Spectrum Policy in the Age of Broadband: Issues for Congress

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Summary

The convergence of wireless telecommunications technology with the Internet Protocol (IP) 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, smart grids, medicine and public health, intelligent transportation systems, 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. 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.

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.

The National Broadband Plan (NBP), a report on broadband policy mandated by Congress, has provided descriptions of perceived issues to be addressed by a combination of regulatory changes and the development of new policies at the Federal Communications Commission, with recommendations for legislative actions that Congress might take.

Among the spectrum policy initiatives that have been proposed in Congress in recent years 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 FCC's statutory authority to implement these measures is limited. The NBP reiterates these proposals and adds several more.

Substantive modifications in spectrum policy would almost surely require congressional action. The Radio Spectrum Inventory Act introduced in the Senate (S. 649, Kerry) and the similar House-introduced Radio Spectrum Inventory Act (H.R. 3125, Waxman) would require an inventory of existing users on prime radio frequencies, a preliminary step in evaluating policy changes. The Spectrum Relocation and Improvement Act of 2009 (H.R. 3019, Inslee) and the Spectrum Relocation Act of 2010 (S. 3490, Warner) would amend the Commercial Spectrum Enhancement Act of 2004 (P.L. 108-494, Title II). The Broadband for First Responders Act (H.R. 5081, King) would allocate additional radio frequencies for public safety use.

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The Role of Spectrum Policy

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 is deemed by the National Broadband Plan[2] (NBP) to 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, law, and regulation is to manage a natural resource[3] for the maximum possible benefit of the public. 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]

Although radio frequency spectrum is abundant, usable spectrum is currently limited by the constraints of applied technology. Spectrum policy therefore requires making decisions about how radio frequencies will be allocated and who will have access to them.[5] Spectrum policy also entails encouraging innovation in wireless technologies and their applications. Arguably, the role of technology policy in crafting spectrum policy has increased with the need to reduce or eliminate capacity constraints that may deter the expansion of broadband mobile services. The adoption of spectrum-efficient technologies is likely to require a rethinking of spectrum management policies and tools. Policies for channel management to control interference might be superseded by managing interference through guidelines for networks and devices. The assignment and supervision of licenses might give way to policies and procedures for managing pooled resources. Auctioning licenses might be replaced by auctioning access; the static event of selling a license replaced by the dynamic auctioning of spectrum access on a moment-by-moment basis.

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

[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.

[2] Federal Communications Commission, *Connecting America: The National Broadband Plan*, March 17, 2010, at http://download.broadband.gov/plan/national-broadband-plan.pdf.

[3] 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).

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

[5] Spectrum allocation and assignment is addressed in **Appendix B**, Competition.

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 2009.[6] 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 to tighten the regulatory structure under which wireless communications are managed. Other approaches might seek ways to modify spectrum policies to increase market competition and to accommodate the age of broadband. In the NBP, the FCC has emphasized the latter course and committed to a number of actions intended to increase opportunities for competition and innovation in mobile broadband.

Competition

With the introduction of auctions for spectrum licenses in 1994, 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.[7] 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).[8] As the bulk of wireless communications traffic moves from voice to data, companies will likely modify their business plans in order to remain competitive in the new environment. A shift in infrastructure technology and regulatory environment[9] might open wireless competition to companies with business plans that are not modeled on pre-existing 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.

The FCC, in the NBP, has concluded that an effective way to improve competition among wireless broadband providers is to increase the amount of spectrum available. This approach was validated by a number of filings with the FCC; for example, the Department of Justice provided

[6] 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. FCC, *Fourteenth Report; annual report and analysis of competitive market conditions with respect to commercial mobile services*, FCC, WT Docket No. 09-66, released May 20, 2010, Table 3, p. 31, reported for second Quarter 2009.

[7] For a discussion of policy issues, see CRS Report R40234, *The FCC's Authority to Regulate Net Neutrality after Comcast v. FCC* , by Kathleen Ann Ruane, and CRS Report R40616, *Access to Broadband Networks: The Net Neutrality Debate* , by Angele A. Gilroy.

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

[9] On December 1, 2009, the FCC published a public notice seeking comments on the "appropriate policy framework to facilitate and respond to the market-led transition in technology and services, from the circuit-switched PSTN system to an IP-based communications world." "Comment Sought on Transition from Circuit-Switched Network to All-IP Network," NBP Public Notice #25, DA 09-2517 at http://hraunfoss.fcc.gov/edocs_public/attachmatch/DA-09-2517A1.pdf.

arguments as to why the "primary tool for promoting broadband competition should be freeing up spectrum."[10] Policy tools that might 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, pooling radio frequency channels, moving to more spectrum-efficient technologies, and changing the cost structure of spectrum access.

Innovation

From a policy perspective, actions to speed the arrival of new, spectrally efficient technologies might have significant impact on achieving broadband policy goals over the long term. In particular, support for technologies that enable sharing could pave the way for dramatically different ways of managing the nation's spectrum resources. The NBP has laid out several opportunities for the FCC, the NTIA, and other government agencies to contribute to and encourage the development of new technologies for more efficient spectrum access.[11] Among the technologies that facilitate spectrum sharing are cognitive radio and Dynamic Spectrum Access (DSA).[12] Enabling technologies such as these allow communications to switch instantly among network frequencies that are not in use and therefore available to any radio device equipped with cognitive technology. Among the steps that might be taken to encourage spectrum-efficient technologies, the NBP has recommended that the FCC identify and free up a "new, contiguous nationwide band for unlicensed use"[13] and provide spectrum and take other steps to "further development and deployment"of new technologies that facilitate sharing.[14]

The NTIA has recommended exploring "ways to create incentives for more efficient use of limited spectrum resources, such as dynamic or opportunistic frequency sharing arrangements in both licensed and unlicensed uses."[15] This suggestion was incorporated into the 2011 Budget prepared by the Office of Management and Budget. The budget document directed the NTIA to collaborate with the FCC "to develop a plan to make available significant spectrum suitable for both mobile and fixed wireless broadband use over the next ten years. The plan is to focus on making spectrum available for exclusive use by commercial broadband providers or technologies, or for dynamic, shared access by commercial and government users."[16]

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[10] *Ex Parte* Submission of the United States Department of Justice, In the matter of Economic Issues in Broadband Competition: A National Broadband Plan for Our Future, GN Docket 09-51, January 4, 2010, p. 21 at http://fjallfoss.fcc.gov/ecfs/document/view?id=7020355122.

[11] *Connecting America*, Recommendations 5.13 and 5.14. The NBP proposed that the National Science Foundation "should fund wireless research and development that will advance the science of spectrum access." p. 96.

[12] Dynamic Spectrum Access, Content-Based Networking, and Delay and Disruption Technology Networking, along with cognitive radio, and decision-making software, are examples of technologies that can enable Internet-like management of spectrum resources. DSA is part of the neXt Generation program, or XG, 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.

[13] *Connecting America*, Recommendation 5.11.

[14] *Connecting America*, Recommendation 5.13.

[15] Letter to the FCC, Re: National Broadband Plan, GN Doc. No. 09-51, January 4, 2010 at http://www.ntia.doc.gov/filings/2009/FCCLetter_Docket09-51_20100104.pdf.

[16] Office of Management and Budget, *Budget of the U.S. Government, Fiscal Year 2011, Appendix*, "Other Independent Agencies," p. 1263. See also, FCC, *Fiscal Year 2011 Budget Estimates Submitted to Congress*, February 2010 at http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-296111A1.pdf.

A Presidential Memorandum[17] has directed the NTIA to take a number of actions in support of NBP goals, including taking the lead in creating and implementing a plan that will facilitate the exploration of "innovative spectrum-sharing technologies."

The NTIA's Commercial Spectrum Management Advisory Committee is actively looking at policy and technology issues in a series of subcommittee reports. The reports are addressing spectrum inventory, transparency, dynamic spectrum access, incentives, unlicensed spectrum, and sharing.[18]

The National Broadband Plan and Spectrum Policy

In the American Recovery and Reinvestment Act of 2009 (ARRA), Congress required the FCC to prepare a national broadband plan, to be delivered not later than February 17, 2010 (later extended to mid-March). 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...."[19]

On March 16, 2010, the FCC publically released its report, *Connecting America: The National Broadband Plan*.[20] The National Broadband Plan is presented as three major policy areas.

- *Innovation and Investment* "discusses recommendations to maximize innovation, investment and consumer welfare, primarily through competition. It then recommends more efficient allocation and management of assets government controls or influences." The recommendations address a number of issues, including spectrum policy.
- *Inclusion* "makes recommendations to promote inclusion—to ensure that all Americans have access to the opportunities broadband can provide."
- *National Purposes* "makes recommendations to maximize the use of broadband to address national priorities. This includes reforming laws, policies and incentives to maximize the benefits of broadband in areas where government plays a significant role." National purposes include health care, education, energy and the environment, government performance, civic engagement, and public safety.

Spectrum Policy Recommendations

The section in the NBP on spectrum policy (Chapter 5) has taken particular note of the convergence of the Internet with mobile devices and the resulting increased demand for spectrum capacity to support mobile broadband services.

[17] The White House, *Presidential Memorandum: Unleashing the Wireless Broadband Revolution*, June 28, 2010, at http://www.whitehouse.gov/the-press-office/presidential-memorandum-unleashing-wireless-broadband-revolution.

[18] See Spectrum Management Advisory Committee website at http://www.ntia.doc.gov/advisory/spectrum/.

[19] P.L. 111-5, Division B, Title VI, Sec. 6001 (k); 123 Stat. 515.

[20] Available at http://www.broadband.gov/plan/.

The NBP has proposed to increase spectrum capacity by

- Making more spectrum licenses available for mobile broadband.
- Increasing the amount of spectrum available for shared use.
- Encouraging and supporting the development of spectrum-efficient technologies, particularly those that facilitate sharing spectrum bands.
- Instituting new policies for spectrum management, such as assessing fees on some spectrum licenses, to encourage more efficient use.

To facilitate the deployment of broadband in rural areas, the NBP also has proposed

- Improving the environment for providing wireless components to build out infrastructure.

Many of the NBP proposals for wireless broadband may be achieved through changes in FCC regulations governing spectrum allocation and assignment. Other actions may require changes by federal agencies, state authorities, and commercial owners of spectrum licenses. To assist the implementation of the NBP there are also a number of areas where congressional action might be required to change existing statutes or to give the FCC new powers. Legislation has been proposed that would create an inventory of existing users on prime radio frequencies, a preliminary step in evaluating policy changes.[21] The NBP included the announcement of plans for the FCC to create what it refers to as a Spectrum Dashboard.[22] The initial release of the FCC's Spectrum Dashboard provided an interactive tool to search for information about how some non-federal frequency assignments are being used.[23] The dashboard could be expanded to meet requirements set by Congress for a spectrum inventory. In addition to the dashboard, the NBP has proposed that the FCC and the NTIA should create methods for recovering spectrum[24] and that the FCC maintain an ongoing spectrum strategy plan.[25] All of these steps will facilitate decisions about spectrum management by providing detailed information about the current and potential use of spectrum resources.

The Administration has supported the FCC's recommendations regarding means to increase the amount of spectrum capacity for wireless broadband.[26] In particular, the NTIA has been directed to collaborate with the FCC to identify spectrum holdings that can be made available for wireless broadband use. A deadline of October 1, 2010, has been set for the completion of a plan and timetable for releasing a total of 500 MHz of spectrum by 2020.

[21] Radio Spectrum Inventory Act introduced in the Senate (S. 649, Kerry) and the similar House-introduced Radio Spectrum Inventory Act (H.R. 3125, Waxman).

[22] *Connecting America*, Recommendation 5.1.

[23] For more information on the Spectrum Dashboard, go to http://reboot.fcc.gov/reform/systems/spectrum-dashboard/about.

[24] *Connecting America*, Recommendation 5.2.

[25] *Connecting America*, Recommendation 5.3.

[26] The White House, *Presidential Memorandum: Unleashing the Wireless Broadband Revolution*, June 28, 2010, at http://www.whitehouse.gov/the-press-office/presidential-memorandum-unleashing-wireless-broadband-revolution.

Spectrum Licenses

One of the management tools available to the FCC is its power to assign spectrum licenses through auctions. Auctions are regarded as a market-based mechanism for rationing spectrum rights. Before auctions became the primary method for distributing spectrum licenses the FCC used a number of different approaches, primarily based on perceived merit, to select license-holders. The FCC was authorized to organize auctions to award spectrum licenses for certain wireless communications services in the Omnibus Budget Reconciliation Act of 1993 (P.L. 103-66). Following passage of the act, 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 gave the FCC auction authority until September 30, 2007. This authority was extended to September 30, 2011, by the Deficit Reduction Act of 2005 and to 2012 by the DTV Delay Act (P.L. 111-4).

In the NBP, the FCC has proposed taking steps to add 300 MHz of licensed spectrum for broadband within five years and a total of 500 MHz of new frequencies in ten years.[27] Approximately 50 MHz would be released in the immediate future by the completion of existing auction plans. An additional 20 MHz might be reassigned from federal to commercial use and made available for auction. Reallocating some spectrum from over-the-air broadcasting to commercial spectrum might provide an additional 120 MHz of spectrum. Final rulings on existing proceedings would release 110 MHz, of which 90 MHz would be for Mobile Satellite Services (MSS); resolution of interference issues between Wireless Communications Services (WCS) and satellite radio would free up 20 MHz of new capacity.

The spectrum assignment proposals put forth in the NBP are contentious in that the various parties affected by the decisions have diverging views on how technology should be used to provide access to these frequencies. Although Congress has shown interest in all of these debates, three proposals that are the most likely to generate pressure for congressional action are the plans for: repurposing and auctioning an estimated 120 MHz of airwaves assigned to over-the-air digital television broadcasting; auctioning the D Block (10 MHz in the 700 MHz band); and auctioning up to 60 MHz of spectrum for Advanced Wireless Services.

Television Broadcast Spectrum

The Balanced Budget Act of 1997, which mandated the eventual transition to digital television, represented the legislative culmination of over a decade of policy debates and negotiations between the FCC and the television broadcast industry on how to move the industry from analog to digital broadcasting technologies. To facilitate the transition, the FCC provided each qualified broadcaster with 6 MHz of spectrum for digital broadcasting to replace licenses of 6 MHz that were used for analog broadcasting. The analog licenses would be yielded back when the transition to digital television was concluded. The completed transition freed up the 700 MHz band for commercial and public safety communications in 2009.

The FCC has revisited the assumptions reflected in the 1997 act and has made new proposals, and decisions based on, among other factors, changes in technology and consumer habits. The NBP

[27] *Connecting America*, Recommendation 5.8.

announced that a new proceeding would be initiated to recapture up to 120 MHz of spectrum from broadcast TV allocations for reassignment to broadband communications. This proceeding would propose four sets of actions to achieve the goal; a fifth set of actions to increase efficiency would be pursued separately.[28] The FCC stipulated in the NBP that its recommendations "seek to preserve [over-the-air television] as a healthy, viable medium going forward, in a way that would not harm consumers overall, while establishing mechanisms to make available additional spectrum for flexible broadband uses."[29]

Many of the proposals for redirecting TV broadcast capacity are based on refinements in the way frequencies are managed and are procedural in nature. Because over-the-air digital broadcasting does not necessarily require 6 MHz of spectrum, the NBP has proposed that some stations could share a single 6 MHz band without significantly reducing service to over-the-air TV viewers. Among the proposals for how broadcasters might make better use of their TV licenses, the NBP has raised the possibility of auctioning unneeded spectrum and sharing the proceeds between the TV license-holder and the U.S. Treasury. The FCC has called on Congress to provide new legislation that would allow these "incentive auctions."

D Block

The D Block refers to a set of frequencies within the 700 MHz band that were among the frequencies made available after the transition from analog to digital television in 2009. In compliance with instructions from Congress to auction all unallocated spectrum in this band, the FCC conducted an auction, which concluded on March 18, 2008. As part of its preparation for the auction (Auction 73), the FCC sought to increase the amount of spectrum available to public safety users in the 700 MHz band. Congress had previously designated 24 MHz of radio frequencies in the 700 MHz band for public safety channels. In 2007, the FCC proposed to designate 10 MHz – part of the original 24 MHz designated for public safety use – specifically for public safety broadband communications. Of the balance, 12 MHz were designated for mission critical voice communications on narrowband networks and 2 MHz were set aside as a guard band to protect against interference. In the FCC plan for Auction 73, the Public Safety Broadband License would be matched with a commercial license for 10 MHz, known as the D Block. The D Block was to be auctioned under rules that would require the creation of a public-private partnership to develop the two 10-MHz assignments as a single broadband network, available to both public safety users and commercial customers. The D Block license was offered for sale in 2008 but did not find a buyer. The FCC then set about the task of writing new service rules for a reauction of the D Block.[30]

In the NBP, the FCC announced its decision to auction the D Block under rules that would not require a partnership with public safety but would establish a framework for priority access to the D Block network by public safety users.[31] Based mainly on FCC efforts to create a public-private partnership, public safety officials have, by and large, anticipated that the D Block would be an integral part of a public safety broadband network. Since the failed D Block auction of 2008, there has also been growing pressure on the FCC and on Congress to take the steps necessary to

[28] *Connecting America*, Recommendation 5.8.5.

[29] *Connecting America*, p. 89.

[30] Background information regarding the D Block is provided in CRS Report R40859, *Public Safety Communications and Spectrum Resources: Policy Issues for Congress*, by Linda K. Moore

[31] *Connecting America*, Recommendation 5.8.2.

reallocate the D Block from commercial to public safety use.[32] The NBP announcement regarding the D Block is considered by many to be a reversal of announced policy, creating controversy and renewed calls for Congress to take action to release the D Block to public safety. Although funding and control are critical elements of the debate, the controversy is rooted in contradictory assumptions about the level of service and reliability that new, largely untried, and in some cases undeveloped technology will be able to deliver for public safety broadband communications.

The FCC would address public safety needs such as developing standards and establishing procedures through the newly established Emergency Response Interoperability Center (ERIC).[33] ERIC would work closely with the Public Safety Communications Research program, jointly managed by the National Institute of Standards and Technology (NIST) and the NTIA, to develop and test the technological solutions needed for public safety broadband communications.[34] The Department of Homeland Security will participate in the areas of public safety outreach and technical assistance, as well as best practices development.[35]

ERIC would take on the role of creating and implementing a federal plan to assist in building a nationwide, interoperable network for public safety. As the lead agency, the FCC would rely on its authority to require the D Block and other commercial license-holders in the 700 MHz band to accommodate public safety needs. Although public safety users would be charged for access to commercial networks, proponents of the plan have argued that overall costs would be less than if a network were built primarily or exclusively for public safety use, because of greater economies of scale. One of the expectations is that ERIC will be able to guide the development of standards for crucial radio components, with the participation of commercial providers and public safety representatives. The participation of commercial carriers in developing and deploying, for example, a common radio interface, is expected to put the cost of public safety radios in the same price range as commercial high-end mobile devices ($500). By contrast, interoperable radios for the narrowband networks at 700 MHz cost $3,000 and up, each.

Advanced Wireless Service Auctions

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 offered to provide free basic service to consumers and public safety and to 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.[36] Proposed provisions for the auction included 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

[32] A bill that would assign the D Block for public safety communications has been introduced (Broadband for First Responders Act of 2010, H.R. 5081, King).

[33] FCC News, "The Federal Communications Commission Establishes New Emergency Response Interoperability Center," April 23, 2010 at http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-297707A1.pdf.

[34] NIST, "Demonstration Network Planned for Public Safety 700 MHz Broadband," December 15, 2009 at http://www.nist.gov/eeel/oles/network_121509.cfm.

[35] FCC News, "The Federal Communications Commission Establishes New Emergency Response Interoperability Center," April 23, 2010.

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

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-1 frequencies.[37]

The FCC did not act on the AWS-3 auction proposal but announced new plans in the NBP that included the 2155-2175 MHz frequencies.[38] As outlined in the NBP, the FCC would seek to pair the AWS-3 frequencies with an additional 20 MHz of frequencies reassigned from federal use. The plan has recommended that the NTIA, in consultation with the FCC, assess the possibility of such a reallocation and, if the reallocation appears feasible, that they move ahead with plans to organize an auction. If reallocation and auction is not deemed feasible, the FCC would proceed "promptly" to auction the AWS-3 frequencies, according to the plan. The plan had proposed using frequencies in the 1755-1780 MHz range, but the NTIA has instead offered to assess the feasibility of using frequencies in the 1675-1710 MHz band.[39] The FCC subsequently requested comments to evaluate approaches to making this band available for shared use that would include wireless broadband services.[40]

In addition to the AWS-3 frequencies, there are two blocks of spectrum under the designation of AWS-2 "H" and "J" that have been under consideration for auction since 2004. The AWS-2 "J" band, with paired frequency assignment at 2020-2025 MHZ and 2175-2180 MHz, might be paired with AWS-3 or with an adjacent Mobile Satellite Service band.

The process of finalizing auction plans for licenses to use the AWS-2 and AWS-3 frequencies might renew the debate over interference. FCC proceedings also might provide an opportunity to revisit the possibility of including a requirement for auction winners to offer basic broadband service at no cost to the consumer. The concept of a lifeline broadband service has received support from many policy makers in Congress.

Shared Resources

The FCC has stated in the NBP that it would facilitate sharing resources through a number of regulatory means.[41] 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,[42] 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—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.

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

[38] *Connecting America*, Recommendation 5.8.3.

[39] Remarks of Lawrence E. Strickling, June 3, 2010 at http://www.ntia.doc.gov/presentations/2010/PublicKnowledge_Spectrum_06032010.html.

[40] FCC, Public Notice, "Office of Engineering and Technology Requests Information on Use of 1675-1710 MHz Band," DA 10-1035, released June 4, 2010, Docket No. 10-123 at http://fjallfoss.fcc.gov/edocs_public/attachmatch/DA-10-1035A1.pdf.

[41] Connecting America, p. 79 and Recommendation 5.7.

[42] 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.

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.

Open Access

In the 2008 auction of spectrum licenses at 700 MHz,[43] 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.[44] 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.[45] 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,[46] 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.

Wholesale Networks

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.[47] 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.[48]

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

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

[45] 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.

[46] 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, p. 63, at http://hraunfoss.fcc.gov/edocs_public/attachmatch/DA-08-595A2.pdf.

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

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

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.

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.[49] Devices using the white-space frequencies would be required to incorporate geolocation technology to signal when and where potential interference was detected.[50] A geolocation database would be created and maintained to facilitate sharing of the white space by authorized devices. The design and operation of this database is being studied by the FCC.[51] 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.[52] 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.[53] One of the recommendations of the NBP is that the FCC complete the proceeding that would allow use of the white spaces for unlicensed devices.[54]

[49] FCC, *First Report and Order and Further Notice of Proposed Rule Making*, ET Docket No. 04-186, released October 18, 2006, at http://fjallfoss.fcc.gov/edocs_public/attachmatch/FCC-06-156A1.pdf.

[50] 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.

[51] FCC, Public Notice, "Office of Engineering and Technology Invites Proposals from Entities Seeking to be Designated TV Band Device Database Managers," ET Docket No. 04-186, released November 25, 2009 at http://fjallfoss.fcc.gov/edocs_public/attachmatch/DA-09-2479A1.pdf.

[52] 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. Requirements intended to protect microphone use in the white spaces are proposed in the Wireless Microphone Users Interference Protection Act (H.R. 4353, Representative Rush).

[53] FCC, *Second Report and Order and Memorandum Opinion and Order*, ET Docket No. 04-185, released November 14, 2008 at http://fjallfoss.fcc.gov/edocs_public/attachmatch/FCC-08-260A1.pdf.

[54] *Connecting America*, Recommendation 5.12.

Spectrum-Efficient Technology

Mobile communications became generally available to businesses and consumers in the 1980s. The pioneering cell phone technologies were analog.[55] 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 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[56] and Long Term Evolution (LTE) networks. Both are based on TCP/IP, the core protocol of the Internet.[57]

Wireless technologies to facilitate broadband deployment for which spectrum may need to be allocated that were identified by the NBP include 4G networks; fixed wireless as an alternative to fiber optic cable; and broadband on unlicensed frequencies.

The NBP spectrum assignment proposals are based on managing radio channels as the way to maximize spectral efficiency while meeting common goals such as minimizing interference among devices operating on the same or nearby frequencies. Today, channel management is a significant part of spectrum management; many of the FCC dockets deal with assigning channels and resolving the issues raised by these decisions. In the future, channel management is likely to be replaced by technologies that operate without the need for designated channels. In the NBP, the FCC refers to these spectrum-seeking technologies as opportunistic. Identifying an opportunity to move to an open radio frequency is more flexible—and therefore more productive—than operating on a set of pre-determined frequencies. The primary benefit from these new technologies will be the significant increase in available spectrum but new efficiencies in operational and regulatory costs will also be realized.

The concept of channel management dates to the development of the radio telegraph by Guglielmo Marconi and his contemporaries. In the age of the Internet, however, channel management is an inefficient way to provide spectrum capacity for mobile broadband. Innovation points to network-centric spectrum management as an effective way to provide spectrum capacity to meet the bandwidth needs of fourth-generation wireless devices.[58] Network-centric technologies organize the transmission of radio signals along the same principle as the Internet. A transmission moves from origination to destination not along a fixed path but by passing from one available node to the next. Pooling resources, one of the concepts that powers the Internet now, is likely to become the dominant principle for spectrum management in the future.

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

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

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

[58] A leading advocate for replacing channel management of radio frequency with network-centric management is Preston Marshall, the source for much of the information about network-centric technologies in this report. Mr. Marshall is Director, Information Sciences Institute, University of Southern California, Viterbi School of Engineering, Arlington, Virginia.

New Technologies

The iPhone 3G and 3GS provide early examples of how the Internet is likely to change wireless communications as more and more of the underlying network infrastructure is converted to IP-based standards. The iPhone uses the Internet Protocol to perform many of its functions; these require time and space—spectrum capacity—to operate. The next generation of wireless networks, 4G, for Fourth Generation, will be supported by technologies structured and managed to emulate the Internet. The wireless devices that operate on these new, IP-powered networks will be able to share spectrum capacity in ways not currently used on commercial networks, greatly increasing network availability on licensed bandwidths. Another technological boost will come from improved ways to use unlicensed spectrum. Unlicensed spectrum refers to bands of spectrum designated for multiple providers, multiple uses, and multiple types of devices that have met operational requirements set by the FCC. Wi-Fi is an example of a current use of unlicensed spectrum.

More efficient spectrum use can be realized by integrating adaptive networking technologies, such as DSA, with IP-based, 4G commercial network technologies such as LTE. Adaptive networking has the potential to organize wireless communications to achieve the same kinds of benefits that have been seen to accrue with the transition from proprietary data networks to the Internet. These enabling technologies allow communications to switch instantly among network frequencies that are not in use and therefore available to any wireless device equipped with cognitive technology. Adaptive technologies are designed to use pooled spectrum resources. Pooling spectrum licenses goes beyond sharing. Licenses are aggregated and specific ownership of channels becomes secondary to the common goal of maximizing network performance.

New Policies

Among the steps that might be taken to encourage "opportunistic" technologies, the NBP recommends that the FCC identify and free up a "new, contiguous nationwide band for unlicensed use" by 2020;[59] and provide spectrum and take other steps to "further development and deployment" of new technologies that facilitate sharing.[60] Unlike its recommendations for auctioning spectrum licenses in the near future, the FCC's plans for bringing new technologies into play provide few details. The NBP provides a glimpse through the keyhole of the horizons beyond, but not the key that might open the door.

The testing of new technologies that increase spectrum capacity, and the policy changes they are likely to bring, has been designated by the NBP as a future event. Its immediate plans for spectrum policy are to fine-tune existing spectrum assignments to increase the availability of licensed capacity. The level of opposition to most of these spectrum assignment plans might suggest that current spectrum management practices have reached the point of diminishing returns. The FCC might consider first identifying the new technologies mobile broadband will require before it begins the hunt for more spectrum.

[59] *Connecting America*, Recommendation 5.11.

[60] *Connecting America*, Recommendation 5.13.

Management Tools

In the NBP, the FCC has asked Congress to consider granting it authority to impose spectrum fees on license holders as a means of addressing inefficient use.[61] The report has presented the hypothesis that "Fees may help to free spectrum for new uses such as broadband, since licensees who use spectrum inefficiently may reduce their holdings once they bear the opportunity cost" of holding the spectrum.[62]

The Obama Administration also has proposed that the FCC be given the authority to levy fees, and to use other economic mechanisms, as a spectrum management tool.[63] The 2011 fiscal year budget prepared by the Office of Management and Budget projects new revenue from spectrum license user fees of $4.775 billion for fiscal years 2011 through 2020.[64] Similar projections were made in the 2010 budget[65] and in budget proposals during the administration of President George W. Bush.[66]

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, the GAO was instructed to examine "national commercial spectrum policy as implemented by the Federal Communications Commission" and report on its findings in 2005.[67] 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

[61] *Connecting America*, Recommendation 5.6.

[62] *Connecting America*, p. 82.

[63] Office of Management and Budget, *Budget of the U.S. Government, Fiscal Year 2011, Appendix*, "Other Independent Agencies," p. 1263. See also, FCC, *Fiscal Year 2011 Budget Estimates Submitted to Congress*, February 2010 at http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-296111A1.pdf.

[64] Office of Management and Budget, *Budget of the U.S. Government, Fiscal Year 2011,* Summary Tables, Table S-8, p. 169.

[65] Office of Management and Budget, *A New Era of Responsibility: Renewing America's Promise,* Table S-6, p. 126.

[66] 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.

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

was a one-time, sunk cost.[68] 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.[69]

The FCC's statutory authority to impose new spectrum user fees is limited. The FCC was authorized by Congress to set license application fees[70] and regulatory fees to recover costs.[71] 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.

Wireless Backhaul

Most mobile communications depend on fixed infrastructure to relay calls to and from wireless networks. The infrastructure that links wireless communications to the wired world is commonly referred to as backhaul. In situations where installing communications cables is impractical, fixed wireless infrastructure may be used to provide the needed backhaul. Microwave technologies, for example, are used in a number of applications to extend coverage to areas not served by fiber-optic or other wire links.

The NBP has predicted that the importance of backhaul will increase with the implementation of 4G technologies, as mobile access to the Internet and other wired networks becomes increasingly prevalent.[72] The FCC therefore has proposed to take a number of procedural steps to increase the flexibility and capacity for point-to-point wireless backhaul technologies.[73] On June 7, 2010, the FCC adopted an order intended to "enhance the flexibility and speed" of acquiring spectrum for wireless backhaul.[74]

National Purposes

Among the requirements for the National Broadband Plan, Congress specified that it should include

> a plan for use of broadband infrastructure and services in advancing consumer welfare, civic participation, public safety and homeland security, community development, health care delivery, energy independence and efficiency, education, worker training, private sector investment, entrepreneurial activity, job creation and economic growth, and other national purposes.[75]

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[68] 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, p. 2.

[69] *Ibid.*, p. 10, footnote 15.

[70] 47 USC § 158 (a).

[71] 47 USC § 159 (a).

[72] *Connecting America*, p. 93.

[73] *Connecting America*, Recommendations 5.9 and 5.10.

[74] FCC, *Report and Order*, released June 8, 2010, Docket No. 09-114 at http://fjallfoss.fcc.gov/edocs_public/attachmatch/FCC-10-109A1.pdf.

[75] P.L. 111-5, § 6001 (k) (2) (D); 123 Stat. 516.

In the plan, the Federal Communications Commission (FCC) has made recommendations that might fulfill both social and economic goals. In the section of the plan titled "National Purposes," it has focused on social goals with an agenda of actions for federal, state, and local agencies. The areas covered in this section are

- Health care. The NBP has identified stated goals of the Department of Health and Human Services that might be effectively supported with technologies that are enhanced by access to broadband communications.
- Education. The NBP has proposed that broadband can provide an effective tool for meeting the educational needs and ambitions of educators, students, and parents of young children as well as support the Department of Education's strategies to improve educational achievement.
- Energy and the Environment. Broadband has multiple applications in the field of energy, conservation, and environmental protection. For example, SmartGrid goals set by Congress[76] might not be achievable without broadband communications.
- Economic Opportunity. Actions proposed in the NBP to further economic opportunity are centered on increasing access to Information Technology for small and medium-sized businesses. The role of broadband in providing job training and employment services and supporting telework are also addressed in recommendations.
- Government Performance. The recommendations for federal government actions encompassed both ways that broadband might improve the effectiveness of government and also steps the federal government might take to increase the availability of broadband networks. The latter included federal actions to improve cybersecurity and ways that federal agencies might assist communities and state and local governments in building broadband infrastructure.
- Civic Engagement. The NBP has described concepts such as government transparency that can lead to greater participation by all in the democratic process. Broadband access has been described in the plan as a useful tool for encouraging civic engagement because of the part it plays in interactive communication and providing information.
- Public Safety. The NBP recommendations dealt primarily with delivering wireless broadband to the radios of first responder. It also considered the role of broadband in upgrading the nation's 911 services and emergency alert systems.

Meeting Policy Goals

Each of the sections on national purposes has mentioned the existing legislative and regulatory framework and trends in the field that might benefit from better broadband access and services. Although each sector serves different needs and goals, the NBP recommendations are fairly similar for each. In general, stakeholders have been encouraged to

- Create incentives to achieve broadband goals.

[76] P.L. 110-140, Sec. 1301; 123 Stat. 1783.

- Leverage broadband technology, including wireless broadband.
- Encourage innovation and improved productivity.
- Provide or increase funding for programs that support broadband policy goals.
- Modify regulations.

The NBP has recommended that the Executive Branch create a Broadband Strategy Council.[77] This council would coordinate efforts by the many agencies that the FCC has identified as having a role in the plan's implementation. The NBP has suggested that the President could require that federal departments and agencies submit broadband implementation plans to the council. The council could also act as an intermediary between the agencies and Congress regarding legislation that might facilitate meeting the NBP's goals. Another recommendation of the NBP would require the FCC to track progress in meeting the plan's goals.[78]

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.[79]

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.[80] In the Telecommunications Act of 1996, Congress barred states from "prohibiting the ability of any entity to provide any interstate or intrastate telecommunications service."[81] 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.

[77] *Connecting America*, Recommendation 17.1.

[78] *Connecting America*, Recommendation 17.2.

[79] 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.

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

[81] 47 U.S.C. 253 (a).

Because community broadband networks can help with NBP goals for inclusion and national purposes, the NBP has considered the possibility that federal investment in broadband infrastructure might be leveraged for community and state broadband services. For example, the NBP has recommended that federal agencies could open their broadband networks to state and local agencies and to unserved and underserved areas.[82] It has also made recommendations to help reduce costs and improve funding to community broadband programs.[83]

Issues for the 111th Congress

The NBP has made a number of recommendations for Congressional action to grant new authorities to the FCC, including several related to spectrum policy and auctions. The Radio Spectrum Inventory bills being considered by the 111th Congress parallel NBP recommendations. The NBP has recommended changes to the Commercial Spectrum Enhancement Act; not all of these recommendations are included in the bill that would amend that act, H.R. 3019, the Spectrum Relocation and Improvement Act of 2009. Congress may decide to consider NBP recommendations for legislation that would permit incentive auctions, particularly as they apply to recommended reassignments of digital TV broadcast frequencies. H.R. 5081, the Broadband for First Responders Act of 2010, would require the reallocation of 700 MHz D Block frequencies, contrary to announced plans to auction the frequencies.

Spectrum Inventory

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 information from the detailed report on users and uses would help policy makers evaluate whether spectrum is being allocated and used effectively. 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.[84]

[82] *Connecting America*, Recommendation 14.1.

[83] *Connecting America*, Recommendation 14.2, 14.3, and 14.4.

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

The Commercial Spectrum Enhancement Act and Federal Relocation

The Spectrum Relocation and Improvement Act of 2009 (H.R. 3019, Representative Inslee) and the similarly worded Spectrum Relocation and Improvement Act of 2010 (S. 3490, Senator Warner) would address issues arising from current experiences in relocating federal users to clear space for commercial license-holders. The bills would define the rights and responsibilities of federal entities in the spectrum relocation process, especially obligations for sharing, and their eligibility for payments from the Spectrum Relocation Fund. The NBP has recommended that Congress consider improvements to the Commercial Spectrum Enhancement Act (CSEA) to provide "adequate incentives and assistance" to support relocation. The NBP has further recommended that the compensation to federal agencies be structured to provide additional incentives "for using commercial services and non-spectrum based operations." In particular, the NBP has recommended that "Congress revise the CSEA to provide for payments of relocation funds to federal users that vacate spectrum and make use of commercial networks instead...."[85]

The Spectrum Relocation Fund was created by the Commercial Spectrum Enhancement Act in 2004, to provide a mechanism whereby federal agencies could recover the costs of moving from one spectrum band to another. The fund is administered by the Office of Management and Budget. Following procedures required by the act, the FCC scheduled an auction of designated federal frequencies for commercial use as Advanced Wireless Services (AWS). The AWS auction was completed on September 18, 2006, attracting nearly $13.9 billion in completed bids.[86] The FCC ruled that auction winners wishing to put acquired licenses to immediate use would in most cases be able to share with current federal users under guidance from the FCC.[87] The act was written to be applied to most transfers of spectrum from federal to commercial use.

Incentive Auctions

The NBP has asked Congress to consider expanding the FCC's auction authority to permit incentive auctions.[88] As outlined in the NBP, such authority would enable spectrum license-holders to return spectrum for auction, with the expectation of receiving part of the proceeds as compensation for the costs associated with relinquishing the asset. Although most spectrum license auction revenues are deposited as general funds,[89] Congress has passed laws, such as the Commercial Spectrum Enhancement Act, that permit the proceeds to be used for other purposes.

Broadband for First Responders Act

The Broadband for First Responders Act of 2010 (H.R. 5081, Representative King) would amend the Communications Act of 1934 by requiring the FCC to allocate an additional 10 MHz of spectrum, known at the D Block, at 758-763 MHz and 788-793 MHz, for public safety services

[85] *Connecting America*, Recommendation 5.5.

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

[87] FCC Public Notice "Coordination Procedures in the 1710-1755 MHz Band," FCC 06-50, April 20, 2006 (WTB Docket No. 02-353).

[88] *Connecting America*, Recommendation 5.4.

[89] As required by the Communications Act of 1934, 47 U.S.C. 309 j (8).

and assign these paired bands for public safety broadband use. The bill would require the FCC to establish rules to encourage the rapid deployment of an interoperable national wireless broadband network.

Service rules would provide priority access to mission critical public safety applications; provide for roaming on public safety spectrum by authorized users; encourage public-private partnerships by requiring consideration of the use of existing or planned commercial infrastructure; meet technical and operational standards for interoperability and roaming; require that networks are built to survive most large scale disasters; ensure networks have the appropriate level of cyber security; and facilitate the shared use of the public safety broadband spectrum and infrastructure with commercial and other entities.

Standards would be set in consultation with the National Institute of Standards and Technology (NIST) and others to enable nationwide interoperability and roaming across any communications system using public safety broadband spectrum.

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.[90] Past policies to regulate a monopolistic market may have influenced current policies for promoting competition. 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-

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

driven auction process unless large amounts of new radio frequencies can be identified and released for that purpose.[91] 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.

Legislation geared to improve auction mechanisms might benefit from the consideration of measures that would use technology to increase the amount of spectrum available, thereby opening the field to new players, fostering competition, and spurring innovation.

To further the transition to new technologies, Congress might choose to require performance goals for improved spectrum efficiency, not unlike the way federal goals have been set for energy conservation or transportation safety.

[91] International Telecommunications Union projects an estimated need for additional spectrum capacity that could reach nearly 1,000 MHz in the United States, as reported in "Summary of Results of ITU-R Report M. 2079," p. 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. See also CTIA-The Wireless Association, *Written Ex Parte Communication*, FCC, GN Docket No. 09-51, September 29, 2009, which suggests a goal of at least 800 MHz, based on extrapolations from the ITU research.

Appendix A. 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. Future technologies include network-centric technologies, which include opportunistic solutions such as Dynamic Spectrum Access (DSA).

Long Term Evolution (LTE)

LTE is the projected development of existing 3G networks built on Universal Mobile Telephone System (UMTS) standards.[92] 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.[93] LTE might operate on spectrum bands at 700 MHz, 1.7 GHz, 2.3 GHz, 2.5 GHz, and 3.4 GHz.[94]

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.[95] 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. 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.[96]

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

[92] See, for example, "Mobile Broadband Evolution: the roadmap from HSPA to LTE," UMTS Forum, February 2009, Universal Mobile Telephone System Forum at http://www.umts-forum.org/.

[93] Implementation summarized in *Connecting America*, Exhibit 5-B, p. 77.

[94] 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.

[95] 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/.

[96] Implementation summarized in *Connecting America*, Exhibit 5-B, p. 77.

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.[97] 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.

Wi-Fi

The popularity of Wi-Fi is often cited as a successful innovation that was implemented using unlicensed frequencies.[98] 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. 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.[99]

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 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,[100] 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. The line between smartphone and netbook technologies is fading as the newer generations of these devices provide many of the same features. The iPad, introduced by Apple Inc. in 2010, provides an example of the interchangeability of features across different platforms. The majority of these 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

[97] 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.

[98] 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.

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

[100] 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.

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.[101]

Network-Centric Technologies

More efficient spectrum use can be realized by integrating adaptive networking technologies, such as dynamic spectrum access, with IP-based commercial network technologies such as LTE. Radios using DSA chipsets are more effective at managing interference and congestion than the channel management techniques currently in use. If a channel's link fails, the radio is cut off. When radios are networked using DSA, individual communications nodes continue to operate and can compensate for failed links. The effects of interference are manageable rather than catastrophic. The network is used to overcome radio limitations.

Adaptive networking has the potential to organize radio communications to achieve the same kinds of benefits that have been seen to accrue with the transition from proprietary data networks to the Internet. Adaptive technologies are designed to use pooled spectrum resources. Pooling spectrum licenses goes beyond sharing. Licenses are aggregated and specific ownership of channels becomes secondary to the common goal of maximizing network performance.

The Department of Defense (DOD) is working to implement network-centric operations (NCO) through a number of initiatives.[102] Leadership and support to achieve DOD goals in the crucial area of spectrum management is provided by the Defense Spectrum Organization (DSO) created in 2006 within the Defense Information Systems Agency (DISA). The DSO is leading DOD efforts to transform spectrum management in support of future net-centric operations and warfare, and to meet military needs for dynamic, agile, and adaptive access to spectrum. The DSO is guiding DOD spectrum management along a path that envisions moving away from stove-piped systems to network-centric spectrum management and, ideally, to bandwidth on demand and cognitive self-synching spectrum use.

Among the steps to advance toward the goal of spectrum access that is fully adaptable to any situation is the testing of network-centric technologies developed by the Defense Advanced Research Projects Agency (DARPA) within the Wireless Network After Next (WNaN) program.

[101] 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.

[102] A discussion of the goals of NCO is included in CRS Report RL32411, *Network Centric Operations: Background and Oversight Issues for Congress*, by Clay Wilson.

WNaN is evaluating DSA, Disruptive Tolerant Networking, and other tools, possibly to replace the existing Joint Tactical Radio System (JTRS) now in use. JTRS uses software-programmable radios to provide interoperability, among other features.[103] WNaN's testing and evaluation of network-centric technologies is expected to lead to a decisison in late 2010. WNAN technology is planned for transition to the Army in 2010.[104]

[103] Information at http://jpeojtrs.mil/.

[104] Information about the WNaN program is based on comments by Bob Wilson, Deputy Program Manager for Army WNaN program, Communications-Electronics Command at DoD Spectrum Symposium, Arlington, VA, October 14-15, 2009.

Appendix B. Competition

A combination of policy and market forces has divided the commercial wireless market into sharply different tiers. Policies that have encouraged economies of scale have favored mergers and acquisitions of wireless companies. There are now four facilities-based[105] wireless companies in the United States that the FCC describes as nationwide: AT&T, Verizon Wireless, Sprint Nextel, and T-Mobile, [106] which had approximately 90% of the subscriber market at the beginning of 2010. Another four providers had subscriber bases of between 1 million and 15 million Over one hundred smaller carriers serve niche markets.[107]

Barriers to Competition

In evaluating competition within an industry, economists and policy makers examine barriers to entry, among other factors.[108] Barriers might come from high costs for market entry such as investment in infrastructure or there might be legal and regulatory barriers to entry. 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."[109] 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[110] 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.[111] 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.

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

[106] *Fourteenth Report*, paragraph 27.

[107] *Fourteenth Report*, paragraph 29.

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

[109] FCC, "Wireless Telecommunications Bureau Seeks Comment on Commercial Mobile Radio Services Market Competition," 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.

[110] 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 reinvestment in infrastructure.

[111] 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.

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. Performance requirements for spectrum license-holders, such as 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.

Spectrum Auctions and Competition

The FCC, acting on the statutory authority given to it by Congress, has broad regulatory powers for spectrum management. The FCC was created as part of the Communications Act of 1934[112] as the successor to the Federal Radio Commission, which was formed under the Radio Act of 1927.[113] The first statute covering the regulation of airwaves in the United States was the Radio Act of 1912, which gave the authority to assign usage rights (licenses) to the Secretary of the Department of Commerce and Labor.[114] 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.[115]

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.

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 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[116] 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.[117] The law prohibited the FCC from making spectrum allocation decisions based "solely or predominately on the

[112] 47 U.S.C. § 151.

[113] P.L. 632, Sec. 3.

[114] P.L. 264, "License."

[115] An "Act to regulate radio communications," usually referred to as 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.

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

[117] 47 U.S.C. § 309 (j), especially (1), (3), and (4).

expectation of Federal revenues....”[118] The Emerging Telecommunications Technologies section[119] 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.[120] 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.[121] 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.[122] 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.”[123] 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.[124]

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.

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. Wireless networks are an important component of smart grid communications. Spectrum resources are also needed for railroad safety,[125] for water conservation,[126] for the safe maintenance of critical infrastructure industries,[127] and for many

[118] 47 U.S.C. § 309 (j) (7) (A).

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

[120] 47 U.S.C. § 923 (b) (1).

[121] 47 U.S.C. § 925 (b) (1).

[122] 47 U.S.C. § 925 (b) (2).

[123] 47 U.S.C. § 925 (b) (3).

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

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

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

[127] 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 (continued...)

other applications that may not have an immediate commercial value but can provide long-lasting value to society as a whole.

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.[128] 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.[129] 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 2.3 GHz. In October 2008, the FCC sought comments on the RTG petition for rulemaking.[130] 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.[131] 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

(...continued)

appears in CRS Report RL30153, *Critical Infrastructures: Background, Policy, and Implementation*, by John D. Moteff.

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

[129] FCC News, "FCC Announces Wireless Spectrum Cap to Sunset Effective January 1, 2003," 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.

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

[131] 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.

and innovation.[132] 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.

In comments filed regarding the National Broadband Plan, the Department of Justice considered the possibility that "the foreclosure value for incumbents in a given locale could be very high."[133] Although it recognized some form of spectrum caps as an option for assuring new market entrants, it observed that "there are substantial advantages to deploying newly available spectrum in order to enable additional providers to mount stronger challenges to broadband incumbents."[134]

Market Competition

There are many ways to view competition. Although competitiveness may be evaluated by factors such as barriers to entry 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."[135] Viewpoints about the level of competitiveness in providing wireless services to the U.S. market differ.[136] 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.

Both the wireless industry and its regulator have focused on "wireless consumer welfare"[137] 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.[138]

[132] 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.

[133] *Ex Parte* Submission of the United States Department of Justice, In the matter of Economic Issues in Broadband Competition: A National Broadband Plan for Our Future, GN Docket 09-51, January 4, 2010, p. 23 at http://fjallfoss.fcc.gov/ecfs/document/view?id=7020355122.

[134] Ibid., p. 24.

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

[136]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.*

[137] 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."

[138]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.

Competition in Rural Markets

Over the years, various legislative and policy initiatives have created a number of requirements to help small and rural carriers acquire spectrum licenses.[139] Some of the FCC's efforts to encourage spectrum license ownership for small, rural, or entrepreneurial businesses are in response to Congressional mandates.[140] 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.[141] As wireless traffic, revenue, and profits migrate to broadband, business models that 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.[142] 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.[143]

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

[140] 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...."

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

[142] 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.

[143] 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.

Appendix C. International Policies for Spectrum Management

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.[144] AT&T, Verizon, and T-Mobile are major players internationally as well as in the United States.[145] 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.

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,[146] was the conclusion of a process initiated by an agreement for international harmonization of spectrum bands.[147] At this auction, T-Mobile was able to acquire new spectrum licenses that improved its competitiveness in the United States[148] and, consequently, the worldwide competiveness of its owner, Deutsche Telekom.[149]

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.[150] The ITU adopts a Table of Frequency Allocations in conjunction with International Radio Regulations. This International Table allocates spectrum for various radio services and

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

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

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

[147] 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.

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

[149] 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.

[150] 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, p. 19, fn. 26.

includes, directly or indirectly, conditions for the use of the allocated spectrum.[151] 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 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 January 2012.[152] 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.

In the NBP, the FCC has briefly discussed its participation in world forums and the role of the ITU in the development of new wireless technologies and services.[153] The NBP has recommended that the FCC should work within the ITU to promote innovative and flexible approaches to global spectrum allocation.[154]

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[151] 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.

[152] The NTIA and FCC websites carry information about planning for WRC 2012. 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.

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

[154] *Connecting America*, Recommendation 5.16.