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Cover Page Footnote

Associate Professor of Law and Telecommunications, University of Colorado. Thanks to Ellen Goodman, Paul Margie, Patrick Ryan, and Doug Sicker for helpful comments and encouragement. Thanks, as well, to the participants in the 2004 Telecommunications Policy Research Conference and the 2005 Fordham Law and the Inforamtion Society Conference. *Adjunct Professor of Telecommunications, University of Colorado.

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POLICING THE SPECTRUM COMMONS

Philip J. Weiser and Dale N. Hatfield***

INTRODUCTION

Some of the bands of radio spectrum originally designed for unlicensed uses (such as industrial operations) were widely regarded as "garbage bands."[1] Many industry observers concluded that the assorted unlicensed uses, in the band of frequencies around 2.4 gigahertz ("GHz"), for example—mostly industrial, noncommunications uses like microwave ovens—crowded that band sufficiently so that no reliable service could operate in that range.[2] Undeterred by the crowded nature of that band, the Institute of Electrical and Electronics Engineers ("IEEE") developed a standard for wireless broadband that would operate in the 2.4 GHz band of spectrum. The subsequent success of the 802.11 standard, popularly known as Wi-Fi, has demonstrated that unlicensed spectrum can be big business.[3] In 2003 alone, for example, equipment manufacturers were expected to sell more than $2.5 billion in Wi-Fi-related devices.[4] For 2004, it was estimated that public Wi-Fi hot spots would reach "almost 140,000 worldwide, with some 30 million users."[5] To top it off, former Federal Communications Commission ("FCC") Chairman Michael Powell and others have touted wireless broadband using unlicensed spectrum as a financially viable approach for delivering broadband services to rural areas.[6] Not bad for a garbage band.[7]

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* Associate Professor of Law and Telecommunications, University of Colorado. Thanks to Ellen Goodman, Paul Margie, Patrick Ryan, and Doug Sicker for helpful comments and encouragement. Thanks, as well, to the participants in the 2004 Telecommunications Policy Research Conference and the 2005 Fordham Law and the Information Society Conference.

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1. *A Brief History of Wi-Fi*, Economist.com, June 10, 2004, http://www.coe.montana.edu/ee/rwolff/EE580/history_of_wifi.htm.

2. *Id.*

3. *See, e.g.*, Wiley Rein & Fielding LLP, Wi-Fi–802.11: The Shape of Things to Come 13-14 (2002), *available at* http://www.wrf.com/docs/publications/8422.pdf (discussing projections for American and global Wi-Fi use).

4. Insight Research Corp., WiFi Market Forecast, http://www.enterprisewirelesstechnology.com/page.cfm/link=62 (last visited Sept. 10, 2005).

5. Nikhil Hutheesing, *Wi-Fi Buys*, Forbes.com, June 8, 2004, http://www.forbes.com/wireless/2004/06/03/cz_nh_wifi04_buys.html.

6. *See* Michael K. Powell, Chairman, Fed. Commc'ns Comm'n, Address at WISPCON: WISPs: Bringing the Benefits of Broadband to Rural America 1 (Oct. 27, 2004), *available at* http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-253686A1.pdf (remarking that formerly "junk" spectrum bands now host "wireless broadband networks that provide not only last-mile connectivity, but last-30-50-mile connectivity"); Mingliu Zhang & Richard S.

Wi-Fi's commercial success has raised a series of important questions for policymakers and has forced the FCC to take seriously the promise of technologies that use "commons access spectrum," such as the unlicensed 2.4 GHz band that facilitated the success of Wi-Fi.[8] First, advocates of a "spectrum commons" are now pressing the FCC to make available additional bands of commons access spectrum, including bands for a next generation "WiMAX" technology. Second, Wi-Fi's success raises the question of whether commons access spectrum can be used effectively to provide commercial services, such as those now offered by "wireless Internet Service Providers" ("WISPs"), which use commons access spectrum to offer broadband services to customers. Third, as WISPs and other firms using commons access spectrum begin to provide broadband services (particularly in rural areas), the FCC is evaluating whether commons access spectrum, as a common resource owned by no individual firm, is prone to overuse and "tragedy of the commons"-type concerns.[9] Fourth, as the FCC adapts to the demands placed on it with respect to commons access spectrum, it has begun to consider whether new models of regulation are warranted, including how to address tragedy of the commons-type concerns.

To date, proponents of increased commons access spectrum have not developed careful solutions for ensuring that it can be used to provide

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Wolff, Crossing the Digital Divide: Cost-Effective Broadband Wireless Access for Rural and Remote Areas 7, http://www.coe.montana.edu/ee/rwolff/Divide-rev4.pdf (last visited Sept. 7, 2004) (concluding that, based on "reasonable assumptions for equipment costs, customer adoption rates, services prices and market share, a Wi-Fi-based broadband Internet access network is financially viable in a rural area"); *see also* Stephen Lawson, *Wi-Fi Brings Broadband to Rural Washington*, Infoworld, Aug. 23, 2004, http://www.infoworld.com/article/04/08/23/HNwifiwash_1.html (reporting on the use of the Wi-Fi system in the 2.4 GHz band to provide wireless broadband service over a 3,700 square mile area in rural Washington and estimating that 8000 such offerings exist throughout the United States).

7. Notably, the 2.4 GHz band (along with other bands, such as the 900 MHz band) supports an array of other unlicensed uses, ranging from cordless phones to garage door openers. For purposes of this paper, however, we will focus on wireless broadband applications. For a discussion of the array of uses of unlicensed spectrum, see Kenneth R. Carter et al., *Unlicensed and Unshackled: A Joint OSP-OET White Paper on Unlicensed Devices and Their Regulatory Issues* (Fed. Commc'ns Comm'n, OSP Working Paper Series, Paper No. 39, 2003), *available at* http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-234741A1.pdf.

8. In general, we use the term "commons access spectrum" interchangeably with "unlicensed spectrum." There are, however, alternative licensing arrangements—i.e., licensing widespread spectrum access by rule or providing members of the public with "nonexclusive licenses"—that afford parties access to spectrum in a very similar manner to unlicensed spectrum. To encompass this broader concept, we use the term "commons access spectrum" to refer to all spectrum bands that are open to public use (or at least to categories of the public). Moreover, some commentators refer to "open spectrum" or "open access spectrum," but we prefer using the commons concept to underscore that "commons access spectrum" may include certain restrictions, whereas open access generally suggests unrestricted access.

9. For a discussion of the "tragedy of the commons" concern, see *infra* notes 50-51 and accompanying text.

commercial services without confronting tragedy of the commons-like concerns.[10] At best, they have suggested that social norms, cooperation in the development of the relevant protocols (through standard-setting bodies like the IEEE) or the FCC's current regime for certifying technologies (through its Part 15 rules) can prevent such problems from emerging.[11] Those who are more mindful of the need to guard against behavior that would undermine the viability of such services have suggested that common law courts can adjudicate tort actions to police the use of commons access spectrum.[12] Yet others have suggested that local property owners should be permitted to manage commons access spectrum on their premises[13] or that the FCC should establish certain etiquette standards (the equivalent of "don't speak unless you have something to say, don't interrupt, and don't speak more loudly than necessary to be heard") to prevent tragedy of the commons-like concerns.[14] In all events, however, the debate over how—if at all—to regulate access to the spectrum commons is only beginning.[15]

This Article both underscores the imperative of, and presents an analytical framework for, regulating the use of commons access spectrum. In particular, it rejects the argument made by many spectrum commons advocates that commons access spectrum can prosper without any FCC

10. Yochai Benkler, a leading advocate of a spectrum commons approach, readily acknowledges that the identification of the content and form of those rules that will most effectively address tragedy of the commons-like concerns constitutes "an important area of study" that must still be addressed. Yochai Benkler, *Overcoming Agoraphobia: Building the Commons of the Digitally Networked Environment*, 11 Harv. J.L. & Tech. 287, 361-62 (1998); *see also* Stuart Buck, *Replacing Spectrum Auctions with a Spectrum Commons*, 2002 Stan. Tech. L. Rev. 2, ¶ 39, http://stlr.stanford.edu/STLR/Articles/02_STLR_2/article_pdf.pdf (noting that Benkler's advocacy of a spectrum commons is not coupled with a description "in any great detail" of the measures necessary to make it work).

11. *See* Buck, *supra* note 10, ¶¶ 40-41.

12. *See, e.g.*, Kevin Werbach, *Supercommons: Toward a Unified Theory of Wireless Communication*, 82 Tex. L. Rev. 863, 931 (2004) ("Conflicts among users of wireless devices should be addressed through a 'negative' regime of tort . . . .").

13. *See* Thomas Hazlett, *Missing the Next (Radio) Wave*, Barrons, Aug. 2, 2004, http://www.manhattan-institute.org/html/_barrons-missing_the_next.htm.

14. Fed. Commc'n Comm'n, Comments of Microsoft Corp., Modification of Parts 2 and 15 of the Commission's Rules for Unlicensed Devices and Equipment Approval, ET Docket No. 03-201, at 5 (2004) [hereinafter Comments of Microsoft] (on file with author).

15. We note that there are two other forms of spectrum commons that we will not address explicitly in this paper, although those contexts raise some related issues to the ones we address here. In particular, the Federal Communications Commission ("FCC") has begun to consider whether to make available "spectrum underlays" within licensed bands (such as those made available for ultra-wideband technology) and whether to authorize opportunistic uses of otherwise licensed spectrum not being used by the licensee at a particular time. *See* Facilitating Opportunities for Flexible, Efficient, and Reliable Spectrum Use Employing Cognitive Radio Technologies, 18 F.C.C.R. 26,859, 26,869-70 (2003) (notice of proposed rulemaking and order) (inquiring into possible uses of cognitive radios to facilitate opportunistic uses of licensed spectrum); Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems, 17 F.C.C.R. 7435 (2002) (first report and order) (authorizing underlays for ultra-wideband). Similarly, we do not discuss the issues raised by "private commons" that are managed by a firm with a spectrum license.

oversight, arguing instead that the FCC should develop a regulatory program that integrates the efforts of end-user groups, interested companies, private standard-setting bodies, and its own enforcement tools.[16] Historically speaking, the FCC's strategy for enforcing limits on the uses of commons access spectrum has focused on equipment certification requirements, specialized rules of operation, and in some rare cases, penalizing those who use spectrum illegally.[17] But where standards are increasingly embedded in software and users are not easily identified, this approach needs to be refined.

In short, we focus on two central reforms: developing additional proactive measures to limit the potential for interference and improving the FCC's system of back-end enforcement. To set the stage for these reforms, Part I outlines the basics of the current spectrum management regime, and Part II discusses the alternative possible approaches—i.e., other than public regulation—for policing commons access spectrum. In recommending regulation of commons access spectrum in Part III, we recognize that the measures we propose will require considerable effort to implement, but we believe that a failure to address these issues would be the Achilles' heel of the commons model of spectrum management. At the same time, we recognize that if the FCC institutes overly restrictive regulations of commons access spectrum, it risks sacrificing some of the benefits of such spectrum by allowing it to fall prey to some of the failings of the legacy command-and-control model.

I. THE RADIO SPECTRUM AND THE CURRENT SPECTRUM MANAGEMENT REGIME

To understand the issues raised by the debate over how to police the spectrum commons, we must first outline the structure of the current regulatory system. Part of the challenge facing the FCC as it seeks to adapt to the changing technologies that make possible more efficient uses of spectrum is both that its statutory authority is antiquated, dating back to the 1930s, and that reforming regulation invariably threatens incumbent interests. Before we can explain the current regulatory model, however, we must first explain what the "radio spectrum" is.

A. *A Succinct Primer on Spectrum Technology*

The radio spectrum refers to electromagnetic waves that travel through space within a frequency range of 3000 cycles-per-second and 400 billion cycles-per-second. These "frequencies," which are measured in Hertz and abbreviated as "Hz," form the basis of wireless communications. In

16. In this sense, we build on some of the conclusions offered by Ellen Goodman. *See* Ellen P. Goodman, *Spectrum Rights in the Telecosm to Come*, 41 San Diego L. Rev. 269, 403-04 (2004) (calling for greater development of the necessary regulatory strategy to facilitate the effective use of commons spectrum).

17. *See* discussion *infra* Part I.B.

particular, a given range of frequencies can be used to communicate information over distances without wires or other physical media. In the case of analog cellular services, for example, a voice channel of 30,000 Hz (or 30 kiloHz, or kHz) can provide sufficient bandwidth to establish a reliable communications link.[18] Significantly, a provider can use a particular 30 kHZ channel to provide analog cellular service on one day and then still have the same amount of radio spectrum available for use tomorrow, meaning that spectrum is infinitely renewable.[19]

The radio spectrum can be divided up along the lines of its frequency, time, and space dimensions. In theory at least, additional users of spectrum can always be accommodated—particularly through the use of smart "cognitive radio" technologies, discussed below, that enable enormous flexibility in spectrum use.[20] But even taking advantage of such technologies, there are practical considerations in terms of cost and complexity that limit the number of users that can be served in a given geographic area at one time and, in that sense, the radio spectrum is a scarce resource. Thus, despite being infinitely renewable, spectrum often has significant economic value, especially in geographic areas with intense demand for wireless communications.

When commentators discuss the radio spectrum, they generally focus on the set of frequencies that are most suitable for commercial uses. Significantly, because different frequency ranges ("bands") within the radio spectrum have different technical characteristics, some bands are more attractive for particular purposes than others. The most notable uses of spectrum rely on the frequencies between 300 MHz and 3 GHz because the physical dimensions of the required antennas are reasonable, the associated transmitting and receiving devices are less costly, and more fundamentally, the radio waves are less susceptible to being blocked or weakened by natural or man-made obstacles such as hilly terrain or tall buildings. Technological change can overcome such obstacles, however, and the range of usable spectrum has expanded over time.

The term "spectrum management" generally refers to the broad array of activities associated with the regulation of this somewhat unusual natural resource. In short, it includes activities such as (1) allocating bands of frequencies for certain purposes (e.g., television broadcasting, terrestrial mobile radio services, or unlicensed spectrum not designated for a

18. One KHz is one thousand Hz, one MHz is one million Hz, and one GHz is one billion Hz. Historically, the greater number of frequencies used for a particular communications link correlated with greater power levels and increased bandwidth. Accordingly, a transmission for a broadcast television station uses 6 MHz, or 200 times as much bandwidth as an analog cellular voice channel. As we discuss below, new digital technologies have begun to undermine these historic patterns of spectrum usage.

19. Like air or water, however, the radio spectrum resource can be "polluted" by interference generated by natural sources of electromagnetic waves (e.g., lightning strokes) or by spurious emissions from radio transmitters or other man-made devices (e.g., florescent lights).

20. *See infra* notes 36-38 and accompanying text.

particular use); (2) assigning licenses that authorize individuals or firms to use particular bands of spectrum (e.g., through an auction process); (3) developing the rules and regulations (e.g., maximum transmitter power) that govern the use of a channel or group of channels within a band in a specified geographical area; and (4) enforcing the associated rules and regulations once they are adopted.[21] As explained at the outset, spectrum commons advocates generally focus on the first two functions—i.e., allocation and assignment—and downplay or ignore the issues associated with the last two—i.e., service rules and enforcement.

B. *The FCC's Spectrum Management Regime*

In 1934, when Congress created the FCC (in the Communications Act of 1934[22]) and instituted an approach for regulating access to the radio spectrum, the concept of "spectrum management" was generally limited to the role of overseeing the licenses to operate broadcast stations (initially for radio and later for television).[23] But over seventy years later, the importance of wireless technologies that use the spectrum—and the FCC's management of that resource—goes well beyond what Congress envisioned in 1934. Unfortunately, the 1934 Act continues to form the basis of spectrum policy, as the FCC continues to use the generations old "command-and-control" model of regulation that tightly prescribes what users can and cannot do with a spectrum license.

Under the legacy command-and-control model, companies live and die by the FCC's decisions regarding the utilization of spectrum. Consequently, the allocation of spectrum for particular uses and the FCC's development of specific technical and service rules governing those allocations are crucial determinants of industry structure and performance. In the mobile telephone industry, for example, the FCC initially allocated only enough spectrum for two operators in each geographic area and it generally restricted the uses permitted under other spectrum licenses so that the bands not previously designated for mobile telephony could not be used to compete against the two authorized providers.[24] In such an environment, innovation in wireless technologies is inhibited, as FCC Chairman Powell put it in 2002, "by the 'mother may I' phenomenon—businesses must go to the FCC for permission before they can modify their spectrum plans to respond to consumer demand."[25]

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21. For an in-depth discussion of these functions, see Jonathan E. Nuechterlein & Philip J. Weiser, Digital Crossroads: American Telecommunications Policy in the Internet Age 231-39 (2005) [hereinafter Digital Crossroads].

22. 47 U.S.C. §§ 151-615 (2000).

23. The Communications Act of 1934 instructed the Federal Communications Commission to grant broadcast licenses to advance "the public interest, convenience, and necessity." *Id.* § 309(a).

24. *See* Digital Crossroads, *supra* note 21, at 268.

25. Michael K. Powell, Chairman, Fed. Commc'ns. Comm'n, Address at University of Colorado at Boulder, Silicon Flatirons Telecommunications Program: Broadband Migration

Over the last fifty years, as firms increasingly sought access to spectrum to provide new services, the command-and-control model came under increasing criticism. Traditionally, the FCC made spectrum available by reallocating spectrum from lower-value to higher-value uses. Using this technique, the FCC follows the "'wise man theory' of regulation," under which it is deemed "capable of deciding what [uses of spectrum are] best for the public."[26] The FCC, for example, has long reserved wide swaths of spectrum for use by the broadcasters (including the often underused UHF frequencies), even while mobile telephone operators clamored for more spectrum. The reason for the FCC's limited success in reallocating spectrum already designated for particular uses is readily understandable: Few incumbent licensees will give up an entitlement to use spectrum without getting something in return. To use the economic term, the fight among incumbent and potential users of spectrum is a form of rent seeking—in that spectrum licensees (and would-be licensees) press vigorously for regulatory decisions that give rise to economic rents for themselves.[27]

The limitations of the command-and-control model have long troubled observers of the FCC's spectrum management regime. In particular, Nobel Laureate Ronald Coase observed in the 1950s that the FCC's command-and-control regulation of spectrum prevented numerous "win-win" trades from taking place.[28] Notably, if the FCC allowed incumbent licensees—such as UHF broadcasters—to sell or lease their spectrum licenses free of any use restrictions, more productive users of the spectrum—say, mobile telephone operators—could purchase those licenses and thereby enhance consumer welfare. Indeed, from the 1950s until the 1990s, the FCC's failure to embrace this "property rights" model gave rise to a cottage industry of scholarship that castigated the agency for its misdirected regulation of spectrum.[29] As the next section makes clear, however, the FCC has not only begun to act on such proposals, it also has begun to consider other fundamental reforms of its traditional spectrum management regime.

III: New Directions in Wireless Policy (Oct. 30, 2002), *available at* http://www.fcc.gov/Speeches/Powell/2002/spmkp212.html.

26. Douglas W. Webbink, *Frequency Spectrum Deregulation Alternatives* 10 (Fed. Commc'ns Comm'n, Working Paper No. 2, 1980), *available at* http:/www.fcc.gov/Bureaus/OPP/working_papers/oppwp2.pdf (emphasis omitted).

27. For a discussion of the rent-seeking aspects of spectrum regulation, see generally 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 (2001).

28. *See* R.H. Coase, *The Federal Communications Commission*, 2 J.L. & Econ. 1, 17-40 (1959).

29. *See* Goodman, *supra* note 16, at 271 n.3 (listing property rights advocates).

C. *Beyond Command and Control and the Commons Model*

Over forty years after Coase first argued for it, the FCC began to reform its traditional spectrum management regime and to treat licenses in a more property-like manner. In particular, the FCC began to heed the calls for reform in the early 1990s and, following the congressional directive to use auctions to assign spectrum licensees, the agency has embarked on a number of initiatives to move spectrum policy towards a property rights model.[30] The FCC's recent Spectrum Policy Task Force Report developed the case for using a property rights model,[31] and the FCC has since followed up this rhetoric with a secondary markets initiative.[32] To date, however, proposed market-based reforms have confronted a series of obstacles, many of which relate to the difficult question of how to transition from the command-and-control regime to a market-based framework. Notably, policymakers continue to debate whether (1) to allow incumbent licensees additional freedom to sell or lease their rights to others who place a greater value on the spectrum, or (2) to prevent incumbent providers from reaping "windfalls" from the enhanced value of the additional flexibility, at the risk of allowing those incumbents to maintain their grip on their spectrum.[33]

Around the same time that the FCC initiated a number of market-based reforms, a notable list of commentators, including Internet pioneer David Reed and law professors Yochai Benkler and Lawrence Lessig, began arguing for a model of spectrum management based on treating spectrum as a "commons."[34] Under this model, which builds off of the FCC's reservation of swaths of spectrum as unlicensed (such as the 2.4 GHz band), anyone can gain access to a block of spectrum or set of channels, subject to certain basic rules.[35] Such a "spectrum commons" approach is somewhat analogous to grazing lands that are used in common by herdsmen in a community, or to public parks or hunting lands that can be accessed by

30. *See* Digital Crossroads, *supra* note 21, at 242-51.

31. *See* Spectrum Policy Task Force, Fed. Commc'ns. Comm'n, Spectrum Policy Task Force Report (2002), *available at* http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-228542A1.pdf.

32. *See* Promoting Efficient Use of Spectrum Through Elimination of Barriers to the Development of Secondary Markets, 18 F.C.C.R. 20,604 (2003).

33. For a discussion of the transitional challenges in moving toward the property rights model, see Digital Crossroads, *supra* note 21, at 245-51. *See also* Evan Kwerel & John Williams, *A Proposal for a Rapid Transition to Market Allocation of Spectrum*, at iv-v (Fed. Commc'ns. Comm'n, OSP Working Paper Series, Working Paper No. 38, 2002), *available at* http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-228552A1.pdf; Gerald R. Faulhaber & David Farber, Spectrum Management: Property Rights, Markets, and the Commons, http://rider.wharton.upenn.edu/~faulhabe/SPECTRUM_MANAGEMENTv51.pdf (last visited Oct. 25, 2005).

34. For an early articulation of this position, see generally Benkler, *supra* note 10. For later ones, see Lawrence Lessig, The Future of Ideas 219-23 (2001); David P. Reed, *Why Spectrum Is Not Property: The Case for an Entirely New Regime of Wireless Communications Policy*, Reed's Locus, Feb 27, 2001, http://www.reed.com/dprframeweb/dprframe.asp?section=paper&fn=openspec.html (draft).

35. *See* Digital Crossroads, *supra* note 21, at 251-57.

anyone. By pushing for such a model of spectrum management, commons advocates have joined forces with property rights advocates in criticizing the command-and-control model, but have advocated a different approach for addressing the rigidities and inefficiencies of the legacy system.

In advocating for a commons model, many commentators highlight the increasing significance of digital technologies that use spectrum efficiently and avoid interference in ways that earlier, "dumb" radios could not. Two notable examples of such technologies are "spread spectrum" and "cognitive radios," both of which can be used to avoid creating large "white spaces" (i.e., unused or underused bands) in the spectrum. Spread spectrum employs digital technologies to spread signals over a wide band of spectrum, sometimes enabling the signals to avoid particular channels depending on which frequencies are being used.[36] Cognitive radios are a distinct innovation that may or may not be used in conjunction with spread spectrum. Such radios enable users to manipulate transmission devices—or for devices to be programmed to self-adjust—so that they can operate using various frequencies, power levels, modulation techniques, or transmission formats.[37] Significantly, such radios are generally defined and controlled by software (i.e., "software-defined radios") as opposed to the traditional hardware-based (and "hard-wired") radios.[38]

In arguing for increased swaths of commons access spectrum, commons model advocates point to the success of devices using the 2.4 GHz band.[39] Like the 2.4 GHz band, a block of spectrum can be designated as commons access spectrum so that any member of the public can use it. Unlike spectrum regulated under the command-and-control or property rights model, however, users of commons access spectrum have no assurance against interference from other such users. Moreover, users of commons access spectrum must comply with specified technical standards (e.g., maximum power restrictions) and, in some cases, specialized requirements (e.g., do not transmit on a particular channel if you detect that it is already in use). Such requirements are set forth in the FCC's Part 15 rules,[40] which are generally enforced through a certification regime that calls for manufacturers to demonstrate that their device (say, a baby monitor, cordless phone, or garage door opener) adheres to the relevant

36. The two most common types of spread spectrum, direct sequence spread spectrum and frequency-hopping spread spectrum, both involve the widening of the basic signal and fall within the FCC's definition of the term. *See* 47 C.F.R. § 2.1 (2004).

37. *See generally* Facilitating Opportunities for Flexible, Efficient, and Reliable Spectrum Use Employing Cognitive Radio Technologies, 18 F.C.C.R. 26,859 (2003) (notice of proposed rule-making and order).

38. The FCC recognized the development of software-defined radios and set forth a certification policy for them in *Authorization and Use of Software Defined Radios*, 16 F.C.C.R. 17,373 (2001) (first report and order). Although software-defined radios are often described as a type of a cognitive radio, there are some software-defined radios that, as a technical matter, are not cognitive. In any event, a more in-depth discussion of this issue is beyond the scope of this Article.

39. *See A Brief History of Wi-Fi*, *supra* note 1.

40. *See* 47 C.F.R. § 15 (2004).

requirements. Finally, the Part 15 rules mandate that any unlicensed device cease operating if it causes interference to its licensed counterparts.[41]

The traditional Part 15 regime, which governs the use of unlicensed devices, is a paradigm of regulatory minimalism. The central goal of this regime is to enable users of unlicensed spectrum to operate without causing harmful interference to licensed uses. Traditionally, the Part 15 rules have regulated the permissible power levels of any authorized device[42] and have assigned liability to manufacturers for failing to follow the applicable certification requirements.[43] In a notable revision of these rules in the late 1980s and early 1990s, the FCC raised the power level requirements in order to facilitate the use of spread spectrum technology in certain unlicensed bands and added additional bands for unlicensed uses.[44] In addition to spurring the development of more sophisticated cordless telephones, these decisions also set the stage for the explosive growth of Wi-Fi systems.

The successful deployment of Wi-Fi systems for the 2.4 GHz band reflects a virtuous cycle that continues to drive adoption of the technology. In particular, with the initial Wi-Fi standards in place and the continuing rapid growth and falling prices of the necessary equipment, entrepreneurs have recognized an opportunity to offer broadband access to the general public through wireless access points located at high-traffic volume locations such as airports and other transportation hubs, hotel lobbies, and coffee shops. Sometimes the access is offered for free as a way of attracting customers to the location (e.g., the coffee shop) or in exchange for a one-time charge or a longer term subscription. In addition, WISPs and other entrepreneurs have recognized the possibility of using very similar technology to extend broadband Internet access to homes or small businesses that were not able to get DSL or cable modem service via wired facilities. For example, a WISP in a small farming community might install an access point with a relatively sophisticated antenna on a high structure such as a water tower and thereby offer high-speed Internet access to an entire cluster of homes and small businesses. Because only the use of widely available and competitively priced equipment—and no radio license—is required, these WISPs can roll out service quickly and at low cost. Various manufacturers have recognized this as a potentially large market and have developed even more sophisticated, "carrier-class" systems that operate over an extended range using commons access spectrum.

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41. *Id.* § 15.5(c).

42. *See* Goodman, *supra* note 16, at 288 n.63.

43. *See, e.g.*, Datel Design & Dev., Inc., 19 F.C.C.R. 17, 20 (2004) (notice of apparent liability) (fining Datel Design and Development $10,000 for importing equipment that radiated emissions beyond that authorized by the Part 15 rules).

44. *See, e.g.*, Revision of Part 15 of the Rules Regarding the Operation of Radio Frequency Devices Without an Individual License, 4 F.C.C.R. 3493, 3516 (1989) (first report and order).

Commons advocates point to the spectacular success of Wi-Fi as a harbinger of what can be expected under a commons model of spectrum management. In particular, they argue that the technical architecture of technologies using commons access spectrum can promote innovation far more rapidly than spectrum subject to the traditional command-and-control or even the property rights model of spectrum management.[45] To do so, they point to the Internet's architecture as a model for spectrum management, highlighting that in the Internet environment, anyone can create a new service by installing software residing in computers (e.g., in clients and servers) external to the "dumb" portion of the network controlled by the carrier or provider. Indeed, the most popular applications that have driven the success of the Internet—email, the Worldwide Web, Instant Messaging, and filesharing to name just the most prominent—have evolved in exactly this way.[46] In short, not only do spectrum commons advocates suggest using decentralized intelligence to dramatically increase the efficient use of spectrum (through shared access based on new technologies), but they also envision it as a way of shifting greater control over service development (as well as content creation, distribution, and consumption decisions) to the general public.

When the FCC reserved spectrum at 2.4 GHz for unlicensed uses, it had no idea that such spectrum would facilitate wireless broadband applications like Wi-Fi. During ongoing spectrum policy debates, however, there is a widespread awareness that the FCC's decisions about making available more commons access spectrum (i.e., whether as unlicensed, licensed to a class of users by rule, or available to all under a nonexclusive license) could spur increased broadband connectivity. Thus, while the initial success of the spectrum commons approach largely reflected a happy historical accident, it has birthed a model of spectrum management which has warranted a closer look from policymakers. The FCC's Spectrum Policy Task Force Report, for example, recognized the commons model as a peer to the property rights model—a model which had long been the sole rival to the traditional command-and-control approach.[47] Additionally, major information technology companies like Intel have picked up the mantle of arguing for increased commons access spectrum, advocating, for example, that the FCC designate frequencies in the 700 MHz range—now used by

45. *See* Yochai Benkler, *Some Economics of Wireless Communications*, 16 Harv. J.L. & Tech. 25, 72-73 (2002).

46. As Andrew Odlyzko has observed, "In spite of many attempts, the established service providers and their suppliers have an abysmal record in innovation in user services. . . . The real 'killer apps,' such as email, the Web, browsers, search engines, IM, and Napster, have all come from users." Andrew Odlyzko, Telecom Dogmas and Spectrum Allocations 7 (2004), *available at* http://wirelessunleashed.com/papers/TelecomDogmas.pdf.

47. *See* Principles for Promoting Efficient Use of Spectrum by Encouraging the Development of Secondary Markets, 15 F.C.C.R. 24,178, 24,180 (2000) (policy statement) ("[T]he best way to realize the maximum benefits from the spectrum is to permit and promote the operation of market forces in determining how spectrum is used.").

UHF stations—as unlicensed spectrum.[48] Indeed, the FCC has recognized that WISPs would use additional unlicensed spectrum at higher power levels to enable them to provide "broadband access networks serving individual customers in sparsely populated areas."[49]

At present, the FCC has only begun to recognize that it may need to reform its regulation of commons access spectrum to protect commons access users from interfering with one another. As commercial providers like WISPs increasingly offer services using commons access spectrum, however, the FCC will need to take seriously the argument that the commons model of spectrum management—at least without additional regulatory oversight—will give rise to the famed "tragedy of the commons."[50] On this argument, a resource that is designated for common usage is prone to despoliation as individual users increase their consumption of the resource without taking care to ensure that they do not overuse the resource.[51] In the spectrum context, a notable concern is that users of commons access spectrum will increase the performance of communications links by increasing their transmitter power, but at the expense of causing more interference to—and reducing the performance of—links operated by other users. Faced with diminished performance, other users will then retaliate by raising their own transmitter power to compensate for the increased interference. With this concern in mind, the FCC should examine how to prevent such vicious cycles before fully embracing the commons model of spectrum management.

II. ENSURING A SUSTAINABLE SPECTRUM COMMONS

The regulatory debate over whether a spectrum commons can avoid tragedy of the commons-type concerns is in its infancy, with commentators only beginning to address this question. The resolution of the issue will depend on whether some form of regulation can prevent users of commons access spectrum from descending into mutually antagonistic forms of behavior. Notably, regulation can take a variety of forms, including (1) social norms that limit certain types of behavior, (2) market ordering that creates incentives for and against certain types of behavior, (3) technical architectures that limit the range of possible behavior, and (4) traditional law enforcement that punishes certain types of behavior.[52] In general, commons advocates focus on some combination of the first three modes of regulation, often contending that FCC regulation is unnecessary or only

48. Michael Singer, *Intel: Spectrum Is the New Frontier*, internetnews.com, July 30, 2004, http://www.internetnews.com/wireless/article.php/3388811.

49. Press Release, Fed. Commc'ns Comm'n, FCC Begins Rulemaking Proposing to Allow Wireless Broadband Operations in the 3650-3700 MHz Band (Apr. 15, 2004), *available at* 2004 WL 828417.

50. *See* Stuart Minor Benjamin, *Spectrum Abundance and the Choice Between Private and Public Control*, 78 N.Y.U. L. Rev. 2007, 2031 (2003).

51. *See generally* Garrett Hardin, *The Tragedy of the Commons*, 162 Sci. 1243 (1968).

52. *See generally* Lawrence Lessig, *The New Chicago School*, 27 J. Legal Stud. 661 (1998).

minimally necessary to enable the commons model of spectrum management to succeed. To evaluate this claim, we consider each of the first three modes in turn and then judge whether they prevented tragedy of the commons-type concerns in analogous, commons-like environments: "ham radio" (formally known as the amateur radio service) and citizen's band ("CB") spectrums.

A. *Social Norms*

The importance of social norms as a form of regulating the use of commons access spectrum is potentially enormous. For years, commentators often invoked the tragedy of the commons concern[53] but did so without investigating whether actual commons uses gave rise to such concerns. Recent scholarship has reversed this trend, suggesting that commons regimes can operate effectively under certain circumstances. In particular, Robert Ellickson famously observed that ranchers in Shasta County settled disputes with one another through a series of social norms about how to use common property—even in the absence of formal legal rules to govern their behavior.[54]

To explain the collaboration necessary to maintain a commons, students of game theory have advanced the argument that participants act very differently—and are far more likely to cooperate—when engaged in a repeat playing game. In such games, participants may well realize that if they deviate from a norm of cooperation in one instance, it might well come back to haunt them in another one.[55] Indeed, in some communities—whether neighboring ranchers or particular industries—the resort to legal formalities and self-interested behavior is unlikely to be constructive; as Stewart Macaulay quoted a purchasing sales agent over forty years ago, "'You don't read legalistic contract clauses at each other if you ever want to do business again.'"[56] Not surprisingly, Macaulay's landmark study of business relations found that the most common type of dispute to end up in

53. For the classic example of such an argument, see Mancur Olson, The Logic of Collective Action 2 (1965) (arguing that "rational, self-interested individuals will not act to achieve their common or group interests"). To be sure, Olson did not discuss the tragedy of the commons concern per se, but rather the closely associated "free rider problem," whereby individuals decline to take any action that would advance the collective interest. On this account, individuals only safeguard their narrow self interest, which means that any collective action issues—such as maintaining common property—are unlikely to be addressed effectively. *See id.*

54. Robert C. Ellickson, Order Without Law: How Neighbors Settle Disputes (1991).

55. *See* Robert Axelrod, The Evolution of Cooperation 73-87 (1984) (discussing the role of reciprocity in fostering cooperation between opposing units entrenched a short distance away from one another during World War I); David Hirshleifer & Eric Rasmusen, *Cooperation in a Repeated Prisoners' Dilemma with Ostracism*, 12 J. Econ. Behav. & Org. 87, 90-94 (1989) (discussing the role of reciprocity in establishing equilibrium among multiple players in different games involving repeated interactions).

56. Stewart Macaulay, *Non-Contractual Relations in Business: A Preliminary Study*, 28 Am. Soc. Rev. 55, 61 (1963).

an appellate court is a fight over the ending of a business relationship—i.e., an action for the wrongful termination of a franchise agreement.[57]

In short, the game theory literature suggests that social norms which address and prevent counterproductive behavior may well arise in repeat games situations, but there are no such guarantees where the parties are not likely to interact with one another on a regular basis.[58] Relatedly, in environments where a firm cares about its reputation, that concern can discourage tragedy of the commons-like behavior.[59] Consequently, the combination of repeated interactions between parties and widespread reputation effects can help to explain how certain markets, such as diamond trading, are characterized by a remarkable degree of trust and a commitment by firms not to press their legal rights to the hilt.[60] Nonetheless, as Paul Mahoney and Chris Sanchirico convincingly explain, it is quite possible that even reputational sanctions in contexts with multiple players will fail to ensure that benevolent norms are followed and noncompliance punished.[61] Finally, in situations where reputational sanctions are not available (i.e., where the parties do not know one another), it is quite likely that only legal enforcement can ensure that individuals follow the relevant social norms.[62]

In the wireless context, the significance of social norms is readily apparent. Two next-door neighbors, for example, can often resolve

57. *Id.* at 65.

58. *See* Eric A. Posner, *The Regulation of Groups: The Influence of Legal and Nonlegal Sanctions on Collective Action*, 63 U. Chi. L. Rev. 133, 137-44 (1996). There are still important unanswered questions about how social norms work in practice, including how they are developed, how quickly they adapt to serve their purpose, and how they are enforced, but we can assume for our purposes that such norms are reasonably effective in regulating behavior under certain conditions. *See, e.g.*, Richard H. McAdams, *The Origin, Development, and Regulation of Norms*, 96 Mich. L. Rev. 338, 352 (1997) (highlighting how the effort necessary to enforce social norms presents a collective action problem in and of itself).

59. *See* Jason Scott Johnston, *The Statute of Frauds and Business Norms: A Testable Game-Theoretic Model*, 144 U. Pa. L. Rev. 1859, 1874-75 (1996) ("Within suitably dense and homogenous communities, the harm to the breacher's reputation and lost future dealings with third parties that she will suffer when the aggrieved party tells others in the community about her breach may supplant the 'second party' sanction of relationship termination."); Lewis A. Kornhauser, *Reliance, Reputation, and Breach of Contract*, 26 J.L. & Econ. 691, 699 (1983) ("[I]n simple worlds with reputations, the rule of law does not matter.").

60. *See* Lisa Bernstein, *Opting Out of the Legal System: Extralegal Contractual Relations in the Diamond Industry*, 21 J. Legal Stud. 115, 126-28 (1992). Bernstein notes that the substantive rules of arbitration to which New York diamond dealers voluntarily submit are based upon trade usage and custom rather than state contract law, and that a dealer who refuses to be bound by an arbitration ruling risks severe reputational damage if the claimant must resort to state court for enforcement of the ruling. *Id.*; *see also* Lisa Bernstein, *Merchant Law in a Merchant Court: Rethinking the Code's Search for Immanent Business Norms*, 144 U. Pa. L. Rev. 1765, 1799-1800 (1996).

61. Paul G. Mahoney & Chris William Sanchirico, *Norms, Repeated Games, and the Role of Law*, 91 Cal. L. Rev. 1281, 1294-95 (2003) (discussing enforcement problems that occur when more than two actors are involved).

62. *See* Robert E. Scott, *A Theory of Self-Enforcing Indefinite Agreements*, 103 Colum. L. Rev. 1641, 1644, 1647 (2003) (noting that conditions of repeat playing games and significant reputation effects are "stringent," and when those conditions are not met, "legal enforcement is necessary").

interference issues amicably and effectively, often by repositioning their antennas. Similarly, equipment manufacturers who produce complementary equipment (say, related Wi-Fi devices) have strong incentives both to minimize interference with one another's equipment and to enable users to identify which users are degrading one another's uses of commons access spectrum. Moving to the analogy of the public park, the role of social norms can be quite powerful where local neighbors know who does and who does not follow certain established social norms (say, cleaning up after one's dog).[63] Indeed, social sanctions—be they collective shunning or "tit for tat" behaviors (say, not cleaning up after one's dog on a neighbor's property)—can be a remarkably effective means of encouraging compliance with a social norm.

In some wireless environments, there are reports that both users of Wi-Fi-like services and of air-to-ground radio channels—i.e., in contexts of limited numbers of users who know one another—have worked with one another constructively to avoid interference.[64] But when anonymous users send signals that travel great distances in dense areas, there are strong reasons to believe that social norms will break down. Similarly, when only small communities of individuals used the Internet to communicate with one another, "Netiquette" was a plausible (if unlikely) means of curbing spam; in today's Internet environment, however, social norms about email usage no longer are suggested as means of stemming the tide of spam.[65] In short, effective enforcement of property rights (including the right to use a commons reasonably) is a public good (e.g., everyone benefits from the deterrent effect of criminalizing trespassing) that the marketplace does not provide. In recognition of this point, the state should provide an effective regime to enforce property rights in most cases (i.e., at least where social norms will not operate effectively to do so).[66]

B. *Free-Market Solutions*

For many Internet-age problems like spam, some commentators argue that free-market solutions can solve collective challenges and obviate the need for public regulation.[67] More generally, some commentators argue that "[c]ompetitive private institutions offer the potential for the

63. Elinor Ostrom, Governing The Commons: The Evolution of Institutions for Collective Action 136, 138-39 (1990).

64. *See* Wireless BANC: Broadband Access Network Coordination, http://www.wbanc.com (last visited Sept. 7, 2005) [hereinafter Wireless BANC].

65. Paul K. Ohm, *On Regulating the Internet: Usenet, a Case Study*, 46 UCLA L. Rev. 1941, 1983-84 (1999) (describing Netiquette).

66. *See* Abraham Bell & Gideon Parchomovsky, *A Theory of Property*, 90 Cornell L. Rev. 531, 560 (2005) ("Public enforcement of property systems will . . . often constitute a public good. Enforcing property rights by monitoring infringements, apprehending transgressors, and prosecuting and punishing violators has the effect of strengthening property value.").

67. *See* David G. Post, *What Larry Doesn't Get: Code, Law, and Liberty in Cyberspace*, 52 Stan. L. Rev. 1439, 1440-42 (2000) (arguing for market responses to spam).

development of mechanisms that can reduce the cost of achieving communication, coordination, and commitment to support transactions on the Internet."[68] In the spam context, for example, there are commercial services that maintain a "blackhole" list of ISPs who send copious amounts of spam, as well as filtering programs that users can install to regulate who can send them email. But such solutions are proving to be imperfect at best, with some suggesting that such techniques are actually blocking up to thirty-five percent of legitimate email and only twenty-five percent of spam messages.[69] After years of hesitating, in part because of claims that market solutions could address the issue, Congress finally instituted a legal regime to regulate spam—the CAN SPAM Act of 2003[70]—although its effectiveness remains to be seen.

In order for market-based solutions to limit interference between uses of commons access spectrum and render public regulation unnecessary, they will need to prove more effective than their counterparts have in the battle against spam (which is, admittedly, an imperfect analogy). At this point, however, firms have only begun to develop such technologies, so it is too early to tell how effective they will be in facilitating effective use of commons access spectrum. Consider, for example, Propogate Network's "swarm logic software," which enables different access points to communicate with one another and to choose nonconflicting frequencies or adjust their power levels to eliminate overlap.[71] If this technology were able to reach a critical mass of adoption, even in localized areas, it could conceivably minimize those transaction costs necessary to adapt to neighboring uses of commons access spectrum. For neighboring buildings with scores of Wi-Fi transmitters, such technologies could prove very important, ensuring that different signals did not overlap and interfere with each other—thereby slowing data transmission and possibly triggering the destructive cycle of behavior noted above. Moreover, a logical extension of the swarm logic software is a function that could enable neighbors to identify those who deviated from accepted social norms in using commons access spectrum and, concomitantly, lower enforcement costs. Indeed, collective efforts—such as the Broadband Access Network Coordination ("BANC")—have already taken root to facilitate joint and controlled efforts to limit interference.[72]

Another marketplace response worth following is the effort by the Wi-Fi Alliance to develop a community of equipment developers, service providers, and users of commons access spectrum, all of whom would be

68. Gillian K. Hadfield, *Privatizing Commercial Law: Lessons From ICANN*, 6 J. Small & Emerging Bus. L. 257, 287 (2002).

69. William G. Schwab, *Take Back Your In Box*, Experience, Winter 2004, at 14, 35.

70. 15 U.S.C.A. § 7701 (West 1998 & Supp. 2005).

71. *See* AutoCell Laboratories, http://www.propagatenetworks.com (last visited Sept. 7, 2005) (founded as Propagate Networks).

72. *See* Gerry Blackwell, *BANC on Non-Interference*, Wi-Fi Planet, Feb. 26, 2004, http://www.wi-fiplanet.com/columns/article.php/1781_3318281_1; Wireless BANC, *supra* note 64.

certified as good actors. As is the case with informational privacy for those engaging in Internet commerce, members of this community have a stake in building the confidence of the customers who use, or may use, equipment or services that rely on commons access spectrum. In this case, the initiative appears to stem (at least in part) from a dispute between two companies, namely Broadcom's claim that certain products manufactured by Atheros prevented Broadcom's own products from working properly.[73] To prevent similar future episodes, and to ensure that all companies that produce Wi-Fi-related equipment do so in a manner that does not impede the operation of equipment manufactured by other vendors, the Wi-Fi Alliance has threatened to withhold or revoke the certification—and the right to use its logo—from any offending companies.[74] At this point, however, the Alliance has not begun policing such possible abuses, so it is too early to quantify the impact of the revocation policy. Nonetheless, at least based on the case of Internet privacy, the Alliance is likely to confront a number of challenges—ranging from effective consumer education efforts to reliable self-regulatory efforts—that will need to be addressed for this initiative (or others like it) to be effective.[75]

What remains to be seen, with respect to market-based responses to the interference that results from the use of commons access spectrum, is whether such measures will be able to overcome the distance and large-number problems that often prevent social norms from addressing such concerns effectively. To be sure, marketplace developments are likely to enhance the abilities of parties who can easily contact—or at least are reasonably proximate to—one another to work out mutually acceptable arrangements. But where parties are not so easily identified, as in the instance of spammers who easily hide from solutions aimed at limiting their effectiveness, it is likely that any privately developed approaches will fall short in preventing tragedy of the commons-type concerns. As in the spam context, the difficulty related to addressing the behavior of bad actors—whether malicious or simply selfish—is that they are not interested in cooperating with a collective solution that would be in the interests of the entire community of users of commons access spectrum. This challenge is exacerbated when there are disparate interests using disparate devices operating disparate services.

C. *Architecture*

In analogizing the potential for commons access spectrum to succeed in a manner similar to the Internet, many commons advocates have suggested that technology-facilitating protocols, such as Wi-Fi, can be self-enforcing

73. Mark Hachman, *Wi-Fi Group Cracks Down on Incompatible Extensions*, PCMag.com, July 19, 2004, http://www.pcmag.com/article2/0,1759,1625097,00.asp.

74. *Id.*

75. Paul M. Schwartz, *Beyond Lessig's* Code *for Internet Privacy: Cyberspace Filters, Privacy Control, and Fair Information Practices*, 2000 Wis. L. Rev. 743, 766-69.

in terms of their effectiveness in combating destructive behavior.[76] On this argument, the network effects phenomenon—where certain technologies become entrenched because they facilitate a wide variety of uses dependent on them[77]—can ensure that a suite of protocols not only is adopted widely, but also adhered to. The challenge in developing protocols that can limit interfering uses is that engineers have proved ingenious in circumventing all sorts of protocols that would otherwise limit behavior condemned by the original inventor.[78] Moreover, this argument overlooks the fact that the basic design ethos of the Internet is antithetical to limiting the potential uses of basic enabling technologies. Rather, the Internet pioneers embraced an "end-to-end" ethos that shifts control to the edges of the network precisely so that users can introduce new innovations, regardless of their social impact.[79]

In short, the effectiveness of technical architecture in limiting interfering uses of commons access spectrum depends on a regulatory regime that requires all equipment to be certified as compliant with certain basic protocols. The current certification regime, embodied in the FCC's Part 15 rules, safeguards only the rights of licensed spectrum users and provides no protection to commons access users.[80] Consider, for example, that a "Wi-Fi Hog," which appropriated an unduly large amount of commons access spectrum, undermining all Wi-Fi systems in a particular area but not disrupting any licensed users, would satisfy Part 15's requirements.[81] Moreover, even if all developers of Wi-Fi transmitters agreed to certain protocols to prevent destructive uses such as the Wi-Fi Hog, it would not be difficult for skilled hackers to circumvent such limitations. Indeed, as transmitters increasingly rely on software, the possibilities for "hard-wiring" protections against noxious uses into the equipment itself will quickly evaporate.[82] Consequently, without a back-end enforcement

76. *See* Buck, *supra* note 10, ¶¶ 88-94 (providing examples of effective cooperative self-enforcement among users of Wi-Fi technology).

77. *See, e.g.*, Michael L. Katz & Carl Shapiro, *Technology Adoption in the Presence of Network Externalities*, 94 J. Pol. Econ. 822 (1986).

78. Consider, for example, the cases involving "hacking" and circumvention of copy protection schemes. *See, e.g.*, Universal City Studios, Inc. v. Corley, 273 F.3d 429 (2d Cir. 2001).

79. Stated simply, the end-to-end ethos is a commitment to (1) openness (both in terms of its basic standards and in the culture of the standard-setting organizations themselves), (2) modularity and protocol layering, and (3) a shifting of control over the relevant applications to the edge of the network. *See* Dale N. Hatfield, 8 Commlaw Conspectus 1, 1 (2000).

80. 47 C.F.R. § 15.5 (2004).

81. This Wi-Fi Hog is not a hypothetical device, but one that has already been invented. *See* Wi-Fi-Hog—2003, http://www.mee.tcd.ie/~bruckerj/projects/wifihog.html (last visited Sept. 10, 2005).

82. The flexibility of software-defined radios built using open-source software will be particularly amenable to modification—for good and for ill. *See, e.g.*, Sam Williams, *Radio Free Software*, Salon.com, Dec. 18, 2002, http://www.salon.com/tech/feature/2002/12/18/gnu_radio/print.html ("We're pretty much turning all hardware problems into software problems [and] want to facilitate evolution in the radio arena.") (quoting Eric Blossom, Founder of the GNU Radio Project).

regime of some kind, the flexibility made possible by software-defined radios may well increase the efficient use of spectrum while also facilitating counterproductive uses.

D. *Case Studies: The CB and Ham Radio Experiences*

In arguing for a spectrum commons approach, a number of commentators have suggested that past experiences with commons access spectrum, in the contexts of ham radio and citizen's band radio, underscore that the forces discussed above—i.e., social norms, marketplace responses, and technical architecture—can limit the potential for destructive behavior. In particular, Stuart Buck and Professors Carol Ting, Johannes M. Bauer, and Steven S. Wildman make this very argument.[83] As we discuss below, however, their accounts of these episodes minimize the degree to which tragedy of the commons-type behavior took place in the absence of governmental regulation and fail to appreciate the unique circumstances that made cooperation possible in those instances.

1. Ham Radio

In arguing for an increased reliance on the commons model, Stuart Buck invokes the example of ham radio—or more precisely, the development of similar commons-type practices at the dawn of ham radio's development.[84] In the ham radio environment, volunteer leaders have taken on the role of policing the use of the spectrum. In many parts of the country, voluntary "spectrum management leaders," who call themselves the amateur auxiliary of the FCC, are able to police illegal conduct somewhat effectively by using threats—in the form of official-looking notifications—that they will spur FCC action to go after bad actors who fail to heed their warnings.[85] This peer pressure is taken seriously by ham operators—when the observer notifies another operator that he or she has been operating in a manner not in accordance with the rules, it generally triggers the desired response.[86] In addition to the official observers who work in conjunction with the FCC, a distinct group of frequency coordinators oversees the use of repeaters in ham radio transmissions, facilitating coordination between different users.[87]

In highlighting the case of ham radio, Stuart Buck acknowledges that it demonstrates how, under certain conditions, social norms and private

83. *See generally* Buck, *supra* note 10, ¶¶ 40-42; Carol Ting et al., *The U.S. Experience with Non-traditional Approaches to Spectrum Management: Tragedies of the Commons and Other Myths Reconsidered*, Sept. 2003, http://quello.msu.edu/wp/wp-03-05.pdf.

84. Buck, *supra* note 10, ¶¶ 78-80.

85. *See* Dave Hassler, Observing the Official Observers, QST Magazine, July 2003, at 1, *available at* http://www.arrl.org/qst/2003/07/0307047.pdf; *see also* American Radio Relay League, The Amateur Auxillary of the FCC, *http://www.arrl.org/FandES/field/org/am_aux.html* (last visited Sept. 11, 2005).

86. *See* Hasler, *supra* note 85, at 1-3. (describing positive responses).

87. *Id.*

enforcement can obviate the need for public enforcement.[88] Indeed, the FCC's decision to ban the sale of amplifiers separate from radio transmission devices[89] underscores the fragility of commons access spectrum environments protected only by social norms and private oversight. Moreover, the rise and fall of CB radio makes this point even more powerfully.

2. The CB Radio Saga

In the mid-1970s, CB radios experienced a brief period popularity with the general public. Prior to that time, the band was used largely by distinct communities of enthusiasts and, more famously, by truckers (think "10-4, good buddy"). Once the band became more widely used, and attracted a more diverse community of users, the previous social norms broke down (including the commitment to refrain from vulgar language and harassment) and users began, among other things, attaching amplifiers to their transmitters to make themselves, in effect, broadcasters. The mutated character of the previously informal communications soon boomeranged, ending the brief explosion of popularity for CB radios once new users discovered that the advertised attractiveness of informal communication among enthusiasts no longer existed.

Commentators Ting, Bauer, and Wildman have a different take on the rise and fall of CB radio. Rather than suggest that the overuse of the band and the rise of amplifiers confirm concerns about tragedy of the commons-like results, they argue that the relative success and workability of the band before and after its rise in popularity actually undermines the case for tragedy of the commons-type concerns. As they put it, "Interference caused by illegally amplified signals has always been and still is a common complaint [among CB users], but unlike during its peak, channel congestion is not a problem anymore, even in metropolitan areas."[90] Notably, these commentators acknowledge the FCC's failings in this area, explaining that it "has never devoted sufficient resources to enforcement to ensure deter [sic] violations of its usage rules or violations of its technical specifications."[91]

The lack of effective enforcement by the FCC undoubtedly contributed to the rising complaints about interference during CB radio's peak years of 1974-1976 and the dramatic falloff in users after that time frame: In fact, the number of complaints escalated from 30,000 to 100,000 during that time.[92] Ting, Bauer, and Wildman have suggested that the misbehavior was confined to a small subset of users who, in violation of the rules of the

88. *See id.*

89. Modification of Parts 2 and 15 of the Commission's Rules for Unlicensed Devices and Equipment Approval, 19 F.C.C.R. 13,539, 13,545-46 (2004).

90. Ting et al., *supra* note 83, at 6.

91. *Id.* at 12.

92. *Id.* at 17.

band, acted as broadcasters rather than individual communicators.[93] Even assuming the validity of this argument, it supports the game theory prediction that outside entrants into a community who face neither social norm pressures nor legal enforcement will be likely to engage in disruptive behavior that will limit the potential of a common resource.[94] Consequently, if the story of CB radio's rise and fall were to be repeated in the case of WISPs, the FCC's effort to promote WISPs would almost certainly fail.

III. PUBLIC REGULATION AND MOVING BEYOND THE TRADITIONAL PART 15 REGIME

As Part II explained, nonpublic regulation is unlikely to be fully effective in guarding against tragedy of the commons-type concerns.[95] In terms of the role of social norms, we believe that they are quite promising, but that they will be of limited effectiveness in addressing relations between distant and anonymous users of commons access spectrum. As for market forces, there are strong reasons to question their effectiveness insofar as they will likely operate in both directions—not only protecting cooperative behavior, but also creating incentives for "cheating." Finally, as to the effect of specific technical architectures, the increased uses of software-defined radios will facilitate the (already possible) circumvention of prescribed protocols, making it important to oversee the behavior of individual users. In short, the success of the commons model is likely to depend, at least in part, on the ability of regulation to guard against the tragedy of the commons and counterproductive uses of commons access spectrum.

While nonlegal regulation forces are unlikely to be fully effective in addressing tragedy of the commons-like concerns, the future role of social norms, marketplace responses, and technical architectures is likely to

93. *Id.*

94. The FCC adopted the broader explanation of congestion—i.e., without assigning blame to a limited class of users—in evaluating the unfortunate fate of CB radio. *See* Creation of an Additional Personal Radio Service, 72 F.C.C.2d 453, 455 (1979) (notice of inquiry) (noting "complaints that the level of congestion (at least in major urban areas) has reached the point where reliable communications are becoming increasingly difficult to achieve").

95. In evaluating the effectiveness of nonpublic regulatory approaches, we have declined to evaluate whether they are open to criticism on other grounds, such as being an illegitimate or an undemocratic means of developing information policy. Such arguments, for example, are commonly leveled at the Internet Corporation for Assigned Numbers and Names ("ICANN"), which is a private, nonprofit corporation that manages access to the Internet's domain name system. *See, e.g.*, Jonathan Weinberg, *ICANN and the Problem of Legitimacy*, 50 Duke L.J. 187 (2000); *see also* Steven L. Schwarcz, *Private Ordering*, 97 Nw. U. L. Rev. 319, 322, 329 (2002) (observing that "commercial private ordering is rarely restricted" by traditional safeguards that confer legitimacy on public bodies, but that "[w]here efficiency is the sole goal of regulation, unrestricted private ordering can be legitimate"). *But see* Jonathan R. Macey, *Public and Private Ordering and the Production of Legitimate and Illegitimate Legal Rules*, 82 Cornell L. Rev. 1123, 1125 (1997) (suggesting that private ordering is more likely to produce legitimate rules and thus should be preferred over public ordering).

remain important. Nonetheless, on their own and without the backstop of law enforcement, they are unlikely to address such concerns effectively. To be sure, even without law enforcement assistance, it is quite possible that commons access spectrum could still be used effectively. But as rival commercial services utilize commons access spectrum and the distance of uses for commons access spectrum continues to expand—the record for a Wi-Fi transmission is already in excess of fifty-five miles[96]—the need for public regulation is likely to become more pronounced. Indeed, the FCC appears to recognize the need to act in this area, as evidenced by Chairman Powell's remark that such regulations are necessary to "protect against [an] interference meltdown,"[97] such as that caused by tragedy of the commons-like concerns.

The FCC, in developing its regulatory regime for commons access spectrum, should recognize the importance of these non-regulatory protections against interference, work in tandem with them where possible, and be sure not to displace them. Significantly, there is a risk that external rules and monitoring by the FCC could, if not carefully developed, prove counterproductive by crowding out constructive cooperative initiatives such as those discussed above.[98] In general, the FCC's regulatory tools for ensuring cooperation in the use of commons access spectrum fall into two categories: proactive requirements and reactive enforcement measures. Before discussing these options, however, we will first address two proposals for taking the job of enforcement responsibility away from the FCC, explaining how each proposal deviates from existing law and why we view these proposals to be inferior to a regulatory regime superintended by the FCC.

A. *Alternatives to FCC Regulation*

Two notable proposals provide alternatives to the FCC's role of overseeing the use of commons access spectrum. One proposal, which draws its inspiration from the property rights model, would be to allow either local property owners or those who aggregate such rights to police the use of commons access spectrum. A second proposal would be to treat abusive uses of commons access spectrum as common law violations to be addressed in judicial forums.

Increasingly, rival users of commons access spectrum are looking to different authorities to settle disputes between them. If, for example, rival services using commons access spectrum at airports bring complaints to the airport authority, that authority will be tempted to adjudicate such disputes and regulate commons access spectrum use at airports just as that authority

96. Kim Zetter, *Wi-Fi Shootout in the Desert*, Wired, Aug. 3, 2004, *available at* http://www.wired.com/news/culture/0,1284,64440,00.html.

97. *Powell Tells CES FCC Must Understand and Protect VoIP This Year*, Comms. Daily, Jan. 12, 2004, at 2, *available at* 2004 WLNR 6932914 (internal quotation omitted).

98. *See* Elinor Ostrom, *Collective Action and the Evolution of Social Norms*, 14 J. of Econ. Persps. 137, 147 (2000) (reporting on experiments that demonstrate this possibility).

regulates disputes among other other concessions. Similarly, if a user is unable to use her device at home because a neighbor's device is incompatible—and they are unable to resolve their dispute amicably—the frustrated user might be tempted to bring an action in court claiming that her neighbor's use of commons access spectrum constitutes a "nuisance" that should be enjoined. In either case, however, the airport authority or the court would lack jurisdiction over the dispute, as the Communications Act clearly assigns such matters to the FCC.[99]

As a legal matter, it is generally accepted that the FCC enjoys exclusive authority over spectrum matters.[100] In particular, the courts have regularly concluded that the FCC's authority in this area preempts the entire field of possible regulation.[101] In so doing, courts have cited the relevant legislative history of Congress's last enactment that addressed the FCC's jurisdiction in this area (i.e., the House Conference Report of the Communications Amendments Act of 1982),[102] which explained that "exclusive jurisdiction over [radio frequency interference] incidents (including pre-emption of state and local regulation of such phenomena) lies with the FCC."[103] Consequently, when individuals have brought actions claiming that a particular operator's transmissions interfered with their home appliances and thus constituted a nuisance, the courts have declined to hear such cases.[104]

As a normative matter, some argue that Congress should address the FCC's stranglehold on spectrum as soon as possible.[105] To be sure, the FCC's management of spectrum has been and continues to be highly

99. *See* Petition of Cingular Wireless L.L.C. for a Declaratory Ruling, 18 F.C.C.R. 13,126, 13,132 (2003) ("The Commission and the federal courts have consistently found that the Commission's authority in the area of [radio frequency interference] is exclusive and any attempt by State or local governments to regulate in the area of [radio frequency interference] is preempted.").

100. We say "generally accepted" because, although the Supreme Court has not addressed the matter, all federal courts of appeals that have considered the matter have agreed that the FCC enjoys complete authority in this area. *See, e.g.*, Freeman v. Burlington Broadcasters, Inc., 204 F.3d 311, 320 (2d Cir. 2000) (reviewing authority and concluding "that federal law has preempted the field of [radio frequency] interference regulation").

101. *See* Rice v. Santa Fe Elevator Corp., 331 U.S. 218, 230 (1947) (holding that field preemption is appropriate when the federal regulatory regime is "so pervasive" and the federal interest "so dominant" as to leave no room for state regulation).

102. *See, e.g.*, *Burlington Broadcasters, Inc.*, 204 F.3d at 321.

103. H.R. Rep. No. 97-765, at 23 (1982) (Conf. Rep.), *as reprinted in* 1982 U.S.C.C.A.N. 2261, 2267; *see also id.* at 33, 1982 U.S.C.C.A.N. at 2277 ("[T]he Conferees intend that regulation of [radio frequency interference] phenomena shall be imposed only by the Commission.").

104. *See, e.g.*, Broyde v. Gotham Tower, Inc., 13 F.3d 994, 996 (6th Cir. 1994) (ruling that a nuisance action, based upon allegations that radio signals exceeded federal standards, could not be brought in federal or state court, and noting that all courts to consider the matter have so held).

105. *See, e.g.*, Pablo T. Spiller & Carlo Cardilli, *Towards a Property Rights Approach to Communications Spectrum*, 16 Yale J. on Reg. 53, 81, 82 (1999) (asserting that "the FCC has shied away from any large-scale revision of the existing spectrum administration to a property rights approach" and that "the adoption of a property rights approach to spectrum in the U.S. could only be accomplished by an Act of Congress").

imperfect, but we are even less sanguine about a model of purely private ordering or common law development.

In terms of private ordering, while the airport authority case is one of the more plausible contexts in which a band manager could ensure some level of cooperation over a broader geographic area, even that environment is plagued by the risk of leaving the oversight of commons access spectrum to local landowners. In particular, airport authorities may view their managerial role as an opportunity to collect rents from those wishing to operate Wi-Fi-like services. Reflecting this concern, the Industrial Telecommunications Association urged the FCC to reject a petition by airport authorities to oversee such spectrum, explaining that "the 'sole motivational goal' of those efforts 'is to increase airport revenue.'"[106] Consistent with a long line of precedent, the FCC staff accepted this argument and retained exclusive jurisdiction over commons access spectrum within airport terminals.[107]

To their credit, the ability of airport authorities to coordinate effectively commons access spectrum uses makes their claim to oversight more compelling than an argument that individuals should be afforded oversight over commons access spectrum on the real estate they own. In particular, for a would-be WISP, such a regime would force it to acquire easements from all in a neighborhood before providing service to any customer. Such a requirement would not only create enormous transaction costs, it would also invite hold-out behavior—i.e., seeking the financial rewards of being the last property owner to grant an easement—because it is not possible for WISPs to prevent a signal from trespassing on a non-consenting property owner's domain. To be sure, if one believed that commons access spectrum could only be used in the home or in very limited geographic areas, this proposal might have some merit, but the increasing distances that can be reached using present technology suggest otherwise.

The second alternative to the FCC is common law courts. Kevin Werbach recently advanced a version of an argument previously promoted by Peter Huber, arguing that common law courts can oversee access to spectrum.[108] Huber maintained that courts can enforce property rights to

106. Bob Brewin, *Airlines Win Wi-Fi Management Battle with Airports*, Computerworld, June 25, 2004, http://www.computerworld.com/mobiletopics/mobile/wifi/story/0,10801,94124,00.html (quoting the Industrial Telecommunications Association).

107. Federal Commc'ns Comm'n, *Commission Staff Clarifies FCC's Role Regarding Radio Interference Matters and Its Rules Governing Customer Antennas and Other Unlicensed Equipment*, June 24, 2004, at 1 (public notice), *available at* http://hraunfoss.fcc.gov/edocs_public/attachmatch/DA-04-1844A1.pdf ("[T]he FCC has exclusive authority to resolve matters involving radio frequency interference [RFI] when unlicensed devices are being used, regardless of venue."); *id.* at 2 ("We also affirm that the consumer protections for the installation and use of consumer antennas under the FCC's Over-the-Air Reception Devices (OTARD) rules apply to unlicensed devices.").

108. *See* Peter W. Huber, Law and Disorder in Cyberspace: Abolish the FCC and Let Common Law Rule the Telecosm 206 (1997) (asserting that "[s]mall-scale and privately-centered common law is the only kind of law that sits comfortably with our traditions of individual freedom and private liberty" and that, under such common-law governance, "the

use spectrum,[109] and somewhat similarly, Werbach has argued that courts can ensure that individuals and firms use commons access spectrum without unduly interfering with one another.[110] The essence of Huber's argument, and presumably Werbach's as well, is that the FCC is unable to manage questions of spectrum interference effectively. To Huber, such authority invites micromanaging by the FCC—an "army of federal employees hanging around indefinitely to meddle and mess up" the industry.[111]

The courts that have resolved private actions have recognized that the issues involved in spectrum management are highly technical and require uniform, national rules.[112] After all, equipment manufacturers and service providers rely on pre-set rules to develop their offerings and would confront considerable uncertainty if the developers were left to defend themselves in unpredictable forums. In short, the court system's expertise and ability to develop determinate rules is inferior to that of the FCC.[113] Finally, to the extent that the FCC makes substantive misjudgments in this area, we view this as an argument for better regulatory strategies, not for different institutional actors.

Even if courts could develop more determinate and expertly guided rules for spectrum policy (say, as the Federal Circuit has for patent policy),[114] there are two other notable reasons to opt for a model of public regulatory enforcement. First, as we will discuss below, the FCC enjoys the ability to work in tandem with other stakeholders and to develop proactive approaches in ways that courts cannot. Second, the ability of private actors to remedy nuisance-like violations is notoriously limited, as they must internalize the relevant enforcement costs. To be sure, there are solutions to this dilemma—including class actions or public prosecutors—but one effective mechanism of addressing this issue is to authorize agency

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telecosm will become again a place of vast freedom and abundance"); Werbach, *supra* note 12, 920-21 ("Common law doctrines of nuisance and trespass may be used to resolve [spectrum interference] disputes.").

109. *See* Huber, *supra* note 108, at 72-74 (advocating the privatization of the spectrum and asserting that courts could adjudicate disputes involving interference between spectrum users).

110. *See* Werbach, *supra* note 12, at 956 (advocating a "deregulation of spectrum" that "puts decisions about who can transmit in the hands of those who wish to transmit and makes use of the private mechanism of common law courts to sort out disputes").

111. Peter Huber et al., Federal Telecommunications Law 402-03 (2d ed. 1999).

112. *See, e.g.*, Broyde v. Gotham Tower, Inc., 13 F.3d 994, 997 (6th Cir. 1994) (noting that the FCC's jurisdiction "'over technical matters associated with the transmission of radio signals 'is clearly exclusive'" (quoting Head v. N.M. Bd. Of Exam'rs in Optometry, 374 U.S. 424, 430 n.6 (1963))).

113. *See* Digital Crossroads, *supra* note 21, at 421 (noting that a court that "finds fault with an agency's decision is expected to remand the matter back to the agency" because "agencies have greater topical expertise than judges"); Philip J. Weiser, *Federal Common Law, Cooperative Federalism, and the Enforcement of the Telecom Act*, 76 N.Y.U. L. Rev. 1692, 1715-18 (2001).

114. *See generally* Rochelle Cooper Dreyfuss, *The Federal Circuit: A Case Study in Specialized Courts*, 64 N.Y.U. L. Rev. 1 (1989).

oversight, as the Federal Trade Commission does for consumer protection issues.

B. *Proactive Requirements Superintended by the FCC*

In regulating commons access spectrum, the FCC's regime centers on enforcing a set of certification requirements that restrict power levels and guard against interference with licensed operators. As the role of commons access spectrum within the economy increases, and as it is used to provide carrier-level services, the FCC will face increasing pressure to develop measures that will limit interference between rival users of commons access spectrum. Building from the Part 15 rules certification regime, the FCC is beginning to experiment with two notable, proactive requirements: (1) the imposition of spectrum etiquette rules, and (2) database registration requirements. We will discuss each in turn.

1. Etiquette Standards

The FCC first experimented with the use of a prescribed etiquette standard for equipment using commons access spectrum when it established the rules for unlicensed Personal Communications Services ("PCS") spectrum in the early 1990s. In that case, the FCC mandated all unlicensed PCS equipment to "monitor the spectrum before transmitting and to use a specific transmission format"[115]—i.e., such devices must "listen before they talk." Later, after the American National Standards Institute ("ANSI") developed a measurement procedure to ensure that manufacturers complied with such requirements, the FCC incorporated this procedure into its rules.[116]

As commons access spectrum applications have proliferated, the FCC has begun to consider whether it should mandate spectrum etiquette more broadly. In particular, in considering how it can reform its rules governing commons access spectrum to facilitate wireless broadband, the FCC asked whether it should impose certain etiquette standards. In response, Microsoft advocated a set of etiquette standards—including listening before talking, ceasing "transmissions if there is no information to be sent," and using "the minimum transmit power necessary to complete a communications link"[117]—on all uses of commons access spectrum in order to limit interference. To date, Microsoft's proposal has proved quite controversial, with a number of commentators arguing that those bands already replete with commons access uses (such as the 2.4 GHz band)

115. Review of Part 15, 16 F.C.C.R. 18,205, 18,216 (2001) (notice of proposed rulemaking and order).

116. Review of Part 15 and Other Parts of the Commission's Rules, 18 F.C.C.R. 14,741, 14,781 (2003) (second report and order).

117. *See* Modification of Parts 2 and 15 of the Commission's Rules for Unlicensed Devices and Equipment Approval, 19 F.C.C.R. 13,539, 13,552 (2004) (describing Microsoft's proposal); *see also* Comments of Microsoft, *supra* note 14.

would incur great costs associated with these requirements. The FCC has acknowledged such concerns and declined to implement any such proposal; in so doing, however, it suggested that such a proposal had merit for bands yet to be dedicated to commons access uses and indicated that it would seriously consider the concept in the future.[118]

With respect to new bands, the primary concern related to spectrum etiquette requirements is that compliance with a particular standard will limit innovation. In short, detailed restrictions—no matter how well intended or well crafted—can reduce the ability of the inventors and others to innovate without seeking changes in the associated rules and regulations. Moreover, regulatory standards are sometimes flawed, either because the regulator lacks necessary technical capabilities or because the regulator succumbs to the pressures of particular groups' efforts to protect their market position through regulation (i.e., rent-seeking behavior).[119]

Even giving the regulators any benefit of the doubt, whether to develop mandated etiquette standards is a difficult question. Certainly, more restrictive requirements—which could limit the ability of innovators to use licensed spectrum quickly and effectively—may well sacrifice long-term innovation in favor of short-term utilization. Indeed, the codification of certain etiquette standards for commons access spectrum could undermine the freewheeling innovation traditionally associated with such bands. To strike a balance between these two goals, we recommend preserving certain bands of spectrum for more wide-ranging uses while experimenting with etiquette standards in other bands. In particular, we believe that it would be a mistake to impose "listen before you talk" (and other spectrum etiquette) requirements on all bands, but such measures clearly have merit insofar as they can enable WISPs to provide levels of service quality associated with carrier-class service.

For the FCC, the challenges associated with standard setting (including those associated with setting etiquette standards) are not novel concerns, as they have arisen in the transition to digital television (among other such initiatives).[120] In setting telecommunications standards, the FCC should be careful to institute only functional requirements and, where possible, to utilize the experience of established standard-setting bodies to define and enforce the relevant criteria. Notably, the FCC's standard-setting oversight has moved in this direction both in superintending aspects of the transition to digital television and in other areas as well, such as the enforcement of its Part 68 Rules that govern what equipment may be attached to the telephone network.[121]

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118. Modification of Parts 2 and 15 of the Commission's Rules for Unlicensed Devices and Equipment Approval, 19 F.C.C.R. at 13,552.

119. For a good discussion of this point, see Abraham Bell & Gideon Parchomovsky, *Of Property and Antiproperty*, 102 Mich. L. Rev. 1, 43-44 (2003).

120. For a discussion of that challenge, see Digital Crossroads, *supra* note 21, at 395-406.

121. For a fuller explication of this point, see *id.* at 385-406.

If managed optimally, the FCC's use of standard-setting bodies to develop the necessary etiquette standards can leverage the expertise of such standard-setting bodies as well as maintain a degree of oversight to be sure that such standards are adopted. By contrast, where standard-setting bodies are left to their own devices, their lack of formal authority may lead to a failure to adopt, or an inability to enforce, compliance with a particular standard.[122] Significantly, the FCC is also in a position to ensure that standard-setting bodies develop standards based on a fair process that provides a collective benefit that would not be internalized fully by any individual user of spectrum.[123]

In a recent decision involving the allocation of unlicensed spectrum, the FCC both recognized the need to resist developing a standard itself and declined to empower the efforts of a particular standards body (e.g., the IEEE) to develop a protocol for avoiding interference in the use of unlicensed spectrum.[124] Presumably, this decision reflects the concern that developing and enforcing proactive requirements embodied in spectrum etiquette rules might, if managed ineffectively, replicate the failings of the command-and-control model—i.e., rigidity, inflexibility to change, and invitations to rent-seeking behavior. Nonetheless, by calling for the creation of a protocol (or set of protocols) to limit interference, but suggesting that it is not regulating the use of the relevant bands of unlicensed spectrum, it risks promoting confusion rather than the development of the WISPs.

2. Registration Requirements

Over the last twenty years, the FCC has increasingly moved away from the laissez-faire Part 15 regime, and instead has begun to adopt limitations that increase confidence that devices using commons access spectrum will not interfere with licensed uses and, in some cases, commons access uses. In addition to the development of etiquette rules, another innovation is the requirement that anyone interested in using a particular band register their commitment to do so.[125] In substance, this regime imposes a nonexclusive licensing requirement that all users provide certain information before using the designated spectrum. In the so-called "millimeter wave" proceeding, for example, the FCC adopted such a requirement, instituting a site-specific coordination and registration process to be superintended by a third party entity serving as a clearinghouse for access to this spectrum.[126] Similarly,

122. For a discussion of this model of standards development, see Philip J. Weiser, *Internet Governance, Standard Setting, and Self-Regulation*, 28 N. Ky. L. Rev. 822 (2001).

123. *See* Philip J. Weiser, *The Internet, Innovation, and Intellectual Property Policy*, 103 Colum. L. Rev. 534, 573-75 (2003).

124. Wireless Operations in the 3650-3700 MHz Band, 20 F.C.C.R. 6502, 6522-23 (2005).

125. *See* Allocations and Service Rules for the 71-76 GHz, 81-86 GHz and 92-95 GHz Bands, 18 F.C.C.R. 23,318, 23,339-41 (2003).

126. *See id.*

in its specialized Part 15 rules for broadband over powerline ("BPL") services, the FCC mandated that all BPL providers use a publicly available database to indicate their operations in particular areas.[127] In theory, such a notification and registration regime facilitates cooperation and creates incentives for good behavior (as well as a greater ability to use the stick of legal enforcement to punish bad behavior).

The use of a registration regime for a spectrum commons raises a host of issues that the FCC will need to consider carefully in the years ahead. In discussing a registration regime, for example, the cautionary tale of Internet Corporation for Assigned Numbers and Names ("ICANN") immediately comes to mind. In that case, a government-sponsored—but not regulated—entity gained control over the important role of overseeing domain names.[128] The registration regime envisioned by the FCC, however, would not cover access to all spectrum, but instead would be similar to a stock exchange's role in facilitating capital formation and thus unlike ICANN's exclusive role vis-à-vis domain names. In this sense, the FCC could facilitate competition between registrars and oversee registrars in a manner similar to how the Securities and Exchange Commission oversees the stock exchanges. Of course, as observers of the recent wave of scandals are aware, that model is not without cautionary tales either, as it can, for example, enable the registrar to limit competition or extract rents that raise the price paid by end users.

C. *Reactive Measures Superintended by the FCC*

While the proactive measures discussed above are more recent innovations, the FCC's traditional enforcement efforts related to commons access spectrum have involved the reactive role of ensuring compliance with the Part 15 certification requirements.[129] As noted above, however, there are many scenarios—ranging from incompatible equipment to a Wi-Fi-Hog to intentional jamming—that can compromise the use of commons access spectrum. In part, Wi-Fi's open standard leaves it vulnerable to hacking of all kinds, including intentional jamming using off-the-shelf equipment.[130] Indeed, even certified equipment can easily be used—either unintentionally (e.g., hogging) or intentionally (e.g., jamming)—to disturb adjacent commons access spectrum uses. Although the FCC's Chief Engineer has indicated that the agency intends to "get serious about

127. Amendment of Part 15 Regarding New Requirements and Measurement Guidelines for Access Broadband over Power Line Systems, 19 F.C.C.R. 21,265, 21,300-01 (2004).

128. Among other things, ICANN's status as a government-sponsored, but not regulated, registrar gives rise to a series of nettlesome issues. *See* Milton Mueller, Ruling the Root 211-26 (2002); Jonathan Zittrain, *What's in a Name*, 55 Fed. Comm. L.J. 153, 153-54 (2003) (reviewing Milton Mueller, *supra*).

129. *See, e.g.*, Datel Design & Dev., Inc., 19 F.C.C.R. 17, 20 (2004) (notice of apparent liability) (fining Datel Design and Development $10,000 for importing equipment that radiated emissions beyond that authorized by the Part 15 rules).

130. *See* Patrick Gray, *New Flaw Takes Wi-Fi off the Air*, The Register, May 13, 2004, http://www.theregister.co.uk/2004/05/13/wifi_security_flaw.

unauthorized use" of commons access spectrum and will "go after abusers of unlicensed spectrum,"[131] neither its relevant rules nor its enforcement apparatus are set up to do this job. In fact, an agency spokesman indicated that the agency has never fined a party for using cellphone-jamming equipment, and industry executives suggest that the rules against jamming are essentially unenforced.[132]

Under its broad enabling authority, the FCC is free to regulate behavior between users of commons access spectrum. The FCC could, for example, begin enforcing certain broad standards—such as "no willful and malicious interference"—or specific rules (like etiquette standards). To do so, it would use its authority under the Communications Act to "govern[] the interference potential of devices" using radio frequencies.[133] More particularly, the FCC could apply to the commons access spectrum the Communications Act command that "[n]o person shall willfully or maliciously interfere with or cause interference to any radio communications of any station licensed or authorized" by the FCC.[134] However, construing users of commons access spectrum as authorized operators and enforcing this command effectively—something the FCC has yet to do—presents the agency with a number of challenges.

For a number of reasons, the devices utilizing commons access spectrum are fundamentally different than their licensed spectrum counterparts, making enforcement efforts measurably more difficult. First, the sheer number of devices involved and the decentralized nature of the networks make it difficult to carry out enforcement activities. Thus, like the issues related to digital content distributed illegally via the Internet, it will often be difficult for enforcement authorities (either public agencies or private actors) to track down relevant violators and then demonstrate their violation of the relevant requirements.[135] Second, unlike the audible or visible forms of interference associated with traditional radio and television broadcasting, interference in a data network may only appear through a slower or more erratic performance, often making the source of the degradation difficult to ascertain. For example, slower data downloads might be caused by a legally operated, proximately located cordless telephone or an illegal data network device operating at high power a kilometer away. Third, distinguishing between levels of intent—e.g., between benign hogging on account of inferior equipment and malevolent jamming—will not always be

131. *OET Chief Sees Potential Solution for "White Spaces" TV Proposal*, Comms. Daily, Apr. 19, 2004, at 2, 3, *available at* 2004 WLNR 6952149 (internal quotation omitted); *see also* Powell, *supra* note 6, at 4 ("[W]e are fully committed to enforcing our technical rules.").

132. Christopher Elliot, *Mystery of the Cellphone that Doesn't Work at the Hotel*, N.Y. Times, Sept. 7, 2004, at C8.

133. 47 U.S.C. § 302a (2000).

134. *Id.* § 333.

135. *See, e.g.*, Recording Indus. Ass'n of Am. v. Verizon Internet Servs., 351 F.3d 1229 (D.C. Cir. 2003).

easy, let alone demonstrable for enforcement purposes.[136] Finally, to engage in effective enforcement efforts, the FCC—possibly in conjunction with other actors—will need to invest in monitoring equipment and also be sufficiently effective to create real deterrent effects. In short, the failure of the FCC to pursue effective enforcement methods can contribute to the illegal uses, or even the failure, of a service, as in the case of the CB radio.[137]

As the FCC considers how to prevent certain uses of commons access spectrum, it is critical that it enlist good actors in local communities to assist their efforts. In so doing, it can follow the model used in the ham radio environment, discussed above, in which the FCC empowers voluntary overseers by providing an enforcement threat to their exercise of unofficial authority.[138] Indeed, the model of empowering private individuals to work together to solve disputes is one the FCC has employed in other contexts. In particular, Part 101[139] of the FCC's rules facilitates cooperation among users of licensed spectrum by specifying that they work together to coordinate their use of a set of frequencies—i.e., to establish operating procedures for those using the same spectrum.[140] In effect, the Part 101 rules empower private frequency coordinators to settle disputes privately by insisting that the relevant parties work through issues cooperatively prior to FCC involvement.[141] Significantly, this regime has spurred the establishment of cooperative institutions that self enforce—through the existence of an institutional memory and a market for reputation—measures that require actors to act reasonably over time.[142] In short, this regime reflects a proper balance of public regulation and private ordering, facilitating private cooperation in order to ensure that a common resource is protected and used appropriately.[143]

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136. This challenge relates more generally to the difficulties associated with defining "harmful interference." *See* R. Paul Margie, *Can You Hear Me Now? Getter Better Reception from the FCC's Spectrum Policy*, 2003 Stan. Tech. L. Rev. 5, http://stlr.stanford.edu/STLR/Articles/03_STLR_5/index.htm.

137. *See* discussion *supra* Part II.D.2.

138. *See FCC Official Acknowledges 00s Really Are "Official,"* The AARL Letter Online (American Radio Relay League), April 9, 1999, http://www.arrl.org/ arrlletter/99/0409/ (quoting an FCC official as stating that "[t]he volunteer work of these Official Observers is a critical element of the Commission's enforcement program").

139. 47 C.F.R. § 101 (2004).

140. *See generally* Reorganization and Revision of Parts 1, 2, 21, and 94 of the Rules to Establish New Part 101 Governing Terrestrial Microwave Fixed Radio Services, 11 F.C.C.R. 13,449 (1996).

141. Schroeder Manatee Ranch, 16 F.C.C.R. 5722, 5723 (2001) (noting that, under the relevant FCC rules, licensees "are expected to cooperate in the use of frequencies and resolve any harmful interference by mutually satisfactory arrangements" (internal quotation and footnote omitted)).

142. For an example of an association that facilitates reputational sanctions, see Lisa Bernstein, *Private Commerical Law in the Cotton Industry: Creating Cooperation Through Rules, Norms, and Institutions*, 99 Mich. L. Rev. 1724 (2001).

143. *See* Ostrom, *supra* note 63, at 138-39 (detailing how a collective institution for water management arose).

To enforce proactive requirements and oversee malicious uses of spectrum, the FCC should enhance its spectrum enforcement capabilities as well as empower other entities to do so.[144] In particular, standard-setting bodies, frequency coordinators, and the volunteer coordinators in the ham radio environment all provide models that the FCC can employ in developing a regulatory regime to govern commons access spectrum. With respect to selecting entities that can aid its enforcement efforts, the FCC can rely on existing institutions (e.g., the IEEE as a competent standard-setting body) and allow social norm entrepreneurs to emerge and be embraced by a relevant community (as has occurred in the ham radio environment). Finally, the FCC can consider delegating responsibility to registrars or band managers who would be accountable to it. Given the FCC's minimal experience with all of these approaches, it would do best to use a combination of all models before emphasizing a particular strategy.

CONCLUSION

As the FCC builds on the initial, unexpected success of the commons access model of spectrum management, it should consider carefully what measures will guard against tragedy of the commons-like concerns. In a technologically dynamic environment, there are numerous challenges that the FCC will face in developing an effective model for reliable enforcement. As this Article has discussed, no one single approach—and particularly no approach that does not involve FCC oversight—is likely to be successful. Consequently, the FCC should continue moving ahead to implement different proactive and reactive measures that will provide users of commons access spectrum with important assurances that new services and products will not be compromised either by bad actors or poor coordination. If the FCC fails to do so, however, it risks allowing the promise of WISP-like services to follow the unfortunate boom-and-bust path of CB radio.

144. Stuart Buck argues for a spectrum commons with rules enforced by local management associations. *See* Buck, *supra* note 10, ¶ 76. While we believe that such an approach must be coupled with other measures as well, both his argument and our endorsement of such a point appreciate that there are considerable benefits to relying on subsidiary entities to enforce basic standards announced by the FCC. *See* Weiser, *supra* note 113, at 1698-1703.