San Diego Law Review

Volume 41 | Issue 1 Article 16

2-1-2004

Spectrum Rights in the Telecosm to Come

Ellen P. Goodman

Spectrum Rights in the Telecosm to Come

ELLEN P. GOODMAN*

TABLE OF CONTENTS

* Associate Professor, Rutgers University Law School, Camden. My thanks to Michael Carroll, Michael Chartier, David Driesen, Frank Goodman, Gerald Faulhaber, Jay Feinman, James Krier, Paul Schomburg, James Speta, Allan Stein, Victor Tawil, Phil Weiser, Kevin Werbach, the participants of the George Washington University Intellectual Property Colloquium, and the participants of the Penn-Temple-Wharton Colloquium for their insights.

I. INTRODUCTION

Fifty years ago, Ronald Coase blazed forth with what his University of Chicago colleague called "an insight more fundamental than we can use."[1] His radical idea was that the electromagnetic frequencies that carry our wireless communications should be treated like any other finite natural resource. That is, they should be allocated to users through market exchanges, with the government simply defining and enforcing private property rights in the resource.[2] In the ensuing decades, a number of economists and legal scholars have followed Ronald Coase in

1. Harry Kalven, Jr., *Broadcasting, Public Policy and the First Amendment*, 10 J.L. & ECON. 15, 30 (1967).

2. R.H. Coase, *The Federal Communications Commission*, 2 J.L. & ECON. 1, 25–26, 35–38 (1959).

advocating a property rights regime for spectrum.[3] These theorists accept the premise of government spectrum regulation: Because radio signals transmitted on the same or adjacent frequencies in the same area tend to interfere with each other, usable spectrum is a scarce resource whose exploitation must be controlled. What they reject is the notion that the control should lie with the government.

As the demand for wireless devices has accelerated, along with pressures on the government to reform its management of spectrum, Coase's insight has traveled from the fringe to the core of current policy debates. It has come to be accepted in the past several years, even by the Federal Communications Commission (FCC), that comprehensive governmental control over radio signal transmission is no longer appropriate. For each year that the speed of technological innovation outpaces administrative decisionmaking, the chances increase that there will be significant change in the way that spectrum is managed.

Over the past decade, scholars and engineers who are deeply influenced by the open architecture of the Internet have challenged the Coasian critique of spectrum policy.[4] These theorists too would liberate

3. *See, e.g.*, Comments of 37 Concerned Economists, *In re* Promoting Efficient Use of Spectrum Through Elimination of Barriers to the Development of Secondary Markets, WT Docket No. 00-230, at 3–4 (F.C.C. filed Feb. 7, 2001); Arthur S. De Vany et al., *A Property System for Market Allocation of the Electromagnetic Spectrum: A Legal-Economic-Engineering Study*, 21 STAN. L. REV. 1499 (1969); 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) [hereinafter Hazlett, *The Wireless Craze*]; Jora R. Minasian, *Property Rights in Radiation: An Alternative Approach to Radio Frequency Allocation*, 18 J.L. & ECON. 221 (1975); Gregory L. Rosston & Jeffrey S. Steinberg, *Using Market-Based Spectrum Policy to Promote the Public Interest*, 50 FED. COMM. L.J. 87, 93 (1997); Pablo T. Spiller & Carlo Cardilli, *Towards a Property Rights Approach to Communications Spectrum*, 16 YALE J. ON REG. 53 (1999); Lawrence J. White, *"Propertyzing" the Electromagnetic Spectrum: Why It's Important, and How to Begin*, 9 MEDIA L. & POL'Y 19 (2000); *see also* Thomas W. Hazlett, *Assigning Property Rights to Radio Spectrum Users: Why Did FCC License Auctions Take 67 Years?*, 41 J.L. & ECON. 529, 534 (1998) [hereinafter Hazlett, *Assigning Property Rights*] (listing proposals to privatize spectrum). Others have advocated property rights in the context of specific spectrum applications. *See, e.g.*, Mark S. Fowler & Daniel L. Brenner, *A Marketplace Approach to Broadcast Regulation*, 60 TEX. L. REV. 207, 211–12 (1982).

4. *See, e.g.*, LAWRENCE LESSIG, THE FUTURE OF IDEAS: THE FATE OF THE COMMONS IN A CONNECTED WORLD 221–22 (2001); Yochai Benkler, *Some Economics of Wireless Communications*, 16 HARV. J.L. & TECH. 25, 82–83 (2002); Stuart Buck, *Replacing Spectrum Auctions with a Spectrum Commons*, 2002 STAN. TECH. L. REV. 2, ¶ 26, *at* http://stlr.stanford.edu/stlr/articles/02_stlr_2; David P. Reed, *When Less Is More*, *at* http://futurepositive.synearth.net/2002/05/21 (May 21, 2002); KEVIN WERBACH, OPEN SPECTRUM: THE NEW WIRELESS PARADIGM 1–3 (New Am. Found., Spectrum Series Working Paper No.

spectrum from absolute administrative control, but not to deliver it to absolute private control. Instead, they advocate a sort of spectrum commons in which spectrum is largely uncontrolled. In this environment, those who wish to transmit radio signals would be free to do so, provided that they used devices that minimized signal interference.[5] According to the commons theorists, spectrum is not like physical property susceptible to division into parcels.[6] Rather, like air—indeed *as* air—spectrum is a medium for communications that is theoretically limitless, depending on the capabilities of the systems that use it.[7] As the capabilities of radio systems improve, commons theorists assert, the carrying capacity of the airwaves will dramatically expand and, conversely, the scarcity value of spectrum used to justify private property rights will dramatically decline.[8]

The proponents of each of these models—private and common property—make bold claims for the future telecosm.[9] The private

---

6, 2002) [hereinafter WERBACH, OPEN SPECTRUM], http://www.newamerica.net/Download_Docs/pdfs/Pub_File_1001_1.pdf; Kevin Werbach, *Supercommons: Toward a Unified Theory of Wireless Communication*, 82 TEX. L. REV. (forthcoming 2004) [hereinafter Werbach, *Supercommons*]. Although not a fellow traveler, Stuart Benjamin investigates the argument of the commons theorists with particular rigor throughout Stuart Minor Benjamin, *Spectrum Abundance and the Choice Between Private and Public Control*, 78 N.Y.U. L. REV. 2007 (2003).

5. Interference is the manifestation of radio frequency energy in a radio communication system as a "performance degradation, misinterpretation, or loss of information which could be extracted in the absence of such unwanted energy." 47 C.F.R. § 2.1 (2002). It can occur when undesired energy, either generated by another transmitter or generated within the receiver itself, is present in a receiver. *See* Interference Immunity Performance Specifications for Radio Receivers, 18 F.C.C.R. 6039, 6040 (2003).

6. The degree to which the private property theorists conceptualize spectrum as land-like can be overstated. Certainly, analogies to land are freely used. Coase, for example, analogized spectrum uses to "growing a crop" and "build[ing] a house." Coase, *supra* note 2, at 14; *see also* PETER HUBER, LAW AND DISORDER IN CYBERSPACE: ABOLISH THE FCC AND LET COMMON LAW RULE THE TELECOSM 29 (1997) (arguing that courts should have created "property rights in the ether, much as the common law had created property rights in the land beneath it"); Thomas W. Hazlett, *The Rationality of U.S. Regulation of the Broadcast Spectrum*, 33 J.L. & ECON. 133, 148–52 (1990) (arguing that common law principles of land use should have been allowed to define and enforce property rights in spectrum). However, Coase also noted that what would be sold in a spectrum market "is the right to use a piece of equipment to transmit signals in a particular way. . . . [I]t is unnecessary to think in terms of ownership of frequencies or the ether." Coase, *supra* note 2, at 33.

7. I take this analogy to air from the commons theorists themselves. *See, e.g.*, WERBACH, OPEN SPECTRUM, *supra* note 4, at 5–6, 9. One must note, however, that even air is a congestible resource. Air, or more precisely, the right to use the clean air resource, has been propertized to some degree under the Clean Air Act emissions trading program. 42 U.S.C. §§ 7401, 7651–7651*o* (2000). Congress, however, made it clear that the emissions allowance "does not constitute a property right." *Id.* § 7651b(f).

8. *See infra* Part V.A.

9. George Gilder appears to have coined the word "telecosm" in the early 1990s to

property theorists describe a future in which spectrum use migrates to its highest and best use without the distortions of government involvement.[10] The productive capabilities of the communications industries will then be unleashed, resulting in welfare gains for consumers. The claims of the commons theorists are even bigger. Technological advances, they say, provide a unique opportunity to liberate communications from centralized control altogether, private or state. For commons theorists, a system of spectrum that is truly decentralized will not only increase *consumer* welfare, but will benefit *human* welfare by enlarging citizens' expressive capacity.[11]

---

refer to the web of electronic communications that course through our telecommunications networks and among our myriad computing devices. *See* GEORGE GILDER, TELECOSM: HOW INFINITE BANDWIDTH WILL REVOLUTIONIZE OUR WORLD 2 (2000); George Gilder, *Into the Telecosm*, 69 HARV. BUS. REV. 150, 150 (1991). I use it with specific reference to that part of the communications web that is wireless.

10. *See infra* Part III.A. In the tradition of Harold Demsetz, *Toward a Theory of Property Rights*, 57 AM. ECON. REV. 347, 350–57 (1967) (writing that private property rights in scarce resources are desirable when technological or population pressures misalign individual gain and social cost), property rights theorists claim that ownership of spectrum would internalize to owners the benefits of efficient spectrum use, as well as the costs of waste. By removing the existing restraints on alienability, the government would allow spectrum to pass to the owners who value it most. *See generally* Guido Calabresi & A. Douglas Melamed, *Property Rules, Liability Rules, and Inalienability: One View of the Cathedral*, 85 HARV. L. REV. 1089, 1111–15 (1972) (discussing the inefficiency of restraints on alienation). By contrast, a spectrum commons would result in the tragedy of overuse forecast by H. Scott Gordon, *The Economic Theory of a Common-Property Resource: The Fishery*, 62 J. POL. ECON. 124, 124, 135 (1954), and Garrett Hardin, *The Tragedy of the Commons,* 162 SCIENCE 1243, 1244–45 (1968).

11. *See, e.g.*, Yochai Benkler, *Siren Songs and Amish Children: Autonomy, Information, and Law*, 76 N.Y.U. L. REV. 23, 84 (2001) [hereinafter Benkler, *Siren Songs*] (discussing the implications of bureaucratic or commercial control over the means of communications for individual autonomy). "Only access to communications infrastructure that is equally privileged to all users can eliminate the autonomy deficit of property entirely." *Id.* This liberationist thread of the commons argument partakes of the democratic theory that is now so prominent in the fields of intellectual property and cyberspace law, where we see similar claims about the impact of open architecture and liberal access rights on human communicative capacities and democratic flourishing. *See, e.g.*, LESSIG, *supra* note 4, at 112–13; Yochai Benkler, *Free as the Air to Common Use: First Amendment Constraints on Enclosure of the Public Domain*, 74 N.Y.U. L. REV. 354, 358–39 (1999) (arguing that continued and extensive enforcement of property rights in information will harm democratic processes by compromising a robust public domain); Niva Elkin-Koren, *Cyberlaw and Social Change: A Democratic Approach to Copyright Law in Cyberspace*, 14 CARDOZO ARTS & ENT. L.J. 215, 217 (1996) (suggesting that laws regulating the flow of information in cyberspace should be based on democratic principles); Lawrence Lessig, *Commons and Code*, 9 FORDHAM INTELL. PROP. MEDIA & ENT. L.J. 405, 411, 416 (1999) (asserting that a "commons is a critical feature of a well-functioning liberal society"); Neil Weinstock Netanel, *Copyright and a*

It is an article of faith for each school of spectrum policy reform that the changes it proposes will correct a central problem of communications law: government mediation among conflicting demands for spectrum in the "public interest." Regime change, we are told, will put an end to the top-down balancing of contending interests, allowing a balance to emerge from the self-executing principles of markets. For the property theorists, this would be a market in spectrum parcels.[12] For the commons theorists, it would be a market in smart wireless devices that function well in the rough and tumble of a relatively unregulated spectrum commons.[13]

So focused has been the exchange between the private and common property theorists on the question of which system is a better substitute for the existing administrative regime that neither side has examined with any degree of specificity how its proposed model of spectrum management would actually function. Interference is the eight hundred pound gorilla in the spectrum policy debate.[14] The existence of interference between spectrum users was the rationale for government regulation of spectrum in the first place. Far from receding in importance, we can expect interference-related conflict to increase along with intensifying demand for the resource and multiplying techniques for its exploitation.[15] Yet, despite the centrality of interference to the current administrative system, and to any legal regime in the future, surprisingly little thought has been given to the variety of interference scenarios and their relevance to the law.

Unanswered is the question of how judicial or extrajudicial mechanisms should be used to resolve conflicts over spectrum, considering the distributional and efficiency-related implications. Today, government resolves spectrum conflicts by trading off interests among service providers according to vaguely and variously defined public interest values and the commands of political power.[16] Tomorrow, it has been suggested, the common law will replace those administrative judgments wherever communicators are vested with private property rights.[17]

Democratic Civil Society, 106 YALE L.J. 283, 285 (1996) (discussing how copyright law chills discourse and cultural development if it extends too broadly).

12. *See infra* Part III.A.

13. *See infra* Part V.A.

14. As the FCC has put it, "At the heart of all spectrum concerns lies the question of interference." KENNETH R. CARTER ET AL., UNLICENSED AND UNSHACKLED: A JOINT OSP-OET WHITE PAPER ON UNLICENSED DEVICES AND THEIR REGULATORY ISSUES 45 (OSP Working Paper No. 39, 2003), *available at* http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-234741A1.pdf.

15. *See infra* Part II.B.3.

16. *See infra* Parts II.C, IV.C.

17. *See infra* Part III.B.

Conflicts in the commons will be prevented ex ante through agreements on open protocols that insist upon interference-reducing technologies.[18] That is about all that has been written on the subject.

This Article reflects on the spectrum conflicts that will arise after the hypothesized sunset of command and control regulation. Yochai Benkler has tantalizingly suggested that a system of property rights in spectrum, lacking the benefits conferred by centuries of gradual development, is "likely to involve more explicit regulatory choices, [requiring] . . . well-designed governmental planning in the initial creation of the property rights and a well-functioning dispute resolution system to fine tune the rights when reality teaches us the limitations of the original design."[19] That is undoubtedly true, but what should the government's role be in this creating, planning, and resolving? What principles might guide spectrum dispute resolution, and what legal work should be done now to achieve the promise of regime change after a revolution in spectrum management?

In pursuing these questions, I arrive at both a caution and a proposal. The caution is that conflict resolution will be neither self-executing nor straightforward. It will require technical prowess that not even an administrative agency can easily summon, the development of liability standards and remedies that involve difficult cost assessments never before made, and tradeoffs between communications services that will embroil decisionmakers in delicate policy choices infused with public interest considerations. In short, those who allocate spectrum entitlements in the future telecosm, be it defined by private or common spectrum rights, will have to grapple with many of the same questions that confront the government today.

Given this complexity, neither commons nor property theorists should be quick to throw over the administrative role in spectrum management. A regulatory agency can improve the efficiency and fairness of applying tort law to private property disputes, on the one hand, and technical controls to forestall common property disputes, on the other. If we take seriously the hybrid nature of the spectrum resource—a mix of something like scarce land and abundant air—we see more clearly the importance of retaining a regulatory role in spectrum management. Like air, spectrum is not only (potentially) abundant, but it has a limited

18. *See infra* Part V.B.
19. Benkler, *supra* note 4, at 66–67.

carrying capacity to absorb the "pollutants" of commerce—in this case electronic communication. Purely private arrangements even in a commons are ill-suited to manage the amount of spectral pollution users experience as noise. This is the traditional province of a regulatory agency. Indeed, perhaps counterintuitively, the use of regulatory powers in conjunction with private control might reduce the ad hoc public interest decisionmaking that has been a more lamentable feature of FCC regulation.

Part II reviews the basic characteristics of the spectrum resource, as well as the current spectrum management regime and its troubles. It offers a framework for understanding the variety of spectrum conflicts and shows how these conflicts will worsen as wireless technology develops. It also systematically analyzes the public interest values that have been brought to bear in resolving spectrum disputes. Part III proceeds to show how private property theorists would upend the current command and control model of spectrum management. In its place, they would install a spectrum market in which interference disputes are treated like real property trespasses or nuisances and resolved by common law courts.

The notion that the common law should be used to resolve spectrum disputes is an idea frequently expressed but never developed. Part IV unpacks this idea by using FCC resolution of a variety of spectrum conflicts as precedent for the would-be common law of spectrum. Given the nature of rights in spectrum and spectrum uses, nuisance is a more natural model for spectrum dispute resolution than is trespass.[20] Yet common law nuisance is hardly a cause of action renowned for its clarity or ease of resolution. The changes to nuisance law over the last century, responding to intensifying uses of land that throw neighbors into more frequent and complex conflict, have plagued the law with high levels of "ad hocery," to use Thomas Merrill's apt term.[21] Ad hocery is the

20. Nuisance law is, of course, a common law cause of action that applies only to interference with the use and enjoyment of land. As such, it is inapplicable to radio interference disputes. In referring to nuisance law in the context of spectrum disputes, I use this term, as others have used it, to refer to a nuisance-like cause of action that might apply to spectrum, setting aside the question of whether the substantive law for such an action would be state or federal common law, although this Article comments on the relevance of federal administrative law to such actions. *See infra* Parts IV.C, VI.B.

21. Thomas W. Merrill, *Trespass, Nuisance, and the Costs of Determining Property Rights*, 14 J. LEGAL STUD. 13, 47 (1985); *see also* Int'l Paper Co. v. Ouellette, 479 U.S. 481, 496 (1987) (holding that "nuisance standards often are 'vague' and 'indeterminate'"); W. PAGE KEETON ET AL., PROSSER AND KEETON ON THE LAW OF TORTS § 86, at 616–17 (W. Page Keeton ed., 5th ed. 1984) (writing that "[t]here is perhaps no more impenetrable jungle in the entire law than that which surrounds the word 'nuisance'"); Richard A. Epstein, *Nuisance Law: Corrective Justice and Its Utilitarian Constraints*, 8 J. LEGAL STUD. 49, 49 (1979) (writing that "[i]t is not uncommon for

natural product of a judicial test that "balances the utilities" of competing land uses in assigning privileges and obligations to landowners. Spectrum use, as it grows more varied and intensive, is undergoing precisely the same kind of "industrialization" that muddied nuisance law in the nineteenth and twentieth centuries. Not surprisingly, then, what we see as we look ahead to a nuisance law of spectrum is a muddle: courts balancing the utilities of competing spectrum uses in assigning privileges and obligations to wireless services. In doing so, courts would displace the FCC as guardians of the public interest. The concept of the public interest would not disappear, but would be elaborated through judicial rather than administrative balancing. Such a common law public interest standard could influence the shape of the future telecosm as markedly as the regulatory standard has influenced the past, affecting the types of wireless services that are deployed, by whom and for whom.

The imperfections of common law resolution of spectrum disputes might seem to bolster the commons theorists' approach to spectrum management reform. Yet, as Part V shows, a commons regime does not eradicate or even substantially simplify today's public interest model of spectrum dispute resolution. Choices of technical protocols, the design of enforcement mechanisms, and the policing of the boundaries between common and private spectrum property would themselves require some vision of the public interest.

Given the failure of either private or common property theorists to articulate a self-executing method of interference control, how should dispute resolution figure in with the reform of spectrum management? The model outlined in Part VI is one possibility. It is a model that accommodates commonly and privately owned spectrum, as well as technical and judicial solutions to interference conflicts. It also reserves a role for regulation in the implementation of both kinds of regime change.

This Article shows how a regulatory agency can make both the avoidance and resolution of nuisance disputes easier by defining a class of per se nuisances. Applying learning from the *Cathedral* literature on liability and property rules to spectrum disputes, I also discuss how an agency can begin the process today of providing a menu of appropriate

---

commentators to describe [nuisance law] as the least systematic area of the tort law or to note that all too often it serves as the dumping ground for many disparate wrongs that do not neatly fit into any recognized doctrinal niche").

remedies for classes of spectrum conflict tomorrow.[22] Not all conflict will be amenable to adjudication, whether because property rights are weak or because interference is diffuse. For these cases, regulatory authority will remain necessary to reduce levels of spectral pollution not easily controlled through nuisance law and to oversee systems of private coercion in the commons.

Far from residing exclusively within the academic domain, the spectrum policy debate is very much alive in Washington. In recent years, the government has implemented changes in spectrum management that head in the precise directions (indeed, in both directions) of reform that have been urged by private property and commons advocates. As this reform progresses, we need to be more attentive to the costs of interference dispute resolution, the regulators' continuing role in reducing these costs, and the policy choices that will have to be made under any system of private spectrum management. The way in which spectrum conflicts are resolved by governing institutions, whether they are courts, administrative agencies, or private standard setting bodies, and the values that are brought to bear could be as important for the wireless telecosm of the future as is the choice of initial property regime.

II. RESOURCE CONFLICTS IN SPECTRUM

I begin where radio regulation began—with conflicts over the use of the electromagnetic spectrum to communicate. Section A briefly describes how it came to be that the federal government asserted control over the use of radio spectrum when radio was young and commercial exploitation still fragile. Government regulation was, and still is, justified by a conception of spectrum as a scarce natural resource, like land. And yet, unlike land, spectrum has never been owned, and its management recognizes that the resource is renewable and sometimes plentiful, like air. Section B shows how these two conceptions of spectrum—one terrestrial and one aerial—are evident in spectrum use conflicts. This Part concludes with an examination of the public interest factors regulators have used to resolve these spectrum use conflicts and the critique of the administrative system of spectrum management.

A. Radio Basics

1. The Spectrum Resource

Radio communication starts with the emission of electromagnetic

22. The *Cathedral* refers to Calabresi & Melamed, *supra* note 10, and subsequent literature. *See infra* notes 209–16 and accompanying text.

waves into the atmosphere over radio frequencies, otherwise known as radio spectrum. Information can be encoded into these radio waves by varying the amplitude or the frequency of the wave.[23] There are almost 300 billion frequencies in the radio spectrum, ranging from the extremely low frequencies at three kilohertz to the extremely high frequencies at 300 gigahertz (GHz).[24] Depending on the frequency range (that is, whether the sound waves are low and long or short and high), radio waves have different propagation characteristics and are more or less vulnerable to refraction when they hit such obstacles as hills, buildings, trees, or rain drops. The lower and longer the radio wave, the farther along the surface of the earth it can travel. Their different characteristics make some frequencies better for particular kinds of communications. Lower frequencies not only have longer reach, but can penetrate water, enabling submarine communications, and penetrate buildings, enabling cellular telephone conversations.[25]

23. *See* STUART MINOR BENJAMIN ET AL., TELECOMMUNICATIONS LAW AND POLICY 25–28 (2001).

24. *See* 47 C.F.R. § 2.1 (2002) (defining "radio" or "Herzian" waves). The Congressional Budget Office has offered this useful definition of radio spectrum:

> The radio spectrum . . . is a conceptual tool used to organize and map a set of physical phenomena. Electric and magnetic fields produce waves that move through space at different frequencies, and the set of all possible frequencies is called the electromagnetic spectrum. The subset of frequencies from 3,000 cycles per second to 300 billion cycles per second . . . is known as the radio spectrum.

CONG. BUDGET OFFICE, WHERE DO WE GO FROM HERE? THE FCC AUCTIONS AND THE FUTURE OF RADIO SPECTRUM MANAGEMENT 2 (1997), *available at* ftp://ftp.cbo.gov/0xx/doc9/fccauct.pdf. Communications systems can operate on wavelengths smaller than 300 GHz using optical technologies. *See, e.g.*, Hughes Communications, Inc.: Application for Authority to Construct, Launch, and Operate a Ka-Band Satellite System in the Fixed-Satellite Service , 16 F.C.C.R. 14,310, 14,316 (2001).

25. At higher frequencies, radio waves propagate more like light waves and tend to be obstructed by buildings or natural barriers. They are also attenuated by air and water in the atmosphere. At lower frequencies, the waves are able to penetrate barriers. As a result, extremely short-range communications are better suited for higher frequencies (often defined as those above 3–6 GHz). Mobile communications typically require frequencies below 3 GHz. Services designed to cover large distances (at least fifty miles for TV broadcasting and hundreds of miles for AM radio) or operate under the water typically require frequencies below 1 GHz. These needs are reflected in the FCC's Table of Frequency Allocations. 47 C.F.R. § 2.106; *see also* BENJAMIN ET AL., *supra* note 23, at 28–31; JERRY KANG, COMMUNICATIONS LAW AND POLICY 13–15 (2001); JENNIFER A. MANNER, SPECTRUM WARS: THE POLICY AND TECHNOLOGY DEBATE 34–37 (2003). It is because of these characteristics of radio waves that the signals of television stations on the VHF band can round the horizon and reach much farther than the signals of stations on UHF television channels. Because UHF waves head off into space rather than following the curvature of the earth, their range is limited to line of sight.

Because of the historic advantage of lower frequencies over higher frequencies, ninety percent of spectrum use is concentrated in the one percent of frequencies below 3.1 GHz—those frequencies best suited for contemporary mobile phone, broadcasting, and satellite systems.[26]

Radio communication ends with the receiver. Once emitted into the atmosphere, a radio signal will interact with any receiving antenna in its path that is tuned to the relevant frequency range. Ideally, only those receivers that are designed to respond to the given radio signal will accept it, and the rest will reject the signal as unwanted noise. Unfortunately, radio signals cannot be contained within a target band of frequencies. The power radiated by a transmitter will attenuate over a range of frequencies, inevitably spilling over into adjacent bands. Many receivers will be unable to reject the unwanted signals as noise without the use of expensive filters and digital processing devices, and even with these devices, many receivers will be unable to eliminate unwanted signals entirely. Instead, users will experience the unwanted signals as interference, which either interrupts or disrupts the desired service. Thus, radio signals transmitted on the same or adjacent frequencies, within the same general area, and at the same time tend to interfere with one another. It is the allocation of entitlements to cause this interference, or the obligation to bear or avoid it, that is at the core of spectrum law.

2. Federal Control of the Resource: Spectrum as Land

It was because of signal interference observed in the early days of radio communication that the U.S. government, like other governments around the world, assumed responsibility for defining and distributing access rights to what Congress calls the "public spectrum resource."[27] In both the language and structure of the law, spectrum is treated as a quasi-physical substance to which access must be limited, just as access is limited to public forests and the ocean commons.

As with forests and ocean riches, the government limited access to spectrum as a response to increased pressure on the resource.[28] The exercise of federal control over radio waves started with the 1912 Act to Regulate Radio Communication,[29] passed only four months after the

---

26. *See History and Current Issues Related to Radio Spectrum Management: Testimony Before the Senate Comm. on Commerce, Science, and Transportation*, 107th Cong. 4 (2002) (statement of Peter F. Guerrero, Director, Physical Infrastructure Issues).

27. 47 U.S.C. § 309(j)(3)(C) (2000).

28. *See generally* STEVEN SHAVELL, ECONOMIC ANALYSIS OF PROPERTY LAW 12–13 (Harvard John M. Olin Discussion Paper No. 399, 2002) (describing the relationship between increasing scarcity and decreasing access to natural resources), *available at* http://www.law.harvard.edu/programs/olin_center.

29. Act of Aug. 13, 1912, ch. 287, 37 Stat. 302 (repealed 1927).

Titanic disaster, which many at the time believed to have been the tragic result of interference to critical radio communications.[30] In the Titanic's wake, any private party using a radio transmitter (then primarily for ship-to-ship and ship-to-shore communication) was required to have a license. To issue such licenses, the federal government established permissible uses of different frequency bands and limited both power emissions and the geographic scope of transmissions.[31] In other words, it was government that defined usable parcels of the spectrum resource and controlled access to those parcels.

Concern for interference and the associated reach of governmental control over spectrum continued after World War I with the shift in radio use from person-to-person communications to person-to-community, or broadcast, transmissions. By 1927, more than 700 broadcast stations were operating fairly chaotically, changing frequencies and increasing power at will.[32] Even though the federal government had asserted dominion over the spectrum, the administrative apparatus was not up to the task of regulating so many chimerical broadcasts, and the brash new technology produced a tangle of sound that listeners were challenged to unravel.[33] This sonic disorder provided the impetus, or at least the excuse, for more complete federal control over the airwaves as Congress concluded that "Radio Communication is a public utility and as such should be regulated

30. The military claimed that rescue efforts had been hampered by interfering signals emitted by amateur radio operators. *See* THOMAS G. KRATTENMAKER & LUCAS A. POWE, JR., REGULATING BROADCAST PROGRAMMING 5–6 (1994).

31. *See* THOMAS STREETER, SELLING THE AIR: A CRITIQUE OF THE POLICY OF COMMERCIAL BROADCASTING IN THE UNITED STATES 78 (1996) (noting that the 1912 Act first asserted the principle of federal limitations on spectrum access and characterized radio transmissions as a privilege sanctioned by the government).

32. *See* Arthur Martin, Comment, *Which Public, Whose Interest? The FCC, the Public Interest, and Low-Power Radio*, 38 SAN DIEGO L. REV. 1159, 1167 (2001).

33. *See* NBC v. United States, 319 U.S. 190, 212 (1943). "[N]ew stations used any frequencies they desired, regardless of the interference thereby caused to others. Existing stations changed to other frequencies and increased their power and hours of operation at will. The result was confusion and chaos. With everybody on the air, nobody could be heard." *Id*. The reason radio transmissions were so poorly controlled, notwithstanding enactment of the 1912 Act, was that courts had interpreted the law to deny then-Secretary of Commerce Herbert Hoover the power to regulate conflicting broadcasts. *See* Hoover v. Intercity Radio Co., 286 F. 1003, 1007 (D.C. Cir. 1923) (holding that the Secretary of Commerce may not deny applications for radio licenses); United States v. Zenith Radio Corp., 12 F.2d 614, 617 (N.D. Ill. 1926) (holding that the Secretary of Commerce may not place restrictions on the uses of radio licenses). *See generally* KRATTENMAKER & POWE, *supra* note 30, at 9–12.

and controlled by the Federal Government in the public interest."[34]

The result was that the federal control first exerted over spectrum in 1912 became more thoroughgoing. The Radio Act of 1927 created an administrative agency to regulate "all the channels of interstate and foreign radio transmission" and "to provide for the use of such channels, but not the ownership thereof, by individuals, firms, or corporations, for limited periods of time."[35] The FCC assumed these obligations in 1934.[36] In the view of the agency itself and the courts, the FCC's central statutory duties are to "license radio stations, prevent chaos, and ensure public safety."[37]

In this way, it has fallen to the FCC to determine what kinds of private and local government uses can be made of hundreds of different frequency bands.[38] The allocation of spectrum is much like the zoning of land. Like a zoning board, the FCC sets aside blocks of frequencies for compatible services and tries to keep incompatible services at some spectral distance to reduce interference.[39] Such zoned services of course

34. KRATTENMAKER & POWE, *supra* note 30, at 9 (quoting *To Amend the Radio Act of 1912: Hearings on H.R. 11964 Before the House Comm. on the Merchant Marine and Fisheries*, 67th Cong. 32 (1923) (statement of Hon. Herbert Hoover, Secretary of Commerce)). Yochai Benkler refers to this history of radio regulation, which justifies governmental control of spectrum as the necessary response to conflicting uses, as the "official history." Yochai Benkler, *Overcoming Agoraphobia: Building the Commons of the Digitally Networked Environment*, 11 HARV. J.L. & TECH. 287, 298 (1998). He contrasts this with the revisionist history told by the private property rights theorists. This revision attributes government control not to necessity, but to the coinciding interests of government, which wanted control, and incumbent broadcasters, who wanted protection from competition. *See id.* at 299–300. For an example of this revisionist history, see Hazlett, *The Wireless Craze*, *supra* note 3, at 366–73; Hazlett, *Assigning Property Rights*, *supra* note 3, at 529, 531, 541–45. A third history, which Benkler himself tells, is a story not of technical or political necessity, but of network architecture. According to Benkler, it was the particular and historically contingent business arrangements of broadcasters and equipment manufacturers that necessitated the regulatory structure Congress adopted in 1927 and 1934. *See* Benkler, *supra*, at 300–13.

35. Radio Act of 1927, Pub. L. No. 69-632, 44 Stat. 1162 (repealed 1934).

36. The Communications Act of 1934, Pub. L. No. 73-416, 48 Stat. 1064 (codified as amended at 47 U.S.C. §§ 151–615b (2000)).

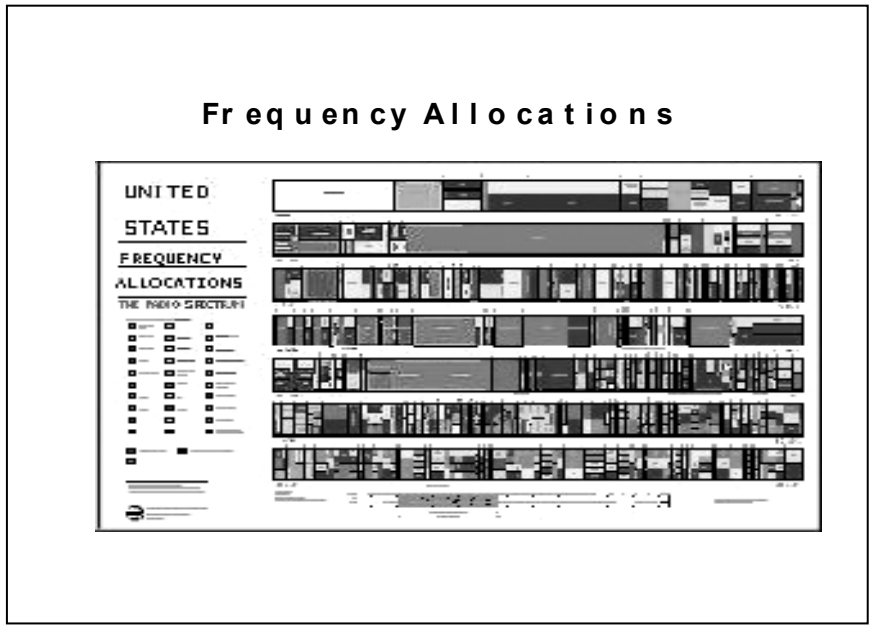
37. Frank Bartholomew, 14 F.C.C.R. 4046, 4047 (1999); *see also* Red Lion Broad. Co. v. FCC, 395 U.S. 367, 375–77 (1969); *NBC*, 319 U.S. at 210–13.

38. The FCC and the National Telecommunications Infrastructure Administration of the Commerce Department (NTIA) each have responsibilities for making spectrum allocations—the FCC for local government and private use, and the NTIA for federal government use. Section 305 of the Communications Act, 47 U.S.C. § 305(a), preserves for the President the authority to assign frequencies to all federal government owned or operated radio stations.

39. Existing zones of spectrum use are not as homogeneous as they might ideally be because of rapidly changing spectrum uses and ossified spectrum allocations. The FCC has recognized that better zoning would increase spectrum efficiency. *See* SPECTRUM POLICY TASK FORCE, FCC, REPORT, ET DOCKET NO. 02-135, at 22 (2002) [hereinafter FCC REPORT] (proposing a "good neighbor" policy of "group[ing] technically compatible systems and devices in close spectrum proximity").

include communications service provided to the public, like mobile telephony and broadcasting. They also include private services used within companies, like utilities or police departments, for their own communications needs.[40] Still other services use the radio spectrum for noncommunications purposes like radio astronomy or medical telemetry.[41] The federal government's chart of spectrum use, though illegible here for particular allocations, reveals how numerous and complexly interrelated the spectrum zones are.

FIGURE 1[42]



After zoning frequency bands for particular uses, the FCC designs

40. *See, e.g.*, 47 C.F.R. pt. 90 (2002) (private radio services).
41. *See, e.g.*, *id.* § 2.107 (astronomy); *id.* pt. 95, subpt. H (medical telemetry).
42. NAT'L TELECOMMUNICATIONS & INFO. ADMIN., DEP'T OF COMMERCE, UNITED STATES FREQUENCY ALLOCATIONS: THE RADIO SPECTRUM (1996), *available at* http://www.ntia.doc.gov/osmhome/allochrt.pdf.

service and technical rules for each spectrum block.[43] These rules are akin to the structural requirements, such as lot size and building design, that zoning boards impose on landowners. In the case of spectrum, the "structural" requirements may include limits on power emissions, interference limits, mandatory schedules for providing services, service definitions, and equipment or system design specifications. After setting these rules, the FCC then, like a landlord, sells (or, as was more common in the past, gives away) licenses to individual users to operate in accordance with the service rules. The assignment of licenses for most services, once achieved by random selection or administrative decision, is now effectuated through public auctions.[44]

Licensees usually have exclusive rights to use the spectrum they have been assigned, but not always. To draw again on analogies from the physical world, there are in today's administrative regime both easements and limited commons in the spectrum. In some bands, "secondary" services have an easement to operate in spectrum that has been allocated to "primary" users so long as these secondary services do not cause interference to the primary services.[45] Beyond easements, there are analogs to cooperative forms of land use by small, close-knit groups.[46] In certain bands, frequencies are shared by a class of users whose exploitation of the spectrum is managed by privately appointed frequency coordinators and industry associations.[47] Spectrum is most

---

43. The FCC is authorized to do the following:
(a) Classify radio stations;
(b) Prescribe the nature of the service to be rendered by each class of licensed stations and each station within any class;
(c) Assign bands of frequencies to the various classes of stations, and assign frequencies for each individual station and determine the power which each station shall use and the time during which it may operate; [and]
(d) Determine the location of classes of stations or individual stations . . . .
47 U.S.C. § 303.

44. The FCC's authority to conduct auctions originated with the Omnibus Budget Reconciliation Act of 1993. Pub. L. No. 103-66, § 6002, 107 Stat. 312, 387 (1993) (codified at 47 U.S.C. § 309(j)). The FCC is not permitted to auction licenses for public safety radio services, for noncommercial educational or public broadcast stations, or for digital television service provided by incumbent television broadcast licensees. 47 U.S.C. § 309(j)(2). The FCC is also prohibited from auctioning licenses to use orbital slots for satellites or licenses to use spectrum for international or global satellite communications services. *Id.* § 765(f).

45. Low-power television service is an example. *See* 47 C.F.R. § 73.6000–26.

46. *See* ELINOR OSTROM, GOVERNING THE COMMONS: THE EVOLUTION OF INSTITUTIONS FOR COLLECTIVE ACTION 60–62 (1990) (describing forms of communal control over property).

47. Although the coordinator may be private, there is often government oversight of coordination activities. For example, FCC rules for private land mobile radio services, such as taxi dispatch services and utility industry communications, require that a private frequency coordinator make a recommendation to the agency for all new frequency assignments, facilities changes, and temporary operation. *See* 47 C.F.R. §

typically allocated in this way for use by private enterprises for their own internal communications rather than for the provision of service to the public. Thus, the private radio services, which provide communication over relatively short distances for petroleum, utility and other industries, are subject to frequency coordination.[48] So too are the frequencies used by broadcasters, cablecasters, and sports producers to relay live shots from onsite to production studios.[49]

3. Uncontrolled Resource: Spectrum as Air

As much as the government's zoning and leasing of frequencies treats spectrum as a resource like land, the regulatory structure also recognizes that spectrum is not like land and that it differs meaningfully as well from the renewable resources, like trees and fish, that the government manages as property. As Congress has put it, "[S]pectrum is a non-depletable natural resource and has finite boundaries."[50] Spectrum is simultaneously finite and renewable, everlasting and degradable. Within the constraints of technological know-how at any given point in time, there is only so much usable spectrum, making frequencies, like acres, valuable for their scarcity.[51] But, unlike real property, radio spectrum cannot be permanently improved. Spectrum can be used more or less efficiently, but is never other than what it is in its natural state: an aerial conduit for electrical signals. Nor can spectrum be captured. As a result, rights to it are necessarily "usufructuary" rather than possessory, as Blackstone described rights to water.[52] Spectrum thus partakes of

90.175. Private coordination and cooperative negotiations to resolve technical problems are required for many other radio services. *See id.* §§ 22.907(a), 24.237, 80.513, 87.305, 90.175, 101.103. Other frequency coordination, particularly for the amateur radio services, is voluntary, but the FCC urges compliance with coordinator plans and puts the burden of interference control on the noncoordinated station. *See id.* §§ 97.201(c), 97.205(c). For a discussion of services that share spectrum, see Buck, *supra* note 4, at ¶¶ 22–26; Douglas A. Galbi, Revolutionary Ideas for Radio Regulation 22–25 (June 12, 2002) (unpublished manuscript), http://papers.ssrn.com/sol3/papers.cfm?abstract_id=316380.

48. 47 C.F.R. pt. 90.

49. *Id.* §§ 101.801–19.

50. H.R. REP. NO. 103-111, 103d Cong. 247 (1993).

51. *See* CARTER ET AL., *supra* note 14, at 48 ("What is often said of real estate is also true for spectrum—they are not making any more of it.").

52. Blackstone observed the following:

> [W]ater is a movable, wandering thing, and must of necessity continue common by the law of nature; so that I can only have a temporary, transient, usufructuary property therein: wherefore if a body of water runs out of my pond into another man's, I have no right to reclaim it.

very different kinds of natural resources, part land in its scarcity, part water in its renewability and fluidity, and part air in its plentifulness but degradability.

The recognition that spectrum is as much air as land is manifest in the regulatory structure for its management. It is a resource that is unowned by either the government or its users.[53] Unallocated spectrum has been likened to unappropriated water. It is "government property only in the special sense that it simply has not been allocated to any real 'owner' in any way."[54] Indeed, if spectrum were government property in the way of forests and grazing lands, then the government could allocate rights to its use without the administrative rulemakings at the heart of today's elaborate regulatory apparatus for spectrum. This is because the Administrative Procedures Act does not apply to the distribution of federal property.[55] In light of the mixed nature of spectrum, it makes sense that it is the authority to *control* the transmission of electrical signals over radio spectrum, rather than actual ownership of the spectrum, that the government asserts.[56]

If spectrum does not belong to the federal government, Congress has made clear that it does not belong to any radio operator either. The Communications Act explicitly denies FCC licensees any property rights in the spectrum they use. Licensees may only "for limited periods of time, under licenses granted by Federal authority" enjoy "the use of [radio] channels, but not the ownership thereof"; furthermore, "no such license shall be construed to create any right, beyond the terms, conditions, and periods of the license."[57] The Act goes further by demanding that each prospective licensee relinquish any claims it may

---

2 WILLIAM BLACKSTONE, COMMENTARIES ON THE LAWS OF ENGLAND 18 (1979). Of course, riparian systems do allow for ownership rights in water, as Blackstone himself acknowledged.

53. *See* Glen O. Robinson, *The Electronic First Amendment: An Essay for the New Age*, 47 DUKE L.J. 899, 912 (1998); Glen O. Robinson, *The Federal Communications Act: An Essay on Origins and Regulatory Purpose*, *in* A LEGISLATIVE HISTORY OF THE COMMUNICATIONS ACT OF 1934, at 3, 8–12 (Max D. Paglin ed., 1989). If Justinian were to assign spectrum to one of his three categories of property—unowned, government (publicly) owned, or private—it would be to the category of unowned resources that includes the "air, running water, the sea, and consequently the shores of the sea." THE INSTITUTES OF JUSTINIAN, bk. 2, tit. 1 (J.T. Abdy & Bryan Walker trans., Gaunt, Inc. 2002) (1876); *see also* Richard A. Epstein, *On the Optimal Mix of Private and Common Property*, 11 SOC. PHIL. & POL'Y 17, 24 (1994) (discussing Justinian's property theories).

54. Time Warner Entm't Co. v. FCC, 105 F.3d 723, 727 (D.C. Cir. 1997) (Williams, J., dissenting).

55. Notice and comment rulemakings are not required for "a matter relating to . . . public property, loans, grants, benefits, or contracts." 5 U.S.C. § 553(a)(2) (2000).

56. 47 U.S.C. § 301 (providing that a central purpose of the Communications Act is "to maintain the control of the United States over all the channels of radio transmission").

57. *Id*.

have to the frequency in question:

> No station license shall be granted by the Commission until the applicant therefor shall have waived any claim to the use of any particular frequency or of the electromagnetic spectrum as against the regulatory power of the United States because of the previous use of the same, whether by license or otherwise.[58]

Given the statutory antipathy to spectrum possession, it is not surprising that spectrum licensees lack most of the perquisites of ownership. They may not assign or transfer their licenses to other parties without prior FCC approval;[59] they may not stockpile or warehouse spectrum purchased at auction;[60] and very often, they may not speculate on licenses by acquiring them merely to sell, rather than to use.[61] Finally, perhaps most maddeningly for licensees, the FCC may modify existing licenses as it likes, subject only to rulemaking procedures, "if in the judgment of the Commission such action will promote the public interest."[62]

Consistent with the intangible, unpropertied qualities of spectrum, the FCC has set aside some frequencies as a common pool resource in the form of unlicensed spectrum. Rather than granting exclusive or even group rights to such frequencies, the FCC has opened the bands for low-power transmissions by operators or members of the public without

---

58. *Id.* § 304. This provision first appeared in the Radio Act of 1927, ch. 169, 44 Stat. 1162 (repealed 1934). *See also* FCC v. Sanders Bros. Radio Station, 309 U.S. 470, 475 (1940) (holding that "[t]he policy of the Act is clear that no person is to have anything in the nature of a property right as a result of the granting of a license").

59. 47 U.S.C. §§ 309(h)(2), 310(d). *See generally* Stephen F. Sewell, *Assignments and Transfers of Control of FCC Authorizations Under Section 310(d) of the Communications Act of 1934*, 43 FED. COMM. L.J. 277 (1991) (discussing the procedural and substantive requirements of the FCC's prior consent rule regarding assignments and transfers). The FCC must approve all transfers and assignments of station licenses and permits, as well as any de facto transfers of control. While Commission approval itself is often pro forma, the approval process gives competitors and other interested parties the opportunity to file petitions to deny license transfer applications, license renewals, and initial applications. 47 U.S.C. § 309(d)(1). The petition to deny process can hold up spectrum transactions for years.

60. 47 U.S.C. § 309(j)(4)(b).

61. Although more lenient than they once were, antitrafficking provisions exist for broadcasting, 47 C.F.R. § 73.3597 (2002), cellular, *id.* § 22.943, fixed microwave, *id.* § 101.55, and DBS, *id.* § 100.55, among other services. *See also* Crowder v. FCC, 399 F.2d 569, 571 (D.C. Cir. 1968) ("[A] license granted in reliance on an applicant's stated intention to operate should not . . . be bartered away for profit . . . rather than [used] to operate a station in the public interest.") (citation omitted).

62. 47 U.S.C. § 316(a)(1); *see* United States v. Storer Broad. Co., 351 U.S. 192, 203 (1956) (recognizing the broad public interest rulemaking authority of FCC in upholding regulations limiting broadcast license ownership).

mandating licensing or coordination. The only requirement is that the equipment used in these unlicensed bands must satisfy certain technical specifications.[63] These devices, which include garage door openers, baby monitors, heart monitors, cordless telephones, and wireless network devices, are not permitted to cause interference to authorized devices and must accept any interference they receive from the lawful transmissions of licensed operators.[64] Unlicensed devices may operate on the same frequencies used by licensed operators, or in some cases, on spectrum that has been dedicated for unlicensed use.[65]

B. Spectrum Use Conflicts

The intensifying use of spectrum, combined with an increasing array of communications architectures within the same licensed or unlicensed bands, portends more frequent and more challenging spectrum use conflicts for the future.[66] As we will see below, this is true whether or not the potential to mitigate interference with new technologies keeps pace or even outpaces the potential for interference among multiplying users. This is because the mere availability of mitigation measures does not settle upon any particular party the obligation to mitigate the actual or potential interference. Thus, however spectrum management evolves, any management regime will have to cope with more radio signal interference disputes that are already difficult to resolve.

Radio interference is defined as "[t]he effect of unwanted energy due to one or a combination of emissions, radiations, or inductions upon reception in a radio-communication system, manifested by any performance degradation, misinterpretation, or loss of information which could be extracted in the absence of such unwanted energy."[67] The premise of FCC spectrum regulation is that agency planning and enforcement can largely prevent degradation of services due to the intrusions of unwanted

63. Part 15 of the FCC's rules permits the operation of authorized low-power wireless devices without a license. Devices will be authorized if they meet standards designed to ensure that the devices are unlikely to cause harmful interference to other users of the spectrum. 47 C.F.R. § 15.5(b). The maximum permitted power for Part 15 transmitters is expressed in terms of field strength at a specific distance, which is a function of the transmitter output power and the transmit antenna gain. *Id.*

64. *Id.* § 15.5.

65. *See infra* notes 287–95.

66. The interference environment grows more complex with increases in the density, mobility, and variability of transmitters, and with the increased use of a flexible use policy that allows users to determine how and where to operate in their assigned spectrum. *See* SPECTRUM POLICY TASK FORCE, FCC, REPORT OF THE SPECTRUM EFFICIENCY WORKING GROUP 26–27 (2002) [hereinafter FCC SEWG REPORT], *available at* http://www.fcc.gov/sptf/files/SEWGFinalReport_1.pdf.

67. 47 C.F.R. § 2.1(c).

energy. Like a restrictive zoning ordinance that physically separates interfering uses, the FCC rules have been fairly successful in preventing systemic and large scale interference between licensees.[68] However, just as real property zoning does not end interfering land uses, spectrum zoning does not end interference or its threat.[69]

The following sections develop a typology of interference conflicts in order to structure the ensuing discussion on interference dispute resolution.

1. Spectrum as Land

The duality of spectrum—a resource vested with the characteristics of both land and air—is apparent in the conflicts among spectrum users. These conflicts sometimes look like in rem trespass or nuisance disputes. *A*'s wireless system degrades *B*'s wireless system, or they degrade each other's systems. This might happen because either *A* or *B* is operating outside of its assigned parameters (trespass) or because even lawful uses of the spectrum may prove incompatible (nuisance). Conflicts in spectrum use can also look more like complex pollution problems in which *A*'s emissions, and *B*'s, and the hundreds of other emitters in their neighborhood, are all reducing the quality of the spectrum resource within the neighborhood and perhaps beyond.

Today's administrative framework is almost entirely structured to deal with the first kind of "terrestrial" conflict. Land-like interference conflicts can be assigned to two categories. First, there may be "intraservice interference," in which *A* and A_1 are licensees in the same service category, such as paging, using the same or similar technologies. *A* might interfere with A_1, A_1 might interfere with *A*, or, less commonly, there might be reciprocal interference between the two. Sometimes, the interference occurs because one or the other licensee is not operating in accordance with its license. More typically, both *A* and A_1 will be operating lawfully, but interference occurs unexpectedly because

68. *See* SPECTRUM POLICY TASK FORCE, FCC, REPORT OF THE INTERFERENCE PROTECTION WORKING GROUP 2, 28–29 (2002) [hereinafter FCC IPWG REPORT], *available at* http://www.fcc.gov/sptf/files/IPWGFinalReport.pdf. "The zoning approach leads to fewer constraints on the systems operating in the exclusive or shared allocations which provides greater technical flexibility for the services to develop, grow and evolve." *Id.* at 23.

69. *See* SPECTRUM POLICY TASK FORCE, FCC, REPORT OF THE SPECTRUM RIGHTS AND RESPONSIBILITIES WORKING GROUP 79 (2002) [hereinafter FCC SRRWG REPORT] (recognizing that allegations of interference by incumbents may simply be a tactical effort to block the entry of competitors), *available at* http://www.fcc.gov/sptf/files/SRRWG FinalReport.pdf; *infra* Part IV.C.

interference predictions were wrong from the start, were not adjusted to reflect the introduction of new radio services, or did not properly account for what would happen when *A* or A_1 modified its system characteristics.

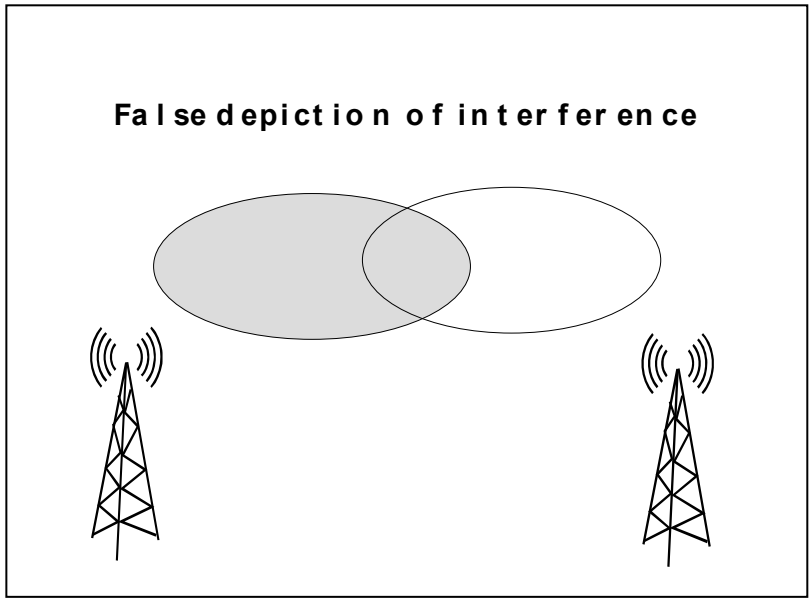
Second, there may be "interservice interference," in which *A* and *B* are licensees in different service categories using different technologies. Again, *A* might interfere with *B*, *B* might interfere with *A*, or there might be reciprocal interference. This interference can occur whether or not both licensees are operating in compliance with the terms of their licenses. Such interservice interference may be fairly simple, involving just two licensees or it may be complex, involving many licensees across different services using different technologies. A special type of interservice interference is "prospective interference" between existing licensee *A* and new entrant *C* such that *C* would cause interference to *A* or receive interference from *A*.[70]

Having categorized possible interference scenarios, let us turn to possible resolution scenarios. It has been pointed out that radio interference generally does not take place in the air where two electrical signals intersect.[71] Thus, in the picture below, there is no interference at the intersection of the two ovals.

70. In addition, two new entrants might battle over access to the same frequencies.

71. *See, e.g.*, Benkler, *supra* note 4, at 39–40; WERBACH, OPEN SPECTRUM, *supra* note 4, at 6.

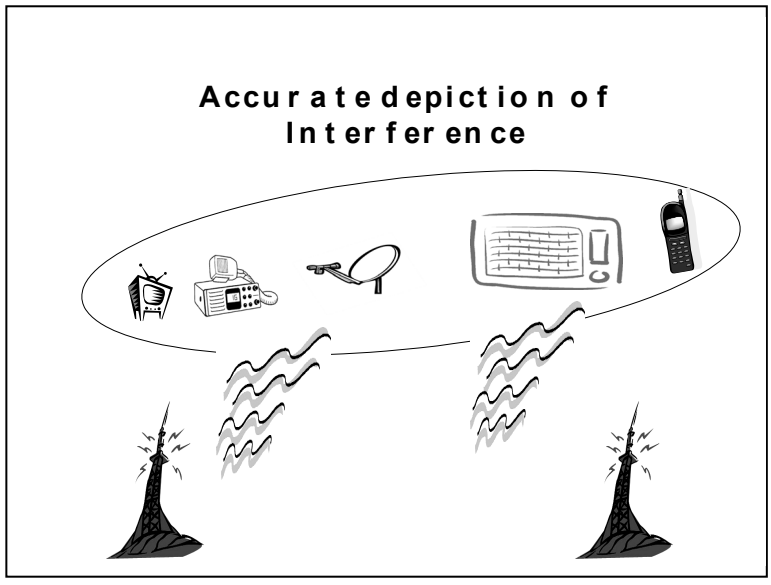
FIGURE 2



Rather, as illustrated below, interference takes place in the receiver where the intrusion of undesired signals disrupts or prevents the acquisition of the desired signal.[72]

72. There is no agreement on how interference should be measured at the receiver. The FCC measures interference at hypothetical receivers within the licensee's predicted service area rather than at actual receivers that are tuned to the desired signal at any given time. Thus, even though no receiver may actually be affected by interference, a reduction in signal availability for that receiver is counted as interference. This approach has been criticized as overly protective. *See, e.g.*, David P. Reed, Comments for FCC Spectrum Policy Task Force on Spectrum Policy, ET Docket No. 02-135, at 11, 16, 19 (F.C.C. filed July 15, 2002) ("As long as the regulatory process (including litigation and lobbying, and even secondary markets) focuses on defining interference without reference to the actual dynamic uses of systems, . . . there will be no economic means to gain these reductions in 'actual' interference (as opposed to the current measures of 'imaginary' interference).").

FIGURE 3



Seen this way, it becomes clear that responsibility for preventing interference may be assigned either to the emitter of the unwanted signal or to the receiver of the unwanted signal. Specifically, (1) the interfering service or the receiving service may stop transmitting, (2) the interfering service or the receiving service may modify its network architecture, or (3) the receiving service may improve the immunity of its devices. To make this more concrete, consider a dispute over interference between a power plant owner and a neighboring homeowner. If the homeowner is disturbed by the power plant emissions, the plant can cease operations, or the homeowner can move away. Alternatively, the plant can install scrubbers and make other changes to its facilities, or the homeowner can change her use of the property to avoid the interference. Finally, the homeowner can wear a facemask, thereby improving her immunity to the interference without actually reducing exposure. Part IV, in examining the applicability of the common law to interference, explores the distinctions among these remedies and their manifestations in communications law.

A final characteristic of wireless systems is important to understanding the implications of interference. This is the distinction between "closed"

and "open" architecture systems. Most radio services, such as cellular telephony and satellite television, employ closed architectures in that the operator controls the design of both the transmitters and the receivers in their systems. The spectrum operators either manufacture their own receivers or dictate the design to independent manufacturers. Unlicensed services like cordless phones are inherently integrated in that the transmitter and the receiver are combined in a single device that resides in the end-user's equipment.

By contrast, some services, most notably television and radio broadcasting, employ an open architecture system in that they do not control the receivers used within their systems. Although open architecture operators might exert some informal influence over the design characteristics of the receivers, they do not specify those characteristics and do not supply the devices themselves. For the purposes of this Article, the difference between closed and open architecture services is that closed architecture services can more easily abate interference to themselves by changing the design of their receivers to avoid or increase immunity to interference.

Thus far, we have considered simple interference disputes. Although many spectrum users may be involved, these are essentially bilateral affairs between two users or two classes of users. What becomes evident in the next section is that, just as spectrum is not always like land, spectrum disputes are not always like disputes over land.

2. Spectrum as Air

In the case of air, as industrial emissions increase, the likelihood that these emissions will interfere with the functions of living beings increases. The same is true of spectrum. As the density of signals increases, some communications systems will be overwhelmed by signal noise that is the cumulative output of many operators.[73] Because most of

73. The amount of ambient radiation in the spectrum is increasing so fast that some say it could lead to a meltdown of existing service. *See, e.g.*, Comments of Cingular Wireless LLC, *In re* the Commission's Spectrum Policies, ET Docket No. 02-135, at 37–38 (F.C.C. filed July 8, 2002).

> [W]e could potentially be entering a period of rapid degradation of the noise environment. Such degradation would reduce our ability to meet the communications needs of the country. The principal negative impacts are likely to be reductions in the performance or reliability of wireless systems or increases in their costs.

Id. at 37 (alteration in original). It may be that digital technologies, which are more robust and resistant to interference than analog systems, can slow this degradation. Such

the favored spectrum bands are already in use, future spectrum use will require more intensive sharing of encumbered frequencies, resulting in more radiation within a given band. The cumulative amount of energy in a band of frequencies is known as the "noise floor."

As illustrated in Figure 4 below, the noise floor rises far above the permitted power levels of any given operator, increasing over time.[74] When a service is licensed, it is usually engineered as cheaply as possible to function adequately in the existing spectral environment. In other words, it is engineered to ensure that the signal can be received, over a given noise floor, throughout the desired service area. As the signal attenuates and the noise increases in relation to the desired signal, reception gets worse. As more operators begin to emit signals in the same or adjacent frequencies, the noise increases even though all operators might be complying with the relevant power limitations. This increase in the level of noise that systems must reject could result in reduced coverage, system capacity, system reliability, and quality of service.[75]

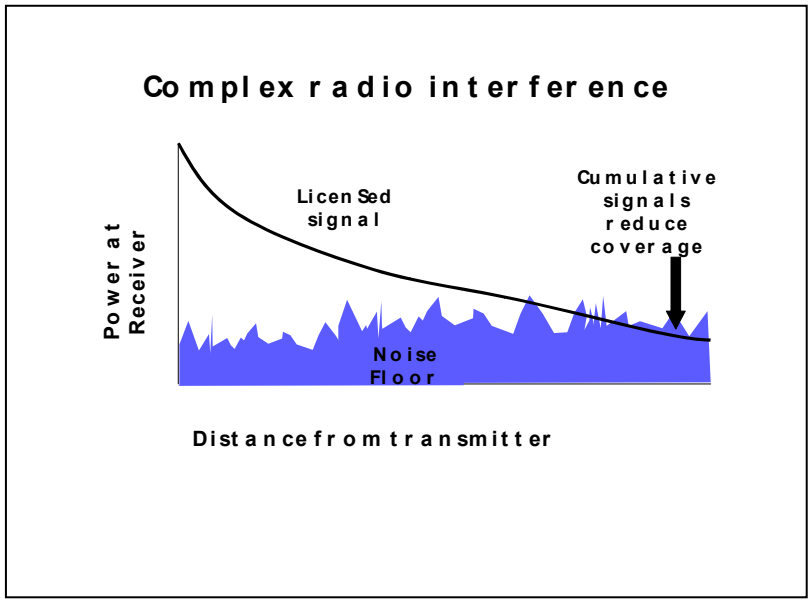
---

systems use error correction and other coding to mitigate the effects of interference. Interference Immunity Performance Specifications for Radio Receivers, 18 F.C.C.R. 6039, 6043–44 (2003). Nobody seems to know whether noise-reducing technology will advance fast enough to keep up with the pace of noise accumulation in the spectral environment.

74. This picture is modified from a graphic in the FCC REPORT, *supra* note 39, at 29.

75. The impact of cumulative noise from multiple "noninterfering" sources on communications operation is well-documented. *See, e.g.*, Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems, 17 F.C.C.R. 7435, 7444 (2002) (discussing the importance of the possible effects of cumulative interference from multiple ultrawideband devices); Amendment of Parts 2 and 25 of the Commission's Rules to Permit Operation of NGO FSS Systems Co-Frequency with GSO and Terrestrial Systems in the Ku-Band Frequency Range, 16 F.C.C.R. 4096, 4140 (2000) (establishing aggregate interference limits for satellite systems); Review of the Technical Assignment Criteria for the AM Broadcast Service, 6 F.C.C.R. 6273, 6293 (1991) (establishing a method for computing responsibility for cumulative interference), *recon. granted in part and denied in part*, 8 F.C.C.R. 3250 (1993).

FIGURE 4



In the past, the noise floor has increased relatively slowly, and operators have been able to redesign receivers and system architectures to respond to new spectral conditions. As increases to the noise floor outpace product cycles, this becomes harder to do.[76] One engineer speaking at a recent FCC workshop on the future of interference professed: "I think I can predict the future fairly confidently that we're going to see the same that we see today, but we're going to see a lot more of it. . . . It may not be so obvious on a day to day basis, but the interference will increase."[77]

76. Software defined radios may be particularly useful in responding to changed signal-to-noise ratios in that the radios can be upgraded by reconfiguring software rather than by replacing hardware. *See infra* note 312.

77. FCC IPWG REPORT, *supra* note 68, at 3 n.13 (quoting the Interference Protection Workshop remarks of Dr. Andrew Clegg).

There is no mechanism in today's administrative regime to allocate rights and responsibilities in a spectral environment that is being degraded by cumulative interference.[78] In fact, the FCC has acknowledged that it does not even measure noise levels or know the rate of increase in noise levels over time.[79] Thus, while we know that the ambient level of energy in the spectrum is increasing, we do not know by exactly how much or what the implications of rising noise levels for service reliability and reach might be.

3. Tendencies and Trends

As noted above, mere congestion alone is likely to exacerbate interference. Moreover, recent innovations in spectrum management may magnify the impact of spectrum congestion with respect to both simple and complex interference in ways that are not yet well understood and certainly have not informed the debate over spectrum management reform. There are reasons to believe that the more flexibility spectrum users have in designing wireless services, whether such flexibility is a product of private property rights, a lightly regulated commons, or simply a more relaxed administrative regime, the more complex the interference environment is likely to be.

There is little doubt that increased flexibility in spectrum use is what we will see. Until the early 1990s, spectrum allocations were both narrow and static. Licensees were bound to use their assigned spectrum for a narrow class of uses specified in the license or the applicable rules and could not change the use even as change was demanded by markets or technology.[80] Several years ago, the FCC announced that allowing licensees more flexibility to determine what kinds of services to provide, bounded only by interference limits at the edges of the service area, would be a key feature of its spectrum policy.[81] Even before that

78. FCC rules in some instances do limit the amount of cumulative interference a particular licensee is expected to bear in cases of intraservice interference. *See, e.g.*, 47 C.F.R. § 73.623(c)(2) (2002) (limiting the amount of new interference a digital television station is required to bear due to the emissions of other digital television stations to ten percent of the population).

79. FCC IPWG REPORT, *supra* note 68, at 11–12.

80. *See* PETER W. HUBER ET AL., FEDERAL TELECOMMUNICATIONS LAW 878 (2d ed. 1999).

81. *See* Principles for Reallocation of Spectrum to Encourage the Development of Telecommunications Technologies for the New Millennium, 14 F.C.C.R. 19,868, 19,870 (1999) (providing that "[f]lexible allocations may result in more efficient spectrum markets"). Under flexible use policies, restrictions take the form of "limits on signal strength at the edge of a licensee's service area and limits on maximum transmitter power, antenna height and out-of-band emissions." Interference Immunity Performance Specifications for Radio Receivers, 18 F.C.C.R. 6039, 6041 (2003).

announcement, the FCC had begun to loosen usage restrictions on licensees. It did this prospectively by allowing multiple technologies and multiple services to operate within a single band of spectrum.[82] It also increased spectrum flexibility retroactively by expanding the range of services that incumbent users could offer based on their existing licenses.[83] In 1995, the FCC went as far as it dared in the direction of flexibility by allocating spectrum for varied uses without any clear idea of what the primary use of the spectrum would be.[84] Flexible service rules have now become the norm in new spectrum allocations.[85]

---

82. The first implementation of "flexible use" was in 1993, when the FCC established service rules for the Personal Communications Service (PCS), allowing the new service to provide a mix of fixed and mobile services without specifying what technology operators should deploy. Amendment of the Commission's Rules to Establish New Personal Communications Services, 8 F.C.C.R. 7700, 7712 (1993).

83. *See, e.g.*, 47 C.F.R. § 624(c) (allowing broadcasters flexibility in the use of digital television channels); *In re* Flexibility for Delivery of Communications by Mobile Satellite Service Providers in the 2 GHz Band, the L-Band, and the 1.6/2.4 GHz Bands: Review of the Spectrum Sharing Plan Among Non-Geostationary Satellite Orbit Mobile Satellite Service Systems in the 1.6/2.4 GHz Bands, Report and Order and Notice of Proposed Rulemaking, 18 F.C.C.R 1962, 1964, 1973 (2003) (allowing satellite services to use spectrum for terrestrial services); Amendment of Part 2 of the Commission's Rules to Allocate Spectrum Below 3 GHz for Mobile and Fixed Services to Support the Introduction of New Advanced Wireless Services, 16 F.C.C.R. 17,222, 17,234 (2001) (granting licensees flexibility to use spectrum for mobile purposes). Another way the FCC provides retroactive flexibility is by authorizing "excess capacity" leasing. Twenty-five years ago, the FCC first allowed wireline common carrier services to resell and share capacity. Regulatory Policies Concerning Resale and Shared Use of Common Carrier Services and Facilities, 60 F.C.C.2d 261, 298 (1976). The practice spread into the wireless services. *See, e.g.*, 47 C.F.R. § 74.931(c), (d), (f) (Instructional Television Fixed Service leasing); *id.* §§ 73.293, 73.295 (FM subcarrier leasing). A new policy allowing wireless capacity leasing in many services may render the practice more widespread. *See* Promoting Efficient Use of Spectrum Through Elimination of Barriers to the Development of Secondary Markets, 18 F.C.C.R. 20,604 (2003) (allowing many wireless services to lease transmission capacity).

84. *See* Allocation of Spectrum Below 5 GHz Transferred from Federal Government Use, 10 F.C.C.R. 4769, 4800–01 (1995). This move was foreshadowed in the creation of the General Purpose Mobile Service, which was never actually licensed. *See* Amendment of Parts 2 and 22 of the Commission's Rules Relative to Cellular Communications Systems, 2 F.C.C.R. 1825, 1838, 1841 (1986); *see also* Implementation of Section 6002(b) of the Omnibus Budget Reconciliation Act of 1993, 12 F.C.C.R. 11,266, 11,273, 11,288 (1997) (describing the creation of the Wireless Communications Service, in which licensees may provide any fixed, mobile, or radiolocation service consistent with international allocations and technical limitations, and the Personal Communications Service, in which licenses can be used for any mobile or fixed service).

85. *See, e.g.*, Service Rules for Advanced Wireless Services in the 1.7 GHz and 2.1 GHz Bands, 18 F.C.C.R. 25,162 (2003) (adopting flexible service rules for the 1710–55 and 2110–55 MHz bands for the provision of "a variety of new and advanced wireless services, including voice, data, and broadband services . . . using high-speed fixed and

The FCC's experiments with flexible use, as well as theoretical work on the increasing complexity of spectrum applications, suggest that interference is positively correlated with variety in spectrum use. Thus, for example, where stationary services might once have been able to work around the interference constraints of other stationary services, they will face greater technical difficulties and expense in working around unpredictable mobile services.[86] Stringent regulations governing the architecture of communications systems reduce conflict in the same way that stringent regulations governing the architecture of road traffic reduces accidents. Where identical vehicles are traveling at identical speeds on an open road, the risk of collision will be fairly small. Once you begin to introduce bicycles, trucks, and differential speeds, the risk of collision increases, even assuming compliance with the traffic laws. The differentiated sets of vehicles have different requirements, capabilities, and vulnerabilities, making road use less predictable and collision more likely. When licensees are permitted to change their service models and technologies, there is an increased likelihood that they will let loose the wireless equivalents of Hummers and scooters into each other's lanes.

One observes this phenomenon in the 800 MHz band when, after the FCC adopted a flexible use policy, services evolved in ways that were not originally contemplated when the initial spectrum allocations were made.[87] The 800 MHz band is shared by high-power cellular transmitters and much lower power public safety operations, such as fire and police communications. The public safety services are vulnerable to interference caused by cellular transmissions, and for obvious reasons, service disruption may impose high costs on the public. These cellular and public safety services coexisted fairly harmoniously when the cellular companies used relatively few stations serving wide areas. After flexible service rules allowed cellular operators to increase the density of their transmitters, interference overwhelmed the poorly functioning public safety receivers used in police cars and fire trucks. The technical

---

mobile networks"); Service Rules for the 746–765 and 776–794 MHz Bands, 15 F.C.C.R. 476, 478 (2000) (reallocating television broadcast channels for a wide range of fixed and mobile wireless services). Although the FCC's flexible use policies are supposed to bring market forces to bear on spectrum allocation decisions, those policies have been criticized for being insensitive to market realities. In particular, the competitors of those licensees that would benefit from retroactive grants of flexibility complain that such flexibility distorts the market by adding value to spectrum that was purchased (if at all) at prices that did not reflect that added value. *See, e.g.*, *Ex Parte* Comments of AT&T Wireless Services, Inc., Public Notice of FCC Spectrum Policy Task Force, ET Docket No. 02-135, at 5–6 (F.C.C. filed July 12, 2002).

86. *See* FCC REPORT, *supra* note 39, at 13.

87. *See* FCC IPWG REPORT, *supra* note 68, at 2 n.5.

specifications governing cellular emissions that were adequate only a few years earlier to protect public safety receivers were rendered inadequate by changes to cellular system architecture.[88] Of course, the FCC could have changed the technical specifications when it allowed more flexibility within the bounds of those technical rules. Similarly, property rights might conceivably be developed to constrain owners on all the relevant margins. This theoretical possibility, however, bumps up against the realities that engineers responsible for creating technical rules, or property rights, cannot model interference scenarios for all signal combinations that may arise in the future under flexible rules.

Modeling challenges are particularly acute in the face of another kind of flexible use—the experimentation with different signal modulation techniques even within the same service. These modulation techniques are known as waveforms.[89] Even if a mobile phone company makes no change to the density of its cellular transmitters or to the amount of power that they emit into the atmosphere, changes to its waveforms may significantly affect the amount of interference that other operators will experience. To understand why this is, one must know something about how the FCC goes about defining spectrum usage rights.

Typically, the FCC determines the contours of spectrum rights by modeling interference scenarios in the laboratory. It models what will happen when a particular spectrum use is introduced into the existing spectral environment. This type of modeling is a relatively reliable predictor of actual interference when the types of signals that will be interacting are few and well-defined. However, according to the FCC, "[a]s the number of available signal waveforms (and combinations thereof) continues to rise, [laboratory testing] will become increasingly unwieldy" and costly.[90] As a result, "it will not always be possible to guarantee well-defined interference protection rights based on comprehensive predictive analyses."[91] For example, suppose that Sam

88. *See* Improving Public Safety Communications in the 800 MHz Band, 17 F.C.C.R. 4873, 4885 n.40 (2002).

89. Examples of waveforms are GSM and CDMA in the mobile phone industry.

90. FCC IPWG REPORT, *supra* note 68, at 5 n.23.

91. *Id*. at 11; *see also* Interference Immunity Performance Specifications for Radio Receivers, 18 F.C.C.R. 6039, 6041 (2003). "[I]t often is not possible to perform a reliable, comprehensive analysis to predict the strength of potential signal sources in a given frequency band and geographic area because licensees have discretion to select and modify transmitter locations, operating power, antenna directivity and type of transmissions." *Id*.

and Jane operate broadcast stations on adjacent channels and use the same transmission technology, which is mandated by the FCC. Now suppose that the FCC implements flexible use rules or even allocates property rights in the broadcast spectrum. Jane then decides to switch to a new waveform, while keeping her power and other relevant coordinates constant. The modeling that underlies Jane's spectrum usage right did not account for this new transmission standard. As a result, Jane might now interfere with reception of Sam's signal where she had not done so before.[92]

The increased risks of interference that attend flexibility may have been responsible for one of the FCC's worst recent experiences in spectrum allocation. In 1997, the FCC auctioned spectrum for a multipurpose "wireless communications service."[93] In the midst of a booming telecommunications market, and not long after the FCC auctioned other spectrum for billions of dollars, the Wireless Communications Service (WCS) auction generated little interest and little revenue.[94] Many blamed the auction failure on the breadth of the spectrum allocation, which left potential investors uncertain about the likely spectrum uses and, therefore, the likely vulnerability of their investments to interference.[95]

---

92. One engineer contributing to the FCC's inquiry on the future of interference had this to say about complexity in spectrum use:

> Obviously, the number of users and the management of the problem becomes dramatically enhanced [as spectrum use becomes more complex. Consideration of interference is] at least a six dimensional problem, meaning spatial, x-y-z, frequency, time and waveform, and of course since the wave form can be infinitely complicated, you can make it an n-fold problem, which basically has more variables than you have numbers.

FCC IPWG REPORT, *supra* note 68, at 5 (quoting the Interference Protection Workshop remarks of Dr. Paul Steffes).

93. FCC, *Auction 14: Wireless Communications Service (WCS) Fact Sheet*, *at* http://wireless.fcc.gov/auctions/14/factsheet.html (last updated Jan. 13, 2004). The WCS spectrum "may be used for any fixed, mobile, radiolocation or broadcast-satellite (sound) use consistent with the international agreements concerning spectrum allocations, and subject to the technical rules of Part 27, Title 47 of the Code of Federal Regulations." *Id*.

94. *See* WCS Auction Closes: Winning Bidders in the Auction of 128 Wireless Communications Service Licenses, 12 F.C.C.R. 21,653, 21,658–67 (1997) (listing auction winners).

95. For examples of industry criticism of the WCS service flexibility, see Comments of Motorola, Inc. Public Notice of FCC Spectrum Policy Task Force, ET Docket No. 02-135, at 9 (F.C.C. filed July 22, 2002); Comments of Nokia Inc., Public Notice of FCC Spectrum Policy Task Force, ET Docket No. 02-135, at 4 (F.C.C. filed July 8, 2002). For a discussion of the causes of failure of the WCS auction, see *WCS Spectrum Finds a Purpose in Broadband*, 12 BROADBAND BUS. REP. (PBI Media, Potomac, Md.), Aug. 27, 2002. In the wake of this mishap, Congress added section 303(y) to the Communications Act, which permits the FCC to provide for "flexibility of use" only after determining, upon public notice and comment, that flexibility will further the public interest, will not deter investment in communications services and systems, and is consistent with international treaties. 47 U.S.C. § 303(y) (2000). For an analysis

There is one other possible consequence of flexible service rules that bears on interference. When there is no constraint on what services may be offered or who may provide them, and when incumbents are strongly protected, interference levels must be kept sufficiently low so as to protect the most sensitive uses along with the more robust ones. Incumbents that want to fence off their spectrum to potentially competing or degrading services therefore have an incentive to maintain or even to introduce hypersensitive uses, newly permitted by flexible service rules, so as to "draw the foul" in the form of interference from potential new entrants. Interference thus becomes a tool to bar the entry of new services unless hypersensitive uses are denied protection.[96]

Returning to the categories of interference conflict we began with, we must consider the impact of flexible use, whether it results from continued regulatory reform or a radical shift in spectrum management regimes. Flexible use will change the meaning of existing service categories like satellite radio or television broadcasting. To the extent that any given service category can be used for multiple consumer applications, such as data or video, then the characteristics of interservice and intraservice interference will be different than they are today. Depending on the degree of flexibility permitted within a set of spectrum usage rights, the meaningful distinction between interference scenarios will come to lie not in the definition of service, but in the

---

of the application of 303(y), see Kathleen Q. Abernathy, *Government Doesn't Always Know Best: Harnessing Self-Interest to Advance the Public Interest*, 1 COMMLAW CONSPECTUS 5, 14–18 (2003).

96. *See* Comments of Jon M. Peha, Public Notice of FCC Spectrum Policy Task Force, ET Docket No. 02-135, at 4 (F.C.C. filed July 7, 2002) (noting that if licensees that will be affected by authorization of new ultrawideband services had had enough flexibility, they might have been able to block the new services with ultrasensitive operations); *see also* Testimony of Dr. Paul Kolodzy Before the U.S. Senate Committee on Commerce, Science, and Transportation 9–10 (Mar. 6, 2003), http://commerce.sentate.gov/~commerce/press/03/kolodzy030603.pdf (writing that "stakeholders in spectrum policy debates can subject the standard of 'harm' to multiple subjective opinions and use it to block or delay new services and devices from being introduced into the market"). There is a possible counterweight to this anticompetitive impulse. In 2003, the FCC adopted rules to facilitate spectrum trades by relaxing restrictions on the transfer of control of spectrum. *See* Promoting Efficient Use of Spectrum Through Elimination of Barriers to the Development of Secondary Markets, 18 F.C.C.R. 20,604 (2003). If licensees can lease their spectrum, they are likely to make their uses as robust as possible, thereby freeing spectrum to rent. However, a rental market in spectrum, like a rental market in housing, is likely to create more evanescent, unpredictable, and varied spectrum uses. Interference is more difficult to predict and control under these conditions.

system architectures and technologies at issue in the interference conflict. Thus, "intraservice" interference cases will arise between operators using a similar architecture, such as low-power satellite transmissions, whatever the end-user service that is provided. "Interservice" disputes will arise between operators using distinct system architectures, such as low-power satellite and high-power broadcast transmissions, again regardless of the associated consumer applications. As we have seen, because of the predictive modeling that goes into the setting of initial spectrum entitlements, the migration to flexible use is likely to exacerbate interservice interference in particular as new and different technologies share spectrum.

C. Public Interest Principles of Conflict Resolution

Thus far, this Article has shown how difficult it is to categorize spectrum as either a terrestrial or aerial resource and how complicated interference conflicts can be depending on the source of the interference and the types of services affected. It has suggested that those conflicts may well become more numerous as spectrum becomes more congested in general and as more varied spectrum applications inhabit the same bands. Part IV develops a framework for understanding the FCC's past attempts to resolve interference and access conflicts between existing and potential spectrum users—a framework that is meant to illuminate the challenges and suggest direction for the resolution of spectrum disputes under a property rights regime. Before turning in that direction, there is one more element of the administrative regime that requires attention. That is the public interest standard governing the FCC's resolution of spectrum conflicts—conflicts over which it has exclusive jurisdiction.[97]

97. The Supreme Court has recognized the FCC's jurisdiction "over technical matters" associated with spectrum as "clearly exclusive." Head v. N.M. Bd. of Exam'rs in Optometry, 374 U.S. 424, 430 n.6 (1963). Courts have declined to find any space between this exclusive jurisdiction and common law tort remedies for signal interference and have routinely dismissed the occasional nuisance claim for spectral disruption. *See, e.g.*, Broyde v. Gotham Tower, Inc., 13 F.3d 994, 997–98 (6th Cir. 1994) (holding that there was no cause of action for radio signal interference with home electronics); Still v. Michaels, 791 F. Supp. 248, 252 (D. Ariz. 1992) (holding that interference was not a valid cause of action for nuisance); Helm v. Louisville Two-Way Radio Corp., 667 S.W.2d 691, 693 (Ky. 1984) (holding that nuisance law was inappropriate for an action involving radio interference); Blackburn v. Doubleday Broad. Co., 353 N.W.2d 550, 557 (Minn. 1984) (holding that no cause of action existed for radio signal interference to consumer's reception of other stations). At least as to interference that may disrupt home electronics, Congress has come close to expressly preempting common law interference claims. A 1982 amendment to the Communications Act gave the FCC authority to regulate home electronics devices with respect to their susceptibility to, and creation of, interference. 47 U.S.C. § 302a(a). According to the legislative history, radio

Eighty years ago, Congress charged the FCC with distributing spectrum usage rights to the public in the agency's discretion, limited only by the requirement that it act "in the public interest."[98] It is a standard that is without clear meaning and is plagued by controversy.[99] While many rightly ridicule the public interest standard, few take pains to unravel its complexities. Some inquiry into what the FCC means when it claims to have resolved spectrum disputes in the public interest

---

frequency interference

> shall not be regulated by local or state law, nor shall radio transmitting apparatus be subject to local or state regulation as part of any effort to resolve [an interference] complaint. . . . [R]adio transmitter operators should not be subject to fines, forfeitures or other liability imposed by any local or state authority as a result of interference appearing in home electronic equipment or systems.

H.R. CONF. REP. NO. 97-765 (1982), *reprinted in* 3 U.S.C.C.A.N. 2261, 2277 (1982). This provision has been interpreted as vesting the FCC with exclusive jurisdiction over spectral interference whether or not home electronics devices are involved. Freeman v. Burlington Broad., Inc., 204 F.3d 311, 320 (2d Cir. 2000).

98. The public interest standard is phrased in different ways in different sections of the Communications Act. For example, the Act, at 47 U.S.C., instructs the FCC to act in the "public interest" in sections 201(b), 215(a), 319(c), and 315(a); in the "public convenience and necessity" in section 214(a) and (c); in the "interest of public convenience and necessity" in section 214(d); in the "public interest, convenience and necessity" in sections 307(c), 309(a), and 319(d); in the "public convenience, interest, or necessity" in section 307(a); and in the "public interest, convenience or necessity" in sections 311(b) and 311(c)(3). *See generally* Erwin G. Krasnow & M. Wayne Milstead, *FCC Regulation and Other Oxymorons Revisited*, 7 MEDIA L. & POL'Y 7, 10 (1999). So too, the public interest standard as applied to the spectrum-related aspects of FCC actions is indefinitely and variously defined. *See, e.g.*, 47 U.S.C. § 302(a) (requiring that the FCC rulemaking power over broadcasting must be exercised in "the public interest, convenience, and necessity"); *id.* § 303 (requiring that the FCC power to classify, license, and regulate radio must be "as public convenience, interest, or necessity requires"); *id.* § 303(g) (requiring that the FCC study new uses for radio that are "in the public interest"); *id.* § 307(a) (requiring that the FCC grant radio broadcast licenses "if public convenience, interest, or necessity will be served"); *id.* § 307(e)(1) (providing that the FCC may authorize certain types of radio broadcasting without a license if it "serves the public interest, convenience, and necessity").

99. *See* Louis G. Caldwell, *The Standard of Public Interest, Convenience or Necessity as Used in the Radio Act of 1927*, 1 AIR L. REV. 295, 296 (1930) (writing that "'[p]ublic interest, convenience or necessity' means about as little as any phrase that the drafters of the [Radio] Act could have used and still comply with the constitutional requirement that there be some standard to guide the administrative wisdom of the licensing authority"); Erwin G. Krasnow & Jack N. Goodman, *The "Public Interest" Standard: The Search for the Holy Grail*, 50 FED. COMM. L.J. 605, 606–07 (1998); Randolph J. May, *The Public Interest Standard: Is It Too Indeterminate to Be Constitutional?*, 53 FED. COMM. L.J. 427, 429–30 (2001); *see also* Hazlett, *The Wireless Craze*, *supra* note 3, at 401–03 (criticizing the public interest standard in the spectrum allocation context).

is worthwhile, especially because the spectrum management reforms we are considering themselves depend upon public interest evaluations of spectrum conflict.

Consideration of the public interest standard must start with the pages of early railroad regulation, from where the obligation to regulate in the public interest emerged.[100] That standard was then applied to the Federal Radio Commission in 1927[101] and to the FCC in 1934.[102] As observed by Judge Henry Friendly, one of the early critics of administrative public interest standards, the standard "conveyed a fair degree of meaning when the issue was whether new or duplicating railroad construction should be authorized . . . . The standard was almost drained of meaning under . . . the Communications Act, where the issue was almost never the need for broadcasting service but rather who should render it."[103]

The meaning of the public interest and its relationship to spectrum disputes does not emerge any more clearly from the courts than it did from Congress. The Supreme Court has said that the public interest invests the FCC with significant powers requiring "imaginative interpretation."[104] While the public interest standard does not grant agencies a "broad license" to promote public welfare in general, it does give them wide-ranging discretion to promote the goals that they discern in their authorizing legislation.[105]

When it has come time for the FCC to articulate the public interests at stake in spectrum management, it has tended to restate, without refinement, the Communications Act's mandate to "make available, so far as possible, to all the people of the United States, . . . a rapid,

100. Senator Clarence C. Dill, who played a major role in the passage of the Communications Act, reportedly attributed the phrase "public interest, convenience and necessity" to a young lawyer on loan to the Senate from the Interstate Commerce Commission who proposed the phrase when the Senate was at an impasse as to how to constrain the FCC's authority. *See* T. BARTON CARTER ET AL., THE FIRST AMENDMENT AND THE FIFTH ESTATE 73 (5th ed. 1999).

101. Act of Feb. 23, 1927, ch. 169, 44 Stat. 1162 (repealed 1934).

102. Communications Act of 1934, ch. 652, 48 Stat. 1064 (codified at 47 U.S.C. §§ 151–615b).

103. HENRY J. FRIENDLY, THE FEDERAL ADMINISTRATIVE AGENCIES: THE NEED FOR BETTER DEFINITION OF STANDARDS 54–55 (1962) (footnote omitted).

104. FCC v. RCA Communications, 346 U.S. 86, 90 (1953) (stating that the public interest standard "no doubt leaves wide discretion and calls for imaginative interpretation"); *see also* Office of Communication of the United Church of Christ v. FCC, 707 F.2d 1413, 1423 (D.C. Cir. 1983) (holding that Congress gave the FCC the power to act according to the agency's view of the "public interest"); Gen. Tel. Co. of the S.W. v. United States, 449 F.2d 846, 853, 858 (5th Cir. 1971) (holding that the public interest standard grants "elastic powers" to the FCC and "is to be construed so as to secure for the public the broad aims of the Communications Act").

105. NAACP v. Fed. Power Comm'n, 425 U.S. 662, 669–70 (1976) (holding that the meaning of the public interest depends on "the purposes that Congress had in mind when it enacted [the authorizing] legislation").

efficient, Nation-wide, and world-wide wire and radio communication service with adequate facilities at reasonable charges."[106] The problem is that almost any spectrum decision, by advancing the interests of one communications provider over another, can be defended as improving communications service to the public and therefore advancing the public interest. Services competing for spectrum will claim that they serve more people, albeit less reliably, or serve fewer people, but for more critical service, or provide broadband service that is fast, though expensive, or narrowband service that is slower, but cheap. Because all of these services can legitimately claim to improve the availability of radio communication service, decisions about which to favor in the public interest require more detailed criteria.

In need of such criteria to choose among spectrum uses that may all serve the Act's spectrum management goals, the FCC has resorted to the same measures that nuisance courts use when it comes to resolving conflicts over land: efficiency in the use of a resource and equity as between users.[107] While the use of efficiency and fairness as surrogates for the public interest is a reasonable response to statutory vagueness, such use has even further obscured the agency's goals in resolving spectrum disputes.

Take, for example, the efficiency goal for spectrum management. Only in 2002, for the first time after decades of using the term, did the FCC attempt to define the word "efficiency." Efficiency, the FCC noted, might be defined as "economic efficiency." An economically efficient result occurs "when all inputs are deployed in a manner that generates the most value for consumers."[108] The achievement of economic efficiency has long been one of the FCC's highest priorities in resolving spectrum usage conflicts. As early as 1980, FCC staff interpreted the public interest requirement of the Communications Act as "encouragining economic efficiency in the use of the frequency spectrum" and, therefore, supporting spectrum deregulation.[109] Since then, all of the FCC's major spectrum policy statements have

106. *See* 47 U.S.C. § 151.

107. *See* James E. Krier & Stewart J. Schwab, *Property Rules and Liability Rules: The Cathedral in Another Light*, 70 N.Y.U. L. REV. 440, 446 (1995) (describing the "general view" of the nuisance balance); *see also infra* Part IV.

108. FCC REPORT, *supra* note 39, at 21.

109. DOUGLAS W. WEBBINK, FREQUENCY SPECTRUM DEREGULATION ALTERNATIVES 12 (FCC Office of Strategic Planning and Policy Analysis, OPP Working Paper No. 2, 1980), *available at* http://www.fcc.gov/Bureaus/OPP/working_papers/oppwp2.pdf.

emphasized the desire to facilitate economically efficient use of the spectrum.[110] Most recently, the FCC has used the language of efficiency in expressing the hope that spectrum reform will give "both licensed users and unlicensed device operators the maximum possible autonomy to determine the highest valued use of their spectrum, subject only to those rules that are necessary to afford reasonable opportunities for access by other spectrum users and to prevent or limit interference among multiple spectrum uses."[111]

The highest valued use of the spectrum is, of course, difficult to measure in the absence of a market for spectrum. The winning bids in a spectrum auction will tell us something about spectrum value. But the FCC's spectrum auction results will not necessarily be the most economically efficient because the decision about how the spectrum will be used is made *before* it is auctioned. As a result, auction participants compete against each other to use the spectrum for roughly the same purpose and under the same constraints even though some other use of the spectrum might produce more value.

Lacking a market metric for arriving at economic efficiency, the FCC often relies on the goal of competition for the same purpose. Thus, it will privilege those spectrum uses that promise to provide competition to an existing wireless service.[112] Even after the spectrum has been

110. *See, e.g.*, Principles for Promoting the Efficient Use of Spectrum by Encouraging the Development of Secondary Markets, 15 F.C.C.R. 24,178, 24,181 (2000); Principles for Reallocation of Spectrum to Encourage the Development of Telecommunications Technologies for the New Millennium, 14 F.C.C.R. 19,868, 19,870 (1999); FCC REPORT, *supra* note 39, at 15. The pursuit of economic efficiency is, at least with respect to the award of initial licenses through competitive bidding, compelled by the statute. *See* 47 U.S.C. § 309(j)(3)(A)–(D) (specifying that auctions should promote "economic opportunity and competition"). The same provisions, however, compel the pursuit of other objectives as well, like public restitution (auctions should avoid "unjust enrichment" for spectrum users) and opportunities for minorities and other underrepresented groups (auctions should disseminate "licenses among a wide variety of applicants, including small businesses, rural telephone companies, and businesses owned by members of minority groups and women"). *Id.*

111. FCC REPORT, *supra* note 39, at 16. For a definition of efficiency as a choice of resource allocation that maximizes the value of the resource, see Krier & Schwab, *supra* note 107, at 446.

112. *See, e.g.*, Amendment of Part 90 of the Commission's Rules to Facilitate Future Development of SMR Systems in the 800 MHz Frequency Band, 12 F.C.C.R. 19,079, 19,173 (1997) (stating that the rapid implementation of wide-area licensing in the SMR service will advance the public interest by fostering economic growth of competitive new services); Rulemaking to Amend Parts 1, 2, 21, and 25 of the Commission's Rules to Redesignate the 27.5–29.5 GHz Frequency Band, to Reallocate the 29.5–30.0 GHz Frequency Band, to Establish Rules and Policies for Local Multipoint Distribution Service and for Fixed Satellite Services, 11 F.C.C.R. 19,005, 19,018 (1996) (authorizing the deployment of LMDS to provide a potential source of competition in the local telephony and multichannel video programming distribution markets); Amendment of Part 90 of the Commission's Rules to Facilitate Future Development of SMR Systems

allocated, we do not know how much licensees in different services value the rights to be free from interference or to interfere. We know in many wireless services what a particular licensee has paid at auction for access to spectrum. But this price was predicated on an interference-free service area as described by the license. There is currently no market, or at least no market of any scale, through which licensees trade spectrum emissions rights. While a licensee might indeed bargain away interference protection with another licensee, the trades are rare enough and secret enough to prevent a public valuation of the cost of interference.

A second complication with the FCC's pursuit of economic efficiency as a surrogate for the public interest is that economic efficiency may be defined as static efficiency or dynamic efficiency. A key input to dynamic efficiency is the pace of technological innovation. As David Driesen has pointed out in the environmental context, regulatory decisions that favor short-term economic efficiency may frustrate long-term technological innovation that will in turn produce longer term consumer welfare.[113]

In defining efficiency, the FCC did not limit the term to economic efficiency. Efficiency, it said, might be defined alternatively as "spectrum efficiency." A spectrally efficient result "occurs when the maximum amount of information is transmitted within the least amount of spectrum."[114] When the FCC makes decisions about reallocating

---

in the 800 MHz Frequency Band, 11 F.C.C.R. 1463, 1494 (1995) (deciding not to limit aggregation of 800 MHz spectrum so as to promote potential competitors to broadband PCS and cellular providers); Amendment of the Commission's Rules to Establish New Personal Communications Services, 8 F.C.C.R. 7700, 7710 (1993), *modified*, 9 F.C.C.R. 4957 (1994) (allocating frequencies for PCS services to introduce competition to cellular providers). The courts have occasionally chastised the FCC for equating competition with the public interest. *See, e.g.*, FCC v. RCA Communications, 346 U.S. 86, 96–97 (1953) (holding that the FCC, in authorizing duplicate broadcast facilities, must show that increased competition serves some other public interest goals); Hawaiian Tel. Co. v. FCC, 498 F.2d 771, 777 (D.C. Cir. 1974) (ruling that the FCC cannot "automatically equate the public interest with additional competition"). However, the Communications Act provides some support for equating competition with the public interest. *See* 47 U.S.C. § 309(j)(3)(B) (providing that spectrum auctions should ensure "that new and innovative technologies are readily accessible . . . by avoiding excessive concentration of licenses and by disseminating licenses among a wide variety of applicants").

113. *See* DAVID M. DRIESEN, THE ECONOMIC DYNAMICS OF ENVIRONMENTAL LAW 75–93 (2003); David M. Driesen, *Free Lunch or Cheap Fix?: The Emissions Trading Idea and the Climate Change Convention*, 26 B.C. ENVTL. AFF. L. REV. 1, 41–46 (1998).

114. FCC REPORT, *supra* note 39, at 21. The FCC also defined a third variant of efficiency as "technical efficiency." A technically efficient result occurs when "inputs, such as spectrum, equipment, capital, and labor, are deployed in a manner that generates

spectrum from an existing use, like paging, to one of several proposed new and interfering uses, like videophones or satellite television, how can it assess the efficiency gains each new use might confer or compare those gains to each other when the uses are so different? As the FCC has acknowledged, it is "neither possible nor appropriate to select a single, objective metric for comparing spectrum efficiency across different radio services."[115]

Although spectral efficiency will be a component of economic efficiency, some spectrum uses will be spectrally efficient but economically inefficient, and vice versa. If the use of spectrum is economically efficient when the maximum amount of *consumer value* is extracted from a unit of spectrum, the use of spectrum is spectrally efficient when the maximum amount of *communication*, regardless of its consumer value, is extracted from a unit of spectrum. In urban areas, where spectrum is scarce, economic and spectral efficiency are likely to coincide.[116] But sometimes, such as in rural areas where spectrum availability far exceeds demand, it may be economically efficient to use an inefficient technology. In fact, wherever spectrum is either free or

---

the most output for the least cost." *Id.* In other words, a result might be technically efficient, but not economically efficient, where it results in the output of the greatest amount, but not the highest value, of communications capacity at least cost. Such a result would be spectrally efficient only if the high yield of communications capacity were achieved with the efficient use of spectrum—only one of the inputs considered in the analysis of technical efficiency.

115. *Id*.

116. The FCC appeared to have in mind this kind of coincidence when it first implemented auctions as a means of assigning licenses in 1994. It concluded that the granting of licenses through a system of competitive bidding was *spectrally* efficient in speeding "the development and deployment of new services . . . and encourag[ing] efficient use of the spectrum" as well as *economically* efficient in placing licenses in the hands of "those parties who value them most highly." Implementation of Section 309(j) of the Communications Act—Competitive Bidding, 9 F.C.C.R. 2941, 2944 (1994). Indeed, both Congress and the FCC frequently conflate spectrum and economic efficiency in touting the benefits of markets. *See, e.g.*, H.R. 2264, 103d Cong. (1993) (finding that "a carefully designed system to obtain competitive bids from competing qualified applicants can speed delivery of services, promote efficient and intensive use of the electromagnetic spectrum, prevent unjust enrichment, and produce revenues to compensate the public for the use of the public airwaves"); Principles for Promoting the Efficient Use of Spectrum by Encouraging the Development of Secondary Markets, 15 F.C.C.R. 24,178, 24,180 (2000) (stating that "the 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"); Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion, 14 F.C.C.R. 2398, 2402 (1999) (stating that the FCC will "rely as much as possible on free markets and private enterprise"); Deployment of Wireline Services Offering Advanced Telecommunications Capability, 13 F.C.C.R. 24,011, 24,014 (1998) (stating that the FCC's role "is not to pick winners or losers, or select the 'best' technology to meet consumer demand, but rather to ensure that the marketplace is conducive to investment, innovation, and meeting the needs of consumers").

sufficiently unused to be cheap, there is no reason for operators to invest in spectral efficiency. Thus, an efficient result in the resolution of a spectrum dispute might variously be one that drives technical innovation towards near-term economic gains unrelated to spectrum efficiency, or one that makes spectrum use more efficient, regardless of the consumer value created in the near term.

Further complicating the FCC's use of efficiency goals is the agency's desire to foster technological innovation as a means to achieve economic efficiency or to spur innovation for its own sake. The FCC's exaltation of technical innovation reached a high-water mark in the early 1990s with its now defunct "pioneer's preference" policy. This was a policy under which the FCC awarded exclusive use of particular frequencies to entities that were particularly innovative without regard to the innovation's economic viability.[117] Sometimes, the FCC has pursued economic efficiency as a means by which to achieve technological innovation, and not the reverse. For example, it has said that it seeks to "[e]ncourage the highest and best use of spectrum domestically and internationally *in order to* encourage the growth and rapid deployment of innovative and efficient communications technologies and services."[118] The promotion of new technologies for their own sake, whether or not they further efficiency goals, was encoded in the Communications Act in 1983, when Congress made it the policy of the United States "to encourage the provision of new technologies and services to the public."[119]

In forging the public interest in spectrum management, the FCC sometimes sacrifices its varied efficiency goals for what it determines to be equitable treatment of incumbent spectrum users. The FCC has demonstrated a solicitude to the ongoing operations and investment-backed expectations of incumbent licensees that exceeds the obligations of due process or the Administrative Procedures Act. As discussed

117. *See* Establishment of Procedures to Provide a Preference to Applicants Proposing an Allocation for New Services, 6 F.C.C.R. 3488, 3498 (1991) (codified at 47 C.F.R. § 1.402(a) (1999)) (establishing a preference in favor of a pioneer in technology that would exclude from consideration for a license all other applications).

118. FCC, STRATEGIC PLAN: FY 2003—FY 2008, at 5 (2002), *available at* http:/www.fcc.gov/omd/strategicplan/strategicplan2003-2008.pdf (emphasis added).

119. 47 U.S.C. § 157(a) (2000). It should be noted that the FCC believes that unlicensed communications services, which grew out of this policy, promote both economic efficiency and technological innovation by allowing users to "channel their investment exclusively into developing robust technology" that can function in a congested and loosely managed spectral environment. FCC REPORT, *supra* note 39, at 39.

below, interference disputes between licensees are settled according to a "first-in-time" principle, whereby the rights of the more established licensee are privileged over those of the newer entrant, regardless of the efficiency implications.[120] At least until recently, the FCC rarely sided with a new entrant in an interference dispute at the expense of an existing operator even where the resulting interference would be efficient.

Particularly when it introduces new services, the FCC is preoccupied with issues of fairness to the existing services threatened with displacement.[121] The agency, for example, will not simply reclaim licenses and issue rights to new users even though it probably has the legal authority to do so.[122] Moreover, the agency shows a striking regard for the embedded base of radio receiving equipment in requiring backward compatibility with, or the gradual replacement of, existing devices as new services are introduced into the spectrum. These policies, which are defended as consumer-friendly, appear to the world as incumbent-friendly.

The current introduction of new wireless services into the television broadcast band, along with the commencement of digital broadcasting in the same band, is a case in point. Because it was not possible to make digital television transmissions backwards compatible with the embedded base of approximately 200 million analog sets, consumers will ultimately have to invest in new television sets, or other receiving devices, in order to receive off-air digital transmissions. Yet, to preserve

120. *See infra* Part IV.C.2.

121. To protect incumbent services, for example, the FCC has required new entrants to pay the costs of relocating the incumbents to new spectrum. *See* Redevelopment of Spectrum to Encourage Innovation in the Use of New Telecommunications Technologies, 9 F.C.C.R. 7797, 7800 (1994); Redevelopment of Spectrum to Encourage Innovation in the Use of New Telecommunications Technologies, 9 F.C.C.R. 1943, 1947 (1994); Redevelopment of Spectrum to Encourage Innovation in the Use of New Telecommunications Technologies, 8 F.C.C.R. 6589, 6590 (1993); Redevelopment of Spectrum to Encourage Innovation in the Use of New Technologies, 7 F.C.C.R. 6886, 6890 (1992). The FCC has since applied the same principle to the new entry and relocation of other services. *See, e.g.*, Amendment of Section 2.106 of the Commission's Rules to Allocate Spectrum at 2 GHz for Use by the Mobile-Satellite Service, 15 F.C.C.R. 12,315, 12,322–38 (2000). This principle of compensation is nowhere more important than in the attempt to free up some of the forty percent of the spectrum under 3 GHz that is used by the federal government. Congress has considered legislation that would set aside spectrum auction proceeds for advanced wireless services to relocate government users. *See* Commercial Spectrum Enhancement Act, H.R. 1330, 108th Cong. (2003).

122. It has been suggested that modification of terms of existing licenses to require increased immunity to interference or reduced production of interference could result in a regulatory taking, violate section 316 of the Communications Act (requiring the Commission to comply with certain procedures before modifying license), or constitute a breach of contract where the licenses were purchased at auction. *See, e.g.*, Comments of Sprint Corporation, *In re* Issues Related to the Commission's Spectrum Policies, ET Docket No. 02-135, at 10–11 (F.C.C. filed July 8, 2002).

the life of those analog sets for as long as possible, the FCC has steadfastly refused to allow digital broadcasts to interfere with existing analog broadcasts for the potentially long period of time when the two technologies will coexist.[123] It has also limited the pace of entry and restricted the operation of new wireless services that will operate in the television band.[124] Because of the FCC's policy of protecting the functionality of broadcast receivers, broadcasting partakes of a unique phenomenon in the electronic media: AM radios that are still useable after eighty years and antique television sets that function after fifty. Although consumers may be served in the short term by policies that protect existing services and embedded equipment, such protection may ultimately conflict with goals of efficiency or justice among operators. The FCC has never articulated a way to rank efficiency and equity considerations or to make choices between short-term sacrifices in one goal for long-term gains in another.

This then is the mixture of efficiency and equity goals that goes into the FCC's determination of which spectrum use entitlements will further the public interest. This is the mixture that has become a flashpoint for criticism and focus of reform proposals.

---

123. *See, e.g.*, Service Rules for the 746–764 and 776–794 MHz Bands, and Revisions to Part 27 of the Commission's Rules, 16 F.C.C.R. 2703, 2712 (2001). The protection of the embedded receiver population has animated television and radio policy from the beginning. For example, in the 1920s, the Federal Radio Commission declined to allocate additional spectrum for radio broadcasting because it did not want to outmode existing receivers that were not designed to operate on the additional frequencies. FRC ANNUAL REPORT 13 (1927), *reprinted in* HISTORY OF BROADCASTING: RADIO TO TELEVISION 1, 13 (Christopher Sterling ed., 1971). The FCC has also chosen to protect existing equipment when considering whether or not to compress broadcasting operations into a more limited amount of spectrum. For example, the FCC originally intended for all television broadcasting to operate in the UHF band. 11 FCC ANN. REP. 21–22 (1946). However, when the FCC first opened up the UHF band for television broadcasting in the 1950s, and it had the opportunity to migrate the entire service into that band, the agency declined to order the move so as to avoid disrupting investments in existing sets. *See* H. Plotkin, TV Networks and the UHF Problems, Report Prepared for the Senate Committee on Interstate and Foreign Commerce, 85th Cong. Sess. 1 (1955) (cited in Improvements to UHF Television Reception, 70 F.C.C.2d 1162, 1164 (1978)).

124. Attempting to preserve the "public good" of free over-the-air broadcasting, for example, the FCC will not allow those stations that provide sole service or sole noncommercial service to a community to sell their stations to new service entrants who might value the spectrum more highly. *See* Service Rules for the 746–764 and 776–794 MHz Bands, and Revisions to Part 27 of the Commission's Rules, 15 F.C.C.R. 20,845, 20,867 (2000) (providing that the "[l]oss of broadcasting service has been a long-recognized detriment to the public interest").

D. Critique of Spectrum Management Status Quo

The system of spectrum management that slowly and haltingly brought us cellular telephone, satellite broadcasting, and digital television service has been the subject of withering critique in both scholarly and policy circles. The changes the FCC has implemented in its command and control regulation have not been enough to satisfy its critics.[125] The FCC itself recognizes that its incremental efforts to update its spectrum management techniques cannot meet the demands of the twenty-first century, and it has posed serious questions about the administrative management of spectrum.[126] In a country in which over sixty percent of all residents use wireless devices, large institutions are rapidly migrating from wired to wireless systems,[127] and there is an explosive growth in the variety and complexity of wireless communications systems, the current spectrum management regime will face constant pressure for reform.

Critics of the current management regime identify two main targets for reform: the protection of incumbent services at the expense of new entrants[128] and the reliance on administrative tools to allocate usage

125. *See* Hazlett, *The Wireless Craze*, *supra* note 3, at 339; *see also* Gregory L. Rosston, *The Long and Winding Road: The FCC Paves the Path with Good Intentions*, STAN. INST. FOR ECON. POL'Y RES. (2001) (arguing that the FCC has missed many recent opportunities to implement a more market-based approach to spectrum management), *available at* http://www.calit2.net/events/2002/Spectrum/presentations/Long_Winding_Road 4-20-02.pdf.

126. *See* Promoting Efficient Use of Spectrum Through Elimination of Barriers to the Development of Secondary Markets, 18 F.C.C.R. 20,604 (2003) (implementing a system of spectrum leasing that removes the FCC from decisions about how the spectrum can be used and proposing more far-reaching changes to the spectrum control structure); FCC REPORT, *supra* note 39, at 1 (laying out an ambitious program for spectrum management reform).

127. *See, e.g.*, Barnaby J. Feder, *For the Gadget Universe, A Common Tongue*, N.Y. TIMES, Jan. 2, 2003, at G1; Jack Schofield, *Radio Ahead*, THE GUARDIAN (London), Mar. 13, 2003; *see also* JOHN B. HORRIGAN, PEW INTERNET PROJECT, CONSUMPTION OF INFORMATION GOODS AND SERVICES IN THE UNITED STATES vi (2003) (noting that sixty-two percent of Americans are cell phone subscribers), *available at* http://www.pewinternet.org/reports/pdfs/PIP_Info_Consumption.pdf.

128. *See, e.g.*, Benkler, *supra* note 4, at 73; Hazlett, *The Wireless Craze*, *supra* note 3, at 360. Critics of command and control regulation point to the FCC's management of broadcast spectrum as the most striking example of regulatory failure to free spectrum for its highest and best use in deference to incumbents. *See, e.g.*, Spiller & Cardilli, *supra* note 3, at 60. One of the most interesting facets of this criticism is the degree to which it is packed with unsupported, and perhaps unsupportable, judgments about the nature of the public interest. If broadcasting is technically inefficient, it is because signals reach consumers who receive the same content through other means (like cable) or who do not want the signals. If broadcasting is economically inefficient, it is because the public would value alternative services more highly than broadcasting if given the choice. Of course, the magnitude of the tradeoff between broadcasting and rival services could be reduced if the public were willing to purchase more sensitive receivers that

rights.[129] Any new service provider, unless it uses unlicensed spectrum, must come to the FCC to obtain access to spectrum.[130] As we have seen, the FCC must then decide what is the best use of a frequency and which user will best serve the public interest. These decisions require the agency to do the very thing its critics say it is incapable of doing—balancing incommensurable interests such as incumbents' investment-backed reliance in existing licenses with the promise of new technologies.[131] As one commentator has put it, we operate under "a 'wise man' theory of regulation [which assumes] that the agency is capable of deciding what is best for the public."[132] The judgments reached by the FCC, which have been described as both "prophetic and managerial," are then treated with uncommon deference by reviewing courts.[133]

---

could decode less powerful signals. Each of these valuations is highly speculative. There have been attempts to document the relative value of broadcasting and other prospective services that might operate on the same spectrum. *See, e.g.*, EVAN R. KWEREL & JOHN R. WILLIAMS, CHANGING CHANNELS: VOLUNTARY REALLOCATION OF UHF TELEVISION SPECTRUM (FCC Office of Strategic Planning & Policy Analysis, OPP Working Paper No. 27, 1992), *available at* http://www.fcc.gov/Bureaus/OPP/working_papers/oppwp27.pdf. I have suggested elsewhere that such valuations tend to have serious methodological flaws because they rely on rapidly obsolete spectrum auctions or other sales and equate services with radically different characteristics and operational needs. *See* Ellen P. Goodman, *Digital Television and the Allure of Auctions: The Birth and Stillbirth of DTV Legislation*, 49 FED. COMM. L.J. 517, 533–35 (1997).

129. *See, e.g.*, Promoting Efficient Use of Spectrum Through Elimination of Barriers to the Development of Secondary Markets, 15 F.C.C.R. 24,203, 24,206 (2000); *see also* Principles for Promoting the Efficient Use of Spectrum by Encouraging the Development of Secondary Markets, 15 F.C.C.R. 24,178, 24,182–83 (2000) (stating that "[a]n effectively functioning system of secondary markets would encourage licensees to be more spectrum efficient by freely trading their rights to unused spectrum capacity").

130. 47 U.S.C. § 301 (2000) (providing that "[n]o person shall use or operate any apparatus for the transmission of energy or communications or signals by radio . . . except under and in accordance with this chapter and with a license in that behalf granted under the provisions of this chapter"). The allowance of spectrum leasing on a large scale will effectively loosen this requirement.

131. *See, e.g.*, Hazlett, *The Wireless Craze*, *supra* note 3, at 403–53 (discussing how the regulatory system suppresses competitive entry, blocks efficient spectrum use, and protects obsolete technology from innovative challenge).

132. WEBBINK, *supra* note 109, at 10.

133. *See* Teledesic LLC v. FCC, 275 F.3d 75, 84 (D.C. Cir. 2001) (according the agency the greatest deference for decisions in which "it must predict the effect and growth rate of technological newcomers on the spectrum, while striking a balance between protecting valuable existing uses and making room for these sweeping new technologies"); *see also* Aeronautical Radio, Inc. v. FCC, 928 F.2d 428, 443–45 (D.C. Cir. 1991) (upholding an FCC allocation decision because it was a predictive judgment of the type historically left to agency discretion); Telocator Network of Am. v. FCC, 691 F.2d 525, 538 (D.C. Cir. 1982) (observing that in its spectrum decisions, the FCC "functions as a policymaker and, inevitably, a seer—roles in which it will be accorded

Even if the FCC could be counted on to reach the most efficient and fair result, a spectrum allocation typically takes several years. The length of the process alone results in significant consumer welfare losses.[134] Moreover, the process inevitably makes spectrum available to services that appeared more promising when the FCC began its rulemaking process than when the first signal is emitted. Because allocations or reallocations consider only apparent current or immediately foreseeable demand, "there is no guarantee that there may not be some other higher value current or future alternative use."[135] For example, in 1995, when the FCC first began the process of allocating spectrum to mobile satellite services, terrestrial digital wireless service was still in its infancy and was not thought to become ubiquitous for many years. Moreover, much of the world was without mobile telephone service at all. It was thought that satellite service would fill a valuable market niche by providing ubiquitous mobile telephony service. By the time the service was finally authorized in 2000, terrestrial digital wireless service had become ubiquitous and most of the satellite service companies were in bankruptcy.[136]

The combination of public interest decisionmaking, delay, and inevitable short-sightedness of spectrum decisions has led critics of all kinds to assail FCC frequency allocations as inconsistent with the needs of the day. Protection afforded to incumbents and the deferred entry of new uses render those allocations, in the words of one critic, "a fossilized record of fading services and technologies."[137]

---

the greatest deference by a reviewing court").

134. *See* Jerry A. Hausman, *Valuing the Effect of Regulation on New Services in Telecommunications*, *in* BROOKINGS PAPERS ON ECONOMIC ACTIVITY: MICROECONOMICS 1, 2 (Martin Nell Bailey et al. eds., 1997), *available at* http://www.nextera.com/pdf/ValuingTheEffectofRegulation.pdf (estimating, using assumptions and estimates about consumer demand, pricing, and welfare loss, losses of about $1.27 billion per year in consumer welfare for voice messaging and about $50 billion per year in consumer welfare loss for cellular telephone due to regulatory delay in authorizing services); JEFFREY H. ROHLFS ET AL., NAT'L ECON. RES. ASSOCIATES, INC., ESTIMATE OF THE LOSS TO THE UNITED STATES CAUSED BY THE FCC'S DELAY IN LICENSING CELLULAR TELECOMMUNICATIONS 1 (1999) (estimating that the delay in rollout of cellular telephone service by 10 to 15 years reduced economic welfare by at least $86 billion). *See generally* Hazlett, *The Wireless Craze*, *supra* note 3, at 445, 477 (discussing costs of administrative delay).

135. WEBBINK, *supra* note 109, at 4–5.

136. *See* Bob Fernandez, *Mixed Signals; Satellite Industry Says Its Future Is Still Sky-High Despite Bankruptcies*, CHI. TRIB., Nov. 15, 1999, at C1.

137. MICHAEL CALABRESE, BATTLE OVER THE AIRWAVES: PRINCIPLES FOR SPECTRUM POLICY REFORM 10 (New Am. Found., Working Paper No. 1, 2001), *available at* http://www.newamerica.net/Download_Docs/pdfs/Pub_File_610_1.pdf. The problem of backward-looking allocations is exacerbated by the narrowness of allocations for particular classes of services. Industry typically wants narrow allocations. As former Commissioner Ness noted, "[S]pectrum bands are generally most efficient when the

III. PROPOSED REGIME CHANGE TO PRIVATE PROPERTY RIGHTS

Two radical alternatives have been proposed to correct the failings of administrative control of spectrum. The first, and most persistently advanced, is the conversion of administrative licenses to private property rights. This proposal starts and ends with the conception of spectrum as land. Over the past half-century, property rights theorists have urged the conversion of FCC licenses to spectrum deeds. Spectrum itself would not become property of course.[138] What would be owned would be the exclusive rights to transmit radio signals over the airwaves, to exclude others from transmitting, and to sell, trade, or reserve exclusive usage rights. Those advancing a second alternative to the current administrative regime, discussed in Part V, conceive of spectrum as air, not land, and urge the dissolution of any kind of exclusive usage rights in spectrum back into the aerial commons. Both of these proposals have significant appeal, and each provides an internally coherent approach to spectrum management. Problematically, neither addresses with specificity what should be done about spectrum conflicts once the administrative regime is dismantled or how questions about the relative desirability of spectrum uses should be resolved. That question—how spectrum disputes should be handled in a future telecosm and what the public role should be—will be the focus of the rest of this Article. This Part takes up this question in the context of the property rights proposal for spectrum management, which I will now describe.

A. Mediate Scarcity with Fee Simple Deeds

1. The Bundle of Spectrum Rights

The private ownership model of spectrum management accepts the premise of FCC spectrum regulation that the "radio spectrum is a limited

services within the band are similar. . . . [Broad or flexible allocations mean] [m]ore insulation is needed to separate incompatible uses, [and] [e]quipment becomes more expensive . . . ." Susan Ness, Remarks Before CTIA's Wireless '97 (Mar. 3, 1997) (transcript available at http://www.fcc.gov/Speeches/Ness/spsn709.html); *see also* FCC REPORT, *supra* note 39, at 22.

138. *See, e.g.*, Coase, *supra* note 2, at 25 (writing that spectrum rights are transmission rights); Howard A. Shelanski & Peter W. Huber, *Administrative Creation of Property Rights to Radio Spectrum*, 41 J.L. & ECON. 581, 584 (1998) (defining spectrum as the capability of transmitting and receiving signals).

resource."[139] Given this scarcity, it is appropriate to allocate rights to the resource just as we allocate rights to most other scarce resources: through market transactions that provide incentives for efficient use and satisfaction of consumer demand. The underpinnings of this regime would be unambiguous and perpetual property rights in spectrum.[140] Included in such rights would have to be the privilege to operate a wide range of spectrum-related services and to deploy new technologies within certain minimal technical constraints.[141] Once endowed with spectrum parcels whose boundaries are clear and utility broad, spectrum owners would have a bundle of rights with respect to the disposition of their property much like the privileges of the land owner.[142] Most

139. STAN GIBILISCO, HANDBOOK OF RADIO AND WIRELESS TECHNOLOGY 547–48 (1999). The more nuanced view of Peter Huber, among others, is that there is no

> inherent scarcity of spectrum, [or any] law of physics that limits how much information can be transported through the air or through any other medium. Since 1927 we have increased by at least a millionfold the amount of information moving through the airwaves—and still we have not run out of space.

HUBER, *supra* note 6, at 75. However, in Huber's view, the absence of inherent scarcity does not mean that there is no practical scarcity, nor that property rights are unnecessary. *Id.* To the contrary, "[w]e would have increased the amount [of information transmitted] ten-million-fold, or a hundred, if the airwaves had been left in private hands all along." *Id.*

140. *See, e.g.*, De Vany et al., *supra* note 3, at 1531 (preferring perpetual rights, but acknowledging the political necessity of starting with a term of years that would allow any potential investor to recover investment). The United Kingdom is considering implementing rolling five- to ten-year terms or perpetual licenses with a compulsory repurchase provision for the government. U.K. RADIOCOMMUNICATIONS AGENCY, GOVERNMENT RESPONSE TO THE INDEPENDENT REVIEW OF RADIO SPECTRUM MANAGEMENT 20 (Oct. 15, 2002), http://www.ofcom.org.uk.

141. *See, e.g.*, Comments of 37 Concerned Economists, *supra* note 3, at 5–6 (arguing in the context of spectrum leasing that broadening the usage rights of licensees would promote efficient transfers of spectrum in secondary markets by reducing uncertainty and increasing flexibility of use and suggesting that the FCC eliminate all requirements not related to interference or anticompetitive concerns); Rosston & Steinberg, *supra* note 3, at 102 (writing that "[s]o long as a spectrum user's emissions comply with objective numerical standards, it should ordinarily be free to offer any services by using any technologies it wishes").

142. S*ee, e.g.*, Spiller & Cardilli, *supra* note 3, at 68 (describing the basic building blocks of a market for spectrum as the right to sell or lease the spectrum, the right to use the spectrum, and the right to exclude from the spectrum); Douglas W. Webbink, *Radio Licenses and Frequency Spectrum Use Property Rights*, 9 COMM. & L. 3, 4 (1987) (defining rights as the right to exclusive use, the right to receive income from the use of the resource, and the right to transfer the exclusive use right in whole or in part to others). An earlier definition of spectrum property rights was the constellation of (1) "emission rights," which are the entitlements to operate on a particular bandwidth at a specific time and place, at a particular power level, with rights to a certain amount of spurious emissions; (2) "admission rights," which are the rights to exclude others from using that spectrum; (3) "usage rights," which are the rights to use the spectrum in any legally permissible way; and (4) "transfer rights," which are the rights to transfer emission, admission, and usage rights freely. *See* Minasian, *supra* note 3, at 227–30. While the rhetoric of the bundle of sticks strongly influences communications policy, leading property theorists have suggested that the metaphor has lost its usefulness in

notably, they would be able to trade interference rights and freely alienate spectrum parcels.[143] These rights would be accompanied by correlative duties not to interfere with other property owners' rights to their own frequencies.[144]

Private spectrum ownership, its proponents claim, will result in both economic efficiency gains, as spectrum is redistributed from low-value users to high-value users, and in spectrum efficiency gains, as more efficient users replace less efficient users. Relatedly, there will be more competition in the communications sector as exiting from the market becomes easier, resources are freed up for new entrants, and incumbents can use existing spectrum in new ways. Finally, spectrum users will benefit from lower transaction costs resulting from the triumph of market mechanisms over the glacial administrative process. If there is a view of the public interest in this model, it is that the public interest is what emerges from the market choices of spectrum users.

In locating a model for spectrum ownership, scholars needed go no further than their front yards. The most influential real property model for spectrum grew out of ideas first presented in Leo Herzel's student note about the selection of a color television standard and later developed by Ronald Coase in the 1950s.[145] Coase observed that the central function of the FCC was to allocate rights to use spectrum in

property law. *See, e.g.*, Michael A. Heller, *The Boundaries of Private Property*, 108 YALE L.J. 1163, 1193–94 (1999) (writing that "[w]hile the modern bundle-of-legal relations metaphor reflects well the possibility of complex relational fragmentation, it gives a weak sense of the 'thingness' of private property").

143. *See, e.g.*, HARVEY J. LEVIN, THE INVISIBLE RESOURCE: USE AND REGULATION OF THE RADIO SPECTRUM 85 (1971); De Vany et al., *supra* note 3, at 1530; EVAN R. KWEREL & JOHN R. WILLIAMS, A PROPOSAL FOR A RAPID TRANSITION TO MARKET ALLOCATION OF SPECTRUM 5 n.11 (FCC Office of Planning & Policy, OPP Working Paper No. 38, 2002) (stating that the FCC should "provide for exhaustive, flexible, exclusive, transferable spectrum-usage rights"), *available at* http://hraunfoss.fcc.gov/edocs_public/attachmatch/ DOC-228552A1.pdf.

144. *See* Wesley Newcomb Hohfeld, *Fundamental Legal Conceptions as Applied in Judicial Reasoning*, 26 YALE L.J. 710, 742–45 (1917).

145. *See* Coase, *supra* note 2, at 14–15; Comment, *"Public Interest" and the Market in Color Television Regulation*, 18 U. CHI. L. REV. 802, 811–16 (1951) (proposing that the FCC lease broadcast channels to the highest bidder without making any judgment about the economic or engineering choices made by the broadcaster). Coase is often credited with the origination of the private property model for spectrum, but he cites earlier discussions. *See* R.H. Coase, *Evaluation of Public Policy Relating to Radio and Television Broadcasting: Social and Economic Issues*, 41 LAND ECON. 161, 167 (1965); R.H. Coase, *The Economics of Broadcasting and Government Policy*, 56 AM. ECON. REV. 440, 440, 444 (1966); Coase, *supra* note 2, at 31 n.56.

ways that minimized interference. Private property rights perform exactly the same function with land. The way to determine whether land would be used to grow wheat or to park cars, Coase observed, "is to create property rights (rights, that is, to exclusive use) in land. The creation of similar rights in the use of frequencies would enable the problem to be solved in the same way in the radio industry."[146]

A modified private ownership approach has emerged from the work of Gerald Faulhaber and David Farber.[147] These scholars, again coming from outside of legal scholarship, support the migration to a system of private property rights in spectrum while acknowledging the insight of the commons theorists that technical advances may allow more than one transmitter to use the same frequencies at the same time. Where such sharing is possible, Faulhaber and Farber say that private ownership rights should be subject to an easement for noninterfering uses.[148] In addition, some spectrum should be set aside, like parks, for use by the public.[149]

---

146. Coase, *supra* note 2, at 25–26.

147. Gerald R. Faulhaber & David Farber, Spectrum Management: Property Rights, Markets, and the Commons, *In re* Issues Related to the Commission's Spectrum Policies, ET Docket No. 02-135, at 2 (F.C.C. filed July 15, 2002).

148. This idea draws on the "underlay," once called "overlay," concept that has appeared in broadcast spectrum management reform proposals since at least the mid-1990s. *See, e.g.*, Spectrum Reform Discussion Draft: The Electromagnetic Spectrum Management Policy Reform and Privatization Act, 142 CONG. REC. 10,672, 10,673, 10,676 (daily ed. May 9, 1996) (statement of Sen. Pressler) (proposing that nonbroadcast services would be allowed to operate in broadcast bands on a noninterfering basis). Along the same lines, the FCC Spectrum Task Force recently proposed that new users be able to operate in owned or licensed bands up to a certain level of interference. FCC REPORT, *supra* note 39, at 30.

149. Faulhaber & Farber, *supra* note 147, at 14–18. Eli Noam theorizes yet a third system of private property rights in spectrum. It is one that partakes of both private and common property theories in that it accepts the need for a pricing mechanism to deal with spectrum scarcity, but rejects the use of a fee simple approach to spectrum ownership. Instead, Noam envisions a commodities market for exclusive transmission rights in spectrum. Clearinghouses would mete out spectrum usage rights in small increments. Bandwidth could be aggregated instantaneously for use on a fluid basis and access charges would vary with congestion. *See* Eli M. Noam, *Spectrum Auctions: Yesterday's Heresy, Today's Orthodoxy, Tomorrow's Anachronism: Taking the Next Step to Open Spectrum Access*, 41 J.L. & ECON. 765, 778–80 (1998); Eli M. Noam, *Taking the Next Step Beyond Spectrum Auctions: Open Spectrum Access*, 33 IEEE COMM. MAG. 66, 66 (1995). Noam's program has been criticized as unworkable because of the "highly complex and massive infrastructure" that would be needed to permit centralized control of the spectrum, with each device using any one of a variety of wireless communication interfaces conveying signal measurements to the central controller. *See* Durga P. Satapathy & Jon M. Peha, *Spectrum Sharing Without Licenses: Opportunities and Dangers*, *in* INTERCONNECTION AND THE INTERNET: SELECTED PAPERS FROM THE 1996 TELECOMMUNICATIONS POLICY RESEARCH CONFERENCE 49, 50–51 (Gregory L. Rosston & David Waterman eds., 1997). Uniform spectrum units, along the lines that Noam envisions, have been created in Australia, which uses standardized packets, or cubes, defined by geography and frequency and combinable to increase

Under the real property model of spectrum property rights, interests in a parcel of spectrum, unlike a parcel of land, might be difficult to establish and defend. The metes and bounds of spectrum usage rights must be described along four dimensions: the time of transmission, the range of transmission, the power level of transmission, and the frequency of transmission. Within a particular geographic market or region, these four dimensions can be collapsed into three because power levels typically correlate with geographic range in that the stronger the signal, the farther it travels.[150] That is, once a place like the East Coast, New York City, one of its boroughs, or even one of its neighborhoods, has been identified, a spectrum parcel would be defined by the right to achieve a particular signal strength on particular frequencies at particular times.[151] It would be the task of government to define and make initial allocations of spectrum property rights.[152] Private property theorists also draw on the administrative apparatus of land ownership in proposing a spectrum rights registry, like the county record of land interests.[153] If ownership in spectrum is based, at least initially, on the contours of spectrum usage rights delineated in individual licenses, then it will be almost impossible for the public to determine who owns what. Prospective spectrum buyers would want a reliable registry that identified spectrum interests along the relevant dimensions so they could

coverage or bandwidth. *See* Spiller & Cardilli, *supra* note 3, at 73–81 (describing the spectrum market approaches in New Zealand and Guatemala).

150. Arthur De Vany, who first developed a detailed proposal for spectrum trading, referred to only three technical dimensions of radiation—time, area, and spectrum (or frequency). He called these TAS units. *See* De Vany et al., *supra* note 3, at 1512–16; *see also* FCC REPORT, *supra* note 39, at 18 (defining spectrum rights parameters as designated frequency range and bandwidth; geographic scope of right to operate; maximum power output within the band and outside the band; and interference protection).

151. Spiller and Cardilli argue that spectrum property owners should be required to maintain a minimum signal strength as well as restricted to a maximum signal strength at the boundary of the coverage area. The purpose of the minimum signal strength would be to prevent property owners from operating services that are hypersensitive to interference. The purpose of the maximum signal strength is to protect adjacent channel users in the same area and cochannel users in neighboring areas. Spiller & Cardilli, *supra* note 3, at 71–72.

152. *See* FCC REPORT, *supra* note 39, at 35; KWEREL & WILLIAMS, *supra* note 143, at 4–5 (advocating that the government exhaustively allocate spectrum rights).

153. Such spectrum registries exist in Australia and New Zealand. *See* Australian Communications Authority, *Register of Radiocommunication Licenses*, *at* http://www.aca.gov.au/pls/radcom/register_search.main_page (last visited Nov. 9, 2003).

aggregate suitable spectrum parcels.[154] The FCC does not currently maintain such a registry. Unless government or some sort of accredited private party were to develop a registry of spectrum ownership interests, the costs of title searches and related barriers to entry would likely be high.[155]

2. From Licenses to Estates

While the concept of estates in spectrum is relatively straightforward, the mechanics by which a system of administrative licenses would be converted to a system of fee simple deeds have not been identified. Most tangible public assets that are privatized, like land and public concessions, are in the hands of the government and can simply be auctioned off. Like such public assets, spectrum usage rights are controlled by the government. Yet, unlike government property, many of these rights have already been auctioned off, in many cases for hundreds of millions of dollars. Where they have not been auctioned, they may have been purchased as part of the sale of a communications company.

In this way, most of the prime spectrum (below 3 GHz) is already occupied by stakeholders or has been made available for unlicensed use. Although licenses to use spectrum are not in fact property rights and licensees are denied the privileges of property ownership, courts have still recognized in FCC licenses some of the attributes of private property.[156] These attributes include the reliance interests licensees may

---

154. De Vany et al., *supra* note 3, at 1530 (writing that a spectrum registry should cover "changes in boundaries of [transmission right] areas, sales or leases of [transmission right] combinations or of any [transmission right] component, and any other transaction affecting the use of a [transmission right] combination that a potential purchaser would care to know about"); Hazlett, *The Wireless Craze*, *supr*a note 3, at 544; White, *supra* note 3, at 31 (writing that "[a] national registry of spectrum ownership would be maintained, comparable to local land registries"). A similar registry has been proposed for the United Kingdom. *See* MARTIN CAVE, REVIEW OF RADIO SPECTRUM MANAGEMENT: AN INDEPENDENT REVIEW FOR DEPARTMENT OF TRADE AND INDUSTRY AND HM TREASURY 13 (2002) (proposing a public "on-line database of spectrum assignments"), *available at* http://www.spectrumreview.radio.gov.uk/2002reveiw/2_title-42.pdf

155. *See* Promoting Efficient Use of Spectrum Through Elimination of Barriers to the Development of Secondary Markets, 18 F.C.C.R. 20,604 (2003) (recognizing that intensive spectrum leasing within the existing administrative regime "would require tradeoffs in multiple dimensions—e.g., time, space, geography, type of use, and technology—and that, in the absence of an effective facilitator, search costs would be high").

156. *See, e.g.*, *In re* Atl. Bus. & Cmty. Dev. Corp., 994 F.2d 1069, 1073–74 (3d Cir. 1993) ("The Communications Act itself seems to imply the existence of a limited property right in an FCC license once it is granted. Section 301 . . . implies the creation of rights akin to those created by a property interest limited only by the 'terms, conditions and periods of the license.'"); Orange Park Fla. T.V., Inc. v. FCC, 811 F.2d 664, 674 n.19 (D.C. Cir. 1987) (holding that, while a broadcast license is not a full-

have in retaining their licenses as well as in maintaining the specific terms of their licenses.[157] The treatment of FCC licenses as property like any other asset in bankruptcy proceedings demonstrates the same phenomenon of quasi-propertization.[158] Given the existence and recognition of quasi-property rights in spectrum, it is hard to conceive of a devolution of spectrum management from public to private spheres that bypassed these existing stakeholders, who in so many ways already look like proprietors. In other words, the government is not about to "repossess" spectrum from licensees in order to auction off spectrum deeds.

Far more conceivable is a process by which the stakeholders themselves would become owners. Just as first possession has provided the starting point for initial property assignments in the real world, so too private property rights in spectrum would probably grow out of what is. In this vein, to avoid frustrating the interests of existing licensees, many of whom paid for their usage rights at auction, it has been proposed that licenses simply be converted to spectrum deeds in a "big bang" revolution in spectrum management.[159]

The transformation of existing licenses into fee simple deeds, whether it happened in a big bang or a slow drift, would have significant interference consequences that have not been addressed by private

---

fledged, indefeasible property interest, "neither is it a non-protected interest, defeasible at will. Indeed, to suggest as much would, among other things, throw considerable doubt on the Commission's well-known recognition of a renewal expectancy that leads applicants to vie for licenses which, if awarded, will require a significant expenditure of resources"); Reuters Ltd. v. FCC, 781 F.2d 946, 950 n.5 (D.C. Cir. 1986) (holding that a properly granted radio license is a "vested interest"); L.B. Wilson, Inc. v. FCC, 170 F.2d 793, 798 (D.C. Cir. 1948) ("[T]he Communications Act itself . . . recognize[s] that a broadcasting license confers a private right, although a limited and defeasible one.").

157. *See generally* William L. Fishman, *Property Rights, Reliance, and Retroactivity Under the Communications Act of 1934*, 50 FED. COMM. L.J. 1, 6–9 (1997); Shelanski & Huber, *supra* note 138, at 583–95 (analyzing the property rights of broadcast spectrum licensees based on the scope of their ability to use, alienate, subdivide, or transfer their spectrum authorizations); *see also* Krystilyn Corbett, Note, *The Rise of Private Property Rights in the Broadcast Spectrum*, 46 DUKE L.J. 611, 634–36 (1996). These accounts of administrative entitlements as a new form of property owe much, of course, to Charles Reich's seminal article on the administrative creation of property rights. *See generally* Charles A. Reich, *The New Property*, 73 YALE L.J. 733 (1964).

158. *See* FCC v. Nextwave Pers. Communications, Inc., 537 U.S. 293, 299, 308 (2003) (holding that the FCC was not permitted under federal bankruptcy law to rescind a license from a bankrupt bidder for failure to pay auction fees because the license was an asset in bankruptcy and the FCC an ordinary creditor).

159. *See* KWEREL & WILLIAMS, *supra* note 143, at 2 (proposing big-bang auctions); *see also* De Vany et al., *supra* note 3, at 1529–34 (supporting this proposal).

property advocates. As discussed above, with the exception of newly granted flexible use licenses, existing licenses are service based.[160] Licenses not only define spectrum usage rights along three dimensions, but also dictate what services can be transmitted, perhaps also dictating what technologies can be used. The power levels designated by existing service rules are thus premised on the use of a particular architecture, certain equipment, and specialized service needs. Radio and cellular phone service, for example, use dramatically different technical architectures, and these differences are reflected in the rules governing each service.

If the property rights of licensees, as well as new entrants, were defined by the terms of existing licenses, these service rules would have to be eliminated or substantially relaxed. This is because the existing service rules prevent most of the trades spectrum owners would want to make. Under existing rules, for example, Jane would not be able to sell her radio transmission rights to Mike for Mike's operation of a cellular phone service, even if Mike agreed to operate according to the same technical limitations (frequency, time, and power) that bind Jane. A relaxation of service rules, permitting more flexibility in the use of spectrum, would be necessary to allow efficient trades. But such relaxation—a disassociation of technical specifications and service rules—is likely to engender increased interference even if every operator kept its power emissions in check. This is true for the same reasons that increased flexibility in the current regime has increased interference concerns.[161] The technical specifications might be rendered either over- or under-protective, meaning that Mike's cellular system might cause significantly more interference, or be more sensitive to interference, than Jane's radio service. The result would be greater uncertainty about the integrity of wireless systems and greater conflict over interference.

Given the likelihood of increased conflict in an altered spectral environment, populated by property owners with substantial flexibility to change technology and network configurations, an account of private property rights in spectrum is not complete without an account of conflict resolution.

B. Common Law Resolution of Spectrum Conflicts

Private property rights theorists, were they to acknowledge the increased interference conflict that would accompany the propertization of spectrum, might well dismiss the costs of such conflict as

160. *See supra* Part II.A.
161. *See supra* Part II.B.3.

insignificant compared with the efficiency gains that a property rights system promises.[162] In fact, proponents of spectrum property tend to minimize the challenges of conflict resolution by looking to courts to resolve the disputes of neighboring owners in radio as in land, as if this kind of adjudication were relatively frictionless.[163] Specifically, Coase suggested that spectrum owners could vindicate rights against interference through actions like nuisance or trespass and then trade such rights to the entity that most values the interference-free spectrum.[164] This basic vision has been incorporated into the work of almost all those who advocate private property rights in spectrum, where nuisance and trespass are invoked as talismans. None of the private property theorists analyzes with any rigor how these causes of action might be applied to interference disputes or identifies the costs that might inhere in the vindication of property rights.

Of all the spectrum property theorists, Arthur De Vany and colleagues, in their 1969 article, devoted the most attention to interference dispute resolution. De Vany advocated a strict liability standard for any transmission within the area that is protected by a spectrum owner's property rights. Injunctions, he argued, should be granted as a matter of right to any complainant who established that his rights had been violated.[165] Although spectrum use has evolved substantially since

162. The early advocates of property rights in spectrum did acknowledge the costs of a private exchange. *See, e.g.*, De Vany et al., *supra* note 3, at 1507–08 ("Exchanging rights is a costly process; it includes the costs for both buyers and sellers of searching out, negotiating, and enforcing mutually beneficial exchange opportunities."); *see also* Minasian, *supra* note 3, at 269 ("[The proposal has] assumed that emission rights could be defined in terms of single-valued power levels—that signal levels did not vary—and that there was no cost associated with enforcing these rights.").

163. *See, e.g.*, HUBER, *supra* note 6, at 72–76 (proposing that common law courts, rather than the FCC, adjudicate interference disputes using theories of trespass and nuisance); Hazlett, *supra* note 6, at 149 (contending that common law courts can, and always could have, mediated interference disputes); *see also* RICHARD A. EPSTEIN, PRINCIPLES FOR A FREE SOCIETY 211–12 (1998).

> [T]he original device for assigning frequencies imitated the patterns that had long been used for determining the ownership of unowned land: the first person who used a frequency [consistently and regularly over a period of time, with the intention to exclude others] was entitled to keep it in perpetuity. . . .
>
> . . . The basic rights could have been protected by trespass analogies. The frequencies could be used, sold, leased, or mortgaged like any other physical asset.

Id. (footnote omitted).

164. *See, e.g.*, Coase, *supra* note 2, at 26–29.

165. De Vany et al., *supra* note 3, at 1521, 1549.

1969, the treatment of spectrum-related, common law actions has not. Pablo Spiller and Carlo Cardilli have recently advocated a property rights system in which there would be a cause of action under "tort law to protect . . . broadcast rights against trespassers" with a damages remedy.[166] Faulhaber and Farber have advocated a system of trespass wherein spectrum owners would be liable for any incursion into the spectrum of another.[167] At the same time, they also suggest a system of nuisance, implying a system in which liability would lie only where the signal incursions are unreasonable and the harm substantial.[168]

The casual treatment of liability and remedies in the interference context seems to reflect a belief that spectrum is enough like land that good old nuisance and trespass, no matter how troubled their application in the real estate context, will rise to the challenge spectrum presents. Peter Huber, for example, asserts the following:

> Had the courts been given time to develop it methodically, this simple idea [of spectrum ownership] would have created property rights in the ether, much as the common law had created property rights in the land beneath it—rules of trespass, easement, nuisance, and the like that define the bounds of ownership in real estate.[169]

The apparent source of the private property theorists' confidence in common law resolution of spectrum disputes is a 1926 Illinois state court's application of trespass law to a case of radio interference. There, the court enjoined a new broadcaster's interference with an existing broadcaster, invoking the time-honored principle of property law that

---

166. Spiller & Cardilli, *supra* note 3, at 70, 72.

167. Faulhaber & Farber, *supra* note 147, at 7–8. "In a property rights regime, [restrictions on power emissions] would be codified in the property rights of the frequency owner, who would then be subject to civil penalties should he or she violate these restrictions." *Id.*

168. *Id*. (comparing potential spectrum use limitations to "my right to use my real property[, which] is restricted by noise and nuisance statutes of my state, county and local municipality").

169. HUBER, *supra* note 6, at 29. For a critique of Huber's reliance on the common law, see Tom W. Bell, *The Common Law in Cyberspace*, 97 MICH. L. REV. 1746, 1770 (1999) (book review) (writing that Huber "too readily embraces a variety of rules that would both clog common law processes and contradict common law principles"); John F. Duffy, *The FCC and the Patent System: Progressive Ideals, Jacksonian Realism, and the Technology of Regulation*, 71 U. COLO. L. REV. 1071, 1102–03 (2000) (noting how difficult it would have been to establish common law adjudication over spectrum disputes especially given that such disputes were likely to be interstate). Interestingly, Peter Huber has strongly opposed the substitution of common law remedies for administrative ones where environmental pollution is at issue, although it is hard to see why a court would be more capable of resolving conflicts arising from ambient air noise than it would be of resolving conflicts arising from ambient air contamination. *See, e.g.*, Peter Huber, *Safety and the Second Best: The Hazards of Public Risk Management in the Courts*, 85 COLUM. L. REV. 277, 330–35 (1985) (asserting that courts do not have the perspective to make adequate comparisons of risk in complex environmental pollution cases).

"priority of time creates a superiority in right."[170] Relying on this decision, private property rights theorists suggest that courts might have developed a common law based on real property causes of action to resolve interference claims if Congress had not stepped in to regulate.[171] Interestingly, it is not clear how the Illinois court would have resolved the complaint in the absence of executive agency guidance, since it was reliance on administratively-determined technical criteria that guided the judge in assigning liability.[172]

There is reason to believe that common law courts struggling to sift through complex issues of causation, thresholds of liability, and remediation might have had great difficulty in assigning rights. Like Coase before them, the contemporary property rights theorists neglect the institutional and legal dimensions of conflict resolution.[173] Whether the desired common law system would be administered by general common law courts, specialized courts, or FCC administrative law judges is addressed only in passing.[174] Whether the law that would be applied would be state common law, federal common law, or some mixture of common law and statutory law or regulation is not addressed at all. Moreover, there is no discussion of why a common law system should be expected to resolve spectrum disputes, particularly in cases of complex interference, when the common law

170. Tribune Co. v. Oak Leaves Broad. Station Inc. (Cir. Ct., Cook County, Ill. 1926), *reprinted in* 68 CONG. REC. 215, 215–19, 69th Cong. (2d Sess. 1926).

171. *See, e.g.*, Hazlett, *The Wireless Craze*, *supra* note 3, at 366–73.

> Radio developed in an "orderly" fashion under priority-in-use rules. These rules did not depend on public interest regulation; the rules were enforceable via common law principles adjudicated by federal regulators lacking public interest discretion (as demonstrated by the U.S. Department of Commerce up until July 9, 1926), or by state courts . . . .

Id. at 371; *see also* Thomas W. Hazlett, *Is the "Public Interest" in the Public Interest?: The Broadcast License Bargain of 1927*, *in* TELECOMMUNICATIONS POLICY: HAVE REGULATORS DIALED THE WRONG NUMBER? 49–50 (Donald L. Alexander ed., 1997).

172. For this insight, see Charles Jackson, Was a Common Law Solution to Chaos in the Radio Waves Reasonable in 1927?, Public Notice of FCC Spectrum Policy Task Force, ET Docket No. 02-135, at 9 (F.C.C. filed July 8, 2002).

173. *See, e.g.*, Thomas W. Hazlett, *Physical Scarcity, Rent Seeking, and the First Amendment*, 97 COLUM. L. REV. 905, 908 (1997); Hazlett, *supra* note 6, at 148–52; Hazlett, *The Wireless Craze*, *supra* note 3, at 339; *see also* R.H. Coase, *Comment on Thomas W. Hazlett: Assigning Property Rights to Radio Spectrum Users: Why Did FCC License Auctions Take 67 Years?*, 41 J.L. & ECON. 577, 579 (1998).

174. *See, e.g.*, KRATTENMAKER & POWE, *supra* note 30, at 17 (advocating a federal court system); White, *supra* note 3, at 31 (same); *see also* Faulhaber & Farber, *supra* note 147, at 9 (suggesting special "spectrum" courts or common law courts); Hazlett, *The Wireless Craze*, *supra* note 3, at 551–55 (envisioning specialized spectrum courts).

has been largely abandoned in the air pollution context.[175]

The failure of private property theorists to grapple with the implications of their regime change for interference conflicts calls out for careful inquiry into such conflicts and the way in which a common law system might or might not be able to improve on FCC resolution. Such inquiry, and its implications for spectrum rights in the telecosm to come, follows.

IV. FCC RESOLUTION OF SPECTRUM CONFLICT THROUGH THE LENS OF NUISANCE

Private property theorists advance an essentially deregulatory agenda. They envision a telecosm in which markets liberate communications from government decisionmaking. One of the claimed benefits of this liberation is that access to spectrum will no longer depend on an opaque and often ad hoc administrative decisionmaking process. In this Part, I argue that the characteristics and limitations of nuisance law make it unlikely that these hopes will be realized. The nuisance law emerging from contemporary courts will require normative judgments about preferred communications technologies and consumer applications. Moreover, these judgments will be made by governmental decisionmakers facing the kinds of tradeoffs that have bedeviled the FCC in distributing spectrum usage entitlements. Nuisance law will be unpredictable for those disputes that look like conflicts over land and unsuitable for those disputes that do not. In both cases—within the nuisance case and where nuisance actions will not lie—administrative guidance should play a meaningful role in spectrum dispute resolution.

To assess whether the common law is equipped to resolve spectrum disputes, and what the implications of dispute resolution might be for spectrum management reform, it is necessary to begin with the common law as it exists in the real world.

A. Nuisance Versus Trespass Law

In positing common law causes of action for wireless interference, private property theorists use the terms "nuisance" and "trespass" without precision or clear differentiation.[176] At common law, of course, these doctrines are distinct. Trespass is a physical invasion of property that interferes with the owner's interest in *exclusive possession* of his property.[177] Historically at common law, trespass liability could be

175. *See infra* notes 406–09.
176. *See supra* notes 165–68.
177. RESTATEMENT (SECOND) OF TORTS § 158 (1965).

imposed even for harmless intrusions, so sacred was the right of the property owner to exclude.[178] By contrast, a private nuisance is an invasion, whether physical or not, of another's interest in the *use and enjoyment* of land.[179] Thus, the property right interfered with by a nuisance is not the possessory right to land, but the right to be free from the nuisance.[180] Today, nuisance liability will lie only for interferences that are substantial and unreasonable.[181] Whether or not an interference is unreasonable depends on a complex balancing of the economic stakes for the plaintiff and defendant, as well as consideration of the greater public impact of proposed remedies and fairness issues.[182]

In recent years, the distinction between trespass and nuisance has blurred at the edges. Courts have tried to make nuisance liability more automatic where harm is substantial and have declined to find trespass liability where there is no harm, thus bringing the two causes of action closer together.[183] Moreover, many jurisdictions no longer take seriously the distinction between physical and nonphysical intrusions.[184] For example, the uninvited entry of electronic signals onto a server has been found to be a trespass to chattels, even though electronic signals are not the kind of physical invasion traditionally recognized as trespass.[185]

178. *See generally* KEETON ET AL., *supra* note 21, § 13, at 67–70; Carol M. Rose, *Crystals and Mud in Property Law*, 40 STAN. L. REV. 577, 584 (1988).

179. RESTATEMENT (SECOND) OF TORTS § 821D (1977).

180. For an influential case underscoring the theory that the right to be free of nuisance is a property right, see *Boomer v. Atlantic Cement Co.*, 257 N.E.2d 870 (N.Y. 1970) (holding that the plaintiff was entitled to an injunction to stop the defendant's emissions of noxious air pollutants unless the defendant paid the plaintiff permanent damages to compensate for past, present, and future losses created by the nuisance).

181. *See* JESSE DUKEMINIER & JAMES E. KRIER, PROPERTY 750–51 (5th ed. 2002).

182. *See infra* Part IV.B.

183. *See* DUKEMINIER & KRIER, *supra* note 181, at 751–53; *see, e.g.*, Borland v. Sanders Lead Co., 369 So. 2d 523, 529 (Ala. 1979) (holding that the plaintiff could not sustain an action for trespass based on airborne pollution because there was no harm).

184. *See* Martin v. Reynolds Metals Co., 342 P.2d 790, 793–94 (Or. 1959) (holding that airborne pollution was a physical intrusion).

185. *See* Register.com, Inc. v. Verio, Inc., 126 F. Supp. 2d 238, 249–50 (S.D.N.Y. 2000); eBay, Inc. v. Bidder's Edge, Inc., 100 F. Supp. 2d 1058, 1069–72 (N.D. Cal. 2000) (holding that an aggregator of auction site data committed trespass to chattels when it invaded eBay's servers with hundreds of automated software query agents); *see also* Thrifty-Tel, Inc. v. Bezenek, 54 Cal. Rptr. 2d 468, 471–73 (Ct. App. 1996) (holding that the electrical signals dispatched by computer hackers were tangible enough to constitute trespass to personal property). *But see* Intel Corp. v. Hamidi, 71 P.3d 296, 300 (Cal. 2003) (holding that a former employee's mass emails to current employees was not trespass to chattels because there was no harm to server functionality). For a critique of the application of trespass doctrine to the Internet, see Dan L. Burk, *The Trouble with*

Liability for trespass to land has been found in the case of sound vibrations.[186] At the same time, electrical signals have been found to constitute a nuisance.[187]

Despite the overlap between the two causes of action, nuisance and trespass law still differ substantially at their cores. Thus, whereas nuisance law incorporates standards of reasonableness that make liability determinations maddenly erratic, trespass law remains the province of bright-line tests. Whereas damages remedies are common in nuisance law, injunctive relief is standard in trespass law. The choice between nuisance and trespass law is therefore not a trivial one for spectrum conflicts.

There is a way to conceive of radio interference, which results from the unwanted intrusion of electrical signals into a receiver, as either trespass or nuisance, but the actual analysis is likely to be much closer to the nuisance-like standard than to the trespass-like rule, particularly as the spectral environment grows more complex. To understand why this is, let us start with the first kind of simple interference conflict that looks most like trespass. In such a case, Jane emits more power than is permitted under the terms of her deed such that she "strays" into Mike's band. That is, Jane's deed permits the transmission of x watts, in y area, at z time, but she transmits $2x$ watts over $1.5y$. In a sense, Jane's excessive signal strength invades Mike's territory. On the surface, this case might look a lot like trespass in that it seems to implicate Mike's right to exclude.[188] Particularly if once conceives of interference as it is depicted in Figure 2, such an intrusion is hardly distinguishable from a person's playing soccer on his neighbor's yard. Spurious emissions into one's airspace might be analogized to spurious footfalls onto one's land.

The problem with such a trespass approach, beyond the incentives it creates for excessive monitoring and insufficient interference prevention on the plaintiff's part, is that interference does not really work this way, and spectrum property rights are unlikely to be defined this way. We have assumed that property rights in spectrum, like usage rights in FCC

Trespass, 4 J. SMALL & EMERGING BUS. L. 27, 33 (2000) (writing that courts have "collaps[ed] the separate doctrines of trespass to land and trespass to chattels back into their single common law progenitor, the action for trespass"); Dan Hunter, *Cyberspace as Place and the Tragedy of the Digital Anticommons*, 91 CAL. L. REV. 439, 484–85 (2003) (writing that courts have confused trespass to chattels, which requires a demonstration of harm, with trespass to real property, which does not require a showing of harm).

186. McNeill v. Redington, 154 P.2d 428, 429–30 (Cal. Ct. App. 1944).

187. *See, e.g.*, Page County Appliance Ctr., Inc. v. Honeywell, Inc., 347 N.W.2d 171, 175–76 (Iowa 1984) (holding that computer radiation from a travel agency that disrupted television reception in a neighboring appliance store was a nuisance).

188. This is the kind of trespass that De Vany imagined in 1969, when the wireless world was much simpler. *See* De Vany et al., *supra* note 3, at 1550.

licenses, are defined along three dimensions within an identified geographic area. The property owner will own the rights to transmit on certain frequencies, but will not own spectral territory (that is, a particular megahertz). As a result, the owner's right to exclude will be the right to keep others from using his transmission rights. Given this definition of rights, there can be no trespass by Jane onto Mike's territory unless Jane's signal interrupts, or can be predicted to interrupt, Mike's ability to transmit signals or Mike's receivers' ability to receive them.[189] Something called, or likened to, trespass law could be applied in these cases. But the cause of action would have none of the crystalline clarity that it does in the real world. Instead, given the rich interaction of rights and duties, it would be more like the muddy nuisance law, requiring proof of causation (did the excess emissions cause the intrusion or potential intrusion into the signal circuit?), harm (were transmission rights actually or potentially compromised?), and reasonableness (should Mike's receivers have performed better?), much as nuisance law does.

Now let us turn to the second, and more likely, way in which interference might occur between Jane and Mike. Suppose that Jane is transmitting within the contours of her spectral property—that is, at *x* power, within *y* area—but her operations have reduced the reliability or reach of Mike's transmissions.[190] In this case, Jane's permissible use of her property interferes with Mike's use and enjoyment of his property. This presents a classic nuisance case. Mike has no right to exclude Jane's signal emissions because they are authorized. Nevertheless, Jane's use of her property is compromising Mike's use of his. If spectrum were land, Mike would have a nuisance claim. As discussed above, a move to private property rights and the attendant increase in flexible use of the spectrum are likely to raise the incidence of this kind of interference case. Clashes between two permissible uses of spectrum are likely to overwhelm, and be far more difficult to resolve, than clashes between an impermissible and permissible use. Given the

189. Predicted interference might be proved, for example, if Mike were operating at less than full power such that Jane's emissions did not actually interfere with Mike's transmissions, but were detected by Mike and would likely interfere with Mike's full power transmissions.

190. This might be the case for any number of reasons, such as faulty modeling in the definition of initial entitlements to the spectrum or the introduction of new applications, in addition to poorly functioning receivers or atmospheric changes. *See supra* Part II.B.

dominance of the nuisance-like conflicts and the absence of the usual advantages that trespass law affords, common law in the spectrum context will rely primarily on a balancing approach typical of nuisance.

The application of nuisance law, of course, will require a standard of liability for an actionable interference. It will require a menu of remedies and some hierarchy among them. Most problematically, it will require a notion of the public interest—a notion not all that dissimilar from the one the FCC has notoriously applied—that can guide a decisionmaker to a proper balance of entitlements between vying communications systems.[191] The following sections will show just how difficult, costly, and value-laden the development of nuisance standards might be in the domain of spectrum.

B. Nuisance Law

Suppose that satellite and microwave licenses have been converted to spectrum deeds, and the owner of the satellite frequencies sues the microwave operator on an adjacent band for interfering with reception of the satellite signals. What law should a nuisance court apply? In the absence of any state or federal common law, such a court might well turn to the FCC's own precedent. The FCC does not conceive of itself as an arbiter of nuisance and rarely uses the language of nuisance to resolve spectrum interference claims. Nevertheless, like a nuisance court, the FCC is called upon to resolve disputes between "neighboring" holders of resource usage rights arising out of the disturbing, though often lawful, exercise of such rights. Sometimes these disputes arise between the holders of usage rights and prospective holders of such rights. These prospective interference claims turn on the same questions as actual intraservice and interservice spectrum disputes: What should be the respective rights and obligations of the parties who want to use spectrum in mutually injurious ways? In resolving such disputes over access to spectrum between existing wireless operators and between existing and prospective wireless operators, the FCC has used concepts and techniques that are familiar from nuisance law and that help elucidate the challenges for future nuisance courts.

After reviewing nuisance law standards of liability and the FCC's own approach to "liability," this section examines the ways in which the FCC's choices in resolving spectrum conflicts do and do not diverge from the conventional wisdom on the efficient assignment of rights. The aim of this discussion is to illuminate the challenges common law courts would face in adjudicating spectrum nuisance claims, as well as the

191. *See supra* Part II.C.

ways in which administrative decisionmaking might be harnessed by the courts to reduce the costs of private property in spectrum.

1. Common Law Standard of Liability

The first issue a nuisance court must determine is whether there is an actionable nuisance. In the real world, according to the widely followed *Restatement (Second) of Torts*, only an "intentional and unreasonable" interference with another's use and enjoyment of land will result in nuisance liability.[192] The determination of whether an intentional interference with property is unreasonable requires courts to balance the social utility of the interference with the gravity of the harm plaintiff has suffered.[193] The gravity of the harm will be measured by the extent and character of the harm, the social value of the plaintiff's activity, the suitability of the plaintiff's activity to the location, and the burden the plaintiff would bear in avoiding the harm.[194] The sum of these factors will then be balanced against the social value of the defendant's activity, the suitability of that activity to the location, and the impracticability of preventing the harm.[195] This balancing, commonly known as a balance of the utilities, is also known in various jurisdictions as a balance of the conveniences, a balance of the equities, or a comparative or relative hardship test.[196]

---

192. RESTATEMENT (SECOND) OF TORTS § 822(a) (1979). Most courts also add a requirement that the nuisance be substantial, although they tend to conflate the substantiality and unreasonableness tests. *See* WILLIAM B. STOEBUCK & DALE A. WHITMAN, THE LAW OF PROPERTY 414 (3d ed. 2000).

193. RESTATEMENT (SECOND) OF TORTS § 826(a) (1979). *See generally* DUKEMINIER & KRIER, *supra* note 181, at 751. If, in a damages action, plaintiff can show that "the harm caused [by the defendant] is serious and the financial burden of compensating for this and similar harm to others would not" make it infeasible for the defendant to continue its conduct, the court might not inquire into relative social values of the competing uses. RESTATEMENT (SECOND) OF TORTS § 826(b) (1979); *see, e.g.*, Crest Chevrolet-Oldsmobile-Cadillac, Inc. v. Willemsen, 384 N.W.2d 692, 695 (Wis. 1986).

194. RESTATEMENT (SECOND) OF TORTS § 827 (1979). The inquiry into the suitability of the victimized land use for its location is particularly important in the evaluation of harm and has resulted in what some commentators have called "judicial zoning," whereby courts end up determining the appropriate uses of land based on the kinds of nuisances they are willing to enjoin or deter. *See* J.H. Beuscher & Jerry W. Morrison, *Judicial Zoning Through Recent Nuisance Cases*, 1955 WIS. L. REV. 440, 443. For historical accounts of the development of nuisance law as zoning law, see MORTON J. HORWITZ, THE TRANSFORMATION OF AMERICAN LAW, 1780–1860, at 74–78 (1977).

195. RESTATEMENT (SECOND) OF TORTS § 828 (1979).

196. *See* George P. Smith, II, *Nuisance Law: The Morphogenesis of an Historical Revisionist Theory of Contemporary Economic Jurisprudence*, 74 NEB. L. REV. 658, 689

With the "unreasonable" interference test, developed in the early twentieth century and used regularly after appearing in the 1939 *Restatement of Torts*, courts sought to stabilize nuisance law between the early fierce protection of plaintiffs and an emerging solicitude for industrial defendants. When land uses were fairly uniform and contained within the boundaries of the property, courts had no trouble holding defendants liable for disturbing plaintiffs' quiet enjoyment of their property.[197] Courts tended to rigidly apply the principle of *sic utere tuo ut alienum non laedas*, roughly translated as an obligation to use your own property in a way that does not injure that of another, as a rule of strict liability that made any interference with another's enjoyment of his real property an actionable offense.[198]

Industrial land use created more demand for land and increased both the negative externalities, such as smoke and smell, and the positive externalities, generated by jobs and increased productivity, of land use.[199] Confronted with these new land use realities, courts became more sympathetic to industrial defendants whose innovative land uses disturbed plaintiffs, but provided great economic advantages. The prospect of these positive externalities challenged the privilege that traditional nuisance doctrine had afforded to preexisting uses.[200] Thus, apace with the development of industrial technology, courts swung to a defendant-centered approach that dominated in the mid-nineteenth century.[201]

The *Restatement*'s unreasonable interference test reflected a new view of nuisance and property law to emerge later in the nineteenth century.

(1995).

197. *See* Louise A. Halper, *Untangling the Nuisance Knot*, 26 B.C. ENVTL. AFF. L. REV. 89, 101 (1998). In an agrarian economy, where cross-boundary annoyances are few, land use conflicts

> can be subjected to an "act at your peril" rule of strict liability, without much damage to the economy. A rule of strict liability in regard to interference with land use was functional at the inception of the doctrine and for centuries thereafter, at least insofar as it protected established sources of wealth. Nuisance was thus not a contested doctrine during the period before the Industrial Revolution.

Id. (footnotes omitted). For a fairness-oriented defense of the strict liability, plaintiff-centered approach to nuisance law even under contemporary land use conditions, see Richard A. Epstein, *Nuisance Law: Corrective Justice and Its Utilitarian Constraints*, 8 J. LEGAL STUD. 49, 69 (1979).

198. *See* HORWITZ, *supra* note 194, at 74–76; *see also* Morgan v. High Penn Oil Co., 77 S.E.2d 682, 689 (N.C. 1953) (implementing the *sic utero* doctrine).

199. *See* Jeff L. Lewin, Boomer *and the American Law of Nuisance: Past, Present, and Future*, 54 ALB. L. REV. 189, 197 (1990).

200. *See generally* Paul M. Kurtz, *Nineteenth Century Anti-Entrepreneurial Nuisance Injunctions—Avoiding the Chancellor*, 17 WM. & MARY L. REV. 621, 632–33 (1976).

201. *See* Lewin, *supra* note 199, at 192–96, 200–04 (discussing swings between plaintiff-centered and defendant-centered approaches to nuisances). *See generally* Joel Franklin Brenner, *Nuisance Law and the Industrial Revolution*, 3 J. LEGAL STUD. 403, 406–07 (1974).

This was the view that property rights need not be absolute, but rather that the victim and the interferer might have correlative rights to be balanced. To accommodate economic development while still honoring preexisting property rights, courts tried to balance the value of incumbent and new uses.[202] The result was a standard for nuisance liability, under which a defendant would be liable for substantial interference with a plaintiff's property, but only where such interference was unreasonable.[203] Nuisance law thus evolved by the early twentieth century from a system of absolute protection of property rights (alternatively the plaintiff's or the defendant's) into "a doctrine of tort law, imbued with concepts of 'fault' and 'reasonableness.'"[204] Consistent with this move from property to tort theories, courts came to prefer damages to injunctions as the remedy of choice in nuisance actions.[205]

There are two basic points to note about modern nuisance law's balancing of the utilities at the liability stage. First, courts balancing such factors as the character of the parties' conduct, their relative economic costs, and the impact of liability on the community are clearly trying to maximize the economic utility of land use, but economic efficiency is not the only goal. Corrective justice or fairness goals also animate nuisance law. For example, an invasion of plaintiff's property interests will be unreasonable if the harm is "severe and greater than the

202. *See* RESTATEMENT OF TORTS § 826 cmt. b (1939) (providing that "[d]etermining unreasonableness is essentially a weighing process, involving a comparative evaluation of conflicting interests in various situations according to objective legal standards"); *Id.* § 822 ; *see, e.g.*, Hendricks v. Stalnaker, 380 S.E.2d 198, 202 (W. Va. 1989) (finding that "[u]nreasonableness is determined by balancing the competing landholders' interests"). *See generally* Lewin, *supra* note 199, at 189–201. Louise Halper associates the emergence of balancing in nuisance law with the assumption of jurisdiction over nuisance claims by courts of equity, which began to replace injunctions with damage awards such that "small-scale plaintiffs could have damages by way of compensation for their injuries, but they were denied the power to halt large-scale uses." Halper, *supra* note 197, at 113.

203. RESTATEMENT (SECOND) OF TORTS § 822 (1977). Contracting nuisance liability even further, courts began to hold that liability should not be imposed to compensate hypersensitive plaintiffs. *See id.* § 821F cmt. d (holding that a hypersensitive victim should not be able to recover on a nuisance theory); *see also* Belmar Drive-In Theatre Co. v. Ill. State Toll Highway Comm'n, 216 N.E.2d 788, 791–92 (Ill. 1966) (holding that no nuisance existed in the case of drive-in theater that was hypersensitive to light pollution). *See generally* Jeff L. Lewin, *Comparative Nuisance*, 50 U. PITT. L. REV. 1009, 1018 (1989); *see also* Robert G. Bone, *Normative Theory and Legal Doctrine in American Nuisance Law: 1850 to 1920*, 59 S. CAL. L. REV. 1101, 1151–52 (1986).

204. Lewin, *supra* note 203, at 1018; *see also* Bone, *supra* note 203, at 1159–60.

205. *See* SHELDON F. KURTZ & HERBERT HOVENKAMP, AMERICAN PROPERTY LAW 746 (3d ed. 1999).

[plaintiff] should be required to bear without compensation."[206] In other words, it may simply be unfair to deprive plaintiff of her property rights even where doing so would be efficient. Moreover, where the plaintiff has come to the nuisance, it may be unfair to characterize the invasion of his property interests as unreasonable even where doing so would be efficient.[207] The second thing to note, as we move back to consideration of the telecosm, is that nuisance law leaves judges wide berth to weigh the parties' interests and to balance them against any identified public interest. Some courts will favor the plaintiff's rights against the defendant's hardships, while others will focus more on the economic significance of the defendant's hardships than on the rights of the plaintiff. As one commentator has noted, "In the final analysis, the judicial 'call' is but a matter of judgment."[208]

2. Transaction Cost Theory of Entitlements

The ad hoc nature of nuisance liability in industrialized America challenged theorists to provide a system for choosing between plaintiffs and defendants at the liability stage, and between injunctions and damages at the remedy stage. No such system has had more influence on subsequent commentary, if not the courts themselves, than the framework developed in 1972 by Guido Calabresi and Douglas Melamed.[209] In their canonical article, Calabresi and Melamed applied Coase's theory of transaction costs to the resolution of nuisance disputes and came up with four rules of decision that continue to shape the discussion of resource management through the common law.[210]

---

206. RESTATEMENT (SECOND) OF TORTS § 829A (1979).

207. *Id.* § 840D.

208. Smith, *supra* note 196, at 703; *see also* Lewin, *supra* note 203, at 1029 (discussing various methods for evaluating nuisance claims).

209. *See* Calabresi & Melamed, *supra* note 10. The authors advanced their transaction cost theory for the allocation of entitlements in general and not only in land use conflicts, but the nuisance conflicts between Marshall and Taney were central to the article as they have been to the ensuing literature. *Id.* at 1115–16, 1122–23, 1122 n.62. *But see* Carol M. Rose, *The Shadow of* The Cathedral, 106 YALE L.J. 2175, 2176 (1997) (arguing that accidents, not nuisances, provided the inspiration for the work of Calabresi and Melamed).

210. *See* Calabresi & Melamed, *supra* note 10, at 1106–17. Important commentary on this article followed shortly after its publication. *See, e.g.*, A. Mitchell Polinsky, *Controlling Externalities and Protecting Entitlements: Property Right, Liability Rule, and Tax-Subsidy Approaches*, 8 J. LEGAL STUD. 1 (1979); A. Mitchell Polinsky, *On the Choice Between Property Rules and Liability Rules*, 18 ECON. INQUIRY 233 (1980); A. Mitchell Polinsky, *Resolving Nuisance Disputes: The Simple Economics of Injunctive and Damage Remedies*, 32 STAN. L. REV. 1075 (1980). More recently, and particularly after the twenty-fifth anniversary of the publication of the original article, a new wave of commentary has reinvigorated the debate on the proper application of property and liability rules in the resolution of nuisance disputes. *See, e.g.*, Ian Ayres & J.M. Balkin,

Calabresi and Melamed gave us a polluting property owner and his victim neighbor. The conflict between these two property owners might generate four possible results, summarized in Table 1 below. Under Property Rule One, the victim's entitlement to be free from pollution is protected by a property rule. The victim may enjoin the pollution. Under Liability Rule Two, the victim's entitlement to be free from pollution is protected by a liability rule. The victim must endure the pollution so long as he is paid court-assessed damages. Under Property Rule Three, the polluter's entitlement to pollute is protected by a property rule. The polluter may essentially enjoin the victim from complaining, meaning that a court would find no liability. Finally, Calabresi and Melamed "discovered" Liability Rule Four, under which the polluter's entitlement to pollute is protected by a liability rule. The polluter must cease polluting so long as he is paid court-assessed damages for the cost of ceasing or relocating his polluting activity.[211]

Legal Entitlements as Auctions: Property Rules, Liability Rules, and Beyond, 106 YALE L.J. 703 (1996); Ian Ayres & Eric Talley, *Distinguishing Between Consensual and Nonconsensual Advantages of Liability Rules*, 105 YALE L.J. 235 (1995); Ian Ayres & Eric Talley, *Solomonic Bargaining: Dividing a Legal Entitlement to Facilitate Coasean Trade*, 104 YALE L.J. 1027 (1995) [hereinafter Ayres & Talley, *Solomonic Bargaining*]; Richard R.W. Brooks, *The Relative Burden of Determining Property Rules and Liability Rules: Broken Elevators in the Cathedral*, 97 NW. U. L. REV. 267 (2002); Louis Kaplow & Steven Shavell, *Do Liability Rules Facilitate Bargaining? A Reply to Ayres and Talley*, 105 YALE L.J. 221 (1995) [hereinafter Kaplow & Shavell, *Reply*]; Krier & Schwab, *supra* note 107, at 440; Louis Kaplow & Steven Shavell, *Property Rules Versus Liability Rules: An Economic Analysis*, 109 HARV. L. REV. 713 (1996) [hereinafter Kaplow & Shavell, *Property Rules*]; Dale A. Nance, *Guidance Rules and Enforcement Rules: A Better View of the Cathedral*, 83 VA. L. REV. 837 (1997); Rose, *supra* note 209.

211. *See* Calabresi & Melamed, *supra* note 10, at 1115–18. As Calabresi and Melamed were writing their article, a court was actually applying Rule Four for the first and, as far as anyone seems to know, the last time. *See* Spur Indus., Inc. v. Del E. Webb Dev. Co., 494 P.2d 700 (Ariz. 1972). For details of the case, see *infra* note 264.

TABLE 1

RULE	ALLOCATION OF RIGHTS	RESULT
Property Rule One	Entitlement to victim Protected by property rule	Interference enjoined
Liability Rule Two	Entitlement to victim Protected by liability rule	Interference continues; Damages to victim
Property Rule Three	Entitlement to interferer Protected by property rule	Interference continues; No damages owed
Liability Rule Four	Entitlement to interferer Protected by liability rule	Interference enjoined; Damages to interferer

Calabresi and Melamed advanced the notion that property rules (Rules One and Three) should be used when the transaction costs associated with negotiation are not high enough to deter the parties from negotiating around an injunction to achieve the most desirable outcome.[212] A court should select between Rules One and Three as the interests of efficiency require. Rule One is superior on these grounds if the polluter/interferer is the least-cost avoider of the nuisance, and Rule Three is superior if the victim is the least-cost avoider. If it is not clear who is the cheaper cost avoider, the property right (to pollute or to be free from pollution) should be given to the party who faces higher transaction costs in negotiating a resolution to the dispute. Liability rules (Rules Two and Four) should be used when transaction costs are high enough to deter the parties from negotiating around an injunction to achieve the most desirable outcome.[213] The academic trend in recent years has been to favor liability rules even where the transaction costs of bargaining are low, but it is too soon to tell whether this new thrust will replace the conventional wisdom on the relative merits of property and liability rules.[214]

212. *See generally* Calabresi & Melamed, *supra* note 10, at 1106–10 (analyzing how different types of transaction costs affect the choice between property and liability rules).

213. *See id*. at 1106–10, 1115–19, 1125–27; *see also* Kaplow & Shavell, *Property Rules*, *supra* note 210, at 725–27 (arguing that liability rules are better in nonbargaining contexts where there are externalities because the court can arrive at a damages assessment more cheaply and accurately than can the parties). *But see* Krier & Schwab, *supra* note 107, at 455–56 (questioning whether courts' "assessment" costs are any lower than parties' transaction costs and any more likely to produce an efficient outcome).

214. *See, e.g.*, Ayres & Balkin, *supra* note 210, at 706–07; Ayres & Talley, *Solomonic Bargaining*, *supra* note 210, at 1032–33 (noting that liability rules, by splitting entitlements into a property right subject to an option and exposing private valuations of these entitlements, facilitate bargaining); *see also* Kaplow & Shavell, *Reply*, *supra* note 210, at 221. This literature has in turn provoked a defense of property

For the most part, and perhaps to the same extent as common law nuisance liability standards, the Calabresi and Melamed menu of remedies is designed to achieve economic efficiency. As a result, the framework provides clear direction for efficiency-maximizing resolutions of nuisance actions. Yet, the *Cathedral* authors explicitly recognize the pursuit of other values in the choice of remedies, such as justice and distributional goals.[215] Their decisional framework is less helpful when it comes to these goals and to tensions between efficiency and other values. As a result, the elegant lines of the *Cathedral* are only faintly visible in the multifactored decisionmaking of nuisance courts.

With this background in nuisance law principles, this Article proceeds to examine the precedent that communications law might provide for a common law court hearing a spectrum nuisance case, the special challenges FCC decisionmaking reveals, and how administrative law might be incorporated onto a property rights regime to ease dispute resolution.

C. FCC Resolution of Spectral Nuisance Cases

We saw in Part II that the FCC's resolution of spectrum conflicts is guided by the indeterminate public interest standard. To the extent that this standard is an amalgam of economic efficiency and fairness concerns, it is similar to the traditional goals of nuisance courts in resolving property disputes. As might be expected, public interest considerations inform the FCC's decisionmaking in unpredictable ways. It is uncertain in any given spectrum dispute, for example, whether the

rules. *See, e.g.*, Richard A. Epstein, *A Clear View of* The Cathedral*: The Dominance of Property Rules*, 106 YALE L.J. 2091, 2105–11 (1997) (arguing that property rules should dominate liability rules, at least when the risk of exploitation by the interferer is greater than the risk of holdout by the victim, to preserve the stability of possession); Daphna Lewinsohn-Zamir, *The Choice Between Property Rules and Liability Rules Revisited: Critical Observations from Behavioral Studies*, 80 TEX. L. REV. 219, 221–22 (2001) (arguing that negotiation under a property rule regime is likely to lead to more efficient and fair results than negotiation under a liability rule regime); *see also* Rose, *supra* note 209, at 2197–98 (arguing that the economic analysis of property and liability rules may have limited application in the realm of property law, where property rules should prevail).

215. *See* Calabresi & Melamed, *supra* note 10, at 1121–22 (considering tradeoffs between economic efficiency and distributional goals and demonstrating how rules that further economic efficiency might also further justice goals); *see also* Edward Rabin, *Nuisance Law: Rethinking Fundamental Assumptions*, 63 VA. L. REV. 1299, 1314–15 (1977) (arguing that Calabresi and Melamed conflated questions of efficiency and fairness).

FCC will adopt a preindustrial approach to property rights by protecting the victim of interference (generally the incumbent), or a modern balancing of the utilities approach, and split the entitlement between victim and interferer. In its efforts to facilitate exploitation of the spectrum resource, the FCC shows the same tendency evident in nuisance law at the turn of the last century. As discussed above, courts moved from a property rights approach favoring plaintiffs to a more nuanced balancing approach as land use pressures increased. Similarly, as pressures have increased on spectrum use, the FCC has been more receptive to arguments that interference to incumbents, even if harmful, should be tolerated.[216]

This section suggests that the similarity of approach between nuisance courts and FCC decisionmaking goes even deeper. Like nuisance courts, the FCC often strays from the economic efficiency ideal celebrated in the *Cathedral* literature. In large part, this is because the FCC, like nuisance courts, defines efficiency more complexly and values it less absolutely than is typical in the *Cathedral* literature. The explanation may also lie in the practical difficulties the FCC and courts face in accounting for the costs that liability rules require.

1. Administrative Standard of Liability

The FCC has its own standard of liability for spectral interference.[217] Interference is of regulatory concern only when it amounts to "harmful interference," defined as "[i]nterference which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service."[218] As with land, determinations about what spectrum uses will substantially and unreasonably interfere with neighboring uses are made at two stages. They are made first when the agency, acting in its zoning

216. *See infra* Part IV.C.2.b.

217. In the context of spectral nuisances, I am referring to simple interference cases between two users or two classes of users, and not to the complex interference that can occur as a result of generally increased signal loading in the atmosphere.

218. 47 C.F.R. § 2.1(c) (2002). This definition of harmful interference is incorporated into the service rules for many radio services. *See, e.g.*, *id.* §§ 21.2, 90.7, 101.3 (providing the definitions of harmful interference of the Domestic Public Fixed Radio Services (Multipoint Distribution Service), Private Land Mobile Radio Services, and Fixed Microwave Services, respectively). The operation of unlicensed devices is conditioned on not causing harmful interference to an authorized radio station. *Id.* § 15.5(b). The same term, "harmful interference," appears in the Communications Act without definition. The FCC "may, consistent with the public interest, convenience, and necessity, make reasonable regulations (1) governing the interference potential of devices which in their operation are capable of emitting radio frequency energy by radiation, conduction, or other means in sufficient degree to cause harmful interference to radio communications." *Id.* § 302a(a).

capacity, specifies the services that are permitted to operate in a given band. These decisions are premised on judgments about harmful interference and about which party should bear responsibility for causing and abating such interference. On the basis of these judgments, the FCC creates terms of entry for new services.[219]

Nuisance-like determinations are made again when the FCC comes to resolve disputes among spectrum users within and between zones.[220] Although these disputes are generally articulated in the context of a rulemaking proceeding rather than in a complaint process, the FCC acts like a court in determining how much service disruption constitutes harmful interference on a case-by-case basis.[221]

2. Transaction Cost Analysis of FCC Dispute Resolution

An efficiency-minded court might well ask how the FCC's grant of interference entitlements accords with the conventional wisdom derived from the Calabresi and Melamed transaction cost thesis of nuisance remedies. In other words, does FCC law provide precedent that would propel courts in a direction pleasing to private property theorists? Answering that question produces a more finely grained assessment of what common law judges would have to do to improve upon FCC

219. *See supra* notes 38–41 and accompanying text.

220. Conflicts between existing spectrum users are brought to the FCC in the form of petitions for rulemaking, comments to rulemaking proceedings concerning the creation of new conflicts, or much more rarely, in complaint proceedings.

221. Harmful interference also goes by the names of "serious degradation" and "repeated interruptions." *See, e.g.*, Comments of Sprint, *supra* note 122, at 13–17 (cataloging FCC definitions of harmful interference); *see also* Comments of National Public Radio, Inc., *In re* Issues Related to the Commission's Spectrum Policies, ET Docket No. 02-135, at 14 (F.C.C. filed July 8, 2002); Comments of XtremeSpectrum, Inc., *In re* Spectrum Policy Task Force Seeks Public Comment on Issues Related to Commission's Spectrum Policies, ET Docket No. 02-135, at 6–9 (F.C.C. filed July 8, 2002). According to XtremeSpectrum, the uncertain meaning of "harmful interference" was partly responsible for the controversy over the authorization of the ultra-wideband service. *Id.* at 6. In that proceeding, "parties generally concurred on the appropriate techniques for predicting interference, but differed greatly on what assumptions to use—and consequently differed on whether interference would or would not occur in practice." *Id.* at 8. FCC Commissioner Martin has expressed concern with the FCC's "case-by-case, *ad hoc* approach" to harmful interference, worrying that not only "does this approach cause a great deal of uncertainty for spectrum users and markets alike, [but] it also creates another problem: the appearance of results-oriented decisionmaking." Aircell, Inc., Petition, Pursuant to Section 7 of the Act, for a Waiver of the Airborne Cellular Rule, or, in the Alternative, for a Declaratory Ruling, 18 F.C.C.R. 1926, 1940 (2003) (Commissioner Martin, concurring).

decisionmaking, for which kinds of conflicts such improvement might or might not be possible, what kinds of "public interest" judgments such courts would be required to make, and what the future role of administrative law might be in a privatized spectrum management regime.

a. Property Rule One

In the main, with fairly few and recent exceptions, the FCC has resolved interservice and intraservice disputes by granting the entitlement not to be interfered with to the incumbent and protecting that entitlement by a property rule. In its "adjudicatory" capacity in resolving disputes between license holders, as well as in its zoning capacity in allocating initial rights to spectrum, the FCC has thus relied heavily on Rule One to distribute entitlements.[222]

The clearest display of Rule One in action is the FCC's invocation of the common law maxim "first in time, first in right" to resolve spectrum disputes in favor of the senior licensee. Under this principle, drawn from the dawn of property law, "the deployment of new facilities must protect existing licensees."[223] The agency has reached these decisions, as preindustrial nuisance courts did, on a finding of harm, without application of the transaction cost analysis that the *Cathedral* model recommends, and without searching inquiry into the relative value of the resource uses, as modern nuisance law requires. In cases of intraservice and uncomplicated interservice interference cases, the use of Rule One can be defended under the transaction cost analysis; in other cases it cannot.

In intraservice cases, which typically involve two parties using the spectrum for the same purpose, the use of Rule One would be perfectly consistent with the conventional wisdom distilled from Calabresi and

222. To the extent that the FCC sees itself as a zoning authority, it is unsurprising that it would favor absolute over partial entitlements. Municipalities issue orders of compliance to those who violate zoning orders to stop interfering uses. *See* Robert C. Ellickson, *Alternatives to Zoning: Covenants, Nuisance Rules, and Fines as Land Use Controls*, 40 U. CHI. L. REV. 681, 692 (1973). In the same way, the FCC enjoins the transmission of radio signals that will cause harmful interference to existing services.

223. Deployment of Wireline Services Offering Advanced Telecommunications Capability, 16 F.C.C.R. 2101, 2126 n.120 (2001); Deployment of Wireline Services Offering Advanced Telecommunications Capability and Implementation of the Local Competition Provisions of the Telecommunications Act of 1996, 14 F.C.C.R. 20,912, 21,008–09 & n.498 (1999) (tracing the history of the first-in-time, first-in-right principle in FCC jurisprudence). For application of this concept in nuisance law, see Helmkamp v. Clark Ready Mix Co., 214 N.W.2d 126, 129 (Iowa 1974) (citing Schlotfelt v. Vinton Farmers' Supply Co., 109 N.W.2d 695, 699 (Iowa 1961)). "Priority of occupation is a circumstance of considerable weight." *Id.*

Melamed. The interference in these cases can be compared to a common nuisance, which typically occurs between neighbors and is repetitive or long-term in nature. Such nuisances demand a permanent solution like an injunction, which the parties are fairly well-equipped to negotiate around.[224] Like neighbors, licensees in the same service cannot easily "move away" from each other. Their systems are designed to operate in the same band, usually using the same or similar technology.[225]

It is indeed Rule One that the FCC has applied to intraservice interference disputes, most frequently between broadcast licensees. The FCC has consistently held that "the 'newcomer' is responsible, financially and otherwise, for taking whatever steps may be necessary to eliminate objectionable interference."[226] In these cases, transaction costs will tend to be fairly low because the parties are identifiable, share a common technical architecture, and are knowledgeable enough about abatement strategies that they can easily negotiate around an injunction.[227] Indeed, in many such cases, the FCC permits the parties to negotiate around the victim's entitlement just as property owners might.[228]

The transaction cost analysis also supports the FCC's application of its

224. *See* Calabresi & Melamed, *supra* note 10, at 1118; Brooks, *supra* note 210, at 305. It is also possible that in a two-party transaction the transaction costs could be artificially high due to bilateral monopoly. For a discussion of the effect of bilateral monopolies on transaction costs, see RICHARD A. POSNER, ECONOMIC ANALYSIS OF LAW 68–70 (5th ed. 1998). Calabresi and Melamed recommend liability rules even in two-party transactions if there is a significant risk of hold-out problems. Calabresi & Melamed, *supra* note 10, at 1106–07.

225. *See supra* Part II.B.1. The widespread deployment of software defined radios, still some time away, will increase the mobility of services and therefore reduce the degree to which parties to an intraservice interference dispute are stuck with each other. *See infra* note 312.

226. Sudbrink Broadcasting of Georgia, Inc., Radio Station WIIN, Atlanta, Georgia, For Construction Permit to Relocate Atenna-Transmitter Site, 65 F.C.C.2d 691, 692 (1977); *see also* Amendment of Parts 1, 21 and 74 to Enable Multipoint Distribution Service and Instructional Television Fixed Service Licensees to Engage in Fixed Two-Way Transmissions, 14 F.C.C.R. 12,764, 12,781 (1999) (establishing that interference protection rights within the "wireless cable" services are based on a first-in-time, first-in-right philosophy); 47 C.F.R. § 101.105 (2002) (establishing interference protection criteria under which fixed microwave services must protect existing or previously applied for systems).

227. *See supra* note 212 and accompanying text.

228. *See, e.g.*, 47 C.F.R. § 24.236 (allowing parties to agree to a higher signal strength at the border of PCS service areas); *id.* § 73.623(g) (allowing digital television broadcasters to agree to accept additional interference from each other).

first-in-time, first-in-right principle to uncomplicated *interservice* interference disputes. In such cases, the parties are few, the interference easily documented, the harm well-understood, and the interference effects localized. For example, when a low-power television station causes interference to the signals carried through a cable system, the earlier user, whether it is the cable system or the low-power TV station, "will be given priority on the channel, and the later user will be responsible for correction of the interference."[229] The transaction costs involved in the cable system's negotiation of interference rights with the interfering broadcaster will tend to be fairly low. In these cases, as in intraservice interference cases, the use of a liability rule requiring a damages calculation might well entail more time and effort and might be more prone to error than would injunctive relief.[230]

It is when we arrive at more complicated interservice interference cases involving multiple operators that the FCC's use of Rule One becomes problematic. The FCC typically applies Rule One in these cases too, even though the transaction costs, including the costs of negotiations and hold-out premiums, are demonstrably high and negotiation around the entitlement is either not permitted or not efficient. For example, the FCC typically requires new licensees entering into encumbered spectrum to provide interference protection to the incumbents.[231] If the new services can share spectrum with incumbent licensees without causing harmful interference, they may do so. If the new services are incompatible with existing uses, the newcomers bear the full burden of mitigation.[232] In addition, the FCC has bucked its own inclinations to make spectrum allocations more flexible when doing so would obviously increase interference to incumbents.[233]

---

229. *Id.* § 74.703(d).

230. *See* Krier & Schwab, *supra* note 107, at 455 n.49. *But see* Brooks, *supra* note 210, at 276 n.41 (writing that the "Coase Theorem tells us that in the low-transaction-cost cases any damage award (just as any property rule) will achieve the efficient allocative result, and therefore the damage calculation does not require any more judicial effort or time than a simple order of injunctive relief").

231. *See, e.g.*, Auction of Licenses in the Lower 700 MHz Band Scheduled for May 28, 2003, 18 F.C.C.R. 3138, 3146 (2003) (citing interference protection that new licensees must provide to incumbent licensees); Lower and Upper Paging Bands Auction Scheduled for June 26, 2001, 16 F.C.C.R. 7657, 7666 (2001) (same); Auction of Licenses for Fixed Point-to-Point Microwave Services in the 38.6 to 40.0 GHz (39 GHz) Band, 15 F.C.C.R. 850, 858 (2000) (same); Auction of 800 MHz Specialized Mobile Radio Service Licenses, 13 F.C.C.R. 1875, 1877 (1997) (same).

232. *See, e.g.*, Amendment of Section 2.106 of the Commission's Rules to Allocate Spectrum at 2 GHz for Use by the Mobile-Satellite Service, 15 F.C.C.R. 12,315, 12,361 (2000).

233. For example, the FCC declined to open up mobile satellite service spectrum to new users because it thought that doing so would increase the interference caused to incumbent licensees. *Id*. at 12,357; *see also* Amendment of Part 2 of the Commission's

A recent and controversial example of the FCC's application of Rule One to a complex interference conflict occurred in the television broadcast spectrum. A sizeable portion (about one quarter) of this spectrum has been designated by Congress and the FCC for use by new services.[234] These services must coexist with the more than 100 incumbent local broadcast stations until the incumbents have completed a conversion from analog to digital transmissions and their viewership has made the associated transition to digital receivers. At the end of this conversion, the broadcasters have been ordered to vacate the reallocated portion of the band.[235] But until then, the FCC has enjoined new entrants from interfering with broadcasters.[236] These interference constraints make it very difficult to operate the kind of nationwide mobile service that most new entrants would want to deploy.[237]

Rules to Allocate Spectrum Below 3 GHz for Mobile and Fixed Services to Support the Introduction of New Advanced Wireless Services, 16 F.C.C.R. 17,222, 17,237 (2001) (holding that "permitting mobile use of the band by new service providers would pose a very high risk of disrupting important incumbent fixed operations that our decision does not pose").

234. Balanced Budget Act of 1997, Pub. L. No. 105-33, § 3003, 111 Stat. 251, 265 (adding new section 309(j)(14) to the Communications Act and establishing a deadline for broadcasters to cease operations on certain channels); *id.* § 3004 (adding new section 337(a) to the Communications Act and establishing an initial timetable for conducting auctions); *id.* § 3007 (setting the September 30, 2002 deadline for the completion of certain auctions and deposit of proceeds). Congress subsequently accelerated the initial auction schedule. District of Columbia Appropriations Act of 2000, Pub. L. No. 106-113, § 213, 113 Stat. 1501A-289, 295, app. E, § 213; *see also* Reallocation of Television Channels 60–69, the 746–806 MHz Band, 12 F.C.C.R. 22,953, 22,953–55 (1997), *recon.*, 13 F.C.C.R. 21,578, 21,578–79 (1988).

235. 47 U.S.C. § 309(j) (2000); Service Rules for the 746–764 and 776–794 MHz Bands, and Revisions to Part 27 of the Commission's Rules, 15 F.C.C.R. 476, 479 (2000).

236. Auction of Licenses in the Lower 700 MHz Band Scheduled for May 28, 2003, 18 F.C.C.R. 3138, 3146 (2003); Petitions for Reconsideration of the Second Memorandum Opinion and Order, 17 F.C.C.R. 13,985, 13,991 (2002). Congress required that broadcasters be protected in this way. 47 U.S.C. § 337(e).

237. The interference protection criteria were held responsible for reduced interest in the reallocated broadcast spectrum and for delaying the auction of one part of the band and depressing the value of the other part. *See, e.g.*, Howard Buskirk & Paul Kirby, *House Panel Backs 700 MHz Auction Delays; Similar Bill Is Introduced in Senate Chamber*, TELECOMM. REP., May 6, 2002, at 2. According to a representative of potential bidders, the broadcast bands to be auctioned

> are heavily encumbered . . . To date, no relocation plan has been put in place that would guarantee the timely relocation of incumbent licensees. In the absence of a relocation plan that would allow prospective bidders to anticipate their deployment schedules, the value of the spectrum for implementation of new services is greatly reduced.

Id. Because of the lack of spectrum availability, prospective bidders asked repeatedly

Recognizing the technical difficulties that incumbent operation created for new entrants, the FCC adopted rules to make it easier for new entrants to buy out existing broadcasters—in other words, to negotiate around the incumbents' "property rights."[238] Few such negotiations were successfully concluded. The problem appeared to be that if the new entrant wanted to provide a national service, it would have to reach agreement with each of the broadcast stations assigned to the relevant frequencies. Recognizing the potentially high transaction costs such a process would impose, brokers stepped in to clear frequencies nationwide.[239] But the number of broadcasters declining to cede their spectrum rights doomed these band clearing efforts, and potential new service providers gave up any large scale plans for the spectrum at least for the near term. It is impossible to know whether the broadcasters who

---

that the auctions be delayed. *See, e.g.*, Letter of Mr. Thomas E. Wheeler President/CEO Cellular Telecommunications & Internet Association to Chairman Michael Powell, WT Docket No. 99-168 (F.C.C. filed Apr. 3, 2002) (requesting indefinite delay of Auctions 31 and 44). In light of the disinterest of prospective bidders, auction of the largest chunk of broadcast spectrum was indefinitely delayed. *See* Auction of Licenses in the 747–762 and 777–792 MHz Bands (Auction No. 31) is Rescheduled, Public Notice (July 26, 2002), *available at* 2002 F.C.C. LEXIS 3668 (setting no auction date). Auction of a smaller chunk went forward in late August and early September of 2002, resulting in net bids of $88.7 million for 484 licenses. This was widely considered to be a paltry sum for the spectrum auctioned. *See* FCC, *Auction 44*, *at* http://wireless.fcc.gov/ auctions/44/ (last updated Nov. 4, 2003); Jay Wrolstad, *FCC Wireless Spectrum Auction Draws Meager Interest*, WIRELESS NEWSFACTOR.COM (Aug. 28, 2002), *at* http://www. wirelessnewsfactor.com/perl/story/19218.html.

238. *See* Service Rules for the 746–764 and 776–794 MHz Bands, and Revisions to Part 27 of the Commission's Rules, 16 F.C.C.R. 21,633 (2001) (setting forth voluntary band clearing policies by which new services could buy out broadcast stations, provided that enough television service, defined in the order, would be left in the market); Service Rules for the 746–764 and 776–794 MHz Bands, and Revisions to Part 27 of the Commission's Rules, 16 F.C.C.R. 2703 (2001) (same). The FCC extended the fundamentals of these voluntary clearing policies to the Lower 700 MHz band. Reallocation and Service Rules for the 698–746 MHz Spectrum Band (Television Channels 52–59), 17 F.C.C.R. 1022, 1096 (2002).

239. The most well-developed band clearing effort was that of the Spectrum Clearing Alliance (run by the Spectrum Exchange Group, LLC and Allen & Company Inc.) to serve as a broker for Upper 700 MHz band incumbent broadcasters and bidders. The Alliance, with the help of the broadcaster that owned the most incumbent stations (Paxson), reported that it had secured agreements with an estimated seventy percent of the incumbent analog stations. Comments of Spectrum Exchange Group, LLC and Allen & Company Incorporated, Service Rules for the 746–764 and 776–794 Bands and Revisions to Part 27 of the Commission's Rules, WT Docket No. 99-168 (F.C.C. filed Feb. 6, 2000). For background on the 700 MHz proceeding, see Service Rules for the 746–764 and 776–794 MHz Bands, and Revisions to Part 27 of the Commission's Rules, 16 F.C.C.R. 21,633, 21,646 (2001); Service Rules for the 746–764 and 776–794 MHz Bands, and Revisions to Part 27 of the Commission's Rules, 16 F.C.C.R. 2703, 2719 (2001); Service Rules for the 746–764 and 776–794 MHz Bands, and Revisions to Part 27 of the Commission's Rules, 15 F.C.C.R. 20,845, 20,882 (2000). For a discussion of the band clearing attempts, see Ellen Goodman et al., *An Overview of Problems and Prospects in U.S. Spectrum Management*, 698 PLI/PAT 327, 368–69 (2002).

did not participate in the spectrum clearing attempts actually valued the spectrum most highly or were simply holding out for premium payments. It does, however, seem likely that at least those licensees with nonoperational or unprofitable stations were indeed holdouts. To that extent, transaction costs can be blamed for inhibiting the trade in the broadcasters' entitlements—a situation that might in the real world and under the conventional wisdom have led to the adoption of a liability rule whereby broadcasters would be compensated for interference caused by the new entrants.

The transaction costs involved in clearing one or two 6 MHz broadcast channels nationwide are dwarfed by the costs a new entrant would incur in clearing several hundred megahertz of spectrum. Take, for example, the new ultra-wideband devices that use hundreds of MHz of spectrum at very low power. In a recent decision, the FCC imposed power limits and design specifications on ultra-wideband devices that are more stringent than those imposed on other unlicensed devices.[240] These usage restrictions, which one of the FCC Commissioners derided in dissent as "ultra-conservative," are designed to prevent the new entrants from causing harmful interference to existing services.[241] The users of ultra-wideband devices will be unlicensed and manifold, while the potential victims of interference, such as cellular operators, comprise a large and varied class of entitlement holders. There is little prospect for

240. Ultra-wideband devices require tiny fragments of spectrum across a very large range of frequencies and can operate beneath the level of sensitivity of most receivers. *See infra* notes 293 –96, 308; *see also* Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems, 17 F.C.C.R. 7435, 7437 (2002). Illustrating just how hard it is for decisionmakers to evaluate contests over prospective harm, PCS operators have argued that even the conservative interference protection parameters are not conservative enough because UWB operations in a given PCS cell could decrease coverage by approximately eight to nine percent. *See* Comments of Cingular Wireless Services, Inc. on Petitions for Reconsideration, Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems, ET Docket No. 98-153, at 7–8 (F.C.C. filed May 2, 2003).

241. Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems, 17 F.C.C.R. 7435, 7551 (2002) (separate statement of Commissioner Copps). At the same time, the potential victims of interference were harshly critical of the ultra-wideband decision for not being protective enough of incumbents. *See, e.g.*, Terry Lane, *Wireless Carriers Say FCC UWB Report Isn't Adequate*, COMM. DAILY, Nov. 26, 2002. Petitions for reconsideration have been filed by both UWB proponents and incumbents on the grounds that the power limits are too severe and not severe enough. *See, e.g.*, Petitions for Reconsideration in ET Docket No. 98-153 of Sprint PCS and Ground Penetrating Radar Industry Coalition (F.C.C. filed June 17, 2002).

negotiation around the incumbent users' property rights no matter how desirable such negotiation might be.[242]

What we see then if we treat interference disputes as nuisances is that FCC application of Rule One to "common nuisances" in the form of intraservice and simple interservice interference cases accords with the conventional wisdom on the assignment of liability and selection of remedy. However, resort to Rule One in high transaction cost interservice disputes is suboptimal, at least from an efficiency standpoint. With increasing pressure on the spectrum, the privilege that Rule One affords the incumbent is less and less tolerable. As we will see below, the FCC has responded to this pressure by attempting to craft liability rules for complex interference cases. But first, an inquiry into the FCC's use of Rule Three—the assignment of an entitlement to the interferer and the absolute protection of that entitlement by a property rule—will complete the discussion of property rules.

b. Property Rule Three

According to the conventional wisdom, Rule Three is appropriate in low-transaction cost contexts where the victim is the least-cost avoider of the interference. In FCC law, as in early industrial era nuisance law, the appearance of Rule Three remedies has much less to do with an analysis of cost avoidance than with a response to increased pressure on the resource. Courts in the mid-nineteenth century were struggling to preserve the notion that property rights deserved absolute protection, while at the same time trying to permit interfering uses of land. Rule Three allowed courts to protect property rights absolutely by assigning the right to the defendant instead of to the plaintiff. As a result, plaintiffs were denied any relief during the onset of industrialization until courts began to resort to damages remedies, which split the entitlement.[243]

In the case of spectrum disputes, we see a similar, although not as pronounced and perhaps still nascent, response to pressure on the resource. The Rule Three remedy appears whenever the FCC finds that even substantial interference will not cause "harmful interference" to the incumbent. Such a finding allows the FCC to license new interfering services without expressly abandoning its first-in-time principle or engaging in the difficult damages assessments that liability rules require. Intensifying demand for the resource has not yet subverted the primacy

242. The FCC has recognized before how difficult such multiparty negotiations are. *See, e.g.*, Amendment to the Commission's Rules Regarding a Plan for Sharing the Costs of Microwave Relocation, 12 F.C.C.R. 2705, 2710 (1997).

243. *See supra* notes 199–02.

of Rule One in FCC decisionmaking, as it did for courts in the early industrial era, but Rule Three remedies have begun to appear more frequently in spectrum decisions.

In intraservice broadcast interference disputes, which comprise the large majority of interference problems that have been brought before the FCC, the FCC historically identified interference as harmful even where a very small percentage of a service's customers risked service loss.[244] In the past several years, however, the FCC has relaxed this threshold in an attempt to allow more new services into the encumbered spectrum. For example, in authorizing digital broadcast television services in the same spectrum that analog television is broadcast, the FCC allowed interference to reach up to ten percent of any station's population. All such interference is classified as de minimis and nonactionable.[245]

In other wireless services too, the FCC has relaxed its interference threshold to foster access by new entrants even when millions of wireless users may be affected by the interference. For example, the FCC recently authorized a terrestrial video service in the same spectrum that satellite television operators use to deliver DirecTV and Dish Network services.[246] The FCC required the new entrants to minimize the amount of new interference caused to the satellite television services.[247] Even though the new entrant was predicted to increase the DBS outage rate by ten percent, the agency defined away this interference as falling below a threshold of concern.[248] It concluded that

244. For example, for the entire history of television broadcasting, the FCC has upheld strict mileage separation limits between stations to minimize interference. It has been willing in some cases to waive those mileage separations when, for example, a would-be broadcaster can bring new service to an unserved area or it is impossible to build a station in a compliant location. Even in these cases, however, the broadcaster seeking a waiver must show that it causes no new, or only very minimal, interference to the existing broadcaster. New interference is presumptively not in the public interest. *See, e.g.*, Application of WSET, Inc. (WSET-TV), Lynchburg, Virginia for Construction Permit, 80 F.C.C.2d 233, 245 (1980) (citing Hall v. FCC, 237 F.2d 567 (D.C. Cir. 1956)) (concluding that "any loss of service to an area is *prima facie* against the public interest, absent a substantial showing of offsetting factors").

245. 47 C.F.R. § 73.623(c)(2) (2002).

246. Amendment of Parts 2 and 25 of the Commission's Rules to Permit Operation of NGSO FSS Systems Co-Frequency with GSO and Terrestrial Systems in the Ku-Band Frequency Range, 17 F.C.C.R. 9614 (2002).

247. *Id.* at 9628.

248. The FCC order noted that even this increase in outages would probably not be perceptible to a majority of customers, because "DBS is, on the whole, extremely reliable with typical service availabilities on the order of 99.8 to 99.9 percent." *Id*. at

the "relatively small theoretical changes" experienced by DBS customers would not rise to the level of "harmful interference," and in any case, such harm was outweighed by the public's interest in gaining a new competitor in the video and data distribution market.[249]

The FCC has made the same "no harmful interference" determination in the wireline context where spectrum disputes arise.[250] One recent controversy posed the question of whether, where two operators share telephone lines, the victim of interference from an incompatible technology should have an entitlement to enjoin the interfering operation.[251] While the FCC adopted a Rule One position that the "carrier deploying the [interfering] technology shall discontinue deployment of that technology" if interference developed, it also carved out a Rule Three exception to the victim's property right in cases where the "interfered-with service itself is a known disturber." In such cases, the interferer would have the entitlement to continue operation. The FCC reasoned that "[t]his exception prevents the undue protection of noisier technologies that are at or near the end of their useful life cycle, at the same time preventing the undue preclusion of new, more efficient and spectrally compatible technologies."[252] In other words, where the factory is creating a nuisance for the farm, which the farm might reasonably avoid by modernizing, the farm will not have recourse against the factory.

In the examples just discussed, the FCC's decision to use Rule Three was necessary according to the conventional wisdom on transaction costs only in the wireline interference case, where there was a determination that the victim service was the least-cost avoider of the interference. In the broadcast and satellite examples, Rule One might have been just as appropriate because it was unclear which party could

---

9640. For a critique of the FCC's decision in this proceeding because it lacked a reasoned standard for permissible interference, see R. Paul Margie, *Can You Hear Me Now? Getting Better Reception from the FCC's Spectrum Policy*, 2003 STAN. TECH. L. REV. 5, *at* http://stlr.stanford.edu/STLR/Articles/03_STLR_5, ¶¶ 33–41.

249. Amendment of Parts 2 and 25 of the Commission's Rules to Permit Operation of NGSO FSS Systems Co-Frequency with GSO and Terrestrial Systems in the Ku-Band Frequency Range, 17 F.C.C.R. 9614, 9628 (2002). In another recent case, the FCC rejected what the cellular industry had long considered to be the interference threshold for acceptable call quality. AirCell, Inc., Petition, Pursuant to Section 7 of the Act, for a Waiver of the Airborne Cellular Rule, or, in the Alternative, for a Declaratory Ruling, 18 F.C.C.R. 1926, 1935 (2003) (defining the increase in interference as "objectionable" but not "harmful").

250. Wireline services transmit electrical signals over the radio frequencies contained within the wires of the phone system.

251. Deployment of Wireline Services Offering Advanced Telecommunications Capability and Implementation of the Local Competition Provisions of the Telecommunications Act of 1996, 14 F.C.C.R. 20,912, 20,990 (1999).

252. *Id*. at 21,035.

most efficiently minimize the harm. The FCC's choice of Rule Three reflected a desire, animated by a public interest rationale, to privilege new entrants.

c. Liability Rule Two

The use of liability rules in the resolution of spectrum conflicts would allow the FCC to split the difference between the legitimate claims of two or more interfering operators. Particularly where there are multiple parties affected by interference, liability rules provide an efficient alternative to property rules. For this reason, Rule Two, which permits a nuisance to continue so long as the victim is compensated in the amount of judicially assessed damages, is the rule most frequently employed by courts in resolving nuisance disputes in which there are many victims.[253] Despite its utility in the real world, Rule Two has not played a major role in FCC dispute resolution. Indeed, as far as I can tell, the FCC has *never* applied Rule Two in its classic form, even though it often deals with multiple-victim interference disputes for which Rule Two might be appropriate. That is to say, the FCC has never permitted an existing or prospective licensee to cause harmful interference to others at the price of FCC assessed damages. What we do see, however, is the application of a quasi-Rule Two remedy involving compensation, the amount of which is negotiated by the parties. In other words, this quasi-Rule Two remedy serves the function of splitting the entitlement, but does not effect the shift in costs of multiparty negotiations from the parties to the decisionmaker that Rule Two ordinarily achieves.

The handling of "blanketing interference" is a prime example of the FCC's quasi-Rule Two remedy. Radio transmitters, particularly high-powered ones like radio and television antennae, can blanket their immediate vicinities with enough energy to interfere with the functioning of nearby receiving devices like television sets, phones, and other electronic equipment. It turns out that it is easier for the victims of this blanketing interference to mitigate the harm than it is for the stations that cause it. Taking the costs of mitigation into account in accordance with the conventional wisdom, the FCC has allowed new FM broadcast stations that would have been enjoined from causing interference under Rule One, to interfere with neighboring receivers so long as the

253. *See* Krier & Schwab, *supra* note 107, at 460–62.

operators pay the costs of mitigation.[254] The FCC has applied the same mitigation rule where the "plaintiff" is another licensee complaining on behalf of its customers who have been harmed by blanketing interference.[255] Thus, the party causing the interference compensates the victim, but at an amount that the parties themselves determine.

This difference between the conventional Rule Two and the FCC's Rule Two—that the decisionmaker does not set the damages award—sacrifices the main benefit of liability rules. In a blanketing interference case, there may be thousands of victims. This is precisely the type of multiparty nuisance dispute for which liability rules are recommended. One of the principal advantages of liability over property rules is that they substitute the assessment costs of the decisionmaker for the negotiation costs of multiple parties.[256] Lacking this advantage, the quasi-liability rule differs from a property rule only in its distributional impact. That is, the interferer's costs will be less than they would have been under Rule One, but not so little as they would be under Rule Three. The transaction costs associated with negotiations, which liability rules should reduce, remain burdensome.

These negotiations over blanketing interference appear to result in payments that fall far short of full compensation.[257] As a consequence, the interferer underinvests in interference prevention. The FCC has tried to address this problem, not by increasing the penalty for interference,

---

254. 47 C.F.R. § 73.318 (2002).

255. *Id.* § 27.58 (blanketing interference rules for Wireless Communications Service (WCS) interference to receiving devices necessary to receive MDS/ITFS service). Here, the FCC did require the interferer to undertake some interference abatement measures as well as to pay for mitigation at the receiver end. The FCC has proposed the same kind of solution to deal with interference caused by new digital satellite radio (DARS) terrestrial repeaters to WCS licensees. Request for Further Comment on Selected Issues Regarding the Authorization of Satellite Digital Audio Radio Service Terrestrial Repeater Networks, 16 F.C.C.R. 19,435, 19,440 (2001) (proposing the establishment of liability zone within which DARS licensee must pay "the reasonable costs of eliminating or mitigating" any blanketing interference to a WCS licensee "that prevents the [licensee's] provision of commercial service").

256. *See* Krier & Schwab, *supra* note 107, at 460–62; *see also* Kaplow & Shavell, *Property Rules*, *supra* note 210, at 755–56.

257. The FCC's rules provide for interference compensation only for a limited period of time after the interferer begins operation. 47 C.F.R. § 73.318(a)–(d). In 1996, the FCC recognized that its blanketing interference rules for radio shifted some of the costs of interference from the victim to the interferer, but that in many cases they did not result in mitigation of the interference for the victim. This is because, in part, there are "no criteria for speed of service for correcting blanketing interference," and months can pass before a complaint is acted upon, much less finally resolved. Amendment of Parts 73 of the Commission's Rules to More Effectively Resolve Broadcast Blanketing Interference, Including Interference to Consumer Electronics and Other Communications Devices, 11 F.C.C.R. 4750, 4754 (1996). The FCC proposed to clarify and tighten these rules to further protect victim devices. *Id.* However, it never completed the rulemaking.

but by introducing property rule elements into its liability rule.[258] In some cases of blanketing interference, the FCC will grant the interferer only a *partial* entitlement to continue the nuisance subject to compensation. It does this by limiting the interferer's permissible signal levels, while also requiring the operator to mitigate any residual damage resulting from the reduced entitlement.[259] Whatever rough justice the agency may have achieved as between interferers and victims by splitting the entitlement to spectrum, it did not forestall extensive negotiations or get the interferer to internalize the costs of the nuisance.

d. Liability Rule Four

Under the Calabresi-Melamed framework, Rule Four is the mirror image of Rule Two. The protection of a defendant, or interferer, by a liability rule follows what is essentially a model of eminent domain.[260] Where a new use of property would interfere with the existing use, the existing user is privileged unless the new user pays the court-determined costs of relocating the incumbent user. In essence, the new user purchases the incumbent's entitlement.[261] In true eminent domain cases,

258. Scholars have observed that there are many intermediate rules that share characteristics with two or more of the basic four property and liability rules. *See, e.g.*, Abraham Bell & Gideon Parchomovsky, *Pliability Rules*, 101 MICH. L. REV. 1, 25–28 (2002) (suggesting new rules that combine aspects of liability and property rules at distinct phases of implementation); Saul Levmore, *Unifying Remedies: Property Rules, Liability Rules, and Startling Rules*, 106 YALE L.J. 2149, 2150–53 (1997) (suggesting additional rules).

259. Amendment of the Commission's Rules to Establish Part 27, the Wireless Communications Service ("WCS"), 12 F.C.C.R. 3977, 3983–84 (1997). The FCC concluded that "the public interest would be best served by setting limits on WCS operating power" without unnecessarily limiting WCS service offerings. Instead of adopting even more severe limits on the operating power, the FCC decided to "assign to WCS licensees certain responsibilities to cure actual interference to existing and soon-to-be-installed MDS/ITFS downconverters." *Id*. at 3983–84. In coming to this Solomonic decision, the FCC rejected the notion that the victim downcoverters were too vulnerable to the interference and therefore should not be protected. Rather, it concluded that because it would not be economical to replace existing devices with more robust ones, "equipment that was designed to operate in a pre-WCS environment should be afforded some degree of protection from interference." *Id.* at 3984. However, the FCC also wanted to encourage the victim MDS/ITFS industry "to employ equipment in the future which [would] not require undue power restrictions on users of nearby spectrum." *Id.* To this end, the FCC agreed to sunset the obligation of the interfering WCS service to remedy interference to MDS/ITFS devices.

260. *See* Rose, *supra* note 209, at 2180 (noting that, viewed as a rule of eminent domain, Rule Four is not as exotic and Calabresi and Melamed suggested).

261. *See* Calabresi & Melamed, *supra* note 10, at 1121–22.

the purchase price that the new entrant (the government) must pay is adjudged to be the fair market value of the incumbent's property.[262] The damages in the paradigmatic Rule Four case are a little different. There, the new entrant pays what a court determines to be the costs of relocating the interfering property owner—in other words, something more like replacement than fair market value costs.[263] There appears to be only one real world nuisance case to have employed Rule Four—*Spur Industries v. Del E. Webb Development Co.*, decided the same year that Calabresi and Melamed "discovered" Rule Four.[264]

Interestingly, whereas the FCC has shied away from the pedestrian Rule Two, it has experimented heavily with the exotic Rule Four, or something like it. The agency has used something like Rule Four in a handful of cases to facilitate services' use of spectrum that is already encumbered by existing, and incompatible, communications services. Here, the use of the terms "victim" and "interferer" can be misleading. As a technical matter, it may be that the signals of the new entrant will interfere with the operations of the incumbent service. In that sense, the question of whether the interferer should have to compensate the incumbent victim presents much as a Rule Two case. But in other cases, particularly where the new entrant is a highly sensitive satellite service, the incumbent will be the interferer, as in *Spur Industries*, where the incumbent was the polluting feed lot and the new entrant was the sensitive residential development.[265] For the sake of simplicity, I treat these two cases alike because the remedies are the same—the incumbent is relocated at the new entrant's expense.

The first implementation of the FCC's quasi-Rule Four remedy came with the introduction of PCS cellular service in the mid-1990s. Here, for

---

262. *See* STOEBUCK & WHITMAN, *supra* note 192, § 9.5, at 539.

263. *See* Calabresi & Melamed, *supra* note 10, at 1122 n.62.

264. Spur Indus., Inc. v. Del E. Webb Dev. Co., 494 P.2d 700 (Ariz. 1972). In *Spur Industries*, a large feedlot polluted a neighboring housing development with fumes and odors. The development had "come to the nuisance," acquiring land after Spur Industries had been operating for some years. For this reason, the court did not want to simply enjoin the operation of the feedlot. On the other hand, the court did not want to leave the residents of the new and growing sunbelt development without a remedy. The feedlot had to go, but the court required the development to pay the costs of relocating the feedlot to another property. *Id.* at 707–08.

265. For example, it is well-known that satellite receivers must

> be sensitive enough to receive low-level signals from 22,300 miles in outer space. This characteristic, coupled with the ability to tune a receiver over the wide range of frequencies employed by most satellite networks, renders earth terminal receivers highly susceptible to interference from nearby, high-powered transmitters.

Comments of the Satellite Industry Association, *In re* Interference Immunity Performance Specifications for Radio Receivers, ET Docket No. 03-65, at 6 (F.C.C. filed July 21, 2003).

the first time, the agency authorized a new class of licensees to acquire the rights to a fairly large swath of spectrum that was already encumbered by thousands of licensees. These incumbents could not coexist with the new entrants without suffering significant service losses. Rather than employing Rule One and simply denying entry to the new service provider, or employing Rule Three and granting an absolute entitlement to the new entrant to interfere, the FCC adopted what is known as its "emerging technologies" policy.[266]

Under this policy, the FCC entitled the existing licensees—the would-be victims—to protection from interference, but protected this right only with a liability rule. Licensed operators in the new interfering service would have to pay "relocation damages" to the incumbents.[267] The purpose of this policy was to ensure that the entry of new services did not disrupt existing services provided by incumbents.[268] In the case of PCS, the relocation of incumbents involved payment from a handful of PCS companies to approximately 30,000 incumbent microwave users to fund the incumbents' move to comparable facilities in a different spectrum band.[269]

Specifically, the FCC set a two-year voluntary negotiation period for PCS entrants to negotiate the terms of relocation, requiring PCS entrants to pay for building and testing, and to assume all costs for fully comparable facilities for the incumbents.[270] It was the FCC's hope that

266. Redevelopment of Spectrum to Encourage Innovation in the Use of New Technologies, 7 F.C.C.R. 6886, 6890 (1993).

267. *Id.* at 6591.

268. *See id.* at 6594; *see also* Redesignation of the 17.7–19.7 GHz Frequency Band, 15 F.C.C.R. 13,430, 13,431–32 (2000) (applying the same principle); Amendment of Section 2.106 of the Commission's Rules to Allocate Spectrum at 2 GHz for Use by the Mobile-Satellite Service, 15 F.C.C.R. 12,315, 12,352 (2000) (same).

269. *See generally* Andrew C. Barrett & Byron F. Marchant, *Emerging Technologies and Personal Communications Services: Regulatory Issues*, 1 COMMLAW CONSPECTUS 3, 8–9 (1993). Some of the PCS band, as noted above, was allocated for unlicensed PCS (1910–30 MHz). This presented a problem for the relocation of incumbent users because unlicensed and therefore unidentified operators could not negotiate. The FCC established a procedure whereby the manufacturers of unlicensed devices would pay to compensate the 400 or so incumbent operators for relocating by paying a fee into a common pool for each unlicensed PCS product. 47 C.F.R. § 15.307 (2002). The compensation mechanism yielded so little money and the development of equipment for use in the unlicensed band proceeded so slowly that today's unlicensed PCS service is relatively weak. *See* FCC SRRWG REPORT, *supra* note 69, at 13.

270. Redevelopment of Spectrum to Encourage Innovation in the Use of New Telecommunications Technologies, 8 F.C.C.R. 6589, 6595 (1993). A portion of the PCS band was set aside for unlicensed use. The voluntary negotiation period for incumbents

this voluntary period would "encourage good faith and fair voluntary negotiations."[271] However, the FCC proceeded to undermine the incumbents' incentive to negotiate by setting a one-year mandatory negotiation period to commence at the end of the voluntary period, after which incumbents would be required to relocate, although still at the expense of the PCS entrants.[272] The FCC recognized the pitfalls of its own procedures: that incumbents might well benefit by dragging out negotiations "to the degree that aging equipment using older technology [might] be replaced with new equipment using state-of-the-art technology."[273]

In the case of another new service authorized in 2000, mobile satellite services, the FCC was faced again with a question of conflicting spectrum uses. This time, the new entrants were the ones who would be interfered with by the incumbent users.[274] The incumbent service, like the feedlot that fouled the air of the new housing development in *Spur Industries*, would overwhelm the new satellite operators with high-power transmissions. The FCC entitled the would-be victim satellite operators to freedom from interference, but required them to pay to relocate the incumbent operators to comparable facilities.[275]

The FCC's requirement that PCS and mobile satellite service entrants compensate incumbent spectrum users was designed to make the incumbents whole and to make the new entrants internalize the costs of their operations. In this respect, the FCC's quasi-Rule Four is similar to

---

in this portion of the band was one year. *Id.* at 6598.

271. *Id.* at 6595.

272. *Id*.

273. *Id*. The D.C. Circuit Court of Appeals, in the context of a similar relocation scenario, downplayed the risk of bad faith negotiations, noting that incumbents have an incentive "to negotiate as advantageous a deal as possible before facing forced relocation" even though this forced relocation would be at the new entrants' expense. *See* Teledesic LLC v. FCC, 275 F.3d 75, 88 (D.C. Cir. 2001).

274. Amendment of Section 2.106 of the Commission's Rules to Allocate Spectrum at 2 GHz for Use by the Mobile-Satellite Service, 15 F.C.C.R. 12,315, 12,321–22 (2000). The incumbents are television broadcasters who use this band for what are known as "broadcast auxiliary services." These are the transmissions of live action shots from location back to the studio. Broadcast auxiliary services, unlike ordinary broadcast services, are licensed to operate on a mobile and nationwide basis, such that a Los Angeles broadcaster is permitted to use spectrum in New York and to transmit on a mobile basis "rolling tape" anywhere in the country. *See* 47 C.F.R. § 74.6. Because of the itinerant nature of the incumbent service and the need for a nationwide roll-out of the new service, the PCS market-by-market approach to incumbent relocation could not be applied in this band, and a much more complicated and administratively staged relocation scheme was ordered.

275. In a similar context at about the same time, the FCC required satellite operators in another band to relocate the terrestrial fixed services (which serve utilities and railroads, as well as provide high speed Internet connections) to comparable facilities so that such services would not interfere with the entering satellite services. Redesignation of the 17.7–19.7 GHz Frequency Band, 15 F.C.C.R. 13,430, 13,433 (2000).

the classic Rule Four, as well as to Rule Two. The conventional wisdom tells us that Rule Four, like Rule Two, should be applied when transaction costs are high, and a judge-determined relocation price is more efficient than a postjudgment negotiated relocation price.[276] However, unlike courts applying the classic rules, the FCC did not assess damages by establishing the price of relocation. Rather, along the lines of its quasi-Rule Two, the agency simply required the parties to negotiate a price under the threat of regulatory intervention if they could not agree. The costs of such negotiations will be significant, particularly because the FCC declined to define the "comparable facilities" to which incumbents were entitled, leaving it to the parties to settle on the replacement costs case by case.[277] Unsurprisingly, this process yielded complaints that the victims were trying to gouge the interferers and hold them up for state of the art facilities.[278]

To summarize, FCC resolution of interference disputes has relied heavily on property rules, historically Rule One, but increasingly Rule Three. The FCC generally has employed these property rules in accordance with prevailing transaction cost theory when bargaining costs are low, particularly in intraservice interference conflicts, but also where they are high, in multiparty interservice interference cases. In selecting between Rules One and Three, the FCC has been as influenced by public interest factors unrelated to economic efficiency as it has by whether the victim or interferer is the least-cost avoider of the interference. That is, its selection of property rules appears to be based on a desire to privilege either incumbents or new entrants depending on its public interest calculation. The same can be said of its choice of liability rules. The FCC's use of liability rules (Rules Two and Four) is

276. *See* Calabresi & Melamed, *supra* note 10, at 1110.

277. *See, e.g.*, Redevelopment of Spectrum to Encourage Innovation in the Use of New Telecommunications Technologies, 8 F.C.C.R. 6589, 6603–04 (1993).

278. *See, e.g.*, Chairman Reed E. Hundt, Remarks at a VIP Luncheon of Phillips Business Information Inc. (Aug. 25, 1995), *available at* 1995 F.C.C. LEXIS 5732 (noting PCS entrants' complaints of "greenmail" by microwave incumbents); Commissioner Susan Ness, Remarks Before the Cellular Telecommunications Industry Association Special Commissioner's Forum Wireless '96 Convention (Mar. 25, 1996), *available at* 1996 F.C.C. LEXIS 1466 (promising to address complaints about "extortionate demands out of all proportion to the true costs of relocation"). In the MSS context as well, the FCC's rules were challenged as being too generous to the incumbents. The central argument advanced was that the measure of damages should be the depreciated value of the incumbents' equipment rather than the replacement value. *See* Teledesic LLC v. FCC, 275 F.3d 75, 85 (D.C. Cir. 2001).

rare. When the agency does employ liability rules, it leaves it to the parties to negotiate the damages that, in the real world, a court would assess.

3. Measuring and Balancing Nuisance Costs in the Public Interest

We have arrived at this point by asking what might be learned about common law approaches to spectral conflicts from the administrative experience. Consideration of which judgments will be required of a court to resolve conflicts between spectrum property owners gives us a much more accurate view of the benefits and costs of a property rights system in spectrum. Examination of FCC nuisance law has shown us that the agency has failed to arrive at an accurate (or sometimes any) measurement of the costs relevant to the assignment of interference entitlements. Courts resolving disputes among spectrum owners, then, will have to tackle what the FCC has not: placing a value on spectral nuisances and nuisance prevention. By the same token, courts balancing the varied interests in spectral nuisance cases will likely do what the FCC itself *has* done: consider public interest goals apart from economic efficiency in the allocation of entitlements.

The costs of making these judicial assessments may be high for a number of reasons. Even for simple interference cases where the class of potential interferers is quite limited, determining causation may be difficult. It is not always obvious, for example, that service disruption apparently caused by signal interference is not instead caused by atmospheric fluctuation.[279] Even if causation is clear, there will be significant uncertainty about the effectiveness and expense of technological advances that either the plaintiff or the defendant might undertake to prevent the nuisance. As we have seen, the FCC, notwithstanding the availability of a technical staff to analyze the feasibility of interference prevention measures and an economic staff to assess their costs, has refrained from making liability judgments in reliance on this expertise. There is a similar hesitancy to tally up the cost of potential harm to the victim service by assessing factors such as lost revenue due to customer defections and equipment replacements, after netting out the likely customer churn and equipment upgrades that would occur anyway. Yet nuisance law, under the rubric of a balancing of the utilities, if not obeisance to the *Cathedral* cannon, would require the courts to consider these facts, dependent as they are on the dynamics of equipment markets, communications markets, and the currents of technological advance.

279. *See* Minasian, *supra* note 3, at 248–52.

An example helps to illustrate the difficulty of applying liability rules to spectral nuisances and to further illuminate why the FCC has not used true liability rules. Suppose, for example, that a court is asked to resolve a dispute between an interfering cellular service and some or all of several hundred victim radio stations operating across the country on frequencies adjacent to those used by the cellular operator. The court would need to assess the nuisance costs to the radio stations and relevant third parties, the nuisance benefits to the cellular operator and relevant third parties, the prevention costs for the cellular operator and the radio stations, and the transaction costs of resolving the interference dispute.[280] The costs of acquiring this information will be high. Information about the cost of interference to the radio stations and the benefit of the nuisance to the cellular operator will be relatively straightforward. Much harder to obtain will be information about the cost of lost or increased service to the public. What information the parties generate will be speculative. Moreover, it is very difficult to compare the utilities of a subscription telephone service with an advertiser-supported radio service, particularly when the competitive landscape in each service is rapidly changing.[281]

The cost to consumers of interference or loss of service is difficult to value for any service, dependent as it is on the availability of substitutes, the costs of replacing equipment, and the network effects of a particular service, which may increase the costs of service loss. In the case of a subscription service operating in a competitive environment, the operator will presumably internalize the costs to consumers. Service loss is more difficult to value in the case of broadcasting or other advertising-supported services where advertisers, not consumers, are the customers. The value broadcasters place on viewer reception of their signals can be ascertained from advertising rates, but the value of marginal viewers to advertisers, and hence to broadcasters, may be less than the value of the service to the viewers themselves.[282] It is

280. *See* Calabresi & Melamed, *supra* note 10, at 1106–10 (discussing relevant costs in nuisance actions); Ellickson, *supra* note 222, at 724–25 (same).

281. I have illustrated the uncertainty of spectrum valuation, particularly when the competing uses are very different, in the context of digital television. *See* Goodman, *supra* note 128, at 533, 535.

282. It has been noted many times that television ratings, which are closely related to the value of television service in the marketplace, do not measure the value that individual viewers place on television service or, even more so, on individual programs. *See, e.g.*, C. Edwin Baker, *Giving the Audience What It Wants*, 58 OHIO ST. L.J. 311,

extremely difficult, for example, to determine how much value a consumer places on receiving a radio signal, depending on the amount of interference ten miles from the transmitter, twenty miles out, or only at the fringe of the service area.

Information about the costs of interference prevention will be scarce as well. What would it cost to make radios that were more immune to interference? Given that radio is an open architecture service, what transaction costs and, possibly, direct payments would be necessary to induce manufacturers to produce such radios? All this is information that the victim service, if anyone, would have, and they are figures the victim will tend to exaggerate.[283] How much would it cost cellular providers to tweak their systems to prevent the interference? This is information that only the interferer has and has every incentive to exaggerate.

Armed with the information it can amass on the costs of nuisance and nuisance prevention, the court must then make a judgment as to whether to privilege the victim, and assign the entitlement to freedom from the interference to it, or to privilege the interferer and assign the entitlement to be free of the interference to *it*. The court must, in other words, balance the value of net service lost with the value of net service gained. Even if courts were to trim nuisance law's multifactored analysis to the single factor of economic efficiency, this will be a difficult and unpredictable endeavor. More likely, courts would apply spectral nuisance law using an inexact mix of efficiency and fairness factors just as they do in real nuisance actions. The result will be a balancing much like the public interest balancing the FCC makes in resolving spectrum disputes. Courts will find themselves, as the FCC has, assessing the relationship between spectrum entitlements on the one hand and various public interests (including economic efficiency) on the other.

The FCC's struggle to balance the utilities and make use of appropriate remedies in resolving spectrum conflicts foreshadows the difficulties courts will face and the consequences of their allocational choices. But the FCC's record casts light as well as shadow on common

319–22 (1997); Cass R. Sunstein, *Television and the Public Interest*, 88 CAL. L. REV. 499, 514–16 (2000); *see also* De Vany et al., *supra* note 3, at 1543.

283. In evaluating the potential for interference to incumbent FM broadcasters by the introduction of a low-power radio service in the same spectrum, for example, the FCC concluded that equipment manufacturers and incumbent broadcasters were exaggerating the risks of interference in their technical studies and were proposing protection criteria for existing radios that were more generous than the public seemed to demand. Creation of Low Power Radio Service, 15 F.C.C.R. 2205, 2236–46 (2000). For a critique of the incumbents' claims in the low-power radio debate, see Stuart Minor Benjamin, *The Logic of Scarcity: Idle Spectrum as a First Amendment Violation*, 52 DUKE L.J. 1, 11–13 (2002).

law dispute resolution in the telecosm. The very steps that the agency might take to improve its own decisionmaking are steps that might also assist a court in a hybrid administrative-judicial approach to spectrum law. It is to these steps that I will turn in Part VI, after first addressing the common property alternative to private property rights in spectrum.

V. THE COMMONS ALTERNATIVE TO PRIVATE PROPERTY RIGHTS

While the complexity of creating a nuisance law for spectrum that is predictable, efficient, and amenable to judicial decisionmaking is a topic largely ignored by private property theorists, the basic point that private property systems are costly to implement and maintain has not been lost on critics of FCC regulation. In recent years, a small but increasingly vocal cadre of engineers and legal academics has advocated another kind of radical regime change from the administrative system of spectrum management. It is a change built on a conception of spectrum as air, not land. Like the right to use air, the right to use spectrum would not be purchased or traded, but would be free for the taking, subject to some important constraints. The FCC itself has shown interest in this type of proposal in making more spectrum available as a sort of commons on an unlicensed basis. Section A outlines the argument for this "commons" model of spectrum use. Section B returns again to the problem of spectrum conflict and shows how the commons model, like the property rights model, fails to grapple with the costs and vagaries of conflict resolution.

A. The Commons Model

1. Origins

If the idea that the right to use the radio spectrum should be a private property right originated in pathbreaking economic work, the greatest rival to that idea has emerged from pathbreaking engineering work. New, low-power wireless systems that rely heavily on digital processing and decentralized network architectures have challenged the view that spectrum rights should be exclusive, perpetual, and auctioned to the highest bidder. Increasingly inexpensive and fast processing capability permits the production of radio receivers that operate across frequencies in ways that cause little interference, at least for some applications. New network architectures, along the lines of the Internet, allow one radio to

exploit the capabilities of another in routing signals through distributed radios to their destinations. The argument of the commons theorists is that exclusive rights to use discrete spectrum bands are not necessary and, in fact, could impose prohibitive costs on the deployment of these technologies. Rather, what these technologies need, and what they make workable, is fairly open access to a spectrum commons.

Unlicensed, or common, use of the spectrum has been a feature of the administrative regime since 1938, when the FCC first allowed very low-power devices to operate within the interference tolerances of licensed services.[284] For decades, there was low-level use of unlicensed devices for garage door openers and heart monitors.[285] However, by the 1980s, it had become apparent that the spectrum available for unlicensed use was inadequate for the new wireless applications then emerging. The most promising of these technologies was spread spectrum. Spread spectrum transmitters, originally designed by the military to withstand interception, were first used commercially in cordless phones.[286] The transmitters spread their energy over a wide band of spectrum, thereby increasing resistance to interference and allowing multiple transmitters to share the same frequencies.

New spread spectrum technologies were not well supported by the existing unlicensed rules because they required higher power levels. Nor were exclusive-use licenses appropriate, because short-range spread spectrum services required access to frequencies over expansive territory, but only in a very small area at any given moment. Responding to the particular requirements of this new technology, the FCC allocated specific bands for unlicensed use in 1989.[287] What did

284. *See* CARTER ET AL., *supra* note 14, at 6.

285. For most of the history of spectrum regulation, the operation of a radio device without a license was limited to amateur radio and extremely localized transmissions. 47 C.F.R. § 15.103 (2002).

286. According to FCC rules, "A spread spectrum system is an information bearing communications system in which: (1) Information is conveyed by modulation of a carrier by some conventional means, (2) the bandwidth is deliberately widened by means of a spreading function over that which would be needed to transmit the information alone." *Id.* § 2.1.

287. Revision of Part 15 of the Rules Regarding the Operation of Radio Frequency Devices Without an Individual License, 4 F.C.C.R. 3493, 3502 (1989). The first bands allocated for unlicensed use were the Industrial, Scientific, and Medical (ISM) bands that had been dedicated for use by equipment like microwave ovens, welding devices, and ultrasonic cleaners rather than communications services. 47 C.F.R. § 15.247. In 1994, the FCC allocated 30 MHz of spectrum in the PCS band for unlicensed PCS use, adding Part 15, Subpart D of the FCC's rules. *Id.* § 15.301–.323. In 1997, the FCC allocated 300 MHz of spectrum for the operation of unlicensed national information infrastructure (U-NII) devices. Amendment of the Commission's Rules to Provide for Operation of Unlicensed NII Devices in the 5 GHz Frequency Range, 12 F.C.C.R. 1576, app. A (1997) (adding Part 15, Subpart E of the FCC's rules, 47 C.F.R. § 15.401 to 15.407). Spread spectrum transmitters may now operate in the 902–28 MHz, 2400–83.5 MHz,

not change was the requirement that these devices refrain from causing any harmful interference to licensed services and bear any interference that the unlicensed devices might receive.[288] The FCC later gave unlicensed transmitters greater ambit by permitting them to operate in many different bands, provided that they maintained their low power levels.[289]

The absence of licensing requirements turned out to be a great boon to innovation, as demonstrated in recent years by the growth of unlicensed devices operating according to industry standards like IEEE 802.11b (popularly known as WiFi),[290] Bluetooth,[291] and Home RF. These

and 5725–5850 MHz bands. 47 C.F.R. § 15.247; *see also* Amendment of Part 15 of the Commission's Rules Regarding Spread Spectrum Devices, 17 F.C.C.R. 10,755, 10,756 (2002) (increasing the class of services that can operate in the unlicensed bands).

288. 47 C.F.R. § 15.5(c).

289. *Id.* §§ 15.207, 15.209. Unlicensed devices are not allowed in bands designated for services that use very low received power levels, such as satellite downlinks or radio astronomy, or in public safety bands. *Id.* § 15.205. With the exception of remote control devices and medical telemetry transmitters, they are also prohibited from operating in TV broadcast bands. *Id.* §§ 15.209, 15.231, 15.241, 15.242. The FCC is now considering allowing unlicensed devices in the TV broadcast band on a noninterfering basis. Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band, 17 F.C.C.R. 25,632, 25,632 (2002).

290. The IEEE 802.11b standard applies to spread spectrum devices operating in the 2 GHz band. Specifically, it applies to direct sequence spread spectrum transmissions, which is one of two kinds of spread spectrum technology. Frequency hopping, *see infra* note 291, is the second kind. In direct sequence spread spectrum, the information is divided into packets that fan out over a particular frequency channel according to a spreading ratio. The receiver recombines the packets using the spreading ratio. Devices operating according to the 802.11b standard can transmit at distances of up to about 150 feet with data rates of up to 11 Mbps. Newer protocols are the 802.11a, which operates at 5 GHz, and 802.11g, which is an extension of 802.11b and provides higher data rates. The advantage of the 5 GHz band is that it is relatively interference-free. However, the 5 GHz band is used by licensed services in Japan and Europe, making international interoperability more difficult. In addition, because the frequency is higher, the expected range of systems using this band is smaller. For a description of these unlicensed technologies, see CARTER ET AL., *supra* note 14, at 26–34.

291. Bluetooth, which provides wireless connectivity between devices, like printers and computers, in close proximity to each other uses frequency hopping spread spectrum technology. In this kind of system, a data stream modulates a radio frequency carrier that hops on either side of the central frequency in concert with a receiver. In a sense, the data signal and the receiving device together surf frequencies so that the signal is never on any given frequency for very long. Frequency hopping typically uses less power, but is less reliable, than direct sequence spread spectrum transmissions. *See* Amendment of Part 15 of the Commission's Rules Regarding Spread Spectrum Devices, 17 F.C.C.R. 10,755, 10,756 (2002). Both direct sequence spread spectrum (WiFi) and frequency-hopping (Bluetooth) technologies reduce the power level of the transmitted signal at any given frequency, thereby reducing the likelihood of interference with other signals occupying the same frequency.

devices typically operate alongside cordless phones and microwave ovens in the same bands. By the end of 2002, about ten million computers used wireless networking technology operating on unlicensed spectrum—an industry that is expected to have a value of $5.2 billion by 2005.[292]

The logical evolution of the FCC's receptivity to unlicensed radio operations was the recent authorization of ultra-wideband transmissions over almost the entire spectrum.[293] Ultra-wideband devices, which may be used for vehicle collision avoidance radar and peer-to-peer communications, pulse signals at extremely low power levels over extremely wide swaths of spectrum.[294] Because the power is so low, ultrawideband emissions are designed to appear as background noise to undesignated receivers.

These new technologies, commons theorists claim, have changed the whole spectrum management inquiry. According to Yochai Benkler, for example, "the important question is no longer how to allocate spectrum among a small number of sophisticated service providers, but rather how to allow better coordination among a large number of end-users with sophisticated equipment."[295] Another way of putting this is that the focus of spectrum management must shift from the allocation of rights to frequencies to the encouragement of system design choices that increase communications through those frequencies.[296] Prime communications

---

292. *See* Comments of Consumer Electronics Association, Public Notice of FCC Spectrum Policy Task Force, ET Docket No. 02-135, at 2–4 (F.C.C. filed July 7, 2002).

293. Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems, 17 F.C.C.R. 7435, 7436 (2002). This decision followed on the FCC's adoption of a generally pro-wideband policy. *See* Principles for Reallocation of Spectrum to Encourage the Development of Telecommunications Technologies for the New Millenium, 14 F.C.C.R. 19,868, 19,871 (1999) (supporting the development of wideband technologies).

294. Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems, 17 F.C.C.R. at 7439. "UWB radio systems typically employ pulse modulation where extremely narrow (short) bursts of RF energy are modulated and emitted to convey information. Because of the very short duration of these pulses, the emission bandwidths from these systems are large and often exceed one gigahertz." *Id*.; *see also supra* note 240; *infra* note 308.

295. Benkler, *supra* note 34, at 314–15; *see also* Benkler, *supra* note 4, at 47.

> The basic point to see is that "spectrum"—the bandwidth of the frequencies used to communicate—is not an independent and finite resource whose amount needed for a communication is fixed prior to the act of communicating, and to which property rights can be affixed so that it is efficiently allocated among communications. Bandwidth is one parameter in an equation that includes radiation power, processing power of receivers and transmitters, bandwidth, antenna design and network architecture.

Id.

296. These system design choices include data switching architecture, information coding schemes, modulation schemes, and antenna placement, among others. *See* Reed, *supra* note 72, at 2.

spectrum, conceived as something akin to physical property, has been valued at more than three trillion dollars, or more than all the gold, silver, and gems ever extracted from the earth.[297] If the commons theorists are correct, spectrum reconceptualized as the capacity to transmit, rather than as frequency parcels, would be worth next to nothing. This is because the spectrum could be used with minimal rivalry and therefore without scarcity.[298] Under these conditions, a spectrum commons, rather than exhaustively distributed property rights in spectrum, would be the cheapest and most efficient mode of spectrum management.[299]

I should note that commons theorists have more on their minds than just efficiency gains. Open access to spectrum, they say, could democratize the use of a critical medium of communications.[300] Paralleling the

297. J.H. Snider, *Who Owns the Airwaves? Four Theories of Spectrum Property Rights*, 3 NEW AMERICA FOUNDATION, SPECTRUM SERIES #3 (2002), *available at* http://www.newamerica.net/Download_Docs/pdfs/Pub_File_808_1.pdf. Prime spectrum is customarily defined as spectrum in bands below 3 GHz. *See supra* note 26 and accompanying text. Snider's number of $3 trillion is presumably derived, as most spectrum valuations are, by extrapolating from past spectrum auctions. The problem with this methodology is that it assumes that the large amount of unauctioned spectrum will have the same scarcity value as the small amount of auctioned spectrum, and that spectrum has the same value regardless of what it is used for or how encumbered it may be by incumbent users.

298. *See, e.g.*, WERBACH, OPEN SPECTRUM, *supra* note 4, at 2 ("If multiple users were allowed to dynamically share frequency bands, and to employ cooperative techniques to improve efficiency, spectrum could be as abundant as the air in the sky or the water in the oceans."); *see also* Yochai Benkler, *From Consumers to Users: Shifting the Deeper Structures of Regulation Toward Sustainable Commons and User Access*, 52 FED. COMM. L.J. 561, 576–78 (2000); Buck, *supra* note 4, ¶¶ 26–27; Lawrence Lessig, *Symposium: Keynote Address: Commons and Code*, 9 FORDHAM INTELL. PROP. MEDIA & ENT. L.J. 405, 415–16 (1999); Noam, *supra* note 149, at 778–80. *But see* Comments of Station Resource Group, Public Notice of FCC Spectrum Policy Task Force, ET Docket No. 02-135, at 4 (F.C.C. filed July 8, 2002) (arguing that the "more speedily the Commission moves to making the spectrum a Commons . . . , the more rapidly we will evolve from the current artificial scarcity construct to real scarcity"); Timothy J. Brennan, *The Spectrum as Commons: Tomorrow's Vision, Not Today's Prescription*, 41 J.L. & ECON. 791, 791–92 (1998) (critiquing the notion of plentiful spectrum); Thomas W. Hazlett, *Spectrum Flash Dance: Eli Noam's Proposal for "Open Access" to Radio Waves*, 41 J.L. & ECON. 805, 814–16 (1998) (noting that spectrum subject to open access would become overly congested).

299. *See, e.g.*, Benkler, *supra* note 4, at 47–48 (refining the efficiency analysis with reference to optimized wireless network communications capacity rather than optimized spectrum use). Others have argued that a spectrum commons, or easements for unlicensed use, will be more efficient when the operators have cleared limited rights to large swaths of spectrum from exclusive rights holders. *See* FCC REPORT, *supra* note 39, at 40.

300. In pursuing notions of personal autonomy and democracy in the context of spectrum property rights, defenders of the commons subscribe to the larger critique of the "enclosure" of the digital environment at the expense of the public domain. *See, e.g.*,

objection to courts' attribution of physical characteristics to, and therefore propertization of, intangibles like electrical signals and server capacity, commons theorists object to the attribution of physical properties to and ensuing propertization of spectrum.[301] The argument is that a spectrum commons, like open source software, open Internet protocols, and limited intellectual property protection, can serve to enhance democracy. Greater public access to the means of communicating wirelessly, commons theorists assert, will result in "a more diverse set of users, greater diversity of information flow and more vibrant public dialogue."[302]

2. The End of Scarcity

How is it that spectrum, now so precious, might become abundant in a commons? How is it that innovation in communications systems—presumably the kind of innovation that is inconsistent with exclusive rights—can eliminate or substantially reduce spectrum scarcity?[303] The answer, the commons theorists contend, lies in three spectrum management changes that would allow for more intensive use

---

JAMES BOYLE, SHAMANS, SOFTWARE, AND SPLEENS 134–35 (1996); James Boyle, *The Second Enclosure Movement and the Construction of the Public Domain*, 66 LAW & CONTEMP. PROBS. 33, 37–49 (2003); *see also* LESSIG, *supra* note 4, at 170–71; Yochai Benkler, *Free as the Air to Common Use: First Amendment Constraints on Enclosure of the Public Domain*, 74 N.Y.U. L. REV. 354, 394 (1999); Jessica Litman, *The Public Domain*, 39 EMORY L.J. 965, 965–69 (1990).

301. For the mounting criticism of the "propertization" of cyberspace due to the use of inapt real space analogies, see, for example, Hunter, *supra* note 185, at 500–08; Mark A. Lemley, *Place and Cyberspace*, 91 CAL. L. REV. 521, 532–42 (2003).

302. DAVID BOLLIER & TIM WATTS, SAVING THE INFORMATION COMMONS: A NEW PUBLIC INTEREST AGENDA IN DIGITAL MEDIA 62 (2002), *available at* http://www.newamerica.net/download_docs/pdfs/pub_file_866_1.pdf; Benkler, *Siren Songs*, *supra* note 11, at 62–84 (describing how the common ownership of communications infrastructure enhances human autonomy).

303. One of the premises of commons communications theory is that unlicensed users are likely to be more innovative and use spectrum more efficiently than are licensed users. Wireless licensees dispute this assumption, noting their market incentives to make the most of their spectrum by improving interference immunity. *See* Comments of Cellular Telecommunications & Internet Association, Interference Immunity Performance Specifications for Radio Receivers, Notice of Inquiry, ET Docket No. 03-65, at 2 (F.C.C. filed July 21, 2003); *see also* Comments of AT&T Wireless Services, Inc., Unlicensed and Unshackled: A Joint OSP-OET White Paper on Unlicensed Devices and Their Regulatory Issues 5 (F.C.C. filed Aug. 21, 2003).

> Because the acquisition of spectrum and network build-out are so capital-intensive . . . the CMRS industry continuously pursues initiatives to 'squeeze' more use out of its assigned spectrum. Innovations that result in more efficient use of spectrum translate directly into greater system capabilities—extended network coverage, improved service quality . . . and more opportunity for bandwidth-intensive services.

Id.

of spectrum. First, low-power wireless systems could operate harmlessly on spectrum now used to buffer licensed signals, just as spread spectrum devices have in the past.[304] Second, and more controversially, even if new technologies operating in the buffer channels did cause interference, the existing services could respond by upgrading their "dumb" receivers so that they could more effectively reject undesirable signals. Finally, if the government allocated entire spectrum bands (and not just the buffer channels) for new system architectures, some systems could actually increase the carrying capacity of spectrum along with the number of participants in ad hoc decentralized networks.[305] If these technological advances resulted in the forecasted spectrum efficiency gains, exclusive transmission rights would not be necessary.[306] In fact, according to commons theorists, property rights to spectrum would impede the development of a commons by forcing operators to clear the rights for large, overlapping sets of cooperative activities.[307] The following subsections flesh out each of these claims before demonstrating that the commons alternative shares with the private property proposal many of the same defects when it comes to conflict resolution in the telecosm.

a. Wideband Transmissions

A conventional radio transmitter emits a signal in a constant electrical impulse within a relatively narrow band of frequencies (for example, 30 KHz for voice or data traffic) or a relatively broad band of frequencies (for example, 6 MHz for video traffic). Assuming that the signals have been transmitted with enough power, they are easy to decode by simple receivers. Wideband transmitters, the most common of which use spread spectrum technology, work very differently. They transmit

304. These buffers are necessary in part because poorly performing receivers have difficulty discerning desired signals from undesired signals when they confront both on the same frequency. *See* FCC SRRWG REPORT, *supra* note 69, at 62. According to David Reed, the buffer channels are so many and so large that "if you take a spectrogram of the radio spectrum in any point in the United States, you'll find that it's 99.999 percent unused by anybody." *Id.*

305. *See* Benkler, *supra* note 4, at 44; Reed, *supra* note 4.

306. *See* BOLLIER & WATTS, *supra* note 302, at 61. "It is no longer necessary to divide the entire spectrum into exclusive, proprietary units of control. Sharing spectrum as a license-free, open commons resource is now a feasible alternative management approach." *Id.*; *see also* WERBACH, OPEN SPECTRUM, *supra* note 4, at 9.

307. *See* FCC REPORT, *supra* note 39, at 36.

signals in periodic impulses rather than in a constant pulse, and they spread those impulses over hundreds of megahertz to receivers that are capable of reassembling the impulses into the original signal. In order to avoid interfering with other services operating in those hundreds of megahertz, wideband transmissions operate at very low power. In essence, wideband systems trade power for bandwidth and computational sophistication.[308] That is, the wider the band, the less power is necessary, but the more complex the receiver needs to be.

Wideband technologies do not coexist easily with either the command and control regime or a private ownership model. Whether licensed by the FCC or sold by spectrum owners, exclusive rights to use a 1 MHz channel do not help an operator that needs little bits of 500 MHz. The obligation to negotiate leases with the tens or hundreds of rights holders in order to transmit their low-power signals would quickly subject wideband operators to a "tragedy of the anticommons" as they encounter holdouts and excessive transaction costs.[309] It is possible for the market, in the context of a private property system for spectrum, to produce rights clearinghouses for noninterfering uses, as it has for copyright clearances.[310] Moreover, one could imagine spectrum proprietors establishing a "commons" in the bands they own and capturing revenue from user fees or equipment fees.[311] Despite these possibilities, commons theorists insist that a market approach simply cannot support optimal deployment of wideband technologies.

b. Smart Radios

Most existing radios are dumb. They are specially designed hardware operating on a narrow range of frequencies and have limited capabilities to discriminate between desired signals and undesired noise.[312] Digital

---

308. The development of ultra-wideband communications theory owes much to Claude Shannon's multiuser information theory, which posited that if communications transmissions were spread out over sufficiently wide bands of spectrum, they could be transmitted at lower powers and still received. *See generally* C.E. Shannon, *A Mathematical Theory of Communication*, 27 BELL SYS. TECH. J. 379 (1948), *available at* http://cm.bell-labs.com/cm/ms/what/shannonday/shannon1948.pdf; *see also* Benkler, *supra* note 4, at 41; FCC SRRWG REPORT, *supra* note 69, at 59 (Comments of David P. Reed) (describing Shannon's reconceptualization of the communications resource as the transmission of bits rather than quantities of spectrum).

309. The phenomenon of splintered property rights that frustrate the efforts of innovators who need to assemble rights from multiple owners has been described as the tragedy of the anticommons. Michael A. Heller, *The Tragedy of the Anticommons: Property in the Transition from Marx to Markets*, 111 HARV. L. REV. 621, 659 (1998).

310. *See* FCC REPORT, *supra* note 39, at 31; *see also* Faulhaber & Farber, *supra* note 147, at 15.

311. *See* Benjamin, *supra* note 4, at 2036–38.

312. *See generally* Authorization and Use of Software Defined Radios, 16 F.C.C.R.

processing permits radios to become much smarter. Instead of relying on special purpose hardware, systems can use software processing to decode signals across a wide range of frequencies and to interact more intelligently with transmitters and the spectral environment at large.[313] Commons theorists envision a world of smarter radios that are defined by their software.

A class of software defined radios, known as "agile" radios, promises to avoid spectrum congestion by detecting the usage of select frequencies before transmitting. Like pedestrians on a crowded sidewalk, the signals these radios emit will be able to weave and dodge among other signals rather than simply traveling headlong into a lamp post. The theoretical model suggests that as long as there is some available frequency within the range of the agile radio, the radio can operate on a broad range of frequencies. As a result, spectrum within a commons could be dynamically and automatically allocated to devices on an as-needed basis.[314]

Even more sophisticated than agile radios are "cognitive radios." A cognitive radio is capable of sensing the type of signal environment it operates in. It can, for example, sense whether there is significant congestion in the spectrum band or whether there is rain or heavy foliage to deflect signals. In these cases, it might sacrifice data rates to spend more bits on aggressive error correction. Such a radio and associated system has the capability to learn and adapt automatically to user needs and the current spectrum environment.[315]

17,373, 17,374 (2001); William Lehr et al., Software Radio: Implications for Wireless Services, Industry Structure, and Public Policy 2–4 (2002), *available at* http://itc.mit.edu.

313. *See* Lehr et al., *supra* note 312, at 3–7.

314. *See generally* Reed, *supra* note 72 ("By cooperatively sensing and manipulating their electromagnetic environment, a network of software defined radio transceivers can adapt to their physical environment to match demand much closer to the capacity achievable by joint action of a group of radios."); *see also* Faulhaber & Farber, *supra* note 147, at 12 (contemplating this kind of automatic allocation of capacity to demand). The FCC has already taken a step to accommodate software defined radios by permitting manufacturers to make changes to a radio's operating parameters, including frequency, radiated power, and modulation type, without any associated change of hardware that would be certified under the FCC's Part 15 rules. As a result, the radios can be reconfigured by a software download to transmit and receive on any frequency in any format. *See* Authorization and Use of Software Defined Radios, 16 F.C.C.R. 17,373, 17,374–75 (2001).

315. *See* Joseph Mitola III & Gerald Q. Maguire, Jr., *Cognitive Radio: Making Software Radios More Personal*, IEEE PERS. COMM. MAG., Aug. 1999, at 13. The FCC has recently adopted rules to facilitate the operation of cognitive radios and has opened a proceeding on the possible implications of cognitive radios for spectrum management.

c. Mesh Networks

More revolutionary than the advent of wideband technologies and smart radios is the creation of decentralized communications network architectures. The idea that increasing the number of users of a wireless communications system could increase the capacity of that system is counterintuitive but critical to the commons project. With conventional high-powered technologies like broadcast television and cellular phone systems, the more transmitters (broadcast antennas and cellular phones) there are, the more stress there is on the spectrum, and the less capacity there is for new communication. That is because the transmissions have preclusive effects on rivalrous transmissions that would use the same frequencies at the same time in the same place. New networked architectures, by contrast, promise to increase the utility of the spectrum by increasing the density of antennas. The way they do this is through something known as "cooperation gain."[316]

The promise of cooperative, rather than interfering, antennas emerged in the 1990s out of the experience of cellular companies. These operators were able to increase capacity by adding cell sites, thereby shortening the distances signals had to travel before being relayed and enabling the reuse of frequencies for more communications. The resulting communications networks reduce the likelihood that any two signals will use the same frequency at the same time at sufficient power to result in interference.

At the same time, technologists looked to the developing Internet as a model for wireless communications.[317] The Internet's architecture

---

Facilitating Opportunities for Flexible, Efficient, and Reliable Spectrum Use Employing Cognitive Radio Technologies, Authorization and Use of Software Defined Radios, 18 F.C.C.R. 26,859 (2003) (exploring the impact of a cognitive radio's ability to determine the location and spectrum use of neighboring devices, change frequency, adjust output power, and alter transmission parameters and characteristics on the use of spectrum in the space, time, and frequency dimensions).

316. *See* Reed, *supra* note 72.

317. Comparisons of wireless communications and Internet architecture are not without problems. First, the analogies being drawn are usually to the logical, not to the physical or content layers of the Internet. While the logical layer, consisting of the protocols for routing data packets through the networks that comprise the Internet, may be a common resource, the actual physical infrastructure consisting of phone and cable lines, as well as licensed wireless connections, fiber, routers, and servers, has always been owned. In other words, the wireless standards that operate at the logical layer (that is, software protocols for transmitting and receiving signals) may be open and comply with the end-to-end principle, but the physical layer is proprietary. Second, the Internet was built on common standards and a telephone platform that already enjoyed a single architecture and a highly controlled transmission environment. By contrast, wireless communications systems use a wide variety of "signal architectures and modulation types for voice, video, data and interactive services." FCC IPWG REPORT, *supra* note 68, at 4. The spectrum commons, in contrast to the Internet, will encompass a wide

suggested that communications, like computing, did not need to be controlled at the center of a network or from a mainframe computer. Rather, the intelligence of a communications network could reside in the consumer's home or office at the edge of the network. The idea of the end-to-end network is that the network itself should not be optimized for any particular application, but should be open to innovation from the edges.[318] These insights led to experimentation with new wireless architectures that rely on a dense network of cells composed of personal communications devices.[319] The use of wireless devices in the field to repeat signals can, in theory, solve interference problems through the very proliferation of radios that ordinarily exacerbates interference. That the Internet end-to-end model can be implemented in the radio space is the basic premise for the commons model.[320]

One type of end-to-end cooperative telecommunications network is the mesh network. In most existing networks, communications are either circulated through closed loops between transmitter and receiver or collected at key transmission points before being distributed to receivers. Your wireline phone call goes to a central switch, from which it is dispatched to its destination. In a mesh network, each communications node is connected to every other node. Communications are handed off from transmitter to receiver to transmitter to receiver without any central

---

diversity of communications architectures that operate in an unpredictable and fragile transmission environment. Finally, wireless communications may interfere with each other in ways that Internet transmissions at the logical layer do not.

318. For a good description of the end-to-end principle, see LESSIG, *supra* note 4, at 36–37; *see also* Mark A. Lemley & Lawrence Lessig, *The End of End-to-End: Preserving the Architecture of the Internet in the Broadband Era*, 48 UCLA L. REV. 925, 928 (2001); David P. Reed et al., *Commentaries on "Active Networking and End-to-End Arguments*," IEEE Network, May/June 1998, at 69–70.

319. *See* Benkler, *supra* note 4, at 40–47 (discussing the implications of multiuser information theory).

320. *See* Benkler, *supra* note 297, at 564.

> Users sometimes receive information and sometimes rework it and send it to others. They can play the roles of producer and consumer. Their acts of reception are dialogic in the sense that they can easily be mapped as moves in a conversation rather than as endpoints for the delivery of a product.

Id.; *see also* David Reed, Why Spectrum Is Not Property—The Case for an Entirely New Regime of Wireless Communications Policy (February 27, 2001) (comparing Internet and wireless architectures focusing largely on technical developments), *at* http://www.reed.com/dprframeweb/dprframe.asp?section=paper&fn=openspec.html. Again, these analogies to the Internet neglect the difference between operation of the end-to-end principle at the logical layer of the Internet and at both the physical and logical layers of wireless systems, where commons theory requires such operation. *See supra* note 317.

points of control. It is here that the analogy between spectrum and air has particular credence: Users in a mesh network use spectrum, as living things use air, without consuming it.

Peer-to-peer networks, akin to mesh networks, have been developed successfully for the transmission of data over the Internet.[321] Kazaa, which allows users to pass requests for music from one to another without any central server, is an example.[322] When this kind of peer-to-peer network is deployed in the wireless space, some engineers think that the capacity of a cooperative wireless network may be virtually unlimited because the greater the density of users, the more capacity for relaying communications.[323] David Reed, engineer and architect of the end-to-end principle, uses the commons image of a sheep's meadow to describe the capabilities of mesh networks. The sheep's meadow becomes a tragedy of resource use as more sheep are added to the meadow and over-graze. In a successfully operating mesh network, each user is like a sheep that brings grass to the meadow, sustaining an endless green that supports an infinite number of sheep.[324]

A change in network architecture from closed and highly structured systems to open and protean systems could have a profound impact on the organization of wireless communications markets. Commons theorists predict that mesh networks, in combination with smart radios and digital processing advances, will shift the value in communications networks from the service provider to the equipment provider.[325] The

---

321. For an analysis of the economics and characteristics of peer production, see generally Yochai Benkler, *Coase's Penguin, or, Linux and the Nature of the Firm*, 112 YALE L.J. 369, 374–77 (2002).

322. *See generally* Metro-Goldwyn-Mayer Studios, Inc. v. Grokster, Ltd., 259 F. Supp. 2d 1029, 1043 (C.D. Cal. 2003) (holding on summary judgment that KaZaA was not liable for the copyright infringement of those using its software to exchange copied digital media via a peer-to-peer transfer network); Stacey L. Dogan, *Code Versus the Common Law*, 2 J. ON TELECOMM. & HIGH TECH. L. (forthcoming 2004).

323. *But see* Motorola, Inc., A White Paper on Future Federal Communications Commission Spectrum Policy, ET Docket No. 02-135 (F.C.C. filed Aug. 30, 2002). Motorola assumes a system with 1000 users randomly placed in a 10 km square. Under these conditions, a significant number of users must relay data for ten percent of the total number of users, suggesting a serious congestion problem associated with the unlimited growth of a cooperative relay network. Relying on recent technical work by Gupta and Kumar, Motorola asserts that "the total system capacity grows faster than the number of users but that the per user capacity decreases as the number of users increases." *Id.* at 9.

324. *See* FCC SRRWG REPORT, *supra* note 69, at 93–94 (Comments of David P. Reed). It was the development of telecommunications and the spread of roads in the last century that conquered space and made physical density a choice rather than a necessity for human commerce. Might new technological developments in this century, in telecommunications of all things, revive the importance of physical density for communication? In this connection, there is some irony in the mesh network evangelists' illusions to highways, which mastered space in the last century, as models for distributed communication. *See infra* note 336.

325. Benkler, *supra* note 4, at 74.

value in mobile phone service today resides with the intelligence: in the network service provider. Equipment is relatively cheap and minutes are relatively expensive because the consumer is paying for the network operator's investment in scarce spectrum and system infrastructure. In a world of mesh networks, which can reuse frequencies with great efficiency, spectrum becomes cheap. In a world of networks that rely on decentralized relays, the system architecture also becomes cheap.[326] What becomes more expensive, as in the Internet's network of computers, is the end-user equipment, which must now be sophisticated enough to do the work of a network operator.[327]

Unanswered questions abound for this utopian vision of cooperative networks. The comparison of peer-to-peer wireless and Internet networks must take into account an important difference. Internet applications take advantage of telecommunications and computing infrastructure that was built with significant governmental support and is supported now through private investments. Thus, even if consumer investment could sustain much of a wireless network, it probably cannot replace the networks of microwave, satellite, cable, fiber, and copper that carry communications from end-users to the Internet backbone and other communications networks. It is unlikely that mesh networks could do without this kind of heavy infrastructure and unclear how industrial

326. The "price" of the network design is in the performance that users give up as more users join the network and traffic management becomes more complex. A major constraint of mesh networks is that, in order to dynamically assign capacity within the network based on user demand, the network must communicate with itself. This communication itself uses more information, and as the size of the network increases, the overhead communications about the communications become denser and more complex. *See* Benkler, *supra* note 34, at 327; Reed, *supra* note 72, at 8; James B. Speta, *A Vision of Internet Openness by Government Fiat*, 96 NW. U. L. REV. 1553, 1572 (2002) (book review).

> [W]here each device controls itself, the best that can be done [to manage spectrum] is to use protocols that permit the spectrum to be used approximately sixty percent of the time. This is because there is no centralized controller for the devices, which must each individually "listen" for free spectrum.

Id. *See generally* Jon M. Peha, *Wireless Communications and Coexistence for Smart Environments*, 7 IEEE PERS. COMM. MAG. 66 (2000); Durga P. Satapathy & Jon M. Peha, *Etiquette Modification for Unlicensed Spectrum: Approach and Impact*, *in* 1 IEEE VEHICULAR TECHNOLOGY CONFERENCE 272, 276 (1998) (writing that an appropriate etiquette can avoid a tragedy of the commons, at the cost of reduced performance).

327. Benkler, *supra* note 4, at 49–62 (explaining why distributed networks will invest more in end-user equipment and less in network infrastructure than will centrally controlled networks).

investments in this infrastructure would persist in the absence of end-user fees.[328] For the purposes of this Article, the most pressing question is how, and according to what values, interference and overuse would be prevented as cooperative networks come to occupy more and more spectrum.

B. Conflict Resolution in the Commons

In the absence of control by either the service provider or the government, what will ensure that this abundance of chattering devices relaying messages from one to the other do not overuse the spectrum and do not interfere with each other? The amount of resources consumed by a transmission depends on transmission duration, bandwidth, and power. Unlicensed devices, if unconstrained, are likely to adopt a greedy approach to the consumption of these spectrum resources.[329]

The solution to greed, commons theorists assert, is modeled by the Internet. Rather than a system of ex post interference resolution like nuisance law, commons theorists envision a system of ex ante control in which access to commons spectrum is limited by the enforcement of technical protocols that are established with some degree of government oversight.[330] Open and universal technical protocols, it is thought, could govern the use of wireless equipment.[331] Consensus spectrum etiquettes and protocols that prevented greedy use of the spectrum and articulated a common language to communicate across frequencies could substitute for any kind of centralized control. According to one etiquette, for example, a device might have to "listen" to make sure that the spectrum is unoccupied before it begins transmitting and to limit transmissions to prevent hogging. The FCC's rules for unlicensed services rely on just these kinds of protocols as a control strategy. These include, in different

328. *Accord* Speta, *supra* note 326, at 1573 (discussing the costs of setting aside spectrum for unlicensed uses); Philip J. Weiser, *The Internet, Innovation, and Intellectual Property Policy*, 103 COLUM. L. REV. 534, 573–75 (2003) (writing about the failings of the commons theory and that the Internet's success came about with the assistance of the government).

329. *See* Satapathy and Peha, *supra* note 326, at 272; *see also* Benkler, *supra* note 34, at 360 (defining spectrum overuse as "using, for a given transmission more spectrum than necessary to transmit the information it has to transmit, hence increasing its potential to conflict with other users").

330. *See* Benkler, *supra* note 34, at 362 (noting the need for industry adherence to technical protocols to safeguard the quality of wireless communications in the commons); Benkler, *supra* note 4, at 77–78 (discussing public regulation of the commons through the instrument of technical protocols); *see also* Benjamin, *supra* note 4, at 2045–50 (discussing the need for protocols in abundant networks and comparing the relative merits of public and private roles in protocol selection).

331. *See* FCC REPORT, *supra* note 39, at 39.

combinations in different unlicensed bands, power limitations,[332] controls on technology,[333] and spectrum-use etiquettes such as listen-before-talk.[334]

The choice of ex ante controls in a future commons will involve tradeoffs between different technologies and different values.[335] Etiquette approaches cannot be agnostic about technical and service choices, even if they do not restrict the technologies that devices may use. Inherent in any agreement to abide by certain technical protocols is a bias towards a set of technical architectures that can be supported. For example, compare rail to road travel. Access to downtown Washington, D.C. at rush hour via a highway from Dulles International Airport is a scarce resource. Replacing that road with a dedicated high-speed rail line might render access abundant, but only if users are required to adhere to the limiting architecture of rail travel.[336] This choice of

---

332. 47 C.F.R. § 15.209 (2002).

333. For example, devices in the ISM bands must use spread spectrum or similar technology. *Id.* § 15.247. By using this technology, operators employ processing gain to compensate for increased power. In the U-NII band, operators are not required to have processing gain. Moreover, they are not limited in total power, so long as they comply with power density requirements. *Id.* § 15.407(a).

334. Sections 15.321 and 15.323 specify listen-before-talk etiquette. The transmitter must listen to the spectral environment to ensure that there are no signals in its path before it emits. This existing listen-before-talk etiquette has been criticized because devices can still improve their performance by causing more interference for their neighbors than is necessary. *See* Durga P. Satapathy & Jon M. Peha, *Performance of Unlicensed Devices with a Spectrum Etiquette*, *in* 1 IEEE GLOBAL TELECOMMUNICATIONS CONFERENCE: CONFERENCE RECORD 414–18 (1997). These protocols have been blamed for the lack of commercial success in the unlicensed PCS service. *See* SPECTRUM POLICY TASK FORCE, FCC, REPORT OF THE UNLICENSED DEVICES AND EXPERIMENTAL LICENSES WORKING GROUP 12 (2002) [hereinafter FCC UDEL REPORT], *available at* http://www.fcc. gov/sptf/files/ UDWGFinalReport.pdf .

335. Stuart Benjamin has identified many of these tradeoffs. *See* Benjamin, *supra* note 4, at 2045.

> [Technical] limitations entail choices that may benefit some services at the expense of others. To pick one obvious example, there may be power limits (as there are in the FCC's unlicensed bands and as there would be in abundant networks). These limits may make some services impossible (*e.g.*, traditional broadcasting) and others difficult (*e.g.*, point-to-point communications over long distances), while having no effect on, and therefore optimizing on that network, other forms of communication (*e.g.*, multi-hop packetized transmissions, as in an abundant network).

Id.

336. Commons theorists have been known to compare unlicensed spectrum to our highway system in which, once one opts into the technical constraints of the system (for example, a motorized vehicle and a speed limit), one can travel freely. *See, e.g.*, Benkler, *supra* note 34, at 388–89; Benkler, *supra* note 4, at 7. Indeed, the transformation of our

architecture confers tremendous benefits on the rail operator and suppliers, as well as on businesses near the rail stops. It has less salutary effects on other interests. Thus, extinguishing scarcity of one resource may create new scarcities, and invest new value, in other resources.

In the spectrum context, technologists have noted that the services enjoying the greatest success in the unlicensed bands today may not be the most efficient or technically superior. The current rules controlling entry to the unlicensed bands favor services that are less vulnerable to uncontrollable interference. They disfavor real-time applications that are more vulnerable to interference and mixed use of the same spectrum.[337] As a general matter, real-time applications cannot sustain delays in the delivery of the signal and require a high quality of service.[338] Citizen Band (CB) radio—a real time "unlicensed" service—ultimately failed in large part because it was inefficient and undependable in crowded regions.[339]

The construction of spectrum etiquettes, by requiring choices among communications architectures and uses, forces choices among possible goals for spectrum management. One possible goal is to maximize coexistence among as many different kinds of services as possible. Another goal is to minimize the amount of interference that users cause each other.[340] Privileging coexistence over interference reduction or

---

transportation system from one built essentially around pedestrian, equestrian, and rail traffic to one built around the automobile dramatically increased freedom of movement. But the new freedom imposed negative externalities that were not taken into account in the early part of the twentieth century as the highway system took shape. We can now look back at that transformation and see how many values were neglected in the haste to roll out the automobile. There has been a steep price in urban blight, time lost to traffic and increased commuting distances, destroyed communities, and air pollution. In the case of highway development, an understanding of the interplay between technological change and social costs was not sufficiently well known and, once known, addressed. *See generally* RICHARD MOE & CARTER WILKIE, CHANGING PLACES: REBUILDING COMMUNITY IN THE AGE OF SPRAWL 58–71 (1997). Those sorts of issues must be confronted in the process of reforming spectrum management.

337. *See* Satapathy & Peha, *supra* note 149, at 50.

338. Comments of Motorola, *supra* note 95, at 20; *see also* Spectrum Policy Task Force Seeks Public Comment on Issues Related to Commission's Spectrum Policies, 17 F.C.C.R. 10,560, 10,562 (2002) (noting that as congestion rises, some uses of unlicensed spectrum are at a disadvantage).

339. Creation of an Additional Personal Radio Service, 72 F.C.C.2d 453, 455 (1979) ("The CB Radio Service meets a wide variety of personal and business needs, but there have been 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."). CB radio is, technically, not an unlicensed service, but a service that is licensed by rule. That is, the FCC rule sets forth that eligible operators may operate without further authorization from the agency. For the purposes of this Article, however, that distinction is unimportant.

340. The FCC rejected the view of the public interest that the objective of

vice versa will have a significant impact on what services are developed. Moreover, fairness to earlier generations of unlicensed users may motivate a shift over time from an emphasis on coexistence to an emphasis on incumbent protection. Another goal might be to adopt protocols that distinguish between low-value and high-value applications. Generally, a commons that relies on etiquette will be optimized for low-value uses.[341] Because Mike's spam and John's X-Ray are treated the same way by the Internet routers and servers through which their communications pass, John's X-Ray may be slowed by Mike's spam. Code may be adopted to tag and prioritize communications, but not without significant dispute and expense.

The protocols that are ultimately selected, most likely after long controversy, can be circumvented. For example, a greedy mesh network user might configure his equipment to refuse to transmit the messages of others or to use more bandwidth than necessary to speed his transmissions.[342] Some have proposed automatic penalties for such discourteous behavior.[343] The penalty would be in the form of a time-out from operation, the duration of which would increase with the amount of spectrum resources consumed. Thus, a device that transmitted at high power or duration might have a larger monitoring time and a smaller power limit.[344] The selection of penalties and relative severity among different kinds of applications will, like the selection of spectrum protocols, influence spectrum rights.

Of course, the software required to comply with protocols, or deliver penalties, can also be changed from time to time. Indeed, one of the chief advantages of software defined radios is that they are adaptable.[345]

---

unlicensed band regulation should be "to maximize co-existence among devices." Amendment of Part 15 of the Commission's Rules Regarding Spread Spectrum Devices, 17 F.C.C.R. 10,755, 10,765 (2002). Instead, it adopted the view that the primary goal of unlicensed band regulation was "interference avoidance." *Id*. at 10,766.

341. *See* Satapathy & Peha, *supra* note 149, at 4.

342. *See* Benjamin, *supra* note 4, at 2022–24 (discussing how overuse of the commons spectrum can degrade the functions of wireless systems).

343. *See, e.g.*, Satapathy & Peha, *supra* note 327, at 273–76.

344. *See id.* at 272–76; *see also* Benkler, *supra* note 34, at 360–61.

> By designing the spectrum sharing protocol so as to reward a device that uses no more spectrum than necessary to transmit its message by giving it faster repeated access to the spectrum for each of its transmission bursts, and penalizing an inefficient device by delaying its access, spectrum utilization protocols can bring into play the incentives of equipment manufacturers to design their equipment so that it suffers the least delay.

Id.

345. The FCC has addressed this problem by requiring the original version of the

The less intensive the certification requirement, the less control there is over modifications of software that lead to the degradation of the spectrum. One approach to reduce the risk of software modification for the purpose of avoiding penalties or compliance with protocols is to subject the most important and stable software, like operating system software, to more stringent certification procedures.[346] And yet, as the antitrust litigation over Microsoft's bundling of its browser with its operating system proved, it can be difficult to base legal rules on distinctions between operating systems and other software.[347] One can only imagine the debates that would arise over whether one or another functionality in a communications device is or is not intrinsically related to the operating system.

Given the importance of protocol selection and enforcement to the ecology of a spectrum commons, and to the kinds of systems that will populate it, disputes over protocols will be vigorous. As with disputes between spectrum owners, disputes in the commons will implicate the same kinds of fairness and efficiency issues we have seen in the FCC context. Will incumbents be privileged? How much equipment churn will consumers be expected to bear? What kinds of services will be provided, at what cost, and through what gatekeepers? And as with disputes between spectrum owners, dispute resolution in the commons will be neither self-executing nor quick. We know this from seeing the process of standard setting in the administrative context. For example, it took three years and two rulemakings for the FCC to change its ex ante controls for unlicensed operation to allow new, nonconforming technologies into the unlicensed bands.[348] Even when industry groups

---

software radio to be certified with the equipment on which it will run (making certification the responsibility of the equipment vendor). The FCC will not certify modifications made by third party software vendors. All modifications are the responsibility of the manufacturers whose radio containing both hardware and software was originally certified. Independent radio software providers must work through equipment manufacturers. Software changes that affect radio frequency, power, and modulation are subject to a more streamlined certification process. Authorization and Use of Software Defined Radios, 16 F.C.C.R. 17,373, 17,383 (2001).

346. *See* Lehr et al., *supra* note 312, at 19; *see also In re* Authorization and Use of Software Defined Radios, Petition for Clarification or Partial Reconsideration of Vanu, Inc., ET Docket No. 00-47, at 1–2 (F.C.C. filed Nov. 5, 2001).

347. United States v. Microsoft Corp., 87 F. Supp. 2d 30, 50–51 (D.D.C. 2000) (holding that Microsoft abused its monopoly position in the operating system market by tying its operating system to its Internet browser), *aff'd in part, rev'd in part, and remanded by* 253 F.3d 34, 53–54 (D.C. Cir. 2001).

348. In response to a request from the Home RF working group, the FCC conducted a rulemaking that resulted in permission for entities to use wider bandwidths and fewer hops for their frequency hopping technology. Amendment of Part 15 of the Commission's Rules Regarding Spread Spectrum Devices, 15 F.C.C.R. 16,244, 16,245 (2000); Amendment of Part 15 of the Commission's Rules Regarding Spread Spectrum Devices, 14 F.C.C.R. 13,046, 13,047 (1999). Then, another entity, Wi-LAN, Inc., came along requesting

are responsible for agreeing to protocols that the regulator merely approves, standard setting has often proved to be staggeringly slow and acrimonious.[349]

Once we consider the systems of authority that will be necessary to create and enforce technology controls in the commons, we see that the distinction between common and private property regimes is not as firm as it once appeared. What is envisioned by the commons theorists is not a true commons, like the upper atmosphere or aquatic life in the deep seas, which are unclaimed and uncontrolled by any community.[350]

---

authorization of its digital transmission technology (W-OFDM) under the existing spread spectrum equipment authorization rules. The FCC denied authorization because the technology did not comply with the rules, but issued a second rulemaking to amend the rules so that Wi-LAN could operate. Amendment of Part 15 of the Commission's Rules Regarding Spread Spectrum Devices, 16 F.C.C.R. 10,036, 10,041 (2001). Finally, the agency decided to amend its rules to allow a range of digital devices to operate in the unlicensed band, using system architecture that had the same interference potential as the previously approved technologies. Amendment of Part 15 of the Commission's Rules Regarding Spread Spectrum Devices, 17 F.C.C.R. 10,755, 10,760 (2002).

349. The FCC's selection of a standard for digital television is an example of acrimony surrounding a technical standard. There, the FCC stepped in to broker a compromise between broadcasters and the computer industry over the standard that would govern the new digital television technology. At issue were critical tradeoffs between the robustness and flexibility of the system for broadcast television versus other computer-based, digital technologies. *See* Advanced Television Systems and Their Impact Upon the Existing Television Broadcast Service, Fourth, 11 F.C.C.R. 17,771, 17,772–73 (1996). An example of a standard setting battle that has been both acrimonious and extremely lengthy comes from the cable world. The cable and consumer electronics industries were charged in 1996 with developing technical standards that would allow consumers to use their digital television sets or retail set-top boxes for digital cable services without having to use the cable operator's set-top box. 47 U.S.C. § 549 (2000); 47 C.F.R. § 76.1204(a)(1) (2003). Seven years and significant amounts of FCC intervention later, the standards are still in the process of being completed. Implementation of Section 304 of the Telecommunications Act of 1996, Commercial Availability of Navigation Devices, 18 F.C.C.R. 7924, 7926 (2003). *See generally* Richard E. Wiley, *CommLaw Conspectus Preface*, 8 COMLCON 189, 190 (2002) (writing that "important standards issues—like cable compatibility, receiver labeling, interactive services interconnection, broadcast modulation and copy protection—have remained unsettled for an extended period of time despite repeated industry promises and government indications that they would be resolved").

350. For the distinction between communal property and unowned property, see Thomas W. Merrill, *Property and the Right to Exclude*, 77 NEB. L. REV. 730, 749–50 (1998); *see also* Hanoch Dagan & Michael A. Heller, *The Liberal Commons*, 110 YALE L.J. 549, 556–57 (2001) (citing JAMES M. ACHESON, THE LOBSTER GANGS OF MAINE 143 (1988)); Robert C. Ellickson, *Property in Land*, 102 YALE L.J. 1315, 1322 (1993); Carol M. Rose, *Left Brain, Right Brain and History in the New Law and Economics of Property*, 79 OR. L. REV. 479, 480–81 (2000); Carol M. Rose, *Rethinking Environmental Controls: Management Strategies for Common Resources*, 1991 DUKE L.J. 1, 3 n.4; Henry E. Smith, *Semicommon Property Rights and Scattering in the Open Fields*, 29 J.

Rather, it is a commons to which access is limited by compliance with technological specifications. It is a controlled property regime in which the many have the right to exclude some, as opposed to a private property regime in which the one has the right to exclude almost all. Access to the commons is limited by the community, which exercises the right to exclude outsiders from the spectrum or to reduce the utility of the spectrum to users once they transmit in violation of the community's norms.[351] The type of spectrum property regime the commons theorists propose is thus a system of limited access in which a finite number of people manage the resource together (those who use compliant equipment and system architectures) and exclude outsiders.[352] Both commonly controlled and privately controlled spectrum will require definitions that distinguish one entity's set of rights as against others.[353]

LEGAL STUD. 131, 131–34 (2000). In a true commons, access is virtually unlimited and no user may exclude any other. *See* Frank I. Michelman, *Ethics, Economics, and the Law of Property*, *in* NOMOS XXIV: ETHICS, ECONOMICS AND THE LAW 3, 5, 176 (1982) (using the vocabulary of duties and privileges developed by Hohfeld to define a commons property regime as one in which "there are never any exclusionary rights. All is privilege. People are legally free to do as they wish, and are able to do, with whatever objects . . . are in the [commons]"); *see also* Hohfeld, *supra* note 144, at 746 (writing that property "consists of a complex aggregate of rights (or claims), privileges, powers, and immunities").

351. Kevin Werbach, recognizing the heavy regulatory component embedded in the notion of a spectrum commons, has developed the intriguing concept of a "supercommons," in which distributed network users would be free to operate largely as they like, subject to tort-like liability for causing interference unless the accused devices were excused under a safe harbor approach. *See* Werbach, *Supercommons*, *supra* note 4. As I hope my exploration of spectral nuisances has shown, the assignment of tort liability and remediation of torts in the telecosm is bound to be a heavily "regulatory" enterprise requiring a definition of harmful interference and a system of values by which to assign liability and contrive remedies. The creation of safe harbors for certain kinds of uses might well make a tort system function more efficiently, but arriving at categories of compliant devices is not very different from creating ex ante protocols and raises many of the same questions.

352. This type of property has also been called a semicommons. *See* Smith, *supra* note 350, at 131–38 (defining a semicommons as a regime in which common and private property rights are both significant, such as the open-field system of medieval and early modern northern Europe, in which peasants had private rights to the grain grown on small plots of land and rights in common to graze animals under a common herdsman on the collection of plots); *see also* OSTROM, *supra* note 46, at 23 (designating such property a "common property resource"). Carol Rose has called this kind of limited commons a private "property on the outside, commons on the inside." Carol M. Rose, *The Several Futures of Property: Of Cyberspace and Folk Tales, Emission Trades and Ecosystems*, 83 MINN. L. REV. 129, 144 (1998). Robert Merges has advocated that limited commons property be increased in the intellectual property domain. *See* Robert P. Merges, *Property Rights Theory and the Commons: The Case of Scientific Research*, 13 SOC. PHIL. & POL'Y 145, 162–63 (1996) (arguing that joint rights to scientific research, combined with group norms that safeguard property rights, further scientific inquiry).

353. *See* Hohfeld, *supra* note 144, at 746–47; *see also* Peter S. Menell & John P. Dwyer, *Reunifying Property*, 46 ST. LOUIS U. L.J. 599, 606 (2002) (explaining how all of

The selection of access and conflict resolution rules will require choices that implicate both equity and efficiency interests. Indeed, the selection and enforcement of technology controls in the commons will engage some of the very same questions the FCC now faces in spectrum conflict resolution. As we have seen, these are also some of the very same questions that nuisance courts would face in a system of private spectrum property. The unresolved difficulties of mediating among conflicting demands for spectrum in both private and common property models of spectrum management suggest a need to think further about the role of the regulator in the transition to a new regime. The next Part reflects on this question and claims that regulatory participation in private and common property regimes in spectrum will be important in ensuring the efficient and fair allocation of rights in the telecosm to come.

VI. A MIXED REGULATORY, COMMONS, PRIVATE PROPERTY RIGHTS APPROACH

We have seen that the ideas of building a telecosm on private property rights in spectrum or on cooperative communications are both strongly utopian. The market utopianism of the first, and the technological utopianism of the second, put excessive distance between the imagined new worlds and the administrative regime left behind. The necessity for resolving disputes between spectrum owners or spectrum users will require tradeoffs between the parties and among public interest values that the FCC currently makes. Because of the complexity of interference, these tradeoffs will be difficult for common law courts, even as they have proved difficult for the expert agency. In commons theory, there has not yet emerged any conceptual framework to guide the choices of technical standards bodies among competing spectrum uses. Nor have the theorists tackled the question of public legitimacy for these private bodies. Clearly much more work needs to be done on both models of spectrum reform.

The complexity of spectrum conflicts and the dual nature of spectrum as land and air suggests that administrative law will be a necessary component of the dispute resolution process whatever the shape of the telecosm. In section A, this final Part posits that, notwithstanding the current oppositional posture of property rights and commons theories,

---

property law, including the law of land ownership and the law of information management, can be explained as the governing of resources through different institutions).

there is no conceptual or practical reason for a choice between the two. Indeed, the most likely outcome of the current policy debate is a mingled approach to spectrum control in the future. Section B lays out a fruitful role for regulatory guidance and oversight in a telecosm of both common and private property rights. The claims of the critics of spectrum regulation have been so bold that important nuance about spectrum conflicts and the potential role of regulatory judgment in a future telecosm has been lost. Recognition that conflict in a private or common property rights regime will present sometimes as private nuisance, sometimes as air pollution, and sometimes as a public standards battle forces reexamination of agency involvement in spectrum conflict.

A. Coexistence of Private Property and Commons Spectrum

Private property and commons theorists have positioned themselves at the poles of the debate over spectrum management. The private property theorists are market utopians, who see the path to consumer welfare running through private spectrum parcels. The commons theorists are technological utopians, who assert that consumer or citizen welfare will be achieved through shared access to spectrum, with only consensual technical protocols to prevent overuse.

The dichotomy between common and exclusive property has been overdrawn in the current academic debate. Spectrum is both land and air. At bottom, both private and common property theorists agree that, to the extent that spectrum is an inherently scarce resource, exclusive property rights are an efficient method of allocation. The crux of the disagreement between the two schools concerns the empirical question of whether technological innovation will effectively render spectrum so abundant that the costs of a private property regime cannot be defended. Thus, it is mainly a view of technology, not of economics or law, that divides private and commons property theorists. Given the theoretical commonality between the two schools, and the practical appeal of a strategy that hedges the risk of creating too much or too little property, combining the private and common property approaches in any new spectrum management system will be irresistible.[354] As the FCC heeds the criticism of command and control regulation and takes tentative

354. According to its proponents, a private property regime in spectrum is flexible enough to support common control of segments of the spectrum where technology makes such control advantageous. The proprietor would simply open up a band to common use, employing a metered or other easily administered pricing scheme. *See, e.g.*, Benjamin, *supra* note 4, at 2036–43, 2055–64; Hazlett, *The Wireless Craze*, *supra* note 3, at 496. Commons theorists counter that the costs of this kind of privately owned "commons" would undermine the benefits of a commons. *See* Benkler, *supra* note 34, at 362.

steps to revamp its spectrum management role, it seems to be heeding the advice of Richard Epstein on the property debate in general: "[N]o matter how shrill the rhetoric on either side, any responsible search for a sound system of property rights searches for the net social advantage by minimizing the sum of the rival inconveniences."[355]

The FCC is introducing reforms that increase the amount of spectrum available for unlicensed use even as it moves to give licensees more property-like rights in spectrum.[356] Congress, having furthered the private property rights project a decade ago by requiring spectrum auctions, is now considering changes to the law that would promote a limited commons.[357] Upheavals in the legal regime governing spectrum use, if there are any, will likely result in the triumph of both common and private property over the command and control regime.[358] Indeed, buried in the scholarship on either side of the property debate is a recognition that a dual mode of spectrum management is desirable.[359]

The almost certain coexistence of the two types of property regime in the telecosm does not mean that the two will assume equal importance in the near future. Exclusive rights to the spectrum will probably dwarf

355. Epstein, *supra* note 53, at 20.

356. *See, e.g.*, Promoting Efficient Use of Spectrum Through Elimination of Barriers to the Development of Secondary Markets, 18 F.C.C.R. 20,604 (2003) (allowing many wireless licensees to lease spectrum without FCC approval); Revision of Parts 2 and 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band, 18 F.C.C.R. 24,484 (2003) (making additional spectrum available for unlicensed devices).

357. *See, e.g.*, Spectrum Commons and Digital Dividends Act of 2003, H.R. 1396, 108th Cong. §1 (2003) (Representative Markey) (creating a spectrum commons in some bands); The Jumpstart Broadband Act, S. 159, 108th Cong. §1 (2003) (Senator Boxer) (requiring the allocation of additional unlicensed bands).

358. *See* FCC REPORT, *supra* note 39, at 37. The United Kingdom is undertaking to implement fairly massive changes in its spectrum management process drawing on each of the private property rights and commons visions. *See* U.K. RADIOCOMMUNICATIONS AGENCY, *supra* note 140, at 6. This document draws on the work of Professor Martin Cave. *See* CAVE, *supra* note 154, at 1–3; *see also* Ofcom, *Spectrum Trading Consultation* (Nov. 2003) (proposing spectrum trading), *available at* http://www.ofcom.org.uk/consultations/ current/spectrum_trading. The FCC is watching the British spectrum reform process closely. Conversation with Peter Tenhula, Director of the FCC's Spectrum Policy Task Force (Oct. 22, 2002).

359. *See, e.g.*, LESSIG, *supra* note 4, at 242 ("We must . . . set off significant bands at each spectrum level, to assure that innovation for different uses of spectrum would be possible."); Benkler, *supra* note 4, at 76–83 (advocating a trial period in which significant amounts of spectrum are thrown into the market and significant amounts are reserved for unlicensed use); Faulhaber & Farber, *supra* note 147, at 18 (advocating a property rights system with pockets of spectrum devoted to unlicensed "parks" and with easements for unlicensed use in some propertized bands).

common ownership in the most intensively used parts of the spectrum. The prevailing view in government is that exclusive rights are warranted "in bands where scarcity is relatively high and transaction costs associated with market-based negotiation of access rights are relatively low."[360] The FCC believes that, applying these criteria, the highly desirable bands below 5 GHz, which are most suitable for long-range and mobile applications, will be appropriate for exclusive rights. It is thought that the suitability of the lower frequencies for a variety of uses will spur the creation of competing network designs.[361] Where a commons approach is used in these lower bands, it will probably be in the form of low-power public easements in frequencies that are otherwise "owned."[362] By contrast, the commons model will be preferred in the upper bands, "where scarcity is low and transaction costs associated with market mechanisms are high."[363]

Underlying these tentative conclusions about the appropriate mix of private and common property rights to spectrum is uncertainty about the technologies on which the commons theorists' arguments are based. The FCC shares the skepticism of private property theorists that technology will loosen the strictures of scarcity any time soon. It has not been proved, at least not to the degree of certainty the government might demand before reconstituting the rights of thousands of licensees, that the smart radios which a commons requires will be marketable for many years to come. For example, software defined radios are currently very expensive and large.[364] One manufacturer in a position to know about the pace of commercially viable technological change has said that it "may take a decade or more before [intelligent or cognitive] radios are available with acceptable size, cost, and battery drain and they may never be competitive for services where the equipment cost to the end-user is a significant issue."[365]

---

360. FCC REPORT, *supra* note 39, at 38.

361. A system of exclusive rights with flexible usage rules will provide "a mechanism for spectrum users to choose among the full range of technically feasible spectrum use options based on market forces." *Id*.

362. *See, e.g.*, Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band, 17 F.C.C.R. 25,632, 25,632–33 (2002).

363. FCC REPORT, *supra* note 39, at 39. There is a certain circularity to these generalizations. Scarcity and transaction costs are not inherent characteristics of particular spectrum bands, but are highly dependent on the management decisions the government makes and on the state of the art of technology. As the commons theorists have argued, spectrum is particularly scarce in the lower frequencies because exclusive licensing has artificially reduced access. For a similar point, see Christopher S. Yoo, *The Rise and Demise of the Technology-Specific Approach to the First Amendment*, 91 GEO. L.J. 245, 272–74 (2003) (arguing that regulatory decisions themselves have been responsible for the scarcity of the broadcast spectrum).

364. *See* FCC SRRWG REPORT, *supra* note 69, at 7.

365. Comments of Motorola, *supra* note 95, at 20; *see also* Jon M. Peha, *Spectrum*

Furthermore, the functionality of mesh networks and the extent to which they can dissipate interference is largely unproven. Unlicensed wireless networks have until very recently been "small, special purpose appendages to the wired networks."[366] We have little experience with densely deployed wireless data networks that operate on the commons model. Moreover, as the commons theorists concede, a network built according to the end-to-end principle is "not optimized for any particular existing application."[367] As a result, such a network is less reliable for urgent or time-sensitive transmissions and cannot guarantee throughput at any given moment. For many applications, particularly those that involve time-sensitive communications, an operator will be able to use the spectrum more efficiently or, at least, to provide better quality of service on private spectrum property.[368]

Given these persistent questions about the suitability of commons spectrum for the full range of spectrum-based services, as well as questions about the pace and direction of technological development, it is both unlikely and undesirable for the commons model to become primary in the reconstitution of spectrum control. At the same time, the private property model has its own limitations, particularly in the domain of implementation. As discussed in Part IV, the avoidance and resolution of interference disputes could add considerably to the cost of

---

Management Policy Options, 1 IEEE COMM. SURVS. 2, 4 (1998) ("Eventually, inexpensive receivers may emerge that can easily switch from one frequency band to another and one transmission standard to another. . . . However, sufficiently inexpensive devices of this kind are still well beyond our grasp, and any reform of today's spectrum management policies cannot depend on this technological progress."), *available at* http://www.comsoc.org/pubs/surveys .

366. Reed, *supra* note 72, at 8.

367. LESSIG, *supra* note 4, at 37.

368. James Speta, in criticizing Larry Lessig for failing to take into account the cost of unlicensed spectrum, noted the following:

> [E]ven the most technologically sophisticated protocols for ensuring coordination in unlicensed spectrum cannot use the spectrum nearly as efficiently as a private owner can. Where there is a single licensee either operating its own service or acting as a bandwidth manager, that licensee can mandate the use of equipment or protocols that fully utilize the spectrum.

Speta, *supra* note 326, at 1572. Yochai Benkler acknowledges that

> these [unlicensed] networks will not supplant absolutely owned wired and wireless networks in delivering real time communications with assured quality of services. They will enable, however, a wide range of uses, from Internet access to online games, overnight (or during dinner) delivery of video on demand, and, potentially, local nonessential video conferencing among friends or for town hall meetings.

Benkler, *Siren Songs*, *supra* note 11, at 62.

a private property regime.[369] The troubled precedent offered by nuisance law and by the FCC's own "nuisance" cases suggests that we are far from a transparent and predictable method of articulating spectrum rights in a private property regime.

The challenge for the commentator and policymaker today is the articulation and perhaps the implementation of dispute resolution procedures that reduce these imperfections, even in the administrative regime. One place to begin is with the role of the regulator. In the proposed revolution to private property rights in spectrum, the regulator will be deposed; in the communal property revolution, the regulator will survive with uncertain mandate. The final sections of this Article propose a role for the regulator in the governance of spectrum access in the future—a role that will ease the operation of both private and common property models and take into account both the terrestrial and aerial characteristics of spectrum. My objective is to begin to sketch out how the regulator might mitigate some of the more troubling aspects of regime change in the telecosm to come and implement some aspects of regime change in the telecosm at hand.

B. The Regulatory Role in a Mixed Regime of Spectrum Management

Assume a telecosm in which some spectrum bands, particularly the prime bands below 3 GHz, are treated like land. Existing licenses, or variants thereof, become something like fee simple deeds. There are public easements for noninterfering wireless activity, and spectrum parks are created as preserves for the wireless systems that the spectrum market will not support. There might even be spectrum condominiums in which some frequencies in some dimensions are individually owned, while other parts of the band are held in common by a community of users. Many higher frequency bands are available for common, or at least widely-shared, use. In privately owned portions of the spectrum, and where private and common property rights meet, many spectrum conflicts will look like nuisances. Others will look like ambient air pollution. In the commons, or more accurately, the limited access commons, conflicts will appear as standards battles and controversy over the design of consumer devices. In the context of all these disputes, a clear regulatory voice will be important in increasing the transparency, equity, and efficiency of the public interest determinations that will inevitably be made in the allocation of spectrum usage rights.

---

369. *See supra* Part IV.C.

1. Spectrum as Land: A New Nuisance Law

As spectrum use intensifies, interference disputes will proliferate in privately held spectrum and at the borders between private and common spectrum property. As described above, exclusive transmission rights will probably be based on laboratory predictions that become less reliable as the density of wireless transmitters increases and radio signals interact in new ways.[370] Put another way, increases in the density and variety of spectrum use will increase modeling failures, which will in turn increase the number of spectrum conflicts.

Nuisance-like conflicts may also occur where commons users and owners interact. Today, the law does not recognize spectrum conflicts between licensed and unlicensed users because the latter operate at their own risk, such that any interference to a licensed service is strictly prohibited and any interference to an unlicensed user is permitted.[371] Even if commons users were never protected against interference, the likelihood that they would be defendants in nuisance disputes increases as unlicensed uses proliferate and unlicensed and licensed services share the same bands.[372] Suppose, for example, public easements are created in frequencies that are subject to exclusive transmission rights, as Faulhaber and Farber propose.[373] Spectrum users would have a general privilege to transmit in these frequencies so long as they caused no interference to those holding "exclusive" transmission rights. Here, of course, we have the same problems of defining what degree of interference will be actionable as we do in a telecosm dedicated only to exclusive property rights.[374] These are essentially nuisance questions.

As unlicensed uses develop, they will not be satisfied to remain

370. *See supra* notes 90–92 and accompanying text; *see also* FCC IPWG REPORT, *supra* note 68, at 11.

371. *See supra* note 288 and accompanying text.

372. For example, in a dispute between satellite radio operators and unlicensed device operators in a neighboring band, the radio operators have argued that while there is no unlicensed device interference problem yet, over the next few years the cumulative out-of-band emissions caused by a projected increase in unlicensed devices (like wireless LANs) will affect their receivers. They claim that the noise could jeopardize their $3 billion technology and spectrum investment. *See In re* Revision of Part 15 and Part 18 of the Rules Regarding the Out-of-Band Emissions of Radio Frequency Devices, Petition for Rulemaking of Sirius Satellite Radio, Inc. 10 (F.C.C. filed Jan. 23, 2002).

373. *See supra* notes 147–49 and accompanying text.

374. There are, in addition, substantial challenges relating to the monitoring and definition of interference and to the proof of causation and identification of proper defendants.

subject to episodic and growing interference from spectrum proprietors or licensees, or from other unlicensed users.[375] They will demand some degree of interference protection. If such protection is incorporated into the mixed regime of the future, then commons operators might become plaintiffs as well as defendants in nuisance-like actions.[376] Nuisance-like disputes might arise wholly within the commons as well.[377] Even if technical protocols are successful in controlling interference, one can imagine a commons user jamming the signal of another or placing obstructions (either electronic or physical) in the path of a competitor's signal.[378] Such activity is the equivalent of a nuisance spite fence that one neighbor erects to block the other neighbor's view or light.[379]

Thus, nuisance-like interference actions will arise regardless of the

375. One of the central normative positions of spectrum commons theory is that unlicensed devices, or commons users, ought not to have to bear all the costs of interference prevention. The first step in shifting these costs from community to private property owners is to reduce the degree of protection commons devices must provide to licensed operators or owners. Commons theorists have proposed such reductions. *See, e.g.*, Benkler, *supra* note 4, at 63–64.

376. One possibility would be for common property users to sue private property users under something akin to a public nuisance cause of action. Whom the private property owners would sue, however, if many unlicensed users caused interference is a difficult question because, as we have seen already, once unlicensed devices enter the marketplace, it is difficult to hold them liable for interference. For example, in 2002 the FCC found that some radar detectors were causing harmful interference to satellite terminals. The FCC imposed more severe emission limits on newly marketed radar detectors, but did not take steps to protect the terminals from interfering detectors that were already in use. It held that "identifying [these] radar detectors is not practical . . . because these devices are mobile and therefore interfere intermittently. Further . . . in most cases it is not possible for the satellite operator to remedy the interference even if the source could be identified" because the satellite operator does not control the radar devices and cannot reasonably reconfigure satellite systems to resist the interference. Review of Part 15 and Other Parts of the Commission's Rules, 17 F.C.C.R. 14,063, 14,067 (2002); *see also* FCC REPORT, *supra* note 39, at 58 (noting that "it may be difficult legally or politically to shut down [the operations of unlicensed devices] even if they begin to cause interference or otherwise limit the licensed user's flexibility").

377. Kevin Werbach contemplates such actions. His proposal that interference disputes in the supercommons should be handled through tort actions would require judges to define levels of unacceptable interference for commons users expressed in liability standards. *See* Werbach, *Supercommons*, *supra* note 4.

378. Signal jamming is illegal under the Communications Act. 47 U.S.C. §§ 501–10 (2000); *see also* S. Robert Carter III, *The Sound of Silence: Why and How the FCC Should Permit Private Property Owners to Jam Cell Phones*, 28 RUTGERS COMPUTER & TECH. L.J. 343, 351–53 (2002). Physical obstructions to the transmissions of radio signals, however, are permissible.

379. "Spite fences" are structures erected for the purpose of causing a nuisance to another, rather than for any utilitarian reason. *See* Jeff L. Lewin, *Compensated Injunctions and the Evolution of Nuisance Law*, 71 IOWA L. REV. 775, 804 n.119 (1986) (noting that the price for purchasing a "rule four" injunction when the nuisance is a spite fence should be zero because, by definition, it has no market value). For a history of spite fences in the context of obstructing sunlight, see *Prah v. Maretti*, 321 N.W.2d 182, 187–91 (Wis. 1982).

balance between private and common spectrum property. Increased pressures on the spectrum, combined with rapidly advancing technologies, will require a nuisance law for the air just as extensive changes in the use of land remade nuisance law on the ground. It is an interesting historical question whether, had there never been an FCC, courts might have developed workable liability standards for spectrum that were at least as coherent as the nuisance law standards that emerged in the early twentieth century. Whatever the likelihood of such successful common law rulemaking in the early days of radio, the chances are much reduced today after seventy years of administrative control of wireless uses, the expansion of the usable spectrum, and the proliferation of wireless system varieties. The baseline of rights that courts or other decisionmakers come to adjudicate in the telecosm to come will have been established by the regulator, based on the regulator's technical predictions, and the regulator's definition of harmful interference. Common law decisionmaking will be tightly bound to administrative decisionmaking, in many cases attempting the same kinds of balances based on the same technical and economic calculations. The role of the regulator in the construction of liability standards and remedies in the modified command and control regime, as well as in a partial or complete property regime, will thus be critical to the allocation of rights through the common law.

a. Structuring Liability Standards

In developing a modern nuisance law for spectrum, courts will have to struggle, as the FCC has, to define harmful interference. They will also have to, as the FCC has not, fashion a "reasonableness" standard for interference, just as real nuisance courts have had to develop notions of reasonableness with the increased density of resource use. There should be no question in anyone's mind about how difficult such determinations will be, given the vastly different characteristics and applications of clashing spectrum usages.[380] What is unreasonable for a real time data service may not be unreasonable for an intermittent data service, for example. Moreover, what is unreasonable for an operator providing a uniquely valuable service, such as medical device communications, may

380. It has, for example, been proposed that the FCC build a reasonableness standard into its definition of harmful interference by adopting multiple definitions of the term depending "on the nature of the victim service and the function it is intended to serve." *See, e.g.*, Comments of Sprint, *supra* note 122, at 15.

not be unreasonable for a redundant or easily duplicated service, such as paging. In arriving at reasonableness determinations, judges will find themselves grappling with highly technical questions of interference prevention strategies and with highly political questions about consumer reliance and the relative values of different communications services. Productive spectrum management reform must accept the inevitability of public interest determinations.

Given the irreducably political aspect of spectrum disputes, the regulator can help courts to rationalize dispute resolution by helping to structure liability standards and remedies in ways that increase transparency and predictability. The uncertainty of any nuisance law, particularly one that is developing from scratch in a quickly evolving technological environment, creates costs for those trying to design systems that can withstand interference. Engineers must choose between overinvesting in interference rejection to ensure the functionality of devices under peak interference conditions or risking intermittent device failure. Uncertainty about interference entitlements will be particularly acute where the parties involved operate incomparable services and know little about each other's technologies or capabilities. An especially useful function for the regulator, even in a property rights regime, would be to reduce this uncertainty about permissible spectrum uses. A regulator might do this by defining (and redefining over time) classes of per se nuisances.

At common law, an ordinary nuisance, or a nuisance per accidens, is an activity or thing that becomes a nuisance because of where or how it is situated.[381] In other words, it is a right thing in the wrong place. By contrast, a nuisance per se is an activity or thing that is a nuisance by its nature and regardless of circumstances or location.[382] The paradigmatic per se nuisances are hazardous activities that threaten public health or unlawful activities or structures.[383] What makes a categorical nuisance so useful is that it takes the "ad hocery" out of nuisance law, at least once the offending activity has been categorized. It relieves courts of the multifactored balancing that characterizes the typical nuisance case. The point to consider now is how the creation of a categorical nuisance in spectral interference, independent of situational balancing, might

381. 58 AM. JUR. 2D *Nuisances* § 15 (2002).

382. Morgan v. High Penn Oil Co., 77 S.E.2d 682, 687 (N.C. 1953) (holding that "[a] nuisance *per se* or at law is an act, occupation, or structure which is a nuisance at all times and under any circumstances, regardless of location or surroundings"); 58 AM. JUR. 2D *Nuisances* §§ 16, 17, 19, 20 (2002).

383. *See, e.g.*, Harrison v. Ind. Auto Shredders Co., 528 F.2d 1107, 1121–22 (7th Cir. 1975) (hazardous activities); Fla. E. Coast Props., Inc. v. Metro. Dade County, 572 F.2d 1108, 1112 (5th Cir. 1978) (illegal construction).

improve dispute resolution in the telecosm.

The ability to identify per se nuisances in spectrum will depend largely on technology. Technologists have suggested that it would be possible to define a maximum "noise level" for every spectrum band. Services operating within that band would then know not only what their permitted signal outputs could be (based on their spectrum deeds), but what signal level they could actually emit at any given time without causing interference to operators in adjacent frequencies or within the same frequencies in neighboring areas. They would also know how much radiation they would be expected to filter out from other operators.[384] It would be as if a homeowner had information about how loud her party could be, given the topography, construction of neighboring homes, and other noise in the environment. With such information, wireless device engineers could design systems with a fair degree of certainty that their products would not experience interference within this noise level and would not cause actionable levels of interference. Sophisticated monitoring devices, along the lines of pollution monitoring devices, would have to be developed. If they functioned well, they could ensure that all operators had timely information about the spectral environment and could automatically reduce power when the noise level limit might be exceeded.

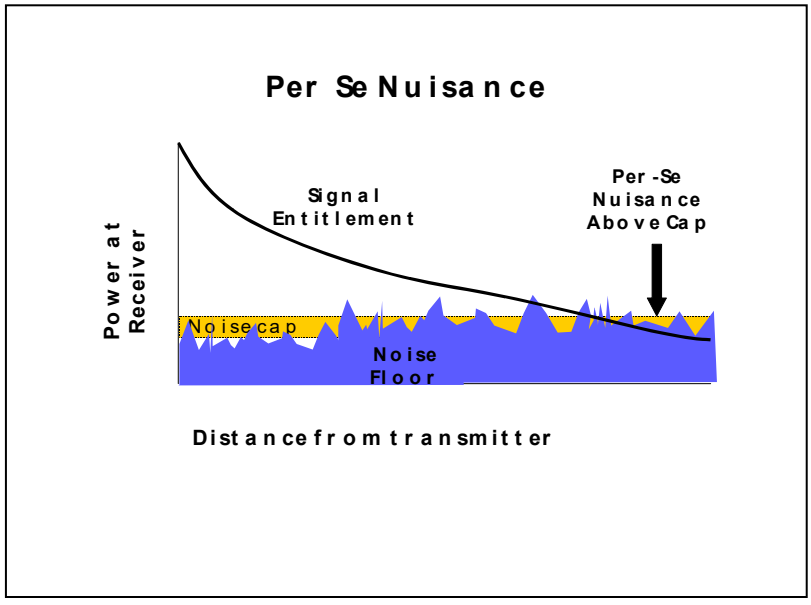
Thus, policy debates over noise floor levels currently beginning in the administrative arena should take into account the way in which the definition of spectrum entitlements for licensees might advance the

384. The FCC has proposed that it develop an "interference temperature" along these lines for individual services. A transmitter would need to know the interference temperature at locations within its signal range either by measuring the temperature directly (for low-power devices with very small signal ranges) or by picking up the temperature from a grid of monitoring stations that continuously scan the environment and broadcast interference data. FCC REPORT, *supra* note 39, at 31; Establishment of an Interference Temperature Metric to Quantify and Manage Interference and to Expand Available Unlicensed Operation in Certain Fixed, Mobile and Satellite Frequency Bands, 18 F.C.C.R. 25,309 (2003). For a discussion of the interference temperature and its limitations, see Margie, *supra* note 248, ¶¶ 65–81 (arguing that there must be a legal definition of permissible interference in order to make the interference temperature useful). Transmitter responses to a dense spectral environment "could include a reduction in transmitter power, antenna beam re-shaping, selection of a different transmitting frequency or 'stand down' decision to wait" for the environment to change. *See* FCC IPWG REPORT, *supra* note 68, at 17, 18. The FCC also notes that there "is no generally accepted methodology for measuring ambient noise levels and format for recording such information." FCC UDEL REPORT, *supra* note 334, at 13.

project of defining the property rights for owners.[385] An established noise floor would have particular utility for common law decisionmakers who do not themselves have expertise in radio frequency radiation and seek expert determinations about reasonable levels of interference. Even if property rights were defined by signal level outputs, rather than by interference protection levels, the noise floor level could demarcate a category of per se nuisances for which the decisionmaker would not have to balance the utilities, but could go straight to a consideration of appropriate remedies. Figure 5 redescribes the picture of complex interference in the administrative regime set forth in Figure 4 in Part II.B.2 above. In Figure 5, the signal entitlement is determined by permissible signal emissions, which fall as the signal attenuates from the point of transmission. Close to the transmitter, the noise floor is likely to be far below the signal entitlement. But as the signal fades, the level of undesired noise approaches the desired signal even though all operators in the relevant bands might be operating lawfully. It is at this point that nuisance claims will arise. If operators are capable of sensing the noise floor and automatically powering down when their devices are close to established limits, then noise floor caps could become a tool for establishing categorical nuisances.

385. If the interference temperature is defined with reference to communications services rather than frequencies, it will be less useful in a property rights regime in which service definitions fall out of the deeded rights. However, even service-related interference measures could be worked into a property rights system based on time, frequency, and power because liability rules could be service-based even if property rights were not. That is, a spectrum property owner might be permitted to operate any service in accordance with the time, frequency, and power dimensions of her property, but would know that, even within those parameters, she will be liable for breaching the relevant service-defined noise floors of neighboring operators.

FIGURE 5



Of course, an operator might well experience interference even where the noise level cap has not been breached. Such interference might result from special topographic or atmospheric conditions, substandard receiving devices, faulty interference predictions, or the clash of particularly incompatible waveforms, among other reasons. The per se standard would not bar claims for other nuisances, just as per se nuisances do not bar claims for nuisances per accidens in the real world. But a robust system of per se nuisances in the spectrum domain might at least economize on judicial and private resources in cases that fall within the per se category and provide a point of reference for actionable interference in all nuisance cases. Because the noise level rises over time, the regulator would continue to have responsibility for adjusting the noise floor cap periodically.

Setting maximum noise levels early, before there is any propertization of the spectrum, would ensure that the spectrum property right would be fairly well-defined at the outset. The noise level cap would both qualify

and protect the metes and bounds of the right, otherwise defined along the three dimensions of spectrum use and by service constraints that continued to apply to particular frequencies. Such elaboration would accomplish two valuable objectives. First, it would allow courts to resolve nuisance claims in many cases without having to determine what is a reasonable amount of interference for satellite or broadcast or data networks to bear. Second, it would reduce the total number of nuisance claims. By providing headroom for new technologies to operate in ways that were not originally predicted when the band was first licensed (or deeded), the incidence of interfering uses would be reduced. Devices would have to be manufactured or made upgradeable to operate interference-free even where the potential for interference had increased because neighboring devices were exploiting the full range of permissible noise levels.[386]

b. Menu of Liability and Property Rules

In addition to assisting in the common law development of liability standards, the regulator might play a useful role in developing and even implementing prior to the privatization of spectrum a menu of rule choices for remedying spectral nuisances.[387] What follows are some preliminary observations about what such a menu might look like based on what we know about interference disputes and what has been theorized about nuisance liability.

Property rules, which are easier and cheaper to implement than liability rules, should be the presumptive favorite in the future telecosm, as they have been for the FCC, wherever common nuisances are at issue. There is good reason to believe that property rules will be appropriate, for example, in intraservice disputes and simple interservice interference disputes. As discussed previously, these kinds of disputes tend to be characterized by relatively few parties and well-known interference characteristics and abatement strategies.[388] As a result, the transaction costs involved in negotiating around a property rule will be relatively

386. The identification of interfering signals will always be challenging, no matter what the regulator's role in a future telecosm. Such identification could be simplified by a requirement that all signals be tagged. However, even with immutable tags, liability for interference might not be clear where multiple signals simultaneously exceeded the cap or where one operator was primarily responsible for the exceedence but was not the one to cross the line. In such situations, liability might be joint and several.

387. For a discussion of the virtue of simplicity in the choice of remedies, see Epstein, *supra* note 197, at 76 (noting that "[w]hen the errors of individualized decision making become too great the system may be better off (i.e., make fewer errors) if gross and imperfect rules of easy application are substituted for perfect rules of difficult application").

388. *See supra* Part IV.B.2.

low and will not justify deviation from the cheaper mode of resolution.

Recent research on transaction costs in relation to property rules helps us to unpack further why property rules might be justified for these kinds of interference disputes. For reasons explained below, intraservice disputes and simple interservice conflicts share characteristics with conflicts over tangible, as contrasted with intangible, goods. The work of Louis Kaplow and Steven Shavell on liability and property rules suggests that property rules may be preferable in conflicts over the possession of tangible items, as opposed to conflicts over usage rights.[389] In advancing this argument, Kaplow and Shavell profess that the chief virtue of liability rules is that they exploit the litigants' private information when a court lacks good information about how the parties value the continuation or discontinuation of the nuisance.[390] The extent and value of private information is likely to be less, and therefore the utility of liability rules is likely to be less, in disputes about possessory rights than in disputes about usage rights for two reasons.

First, the value that two contending parties place on a possessory right tends to be more highly correlated, and thus more easily known, than the value that two contending parties place on a usage right.[391] Suppose, for example, that Sally has taken Jane's car. Sally and Jane both value the utility of the car, even though they might value it to different degrees. By contrast, in the case of a conflict over air pollution, the polluter values the entitlement to pollute as a means to enhance the value of an enterprise, while those adversely affected by pollution value the absence of pollution. There is likely to be far less correlation between the two valuations of the air than the two valuations of the car. As a result, Sally and Jane will have better information, as compared to a court, than will the factory and homeowner.

Second, in the case of possessory things, the risk of repeated conflict arising from repeated takings in the wake of damages rulings is far higher than where usage rights are involved. If Sally takes Jane's car and pays Jane damages, Jane might then take the car back from Sally, paying her damages, and so on, creating a cycle of property incursions

389. *See, e.g.*, Epstein, *supra* note 214, at 2096–97; Kaplow & Shavell, *Property Rules*, *supra* note 210, at 765–67; Krier & Schwab, *supra* note 107, at 460–62.

390. *See* Kaplow & Shavell, *Property Rules*, *supra* note 210, at 725 (writing that "the virtue of the liability rule is that it allows the state to harness the information that the injurer naturally possesses about his prevention cost").

391. *Id*. at 771–73. The authors refer to usage rights as "harmful externalities" and to possessory rights as the "taking of things." *Id*.

that is highly unproductive. By contrast, the homeowner who is paid damages for a factory's pollution cannot unilaterally retrieve the entitlement to be free from pollution.[392]

All commentators since Coase have written about spectrum rights as though they were usage rights, not possessory rights.[393] Even those who use the language of "fee simple" interests in spectrum do not believe that spectrum is a thing. Certainly it is not. And yet there is validity to the analogy of spectrum as land and, correspondingly, to the equation of some spectrum disputes with disputes over physical things. Especially in intraservice interference conflicts, we see that disputes over spectrum can be more like disputes over possessory rights than like pollution rights. The values placed on the spectrum by the victim and the interferer tend to be correlated because both parties are using the same kind of architecture with the same kind of spectral efficiency. Although the two operators might place different values on the spectrum they use, just as Sally and Jane might value Jane's car differently, it is the utility of the spectrum for the same kind of use that they value. Moreover, there is a risk of reciprocal takings. If Mike and John operate devices in the same service, and Mike's transmitter interferes with the reception of John's signals, in some cases John can dial up his power and interfere with the reception of Mike's signals, and so on.[394]

Turning to the selection among and between liability and property rules for interference disputes more generally, we should consider the kinds of ex ante investments we want nuisance law to motivate. The recent work of Lucian Bebchuk, while supporting the conventional preference for liability rules in high transaction cost contexts, adds an important asterisk to that preference. It suggests that the effects of nuisance rules on ex ante investments in property enhancements and interference reduction may either reduce or magnify the advantage of

---

392. *Id.* at 724–32, 759–63, 767–70, 772. *But see* IAN AYRES & PAUL M. GOLDBART, A CRITIQUE OF "TANGIBILITY" AS THE BASIS OF PROBABILITY RULES 45–47 (Yale Law School, Program for Studies in Law, Economics, and Public Policy, Working Paper No. 251, 2000) (arguing that the virtues of liability rules apply even where values are correlated and there is a risk of multiple takings and that the solution to the multiple takings problem is simply to increase the damages for the taking of tangible things), *available at* http://papers.ssrn.com/paper.taf?abstract_id=262185. To be sure, there are property disputes that evince characteristics of both disputes over things and over usage rights. Kaplow and Shavell use the example of one hotel's blocking another hotel's ocean view. The ocean view has characteristics of a possessory thing (easy ex ante negotiating and common value) as well as of a usage right (no reciprocal takings). *See* Kaplow & Shavell, *Property Rules*, *supra* note 210, at 771–72.

393. Coase, *supra* note 2, at 25–26; De Vany et al., *supra* note 3, at 1512; Hazlett, *The Wireless Craze*, *supra* note 3, at 338–39.

394. It will not always be the case that each party to an intraservice interference dispute will have symmetrical technical or financial capabilities to cause harm to the other party.

liability rules, depending on the desired investment.[395] What Bebchuk has found is that property rules tend to lead to inefficiencies in investments in both property enhancements and harm reduction.[396] By contrast, liability rules tend to produce optimal investments, but only in harm reduction *or* in property enhancements, and only for one or the other party in any given dispute.

So, for example, Rule Two will create incentives for the victim to invest optimally in property enhancements, but to underinvest in the prevention of harm. The interferer will be motivated to invest optimally in the prevention of harm, but to overinvest in property enhancements. Rule One will motivate the victim to overinvest in its property and underinvest in the prevention of harm, while motivating the interferer to underinvest in both its property and the prevention of harm.[397] Thus, for any given application of liability or property rules, choices must be made as to what kinds of investments should be encouraged, and by whom.

In the spectrum context, investments in interference prevention might take the form of victim investment in more robust receiver technologies or interferer investment in quieter transmission technologies.[398] Property enhancements in spectrum might include increasing the density of transmission towers, upgrading system architecture, or investing in better consumer devices. The relative desirability of such investments might differ dramatically depending on the service involved.

Some communications systems, because of their technical architecture

---

395. Bebchuk observes that "total value—that is, the total size of the pie [in a nuisance dispute]—depends not only on whether a legal rule reaches the efficient outcome in any given ex post situation, but also on which ex post situation the rule produces in the first place." Lucian Arye Bebchuk, *Property Rights and Liability Rules: The Ex Ante View of the Cathedral*, 100 MICH. L. REV. 601, 613 (2001).

396. In the case of investments in the value of the property, the party receiving the entitlement invests too much and the other party too little. In the case of investments in harm reduction, the party receiving the entitlement invests too little and the other party too much. *Id*. at 635–36.

397. As applied to the other two basic property and liability rules, Bebchuk's method yields the following:

> Rule 3: Interferer will overinvest in the value of its property and underinvest in the prevention of harm. Victim will underinvest in the value of its property and overinvest in the prevention of harm.
>
> Rule 4: Interferer will invest optimally in the value of its property and underinvest in prevention of harm. Victim will overinvest in the value of its property and invest optimally in the prevention of harm.

Id. at 633–34.

398. *See supra* Part II.B.

or commercial structure, cannot make ex ante investments in interference prevention—a feature that a court's choice of remedies should take into account. These are, as discussed above, the *open* architecture systems like broadcasting. The operators have no control, either directly or through contractual relations, over the receivers to which they transmit. As a result, they are ill-equipped to prevent interference to themselves. By contrast, other systems are *closed*, in that they can make the devices that receive their signals more impervious to interference. Because open services cannot be motivated to invest in interference prevention when they are the victims, neither Rule One nor Rule Two, which deter the victim's investment in interference prevention, has the disadvantage that it would have if the victim were an integrated service. These are thus probably the best rules to use where the victim service is open, to the extent that ex ante investment in interference prevention and system performance are of primary concern.

One final consideration in the choice among rules is the most obvious. The choice as between two possible property or liability rules privileges the party that gets the entitlement to interfere or not to be interfered with.[399] As we have seen, the FCC's preference for Rule One over Rule Three is a product of its first-in-time, first-in-right policy of privileging incumbents.[400] This policy choice might be justified by public interest rationales, such as the preservation of existing service and consumer investments, or it might merely reflect incumbent power. Rule Two might also privilege the incumbent if the damages award is high enough. By contrast, Rule Three will privilege the new entrant as will Rule Four if the damages award is low enough. Again, public interest concerns, such as the promotion of more efficient service and competition, might supply the rationale for privileging new entrants, or the choice might merely reflect successful interest group lobbying. Interestingly, the "exotic" Rule Four might find its most natural application in spectrum conflicts, where the FCC has already used a Rule Four variant more than Rule Four has been used in the real world. Table 2 summarizes some of the major considerations that should go into a choice among rules of entitlement in spectral nuisance cases.

399. *See* Rose, *supra* note 209, at 2177–79.
400. *See supra* Part IV.C.2.

TABLE 2

	RULE ONE	RULE TWO	RULE THREE	RULE FOUR
INTRASERVICE OR SIMPLE INTERSERVICE	X		X	
COMPLEX INTERSERVICE		X		X
CLOSED SERVICE			X	X
OPEN SERVICE	X	X		
PRIVILEGE EXISTING SERVICE	X	X (depends on level of damage award)		
PRIVILEGE NEW ENTRANT			X	X (depends on level of damage award)[401]

Given all these considerations in the selection of nuisance rules, what is the role of the regulator? At a minimum, self-conscious agency experimentation with different rules before privatization would provide precedent for common law courts facing the same kinds of disputes. More ambitiously, courts might draw on administrative expertise on an ongoing basis in the development and selection of nuisance rules just as in the development and selection of thresholds of liability. The spectrum context could provide a laboratory for testing the transaction cost and investment incentive hypotheses that have developed out of the *Cathedral* literature. Moreover, articulation by the agency in the

401. Unless the damage award includes some of the gains of trade of the one who purchases the entitlement, a liability rule will not be as favorable to the entitlement holder as a property rule will be. This is because the rights holder will only be compensated for its damages rather than for an amount that lies somewhere between its damages and the value of its rights to the defendant.

administrative regime of what rule it was using and why would reveal where political power or public interest considerations other than economic efficiency goals were driving the choice of interference rule.

Certainly, default nuisance rules for the resolution of interference conflicts in no way make nuisance law self-executing. For any given conflict, there might be reason to select any of the four rules. What administrative, and then judicial, implementation of a menu of rules might achieve, however, is greater transparency, fairness, and efficiency in dispute resolution. The consideration of the public interest, including equity and efficiency goals, would come to the surface in the choice between privileging an existing or a new service, even though other characteristics of the dispute might argue for a different rule. Moreover, those engaged in a complex interservice dispute could assume that it would be resolved with a liability rule, revealing their private valuations of the nuisance and prevention costs.

2. Spectrum as Air: Ambient Interference and the Commons

Thus far, the continuing role I have described for the regulator is as a draftsman of deeds and a special master to the courts, providing technical assistance in the adjudication of common law nuisances among property owners. But, recalling that spectrum is as much air as it is land, we can see the regulator's proper role morphing with the perception of the resource. Throughout the spectrum, as the density of wireless transmitters increases, the amount of energy radiated into the radio frequencies will increase, threatening low-level degradation (like air pollution) of all services. In the face of this problem, there is a need for some command and control regulation. In the commons, spectrum will be shared like the air, subject to compliance with technological controls. In a world where all can breathe recycled air, provided that they use particular masks (equipment standards), some regulatory oversight over the mask selection process is desirable. At the very least, there should be a minimal degree of transparency and opportunity for participation in this process.

a. Spectral Pollution

In the discussion of spectrum conflicts and nuisance law, I excluded a class of conflict that has yet to be addressed by the FCC and is problematic for the application of nuisance law. These are the conflicts that result from what was described above as spectral pollution, in which

cumulative noise interferes with the signals of multiple operators.[402] Devices that are particularly sensitive, such as satellite receivers, will be the canaries in the coal mine, feeling the first effects of ambient noise pollution. This phenomenon is likely to occur no matter what kind of spectrum management regime is implemented, although it will probably be more pronounced in the presence of the high-power services advantaged by a private property rights system. Grievances resulting from this kind of ambient interference will be very difficult to address through the common law.[403] Like environmental pollution, spectral pollution may have far-reaching negative externalities for consumers, as communication is compromised without obvious cause. Like environmental pollution, spectral pollution presents the kind of polycentric problem that courts have difficulty resolving. Coase, after all, limited his nuisance examples to two-party conflicts, apparently assuming that regulation would be needed where there were large numbers of affected people.[404]

Quite clearly, there is a role for regulation in the control of ambient spectral pollution.[405] Indeed, it was the advent of scientifically complex, large impact pollution disputes that propelled environmental law out of the courts and into administrative procedures.[406] The "general conclusion

---

402. *See supra* Part II.B.2.

403. *See infra* notes 406–09 and accompanying text.

404. *See* Coase, *supra* note 2, at 29. However, Calabresi and Melamed applied their theories to cases involving thousands of owners. *See* Calabresi & Melamed, *supra* note 10, at 1106–08. For this insight, see Thomas W. Merrill & Henry E. Smith, *What Happened to Property in Law and Economics?*, 111 YALE L.J. 357, 381–82 (2001).

405. Property rights theorists have at least contemplated a continuing regulatory role in the new spectrum management system. *See, e.g.*, White, *supra* note 3, at 31.

> In instances where the numbers of interferers and/or the numbers of encroached-upon parcel holders were large enough that private enforcement through the courts was considered too costly and burdensome, alternative mechanisms—government enforcement of the private transmission rights, administrative methods for dealing with "polluting" transmissions from multiple incidental sources (such as high voltage lines, motors, etc.), perhaps even "zoning" of bands or areas—might be developed.

Id.

406. *See* ROBERT V. PERCIVAL ET AL., ENVIRONMENTAL REGULATION: LAW, SCIENCE, AND POLICY 114–16, 464 (2d ed. 1996) (documenting the shift from tort to statutory law as a means of environmental regulation); *see also* City of Milwaukee v. Illinois, 451 U.S. 304, 317 (1981) (stating that "Congress has not left the formulation of appropriate federal standards to the courts through application of often vague and indeterminate nuisance concepts and maxims of equity jurisprudence, but rather has occupied the field through the establishment of a comprehensive regulatory program supervised by an expert administrative agency"). In an intriguing new piece, Daniel Esty has argued that

[was] that nuisance litigation is ill-suited to other than small-scale, incidental, localized, scientifically uncomplicated pollution problems."[407] Legal scholars and courts appear to have reached the conclusion that nuisance law is a fairly poor way to resolve modern environmental problems for at least five reasons, all of which apply to spectral pollution as well: (1) The diffusion of a pollution problem may deter victims from bringing suit because the costs exceed the benefits of injunctive or monetary relief, (2) the ability of some victims to free ride on others will also deter suits, (3) proof of causation is often difficult, (4) the assessment of damages is difficult where there are multiple effects on multiple victims, and (5) judges may not be technically competent to assess the costs of the nuisance.[408] Notwithstanding the efforts in the past several decades to introduce market mechanisms into the federal pollution control system, it is in the administrative arena that environmental disputes have largely remained.[409]

In discussing the relative merits of tort law and regulation as mechanisms for controlling environmental pollution, Steven Shavell argues that common law liability and regulation should not be mutually exclusive solutions. A combination of the two systems of law exploits the benefits of each.[410] The coexistence of common law with federal

---

new information technologies will enable a return, at least in part, to private law to control environmental harms. DANIEL C. ESTY, ENVIRONMENTAL PROTECTION IN THE INFORMATION AGE (Yale Law School, Working Paper No. 58, 2004), *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=429580.

407. DUKEMINIER & KRIER, *supra* note 181, at 777; *see also* Joseph L. Sax, *Using Property Rights to Attack Environmental Protection*, 19 PACE ENVTL. L. REV. 715, 719 (2002) (arguing that "[n]uisance law is poorly suited both to cumulative harms and to those matters that involve sophisticated science, and difficult decisions about risk—precisely the reason that common law nuisance has largely given way to statutory regulation across the spectrum of environmental matters"); *see also* Christopher H. Schroeder, *Lost in the Translation*: *What Environmental Regulation Does That Tort Cannot Duplicate*, 41 WASHBURN L.J. 583, 584–601 (2002) (comparing environmental administrative and tort law).

408. *See, e.g.*, Andrew Jackson Heimert, *Keeping Pigs out of Parlors: Using Nuisance Law to Affect the Location of Pollution*, 27 ENVTL. L. 403, 414–15 (1997). On the competence of courts to resolve environmental disputes, see Steven Shavell, *Liability for Harm Versus Regulation of Safety*, 13 J. LEGAL STUD. 357, 369 (1984) (writing that "in dealing with many health-related and environmental risks, a regulatory agency may have better access to, or a superior ability to evaluate, relevant medical, epidemiological, and ecological knowledge"); *see also* Peter Huber, *Safety and the Second Best: The Hazards of Public Risk Management in the Courts*, 85 COLUM. L. REV. 277, 330–35 (1985) (arguing that courts do not have the perspective to make adequate comparisons of risk in the environmental context).

409. *See* Thomas W. Merrill, *Explaining Market Mechanisms*, 2000 U. ILL. L. REV. 275, 278–86.

410. *See* Shavell, *supra* note 408, at 365 (writing that administrative costs and knowledge disparities favor the use of tort law, but polluters' inability to pay and insufficient threat of suit favor regulation).

regulation is not new.[411] Indeed, we can find precedent for such coexistence in both nuisance law[412] and FCC law.[413] It is not hard then to envision the coexistence of a federal regulatory apparatus for the control of ambient spectral pollution alongside a common law regime for the control of spectral nuisances.

One of the nice features of the per se nuisance standard proposed above is that it could serve a function in both common law and federal regulatory regimes. As discussed above, the maximum noise level, adjusted periodically through notice and comment rulemakings, might establish a threshold of liability for many nuisance actions.[414] It could also serve to control the total amount of spectral pollution, in the form of background noise, in the atmosphere.

b. Regulatory Oversight of Technology Controls

As in the resolution of spectrum conflicts in a private property rights regime, the design and enforcement of ex ante controls on spectrum use in a commons regime will implicate tradeoffs among efficiency, fairness, and public service values.[415] These are tradeoffs in which the public, through a regulatory agency, ought to be involved. Commons theory is premised on the notion that, by agreeing to be bound by particular etiquettes and protocols, wireless operators can increase the supply of spectrum. But who will judge the competing demands for spectrum and pick the winners, defined through technical standards, in the commons? Commons theorists have been vague about the government's role in developing, endorsing, and enforcing new and

411. *See generally* Philip J. Weiser, *Federal Common Law, Cooperative Federalism, and the Enforcement of the Telecom Act*, 76 N.Y.U. L. REV. 1692, 1717–20 (2001).

412. *See, e.g.*, Int'l Paper Co. v. Ouellette, 479 U.S. 481, 483, 500 (1987) (allowing common law nuisance suits to proceed in federal court as a supplement to the Clean Water Act). For criticism of this case, see Daniel A. Farber & Philip P. Frickey, *In the Shadow of the Legislature: The Common Law in the Age of the New Public Law*, 89 MICH. L. REV. 875, 894 (1991) (arguing that nuisance actions for environmental harms pose a risk of fifty separate versions of nuisance doctrines). *But see* Weiser, *supra* note 411, at 1719 n.142 (arguing that the supplementation of federal statutory law by state common law is "a hallmark of cooperative federalism" and "state tort law is likely to cohere with federal regulation").

413. *See, e.g.*, Ivy Broad. Co. v. AT&T, 391 F.2d 486, 491 (2d Cir. 1968) (creating federal common law pursuant to the Communications Act, authorizing the FCC to set terms for the provision of telephone service by common carriers).

414. *See supra* Part VI.B.1.a.

415. *See supra* Part V.B.

evolving industry protocols and etiquettes, although they clearly contemplate some public role.[416]

To the extent that the spectrum protocols of the commons were encoded in FCC rules, the equipment certification or standard setting process would simply recreate the inefficiencies and unpredictability of the current command and control regime.[417] This cannot be what the commons theorists have in mind. And yet, to the extent that the government has nothing to do with the design and enforcement of technical controls, there may well be problems of access to the standard setting process, particularly by new innovators, as well as competitive abuse and industry capture of the process.[418] There is also a risk, as has been recognized in other contexts by property rights skeptics, that the self-help enforcement mechanisms adopted by technical protocol could compromise public interest objectives.[419] A robustly competitive market in consumer devices would help to ensure that consumer welfare was not sacrificed to technical control, except that the range of devices on the market will be only as wide as industry adopted standards permit. Thus, it might well be in the interest of all manufacturers to promote some technologies over others, to design for some (particularly urban) populations over rural ones, and to trade longevity in communications devices for rapid obsolescence. This is all to say that, depending on the regulator's role in the commons, interference control and the resolution of spectral conflict could endow private standard setting bodies with

---

416. *See, e.g.*, Benkler, *supra* note 34, at 361–62.

> [A]n important area of study into unlicensed spectrum is to identify which rules will reward efficient devices with better access to the shared spectrum and penalize inefficient devices—whether such rules take the form of administrative regulations by the FCC or protocols and standards set by the industry to prevent defection and degradation of the quality of performance all industry members can deliver to their customers.

Id. One approach is to utilize the FCC as a facilitator, assisting local spectrum groups with management and conflict resolution. Buck, *supra* note 4, at 76.

417. *See* Hazlett, *The Wireless Craze*, *supra* note 3, at 506–07.

418. The FCC has considered an approach that combines property rights with the commons in the establishment of protocols. Under this approach, a band or protocol manager would purchase spectrum at auction and manage the band as a commons. The manager would prescribe the protocols to be used by the unlicensed devices in the band and approve the manufacture and sale of all such devices for a period of time. FCC UDEL REPORT, *supra* note 334, at 17. While this approach would allocate responsibilities for standard setting, it would also change the economics of the commons model by imposing a cost on users for spectrum access. Moreover, a managed commons allocated by auction would result in commons of limited size, rather than the very wideband spectrum access that commons theorists believe is required.

419. Julie Cohen in particular has documented the dangers of self-help in the copyright context. *See, e.g.*, Julie E. Cohen, *Copyright and the Jurisprudence of Self-Help*, 13 BERKELEY TECH. L.J. 1089, 1090–92 (1998); Julie E. Cohen, *DRM and Privacy*, 18 BERKELEY TECH. L.J. 575, 586–88 (2003); Julie E. Cohen, Lochner *in Cyberspace: The New Economic Orthodoxy of "Rights Management,"* 97 MICH. L. REV. 462, 531–32 (1998).

quasi-public power in the regulation of communications devices and systems.

The best antidote to this threat is an injection of public scrutiny into the critical stages of standard setting and standards enforcement. At a minimum, assuming that the government relinquished its current role in the certification of equipment for unlicensed bands, it should establish requirements of openness and participation for private entities that take effective control of access to commons spectrum through their standard setting activities. Such openness and participation might assuage concerns about fairness and access to spectrum among equipment providers, but do very little to address public concerns about the particular technologies that are allowed to flourish and the segments of the population being served. Thus, it is conceivable that more significant government oversight would be desirable in the operation of a commons. One could imagine, for example, a set of substantive criteria that technical standards, protocols, and etiquettes would be required to meet. In conjunction with these criteria, there might be an administrative forum to which consumers or competing spectrum users could bring complaints about standards being adopted or enforced in the commons. The regulator would then have the authority to enjoin or order alterations to the development and implementation of such standards.

VII. CONCLUSION

The spectrum of electromagnetic frequencies will increasingly structure the way we communicate with each other and with the electronic devices that populate our bodies, homes, businesses, and public spaces. How we communicate through those devices, at what speed, with how much security and reliability, through what gatekeeper, and at what cost will all be influenced by the law and policy choices that are now the focus of intense debate. It is a debate that goes beyond the question of spectrum management to the underlying values of the telecosm to come.

Two profoundly different visions have shaped the current discussion about reforming the governance of spectrum. One envisions spectrum as a common resource that should be accessible to all with minimal restrictions, so long as technology cooperates. Another envisions frequencies as fenced plots that should belong to individual owners and then aggregated or sold, abandoned or reserved, as the market demands.

These visions can and probably will coexist in any radical alteration of the current spectrum management regime. What is important to grapple with now is how conflict over the spectrum resource, whether it is fenced or not, will be resolved and how such resolution can be rationalized, made more transparent, and fairer in the construction of a new management model.

The regulatory agency must play a continuing role in the resolution of spectrum conflict. In this Article, I have outlined desirable regulatory functions in systems of private and commonly owned spectrum rights, including the development of "common law" rules for the allocation of entitlements to cause or be free from interference and overseeing the selection of standards and enforcement tools for the commons. Perhaps most importantly in the most congested portions of the spectrum, the regulator should control ambient interference levels that could degrade the ability of all spectrum users to communicate. The precise relationship between the regulator and courts in a private property rights regime, or between the regulator and private standards bodies in the commons, must be articulated with greater refinement and must be allowed to evolve. It is time to begin this articulation with a frank recognition that there is no spectrum utopia in which disputes disappear or can be resolved through value-neutral and self-executing processes. There is no escape from the calls of the public interest on the allocation of spectrum usage rights. There is no way around the privileging of some communications technologies over others in the resolution of spectral conflict.