Water Law Principles Applied to Spectrum Opportunities for Wireless Rural Broadband

Table of Contents **page**

I. Introduction

The Federal Communications Commission (FCC) issued an order in November 2008 to free up unused radio spectrum in the television frequency band for unlicensed use by low power devices.[1] A goal of the order is to help lower the costs of entry to potential wireless broadband providers by making more spectrum available for free to businesses and consumers.[2]

One shortcoming in relation to rural users is the order's failure to address backhaul between a rural community and backbone networks.[3] Frequencies in the television spectrum that are the focus of the White Spaces Order do not lend themselves well to point to point communication necessary for longer distance backhaul from a community to a backbone connection point. Without access to spectrum for backhaul, rural communities will be forced to rely on other alternatives such as more expensive fiber

1 FCC, Second Report and Order and Memorandum Opinion and Order, In the Matter of Unlicensed Operation in the TV Broadcast Bands, ET Docket No. 04-186, Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band, ET Docket No. 02-380, 23 F.C.C.R. 16807, 16814 (Nov. 4, 2008) [hereinafter White Spaces Order].

2 *Id.* at 16808.

3 Backhaul and backbone are discussed in more detail below, in Section IV. In short, backhaul is a necessary component of any network, connecting that local network to a long haul backbone network.

cables. As such, the Commission will need to provide spectrum that is better suited for backhaul required for viable and economic high speed Internet services in rural communities. To that end, I suggest that the Commission apply three modified principles of water law that: 1) require spectrum use be beneficial and reasonable; 2) require the licensee to actually use the spectrum and not hold a license for speculative purposes; and 3) provide for equivalent replacement of a communications signal.[4] Applying these principles will free up unused and underutilized spectrum for more productive purposes including point to point backhaul connections.

High speed access to the Internet is now essential.[5] Rural communities risk economic stagnation without high speed Internet access. Major studies demonstrate that high speed Internet access, often referred to as broadband, has a significant positive impact on economic growth.[6] This is because increased broadband deployment fosters a network effect multiplier that encourages investment in technologies and industries that create innovative applications and services.[7] In turn, technological innovation and change are important to economic growth and welfare of the people.[8] A Brookings report estimates that "every one percentage point increase in [broadband] penetration in a state, employment is projected to increase by 0.2 to 0.3 percent per year," or 300,000 jobs nationally.[9] In addition, broadband

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4 These principles are discussed in greater detail below, in Section V.

5 Richard S. Whitt, *Evolving Broadband Policy: Taking Adaptive Stances to Foster Optimal Internet Platforms*, 17 COMMLAW CONSPECTUS 417, 422-23 (2009) [hereinafter Whitt, *Evolving Broadband Policy*].

6 Whitt, *Evolving Broadband Policy, supra* note 5, at 439-40; *See also* Berkman Center for Internet & Society, *Next Generation Connectivity: A Review of Broadband Internet Transitions and Policy From Around the World,* 21-23 (citing Christing Zhen-Wei Qiang et al., *Information and Communications for Development 2009: Extending Reach and Increasing Impact*, World Bank (July 2009)) ("a July, 2009 report from the World Bank ... calculates that every 10 additional broadband subscribers out of every 100 inhabitants are correlated in high income countries with GDP growth increases of 1.21%.... [T]he average growth rate of a developed economy over the period of the study—from 1980 to 2006—was 2.1%. U.S. growth in the shorter period of 1997-2008 was 2.8%.").

7 Whitt, *Evolving Broadband Policy, supra* note 5, at 441.

8 Stuart Minor Benjamin & Arti K. Rai, *Fixing Innovation Policy: A Structural Perspective*, 77 GEO. WASH. L. REV. 1, 8-9 (2008); Whitt, *Evolving Broadband Policy, supra* note 5, at 422-23 ("In Paul Romer's words, "technological change ... lies at the heart of economic growth."").

9 Robert Crandall, William Lehr & Robert Litan, *The Effects of Broadband Deployment on Output and Employment: A Cross-sectional Analysis of U.S. Data, Issues in Economic Policy*, 2 (Brookings Institution July 2007) available at http://www.brookings.edu/~/media/Files/rc/papers/2007/06labor_crandall/06labor_crandall.pdf. These numbers were measured during a period of economic growth, 2003-2005, so I am not sure about the long-term prospects for these figures. I do wonder about the long term prospects since Pew reported a 15% increase in broadband penetration in the past year; however, the unemployment rate rose nationwide. *See also* Anthony E. Varona, *Toward a Broadband Public Interest Standard*, 61 ADMIN. L. REV. 1, 85 (2009).

plays a vital role as a connectivity platform, with numerous economic and non-economic benefits such as civic engagement and connection with family or friends.[10] As such, broadband is a very important basic tool in the current economy and will play an increasingly important role going forward.[11]

Congress has taken a strong interest in promoting the Internet as an engine of economic growth.[12] With that in mind, Congress delegated to the Commission and supplied broad mandates and authority to foster Internet access. The Commission is mandated to "encourage the deployment . . . of advanced telecommunications capability to all Americans . . . by utilizing . . . regulating methods that remove barriers to infrastructure investment."[13] The Commission has taken that mandate to mean that Congress expects universal broadband access to the Internet.[14] Its goal in regard to broadband access has not been met.[15] As of April 2009, 63% of adult Americans have broadband Internet connections at home.[16] Broken

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[10] Whitt, *Evolving Broadband Policy, supra* note 5, at 441-42. *See also* Varona, *Toward a Broadband Public Interest Standard*, *supra* note 9, at 4-5, 125.

[11] Whitt, *Evolving Broadband Policy, supra* note 5, at 439-40.

[12] U.S. Gov't Acct. Office, Broadband Deployment is Extensive Throughout the United States, but it is Difficult to Assess the Extent of Deployment Gaps in Rural Areas, GAO-06-426, 1 (May 2006) [hereinafter GAO Rural Broadband Report] ("[GAO Highlights] Broadband is seen as a critical economic engine, a vehicle for enhanced learning and medicine, and a central component of 21st century news and entertainment.");

[13] Telecommunications Act of 1996 § 706(a), 47 U.S.C. § 1302(a), 110 Stat 56, PL 104-104. Moreover, Congress defined "advanced telecommunications capability" as , "highspeed, switched, broadband telecommunications capability that enables users to originate and receive high-quality voice, data, graphics, and video telecommunications using any technology." Telecommunications Act of 1996 § 706(c)(1); 47 U.S.C. § 1302(d)(1). The Commission takes that to mean that "advanced telecommunications capability" includes broadband Internet access. FCC, In the Matter of a National Broadband Plan for Our Future, Notice of Inquiry, GN Docket No. 09-51, FCC 09-31, 49 (June 8, 2009). In that regard, the Commission has used the terms "broadband" and "advanced telecommunications capability" interchangeably to refer to high speed Internet access in it 5th report to Congress on Section 706. FCC, In the Matter of Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion, and Possible Steps to Accelerate Such Deployment Pursuant to Section 706 of the Telecommunications Act of 1996, Fifth Report to Congress, GN Docket No. 07-45, 23 F.C.C.R. 9615 (March 19, 2008) [hereinafter FCC, Fifth Section 706 Report to Congress].

[14] FCC, Fifth Section 706 Report to Congress, *supra* note 13, at 9615 ("The end goal is to ensure the ubiquitous and affordable availability of broadband for all Americans.").

[15] The Commission reported the opposite in its 5th report to Congress on Section 706. FCC, Fifth Section 706 Report to Congress, *supra* note 13, at 9616. GAO, among others, have panned the measurements used by the Commission. "Based on our analysis is appears that these data may not provide a highly accurate depiction of deployment of broadband infrastructures for residential service in some areas." GAO Rural Broadband Report, *supra* note 12, at 3. More recently, the Commission has said its next inquiry has begun "on a clean slate." FCC, In the Matters of Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion, and Possible Steps to Accelerate Such Deployment Pursuant to Section 706 of the Telecommunications Act of 1996, as Amended by the Broadband Data Improvement Act, Notice of Inquiry, GN Docket No. 09-137, 24 F.C.C.R. 10505, 10506 (July 31, 2009).

[16] John Horrigan, *Home Broadband Adoption 2009*, Pew Internet & American Life Project (June 17, 2009) http://www.pewinternet.org/Reports/2009/10-Home-Broadband-Adoption-2009.aspx. One problem with this number is that it might not be reliable since Pew does not actually ask if people are in rural areas, rather it guesses based on the

down, 46% of rural Americans and 67% non rural Americans have broadband access.[17] That means over 50% of rural Americans do not subscribe to broadband service, often because none are available where that person lives or they cannot afford the service offered.[18] This means that over fifty percent of people who live in rural areas lack access to a very important engine of economic growth.

Universal broadband service is costly. The Internet is the latest generation telecommunications system. It mostly consists of newer technologies and equipment but has backwards compatibility so it can be used with the old copper telephone system when economically efficient to do so.[19] Building the infrastructure requires big capital investment because about eighty to ninety percent of the total cost to provide broadband service may be fixed costs.[20] For example, it reportedly costs Verizon about $4,000 in capital costs per individual home to deploy FiOS, its fiber to the home service.[21] This also reportedly costs more than $2,500 above the expected incremental revenues and cost savings.[22] Costs are inversely proportional to density and increase as density decreases.[23] About seventy percent of the total cost of

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prefix. *Id.* ("blocks of cell phone numbers do not neatly map to Census definitions of urban, suburban, and rural. However, samples of cell phone numbers do include the Metropolitan Statistical Area (MSA) in which the cell phone was activated, which is a close proxy for where the user lives. Respondents who do not live in MSAs live (to a very close approximation) in rural areas and in this report such respondents are categorized as rural residents.").

17 *Id.* One problem with this number is that it might not be reliable since Pew does not actually ask if people are in rural areas, rather it guesses based on the prefix. *Id.* ("blocks of cell phone numbers do not neatly map to Census definitions of urban, suburban, and rural. However, samples of cell phone numbers do include the Metropolitan Statistical Area (MSA) in which the cell phone was activated, which is a close proxy for where the user lives. Respondents who do not live in MSAs live (to a very close approximation) in rural areas and in this report such respondents are categorized as rural residents.").

18 GAO Rural Broadband Report, *supra* note 12, at 30 ("[The GAO survey] found that only 17 percent of rural households subscribe to broadband service.... [W]hen the availability of broadband to households [and] demographic characteristics [are considered] rural households no longer appear less likely than urban households to subscribe to broadband.... [T]he difference in ... subscribership ... appears ... related to ... availability of the service across these areas, and not to a lower disposition of rural households to purchase the service.").

19 It is actually a converged network of networks, encompassing telephone networks, cable networks, fiber long haul backbone networks, and networks with newer generation technologies.

20 Whitt, *Evolving Broadband Policy, supra* note 5, at 433.

21 Whitt, *Evolving Broadband Policy, supra* note 5, at 449.

22 *Id.*

23 GAO Rural Broadband Report, *supra* note 12, at 4, 19-20 ("Many stakeholders ... said population density—which is the population per square mile—was a critical determinant of companies' deployment decisions.... [T]he cost of building a broadband infrastructure in areas where people live farther apart is much higher than building infrastructure to serve the same number of people in a more urban setting. As such, some stakeholders noted that highly rural areas—which generally have low population density—can be costly to serve."). This is demonstrated in the costs of fiber deployment. CSMG, working on behalf of Corning, estimates that the cost for fiber deployment in 2009 to pass a household (HH) is $700 in dense areas with 879.5 HH per square mile, $1,246 in less dense areas with 174.9 HH per square mile, and $1,661 in areas with 71.9 HH per square mile cost. Corning, Inc., Innovations in FTTH Reduced Cost and Improved Scalability

fiber deployment is in utilizing labor, securing the rights of way, and digging trenches.[24] Wireless networks are more affordable but not immune from these costs.[25] Towers that hold wireless equipment cost an average of $100,000 to build or between $18,000 and $30,000 per year to lease.[26] In addition, the wireless provider needs to connect the wireless equipment on the tower to its facilities using backhaul and then pay connection fees at the backbone.[27] Wireless networks also need access to the radio spectrum.[28] The provider can share some unlicensed bands of radio spectrum but must then accept interference or otherwise it must purchase an exclusive use license for a specific chunk of spectrum.[29] An exclusive use license can cost billions.[30]

The White Spaces Order is partly directed at lowering those costs associated with access to spectrum, which in turn is intended to help lower the costs of entry to potential wireless broadband providers. Before addressing the order more directly, it is important to provide context and first discuss radio spectrum, licensing models used, spectrum opportunities, and a sea change occurring in radio technology. Once framed, this paper addresses the White Spaces Order, its goals, and its limited affect on backhaul. I then suggest that one way to free up unused and underutilized spectrum for more productive purposes including point to point backhaul connections is to apply water law principles to spectrum.

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of Deployments, Ex Parte Presentation, GN Docket No. 09-51 (Filed Oct. 15, 2009). In addition, it costs about $650 in 2009 to hook up each household. *Id.* According to CSMG, there is an average density of 1,027 HH per square mile in urban areas, 564 HH per square mile in suburban areas, and 7 HH per square mile in rural areas. *Id.* I assume the average density of rural households includes both areas in town and further away. In which case, the number may be somewhat misleading since towns and cities may have a greater density near the center of town.

[24] Whitt, *Evolving Broadband Policy, supra* note 5, at *449*.

[25] Whitt, *Evolving Broadband Policy, supra* note 5, at 433. Despite the intensive use of wireless devices in building out a network in rural Vermont, it will cost about $850 more per household than it did to build out a fiber network in Burlington, Vermont's largest city. David Chafee and Mitchell Shapiro, *Municipal & Utility Guidebook to Bringing Broadband Fiber Optics to Your Community*, 99 (2008), http://www.pti.org/docs-cio/Municipal&UtilityGuidebook.PDF

[26] Whitt, *Evolving Broadband Policy, supra* note 5, at 433. *See also* ColusaNET's WISPTower Project, http://www.doityourselftower.com/selftowerinstall.pdf (last visited Dec. 10, 2009) (chronicling construction for a tower to hold equipment for a wireless Internet service provider (WISP) and generally commenting that it is expensive, even as a do-it-yourself project).

[27] Whitt, *Evolving Broadband Policy, supra* note 5, at 433; Backbone networks and backhaul are discussed below.

[28] Whitt, *Evolving Broadband Policy, supra* note 5, at 433;

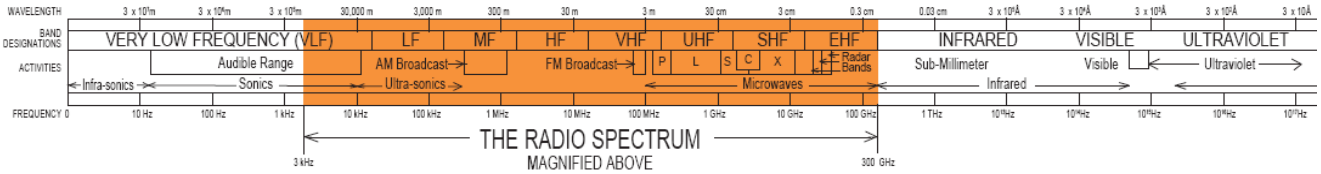
[29] Whitt, *Evolving Broadband Policy, supra* note 5, at 433;

[30] This is discussed more below. *See also,* Whitt, *Evolving Broadband Policy, supra* note 5*,* at 433.

II. Radio Spectrum

Radio Spectrum is a small slice of the full electromagnetic spectrum used by modern communications systems. The electromagnetic spectrum ranges from cosmic rays to sound waves and is shared by all communications that use a particular physical transmission medium such as air or wire.[31] Radio spectrum is commonly known by its components such as microwave, very high frequency (VHF), and infrared. It encompasses the segment between audible sound waves and infrared light (see Figure 1).

Figure 1: Radio Spectrum as Part of the Electromagnetic Spectrum[32]



Radio waves radiate from an antennae, broadcasting a signal in the radio spectrum to the farthest extent of its range.[33] The broadcast pattern is generally dependent upon the frequency. The frequencies used for television and radio lend themselves better to broadcast systems, also referred to as unguided systems.[34] Such signals spread from the antennae in all directions and do not discriminate or choose where to go, or not go, within its range.[35] In contrast, other higher frequencies in the multi-gigahertz range allow for a fairly tight beam from transmitter to receiver and can be used for point-to-point communications.[36]

The frequency of a signal determines how well that signal will deal with interference. Interference can come from anything that blocks the path of the signal such as a mountain, tree, or building.[37] In

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31 Warren J. Smith, Modern Optical Engineering, 1 (3rd ed. 2000). Some of the most common physical transmission media used in communications technology include air (wireless), glass (fiber optics), and metal wire (coaxial or copper telephone line). Each media uses parts of the electromagnetic spectrum. For example, fiber optics use light.

32 Derived from the National Telecommunications and Information Administration (NTIA) U.S. spectrum Frequency Allocation Chart as of October 2003, available at http://www.ntia.doc.gov/osmhome/allochrt.pdf, (last visited October 18, 2009).

33 Fred Halsall, Multimedia Communications: Applications, Networks, Protocols and Standards 298 (2001).

34 Richard Thanki, *The Economic Value Generated by Current and Future Allocations of Unlicensed Spectrum*, 55 (2009) (prepared for Microsoft) [hereinafter Thanki, *Economic Value of Unlicensed Spectrum*].

35 Ray Horak, Communications Systems and Networks, 34 (3rd ed. 2002).

36 Thanki, *Economic Value of Unlicensed Spectrum*, *supra* note 34, at 23, 55.

37 *See* GAO Rural Broadband Report, *supra* note 12, at 19, 37.

addition, any other electromagnetic waves traveling at the same frequency potentially serve as interference. Some frequencies have better propagation properties than others and will deal better with interference. For example, signals in the television frequency band deal better with objects such as trees or buildings than higher frequencies.[38]

In addition to frequency, signals also differ based on the encoding used. Even though you may build a device to receive signals in the radio spectrum, it will be worthless unless that device can decode the signal. Generally speaking, any person with a receiver built to capture and decode that specific signal will be able to access the contents of the signal.[39] The switch from analog to digital television provides a recent demonstration. Old television sets were built to decode only analog television signals and cannot decode the digital signals they receive. To remain usable, viewers need to hook the old television set to another device that will input an analog signal the television can then use. In most cases, a cable converter box provides the analog signal; however, people without cable subscriptions need to buy a special box that converts the digital signals received over the air to analog.

A. Radio Spectrum Licensing

Radio spectrum is a natural resource held in the public trust.[40] Outside of spectrum reserved for government use, the Commission generally allocates radio spectrum through a license to use specific frequency bands within a particular geographic area.[41] Licensees do not have a property right in the spectrum; however, it is generally understood that the licenses are perpetual in nature.[42]

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38 *See* Sascha D. Meinrath & Michael Calabrese, *White Spaces Devices & the Myths of Harmful Interference*, 11 N.Y.U. J. Legis. & Pub. Pol'y 495, 500 (2008); Susan P. Crawford, *The Radio and the Internet*, 23 Berkeley Tech. L.J. 933, 963 (2008).

39 Ray Horak, Communications Systems and Networks, 440 (3rd ed. 2002).

40 *See* 47 U.S.C. §301 ("It is the purpose of this chapter, among other things, to maintain the control of the United States over all the channels of radio transmission").

41 FCC, Fostering Innovation and Investment in the Wireless Communications Market, Notice of Inquiry, 24 F.C.C.R. 11,322, para. 21 (2009) [hereinafter NOI Fostering Innovation & Investment]. The Department of Commerce, National Telecommunications and Information Administration (NTIA) manages spectrum reserved for government uses. *See* http://www.ntia.doc.gov/.

42 47 U.S.C. § 301 ("It is the purpose of this chapter ... to provide for the use of such channels, but not the ownership thereof, by persons for limited periods of time, under licenses granted by Federal authority"); Linda K. Moore, *Spectrum Management: Auctions, Congressional Reports Service*, 7 (September 2, 2008), available at http://assets.opencrs.com/rpts/RL31764_20070820.pdf ("Even though licenses must be renewed periodically, it is

Over time, the Commission has used two basic models for spectrum licensing, and sometimes a mix: 1) exclusive use, and 2) commons.[43] Most radio spectrum is set aside for the exclusive use of a licensee or, in the case of reserved spectrum, by the government.[44]

On the flip side, the Commission also utilizes an unlicensed approach through the commons model.[45] In this licensing method, the Commission allows unlimited numbers of users to share the same, albeit small, frequency bands.[46] Unlicensed devices are prohibited from operating in frequencies not designated for unlicensed use, which had included the television frequency band until the White Spaces Order.[47] In the commons model, the usage rights are governed by basic technical standards that set power limits and some other criteria but with no protection from interference.[48] For instance, the Commission has set aside a small set of frequency bands without any particular use or technology in mind.[49] Over time, a variety of proprietary and open standards for communication have developed to

generally understood that license winners will be able to keep the license perpetually, as long as they comply with FCC service rules. "); Crawford, *The Radio and the Internet*, *supra* note 38, at 965; Philip J. Weiser & Dale Hatfield, *Spectrum Policy Reform and the Next Frontier of Property Rights*, 15 Geo. Mason L. Rev. 549, n5 (2008), [hereinafter Weiser & Hatfield, *Spectrum Policy Reform*] ("Technically speaking, the Communications Act does not allow any individual or firm to possess a property right in radio spectrum.").

43 The Commission has previously stated there are three models. FCC, Spectrum Policy Task Force Report, ET Docket No. 02- 135, 35 (Nov. 2002), available at http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-228542A1.pdf [hereinafter FCC Spectrum Policy Report]. In reality, command and control is a form of an exclusive license based on its descriptions. There happen to be different degrees of control within that exclusive license model that range from command and control, where the Commission identifies and approves a limited set of spectrum uses and often will specify operational aspects such as power levels and antennae height, to flexible use and transfer rights such as is generally found in cellular licenses. *Id.* ("[The Commission] allocates and assigns frequencies to limited categories of spectrum users for specific government-defined uses. Service rules for the band specify eligibility and service restrictions, power limits, build-out requirements, and other rules."); *See also* Weiser & Hatfield, *Spectrum Policy Reform, supra* note 42, at 550-552; Thomas W. Hazlett, *A Law & Economics Approach to Spectrum Property Rights: A Response to Weiser and Hatfield*, 15 Geo. Mason L. Rev. 975, 1012 (2008) [hereinafter Hazlett, *Response to Weiser & Hatfield*]; NOI Fostering Innovation & Investment, *supra* note 41, at 6 ("The Commission also shifted away from mandating technical standards other than those designed to control interference or to meet specified public interest objectives ... [and] subsequently adopted more flexible technical rules, which in turn have enabled the introduction of second, third, and fourth generation digital wireless phones, all without the need for further Commission action.").

44 *See* Thanki, *Economic Value of Unlicensed Spectrum*, *supra* note 34, at 4, Figure 1 (providing a visual representation of unlicensed spectrum in the United States).

45 FCC Spectrum Policy Report, *supra* note 43, at 35. *See also* Renee Dopplick, *Hidden Costs of the Wireless Broadband Lifestyle: Comparing Consumer Protections in the United States, Canada, and the European Union*, 15 Rich. J. L. & Tech. 5, 7 (2008) [hereinafter Dopplick, *Hidden Costs of Wireless Broadband*] ("Consumers have been able to use unlicensed devices since 1934").

46 FCC Spectrum Policy Report, *supra* note 43, at 35.

47 White Spaces Order, *supra* note 1, at 16812-16.

48 White Spaces Order, *supra* note 1, at 16812-13; FCC Spectrum Policy Report, *supra* note 43, at 35. *See also* Dopplick, *Hidden Costs of Wireless Broadband*, *supra* note 45, at 10; 47 C.F.R. § 15.

49 James B. Speta, *Spectrum Policy Experiments: What's Next?*, 2008 U. Chi. Legal F. 389 (2008).

make use of the spectrum available.[50] Applications built using these standards have been deployed in many sectors, including for use by consumers, businesses, public agencies, and industry.[51]

In addition, as with the White Spaces Order, the Commission uses a hybrid model that mixes spectrum (e.g. 6 MHz channel in the television frequency band) exclusively licensed to one party with a commons approach to regulate devices that operate within spectrum opportunities in that band.[52]

B. Spectrum Opportunities

In practice, large swaths of spectrum are vastly underutilized or used for relatively low value activities.[53] Depending on the time and location, statistics show the utilization of both licensed and unlicensed spectrum can be low.[54] Measurements made in New York City found that only 13% of spectrum between 30 MHz and 2.9 GHz was occupied at one time or another during a four day period in 2004.[55] This measurement includes spectrum reserved for government use and misses out on some higher frequency spectrum use. Even then, the Commission has acknowledged these and other measurements suggest some spectrum is underutilized and could be made available for secondary users.[56]

In addition, frequency utilization has geographic and temporal variations. While some frequency

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50 Meinrath & Calabrese, *White Spaces Devices & the Myths of Harmful Interference*, *supra* note 38, at 499-500.

51 Thanki, *Economic Value of Unlicensed Spectrum*, *supra* note 34, at 5.

52 Weiser & Hatfield, *Spectrum Policy Reform*, *supra* note 42, at 549.

53 Weiser & Hatfield, *Spectrum Policy Reform*, *supra* note 42, at 549.

54 Dusit Niyato & Ekram Hossain, *Cognitive Radio for Next-Generation Wireless Networks: An Approach to Opportunistic Channel Selection in IEEE 802.11-Based Wireless Mesh*, IEEE Wireless Comm., 46 (Feb. 2009) [hereinafter Niyato & Hossain, *Cognitive Radio*].

55 U.S. Gov't Acct. Office, Strong Support for Extending FCC's Auction Authority Exists, but Little Agreement on Other Options to Improve Efficient Use of Spectrum, GAO-06-236 (Dec. 2005) [hereinafter GAO FCC Auction Authority Report] (citing Mark McHenry & Dan McCloskey, *New York City Spectrum Occupancy Measurements September 2004* (2004)). It should be noted that this percentage does not take into account spectrum above 2.9GHz, which is also used for communications. In addition, this percentage includes spectrum reserved for government use only. While commercial services show a somewhat steady use, military spectrum is in great demand (due to high volume communications) during times of war. On the other hand, military spectrum is highly underutilized during peace time. Shamik Sengupta et al., Enhancements to cognitive radio based IEEE 802.22 air-interface, IEEE International Conference on Communications (2007).

56 NOI Fostering Innovation & Investment, *supra* note 41, at 13. It is unclear whether anyone clearly understands why all spectrum goes underutilized. Some known reasons based on time of day, geography, and who reserved the spectrum. Telecommunications systems are less apt to be used in the middle of the night while people sleep. It is also likely to be underutilized in places licensees have fewer subscribers or that generally have fewer people.

bands get heavy use in one location during one part of the day, the same frequencies might not get much use at other times of the day or in another geographic location.[57] For example, while a wireless system may heavily use its allocated frequency at a given time or location, the same frequency may not get used much at other times of the day or in other locations.[58] The unused spectrum at that particular time or location is referred to as a spectrum hole or spectrum opportunity by engineers.[59]

Television provides us a good example of spectrum opportunities. The Commission has traditionally used command and control over the television frequency band, dividing the 300 MHz wide band into 6 MHz channels.[60] Terrestrial television stations broadcast signals over large areas many miles in diameter using very high powered transmitters.[61] The frequency, power level, and local topography determines the range the station has without causing interference.[62] In addition, geographic and spectral space is kept between stations to prevent interference with each other.[63] For example, if channel 9 is licensed in a market then channel 8 and 10 will be vacant, as will channel 9 in any neighboring viewing market. These vacancy requirements along with economic decisions by broadcasters to focus on metropolitan service has resulted in many rural markets with a relatively small number of licensed television channels.[64] Most television markets use less than half of the available 49 channels.[65] The national average is 8 full power broadcast stations per market, which results in 83.5 percent of TV channels unused nationwide.[66] This method of spectrum allocation results in vacant channels in the

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57 Niyato & Hossain, *Cognitive Radio*, *supra* note 54, at 46-47.
58 Niyato & Hossain, *Cognitive Radio*, *supra* note 54, at 46-47.
59 Niyato & Hossain, *Cognitive Radio*, *supra* note 54, at 47; Simon Haykin, *Cognitive Radio: Brain-Empowered Wireless Comm.*, 23 IEEE J. ON SELECTED AREAS IN COMM., 2 (Feb. 2005) [hereinafter Haykin, *Cognitive Radio*].
60 Crawford, *The Radio and the Internet*, *supra* note 38, at 1002; White Spaces Order, *supra* note 1, at 16812-15
61 Thanki, *Economic Value of Unlicensed Spectrum*, *supra* note 34, at 53.
62 Thanki, *Economic Value of Unlicensed Spectrum*, *supra* note 34, at 53
63 Thanki, *Economic Value of Unlicensed Spectrum*, *supra* note 34, at 53; Weiser & Hatfield, *Spectrum Policy Reform*, *supra* note 42, at 559; White Spaces Order, *supra* note 1, at 16814.
64 Meinrath & Calabrese, *White Spaces Devices & the Myths of Harmful Interference*, *supra* note 38, at 497-98.
65 Crawford, *The Radio and the Internet*, *supra* note 38, at 999.
66 There are 1,700 stations in 210 television markets nationwide. Hazlett, *Response to Weiser & Hatfield*, *supra* note 43, at 1012. It is unclear if this factors in border regions such as Detroit, which also gets Canadian channels from Windsor and surrounding areas in Ontario.

television band that provide spectrum opportunities, labeled white spaces.[67] Unlike most spectrum in use today, the television white spaces is fragmented into 6MHz segments that may or not be contiguous.[68] In that way, it has been likened to swiss cheese.[69] The amount of fragmentation depends largely on the number of television stations in a given area, generally corresponding to population density.[70]

Figure 2: Left to right: television frequency band white spaces in urban cluster, urbanized, and rural areas[71]

Spectrum opportunities will only increase as newer technology further shrinks the unit size of spectrum used and improves the ability for spectrum users to treat each other as manageable noise rather than interferences that cause degradation of reception, thus allowing multiple users to better share the

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67 White Spaces Order, *supra* note 1, at 16814.

68 Paramvir Bahl, et al., *White Space Networking with Wi-Fi like Connectivity*, PROCEEDINGS OF THE ACM SIGCOMM 2009 CONF. ON DATA COMM., BARCELONA, SPAIN (Aug. 2009) (Microsoft) [hereinafter Bahl, *White Spaces Networking*], http://research.microsoft.com/pubs/80952/whitefi.pdf (last visited Dec. 10, 2009) ("A UHF channel is narrow (6 MHz wide in the US), and prior research has shown that aggregating contiguous channels improves throughput").

69 Crawford, *The Radio and the Internet*, *supra* note 38, at 1002.

70 Bahl, *White Spaces Networking*, *supra* note 68, at 2. You can partly see this in the number of white spaces shown in Figure 2.

71 Check marks indicate television white spaces. The X marks indicate black spaces, which are used by incumbent high powered television station, and microphones indicate channels reserved in certain metropolitan areas for television auxiliary devices such as wireless mics. Images are derived from white spaces database at http://www.showmywhitespace.com/ Mountain View, California is in the San Francisco-San Jose-Oakland metropolitan area and is classified by the U.S. Census Bureau as an urbanized area. Burlington, Vermont is likewise classified by the U.S. Census Bureau as an urbanized area although with only 105,000 people. In contrast, Claudville, Virginia is classified by the U.S. Census Bureau as rural. *See* Qualifying Urban Areas for Census 2000, Bureau of the Census, Department of Commerce, 67 Fed Reg. 84, 21961, 21965 (May 1, 2002), available at http://www.census.gov/geo/www/ua/frmay102.txt

same frequency band.[72]

C. Smarter Radios

Software defined radio, often called smart radio, enables a device to operate in multiple frequency bands and at varying power levels without requiring changes to the hardware components as would have been required in the past.[73] Cognitive radio, an advanced form of software defined radio, learns from and adapts itself to the changing environment.[74]

The traditional model of wireless communications created in the 19th century looks at the world through the eyes of a stupid receiver that treats all radio signals as equal and cannot sort out signal from noise.[75] That stupid receiver view, the exclusive use licensing scheme it precipitated, and regulations based on that view have become obsolete because software defined radios can better differentiate signals and, together with improvements in computing, utilize spectrum more efficiently through various algorithms and standards intended to allow the device to learn from and adapt to its environment. The new world order will see smart radio devices that communicate with each other using widely accepted protocols and standards that allow devices to most efficiently utilize the radio spectrum, similar to how computers communicate with each other when connected to the Internet.[76]

The ultimate goal of software defined radio is to increase the efficiency of spectrum usage.[77] It is intended to help resolve the imbalance between spectrum scarcity and spectrum underutilization.[78] Software defined radio will allow secondary uses of frequencies that are underutilized due to lack of deployment by primary licensees, regulatory command and control edicts, such as with the television

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72 Yochai Benkler, *Overcoming Agoraphobia: Building the Commons of the Digitally Networked Environment*, 11 Harv. J.L. & Tech. 287, 324 (1998).

73 Niyato & Hossain, *Cognitive Radio*, *supra* note 54, at 46-47; NOI Fostering Innovation & Investment, *supra* note 41, at 15.

74 Niyato & Hossain, *Cognitive Radio*, *supra* note 54, at 46; NOI Fostering Innovation & Investment, *supra* note 41, at 15.

75 Yochai Benkler, *Economics of Wireless Communication*, 16 Harv. J.L. & Tech. 25, 38 (2002). *See also* Gerald R. Faulhaber, *Deploying Cognitive Radio: Economic, Legal and Policy Issue*s, 2 Int'l J. of Comm. 1114 (2008) ("Government allocation is the 1927 solution to the problem of interference, instituted by the Federal Radio Act").

76 Benkler, *Economics of Wireless Communication*, *supra* note 75, at 28.

77 Niyato & Hossain, *Cognitive Radio*, *supra* note 54, at 46.

78 Qiwei Zhang et al., *A Reconfigurable Radio Architecture for Cognitive Radio in Emergency Networks*, The 9th European IEEE Conference on Wireless Technology, 35 (2006).

white spaces, or lack of temporal need as is the case with spectrum reserved for military use during peace time.[79] Spectrum sensing, a function of software defined radio, locates unused spectrum and optimally uses those frequencies without harmful interference to the licensed user.[80] The spectrum sensing requirement in the White Spaces Order, discussed below, is directed at the promising future of software defined radio.[81]

Further improvements in software defined radio technology will provide opportunities to make all devices reprogrammable.[82] In which case, changes in spectrum allocation for specific uses or service providers will only need software upgrades for devices to make the necessary changes. In contrast, the recent digital television transition required broadcasters and consumers to upgrade equipment. In the future with ubiquitous software defined radio, such transition may only require a software update for devices, thus making spectrum allocation shifting both cost effective and efficient.

Some early cognitive radio technologies have already been employed into wireless networks, providing some basic ability to adapt power level and dynamically select channels in response to the radio frequency environments.[83] However, current cognitive radio technology has not reached the ability to provide full awareness and intelligent learning capability.[84] That current inability to comprehensively learn and adapt to the radio environment, along with its early developmental state, leads some observers to consider the the technology expensive or unproven.[85] However, others feel the technology is already proven and making its mark.[86] Regardless of the view, many different people including the U.S. military

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79 Shamik Sengupta & Mainak Chatterjee & Kevin Kwiat, *Dynamic Spectrum Access in Cognitive Radio based Tactical Networks*, IEEE Wireless Communications and Networking Conference (2009).

80 Zhang et al., *supra* note 78, at 35; Haykin, *Cognitive Radio*, *supra* note 59.

81 White Spaces Order, *supra* note 1, at 16895.

82 Zhang et al., *supra* note 78, at 36.

83 Youping Zhao et al., *Performance Evaluation of Cognitive Radios: Metrics, Utility Function and Methodology*, 97 Proceedings of the IEEE 642 (April 2009).

84 *Id.*

85 Weiser & Hatfield, *Spectrum Policy Reform*, *supra* note 42, at 557.

86 Meinrath & Calabrese, *White Spaces Devices & the Myths of Harmful Interference*, *supra* note 38, at 515. *See also* Toshiaki Yamamoto et al., *Field Trial on Cognitive Radio Technology: Adaptive Co-Use of Heterogeneous Wireless Media on Multiple Base Stations*, 6th IEEE Consumer Communications and Networking Conference, 5 (Jan. 2009) ("It is found that the cognitive radio technologies can provide the appropriate wireless communication routes to meet various demands for application [Quality of Service (QoS)].").

and some of our biggest technology companies are heavily investing in software defined radio and cognitive radio technologies.[87] As the Commission recognized, cognitive radio and the goal of spectrum sensing is not yet sufficient to adequately protect incumbents in the television frequency band from interference.[88]

III. White Spaces Order

Responding to complaints from some economists, legal observers, and industry[89], the Commission instituted proceedings to best determine how to use the spectrum opportunities provided by white spaces in the television frequency band (television white spaces).[90] Citing its mandates under 47 U.S.C. §§ 302, 303(e), 303(f), and 307,[91] the Commission issued an order making some of the television white spaces available for unlicensed devices.[92]

The Commission's goal in the white spaces proceeding and order was to allow new, innovative uses of radio on unused television channels.[93] It concluded that the public interest is best served by allowing devices to operate in these unused bands on an unlicensed basis with some restrictions intended to protect users of incumbent licensed television services.[94] Although not stated explicitly, the White

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87 The Pentagon is satisfied that smarter WiFi devices can share the 5GHz band with military radar. Meinrath & Calabrese, *White Spaces Devices & the Myths of Harmful Interference*, *supra* note 38, at 515. Software defined radio is also central to the military's DARPA XG initiative to identify and and use spectrum opportunities. *Id.*

88 White Spaces Order, *supra* note 1, at 16818, 16835-36, 16895.

89 A coalition of technology companies including Microsoft and Google petitioned the Commission to establish rules permitting low-power unlicensed devices to access the "white space" frequencies not hosting a TV broadcaster. Hazlett, *Response to Weiser & Hatfield*, *supra* note 43, at 1012.

90 Thomas W. Hazlett, *Assigning Property Rights to Radio Spectrum Users: Why Did FCC License Auctions Take 67 Years?*, 41 J. L. & Econ. 529, 530-31 (1998); Thomas W. Hazlett, *The Wireless Craze, the Unlimited Bandwidth Myth, the Spectrum Auction Faux Pas, and the Punchline to Ronald Coase's "Big Joke": An Essay on Airwave Allocation Policy*, 14 Harv. J.L. & Tech. 335, 336 (2001); R. H. Coase, *The Federal Communications Commission*, 2 J. L. & Econ. 1, 17-40 (1959); Hazlett, *Response to Weiser & Hatfield*, *supra* note 43, at 1012; Thomas W. Hazlett & Matthew L. Spitzer, *Advanced Wireless Technologies and Public Policy*, 79 S. Cal. L. Rev. 595 (2006).

91 Discussed briefly above, in the Introduction.

92 White Spaces Order, *supra* note 1.

93 White Spaces Order, *supra* note 1, at 16808.

94 In addition to full power television stations, the television band supports other incumbents that utilize the television band on a secondary basis, such as broadcast auxiliary services, low power television, and private land mobile radio service. For purposes of this paper, I will refer to all current users of the television spectrum as the incumbents. *See* White Spaces Order, *supra* note 1, at 16808, 16810-11. Those devices may not interfere with incumbent uses of that spectrum and must meet some requirements in addition to the general requirements for unlicensed use. *Id.* ("We also anticipate that these new devices will have economic benefits for consumers and businesses by facilitating the development of additional competition in the broadband market"); *See also* 47 C.F.R. 15 (providing general requirements for unlicensed use).

Spaces Order sets the stage for a shift in regulatory models precipitated by rapidly developing software defined radio technologies. The White Spaces Order is not the last word on television white spaces. FCC staff will report back in two years on the successes and failures of the order. [95] Regardless of whether the order is considered a success, the Commission is unlikely to end the white spaces experiment on its own because of the promise it holds.

To that end, the White Spaces Order divided devices into two categories based on current unlicensed spectrum uses.[96] The first category consists of lower power personal or portable unlicensed devices, such as WiFi enabled laptop computers or routers used for home networks.[97] The second category consists of higher power unlicensed devices that operate from fixed locations.[98] This type of device can be used to provide commercial services such as broadband Internet access or backhaul.[99]

Although each type of television white spaces device has specific requirements, three universal principals apply to all such devices. Each device will need: 1) to check a location database; 2) to use spectrum sensing to identify other devices using the spectrum; and 3) certification by the Commission. To be certified, the device must meet a "proof of performance" standard that it will not cause harmful interference to incumbent radio services.[100] The devices will also need to further operate under part 15, governing unlicensed devices.[101]

Television white spaces are attractive to the Commission because of its Congressional mandates, the spectrum opportunities, and its propagation properties.

First, the Commission has several mandates from Congress to make high speed Internet access available to more people.[102] To that end, Congress has held key hearings questioning the Commission's

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[95] White Spaces Order, *supra* note 1, at 16810.
[96] White Spaces Order, *supra* note 1, at 16810-11.
[97] White Spaces Order, *supra* note 1, at, at 16810-11.
[98] White Spaces Order, *supra* note 1, at, 16811-12.
[99] White Spaces Order, *supra* note 1, at, 16811. As discussed below, the television frequency band may not be the best choice to provide wireless backhaul to rural communities.
[100] White Spaces Order, *supra* note 1, at 16811.
[101] White Spaces Order, *supra* note 1, at 16811. *See also* 47 C.F.R. §15.
[102] Discussed above, in the Introduction. More specifically, Congress mandated the Commission to "encourage the

approach to spectrum policy[103] and introduced bills to reform spectrum allocation and require the Commission to allow use of the television white spaces.[104] Since the White Spaces Order, Congress demonstrated how active a role it has assumed in telecommunications policy when it passed the Recovery Act, which mandated the Commission craft a national broadband plan with the intent to have universal broadband service.[105] In addition to funding the Commission's broadband plan, Congress kicked in $7.2 billion for the the Rural Utilities Services and NTIA to fund broadband in under served communities.[106]

As discussed above, rural areas are under served by incumbent broadband providers. While urban areas have some intermodal competition for broadband, many rural areas of the country continue to rely on dial up service and lack access to affordable broadband services with comparable speeds or quality of service.[107] Moreover, costs to rural customers are higher when broadband is available. For example, Frontier Communications primarily serves rural customers and has the highest average revenue in the industry, at $40 a month per customer for Internet service.[108] It recently purchased a large piece of Verizon's rural business across fourteen states and expects to offer DSL service to 90 percent of its new customers, whereas service is currently available to only 60 percent of those customers today.[109] It can

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deployment on a reasonable and timely basis of advanced telecommunications capability to all Americans . . . by utilizing . . . regulating methods that remove barriers to infrastructure investment." Telecommunications Act of 1996 §706(a), 47 U.S.C. §1302(a), 110 Stat 56, PL 104-104.

[103] Crawford, *The Radio and the Internet*, *supra* note 38, at 941.

[104] Communications, Consumer's Choice, and Broadband Deployment Act of 2006, S.2686, 109th Cong. §602 (2006) (as referred to the Comm. on Commerce, Sci., and Trans.). White Spaces Act of 2007, S. 337, 110th Cong. (2007); Wireless Innovation Act of 2007, S. 234, H.R. 1597, 110th Cong. (2007). Cf. Interference Protection for Existing Television Band Devices Act of 2007, H.R. 1320, 110th Cong. (2007).

[105] American Recovery and Reinvestment Act of 2009, § 6001(k)(2), Pub. L. No. 111-5, 123 Stat. 115 (2009) (tasking the Commission with developing a national broadband plan to seek to ensure that all people of the United States have access to broadband)

[106] *Id.*

[107] GAO Rural Broadband Report, *supra* note 12. *See also* Robert D. Atkinson, *The Role of Competition in a National Broadband Policy*, Telecomm. & High Tech. L. 1, 11-12 (2009).

[108] Saul Hansell, *Frontier to Buy Verizon Lines*, New York Times, at B6 (May 14, 2009), available at http://www.nytimes.com/2009/05/14/technology/companies/14phone.html.

[109] Verizon Press Release, *Verizon to Divest Wireline Businesses in 14 States; Significant Benefits to Verizon Shareholders* (May 13, 2009) [hereinafter *Verizon to Divest Wireline Business*], http://newscenter.verizon.com/press-releases/verizon/2009/verizon-to-divest-wireline.html. *See also* Saul Hansell, *Frontier to Buy Verizon Lines*, New York Times, at B6 (May 14, 2009).

afford to increase the DSL service area in part because it charges high prices and faces little competition.[110]

An explicit goal of the White Spaces proceedings was to "allow the development of new and innovative types of unlicensed devices that provide broadband data and other services for businesses and consumers."[111] In other words, the Commission intends for unlicensed use of the television white spaces to lower barriers to market entry for new or existing businesses to provide competitively priced high speed Internet services. In which case, it is possible that Frontier Communications would face competition to provide broadband services and not have the highest revenue in the industry.[112]

Second, the television white spaces contains significant amounts of unused spectrum.[113] According to Blair Levin, broadband advisor to the Commission,[114] "it is very clear in the record that for America to be successful in mobile broadband, we're going to need more spectrum in the near term. Not tomorrow, but within a few years."[115] The amount of white spaces compares favorably with the size of the 2.4 GHz unlicensed band[116] and is larger, in total size, than the 700MHz auction tied to the digital television transition.[117] White spaces spectrum increases the available unlicensed spectrum for WiFi by between nine and twenty two percent in a typical location in the US.[118] As discussed above, 83.5 percent of television channels, equivalent to 250.5 MHz, are unused nationwide. According Blair Levin, "[e]stimates vary, but most of the population (between 73% and 97%) lives in areas with access to 24 MHz or more of white space."[119] A significant share of the spectrum opportunities available in the white

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[110] Saul Hansell, *Frontier to Buy Verizon Lines*, New York Times, at B6 (May 14, 2009).
[111] White Spaces Order, *supra* note 1, at 16808.
[112] It is also possible that Frontier would not have paid as much as it did, $8.6 billion, to purchase such a large chunk of Verizon's rural business or may be bankrupted if it cannot cover its costs in a competitive marketplace.
[113] Thanki, *Economic Value of Unlicensed Spectrum*, *supra* note 34, at 53.
[114] FCC, Blog Profile for Blair Levin, http://blog.broadband.gov/blog/index.jsp?authorId=10331 (last visited Dec. 10, 2009).
[115] John Eggerton, *NRB: Spectrum Reclamation Could Be "Unholy Sacrifice,"* Broadcasting & Cable (Nov. 9, 2009), http://www.broadcastingcable.com/article/374338-NRB_Spectrum_Reclamation_Could_Be_Unholy_Sacrifice_.php.
[116] Thanki, *Economic Value of Unlicensed Spectrum*, *supra* note 34, at 53, 60.
[117] The 700MHz auctions totaled 62MHz. FCC, Upper 700 MHz Auction Fact Sheet, http://wireless.fcc.gov/auctions/default.htm?job=auction_factsheet&id=73.
[118] Thanki, *Economic Value of Unlicensed Spectrum*, *supra* note 34, at 60.
[119] Thanki, *Economic Value of Unlicensed Spectrum*, *supra* note 34, at 53 (citing M. Mishra & A. Sahai, *How Much White Space is There?*, Berkeley Wireless Research Center (January 2009),

spaces occurs in rural areas because they generally have fewer television broadcasters.[120]

Third, the propagation characteristics of the television frequency band are very good and well suited to provide better range and object penetration than higher frequency unlicensed bands, namely the 2.4 and 5 GHz bands.[121] Transmissions in the television frequency band are less subject to propagation losses than are transmissions in the higher unlicensed frequencies currently used by low power broadband devices.[122] Most notably, signals in the television band are much better at penetrating walls, people, foliage, and other objects than signals at the current unlicensed frequencies.[123]

Wireless Internet Service Providers (WISP) often use fixed WiFi devices to provide point-to-point wireless broadband services over several kilometers.[124] WISPs have noted that frequencies in the television white spaces would provide improved services over other unlicensed bands used by WiFi (i.e. 2.4 and 5 GHz ranges) due to the improved propagation properties.[125] Many WISPs service rural areas and the hope is that freeing the television white spaces for unlicensed devices will facilitate improved and more economical high speed Internet service to consumers in rural areas where transaction costs may be higher than elsewhere.[126]

An added advantage is that signals in the television frequency band travel further using the same power level than higher frequencies, thus requiring fewer base stations and requiring less capital expenditure to build out a wireless network.[127] In this way, frequencies in the television band will provide improved signal coverage for a number of existing services.[128] To this end, a WiFi device using

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http://bwrc.eecs.berkeley.edu/php/pubs/pubs.php/822.html (last visited Dec. 10, 2009)) ("Mishra & Sahai project that between 8 and 15 UHF TV channels, 48 – 120 MHz, could be usable in an average location.").

120 Crawford, *The Radio and the Internet*, *supra* note 38, at 999, 1002; Bahl, *White Spaces Networking*, *supra* note 68, at 2.

121 Thanki, *Economic Value of Unlicensed Spectrum*, *supra* note 34, at 51-52.

122 White Spaces Order, *supra* note 1, at 16919.

123 Meinrath & Calabrese, *White Spaces Devices & the Myths of Harmful Interference*, *supra* note 38, at 501; Crawford, *The Radio and the Internet*, *supra* note 38, at 964, 970-71.

124 White Spaces Order, *supra* note 1, at 16828.

125 White Spaces Order, *supra* note 1, at 16825; Thanki, *Economic Value of Unlicensed Spectrum*, *supra* note 34, at 60. (WiFi uses 2.4 and 5GHz bands)

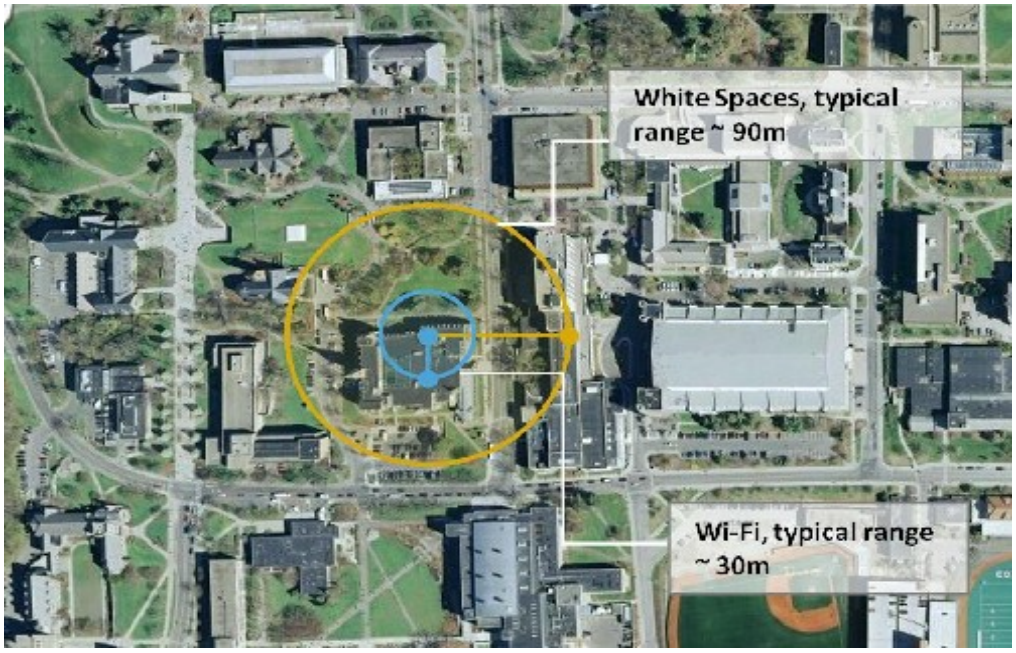
126 White Spaces Order, *supra* note 1, at 16825.

127 Meinrath & Calabrese, *White Spaces Devices & the Myths of Harmful Interference*, *supra* note 38, at 501; Crawford, *The Radio and the Internet*, *supra* note 38, at 964.

128 White Spaces Order, *supra* note 1, at 16825.

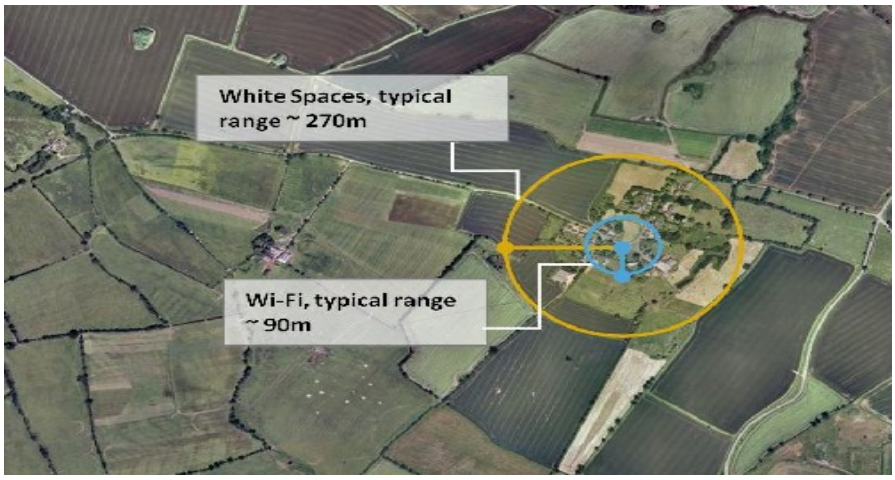
the television frequency band can transmit data significantly further distances using the same amount of power as it can using the existing higher frequency unlicensed bands.[129] It may increase the possible range of communication by a factor of three, and correspondingly increase the area of coverage by a factor of 981.[130] Likewise, a WiFi device will use less power to transmit the same distance as it would with the higher frequency unlicensed bands.[131]

Figure 3: Image comparing current indoor WiFi range with WiFi using white spaces[132]



[129] Thanki, *Economic Value of Unlicensed Spectrum*, *supra* note 34, at 59.
[130] Thanki, *Economic Value of Unlicensed Spectrum*, *supra* note 34, at 59.
[131] Thanki, *Economic Value of Unlicensed Spectrum*, *supra* note 34, at 72-73.
[132] Thanki, *Economic Value of Unlicensed Spectrum*, *supra* note 34, at 59.

Figure 4: Image comparing current outdoor WiFi range with WiFi using white spaces[133]



It is these propagation characteristics that make the spectrum in the television frequency bands so valuable. It is even likened to "beach front property."[134] The C block in the 700 MHz frequency band concerned just a 22 MHz band of spectrum[135] that fetched nearly $4.7 billion at auction.[136] The value of the spectrum is not lost on the incumbent users of the television frequency band who filed two lawsuits soon after the White Spaces Order. The incumbents allege the order is arbitrary and capricious because the devices could cause interference and the prototype devices failed during testing.[137] It is hard to believe the cases will succeed since the stated goal of the tests was to determine proof of concept, as opposed to requiring a fully operational device, and the Commission requires devices be certified with field and lab testing before they may operate. Moreover, Congress has stated that it is the policy of the

[133] Thanki, *Economic Value of Unlicensed Spectrum*, *supra* note 34, at 59.

[134] Weiser & Hatfield, *Spectrum Policy Reform*, *supra* note 42, at 578; Speta, *Spectrum Policy Experiments: What's Next?*, *supra* note 49, at 399. *See also Crawford, The Radio and the Internet*, *supra* note 38, at 936 ("The airwaves may be the most valuable natural resource that the government perceives itself as managing."); Thomas W. Hazlett & Matthew L. Spitzer, *Advanced Wireless Technologies and Public Policy*, 79 S. CAL. L. REV. 595, 655 (2006) ("[L]ow frequencies (below 3 GHz) are considered the most valuable part ... because the propagation characteristics of the low frequency radio waves enable wide-area coverage.").

[135] Crawford, *The Radio and the Internet*, *supra* note 38, at 997, 999.

[136] FCC, Upper 700 MHz Auction Fact Sheet, http://wireless.fcc.gov/auctions/default.htm?job=auction_factsheet&id=73; https://auctionbidding.fcc.gov/auction/index.htm; Saul Hansell, *Verizon and AT&T Win Big in Auction of Spectrum*, NEW YORK TIMES, (Mar. 21, 2008). In full, about 62 MHz was auctioned in the 700 MHz band for 19.6 billion. Weiser & Hatfield, *Spectrum Policy Reform*, *supra* note 42, at 549.

[137] The cases have been consolidated and were held in abeyance until December, tied to proceedings tied to the White Spaces order. *See* Appendix: Pacer printouts.

United States "to encourage the provision of new technologies and services to the public," and that anyone who opposes a new technology or service will have the burden of demonstrating that the proposal is inconsistent with the public interest.[138] It is not clear the incumbents can meet that burden.

A. Timing of White Spaces Devices

Despite some current experiments and at least one special demonstration deployment,[139] it is unclear when devices that satisfy the White Spaces Order will be commercially available or at what cost. As noted by some critics of the order, the devices tested by the Commission did not successfully pass the tests performed by the Commission's Office of Engineering and Technology.[140] At least some manufacturers had hoped to market devices by the end of 2009 but the Commission has not certified any products or created a database for devices to use.[141] On the bright side, Microsoft has an experimental license and an operational white spaces network at its headquarters near Seattle.[142] Microsoft uses WiFi devices specially modified to operate in the television white spaces.[143] In that regard, I expect the devices to cost about the same price, if not a small percentage higher, than current WiFi devices. In addition, distribution of some some white space devices may be fairly quick once approved by the Commission since there is an existing distribution network and ready market for WiFi devices.

Devices utilizing existing wireless technologies, WiFi and WiMax, will be the first to operate in

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138 47 U.S.C. §157(a) (2000); Crawford, *The Radio and the Internet*, *supra* note 38, at 966.

139 Spectrum Bridge LLC rolled out a demonstration in rural Claudville, VA. It deploys WiFi device operating in the white spaces but only utilizes a database. *See* Figure 2 to see how many white spaces are available in that town. Nate Anderson, *First White Space Broadband Deployment in Small Virginia Town*, Arstechnica (Oct. 21, 2009), http://arstechnica.com/tech-policy/news/2009/10/first-white-space-broadband-deployment-in-small-virginia-town.ars. In addition, it seems the experimental deployment to Claudville, VA had a high power booster in Congressman Rick Boucher to push through the variance to provide the test opportunity. *See* Congressman Rick Boucher, *First White Spaces Network in the Nation Will Provide Internet Service to Claudville* (Oct. 21, 2009), http://www.boucher.house.gov/index.php?option=com_content&task=view&id=1857&Itemid=31

140 White Spaces Order, *supra* note 1, at 16811.

141 *See* Reuters, *Google Offers New Plan for the Airwaves*, New York Times (Mar. 24, 2008), available at http://www.nytimes.com/2008/03/24/technology/24google-web.html; *See also* The Commission, Office of Engineering and Technology posted a request for proposals for database operation on Dec. 1, 2009. *See* FCC, Notice of Request for Proposals From Entities Seeking to be Designated TV Band Device Database Managers, http://hraunfoss.fcc.gov/edocs_public/attachmatch/DA-09-2479A1.pdf

142 *See* Microsoft.com, *Networking Over White Spaces (KNOWS)*, http://research.microsoft.com/en-us/projects/KNOWS/ (last visited Dec. 10, 2009).

143 Bahl, *White Spaces Networking*, *supra* note 68.

the white spaces.[144] WiFi has a number of uses today. It is a common way of networking a home or business. Businesses also create WiFi hotspots[145] or deploy networks that cover cities or portions of cities, generally in one of two configurations. Mesh networks use many WiFi nodes arranged in a grid-like pattern.[146] A second configuration provides point-to-point connections.[147] Both types of network configurations are able to provide 1 Mbps speeds.[148] WiFi devices are embedded in many computers and some mobile phones.[149] WiMax is often referred to as a fourth generation (4G) wireless technology and is already in use in some commercial cellular wireless networks as they are deployed.[150] This technology will replace third generation (3G) technology currently used to provide wireless data transport. Unlike WiFi, WiMax is designed to operate flexibly in both licensed and unlicensed spectrum.[151] WiMAX can also operate at greater distances, up to 30 miles,[152] and provides greater interoperability to other network equipment.[153]

IV. Backhaul

The White Spaces Order does not adequately address backhaul, an essential component for any high speed Internet service. Backhaul, also referred to as the middle mile, is the connection between a

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144 Both technologies are already in the marketplace. WiFi and WiMax are projects of the IEEE standards organization and were developed largely by chip manufacturers and WiFi vendors. NOI Fostering Innovation & Investment, *supra* note 41, at 50, n. 54.

145 Starbucks, *High Speed Wireless Internet Access*, http://www.starbucks.com/retail/wireless.asp (last visited Dec. 10, 2009).

146 For example, Google has deployed a mesh network in Mountain View, California. Google, *How does the Google WiFi service work?*, http://wifi.google.com/support/bin/answer.py?hl=en&answer=30814 (last visited Dec. 10, 2009).

147 ColusaNET is a WISP that provides wireless broadband services in Colusa, California. ColusaNET, *How ColusaNET stacks up against the competition*, http://www.colusanet.com/competition.htm (last visited Dec. 10, 2009).

148 Google WiFi, *What data speeds should I expect?*, http://wifi.google.com/support/bin/answer.py?hl=en&answer=30794 (last visited Dec. 10, 2009); ColusaNET, ColusaNET Presentation, slide 7 ColusaNET Wireless Broadband, (showing a diagram of the network) http://www.colusanet.com/PowerPoint/CLNWB-1_files/frame.htm (last visited Dec. 10, 2009).

149 Kazunori Takeuchi, et al., *Cognitive Radio Using Multi-transmission Links*, 2nd IEEE Int'l Conf. on Cognitive Radio Oriented Wireless Networks and Comm., 292 (Aug. 2007).

150 This includes Clearwire. Thanki, *Economic Value of Unlicensed Spectrum*, *supra* note 34, at 23.

151 Thanki, *Economic Value of Unlicensed Spectrum*, *supra* note 34, at 23; *See also* Alexe E. Leu & Brian L. Mark Member & Mark A. McHenry, *A Framework for Cognitive WiMAX with Frequency Agility*, 97 Proceedings of the IEEE, 1-2 (April 2009) ("WiMAX allows the user to select an adjustable channel bandwidth from 1.25 MHz to 20 MHz.... [and provides] several operational frequency bands, including 2–11 GHz for fixed applications and 2–6 GHz for mobile applications.").

152 U.S. Gov't Acct. Office, Current Broadband Measures Have Limitations, and New Measures Are Promising but Need Improvement, GAO-10-49, 10 (Oct. 2009) [hereinafter GAO Measurement Report].

153 Thanki, *Economic Value of Unlicensed Spectrum*, *supra* note 34, at 23; Leu & Member & McHenry, A Framework for Cognitive WiMAX with Frequency Agility, *supra* note 151.

local network and the long haul backbone network that connects the many local networks, similar to how the long distance telephone network once connected the various local exchange systems. An analogy may help explain what is meant by backhaul and backbone, as well as how to differentiate between the two.

A. A Communications Network is Like a Transportation System

A communications network is analogous to a transportation system. A transportation system can use a variety of platforms, such as rail, airline, or boat, over a number of different physical media (ground, air, or water). The platform and physical media together determine how much can be carried simultaneously, speed to transport, and the costs involved. In the same way, a communication network can use a variety of platforms such as voice or video over different physical media such as air or fiber optic cable. The platform and media together help to dictate volume, speed, and cost of transport.

At its most basic, a communications network sends packets of data from one point to another. A packet is like a package you might send through the postal service. It includes a header label that provides information about the sender, recipient, and encoding used. Inside the packet are bits of data that make up the content that is being sent. When the packet is sent by your device it enters the possession of your Internet Service Provider (ISP) much like the postal service would take possession of the package you put in the mail box. Your ISP's system then determines how your packet will get to its destination computer. The ISP can send it by copper wire through one section, then by fiber optic line through a second section, a microwave transmission in a third section, and so forth until it reaches its destination. This is similar to the postal service, which will send your package by whatever route it determines is best to get it to its destination in the quickest way possible. It can send by truck, then airplane, boat, rail car, and so on.

Communications networks mostly resemble a network of roads.[154] In the case of roads, urbanized

[154] Roads are easiest to visualize although this applies just as well to air or water transport based on size of planes or boats used to carry packages.

areas will have more extensive and densely spaced roads consisting of 8 lane expressways in the core to some dirt roads further out while a rural area might have a few two lane paved roads mixed with dirt roads. Major highways connect different urbanized areas and are analogous to the backbone of modern communications networks. Sometimes, those highways go through rural areas and sometimes not. Not only are rural roads generally slower than major highways but they also cannot handle as much traffic. In that way, the further from the major highway the longer it takes for a package to get from that rural area to its destination. That is, if the package is not sent to a local address easily accessible to the local road network. In the same way, the further a computer is from the backbone, the longer it takes for data to get to computers outside of that network. If the local communications network is not connected to a backbone then that network will not be much good to the local community for communicating with the wider world. That connection between the local communications network to the backbone is called a backhaul. A community should ideally have more than one backhaul connected to more than one backbone or backbone provider (in case one goes down). The San Francisco Bay area has several bridges crossing the bay for convenience and for redundancy. If one bridge is taken out of commission, the others are still available to handle the traffic, albeit at higher levels of congestion than normal.

Figure 5: Network Map for Level3, an Internet Backbone Provider[155]

B. <u>The White Spaces Order May Not Adequately Address Backhaul Needs</u>

Some parties in the white spaces proceedings have pointed out that the sub-1 GHz spectrum, including the television frequency band, is an odd choice for backhaul because it is more difficult to focus into the small beams used for point-to-point connections required for backhaul than is higher frequency spectrum.[156] Higher frequencies also have the ability to carry much more data.[157] Furthermore, the white spaces have less of a propagation advantage over higher frequencies when the connections are line-of-sight.[158]

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[155] This map provides a good example of a backbone network. Level 3 is one of the smaller national backbone providers, relative to AT&T and Verizon. Level 3 connects major cities and towns with major research universities. A backhaul would need to be provided between a rural town and a connection point, either in one of the cities or specific places along the route taken by the backbone network. Level3, *The Level3 Network*, http://www.level3.com/downloads/Level_3_Network_map.pdf (last visited 11/23/09).

[156] Thanki, *Economic Value of Unlicensed Spectrum*, *supra* note 34, at 23, 55.

[157] Thanki, *Economic Value of Unlicensed Spectrum*, *supra* note 34, at 60-61.

[158] Thanki, *Economic Value of Unlicensed Spectrum*, *supra* note 34, at 55.

Most point-to-point connections are made using licensed spectrum; however a large number of systems do use unlicensed spectrum in the 5 GHz frequency band.[159] Backhaul is better suited by higher frequencies, which are often unavailable because of allocation to other licensees.[160]

With that in mind, rural communities will need access to more spectrum outside of the television white spaces for backhaul and other purposes in order to get and best take advantage of high speed Internet access. Utilizing water law principles to free up spectrum from exclusive use licenses or to allow secondary use of underutilized spectrum might allow a rural area to pick the technology that best fit its needs for backhaul.

V. Principles of Water Law Applied to Spectrum

Spectrum is analogous to water, another natural resource held in public trust.[161] As discussed above, one reason we currently suffer from spectrum scarcity is that the spectrum is underutilized by those who have exclusive rights to its use. Laws and regulations prohibit any third party from using fallow or underutilized spectrum regardless of the value a third party might add.[162] Fortunately, spectrum is not the only natural resource held in public trust suffering from scarcity that is potentially exacerbated by a particular legal regime in force. In the same way, we can and should borrow from laws governing other natural resources such as water when considering spectrum.

Applying principles of water law to spectrum is not new but its application has not been thoroughly analyzed yet. Recently, Hazlett hinted at applying water law principles[163] and Weiser & Hatfield specifically stated spectrum should be recognized as a property right like water but provided no

[159] Thanki, *Economic Value of Unlicensed Spectrum*, *supra* note 34, at 23; The 5 GHz range unlicensed band is helpful but not wide enough a band to serve on its own for backhaul.

[160] The 5 GHz range unlicensed band is helpful but not wide enough a band to serve on its own for backhaul.

[161] Nat'l Audobon Soc. v. Sup. Ct. of Alpine County, 33 Cal.3d 419, 425-26 (1983) ("[T]he core of the public trust doctrine is the state's authority as sovereign to exercise a continuous supervision and control over the navigable waters of the state and the lands underlying those waters ... and bars ... [anyone] from claiming a vested right to divert waters once it becomes clear that such diversions harm the interests protected by the public trust."); Illinois Central Railroad Company v. Illinois, 146 U.S. 387 (1892). *See also* Joseph L. Sax, *The Public Trust Doctrine in Natural Resource Law: Effective Judicial Intervention*, 68 Mich. L. Rev. 470 (1970) (providing a history of the public trust doctrine).

[162] Gigi Sohn, *The Gore Commission Ten Years Later: Reimagining the Public Interest Standard in an Era of Spectrum Abundance*, 17 CommLaw Conspectus 657, 668 (2008).

[163] Hazlett, *Response to Weiser & Hatfield*, *supra* note 43, at 982.

detail or analysis of how water law principles would translate to spectrum governance.[164]

Water is in the bundle of property rights. For brevity and simplicity of argument, I only refer to appropriative water rights.[165] "The appropriation doctrine confers upon one who actually diverts and uses water the right to do so provided that the water is used for reasonable and beneficial uses," regardless of whether that person owns land contiguous to the watercourse.[166] In addition, all appropriative rights are subordinate to earlier appropriators, subject to the "first in time, first in right" rule of priority.[167] Despite water's recognition as part of the bundle of property rights, water rights are not boundless. They may not be speculative. The use must be current or imminent, and must be reasonable and beneficial. Moreover, the state may attach terms specific to an appropriative right. For example, the state and federal agencies that pump water from the Sacramento and San Joaquin Rivers Delta must comply with salinity restrictions attached to their water rights allowing diversion from the Delta.[168] Someone who fails to adhere to principles of water law or requirements attached to a water right may forfeit or otherwise lose their property rights to that water without compensation.[169]

In this regard, spectrum licensing and water rights share similarities.[170] Licenses granted by the Commission are, for all intents and purposes, perpetual use licenses.[171] The licensees need only meet

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164 Weiser & Hatfield, *Spectrum Policy Reform*, *supra* note 42, at 552, 608.

165 A number of different water rights apply with varying force in Western states. For example, California recognizes pueblo water rights granted to pueblos under the Spanish and Mexican governments, *City of Los Angeles v. Pomeroy*, 124 Cal. 597, 640-41 (1899), *Hooker v. City of Los Angeles*, 188 U.S. 314, 319-320 (1903), legacy riparian water rights, *In re Waters of Long Valley Creek Stream System*, 25 Cal.3d 339 (1979), and water reserved by the United States government.

166 United States v. State Water Res. Control Bd., 182 Cal.App.3d 82, 102 (1986).

167 United States v. State Water Res. Control Bd., 182 Cal.App.3d 82, 102 (1986).

168 United States v. State Water Res. Control Bd., 182 Cal.App.3d 82, 102 (1986) (holding that the State Water Resources Control Board has the power to modify and attach conditions on water use permits).

169 Joslin v. Marin Mun. Water Dist., 67 Cal.2d 132 (1967) ("[S]ince there was and is no property right in an unreasonable use, there has been no taking or damaging of property by the deprivation of such use and, accordingly, the deprivation is not compensable."); *In re* Waters of Long Valley Creek Stream System, 25 Cal.3d 339 (1979).

170 It is these similarities that lend themselves well to shared economic analysis such as that advocated by Elinor Olstrom in Governance of the Commons. Yochai Benkler recommends following a commons model for governing spectrum. Benkler, *Economics of Wireless Communication*, *supra* note 75.

171 Linda K. Moore, *Spectrum Management: Auctions, Congressional Research Service*, 7 (September 2, 2008) [hereinafter Moore, *CRS Spectrum Report*], available at http://assets.opencrs.com/rpts/RL31764_20070820.pdf ("Even though licenses must be renewed periodically, it is generally understood that license winners will be able to keep the license perpetually, as long as they comply with FCC service rules."); Crawford, *The Radio and the Internet*, *supra* note 38, at 965. *See also* Weiser & Hatfield, *Spectrum Policy Reform*, *supra* note 42, at 610, n5 ("Technically speaking, the Communications Act does not allow any individual or firm to possess a property right in radio spectrum.").

nominal service rules attached to the license, defined in the Communications Act, or identified in regulations issued by the Commission.[172] In addition, it is nearly impossible for a licensee to lose that license without violating those license terms, akin to water rights holder retaining that right unless violating a water law principle.[173]

With those similarities in mind, a set of principals from water law can be analogized to spectrum management. Western water law: 1) requires the use be beneficial and reasonable; 2) requires that the appropriation not be speculative; and 3) provides for equivalent replacement.

A. Beneficial and Reasonable Use

In California, the right to water, its use, or its flow, must be limited to beneficial and reasonable uses.[174] What constitutes reasonable use is fact-based, determined by the circumstances and varies as a situation changes with time.[175] For example, common practices for irrigating crops can become unreasonable with the introduction of technologies that provide for more efficient use of water. As such, courts have found it unreasonable to flood fields for pest control[176] or to expose rocks and gravel.[177] In which case, those parties lost rights to water used for those purposes.

A principle that spectrum use be beneficial and reasonable already is applied in practice by Congress and the Commission. For example, Congress has reallocated spectrum that had been reserved for government use and required it be put to beneficial commercial use.[178] Most recently, Congress and the Commission modified licenses during the digital television transition[179] and again with the White

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[172] Moore, *CRS Spectrum Report*, *supra* note 171, at 7.

[173] Even an auction winner that defaulted on its payment obligations did not lose its license while under bankruptcy protection. United States v. Nextwave, 537 U. S. 293 (2003).

[174] *In re* Waters of Long Valley Creek Stream System, 25 Cal.3d 339 (1979).

[175] Joslin v. Marin Mun. Water Dist., 67 Cal.2d 132 (1967); Environmental Defense Fund, Inc. v. East Bay Mun. Util. Dist., 26 Cal.3d 183 (1980).

[176] Tulare Irrigation Dist. v. Lindsay-Strathmore Irrigation Dist., 3 Cal.2d 489 (1935).

[177] Joslin v. Marin Mun. Water Dist., 67 Cal.2d 132 (1967).

[178] *See* Speta, *Spectrum Policy Experiments: What's Next?*, *supra* note 49, at 398-99 (discussing how Congress, in the Commercial Spectrum Enhancement Act of 2005, ... transferred 57 MHz of spectrum from federal users to commercial services, subject to the auctions' raising sufficient funds to relocate the federal users to other portions of the spectrum. When it was auctioned in late 2006, a total of 104 winning bidders paid a net total of $13.7 billion for licenses to operate in this spectrum.).

[179] FCC, In the Matter of Implementation of the DTV Delay Act, DTV Consumer Education Initiative, Third Periodic

Spaces Order.[180]

That said, Congress and the Commission should formalize the reasonable and beneficial use principle with regard to the radio spectrum. Similar to water, whether a particular use of spectrum is beneficial or reasonable is determined by the circumstances and varies as a situation changes with time.[181] For example, common practices for utilizing spectrum can become unreasonable with the introduction of technologies that provide for more efficient use of spectrum. In this regard, uses of the radio spectrum must be revisited from time to time. The Commission, together with NTIA, can evaluate both the utilization level of spectrum, the various types of uses, and how to best migrate to more efficient uses. Such a rule provides incentive for licensees to regularly self-evaluate their own uses of the radio spectrum and invest in new technologies. Most importantly, it can serve as one more directive for licensees to deploy advanced telecommunications capability throughout the country. In addition, it provides incentives for third parties to identify and develop more efficient uses of spectrum and, combined with the principle of equivalent replacement, ways to pay to migrate from one use to another.

For good or bad, this principal also reaches beyond spectrum utilization and allocation to touch other business practices of the licensee. For example, it can be used to require radio and television stations to focus more on local issues. It not beneficial to the local community and is unreasonable for a station to provide little to no local information, especially in rural areas that likely are served by fewer stations than a major metropolitan area with a crowded radio or television dial.

B. Speculative use

Appropriation of the public's water resource must be for an actual beneficial use.[182] In other words,

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Review of the Commission's Rules and Policies Affecting the Conversion To Digital Television Digital Television Distributed Transmission System Technologies, Third Report and Order and Order on Reconsideration, FCC 09-19, MB Docket No. 09-17 (March 13, 2009), available at http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-09-19A1.pdf (last visited Dec. 10, 2009). *See also* FCC, Digital Television (DTV) Regulatory Information, http://www.fcc.gov/dtv/ (last visited Dec. 10, 2009).

[180] White Spaces Order, *supra* note 1.

[181] Joslin v. Marin Mun. Water Dist., 67 Cal.2d 132 (1967); Environmental Defense Fund, Inc. v. East Bay Mun. Util. Dist., 26 Cal.3d 183 (1980).

[182] High Plains A & M, LLC v. Southeastern Colorado Water Conservancy Dist., 120 P.3d 710, 714 (2005).

it may not be speculative. Use it or lose it is an appropriate mantra that water rights holders are encouraged to live by. An appropriative right to use water is not perfected until the water is placed to an actual beneficial use.[183] Moreover, appropriative water rights can be lost by non-use. A water user may lose all rights to use water if they fail to make beneficial use of the water for a continuous period.[184]

The mantra, use it or lose it, should be just as applicable to spectrum as it is to water. The licensee has exclusive use to spectrum only if it serves the public interest;[185] however, it does not serve the public interest to allow spectrum to go significantly underutilized. In this way, the licensee that routinely only uses twenty-five, or even fifty, percent of the spectrum allowed by the license is significantly underutilizing the spectrum and should make way to other possible uses that would better use that spectrum.[186]

There are many ways for the Commission to deal with a licensee who fails this principle. For example, secondary licenses with defined terms can be instituted in areas the primary licensee has not or will not deploy anytime soon. Actively enforcing such a provision will create incentives to build out more quickly. It also provides some flexibility and recognizes the economic reality that a provider might take years to fully deploy a network. Giving an option to assign or allow secondary licenses will allow companies to build out the most technologically advanced network but allow others to roll out stop gap measures in the mean time. A buy out clause that requires the primary licensee to pay the secondary

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[183] High Plains A &M, LLC, 120 P.3d at 717.

[184] Jenkins v. State Dept. of Water Res, 103 Idaho 384, 388-89 (1982).

[185] As discussed above, the Commission must manage and govern spectrum in the public interest. Implicit in its mandates is that the Commission should not tolerate uses by licensees that do not serve the pubic interest. In addition, some licensees are explicitly mandated to utilize their exclusive slice of spectrum in the public interest, 47 U.S.C. §336(d), or are subject to common carriage regulation in the public interest, 47 U.S.C. § 332(c).

[186] Based on its current mandates, the Commission should already be taking affirmative steps to improve usage of this spectrum. *See* 47 U.S.C. § 303(g) ("[T]he Commission from time to time, as public convenience, interest, or necessity requires, shall ... generally encourage the larger and more effective use of radio in the public interest."). Moreover, the Commission must safeguard the public interest and promote three objectives when issuing licenses: 1) "development and rapid deployment of new technologies, products, and services for the benefit of the public, including those residing in rural areas, without administrative or judicial delays, 47 U.S.C. § 309(j)(3)(A);"2) promoting economic opportunity and competition and ensuring that new and innovative technologies are readily accessible to the American people by avoiding excessive concentration of licenses, 47 U.S.C. § 309(j)(3)(B); and 3) efficient and intensive use of the electromagnetic spectrum."47 U.S.C. § 309(j)(3)(D).

licensee and its consumers can provide more incentives for secondary licensees to make the investment. Rural areas would be the beneficiaries of such a rule. Major wireless providers focus more on more densely populated areas. This principle will likely provide rural providers access to higher frequencies that provide better bandwidth transport for point-to-point backhauls.

At least some of the value of spectrum today is based on speculation about future direct and indirect values. Valid arguments can be made that the values Verizon and AT&T attached to spectrum in the 700 MHz auction was based more on locking out competition than providing services.[187] Such incumbents are willing to pay whatever it takes to win an auction to block new entrants to the market, according to suggestions by economists.[188] Verizon and AT&T now have exclusive right to use the frequency bands they won licensing rights to through the auctions. Nobody else can provide a competing service using those frequencies, even in areas the two companies have no intention of providing services. Moreover, the companies have control over radio spectrum under 1 GHZ making it possible to provide more resilient communications that rely on less infrastructure investment, providing added competitive advantage.[189] In which case, those incumbents will pay more than market value for a particular band of spectrum.[190] Applying water law principle to prevent speculation will provide disincentives to paying any price to block out competition and force companies to pay more closely to market value for spectrum. As a result, the burden of entry would be lower and companies can afford to charge less to provide a competing product.

C. Equivalent Replacement Standard

The equivalent replacement standard allows a court or agency to compel a senior water right holder to accept substitute water from a different source or a modification of diversion, distribution, or

[187] Crawford, *The Radio and the Internet*, *supra* note 38, at 974-75.
[188] Crawford, *The Radio and the Internet*, *supra* note 38, at 974-75.
[189] Crawford, *The Radio and the Internet*, *supra* note 38, at 974-75. That appears to go against mandates in the Communications Act. *See* 47 U.S.C. §257(b) ("the Commission shall seek to promote the policies and purposes of this chapter favoring diversity of media voices, vigorous economic competition, technological advancement, and promotion of the public interest, convenience, and necessity.").
[190] Crawford, *The Radio and the Internet*, *supra* note 38, at 974-75.

use of water in order to benefit a junior user and achieve better overall utilization of the resource.[191] It is a practical solution that does not affect vested rights.[192] In that regard, substitute water must generally be equivalent in amount and quality.[193] The general rule is to determine if an alternative exists that can avoid inefficient use of water, and if so, ask whether that alternative will not unreasonably and adversely affect the prior appropriator's vested property right.[194] For example, courts have allowed a junior appropriator to divert water upstream from a senior appropriator's water source and provide substitute water to that senior appropriator in return[195] and allowed a junior appropriator rights to surplus water due to improvements they made to the water delivery system of senior appropriators.[196]

In applying the equivalent replacement standard to spectrum, we need to determine if an alternative exists that can avoid inefficient use of spectrum and, if so, ask whether that alternative will unreasonably and adversely affect the incumbent licensee's communication signal or the viewer's reception of that signal.[197] The focus in this analysis is on the end user rather than the licensee because it is the end user's communication that is being moved from one delivery method to the alternative, just as the water law principle of equivalent replacement is only concerned with the senior appropriator's water but not the effects on any person in between, such as an irrigation company that might have previously delivered the target water.

In the case of the television frequency band, there are at least two alternatives to avoiding inefficient use of spectrum. The first involves relying on other modes of delivery and the other requires

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[191] In California, this is called the physical solution. City of Barstow v. Mojave Water Agency, 23 Cal.4th 1224, 1249 (2000). *See also* Harrison C. Dunning, *The Physical Solution*, 57 UCOLR 445, 448 (1986). It is called the right of replacement in Utah and New Mexico, substitute supply in Colorado, and is generally referred to as a plan for augmentation. *Id.*

[192] City of Barstow, 23 Cal.4th at 1250.

[193] Dunning, *The Physical Solution*, *supra* note 191, at 459.

[194] City of Lodi v. East Bay Municipal Utility District, 7 Cal. 2d 316, 60 P.2d 439 (1936); *See also* Dunning, *The Physical Solution*, *supra* note 191, at 448.

[195] Montecito Valley Water Company v. City of Santa Barbara. 144 Cal. 578, 77 P. 1113 (1904); Bower v. Moorman, 27 Idaho 162, 183-84, 147 P. 496, 503 (1915); City of Lodi v. East Bay Municipal Utility District, 7 Cal. 2d 316, 60 P.2d 439 (1936);

[196] Tulare Irrigation Dist. v. Lindsay-Strathmore Irrigation Dist., 3 Cal. 2d 489, 524, 45 P.2d 972, 985-86 (1935).

[197] By signal, I also mean the content that goes with that signal. In the case of television, at issue in the White Spaces Order, *supra* note 1, interfering with the signal means interfering with the picture on the viewer's television set. In the case of a mobile phone, it is the signal that carries a voice or data stream.

changes to technological standards used by the television industry.[198]

Consumers already take advantage of a variety of alternative modes to receive broadcast television signals that do not utilize the frequency reserved for that purpose. As of June 2006, almost 87% of U.S. households[199] subscribe to a service provided by a multichannel video programming distributor (MVPD), such as cable, satellite, and IPTV.[200] Although the White Spaces Order does not allow for interference with high powered television stations, it is possible under a theory of equivalent replacement for a secondary user to interfere if it could guarantee that the 13% of viewers[201] who rely upon over the air broadcasts would receive the television channel through one of those MVPD systems or through another mode that was equivalent to the television reception currently received. This is akin to a junior appropriator capping an artesian well and piping an equivalent amount of water to the senior appropriator and keeping the rest as has been allowed under the equivalent replacement doctrine.[202]

Next, we ask whether that alternative will unreasonably and adversely affect the incumbent licensee's communication signal or the viewer's reception of that signal. As long as the viewer is able to receive the incumbent television station's signal with equivalent quality or better, then the interference is not adverse or unreasonable. As stated before, the key is to focus on the consumer who is the most important party in the communications signal. Although there are valid arguments that any interference does adversely and unreasonably affect the incumbent licensees, the broadcaster is not the important party. Although slightly out of context, we can borrow from Red Lion and say that "[i]t is the rights of the viewers and listeners, not the right of the broadcasters, which is paramount."[203] In that regard, if there no longer is a need because the users have disappeared, the spectrum should be reallocated with

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[198] I'm certain there are more alternatives that secondary users will have plenty of incentive to identify.

[199] Approximately 95.8 million

[200] FCC, In the Matter of Annual Assessment of the Status of Competition in the Market for the Delivery of Video Programming, Thirteenth Annual Report, MB Docket No. 06-189, 5 (Nov. 27, 2007) [hereinafter FCC, Thirteenth Report on Video Competition].

[201] The number might be higher or lower in some areas.

[202] Montecito Valley Water Co. v. City of Santa Barbara. 144 Cal. 578, 77 P. 1113 (1904); Bower v. Moorman, 27 Idaho 162, 183-84, 147 P. 496, 503 (1915); City of Lodi v. East Bay Mun. Util. Dist., 7 Cal. 2d 316, 60 P.2d 439 (1936).

[203] Red Lion Broad. Co. v. FCC, 395 U.S. 367, 390 (1969).

consideration paid to the users who have not abandoned that spectrum. It could be a reduced amount of spectrum requiring a software change to a software defined radio or phase out of one technology in favor of another. For example, if the state of Vermont builds out a fiber network to cover its entire population and provides IPTV, in essence providing a functional equivalent, then the state of Vermont should be able to request that the Commission open up the full broadcast television spectrum to unlicensed uses.

A second alternative is to replace the technical standards used to deliver the television broadcast. Broadcast television currently uses the MPEG-2 encoding standard.[204] More efficient compression is available. For example, AT&T's U-verse video delivery system uses the newer and more efficient MPEG-4 encoding scheme, which requires less spectrum to deliver the same amount of video content.[205] MPEG-4 content can be transported over an MPEG-2 transport stream, allowing existing delivery systems to be used.[206] Under the doctrine of equivalent replacement a secondary user can pay for any upgrades to the broadcaster's encoding device so it uses MPEG-4 and likewise provides viewers a way to decode that new signal. The secondary user can then utilize the spectrum freed up by those technology upgrades. Next, we ask whether that alternative will not unreasonably and adversely affect the incumbent licensee's communication signal or the viewer's reception of that signal. As above, if the viewer is able to receive the incumbent television station's signal with equivalent quality or better, then the interference is not adverse or unreasonable.

It is possible that, in this example, the broadcasters could be forced to pay for at least part of the upgrade their equipment to further compress the signals. This determination could depend on how long

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[204] FCC, In the Matter of Annual Assessment of the Status of Competition in the Market for the Delivery of Video Programming, Twelfth Annual Report, 8, (Feb. 10, 2006) [hereinafter FCC, Twelfth Report on Video Competition].

[205] U-Verse delivers video using spectrum available within its pipes; it does not use radio spectrum. Its data stream runs over a mix of fiber and copper, with bandwidth allocated in-band between video, voice, and Internet. Whitt, *Evolving Broadband Policy, supra* note 5, at 427-28. *See also* FCC, Twelfth Report on Video Competition, *supra* note 204, at 8; FCC, Thirteenth Report on Video Competition, *supra* note 200, at 11, 42, 47 (reporting that direct broadcast satellite (DBS) television providers already use the MPEG-4 standard).

[206] International Organisation for Standardisation, Overview of the MPEG-4 Standard, ISO/IEC JTC1/SC29/WG11 N4668, http://www.chiariglione.org/mpeg/standards/mpeg-4/mpeg-4.htm (last visited Dec. 10, 2009).

it has been since the last upgrade and whether it is unreasonable for the broadcaster to not update its technology. Congress may not like this idea very much. Local broadcasters are more likely to give air time to local politicians' activities than are national companies[207] and the Internet audience is not captive like the television audience. Then again, the broadcast television audience is already small and is getting older.[208]

D. Authority to Apply Principles of Water Law to Spectrum

The Commission has the power to modify its regulations to apply principles of water law. Congress, through the Communications Act, has delegated to the Commission authority over the use of the electromagnetic spectrum to propagate communications signals and to "prescribe such rules and regulations as may be necessary in the public interest to carry out the provisions" of the Act.[209] The mandate is nebulous and invests the Commission with enormous discretion.[210] Although the statute does tell the Commission to get prior consent of a station before changing frequencies, power levels, or times a station may operate, it does not need to if "the Commission determine[s] that such changes will promote public convenience or interest or will serve public necessity, or the provisions of this chapter will be more fully complied with."[211] Such a standard is broad enough to drive a tank through. As long as it appears to be in the broadly defined public interest, the Commission has discretion to apply principles

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207 Speta, *Spectrum Policy Experiments: What's Next?*, *supra* note 49, at 410.

208 *See* Robert Seidman, The Internet Didn't Kill TV Viewing, But Cable Crushed Broadcast Nets in the 2000s, TV By the Numbers blog (Dec. 11, 2009) http://tvbythenumbers.com/2009/12/11/the-internet-didnt-kill-tv-viewing-but-cable-crushed-broadcast-nets-in-the-2000s/35998 (providing a graph showing how television hours are increasing while hours speng watching a broadcast network is decreasing); Cabletelevision Advertising Bureau, Press Release: Cable Programming's High Ratings Driving Current Television Season's Audience Growth, http://www.thecab.tv/main/press/releases/cable-programmings-high-ratings-driving-current-te.shtml (Feb. 2, 2009); *See also* Pew Project for Excellence in Journalism, The State of the News Media for 2008, Audience (2009) http://www.stateofthemedia.org/2009/narrative_networktv_audience.php?cat=2&media=6 (Last visited Dec. 10, 2009) ("The median age of nightly news viewers was 61.3 years for all three evening newscasts in 2008.... The median age was roughly 60 years of age between 2004 and 2006.").

209 47 U.S.C. § 151. *See also* Nat'l Cable & Telecomm. Ass'n v. Brand X Internet Svcs., 545 U.S. 967, 980 (2005); Schurz Comm., Inc. v. F.C.C., 982 F.2d 1043, 1048 (7th Cir. 1992) (opinion by Posner). A similar mandate is also found in 47 U.S.C. § 303(f) ("the Commission from time to time, as public convenience, interest, or necessity requires, shall ... [m]ake such regulations ... as it may deem necessary ... to carry out the provisions of this chapter.").

210 Schurz Comm., Inc. v. F.C.C. 982 F.2d at 1048.

211 47 U.S.C. § 303(f).

of water law to spectrum.

Utilizing water law principles will help the Commission to meet its obligations under the Communications Act, thus serving the public interest as defined and mandated by Congress. Most notably, it will make spectrum available for "deployment of new technologies, products, and services for the benefit of the public,"[212] such as services that use software defined radio and provide high speed Internet access services. Incumbents that currently underutilize that spectrum will have incentive to invest in providing services, relinquishing the spectrum, or making it available for secondary users who will likely use it to provide competitive or alternative services to those provided by the incumbent spectrum user.[213] In this case, the incumbent or secondary users in rural areas are likely to provide backhaul and high speed wireless Internet access using that spectrum. Secondarily, it will promote the efficient and more intensive use of the electromagnetic spectrum.[214] An added benefit is that, in providing more spectrum in rural areas through the application of water law principles, the Commission will create a test bed for new and innovative technologies and methods for data delivery and efficient use of spectrum that can then be utilized in more densely populated areas. It can also provide a test bed for large scale commons approach advocated by Benkler.[215]

In this regard, applying principles of water law discussed above would assist the Commission in meeting its obligations under the Communications Act and serve the public interest.

V. Conclusion

Television white spaces will help connect residents in rural communities to broadband services; however, the White Spaces Order is not enough on its own. Frequencies in the television spectrum that are the focus of the White Spaces Order do not lend themselves well to point to point communication

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[212] 47 U.S.C. § 309(j)(3)(A).

[213] That is, incumbents other than broadcasters or others restricted by license. For example, current broadcast licenses only allow the licensee to operate a television station. It cannot go dark Saturday and open up for business on Sunday as a high-speed wireless broadband provider. Hazlett, *Response to Weiser & Hatfield*, *supra* note 43, at 1012.

[214] As mandated by 47 U.S.C. § 309(j)(3)(D).

[215] Benkler, *Economics of Wireless Communication*, *supra* note 75.

necessary for longer distance backhaul from a community to a backbone connection point. As such, the Commission will need to provide spectrum that is better suited for backhaul required for viable and economic high speed Internet services in rural communities.

As discussed above, applying water law principles to spectrum can free up unused and underutilized spectrum for more productive purposes including point to point backhaul connections. The principles discussed in this paper: 1) requires spectrum use be beneficial and reasonable; 2) requires the licensee to actually use the spectrum and not hold a license for speculative purposes; and 3) provides for equivalent replacement of a communications signal.

On a similar note, spectrum made available through the application of water law principles can be used for a variety of different purpose aside from backhaul. All wireless services are critically dependent on access to spectrum. As the Commission has acknowledged, "wireless is increasingly used as a platform for broadband communications services [in general and] the demand for spectrum bandwidth will likely continue to increase significantly, and spectrum availability may become critical to ensuring further innovation and deployment in the wireless sector."[216]

Furthermore, applying water law principles to spectrum provides additional benefits. They create a test bed for new and innovative technologies, methods for data delivery, and efficient use of spectrum. Engineers and investors will have incentive to innovate and find ways to better utilize spectrum. In addition, they provide an environment conducive to a large scale experiment with the commons approach advocated by Benkler.

[216] NOI Fostering Innovation & Investment, *supra* note 41, at 5.