urban areas, the ability to add additional towers is very limited, either due to the fact that carriers already have reached capacity in terms of the number of cell sites that an area can support from a practical-implementation perspective, or because local zoning restrictions make it unrealistic to add sufficient towers to provide relief.

Furthermore, deploying a 10 MHz LTE radio channel costs almost the same as deploying a 5 MHz HSPA channel, but the LTE channel has about four times the capacity. In other words, additional spectrum in wide radio channels using the latest technology represents the most effective means of augmenting capacity. In a competitive broadband market with constrained capacity, it is essential that operators can expand capacity in the most economical way possible.

The question is what happens if such spectrum is not made available in a timely fashion. Unfortunately, there will be severe consequences including declining performance and reliability, different and possibly more expensive service plans (reversing a trend in declining costs to consumers), and wireless and mobile applications markets that do not realize their potential.

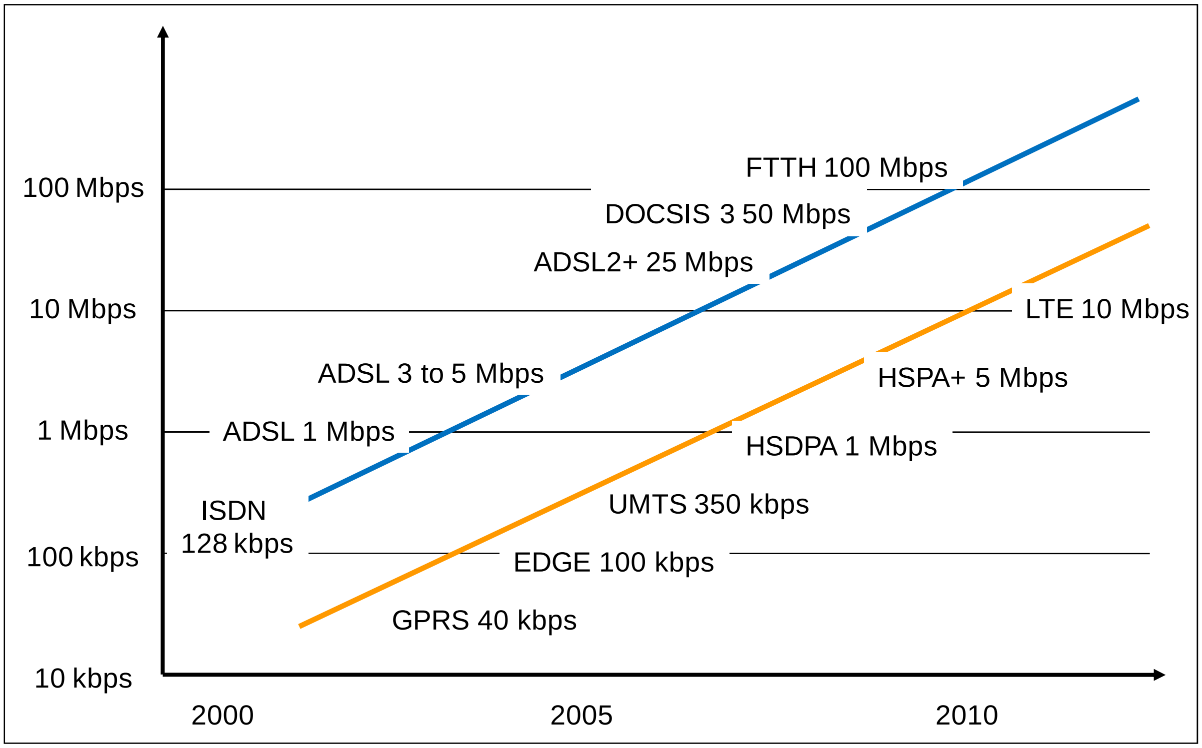
Technical Consequences of Insufficient Spectrum

With insufficient spectrum, users will experience severely degraded network performance, and one that significantly deviates from wireline performance. As shown in Figure 1, wireless performance has largely tracked wireline performance, though with a certain lag factor.

---

[8] For more details, refer to the report from Rysavy Research, "Mobile Broadband Capacity Constraints and the Need for Optimization," February 16, 2010, http://www.rysavy.com/Articles/2010_02_Rysavy_Mobile_Broadband_Capacity_Constraints.pdf.

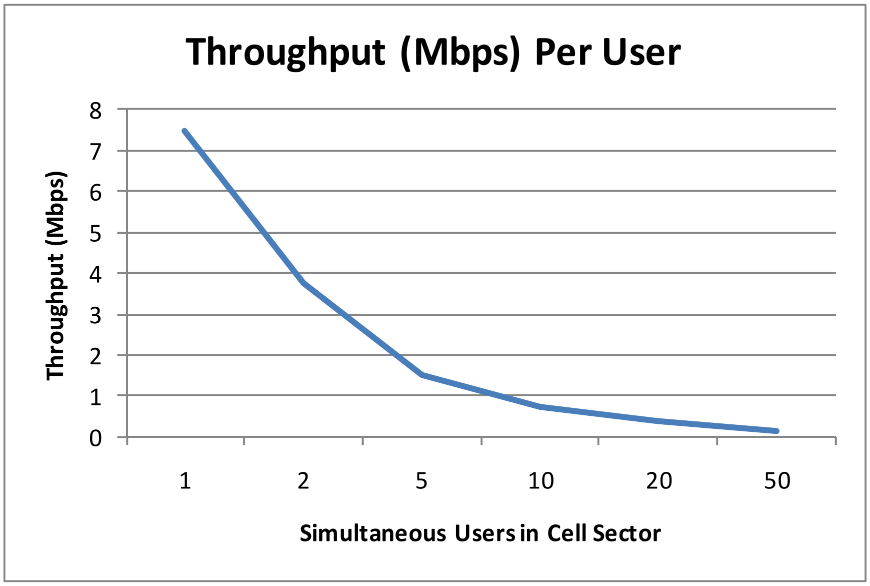
Figure 1: Historical Wireline vs. Wireless Throughputs



Wireless users cannot necessarily achieve the same throughputs over wireless connections as over wireline, but the throughput shortfall is minor enough, and the benefits of mobility so great, that the service remains compelling.

A chief consequence of insufficient spectrum is that since the radio channels are a shared resource, as the number of users increases, the average throughput that users experience will decrease to unacceptable levels. Consider a scenario of 20 MHz of spectrum allocated to HSPA, as shown in Figure 2. The effective throughput per active user depends on the number of simultaneous users in the cell sector. When going from 5 to 10 users, throughputs fall below 1 Mbps. Adding enough users (who by definition take their mobile devices from site to site) can result in users failing to benefit from a true broadband experience. Considering that in the U.S. there are on average 1,000 wireless subscribers per cell site, and up to three times this amount in busy markets, this means that the number of subscribers per cell sector can range from between about 300 and 1000. Ten active users only constitute 1% to 3% of total subscribers. Thus, just a small percentage of subscribers can consume available capacity.

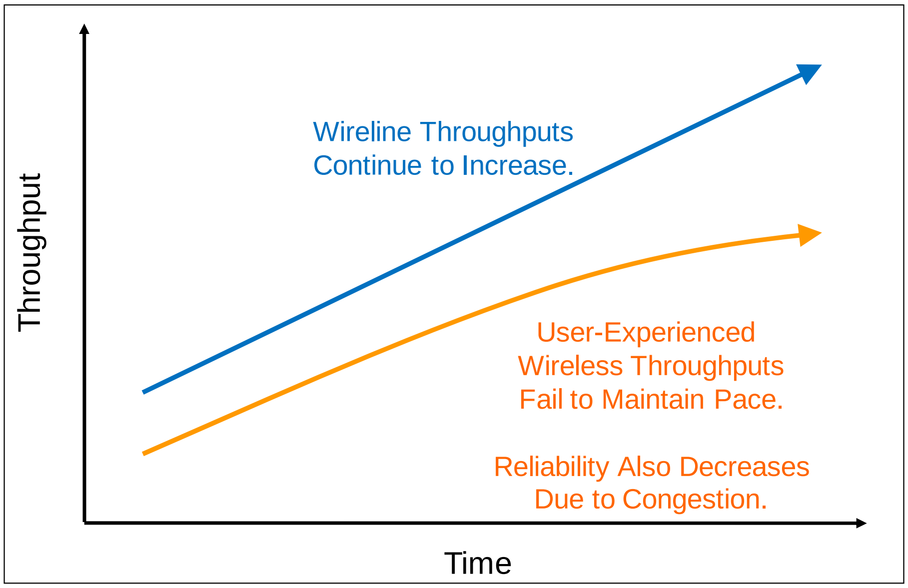
Figure 2: Throughput Per User Relative to Number of Users in Cell Sector



To increase the percentage of subscribers that can be supported will require more spectrum. In the absence of such spectrum, either only a small percentage of users will be able to enjoy a broadband experience, or a larger percentage will obtain sub-broadband performance.

Furthermore, as the number of broadband users increases in these limited-capacity scenarios, wireless networks will experience congestion, which has a number of undesirable consequences. Not only do throughput rates decrease as just discussed, packet latency (delay) increases, packets may be dropped, and communication transport layer protocols such as Transmission Control Protocol (TCP) can time out, as can applications. This results in excessive data retransmissions and poor application performance. Figure 3 illustrates the technical consequences of insufficient spectrum. The market consequence is that users find the service unattractive and stop using it, or that developers move their innovation to other markets that can better support new technologies.

Figure 3: Technical Consequences of Insufficient Spectrum



Deploying additional data channels with additional spectrum is the most effective way of adding data capacity. But the type of spectrum is also crucial. New technologies such as LTE are most effective and efficient when deployed in wide channels such as 10 or 20 MHz. Spectrum must also be at suitable frequencies that properly support mobility.

Service Plan Consequences of Insufficient Spectrum

We are at a critical point in time in which mobile-broadband will either become a transformative service fostering huge innovation and investment, or it will become a highly-constrained broadband solution with higher prices, compromised applications, and an industry that does not reach its potential.

Essentially, with constrained capacity, operators must manage demand so as not to overwhelm their networks. Among their tools for avoiding congestion, operators can change terms of service, utilize network management, and change service pricing.

For example, given limited capacity, operators will be required to take steps to prevent serious degradation of consumers' experience, perhaps by adjusting terms of service to limit applications such as Web servers operating over a wireless connection. This is because the server might have to deliver content to a large numbers of client systems, resulting in almost continuous use of the connection over extended periods of time. It is important to remember that the radio channel is a shared resource, meaning that one consumer's use of the network directly impacts the capacity and performance available to other consumers. But, beyond Web servers, there are other applications that can consume large amounts of data, such as video streaming. To control demand, an operator could disallow such applications, but in so doing, will limit what users can do with their broadband service. This will inevitably result in fewer subscribers since it is exactly these applications that users desire.[9]

Monthly usage caps are another way to control demand. In today's complex computer environments, however, there are many operations that consume bandwidth that are largely invisible to users. Examples are operating systems or security software receiving updates in the background. Many of today's caps were created so that "typical" usage is not impacted, but where "abusive" use is limited, thus providing the operator a tool to manage such users. The caps an operator imposes are based on available capacity. With constrained capacity, operators may have no choice, but to use highly restrictive caps. The consequence will be that an increasing percentage of users will exceed the caps, resulting in overage charges that are likely to frustrate subscribers and may dampen future usage. This will result in fewer subscribers, diminishing the cycle of innovation and usage described above.

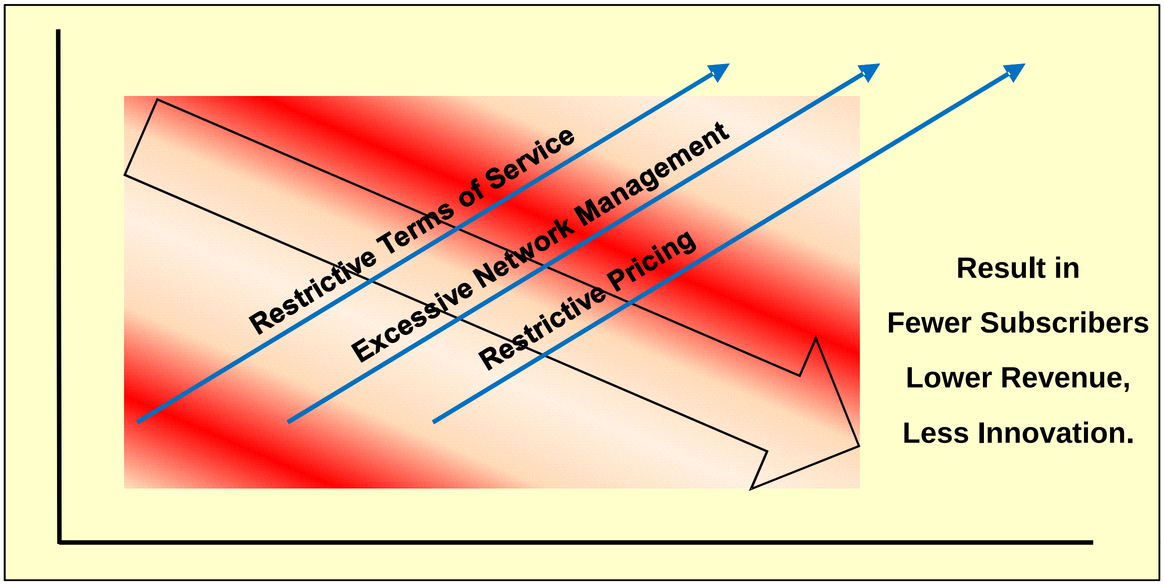
Network management provides another means of managing demand. Defined in wireless standards, policy management will allow operators to assign user traffic to different bearer channels that have different quality-of-service characteristics. Using these methods, an operator could, for example, provide a video stream with managed throughput if it falls within a service plan offer, or deliver it on a best-efforts basis otherwise. With sufficient capacity, dynamic policy management will enable a vast array of new service offerings that benefit all users. With insufficient capacity, however, the potential of this management will never be realized.

Another powerful tool that operators have to control demand is pricing. The simplest means to control demand is to institute strict usage-based pricing. Unfortunately, this will be contrary to what has enabled the wireless voice market to grow – relatively unrestricted usage through simple, predictable flat monthly rates. Innovative new pricing approaches, such as lower-rate monthly netbook plans, are now emerging, and other types of plans will follow. It is essential that pricing be at a level that allows subscribers to use a sufficiently broad range of applications. If pricing is too high, subscribers will either terminate their service or will never subscribe in the first place. Given the direction towards exhaustion of capacity, operators without additional spectrum may have no choice, but to initiate new pricing models that could inhibit market growth.

The consequence of the varying methods to restrict demand is fewer subscribers, lower revenues, less demand for innovative devices and applications, and lower productivity for the many areas that stand to benefit from the wireless ecosystem, as illustrated in Figure 4.

[9] For example, a large operator recently allowed the popular Sling Media video streaming service over its 3G network.

Figure 4: Lost Business Opportunity with Overly Restrictive Service



Regardless of the amount of capacity that operators provide, it is likely that users' data applications will always increase to consume available capacity. Therefore, operators will still need to employ the mechanisms discussed to control demand to some extent. But for market growth, these congestion-control mechanisms have to be at a level at which they do not constrain market adoption and growth, and they must be supplemented with increased capacity through additional spectrum. Otherwise, companies will reduce their investments, because of the limited business opportunity. This will lead to a downward market spiral.

Market Consequences

If networks cannot deliver the performance needed for the applications that subscribers wish to use, and if operators cannot offer service at price points and with terms of service that are attractive, the market will lose traction, and the effects will be multifold. Fewer people will subscribe to mobile-broadband services, and they will purchase fewer wireless applications. The burgeoning wireless applications market will fall short of its true potential. Wireless and mobile-computing chip vendors will sell fewer of their advanced integrated circuits. Mobile operating systems vendors will experience declining opportunities. And mobile operators will suffer diminishing wireless-data revenue. Regrettably, the virtuous cycle of innovation in the U.S. will falter as investors, developers, and manufacturers turn their attention to less-constrained platforms here in the U.S. and less-constrained markets elsewhere in the world. Other countries around the world have recognized the need to bring additional spectrum to market to prevent these potential market consequences – the U.S. needs to do the same in order to maintain its global wireless leadership.

Conclusion

Mobile broadband services are surging in popularity. Now, we are at a transformational juncture. Our current networks have demonstrated what is possible with mobile devices, wireless applications, and mobile broadband services, and the innovation is increasing every day. But our networks simply do not have the capacity to support continued wide-scale market growth without additional spectrum resources. Operators will use multiple methods to augment capacity, but ultimately additional spectrum is an absolutely crucial component. Without it, the market will stall due to less-attractive service plans and suboptimal technical performance.

Right now, the U.S. supports the most competitive and dynamic wireless computing environment in the world. Innovation and investment will go elsewhere if the market is constrained through lack of spectrum. Given that mobile computing is the forefront of computing and that wireless technology is the forefront of data communications, losing global leadership in these strategically important areas will ultimately lead to economic impacts that are so severe that they cannot, and should not, be permitted. As discussed throughout this paper, the key element to maintaining our global leadership in wireless is to provide sufficient spectrum resources to support the continued growth and evolution of the mobile ecosystem.