



## **CRS Report for Congress**

# **Wireless Technology and Spectrum Demand: Advanced Wireless Services**

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### **Summary**

Advances in wireless telecommunications technology are converging with Internet technology to foster new generations of applications and services. Presently, the United States and other countries are moving to third-generation (3G) and fourth-generation (4G) mobile telephony. A related trend is the growth in use of Wi-Fi (wireless fidelity) and WiMAX (an industry designation for a type of broadband standard). Wi-Fi uses local wireless networks for high-speed (broadband) mobile access to the Internet. WiMAX uses broadband wireless to link fixed points and also supports mobile devices.

From the perspective of spectrum management, a significant difference in the technologies is that 3G, 4G, and WiMAX services operate on designated, licensed frequencies, while Wi-Fi shares unlicensed spectrum with other uses. From the perspective of spectrum policy, a key difference between licensed and unlicensed use is that the market for services delivered over licensed frequencies is developed by the license-holder whereas demand for services on unlicensed frequencies is developed by the manufacturers of the devices. As the markets for Wi-Fi and WiMAX expand, policy issues before Congress include the competitive impact on commercial wireless carriers when municipalities offer wireless broadband services, promoting the development of broadband wireless access, and assuring the availability of appropriate spectrum.

Legislation providing terms for the release of spectrum for unlicensed or licensed use in TV “white space” includes S. 234 (Senator Kerry) and its companion bill H.R. 1597 (Representative Inslee); S. 337 (Senator Sununu); and H.R. 1320 (Representative Rush). A bill to strengthen the national digital and wireless infrastructure, H.R. 694 (Representative Towns), is matched by a number of similar bills in the Senate. The substance of these bills is reflected in an amendment to S. 1642 (S.Amdt. 2371), which has been approved by the Senate. A research program focused on making advanced communications services available and affordable to all would be established by S. 1493 (Senator Inouye). S. 1853 (Senator Lautenberg), the Community Broadband Act, would assure the right of communities to offer advanced telecommunications services.

## Wireless Technology: Development and Demand

In order to deploy advanced wireless technologies, telecommunications carriers, broadcasters, cable companies, content providers and others are seeking effective strategies to move to new standards, upgrade infrastructure, and develop new services and content. This migration path includes decisions about acquiring and using spectrum. 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.<sup>1</sup> Spectrum is segmented into bands of radio frequencies and typically measured in cycles per second, or hertz.<sup>2</sup>

Commercial wireless communications typically rely on bandwidth below 3 GHz because of limitations in current technology. Although developments in technology increase the efficiency of spectrum and expand its usable range, there is persistent demand for spectrum to carry new services as other technologies reach the market. New developments in wireless technology support many services for business and consumer markets, such as enhanced Internet links, digital television and radio broadcast reception, high-quality streaming video, and mobile commerce (m-commerce) — including the ability to make payments.

**Mobile Telephony.** Mobile communications became generally available to businesses and consumers in the 1980s. This “first generation” technology, still in use, is analog, the prevailing telecommunications technology of the time. Second generation (2G) wireless devices are characterized by digitized delivery systems. Third generation (3G) mobile technology represents significant advances services in cell phone technology. 3G and 4G networks provide capacity for broadband applications that include video and mobile (transportable) television.<sup>3</sup> These leading-edge technologies can easily support multi-function devices, such as the BlackBerry and the iPhone. Business and consumer demand for mobile services is considered by many to be an important engine for future growth in American and global economies. The United States had over 245 million mobile phone subscribers in October 2007.<sup>4</sup>

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<sup>1</sup> The International Telecommunication Union (ITU), part of the United Nations, is the primary organization for coordinating global telecommunications and spectrum management.

<sup>2</sup> Radio waves are usually identified by frequency. 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.

<sup>3</sup> Broadband refers to the capacity of the radio frequency channel. A broadband channel can transmit live video, complex graphics and other data-rich information as well as voice and text messages whereas a narrowband channel might be limited to handling voice, text and some graphics. For an in-depth study of wireless broadband, see *Connected on the Go: Broadband Goes Wireless*, Wireless Broadband Access Task Force, Federal Communications Commission, February 2005 at [[http://hraunfoss.fcc.gov/edocs\\_public/attachmatch/DOC-257247A1.pdf](http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-257247A1.pdf)]. Viewed October 23, 2007.

<sup>4</sup> Statistic updated regularly at [<http://www.ctia.org/>].

**Wi-Fi and WiMAX.** In 1999, what is now known as the Wi-Fi Alliance formed to develop and promote a worldwide standard for localized, high-speed wireless networking.<sup>5</sup> Today, most new laptop computers come equipped with the technology that allows wireless access to the Internet using Wi-Fi technology. Wireless Local Area Networks (WLANs) operate on unlicensed spectrum, using radio frequencies in the free 2.4 GHz and 5.4/5.7GHz spectrum bands. A group of standards for frequency use in these bands is known as the 802.11 family, or legacy. The 802.11a/n standards are commonly referred to as Wi-Fi, for wireless fidelity. Wi-Fi provides high-speed 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 wireline (landline) either at a business location or through hotspots. Hotspots are typically located in homes or convenient public locations, including many airports and café environments such as Starbucks. Another standard for wireless Internet is Bluetooth, which has a shorter range than Wi-Fi but works well in cell phones. Bluetooth handles both voice and data; Wi-Fi is mostly data but also supports Voice over Internet protocol (VoIP) calls, sometimes known as VoWiFi.

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<sup>6</sup> that have agreed to develop interoperable broadband wireless based on a common standard (IEEE 802.16) for point-to-point transmissions. WiMAX technology can transmit data over distances of up to 30 miles and is used in the United States as a “last mile” technology, that is, a means to provide fixed wireless service to locations that are not connected to networks by cable or high-speed wires. Mobile WiMAX is still in the early stages of development.<sup>7</sup> WiMAX uses multiple frequencies around the world in ranges from 700 MHz to 66 GHz. In the United States, frequencies where WiMAX is being tested or used include 700 MHz, 1.9 GHz, 2.3 GHz, 2.5 GHz and 2.7 GHz. Not later than January 28, 2008, the FCC must hold auctions of available spectrum at 700 MHz.<sup>8</sup> The technologies and services chosen for this spectrum by the winning bidders could have a significant impact on the choice of mobile devices and wireless access to the Internet in the United States.

## **Broadband Wireless Access to the Internet**

As demand for Internet services grows, policymakers at all levels of government are seeking ways to make access — especially high-speed, or broadband, access — to the Internet available to all. As wireless technologies have improved, they have become a popular option for deploying municipal broadband, especially to disadvantaged sectors

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<sup>5</sup> website at [<http://www.wi-fi.org>].

<sup>6</sup> 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/>].

<sup>7</sup> A global standard for mobile WiMAX, 802.16e has been established by the IEEE 802.16 Working Group; documentation is at [<http://www.wimaxforum.org/technology/documents/>]. Viewed October 23, 2007. WiMax has been accepted as a 3G standard by the International Telecommunications Union.

<sup>8</sup> P.L. 109-171, Sec. 303 (a).

of a community. Successive Congresses have seen the introduction of bills supporting programs to bridge what is often called the digital divide, the inequality of access to the Internet because of technical or economic constraints.<sup>9</sup>

**Municipal Deployment of Broadband.** The two main broadband technologies that are particularly attractive to communities, in part because they support existing community services such as Internet access for schools and communications for public safety, are fiber-optic cable networks and wireless access — WiFi today, possibly WiMAX in the future. The spread of wireless services such as access to the Internet and anticipated advances in wireless technology are modifying the business case for choosing a broadband technology. Networks that depend on a fiber-optic cable backbone are capital-intensive and usually more profitable in high-density urban areas. A number of rural communities have used their resources to install fiber-optic broadband services in part because they were too small a market to interest for-profit companies. Increasingly, communities are looking at wireless technologies to support their networks.

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.<sup>10</sup> In the Telecommunications Act of 1996, Congress barred states from “prohibiting the ability of any entity to provide any interstate or intrastate telecommunications service.”<sup>11</sup> 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. The central debate is whether municipal broadband services are part of essential infrastructure with many public benefits, including stimulus to the local economy, or whether they provide unfair competition that distorts the marketplace and discourages 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 and a form of unfair competition.

Municipalities installing free Wi-Fi zones often contend that generally available access to the Internet through wireless connections has become an urban amenity, arguably a necessity in sustaining and developing the local economy. Municipal Wi-Fi also provides the opportunity to improve social services and Internet access in disadvantaged communities that often are not served by fiber optic networks.<sup>12</sup>

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<sup>9</sup> For further information, see CRS Report RL30719, *Broadband Internet Access and the Digital Divide: Federal Assistance Programs*, by Lennard G. Kruger and Angele A. Gilroy.

<sup>10</sup> U.S. Supreme Court, Docket Number 02-1238.

<sup>11</sup> 47 U.S.C. 253 (a).

<sup>12</sup> The Federal Trade Commission's 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>]. Viewed October 23, 2007.

**White Space.** 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. New technologies that can use unlicensed spectrum without causing interference are proposed for vacant spectrum designated to provide space between the broadcasting signals of digital television, known as white space. On September 11, 2006, the FCC announced a timetable for allowing access to the spectrum so that devices could be developed and ready for retail sales by February 2009.<sup>13</sup> One of the potential uses for white space is wireless broadband to support access to the Internet.<sup>14</sup> These unlicensed applications could be used as an extension of the licensed applications that will be possible on the 700 MHz band once it is cleared of analog broadcasts. The National Association of Broadcasters (NAB), and others, are protesting the use of white space for consumer devices on the grounds that they could interfere with digital broadcasting. Companies such as Microsoft, Dell, and Motorola, however, have stated that they believe solutions can be found to prevent interference. NAB has asked the FCC to complete the rule-making process by banning unlicensed devices from white spaces. Other interests, including consumer groups, argue that the potential for new services, especially the possibility of wireless access to the Internet in under-served areas, merits that the FCC continue to evaluate technologies. There have also been proposals to license some of the frequencies in white space and auction the licenses.

**Fair Access.** In recent Congresses, bills have been proposed to improve access to the Internet that have focused on overcoming technological or economic barriers that excluded some sectors of the population. In the 109<sup>th</sup> Congress, the policy debate expanded to include the concept of net neutrality. In general, net neutrality is the principle of non-discriminatory access by all website providers to all Internet users, with no artificial barriers.<sup>15</sup> The role of wireless technologies in enhancing competition or side-stepping regulations governing the Internet is an aspect on the net neutrality debate that has not been fully engaged by Congress. Some observers are asking if there should be a “wireless exception” in net neutrality laws and regulations or whether net neutrality laws can be written that apply to wireless services. One proposal to develop network neutrality regulations or laws for wireless networks argues that requirements for neutrality are essential for wireless services, which are often linked to proprietary technologies.<sup>16</sup> The FCC has set aside licenses in the upcoming auction of 700 MHz open access to acceptable devices. Such an approach could combine the consumer-driven, open access features of unlicensed spectrum with the structured traffic-control rules of licensed spectrum.<sup>17</sup>

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<sup>13</sup> FCC, *First Report and Order and Further Notice of Proposed Rule Making*, ET Docket No. 04-186, released October 18, 2006.

<sup>14</sup> “Tech Firms Push to Use TV Airwaves for Internet,” by Charles Babington, *The Washington Post*, March 13, 2007.

<sup>15</sup> A discussion of net neutrality and issues facing the 110<sup>th</sup> Congress is provided in CRS Report RS22444, *Net Neutrality: Background and Issues*, by Angele A. Gilroy.

<sup>16</sup> Wireless Net Neutrality: Cellular *Carterfone* on Mobile Networks, by Tim Wu, February 2007. At [[http://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=962027](http://papers.ssrn.com/sol3/papers.cfm?abstract_id=962027)]. Viewed October 23, 2007.

<sup>17</sup> FCC News, “FCC Revises 700 MHz Rules to Advance Interoperable Public Safety (continued...)”

## Bills in the 110<sup>th</sup> Congress

Bills to increase the availability of unlicensed spectrum for community broadband are H.R. 1597, S. 234 and S. 337. The Wireless Innovation Act of 2007 (S. 234, Senator Kerry) would require the FCC to complete Docket 04-186 and issue a final order, among other requirements, within 180 days of the bill becoming law. H.R. 1597 (Representative Inslee) is a companion bill. The White Spaces Act (S. 337, Senator Sununu) would provide terms for the release of white space spectrum for unlicensed or licensed use, prohibit the FCC from banning the marketing of technologies that work on the white space, and address uncertainty stemming from legal proceedings regarding authority over the use of the spectrum, among other uses. The Interference Protection for Existing Television Band Devices Act (H.R. 1320, Representative Rush) would prohibit the use of unlicensed devices of any kind in white space in rural areas until after February 17, 2009, and of mobile devices until at least three years later. In particular, unlicensed devices would not be allowed to operate on channels already in use by low-power auxiliary television broadcast devices and the FCC would be required to seek additional way to protect these broadcasts from interference by unlicensed devices.

The Community Broadband Act of 2007 (S. 1853, Senator Lautenberg) would specifically assure the rights of communities to offer broadband services. Other provisions of the bill, would prohibit discrimination against competing service providers, and would require full disclosure of the intended project to the community. Public-private partnerships are encouraged in the bill's language. S. 1853 was unanimously reported out of the Committee on Commerce, Science, and Transportation on October 30, 2007.

Bills to improve access to digital and wireless services are S. 291 (Senator Smith), S. 315 and S. 1857 (Senator Warner), S. 1650 (Senator Kerry), and H.R. 694. All the bills would provide grants to strengthen the national digital and wireless infrastructure by supporting investment in minority-serving institutions. Of these, S. 1650 was reported favorably, with amendments, by the Senate Committee on Commerce, Science, and Transportation on June 27, 2007. The bill had previously been discharged by unanimous consent by the Committee on Health, Education, Labor, and Pensions. Different language, based on S. 1857, but incorporating elements of S. 1650, was included in S. 1642, Higher Education Amendments of 2007 (Senator Kennedy) as S.Amdt. 2371. The Senate passed S. 1642, as amended, on July 24, 2007. H.R. 694, as amended, was passed by the House on September 4, and sent to the Senate.

A different approach for increasing access is taken in S. 1493 (Senator Inouye). The bill would establish a research program focused on making advanced communications services available and affordable to all, as part of a broader program to promote innovation and research in information and communication technologies. crsphgww

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<sup>17</sup> (...continued)

Communications and Promote Wireless Broadband Deployment," July 31, 2007.