


# Spectrum Policy in the Age of Broadband: Issues for Congress

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# Summary

The convergence of wireless telecommunications technology and Internet protocols is fostering new generations of mobile technologies. This transformation has created new demands for advanced communications infrastructure and radio frequency spectrum capacity that can support high-speed, content-rich uses. Furthermore, a number of services, in addition to consumer and business communications, rely at least in part on wireless links to broadband backbones. Wireless technologies support public safety communications, sensors, medicine and public health, intelligent transportation systems, electrical utility smart grids, and many other vital communications.

Existing policies for allocating and assigning spectrum rights may not be sufficient to meet the future needs of wireless broadband and national broadband policy. A challenge for Congress is to provide decisive policies in an environment where there are many choices but little consensus. In formulating spectrum policy, mainstream viewpoints generally diverge on whether to give priority to market economics or social goals. Regarding access to spectrum, economic policy looks to harness market forces to allocate spectrum efficiently, with spectrum license auctions as the driver. Social policy favors ensuring wireless access to support a variety of social objectives where economic return is not easily quantified, such as improving education, health services, and public safety. Both approaches can stimulate economic growth and job creation. Choices about the direction of policy, however, can favor some industries over others.

Deciding what weight to give to specific goals and setting priorities to meet those goals pose difficult tasks for federal administrators and regulators and for Congress. Meaningful oversight or legislation may require making choices about what goals will best serve the public interest. Relying on market forces to make those decisions may be the most efficient and effective way to serve the public but, to achieve this, policy makers may need to broaden the concept of what constitutes competition in wireless markets.

This report considers the possibility of modifying spectrum policy: (1) to support national goals for broadband deployment by placing more emphasis on attracting new providers of wireless broadband services; and (2) to accommodate the wireless broadband needs of industries that are considered by many to be the economic drivers of the future, not only communications, but also areas such as energy, health care, transportation, and education.

Among the spectrum policy initiatives that have been proposed in Congress are: allocating more spectrum for unlicensed use; auctioning airwaves currently allocated for federal use; and devising new fees on spectrum use, notably those collected by the Federal Communications Commission (FCC). The FCC's statutory authority to implement these measures is limited. Substantive modifications in spectrum policy would almost surely require congressional action. The Radio Spectrum Inventory Act introduced in the Senate (S. 649, Senator Kerry) and the similar House-introduced Radio Spectrum Inventory Act (H.R. 3125, Representative Waxman) would require an inventory of existing users on prime radio frequencies, a preliminary step in evaluating policy changes. The FCC also has the opportunity to establish a new course for spectrum policy in the preparation of a Congressionally mandated report on broadband policy, due in February 2010.

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# Introduction

Wireless broadband[1] can play a key role in the deployment of broadband services. Because of the importance of wireless connectivity, radio frequency spectrum policy could be a critical factor in national broadband policy and planning. Wireless broadband, with its rich array of services and content, requires new spectrum capacity to accommodate growth. Spectrum capacity is necessary to deliver mobile broadband to consumers and businesses and also to support the communications needs of industries that use fixed wireless broadband to transmit large quantities of information quickly and reliably.

The purpose of spectrum policy, laws, and regulation is to manage a natural resource[2] for the maximum possible benefit of the public. Although radio frequency spectrum is abundant, usable spectrum is limited by the constraints of technology. Spectrum policy therefore entails making decisions about how radio frequencies will be allocated and who will have access to them.[3] Radio frequency spectrum is managed by the Federal Communications Commission (FCC) for commercial and other non-federal uses and by the National Telecommunications and Information Administration (NTIA) for federal government use. International use is facilitated by numerous bilateral and multilateral agreements covering many aspects of usage, including mobile telephony.[4]

Current spectrum policy relies heavily on auctions to assign spectrum rights through licensing. Economy of scale in wireless communications has become an important determinant in the outcome of these auctions. Companies that have already made substantial investments in infrastructure have been well placed to maximize the value of new spectrum acquisitions. Corporate mergers and acquisitions represent another way to improve scale economies. Efficiencies through economy of scale have contributed to creating a market for wireless services where four companies—Verizon Wireless LLC, AT&T Inc., Sprint Nextel Corporation, and T-Mobile USA Inc.—had approximately 90% of the customer base of subscribers at the end of 2008.[5] These companies also own significant numbers of spectrum licenses covering major markets nationwide.

The leading position of these few companies in providing a critical distribution channel—wireless—for information and services may need to be considered in plans for national broadband deployment. One approach to ensuring wireless access to meet national broadband goals might be

[1] Broadband refers here to the capacity of the radio frequency channel. A broadband channel can quickly transmit live video, complex graphics, and other data-rich information as well as voice and text messages, whereas a narrowband channel might be limited to handling voice, text, and some graphics. For an in-depth study of wireless broadband, see *Connected on the Go: Broadband Goes Wireless,* Wireless Broadband Access Task Force, Federal Communications Commission, February 2005 at http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-257247A1.pdf.

[2] The Code of Federal Regulations defines natural resources as "land, fish, wildlife, biota, air, water, ground water, drinking water supplies and other such resources belonging to, managed by, held in trust by, appertaining to, or otherwise controlled by the United States.... " (15 CFR 990, Section 990.30).

[3] Spectrum allocation and assignment is addressed in the section Spectrum Policy.

[4] The International Telecommunication Union (ITU), an agency of the United Nations, is the primary organization for coordinating global telecommunications and spectrum management.

[5] Subscribers are customers who have signed up for a plan, including those with more than one plan subscription; prepaid and pay-as-you go customers may not be included in reported totals. See **Appendix A**, Top Ten U.S. Wireless Companies by Number of Subscribers.

to change the regulatory structure under which wireless communications are managed. Another approach might seek ways to modify spectrum policies to accommodate the age of broadband.

# New Policies for New Technologies

With the introduction of auctions for spectrum licenses in 1994,[6] the United States began to shift away from assigning spectrum licenses based on regulatory decisions and toward competitive market mechanisms. One objective of the Telecommunications Act of 1996 was to open up the communications industry to greater competition among different sectors. One outcome of the growth of competition was the establishment of different regulatory regimes for information networks and for telecommunications. As a consequence of these and other legislative and regulatory changes, the wireless industry has areas of competition, e.g. for spectrum licenses, within a regulatory shell, such as the rules governing the Public Switched Telephone Network (PSTN).[7] Competitive wireless business plans therefore rely to some extent on the existence of regulated infrastructure. For example, most wireless calls that are voice communications pass through the PSTN, which is closely regulated. Access to the Internet, however, is through networks that use packet switching and may bypass the PSTN (and its rules about access and use). As the bulk of wireless communications traffic moves from voice to data, the necessary infrastructure is less regulated and companies will likely modify their business plans in order to remain competitive in the new environment. The shift in infrastructure technology and regulatory environment[8] could open wireless competition to companies with business plans that are not modeled on telecommunications industry formulae. Future providers of wireless broadband might include any company with a robust network for carrying data and a business case for serving broadband consumers. Potential new entrants, however, may lack access to radio frequency spectrum, the essential resource for wireless broadband.

## Policy Tools

Many factors shape spectrum policy decisions. The arrival of new technologies, societal values, political motivations, perceptions about the importance of technologies, and business climate are among the external forces that go into the making of spectrum policy. Policy, however, tends to be less flexible than technology. To benefit from new broadband technologies, a restructuring of spectrum policy and regulation may be needed to meet social and economic goals established by the Administration and Congress.[9]

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[6] The Federal Communications Commission (FCC) was given the authority to conduct auctions in the Omnibus Reconciliation Act of 1993 (P.L. 103-66).

[7] PSTN is a global system; rights of access and usage in the United States are regulated by the FCC.

[8] According to the FCC "... the mobile telephone industry is in the process of transitioning from the provision of interconnected mobile voice service and mobile data services over legacy mobile wireless networks to the provision of mobile voice and data services over mobile wireless broadband networks." *Thirteenth Report; annual report and analysis of competitive market conditions with respect to commercial mobile services*, FCC, DA 09-54, released January 16, 2009, paragraph 14 at http://hraunfoss.fcc.gov/edocs_public/attachmatch/DA-09-54A1.pdf., paragraph 30.

[9] The question as to whether "regulatory models" have kept up with changes in the wireless industry was raised in the opening statement of Senator John D. Rockefeller, IV at a hearing on "The Wireless Consumer Experience," Senate Committee on Commerce, Science, and Transportation, June 17, 2009. On a global level, the International Telecommunications Union (ITU) is considering how policies and regulations may need to be changed in response to new technologies. A World Telecommunication Policy Forum in April 2009, organized by the ITU, addressed these (continued...)

Policy tools that could be used to increase the availability of radio frequency spectrum for wireless broadband include allocating additional spectrum, reassigning spectrum to new users, requiring that wireless network infrastructure be shared, and changing the cost structure of spectrum access. Each of these possible solutions (and others not mentioned here) challenges the vested interests of current beneficiaries of past spectrum policy decisions. There is, therefore, an ongoing, vigorous debate as to how spectrum policies might be revised.

In a preliminary step to address this debate in the 111th Congress, two bills have been introduced that would require an inventory of spectrum bands and their users.[10] This information could be used to identify unused or potentially under-used radio frequencies that could be redirected to wireless broadband.

Several hearings have considered some aspects of wireless competition and spectrum policy. A subcommittee of the House Committee on Energy and Commerce explored a range of regulatory and other issues in a hearing on wireless competition on May 7, 2009.[11] Topics discussed at the hearing included rules governing cellular tower siting and zoning, the need for improving regulations for consumer protection at the state and federal level, the regulatory framework that governs wireless providers' access to high capacity infrastructure (special access), and the availability of spectrum. Wireless competition was also the main focus of two Senate hearings in June. The Senate Committee on the Judiciary, Subcommittee on Antitrust, Competition Policy and Consumer Rights held a hearing on "Cell Phone Text Messaging Rate Increases and the State of Competition in the Wireless Market," on June 16, 2009. The subcommittee focused on reports of significant increases in the price of sending text messages and how this might be an indicator of declining competitiveness but also considered other possible barriers to competition, such as market concentration, roaming fees, difficulties in obtaining spectrum, and handset exclusivity agreements. Handset exclusivity, and its roll in fostering or hindering competition and innovation, was the main topic of a hearing on "The Consumer Wireless Experience," held on June 17, 2009, by the Senate Committee on Commerce, Science, and Transportation. Access to wireless broadband in rural areas and the apparent failure of market competition to meet rural demand for services was also discussed as was the impact of spectrum policy on competition. Testimony from the Government Accountability Office (GAO) provided a report on consumer satisfaction and problems with wireless service.[12] This report presented preliminary observations based on ongoing work being performed at the request of the Senate committee and the House Committee on Energy and Commerce. The GAO preliminary findings were criticized by several members of the committee, including its Chairman, Senator John D. Rockefeller, IV, for not providing sufficient attention to the experiences of consumers in rural areas.[13]

(...continued)

and other topics. See http://www.itu.int/osg/csd/wtpf/wtpf2009/about.html.

[10] Radio Spectrum Inventory Act (S. 649) and Radio Spectrum Inventory Act (H.R. 3125).

[11] House of Representatives, Committee on Energy and Commerce, Subcommittee on Communications, Technology, and the Internet, "An Examination of Competition in the Wireless Industry," May 7, 2009.

[12] GAO, *Telecommunications: Preliminary Observations about Consumer Satisfaction and Problems with Wireless Phone Service and FCC's Efforts to Assist Consumers with Complaints*, Statement of Mark Goldstein, Director, Physical Infrastructure Issues, June 17, 2009, GAO-09-800T.

[13] Senate, Committee on Commerce, Science, and Transportation, "The Wireless Consumer Experience," June 17, 2009.

The ARRA, the American Recovery and Reinvestment Act of 2009 (P.L. 111-5), has provided for grants for investments in infrastructure to improve high-speed access to the Internet. Members of Congress have expressly urged, in a letter to the Federal Communications Commission, that "spectrum allocation, assignment, and use" be considered as part of a national broadband plan mandated by the ARRA.[14]

The Obama Administration has proposed that new fees be levied on spectrum use.[15] Other spectrum policy issues that may be considered by Congress include recommendations for more spectrum for unlicensed use and ensuring access to networks and services (an aspect of net neutrality).[16]

## Shared Resources

Among the regulatory options available to the FCC to increase the utility of available spectrum are various forms of sharing. Sharing resources is a growing trend that is viewed by regulators in many countries as a pro-competitive way to encourage the efficient deployment of next-generation wireless networks.[17] Requiring wholesale access to a network obliges the network owner to negotiate sharing agreements with third-party providers. Network sharing can also occur through co-ownership or co-operative agreements. Spectrum licenses can be shared by contract or regulatory requirement.

Among the methods of sharing wireless connectivity currently practiced in the United States are sharing network facilities, sharing network operations, and sharing spectrum. Examples of sharing include nationwide roaming,[18] selling packages of minutes purchased from a facilities-based network, leasing network capacity and spectrum access from a facilities-based network to create a new service provider—known as a Virtual Mobile Network Operator[19]—and spectrum sharing. In general, access is leased from an owner—of a tower, a network, or a spectrum license. Another option is to allocate spectrum for unlicensed use; any device authorized by the FCC may operate on the designated frequencies.

With the growing cost of building out network capacity to accommodate mobile broadband, some wireless carriers—notably in the European Union—are entering into cooperative agreements to jointly own and build networks; in this situation each carrier operates on its own frequencies. A regulatory challenge in overseeing co-operative networks is to ensure a level of transparency of operations to prevent collusion or other anti-competitive behavior.

[14] Letter to the Honorable Michael J. Copps, Acting Chairman, Federal Communications Commission from the chairmen and ranking members of the Committee on Energy and Commerce and the Subcommittee on Communications, Technology, and the Internet, House of Representatives, March 25, 2009.

[15] Proposal discussed in "Brief Analysis: President Obama's FY2010 Budget," Prepared by Senate Majority Staff, Senate Budget Committee, February 27, 2009, page 12. Background on the proposal is provided in this report under the section "Issues for Congress."

[16] The term net neutrality refers in general to the concept of access to the Internet with the minimum of intervention, regulation, or external control. A more detailed description of the concept and policy issues is available in CRS Report R40616, *Access to Broadband Networks: The Net Neutrality Debate* , by Angele A. Gilroy.

[17] *Trends in Telecommunication Reform 2008: Six Degrees of Sharing*, International Telecommunications Union, November 2008. Report available at http://www.ifap.ru/library/book385.pdf.

[18] The practice of transferring a wireless call from one network to another—or roaming—is described in *Understanding Wireless Telephone Coverage Areas,* FCC Consumer Facts at http://www.ifap.ru/library/book385.pdf.

[19] See **Appendix A**, Top Ten U.S. Wireless Companies by Number of Subscribers.

The primary difficulty for regulators in overseeing the sharing of spectrum is to minimize interference among devices operating on the same or nearby frequencies. It was primarily to prevent interference to wireless messages that spectrum licensing was first instituted. Today, a number of administrative and technological methods are available to minimize interference of wireless transmissions. In theory, all spectrum bands can be shared if interference can be managed. Among the technologies that facilitate spectrum sharing are cognitive radio and Dynamic Spectrum Access, also referred to as XG networks.[20] These enabling technologies allow communications to switch instantly among network frequencies that are not in use and therefore available to any radio device equipped with cognitive technology.

## Technology

Mobile communications became generally available to businesses and consumers in the 1980s. The pioneering cell phone technologies were analog.[21] Second-generation (2G) wireless devices were characterized by digitized delivery systems. Third-generation (3G) wireless technology represents significant advances in the ability to deliver data and images. The first commercial release of 3G was in Japan in 2001; the technology successfully debuted in the United States in 2003. 3G technologies can easily support multi-function devices, such as the BlackBerry and the iPhone. Successor technologies, often referred to as 4G, are expected to support broadband speeds that will rival wireline connections such as fiber optic cable, with the advantage of complete mobility. 4G wireless broadband technologies include WiMAX[22] and Long Term Evolution (LTE) networks. Both are based on TCP/IP, the core protocol of the Internet.

Wireless technologies that will facilitate broadband deployment and for which spectrum may need to be allocated include 4G networks; fixed wireless as an alternative to fiber optic cable; broadband on unlicensed frequencies (such as Wi-Fi); high performance mobile devices such as smartphones and netbooks; and cloud computing.[23]

# Broadband Requires Bandwidth

Growth and acceptance of these new technologies have been hampered in part by the limitations of the existing wireless network, much of it built for voice communications.[24] For example, the performance of the iPhone 3G, introduced in June 2008, confirmed what many iPhone users had already discovered: the commercial wireless network that supports the iPhone is not fully built

[20] The neXt Generation program, or XG, is a technology development project sponsored by the Strategic Technology Office of the Defense Advanced Research Projects Agency (DARPA). The main goals of the program include developing both the enabling technologies and system concepts that dynamically redistribute allocated spectrum.

[21] A wireless analog signal uses a continuous transmission form. Digital signals are discontinuous (discrete) transmissions.

[22] WiMAX stands for Worldwide Interoperability for Microwave Access.

[23] Key technologies for mobile broadband are summarized in **Appendix B**, Spectrum-Hungry Technologies.

[24] CTIA—The Wireless Association observed "Of course, 3G handsets cannot perform to their full potential without a strong network supporting them, and so carriers have made significant strides in bulking up the nation's infrastructure." See *Written Ex Parte Communication,* FCC, RM-11361; GN Docket No. 09-51; WC Docket No. 07-52, filed May 12, 2009.

and, as a consequence, in many areas of the country the range of iPhone features is curtailed or degraded.[25]

The story of the iPhone is indicative of the challenges faced by all wireless carriers as they move to 3G and 4G technologies: upgrading networks to meet consumer and business expectations for broadband services will require ongoing investments of billions of dollars annually.[26] For many companies, it will also require additional spectrum capacity. Web applications used on the iPhone have been described as "bandwidth hogs," based on a study that found that Web browsing was consuming 32% of data-related airtime and 69% of network bandwidth.[27]

Available means for increasing network capacity (bandwidth) include increasing spectral efficiency (usually by moving to a newer technology), increasing the number of cell sites,[28] and acquiring access to additional radio frequencies. Estimates of how much spectrum is needed for national coverage with 4G technologies vary but several experts have estimated that 40 MHz[29] is a minimum requirement per network, and 100 MHz of spectrum bandwidth might be needed for a network to meet demand for projected growth.[30]

# Broadband Policy and Spectrum Needs

In the American Recovery and Reinvestment Act of 2009 (ARRA), Congress has required the FCC to prepare a national broadband plan, to be delivered not later than February 17, 2010. The primary objective of the plan is "to ensure that all people of the United States have access to broadband capability.... " The plan is to include "an analysis of the most effective and efficient mechanisms for ensuring broadband access ... " and "a plan for use of broadband infrastructure and services in advancing consumer welfare.... "[31]

## Planning for Broadband

The FCC has issued a *Notice of Inquiry* to collect information and ideas for how to respond to Congress's mandate for a national plan for broadband.[32] In this notice, the FCC includes licensed

[25] "3G Phones Exposing Networks' Last Gen Technology," by Matt Richtel, The New York Times, March 14, 2009.

[26] AT&T, for example, announced plans to spend up to $18 billion on infrastructure investment in 2009, of which two-thirds would be to expand its wireless and wireline broadband networks. "AT&T to Invest More Than $17 Billion in 2009 to Drive Economic Growth," AT&T—News Room, March 10, 2009.

[27] "Heard on the Street/Financial Analysis and Commentary," *Wall Street Journal*, May 11, 2009. The cited percentages refer to traffic measured during one hour of wireless network traffic at midday.

[28] A cell site is the antenna and communications equipment placed on a tower or other structure to serve a small geographical area, or cell. Each cell provides capacity to serve expected demand. Within limits, increased demand can be met by increasing the number of cell sites.

[29] Spectrum is segmented into bands of radio frequencies and typically measured in cycles per second, or hertz. Standard abbreviations for measuring frequencies include kHz—kilohertz or thousands of hertz; MHz—megahertz, or millions of hertz; and GHz—gigahertz, or billions of hertz.

[30] The amount of capacity (MHz) needed is primarily a function of the size of the area covered, the type of traffic, the number of users, the technology used, and the desired levels of speed and reliability. At an FCC workshop on spectrum, September 17, 2009, 100 MHz was frequently cited as the likely increase needed for mobile broadband networks in five years time, http://www.broadband.gov/ws_spectrum.

[31] P.L. 111-5, Division B, Title VI, Sec. 6001 (k).

[32] *A National Broadband Plan for Our Future*, FCC, *Notice of Inquiry*, Docket No. 09-51, Released April 8, 2009.

and unlicensed radio frequencies as delivery channels for broadband.[33] It seeks comment on the effectiveness of current spectrum policies and asks whether access to spectrum may pose a constraint on broadband access and development.[34] However, in the same notice, regarding policies to increase the availability of spectrum for wireless broadband, the FCC states that it "has made significant wireless spectrum suitable for broadband service available through auction and through other mechanisms."[35] The notice does not commit to delivering a coordinated spectrum policy as part of the national plan for broadband.

## Meeting Broadband Policy Goals

Investment in broadband capacity is seen as a means to enhance America's global leadership by, for example, serving as: an economic driver; a creator of jobs; an equalizer in society; a tool for energy efficiency; a deliverer of health care and education; and a boon to business efficiency.[36] Some of these investments will be made through ARRA grants. It is too early to know how many of these investments will be through public-private partnerships. What is known is that the approximately $7 billion that will be channeled into broadband investments is a fraction of what is required to build the needed communications infrastructure, most of which up to now has been built by the private sector.[37] Absent additional appropriations of significant sums from the federal or state governments, the bulk of investment will continue to come from the private sector.[38] Access to spectrum could become a bottleneck and policies for allocating it could distort market decisions for investment.

Ideally, spectrum policy should be synchronized with broadband policy. The effort to move to energy efficiency is an example of how spectrum policy can affect other policy goals. The installation of smart meters in homes and other buildings is a key component of Smart Grid planning.[39] Establishing the connection between a home's smart meter and a utility could be done over wires, or with a wireless link over unlicensed or licensed frequencies. Coordinating Smart Grid goals with the goal of providing high-quality broadband to all could be achieved through the smart meter link by investing in fiber to the home (FTTH) or assuring that a wireless connection to a smart meter has sufficient bandwidth to provide robust broadband service. Furthermore, an efficient Smart Grid requires spectrum capacity to support the broadband communications infrastructure required to operate the grid. A Smart Grid policy that presumes the availability of suitable spectrum for wireless connections could fall short of its intended goal unless spectrum

[33] Ibid. For example, in paragraphs 19 and 20.

[34] Ibid. Paragraph 44.

[35] Ibid. Appendix A, paragraph 12.

[36] See CRS Report R40436, *Broadband Infrastructure Programs in the American Recovery and Reinvestment Act*, by Lennard G. Kruger.

[37] The International Telecommunications Union (ITU) has reported that United States networks need to invest an estimated $72 billion between 2008-2012 to meet growing demand for Internet access; an additional $42 billion to $55 billion would need to be spent to maintain US competitiveness, ITU, *Confronting the Crisis: Its Impact on the ICT Industry*, Section 4.1, January 2009.

[38] USTelecom—The Broadband Association reported investments in broadband infrastructure in the United States was $60 billion in 2008. "USTelecom Commends FCC's Plans to Develop a National Broadband Strategy," News, April 8, 2009, at http://www.ustelecom.org/News/NewsItems/USTelecom-Commends-FCCs-Plans-to-Develop-a-National-Broadband-Strategy.html.

[39] The Smart Grid is a suite of initiatives to improve energy efficiency. Interactive smart meters can monitor electric power consumption, inform consumers of steps to take to decrease consumption, and provide detailed usage reports to utilities. See http://www.oe.energy.gov/smartgrid.htm.

policy is aligned.[40] UTC—The Utilities Telecom Council—has published a report that argues for the allocation of 30 MHz of spectrum at 1800-1830 MHz to meet wireless communication needs.[41] *The Utility Spectrum Crisis: A Critical Need to Enable Smart Grids*, Utilities Telecom Council, January 2009, at http://www.utc.org/utc/utility-spectrum-crisis-critical-need-enable-smart-grids. Canada is in the process of a rule-making procedure that would make the 1800-1830 MHz band available for "electrical infrastructure."[42] The FCC has opened a pleading cycle for comments on the implementation of Smart Grid technology.[43] It includes questions about spectrum needs and use and its role in Smart Grid deployments.

# Spectrum Policy

Spectrum policy is shaped by decisions made by the FCC, acting on the statutory authority given to it by Congress. The FCC was created as part of the Communications Act of 1934[44] as the successor to the Federal Radio Commission, which was formed under the Radio Act of 1927.[45] The first statute covering the regulation of airwaves in the United States was the Radio Act of 1912, which gave the statutory authority to assign usage rights (licenses) to the Secretary of the Department of Commerce and Labor.[46] Licensing was necessary in part because, as radio communications grew, it became crucial that frequencies be reserved for specific uses or users, to minimize interference among wireless transmissions.[47]

A key component of spectrum policy is the allocation of bands of frequencies for specific uses and the assignment of licenses within those bands. Allocation refers to the decisions, sometimes reached at the international level, that set aside bands of frequencies for categories of uses or users; assignment refers to the transfer of spectrum rights to specific license-holders. Radio frequency spectrum is treated as a natural resource that belongs to the American people. The FCC, therefore, licenses spectrum but does not convey ownership. Before auctions became the primary method for assigning spectrum licenses the FCC used a number of different approaches, primarily based on perceived merit, to select license-holders.

## Introduction of Auctions

Auctions are regarded as a market-based mechanism for assigning spectrum. The FCC was authorized to organize auctions to award spectrum licenses for certain wireless communications

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41 *The Utility Spectrum Crisis: A Critical Need to Enable Smart Grids*, Utilities Telecom Council, January 2009 at http://www.utc.org/utc/utility-spectrum-crisis-critical-need-enable-smart-grids."

42 Gazette Notice SMSE-008-08, June 7, 2008 at http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf08971.html.

43 FCC, "Comments Sought on the Implementation of Smart Grid Technology" GN Docket Nos. 09-47, 09-51, 09-137, September 4, 2009 at http://hraunfoss.fcc.gov/edocs_public/attachmatch/DA-09-2017A1.pdf.

44 47 U.S.C. § 151.

45 P.L. 632, Sec. 3.

46 P.L. 264, "License."

47 The Radio Act of 1912 was passed partly in response to radio problems—including interference—associated with the sinking of the *Titanic*. Hearings Before a Subcommittee of the Committee on Commerce, 62nd Congress, 2nd Session, pursuant to S. Res. 283, "Directing the Committee on Commerce to Investigate the Cause Leading to the Wreck of the White Star Liner 'Titanic,'" testimony of Guglielmo Marconi, et al.

services in the Omnibus Budget Reconciliation Act of 1993 (P.L. 103-66). The act amended the Communications Act of 1934 with a number of important provisions affecting the availability of spectrum. The Licensing Improvement section[48] of the act laid out the general requirements for the FCC to establish a competitive bidding methodology and consider, in the process, objectives such as the development and rapid deployment of new technologies.[49] The law prohibited the FCC from making spectrum allocation decisions based "solely or predominately on the expectation of Federal revenues.... "[50] The Emerging Telecommunications Technologies section[51] directed the NTIA to identify not less than 200 MHz of radio frequencies used by the federal government that could be transferred to the commercial sector through auctions.[52] The FCC was directed to allocate and assign these released frequencies over a period of at least ten years, and to reserve a significant portion of the frequencies for allocation after the ten-year time span.[53] Similar to the requirements for competitive bidding, the FCC was instructed to ensure the availability of frequencies for new technologies and services, and also the availability of frequencies to stimulate the development of wireless technologies.[54] The FCC was further required to address "the feasibility of reallocating portions of the spectrum from current commercial and other non-federal uses to provide for more efficient use of spectrum" and for "innovation and marketplace developments that may affect the relative efficiencies of different spectrum allocations."[55] Over time, auction rules have been modified in accordance with the changing policy goals of the FCC and Congress but subsequent amendments to the Communications Act of 1934 have not substantively changed the above-noted provisions regarding spectrum allocation.[56]

Following passage of the Omnibus Budget Reconciliation Act of 1993, subsequent laws that dealt with spectrum policy and auctions included the Balanced Budget Act of 1997 (P.L. 105-33), the Auction Reform Act of 2002 (P.L. 107-195), the Commercial Spectrum Enhancement Act of 2004 (P.L. 108-494, Title II), and the Deficit Reduction Act of 2005 (P.L. 109-171). The Balanced Budget Act of 1997 contained several spectrum management provisions. For example, whereas previous statutes gave the FCC the authority to conduct auctions, the act required the FCC to use auctions to award ownership for most types of spectrum licenses.[57] The act also gave the FCC auction authority until September 30, 2007 (extended to September 30, 2011, by Deficit Reduction Act of 2005[58]). Furthermore, the act directed the FCC to allocate spectrum for "flexible use," which means defining new services broadly so that services can change as telecommunications technology evolves.

[48] P.L. 103-66 Title III, Subtitle C, Chapter 1.

[49] 47 U.S.C. § 309 (j), especially (1), (3), and (4).

[50] 47 U.S.C. § 309 (j) (7) (A).

[51] P.L. 103-66 Title III, Subtitle C, Chapter 2.

[52] 47 U.S.C. § 923 (b) (1).

[53] 47 U.S.C. § 925 (b) (1).

[54] 47 U.S.C. § 925 (b) (2).

[55] 47 U.S.C. § 925 (b) (3).

[56] See United States Code Annotated, Title 47, sections as footnoted, WEST Group, 2001 and the 2007 Cumulative Annual Pocket Part.

[57] 47 U.S.C. § 309 (j) (1).

[58] P.L. 109-171, Title III, Section 3003 (b).

## Spectrum Caps

As part of its preparations for the first spectrum license auctions, the FCC decided to set caps on the amount of spectrum any one company could control in any geographically designated market.[59] The theory behind spectrum capping is that each license has an economic value and a foreclosure value. The economic value is derived from the return on investment in spectrum licenses and network infrastructure. The foreclosure value is the value to a wireless company that already has substantial market share and wants to keep its dominant position by precluding competition. Spectrum caps were chosen as the method to prevent foreclosure bidding. The intent was to ensure multiple competitors in each market and to restrict bidding to only the licenses that could be used in the near term.

Beginning in 2001, spectrum policy placed increased emphasis on promoting spectrum and market efficiency through consolidation. The FCC ruled to end spectrum caps, citing greater spectral efficiency from larger networks as one benefit of the ruling. Spectrum caps were seen as barriers to mergers within the wireless industry, to the growth of existing wireless companies, and to the benefits of scale economies. The spectrum caps were eliminated on January 1, 2003.[60] Auction rules requiring the timely build-out of networks became a key policy tool to deter hoarding. The FCC instituted a policy for evaluating spectrum holdings on a market-by-market, case-by-case basis—a practice referred to as spectrum screening—as a measure of competitiveness.

In 2008, the Rural Telecommunications Group, Inc. (RTG) petitioned the FCC to impose a spectrum cap of 110 MHz for holdings below 2.3GHz. In October 2008, the FCC sought comments on the RTG petition for rulemaking.[61] RTG argued that competition in the industry was declining as it became more concentrated. It claimed that the larger carriers were warehousing their spectrum holdings in rural areas while rural carriers were struggling to acquire spectrum capacity for mobile broadband and expansion. Rural carriers, RTG reported, were being shut out of opportunities to acquire new spectrum holdings and were being outbid in spectrum auctions.[62] Opponents to the spectrum cap cited data to support their claims that the wireless communications market is competitive. They argued that additional amounts of spectrum are needed to support the growth in mobile broadband and that a spectrum cap could cut off growth and innovation.[63] Implementing spectrum caps as a tool for regulating competition would represent a significant shift in policy for the FCC, were it to take that course.

[59] Licenses are designated for a specific geographic area, such as rural areas, metropolitan areas, regions, or the entire nation.

[60] "FCC Announces Wireless Spectrum Cap to Sunset Effective January 1, 2003," FCC News, November 8, 2001. Report and Order FCC-01-328. See Docket No. 01-14, *Notice of Proposed Rulemaking*, released January 23, 2001 at http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-01-28A1.pdf.

[61] FCC RM No. 11498, October 10, 2008. Comments supporting and opposing the petition are published in this proceeding.

[62] Those supporting the RTG petition included the Organization for the Promotion and Advancement of Small Telecommunications Companies (OPASTCO), the National Telecommunications Cooperative Association, the Public Interest Spectrum Coalition, and a number of smaller (non-dominant) wireless carriers.

[63] Opponents to spectrum caps that filed comments were AT&T Inc., Verizon Wireless, CTIA – The Wireless Association, the Telecommunications Industry Association, and the Wireless Communications Association International.

## Market Concentration

Policies that have encouraged economies of scale have favored mergers and acquisitions of wireless companies. There are now four facilities-based[64] wireless companies in the United States that the FCC describes as nationwide: AT&T, Verizon Wireless, Sprint Nextel, and T-Mobile. [65] A combination of policy and market forces has divided the commercial wireless market into sharply different tiers.[66] The top-ranked provider, Verizon Wireless, ended 2008 with 83,700,000 subscribers. T-Mobile, the fourth largest company, reported 32,100,000 customers in 2008; the fifth ranked company, U.S. Cellular, had 6,200,000 customers with service contracts. Number ten on the list had 407,000 subscribers. Several hundred smaller carriers serve niche markets.

The FCC recognizes that the promotion of economy of scale favors market concentration, but concludes that "U.S. consumers continue to benefit from effective competition" in the commercial wireless marketplace, citing such factors as usage, pricing, the number of providers in individual markets, and improvements in quality of service, among other factors.[67]

## Providers to Markets

In measuring the number of service providers in a market, the FCC uses U.S. Census Data to identify the percentage of the population served by one or more providers, based on census block population figures. The most recent data, for example, indicates that 8,052,071 census blocks representing 284,153,539 inhabitants, 99.6% of the U.S. population, had at least one wireless service provider.[68] Based on providers to census blocks, 90.5% of the population lived in an area served by four or more companies, diminishing to 24.6% for six or more providers and 4.4% for seven or more. Some of the smaller companies included in the count of competitive providers may be able to stay in business because of subsidies and other policies for rural and underserved areas. Companies that benefit from special considerations might be able to serve a market, as measured by the FCC, but may not be influencing prices or stimulating innovation, two benefits of competition that are discussed in the following section.

Over the years, various legislative and policy initiatives have created a number of requirements to help small and rural carriers acquire spectrum licenses.[69] Some of the FCC's efforts to encourage spectrum license ownership for small, rural, or entrepreneurial businesses are in response to Congressional mandates.[70] These and other statutory and regulatory programs may have allowed many small carriers to remain in business even though many others have been absorbed by larger carriers.[71] As wireless traffic, revenue, and profits migrate to broadband, business models that

[64] Facilities-based mobile telephone operators own and operate their network facilities.

[65] *Thirteenth Report,* paragraph 14.

[66] See **Appendix A**, Top Ten U.S. Wireless Companies by Number of Subscribers.

[67] *Thirteenth Report*, paragraph 274.

[68] Ibid., page 6.

[69] For example, most auctions have provided bidding credits for small businesses.

[70] In 47 USC § 309 (j) (3) (B), the FCC is instructed to promote "economic opportunity and competition and ensuring that new and innovative technologies are readily available to the American people by avoiding excessive concentration of licenses and by disseminating licenses among a wide variety of applicants.... "

[71] The Congressional Budget Office (CBO) reported in a 2005 study that a significant number of small companies that acquired spectrum licenses through preferential programs later transferred the licenses to larger companies*: Small Businesses in License Auctions for Wireless Personal Communications Services*, A CBO Paper, October 2005, at (continued...)

were effective for voice traffic may no longer be viable, especially for companies that have relied on the regulatory environment to protect their markets. This change in operating environment may have disproportionately affected the ability of rural wireless carriers, in particular, to compete effectively.[72] A study of how new technologies might be affecting the competitiveness of small and rural carriers might be useful in reviewing the effectiveness of policies intended to aid them.[73]

Wireless companies also compete as providers in global markets. Although international traffic may be a small part of wireless voice communications, competition in providing services is global.[74] AT&T, Verizon, and T-Mobile are major players internationally as well as in the United States.[75] Corporate decisions such as the introduction of new technologies and services are made for both the United States and international markets. Actions taken for domestic markets may influence decisions made to enhance global competition and vice versa. Therefore, policies for assigning spectrum assets might incorporate U.S. goals for global competiveness.

# Market Competition

There are many ways to view competition. Although competitiveness may be evaluated by factors such as barriers to entry[76] or number of market participants, a key measure of whether market competition is working is an assessment of the dynamic of a specific market: its prices, variety, level of service, and other indicators that are considered hallmarks of competitive behavior. The Federal Trade Commission, for example, promotes competition as "the best way to reduce costs, encourage innovation, and expand choices for consumers."[77] Viewpoints about the level of competitiveness in providing wireless services to the U.S. market differ.[78] However, telecommunications business analysts generally describe the U.S. market for wireless services as competitive because consumers benefit in many ways from competition on price, service, coverage, and the availability of new devices.

Congress provided guidelines for measuring wireless competition in the Omnibus Budget Reconciliation Act of 1993. It directed the FCC to provide an annual report to Congress on

(...continued)

http://www.cbo.gov/ftpdocs/68xx/doc6808/10-24-FCC.pdf.

[72] A number of rural wireless carriers and their associations have filed comments on the increasing difficulties they face in competing for wireless customers. Comments are in a number of FCC dockets, such as RM11498, regarding spectrum caps, and WT Docket No. 09-66, on the state of wireless competition.

[73] The CBO study cited above was prepared at the request of the Senate Budget Committee to examine the impact of small-bidder preferences on federal revenue and was completed before data traffic became a significant factor in providing wireless services.

[74] The international framework for spectrum management and wireless competition is summarized in **Appendix D**, International Policies for Spectrum Management.

[75] Verizon Wireless is 45% owned by the British Telecommunications giant Vodafone, PLC. T-Mobile is 100% owned by Deutsche Telecom.

[76] Barriers to entry in the wireless market are discussed in **Appendix C**, Barriers to Competition in the Wireless Industry.

[77] "Competition in the Technology Marketplace" at http://www.ftc.gov/bc/tech/index.htm.

[78] Different assessments of competition in the wireless market have been filed as comments in FCC Docket No. 09-66, part of the process for the preparation of the FCC's *Fourteenth Report; annual report and analysis of competitive market conditions with respect to commercial mobile services.*

competition that would examine the number of competitors offering various services, assess the effectiveness of competition, evaluate whether any competitors have a dominant share of the market for such services, and prepare a statement about whether additional providers might enhance competition.[79] In interpreting these Congressional guidelines, the FCC has over the years placed the greatest emphasis on measuring competition in Commercial Mobile Radio Services (CMRS) through the examination of these factors: market structure; provider conduct; consumer behavior; and market performance.[80]

Both the wireless industry and its regulator have focused on "wireless consumer welfare"[81] in evaluating competition and the effectiveness of spectrum policies for assigning spectrum licenses. Auctions are judged to be an efficient way of assigning spectrum for commercial uses that adhere to traditional business plans.[82]

## Spectrum Auctions and Competition

Auction winners are deemed to be the companies that can maximize the value of the spectrum to society by maximizing its value as a corporate asset. However, auction-centric spectrum policies appear to have generally focused on assigning licenses to commercial competitors in traditional markets that serve consumers and businesses. Auctioning spectrum licenses may direct assets to end-use customers instead of providing wireless services where the consumer may be the beneficiary but not the customer. The role of wireless communications to support a smart grid has been briefly noted in this report. Spectrum resources are also needed for railroad safety,[83] for water conservation,[84] for the safe maintenance of critical infrastructure industries,[85] and for many other applications that may not have an immediate commercial value but can provide long-lasting value to society as a whole.

In its *Thirteenth Report* on competition, the FCC ratified its auction policies by citing the success of several new entrants in acquiring spectrum licenses at auction. It concluded that these successes demonstrated that spectrum allocation and assignment policies do not "create an

[79] 47 U.S.C. § 332 (c) (1) (C). The most recent report is *Thirteenth Report; annual report and analysis of competitive market conditions with respect to commercial mobile services*, FCC, DA 09-54, released January 16, 2009.

[80] *Thirteenth Report*, paragraph 5.

[81] This phrase is used in the written statement of AT&T Inc. submitted for a hearing before the House of Representatives, Committee on Energy and Commerce, Subcommittee on Communications, Technology, and the Internet, "An Examination of Competition in the Wireless Industry," May 7, 2009. In written testimony submitted by Verizon Wireless for the same hearing, comments stated that wireless providers need suitable and sufficient spectrum because of "consumers' reliance on broadband services."

[82] The GAO has reported this viewpoint in several reports, including *Telecommunications: Strong Support for Extending FCC's Auction Authority Exists, but Little Agreement on Other Options to Improve Efficient Use of Spectrum*," December 20, 2005, GAO-06-236 and *Telecommunications: Options for and Barriers to Spectrum Reform,* March 14, 2006, GAO-06-526T.

[83] The railroad industry uses wireless communications as part of their information networks to monitor activity.

[84] For example, sensors buried at the level of plant roots recognize when watering is needed and communicate this information over wireless networks.

[85] In general, critical infrastructure industries facilitate the production of critical goods and services such as safe drinking water, fuel, telecommunications, financial services, and emergency response. A discussion of key issues appears in CRS Report RL30153, *Critical Infrastructures: Background, Policy, and Implementation*, by John D. Moteff.

effective barrier to entry.... "[86] A different FCC study of market conditions,[87] however, questioned whether the comment process on proposed spectrum license auction and service rules might incorporate industry biases by relying on "the reported needs of interested parties,"[88] described in the study as companies with large holdings of spectrum licenses. The study suggests that large wireless companies with significant holdings of spectrum licenses and investment in infrastructure—the wireless incumbents—are disproportionately influencing the structure of auctions.

The rules set by the FCC for using spectrum licenses (service rules) may have been oriented toward the concepts of building and managing networks that were formed in the days of the telephone, favoring traditional telecommunications business plans over those of companies with different business models. Some companies that might be well suited to meet social goals, such as access in rural areas, might have been precluded from bidding at all because of constraints not considered relevant to market-driven allocations. For example, public utilities, municipal co-operatives, commuter railroads, and other public or quasi-public entities face a variety of legal, regulatory, and structural constraints that limit or prohibit their ability to participate in an auction or buy spectrum licenses. Many of these constraints exist at the state level but federal spectrum policy plays a role in perpetuating the status quo.

## Network Access and Competition

The belief that a competitive environment for providing wireless services is best served through spectrum auctions is widely supported by the leaders of the cell phone industry such as Verizon Wireless, AT&T Inc., and the industry association CTIA—The Wireless Association.[89] From the perspective of the information technology industry, however, there is concern that existing distribution channels for wireless are hampering the introduction of innovative wireless services and devices that might be marketed directly to consumers.

Although a number of computer and Internet equipment manufacturers are planning to enter the smartphone market with the intention of bringing their skills to the convergence of mobile and Internet technologies,[90]economic success of these products depends in part on access to radio frequencies that cover key markets nationwide.[91] Even long-established manufacturers of wireless devices, such as Motorola, Inc., are dependent on the major wireless companies for the success of their products, as these companies determine which devices reach their customers.[92] The *New York Times* has reported that sales of 100,000 units is considered the threshold for the market success of a wireless device.[93] Using this threshold as a guideline, wireless channels must be able

[86] *Thirteenth Report*, paragraph 68.

[87] OSP Working Paper Series # 43, A Market-based Approach to Establishing Licensing Rules: Licensed Versus Unlicensed Use of Spectrum, FCC, Office of Strategic Planning and Policy Analysis, February 2008. At http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-280523A1.pdf.

[88] Ibid., page 1.

[89] For example, CTIA Ex Parte filing with the FCC, January 8, 2008, Docket No. 07-71 at http://files.ctia.org/pdf/080108_US-OECD_10_Comparison_Ex_Parte.pdf.

[90] "Computer Makers Prepare to Stake Bigger Claim in Phones," by Ashlee Vance, The New York Times, March 16, 2009.

[91] See, for example, "A Dell Smartphone Would Face Big Hurdles," by Olga Kharif, *BusinessWeek*, March 25, 2009.

[92]"Motorola Scrambles to Restore Its Lost Cellphone Glory," by Matt Richtel, The New York Times, May 1, 2009.

[93] "Summer's Pocket-Size Blockbusters," by Matt Richtel, *New York Times*, May 18, 2009.

to reach enough customers so that at least 100,000 of them will buy a new wireless device. The need for a device manufacturer to partner with a large provider of wireless services could be viewed as a barrier to entry or as the means to achieve needed economies of scale.

In the 2008 auction of spectrum licenses at 700 MHz,[94] several companies associated with Silicon Valley and Internet ventures petitioned the FCC to set aside a block of spectrum as a national license with a requirement that the network be available—open—to all. Open access was defined as open devices, open applications, open services, and open networks.[95] The position put forward by these companies was that access of unlicensed airwaves was not enough to stimulate innovation and competition for new devices, services, and applications. They argued that innovators, especially start-up companies, were often closed out of markets unless they could convince a wireless network operator to accept and market their inventions.[96] The FCC subsequently ruled to auction licenses for 22 MHz of spectrum (designated as the C Block) with service rules requiring the first two criteria: open devices and open applications. The winning bidders, most notably Verizon Wireless,[97] are required to allow their customers to choose their own handsets and download programs of their choice, subject to reasonable conditions needed to protect the network from harm.

Proponents of open access argue that only an open network that anyone can use—not just subscribers of one wireless company—can provide consumer choice. From this perspective, a wholesale network could provide more market opportunities for new wireless devices, especially wireless devices that could provide unrestricted access to the Internet. A wholesale network would allow customers to choose their own wireless devices without necessarily committing to a service plan from a single provider. The network owner would operate along the same principles used for shopping malls, providing the infrastructure for others to retail their own products and services.

The FCC was also petitioned to designate spectrum licenses at 700 MHz for networks that would operate on a wholesale business model. It was argued that the wholesale business model would be the most viable for a small business new entrant and that the auction rules and conditions adopted by the FCC were prejudicial to small business.[98] Wireless incumbents, in particular, have challenged the concepts of open access and wholesaling. They have claimed that the unproven nature of a wholesale business model makes it risky and that therefore the auction value of licenses with a wholesaling requirement would be diminished. They have argued that imposing requirements that would create a wholesale network introduces an extra level of regulatory oversight, covering such areas as handset compatibility, applications standards, market access regulation, and interconnection rules.[99]

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[94] For information, see Auction 73 at http://wireless.fcc.gov/auctions/default.htm?job=auction_summary&id=73.

[95] FCC filings, WT Docket No. 96-86, by Frontline Wireless, LCC, Google, Inc., the 4G Coalition, and the Public Interest Spectrum Coalition.

[96] Comments, for example, made by Ram Shriram and Vanu Bose at the Frontline Town Hall, July 12, 2007, Washington, DC, and by Jason Devitt at a panel discussion during the State of the Net conference, January 30, 2008, Washington, DC.

[97] Of the 10 licenses of the C Block, seven were auctioned to Verizon Wireless: all six licenses covering the continental United States and a seventh license for Hawaii. Licenses providing coverage for Alaska, Puerto Rico, and the Gulf of Mexico were won by other bidders. See "FCC 700 MHz Band Auction, Auction ID:73, Winning Bids," attachment A, page 63, at http://hraunfoss.fcc.gov/edocs_public/attachmatch/DA-08-595A2.pdf.

[98] Petition for Reconsideration of Frontline Wireless, LLC, WT Docket No. 96-86.

[99] FCC filings, WT Docket No. 96-86, by CTIA-The Wireless Association, AT&T, and others.

# Issues for the 111th Congress

As the nation works toward development of a national broadband policy, Congress has indicated an interest in some aspects of related spectrum policies. As more information about broadband deployment and needs becomes available, Congress could choose to review existing policies, regulations, and legislation regarding spectrum management

## The Hunt for More Spectrum

Similar versions of a Radio Spectrum Inventory Act (S. 649, Senator Kerry and H.R. 3125, Representative Waxman) would require the FCC and NTIA to prepare an inventory of spectrum allocations and assignments in prime radio frequency bands. The Senate bill specifies a range from 300 MHz to 3.5 GHz, although an amendment added when the bill was voted out of committee would give the agencies discretion to expand the range.[100] The House bill specifies that the inventory cover frequencies from 225 MHz to 10 GHz. The information from the detailed report on users and uses would help policy makers evaluate whether spectrum is being allocated and used effectively.[101] The bills would require an accounting of spectrum allocation in the designated bands that would identify commercial license-holders, government agency spectrum allocations, and the number of devices deployed in those bands. If available, information would be provided on the types of wireless devices used on licensed frequencies and on unlicensed frequencies within each band. Contour maps and information on the location of base stations and other fixed transmitters might also be included in the inventory. The inventory results would be available over the Internet. Exemptions from public access to some information may be granted for reasons of national security, although the two bills vary on terms for these exemptions. The inventory is to be completed and submitted in reports to Congress within 180 days of passage into law.[102] The House version also would require the agencies to submit an update report to Congress annually that would identify the least used blocks of spectrum in the inventory and possibly recommend spectrum reallocation to a different use.

## License Fees

The 2010 fiscal year budget prepared by the Office of Management and Budget projects new revenue from spectrum license fees of $4.775 billion, based on the assumption that additional license fees will be collected by the FCC.[103] An analysis of the budget, prepared by the Majority Staff of the Senate Budget Committee, states that these would be user fees collected by the FCC on spectrum licenses that were assigned but not auctioned (unauctioned).[104] Similar suggestions

[100] Senate Committee on Commerce, Science, and Transportation, Mark Up, July 8, 2009.

[101] "Kerry, Snow Call for Inventory of Airwaves," Newsroom, Office of Senator John F. Kerry, March 19, 2009.

[102] The status of the bills can be monitored through the Legislative Information System (LIS) at http://www.congress.gov.

[103] *A New Era of Responsibility: Renewing America's Promise,* Office of Management and Budget, Table S-6, page 126, http://www.whitehouse.gov/omb/assets/fy2010_new_era/A_New_Era_of_Responsibility2.pdf.

[104] "Brief Analysis: President Obama's FY2010 Budget," Prepared by: Senate Majority Staff, Senate Budget Committee, February 27, 2009, page 12 at http://budget.senate.gov/democratic/statements/2009/Obama%20FY%202010%20Budget%20Brief%20Analysis_022709.pdf.

were made in successive budget proposals during the administration of President George W. Bush.[105]

Although Congress never took up legislation in response to the Bush Administration proposals, the 108th Congress instructed the GAO to take note of the possible impact of changing the spectrum license fee structure. In the Commercial Spectrum Enhancement Act (P.L. 108-494, Title II) the GAO was instructed to examine "national commercial spectrum policy as implemented by the Federal Communications Commission" and report on its findings in 2005.[106] The GAO was to examine the impact of auctioning licenses on the economic climate for broadcast and wireless technologies and to assess whether the holders of spectrum licenses received before the auction process was instituted (i.e., largely for free) have an economic advantage over license holders that purchased spectrum through the auction process. The GAO was also to evaluate whether the disparate methods of allocating spectrum had an adverse impact on the introduction of new services. The conclusions of the study were to be reviewed in the context of an Administration proposal to introduce license user fees on licenses that had not been auctioned. The GAO was also to provide an evaluation for Congress regarding the impact of assessing license fees on the competitive climate in the wireless and broadcast industries.

After consultation with the committees of jurisdiction, the GAO did not include an analysis of license fees in its report. Instead it focused on the impact of auctions on factors such as end-user prices, investment in infrastructure, and competition. One of the report's conclusions was that the cost of purchasing licenses did not affect price and competition in the long run because the cost was a one-time, sunk cost.[107] New licensing regimes were mentioned in the report as a possible means of increasing spectral efficiency but the suggestion received no discussion in the report.[108]

The FCC's statutory authority to impose new spectrum user fees is limited. The FCC was authorized by Congress to set license application fees[109] and regulatory fees to recover costs.[110] A new fee structure seeking recovery beyond costs would require Congressional authorization, either through an appropriations bill or new legislation. New fees could be difficult to devise as many of the licenses originally assigned at little cost to the acquirer were subsequently sold to other carriers.

It seems unlikely that new licensing fees would even out any competitive imbalances, if they exist, between companies that have purchased licenses and those that have not. Licensing fees might serve other policy goals, however. For example, if the purpose of a new user fee regime is to encourage more efficient use of spectrum, one approach might be to assess fees on any license-holder that does not take steps to maximize the benefit of its spectrum holdings. Fees could

[105] For example, the President's budget for FY2004 and again for 2006 proposed that (1) the FCC's authority to conduct auctions be extended indefinitely; (2) user fees be levied on unauctioned licensed spectrum; and (3) broadcasters pay an annual lease fee on analog TV spectrum that they are holding as part of the Congressionally-mandated transition to digital television. In his budget for 2005, the President supported proposals for indefinitely extending the FCC's auction authority and giving the FCC the authority to set user fees on unauctioned spectrum.

[106] P.L. 108-494, Title II, Sec. 209 (a).

[107] GAO, *Telecommunications: Strong Support for Extending FCC's Auction Authority Exists, but Little Agreement on Other Options to Improve Efficient Use of Spectrum*," December 20, 2005, GAO-06-236, page 2.

[108] Ibid., page 10, footnote 15.

[109] 47 USC § 158 (a).

[110] 47 USC § 159 (a).

become a tool for implementing wireless broadband if policy determines that broadband networks provide the maximum value to society (the ultimate owner of the spectrum holdings).

## Access to Spectrum

Past Congresses have introduced legislation addressing various aspects of access to spectrum and wireless networks. Among the issues that have been frequently raised and are still matters of concern to Congress are municipality-owned broadband networks, the possibility of creating a network that would offer free basic broadband connectivity for free, the designation of new frequencies for unlicensed use, and public safety communications.

### Community Broadband

Rural communities have on occasion used their resources to install fiber-optic networks in part because they were too small a market to interest for-profit companies. Networks that depend on a fiber-optic cable backbone are capital-intensive and usually more profitable in high-density urban areas. Increasingly, communities of all sizes are looking at wireless technologies to support their networks. Municipalities, for example, are installing free Wi-Fi zones. Among the reasons often cited for installing wireless facilities are that generally available access to the Internet through wireless connections has become an urban amenity, a necessity in sustaining and developing the local economy, and a part of essential infrastructure with many public benefits.[111]

Opponents to community-owned networks contend that they provide unfair competition, distorting the marketplace and discouraging commercial companies from investing in broadband technologies. In particular, the fact that urban areas are creating Wi-Fi networks and providing, among other services, free wireless links to the Internet is viewed as a threat to commercial companies.

Several states have passed laws prohibiting or limiting local governments' ability to provide telecommunications services. An effort to challenge such a law in Missouri by municipalities offering local communications services in the state was heard before the U.S. Supreme Court in 2004.[112] In the Telecommunications Act of 1996, Congress barred states from "prohibiting the ability of any entity to provide any interstate or intrastate telecommunications service."[113] The Court ruled that "entity" was not specific enough to include state political divisions; if Congress wished specifically to protect both public and private entities, they could do so by amending the language of the law. This Court decision and the steady improvement in broadband communications technologies that municipalities wish to have available in their communities have provided fuel for a policy debate about access to broadband services.

### National Deployment of Free Broadband

During 2007, the FCC was petitioned by several companies, led by M2Z Networks Inc., to release 20 MHz of spectrum licenses at 2155-2175 MHz for a national broadband network. M2Z

[111] The Federal Trade Commissions' Internet Access Task Force has published a report discussing many aspects of municipal broadband implementation and related issues, at http://www.ftc.gov/opa/2006/10/muniwireless.htm.

[112] U.S. Supreme Court, Docket Number 02-1238.

[113] 47 U.S.C. 253 (a).

offered to provide free basic service to consumers and public safety and offer content filtering for family-friendly access. In return for the grant of the license, which would be assigned without auction, M2Z offered to pay a percentage of gross revenues to the U.S. Treasury. In September 2007, the FCC issued a Notice of Proposed Rulemaking to establish service rules for the auction of a license or licenses at 2155-2175 MHz, designated as Auction AWS-3.[114] Proposed provisions include obligations to offer free broadband service similar to that proposed by M2Z and family-friendly access. The proposed spectrum band is adjacent to bands previously auctioned in the Advanced Wireless Service (AWS-1) auction that concluded in 2006. T-Mobile, a major winner in the AWS-1 auction, has stated to the FCC that the network proposed by M2Z would cause "pervasive harmful interference" to licensees of the AWS frequencies.[115] The concept of a lifeline broadband service has significant support from many policy makers in Congress. The FCC did not act on the auction proposal and the issues surrounding it remain unresolved.

## Unlicensed Use

Unlicensed spectrum is not sold to the highest bidder and used for the services chosen by the license-holder but is instead accessible to anyone using wireless equipment certified by the FCC for those frequencies. Both commercial and non-commercial entities use unlicensed spectrum to meet a wide variety of monitoring and communications needs. Suppliers of wireless devices must meet requirements for certification to operate on frequency bands designated for unlicensed use. Examples of unlicensed use include garage door openers and Wi-Fi communications.

New technologies that can use unlicensed spectrum without causing interference are being developed for vacant spectrum designated to provide space between the broadcasting signals of digital television, known as white spaces. On September 11, 2006, the FCC announced a timetable for allowing access to the spectrum so that devices could be developed.[116] Devices using the white space frequencies would be required to incorporate geolocation technology to signal when and where potential interference was detected.[117] The National Association of Broadcasters (NAB), and others, have protested the use of white space for consumer devices on the grounds that they could interfere with digital broadcasting and with microphones used for a variety of purposes.[118] Companies such as Microsoft, Dell, and Motorola, however, have stated the belief that solutions can be found to prevent interference. In November 2008, the FCC established rules that permit the unlicensed use of the white spaces, with special provisions to protect microphone use.[119]

[114] FCC, *Notice of Proposed Rulemaking*, WT Docket No. 07-195, released September 19, 2007.

[115] See for example, comments by T-Mobile USA, Inc. filed July 25, 2008, FCC Docket No. 07-195.

[116] FCC, First Report and Order and Further Notice of Proposed Rule Making, ET Docket No. 04-186, released October 18, 2006.

[117] Geolocation associates a geographic location with a device using embedded information such as an IP address, Wi-Fi address, GPS coordinates, or other, perhaps self-disclosed information. Geolocation usually works by automatically looking up an IP address.

[118] In addition to filed comments with the FCC. NAB, the Association for Maximum Service Television, and a coalition of theater groups, sports leagues, and TV networks have challenged the FCC white spaces order in the U.S. Court of Appeals for the District of Columbia.

[119] FCC News, "FCC Adopts Rules for Unlicensed Use of Television White Spaces," November 4, 2008.

### Public Safety

The transition from analog to digital television freed up spectrum in the 700 MHz band. Most of this spectrum was auctioned in 2008. Congress had previously directed the FCC to assign 24 MHz in this band to public safety use;[120] these frequencies were therefore not part of the 2008 auction. Provisions in the auction rules, however, provided for a new, interoperable communications network for public safety users to be shared with commercial users.[121] A Public Safety Licensee was designated by the FCC and assigned a single, national license for part of the 24 MHz originally set aside for public safety use. A national license for 10 MHz, designated as Upper Block D, was put up for auction under service rules that required working with a Public Safety Licensee to build and manage a shared network. The costs of building the network would be borne by the D Block licensee. The two licensees (public safety and commercial) would have been required to negotiate a Network Sharing Agreement, subject to FCC approval.[122] The auction did not yield a winner for the D Block and so the FCC began the process of drafting new auction rules for that license.[123] A new auction for the D Block has yet to be announced.

There is currently no federal plan to assist in building a nationwide, interoperable network for public safety; a partnership would give some public safety agencies access to private-sector capital and expertise to build the network. Although public safety users would be charged for access to the network, proponents of the plan argued that overall costs would be less than if the network were purely for public safety, because of greater economies of scale. The FCC agreed that sharing was desirable, citing reasons such as efficient use of spectrum resources. Sharing would provide public safety with the communications capacity to respond in critical situations and also support commercial uses in normal circumstances. However, the FCC may need assistance from Congress in order to further plans for a shared network. Several proposals for how to create this network would require Congress to amend past legislation; federal funding might also be necessary to aid in the planning and building of the envisioned network.

# Conclusion

Telephone service was once considered a natural monopoly, and regulated accordingly. The presumption was that redundant telephone infrastructure was inefficient and not in the public interest. State and federal regulators favored granting operating rights to a single company, within a specific facilities territory, to benefit from economies of scale, facilitate interoperability, and maximize other benefits. In return for the monopoly position, the selected provider was expected to fulfill a number of requirements intended to benefit society. Thus, for decades, the regulated monopoly was seen by most policy-makers as (1) ensuring that costly infrastructure was put in place and (2) meeting society's needs, as interpreted by regulations and the law.[124] Past policies to regulate a monopolistic market may have influenced current policies for promoting competition.

[120] As required by Title III of the Balanced Budget Act of 1997 (P.L. 105-33).

[121] *Service Rules for the 698-746, 747-762 and 777-792 MHz Bands*, FCC. *Second Report and Order*, Docket No. 06-150, released August 10, 2007 at http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-07-132A1.pdf.

[122] FCC plans for the D Block are discussed in CRS Report RL34054, *Public-Private Partnership for a Public Safety Network: Governance and Policy*, by Linda K. Moore.

[123] *Auction of the D Block License in the 758-763 and 788-793 MHz Bands*, FCC, *Order*, Docket No. 07-157, released March 20, 2008 at http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-08-91A1.pdf.

[124] The original Communications Act of 1934 codified many regulations for monopolies as practiced at the time.

The FCC's emphasis on efficiency for delivering services to a pre-determined market could be leading wireless competition toward monopoly; new regulatory regimes might be a consequence of this trend, if it continues.

Current spectrum policy seeks to maximize the value of spectrum by encouraging economies of scale and appears to treat spectrum assets as an extension of existing infrastructure (spectrum license ownership and network management, for example) instead of an alternative infrastructure (Wi-Fi and wireless backhaul are examples). This policy course has provided a form of workable competition that has brought wireless services (until 2006, almost exclusively voice) at affordable prices to most of the country. However, wireless technology has reached an inflection point and is shifting from voice to data. Some argue that wireless policy should also shift, placing a greater value on innovation to achieve goals deemed to be in the public interest. A policy that prioritizes providing spectrum to spur innovation, for example, could create new markets, new models for competition, and new competitors. If spectrum policy serves broadband policy and broadband policy serves multiple sectors of the economy, then perhaps spectrum should be more readily available for a wider pool of economic participants.

The amount of spectrum needed for fully realized wireless access to broadband is such that meeting the needs of broadband policy goals could be difficult to achieve through the market-driven auction process unless large amounts of new radio frequencies can be identified and released for that purpose.[125] Without abandoning competitive auctions, spectrum policy could benefit from including additional ways to assign or manage spectrum that might better serve the deployment of wireless broadband and the implementation of a national broadband policy.

In response to Congress's intent to use competitive methods to expand the market for wireless service, the FCC spliced a competitive model onto a regulatory root. The resulting hybrid achieved the goal of spreading wireless access but may have excluded innovative new players. The policies worked well enough when most of wireless traffic was voice. They may not work well enough to meet the new goals that Congress and the Administration are setting for broadband deployment and technology as an engine of growth.

[125] International Telecommunications Union projects an estimated need for additional spectrum capacity that could reach nearly 1,000 MHz, as reported in "Summary of Results of ITU-R Report M. 2079," page 13, presented by Cengiz Evci, Chief Frequency Officer, Wireless Business Group, Alcatel-Lucent, August 28, 2007. Available at http://standards.nortel.com/spectrum4IMT/Geneva/R03-WRCAFR07-C-0024.pdf.

# Appendix A. Top Ten U.S. Wireless Companies by Number of Subscribers

The following table is based on Federal Communications Commission (FCC) rankings of facilities-based wireless companies[126] for 2007,[127] updated to reflect reported numbers of customers at year end 2008. The United States had approximately 270 million mobile phone subscribers at the end of 2008.[128] Not included in this table are resellers such as Virtual Mobile Network Operators (VMNOs) which create virtual networks by purchasing access from facilities-based operators.

Customers for prepaid wireless services are a growing segment of the wireless market. The two largest companies specializing in prepaid services are VMNOs: TracFone Wireless with 11 million customers and Virgin Mobile USA with 5.38 million customers. On July 28, 2009, Sprint Nextel announced its intention to acquire Virgin Mobile USA.[129]

**Table A-1. Facilities-Based Wireless Companies Ranked by U.S. Subscribers**

| Company | Wireless Customers in Thousands |
|---|---|
| Verizon Wireless | 83,700 |
| AT&T Mobility | 77,000 |
| Sprint Nextel | 50,500 |
| T-Mobile | 32,100 |
| U.S. Cellular | 6,200 |
| Metro PCS | 5,400 |
| Leap Wireless International | 3,840 |
| Centennial Wireless[a] | 1,100 |
| Cincinnati Bell Wireless | 551 |
| nTelos Wireless | 407 |

**Source:** Compiled by CRS from company annual reports and press releases.

a. Subject to FCC approval and other conditions, AT&T expects to acquire Centennial Communications in 2009. 2008 wireless subscriber number is for the United States and Puerto Rico.

[126] Facilities-based mobile telephone operators own and operate their network facilities.

[127] *Thirteenth Report; annual report and analysis of competitive market conditions with respect to commercial mobile services*, FCC, DA 09-54, released January 16, 2009, Table A-4, page 138.

[128] Statistic provided by CTIA—The Wireless Association.

[129] Sprint News Release, Sprint Nextel to Acquire Virgin Mobile USA," July 28, 2009 at http://newsreleases.sprint.com/phoenix.zhtml?c=127149&p=irol-newsArticle_newsroom&ID=1312854.

# Appendix B. Spectrum-Hungry Technologies

Enabling technologies that are fueling both the demand for mobile broadband services and the need for radio frequency spectrum include Long Term Evolution, WiMAX; fixed wireless; Wi-Fi; high performance mobile devices such as smartphones and netbooks; and cloud computing. Fixed wireless and Wi-Fi are not new technologies but mobile broadband has given them new roles in meeting consumer demand.

## Long Term Evolution (LTE)

LTE is the projected development of existing 3G networks built on Universal Mobile Telephone System (UMTS) standards.[130] Like all fourth-generation wireless technologies, LTE's core network uses Internet protocols. The network architecture is intended to facilitate mobile broadband deployment with capabilities that can deliver large amounts of data, quickly and efficiently, to large numbers of simultaneous users. LTE will likely be implemented in stages through modifications to networks using frequencies in bands already allocated for commercial wireless networks.[131] LTE can also operate on spectrum bands at 2.3 GHz, 2.5 GHz, and 3.4 GHz.[132] Many of the global mobile network operators have reportedly announced their intention to move to LTE. [133] Verizon plans to provide LTE service to 25 to 30 U.S. markets by the end of 2010.[134]

## WiMAX

WiMAX provides mobile broadband but its earliest applications were for fixed wireless services. WiMAX (Worldwide Interoperability for Microwave Access) refers to both a technology and an industry standard, the work of an industry coalition of network and equipment suppliers.[135] WiMAX uses multiple frequencies around the world in ranges from 700 MHz to 66 GHz. In the United States, available frequencies include 700 MHz, 1.9 GHz, 2.3 GHz, 2.5 GHz and 2.7 GHz.

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[130] Alcatel-Lucent, a major communications technology provider, on March 31, 2009 announced a network technology that can simultaneously support LTE and the 3G standard known as CDMA. Press release at http://www.alcatel-lucent.com/wps/portal/!ut/p/kcxml/04_Sj9SPykssy0xPLMnMz0vM0Y_QjzKLd4x3tXDUL8h2VAQAURh_Yw!!?LMSG_CABINET=Docs_and_Resource_Ctr&LMSG_CONTENT_FILE=News_Releases_2009/News_Article_001510.xml. See also, "Mobile Broadband Evolution: the roadmap from HSPA to LTE," UMTS Forum, February 2009, Universal Mobile Telephone System Forum at http://www.umts-forum.org/.

[131] The FCC has approved an LTE device that will transmit in the 1,700 MHz band and receive in the 2,100 MHz band. FCC, *Certificate of Compliance, Test Report*, Report No. HCT-RF09-0309, FC ID: BEJLEO3, March 9, 2009. LTE is also expected to be approved for operation on spectrum licenses at 700 MHz.

[132] Spectrum is segmented into bands of radio frequencies and typically measured in cycles per second, or hertz. Standard abbreviations for measuring frequencies include kHz—kilohertz or thousands of hertz; MHz—megahertz, or millions of hertz; and GHz—gigahertz, or billions of hertz.

[133] "Mystery LTE Device Gets OK From FCC," by Marin Perez, Information Week, March 20, 2009.

[134] "Verizon's Seidenberg: Wireless Industry Innovation Can Help Put U.S. Economy Back on Path to Growth," Verizon News Release, April 1, 2009, http://newscenter.verizon.com/press-releases/verizon/2009/verizons-seidenberg.html.

[135] Founding members of the WiMAX Forum include Airspan, Alvarion, Analog Devices, Aperto Networks, Ensemble Communications, Fujitsu, Intel, Nokia, Proxim, and Wi-LAN. For additional information, see http://www.wimaxforum.org/.

The introduction of WiMAX in the United States is being jointly led by Sprint Nextel Corporation and Clearwire Corporation under the name Clearwire. Clearwire Wi-MAX, branded CLEAR, plans to serve 80 markets by the end of 2010.[136]

## Fixed Wireless Services

Fixed wireless services have taken on new importance as a "backhaul" link for 4G. Backhaul is the telecommunications industry term that refers to connections between a core system and a subsidiary node. An example of backhaul is the link between a network—which could be the Internet or an internetwork that can connect to the Internet—and the cell tower base stations that route traffic from wireless to wired systems. Two backhaul technologies well-suited for mobile Internet access are fiber optic cable and point-to-point microwave radio relay transmissions.[137] Network expansion plans for WiMAX and LTE include microwave links as a cost-effective substitute for fiber optic wire under certain conditions. Radio frequencies available in the United States for microwave technologies of different types start in the 930 MHz band and range as high as the 90 GHz band. It is possible that some frequencies may be designated for wireless backhaul in frequencies between 450 MHz and 698 MHz.[138]

## Wi-Fi

The popularity of Wi-Fi is often cited as a successful innovation that was implemented using unlicensed frequencies.[139] Wi-Fi provides wireless Internet access for personal computers and handheld devices and is also used by businesses to link computer-based communications within a local area. Links are connected to a high-speed landline either at a business location or through hotspots. Hotspots are typically located in homes or convenient public locations, including airports and café environments such as Starbucks. In 2008, there were over 7,000 Starbucks locations with Wi-Fi access in the United States.[140]

Wi-Fi uses radio frequencies in the free 2.4 GHz and 5.4/5.7GHz spectrum bands. Many 3G and 4G wireless devices that operate on licensed frequencies can also use the unlicensed frequencies set aside for Wi-Fi.[141] In 2008, 387 million Wi-Fi chip sets were shipped, worldwide. Of these 200 million were for use in cellular Wi-Fi phones, smartphones, personal computer notebooks, and other mobile Internet devices.[142]

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[136] "Clearwire Launches Development Network," by Marguerite Reardon, CNET Reviews, CTIA 2009, April 2, 2009, http://reviews.cnet.com/8301-12261_7-10210495-51.html

[137] A discussion of backhaul technology is part of the testimony of Ravi Potharlanka, Chief Operating Officer, Fiber Tower Corp., at House of Representatives, Committee on Energy and Commerce, Subcommittee on Communications, Technology, and the Internet, "An Examination of Competition in the Wireless Industry," May 7, 2009.

[138] Being considered under FCC ET Docket No. 04-186.

[139] Unlicensed frequencies are bands set aside for devices approved by the FCC. The frequencies are effectively managed by the FCC instead of by a license-holder.

[140] "Starbucks to Expand Technology Relationship with AT&T," Starbucks Corporation Press Room, February 11, 2008, http://www.starbucks.com/aboutus/pressdesc.asp?id=826.

[141] "Wi-Fi Popular Now in Smartphones, Set to Boom," by Matt Hamblen, Computerworld, April 1, 2009.

[142] "Wi-Fi Chipset Sales Grew 26 Percent to 387 Million in 2008," Wi-Fi Alliance Press Room, January 8, 2009, http://www.wi-fi.org/pressroom_overview.php?newsid=770.

## Smartphones and Netbooks

Two of the fastest growing segments in the category of mobile Internet devices are smartphones and netbooks. The introduction of Apple Inc.'s iPhone, in January 2007, is widely viewed as heralding a new era in wireless smartphones. The smartphone market is predicted to thrive on growing demand for downloadable applications,[143] interactive websites, and imaginative videos—all delivered wirelessly. A parallel development has been the accelerating use of netbooks. These book-sized laptop computers are designed to provide broadband wireless access to the Internet.[144] The line between smartphone and netbook technologies is fading as the newer generations of these devices provide many of the same features. The majority of these new devices can operate on Wi-Fi as well as over 3G and 4G networks using licensed frequencies.

## Cloud Computing

Cloud computing is a catch-all term that is popularly used to describe a range of information technology resources that are separately stored for access through a network, including the Internet. An Internet search on Google, for example, is using cloud computing to access a rich resource of data and information processing. Network connectivity to services is another resource provided by cloud computing. Google Inc. also offers word processing, e-mail and other services through Google Docs. Although off-site data processing and information storage are not new concepts, cloud computing benefits from the significant advances in network technology and capacity that are hallmarks of the broadband era. Cloud computing can provide economies of scale to businesses of all sizes. Small businesses in particular can benefit from forgoing the costs of installing and managing hardware and software by buying what they need from the cloud. Consumers also can benefit because they no longer need to buy personal computers in order to run complex programs or store large amounts of data. The convergence of 4G wireless technology—with its smartphones and netbooks—and the growing accessibility of cloud computing to businesses and consumers alike will contribute to the predicted explosive growth in demand for wireless bandwidth.[145]

[143] See, for example, "Smart Phones are Edging Out Other Gadgets," by Christopher Lawton and Sara Silver, The Wall Street Journal, March 25, 2009, for a discussion of how "beefed up cellphones" are replacing some electronic devices as their functions are incorporated into smart phones.

[144] "Light and Cheap, Netbooks Are Poised to Reshape PC Industry," by Ashlee Vance and Matt Richtel, The New York Times, April 2, 2009.

[145] The many factors driving demand for mobile broadband and the impact of growth in data and video services on demand for spectrum are reviewed in *Mobile Spectrum Broadband Demand*, Rysavy Research, December 2008.

# Appendix C. Barriers to Competition in the Wireless Industry

In evaluating competition within an industry, economists and policy makers examine barriers to entry, among other factors.[146] Barriers might come from high costs for market entry such as investment in infrastructure or there might be legal and regulatory barriers to entry. The Federal Communications Commission (FCC) has noted the possibility of "coordinated interaction" among wireless providers in pricing and services, which it attributes primarily to a concentrated market and barriers to entry such as high capital costs.[147] As part of its evaluation of competition for mobile services, the FCC has identified three factors that could constitute barriers to entry to the commercial mobile communications industry. These barriers affect not only competitiveness but also access to networks and investment in new technology. The factors are: "first-mover advantages, large sunk costs, and access to spectrum."[148] All three of these factors are subject to regulations that have been influenced by past or existing policies regarding spectrum allocation and assignment.

First-mover advantages[149] have accrued primarily to the early entrants in the wireless industry. Early in the development of the cell phone industry, the FCC created cellular markets and assigned two spectrum licenses to each market; one license went automatically to the incumbent provider in that market. The second license was made available to a competing service provider (not the market incumbent); the difficulties in choosing the competitors that would receive licenses contributed to the subsequent move to auctions as a means for assigning spectrum rights.[150] These early entrants, and the successor companies that acquired them and their licenses, have maintained their core customer base and benefit from early investments in infrastructure. Many first movers into the wireless market, therefore, acquired their market-leader status through regulatory decisions that provided them with spectrum licenses, not through market competition.

Large sunk costs refer to the high levels of investment needed to enter the wireless market. Not including the price of purchasing spectrum, billions of dollars are required to build new infrastructure. The sunk costs of incumbent wireless service providers set a high bar for new entrants to match if they are to compete effectively in major markets. In the mobile telephone industry, the FCC has observed that most capital expenditures are spent on existing networks: to expand and improve geographic coverage; to increase capacity of existing networks; and to improve network capabilities.[151] Performance requirements for spectrum license-holders, such as

[146] For example, U.S. Department of Justice and the Federal Trade Commission, "Horizontal Merger Guidelines," Jointly issued April 2, 1992, revised April 8, 1997.

[147] *Thirteenth Report; annual report and analysis of competitive market conditions with respect to commercial mobile services*, paragraph 110, additional discussion in paragraphs 100 and 101.

[148] "Wireless Telecommunications Bureau Seeks Comment on Commercial Mobile Radio Services Market Competition," FCC, Public Notice, February 25, 2008, DA 08-453, WT Docket No. 08-27 at http://hraunfoss.fcc.gov/edocs_public/attachmatch/DA-08-453A1.pdf. Earlier annual reports have also cited these barriers.

[149] The initial occupant of a market segment may benefit from a number of advantages such as preemption of resources, advantageous relationships with customers and suppliers, and early profits for re-investment in infrastructure.

[150] The distribution of licenses for cell phone networks from the early days of the technology until the introduction of auctions is described in *Wireless Nation: The Frenzied Launch of the Cellular Revolution in America*, by James B. Murray, Jr., Perseus Press, 2001, 2002.

[151] *Thirteenth Report*, paragraph 155.

the size of a market that must be served or deadlines for completing infrastructure build-outs, are some of the policy decisions that can add to the cost of entry.

Access to radio frequency spectrum is an essential input for producing wireless communications. The FCC has stated that "Government control of spectrum allocation and assignment has the potential to create a barrier to entry.... "[152] Among the steps the FCC has reported taking are (1) making more spectrum available for Commercial Mobile Radio Services (CMRS); and (2) implementing usage rules that allow license-holders to decide which services to offer and what technologies to use on their CMRS holdings; and permitting CMRS license-holders to buy and sell their licenses in secondary markets.

In analyzing competition in rural areas, the FCC compared the availability of spectrum for wireless use in rural and urban counties. To do this, it measured the amount of licensed spectrum used for CMRS that was not held by the four nationwide providers (Verizon Wireless, AT&T, Sprint Nextel, and T-Mobile USA). It found that, in urban areas, 46% of the counties had more than 100 MHz of spectrum not licensed to the top four and, in rural areas, 80% of the counties had more than 100 MHz of spectrum not licensed to the nationwide carriers.[153] The analysis also showed that 96% of rural counties (representing 91% of the rural population) had at least 50 MHz of spectrum that was not being used to provide mobile telephone service. At least 50 MHz of spectrum was potentially available in 85% of the urban counties, covering 68% of the urban population.[154]

[152] *Ibid.*, paragraph 65, additional discussions in paragraphs 66 and 67.

[153] *Ibid.*, paragraph 106.

[154] *Ibid.*, paragraph 107.

# Appendix D. International Policies for Spectrum Management

Spectrum allocation is not a uniquely domestic process. Some spectrum allocations are governed by international treaty. Additionally, there is a trend to harmonize spectrum allocations for commercial use across countries through international agreements. Harmonization of radio frequencies is achieved by designating specific bands for the same category of use worldwide. With harmonization, consumers and businesses are able to benefit from the convenience and efficiency of having common frequencies for similar uses, thus promoting development of a seamless, global communications market. Spectrum allocation at the national level, therefore, is sometimes coordinated with international spectrum allocation agreements. The Advanced Wireless Services (AWS) auction in the United States, completed in 2006,[155] was the conclusion of a process initiated by an agreement for international harmonization of spectrum bands.[156] At this auction, T-Mobile was able to acquire new spectrum licenses that improved its competitiveness in the United States[157] and, consequently, the worldwide competiveness of its owner, Deutsche Telekom.[158]

The International Telecommunications Union (ITU), the lead United Nations agency for information and communication technologies, has been vested with responsibility to ensure interference-free operations of wireless communication through implementation of international agreements.[159] The ITU adopts a Table of Frequency Allocations in conjunction with International Radio Regulations. This International Table allocates spectrum for various radio services and includes, directly or indirectly, conditions for the use of the allocated spectrum.[160] There is also a domestic table for each country. The United States Table of Allocations is maintained by the National Telecommunications and Information Administration (NTIA). The U.S. Table of Allocations is modified to correspond with changes in international spectrum allocations agreed to under the auspices of the ITU. These agreements are reached through processes such as the World Radiocommunications Conferences (WRC). Each WRC provides an opportunity to revise the International Radio Regulations and International Table of Frequency Allocations in response to changes in technology and other factors. Modifications to rules from one WRC to the next are part of an ongoing process of technical review and negotiations. WRC meetings are held approximately every two years. Provisions that require changes in frequency allocation to

[155] "FCC's Advanced Wireless Services (AWS) Spectrum Auction Concludes," FCC News, September 18, 2006.

[156] The WRC-2000 agreed on spectrum bands to be harmonized for advanced wireless services, referred to as IMT 2000. See FCC News, "International Bureau Reports on Success of the 2000 World Radio Communications Conference," June 8, 2000, http://www.fcc.gov/Bureaus/International/News_Releases/2000/nrin0009.html.

[157] *Twelfth Report; annual report and analysis of competitive market conditions with respect to commercial mobile services*, FCC, Docket No. 07-71, released February 4, 2008, page 9 and paragraph 75, at http://hraunfoss.fcc.gov/edocs_public/attachmatch/DA-08-453A1.pdf.

[158] Deutsche Telekom owns 100% of T-Mobile International, which includes T-Mobile USA. For information see "Global Player on the Mobile Communications Market" at http://www.telekom.com/dtag/cms/content/dt/en/530494.

[159] The GAO notes that "The federal government considers ITU the principal, competent, and appropriate international organization for the purpose of formulating international treaties and understandings regarding certain telecommunications matters." *Better Coordination and Enhanced Accountability Needed to Improve Spectrum Management*, GAO-02-906, September 2003, page 19, fn. 26.

[160] There are 39 internationally defined wireless services, including broadcasting, meteorological satellite, and mobile services. Description of ITU-R functions are at http://www.itu.int/ITU-/index.asp?category=information&rlink=rhome&lang=en.

accommodate new technology will typically take effect 10 to 15 years after agreement is reached. These delays give time to phase out older technologies and to formulate new investment strategies.

The possibility of allocating additional spectrum for mobile broadband was among the deliberations of WRC-07 (October 22-November 16, 2007) and may be considered at the next WRC, scheduled to be held in 2011.[161] Future decisions about spectrum allocation for broadband in the United States might be influenced by international agreements. Worldwide harmonization of frequencies for mobile broadband may be sought in bands at 3 GHz and higher.

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[161] The NTIA and FCC websites carry information about planning for WRC 2011. For FCC, see IB Docket No. 04-286, Public Notice at http://hraunfoss.fcc.gov/edocs_public/attachmatch/DA-09-763A1.pdf. An NTIA overview is at http://www.ntia.doc.gov/osmhome/wrc/ntia.html. The ITU site is at http://www.itu.int/ITU-R/index.asp?category=conferences&rlink=wrc-11&lang=en.