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Spectrum Policy Wonderland:

A Critique of Conventional Property Rights and Commons Theory in a World of Low Power Wireless Devices

by

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Abstract

A debate has raged in the telecommunications policy literature over the comparative merits of the property rights and commons models of spectrum management. In this debate, the property rights model has been treated as essentially identical to the licensed model, and the commons model as essentially identical to the unlicensed model. But in making this linkage the debate has been poorly specified. There are in fact two types of property rights models—an unlicensed and licensed one—with the unlicensed model overlapping with the commons model.

The debate moving forward should shift focus from the virtues of the property rights vs. commons models to the licensed vs. unlicensed property rights models. The key question to answer in this new debate is whether spectrum is an asset that is complementary to or independent of the possession of tangible property. If it is complementary to, then the appropriate model for spectrum management is the unlicensed property rights model; if it is independent of, it is the licensed property rights model.

Beginning with the creation of its unlicensed rules in 1938, the FCC has developed unlicensed policy in an ad hoc way in response to practical considerations. The result has been a system of unlicensed regulation that implicitly follows the unlicensed property rights model based on the recognition that at least some spectrum rights should be linked to the possession of tangible property. Only recently has the FCC attempted to apply property rights and commons theory to its allocation of spectrum. The theory was brilliant and powerful but it was misapplied to the FCC's regulatory framework, which was based on a distinction between licensed and unlicensed spectrum. History may reveal that the empirically driven engineers rather than the theory driven economists had a better intuitive grasp of the fundamental economics of spectrum.

The distinction between the unlicensed and licensed property rights models would matter little if it weren't for the fundamental economic forces leading to the proliferation of low power wireless devices. This change makes the economic case for the unlicensed property rights model increasingly compelling. Moreover, if the costs of transitioning between two types of property rights regime are quite substantial, it matters how the initial property rights regime is set up. Property rights theorists who argue that the costs are negligible haven't marshaled the evidence necessary to make their case in this particular context.

One way to seek an efficient balance between the unlicensed and licensed property rights models is to allocate spectrum underlays following the unlicensed property rights model and spectrum overlays following the licensed property rights model. Whereas unlicensed property rights have conventionally been treated as secondary to licensed property rights, this regulatory regime would place them on a co-equal basis.

To the extent that an unlicensed property rights regime is desirable, management of such spectrum rights should transfer from the federal government to state and local governments. In particular, keeping enforcement in the hands of the federal government may be highly inefficient.

Spectrum Policy Wonderland:

A Critique of Conventional Property Rights and Commons Theory in a World of Low Power Wireless Devices[1]

> "When we contemplate the simple misunderstandings which are rife in discussions of government policy toward the radio industry, it is difficult to resist the conclusion that one factor that has helped to bring this about is terminological in character."
>
> --R.H. Coase[2]

The spectrum policy literature has in recent years distinguished between three models of spectrum resource management: Command & Control, Property Rights, and Commons. There has been widespread consensus that the federal government should move away from the command and control model, with the policy debate centering on whether new spectrum rights should be allocated in accord with the property rights or commons models.

The debate over the merits of the property rights and commons models of resource management has an illustrious history in the academic literature, going back hundreds of years.[3] Unfortunately, when scholars, inspired by that literature, applied property rights and commons models to the FCC's existing licensed vs. unlicensed spectrum management models, much was lost in the translation.

Without bothering to develop a grand economic theory of property rights or commons, the FCC has historically divided spectrum management into licensed and unlicensed models. A group of academics cum advocates observed this distinction and grafted their property and commons theories onto it. Licensed spectrum was assumed to be the foundation of the property rights model, and unlicensed spectrum of the commons model.

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[1] Earlier versions of many of the ideas in this paper can be found in: J.H. Snider, "FCC Lets the Telecom Giants Steal from You: Via Eminent Domain, Fat Cat Donors Get Airwaves -- Worth Billions -- In Our Homes," *Sacramento Bee*, April 7, 2002; J.H. Snider with Nigel Holmes, "The Cartoon Guide to Federal Spectrum Policy: What if the government regulated spoken words the way it regulates the airwaves?" (Washington, DC: New America Foundation, April 2004), J.H. Snider, "The Economic Case for Re-Allocating the Unlicensed Spectrum (White Space) Between TV Channels 2 and 51 to Unlicensed Service," Issue Brief #18 (Washington, DC: New America Foundation, February 2006). None of those works was geared to an academic audience.

[2] R.H. Coase, "The Federal Elections Commission," *The Journal of Law and Economics*, Volume 2, October 1959, p. 32.

[3] John Locke and Karl Marx were, respectively, famous progenitors of property rights and commons theories. Sophisticated recent theorists include, on the property rights side: Armen A. Alchian and Harold Demsetz, "The Property Rights Paradigm," *The Journal of Economic History*, Volume 33, Issue 1, March 1973, 16-27; and Yoram Barzel, *Economic Analysis of Property Rights*, New York: Cambridge University Press, 1997. And on the Commons side: Elinor Ostrom, *Governing the Commons: The Evolution of Institutions for Collective Action*, New York: Cambridge University Press, 1990; and David Bollier, *Silent Theft: The Private Plunder of Our Common Wealth*, New York: Routledge, 2002.

There was indeed a linkage between the property rights and licensed models, and the commons and unlicensed models. But it wasn't as tight as the property rights and commons theorists assumed. As long as the goal of spectrum management was to foster coverage of large areas ("cells") with a single transmitter, linking the property rights model to the licensed model, and the commons model to the unlicensed model, was apt. But if efficiency came to dictate small cell sizes within property lines, these linkages could be broken. The unlicensed model would not only take on the characteristics of the property rights model; it would become the dominant model for efficient spectrum use.

In recent years, when the anomaly of small unlicensed cells within property lines was explicitly pointed out to them, some property rights and commons theorists acknowledged that their theories broke down in small cell situations. But this anomaly didn't much bother them because they thought it was an insignificant aberration. Moreover, their primary goal was to create a new last mile competitor for wired networks so they could free telecom from being a monopoly and pursue a cyber libertarian deregulatory agenda. Viewing wireless as a complementary good rather than a substitute good to the wired network did not help them to pursue that agenda. For both types of theorists, small area devices belonged to the realm of toys. Lots of kids might like to play with them but they weren't worth the attention of a truly serious telecom analyst.

But what if the future belongs to small area rather than large area wireless devices? Then the distinction between the two types of property rights models could become increasingly important. This paper argues that the key debate moving forward should shift from the property rights vs. commons models to what I call the unlicensed vs. licensed property rights models.

Subdividing the Property Rights Model

In the old conceptual scheme, we have four spectrum management models.

In the **property rights model**, the government grants *exclusive* rights to spectrum to particular entities.

In the **commons model**, the government grants *non-exclusive* rights to spectrum; that is, rights of access are shared by multiple entities.

In the **licensed model**, the government grants exclusive rights to use spectrum in a unique geographic territory. [4]

In the **unlicensed model**, the government grants rights to use spectrum up to a certain power level without explicit reference to a unique geographic territory.

[4] A more refined concept of territorial rights is the electrospace. But this is a level of detail we don't need to enter into here. For a description of the electrospace model of property rights to spectrum, see Robert Matheson, "The Electrospace Model as a Tool for Spectrum Management," a paper presented at the International Symposium on Advanced Radio Systems, Boulder, Colorado: ISART, March 2003.

In the new conceptual scheme, we subdivide the property rights model into two models depending on whether spectrum is viewed as a *complementary* or *independent* asset. When two assets are complementary and the transaction costs of separating them are high, the most efficient economic arrangement is to bundle them as a package. For example, real property is generally sold as a bundle of assets wholly separate from personal property. This is explained by the fact that the countless assets that constitute real property are, by definition, tightly fixed to a specific location, so they are complementary. In contrast, personal property, by definition, is easily moveable so is *independent* of real property. A more specific example of a complementary good is the windows in a house. There could ostensibly develop separate markets for house frames and house windows. But it is generally recognized that the most efficient market structure is to bundle together the frame and the windows of a house. In contrast, the furniture in a house is generally recognized to be an independent good, so houses with furniture are rarely sold as a bundle.

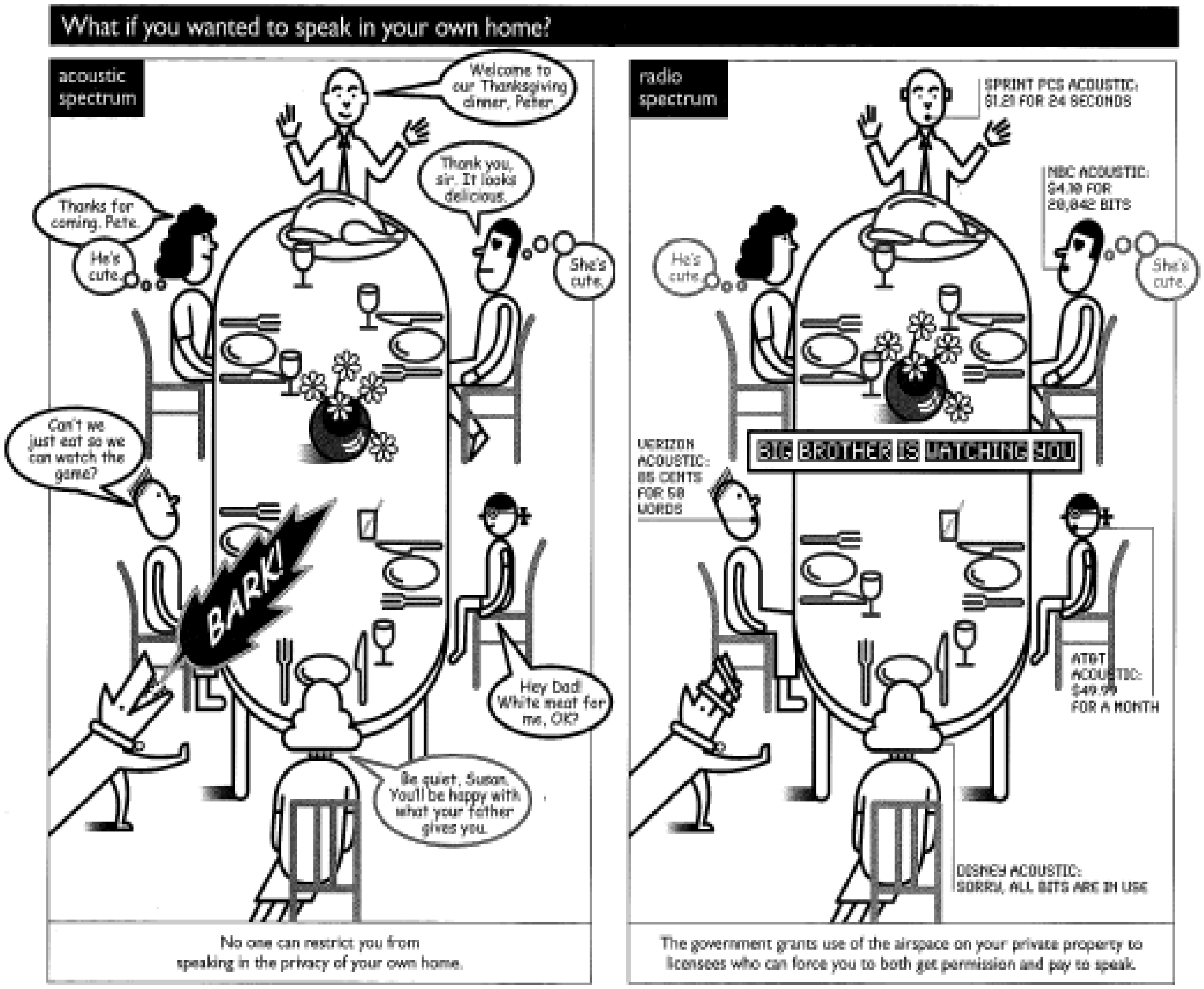
Framing the question differently, it is generally most efficient to have the direct users of an asset possess it. For example, an independent company could own the windows in the house that I otherwise own. But it is self-evident to most people that homeowners have the greatest incentive to maintain their windows in such a way to enhance their overall property value.

To the extent that spectrum and tangible property are complementary assets, the most efficient allocation of spectrum rights is to *possessors of tangible property*. The types of physical property that are typically possessed include homes, offices, vehicles, public-right-of-way, and space in the immediate vicinity of one's own person. To the extent that spectrum and tangible property are independent assets, the most efficient allocation of spectrum rights is to *independent entities*, which the FCC calls licensee. Types of independent entities include broadcast, mobile telephone, and satellite operators.

Tangible property, including both real (fixed) and personal (moveable) property, is property that one can touch. Certain types of intangible property, such as the right to communicate via sound waves or walk through open spaces within a house, have generally been treated as complementary to tangible property. The Cartoon in Figure 1 suggests that the rights to speak and communicate via spectrum within one's own house are both complementary to possession of real property.[5]

[5] From J.H. Snider, "The Cartoon Guide to Federal Spectrum Policy: What if the government regulated spoken words the way it regulates the airwaves?" (Washington, DC: New America Foundation, April 2004), pp. 10-11.

Figure 1. Who Should Have Property Rights to the Air Within Your Home?



Possession is a property right based on having some degree of control over something else. According to West's Encyclopedia of American Law:

> Possession is a property interest under which an individual to the exclusion of all others is able to exercise power over something. It is a basic property right that entitles the possessor to continue peaceful possession against everyone else except someone with a superior right….To have possession an individual must have a degree of actual control over the object, coupled with an intent to possess the object and exclude others from possessing it.[6]

Note that the right of possession is a property right different from the right of ownership. Both ownership and possession entail the right to exclude others but it is possible to have a right of exclusion without ownership. For example, while using a rented car on property one doesn't own, one still has basic property rights by dint of possession.

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[6] "personal property." *West's Encyclopedia of American Law*. The Gale Group, Inc, 1998. *Answers.com* 17 Sep. 2006. http://www.answers.com/topic/personal-property.

Similarly, it is illegal for a stranger to forcibly evict me from a park bench on which I sit and temporarily possess, although if the stranger first possessed it, the rights would be reversed.

Unlike ownership rights to real property, rights of possession are hierarchically organized in geographic space. For example, a mall owner may own the land on which I park my car, but he doesn't have the right to take the contents of my car or the clothes on my person.

An important difference between complementary and independent spectrum assets is that with complementary spectrum assets the communications occurs within tangible property lines rather than across them. Consequently, when spectrum is treated as a complementary asset, spectrum rights are more geographically dispersed than when they are treated as an independent asset.

The various spatial distinctions I am making loosely correspond to the widely used terms in the telecommunications literature of Wide Area Networks (WANs), Local Area Networks (LANs), and Personal Area Networks (PANs). WANs span property lines; LANs are within real property lines; and PANs are in the immediate vicinity of persons. Spectrum rights for both LANs and PANs are complementary to tangible assets. With a WAN, they are independent of such assets.

Let us now label the two property rights models--underpinned by different notions of natural linkages between spectrum rights and tangible property--the unlicensed property rights model and the licensed property rights model.

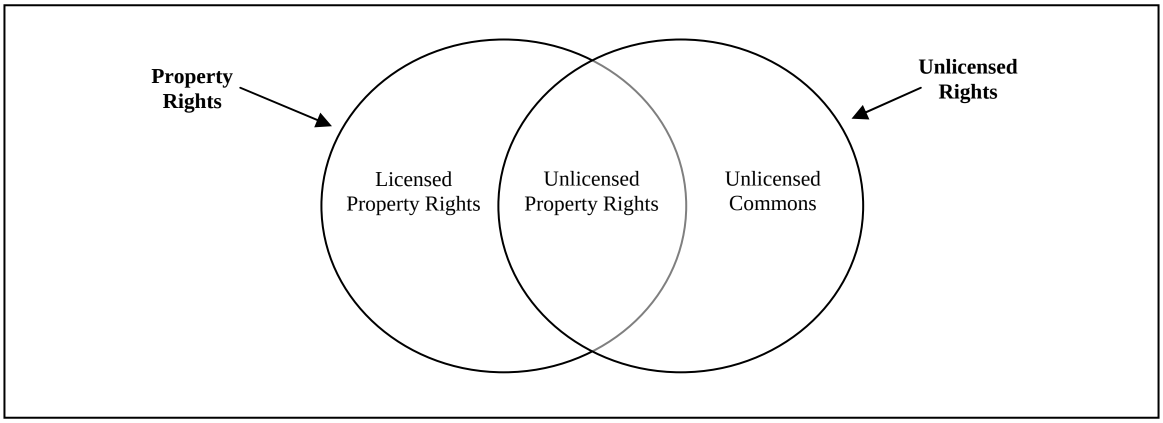
In the **unlicensed property rights model**, the government grants the exclusive property right to communicate to entities with possession of tangible property. Examples include the right to communicate within homes, offices, and vehicles; over local public rights-of-way; and in the immediate vicinity of one's own person.

In the **licensed property rights model**, the government grants the exclusive property rights to communicate to entities spanning many tangible property boundaries. Examples include the right to provide broadcast TV, mobile telephone, or satellite radio service across millions of homes, businesses, and public rights-of-way.

In the long run these may not be the best titles for the two different types of property rights models. But they have the short run virtue of being based on familiar spectrum management concepts whose juxtaposition I hope will jar readers into thinking carefully about the anomalies in the regnant spectrum management models.

Now that we have defined the various spectrum management models, let's see how they overlap in a Venn Diagram.

Figure 2. The Relationship of the Various Spectrum Management Models



The major debate going forward should center on the social welfare gains from each type of model. Now let us define the size of the diagram circles as representing the social welfare gains from each model. Three very distinct possibilities for the distribution of social welfare gains are suggested by the figures below.

Figure 3. The Two Model World According to Unlicensed Commons Advocates

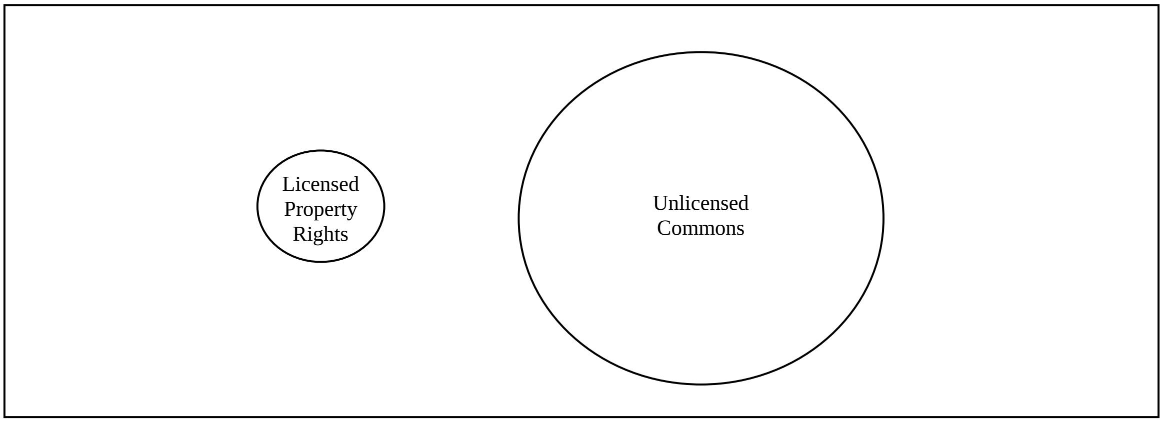


Figure 4. The Two-Model World According to Licensed Property Rights Advocates

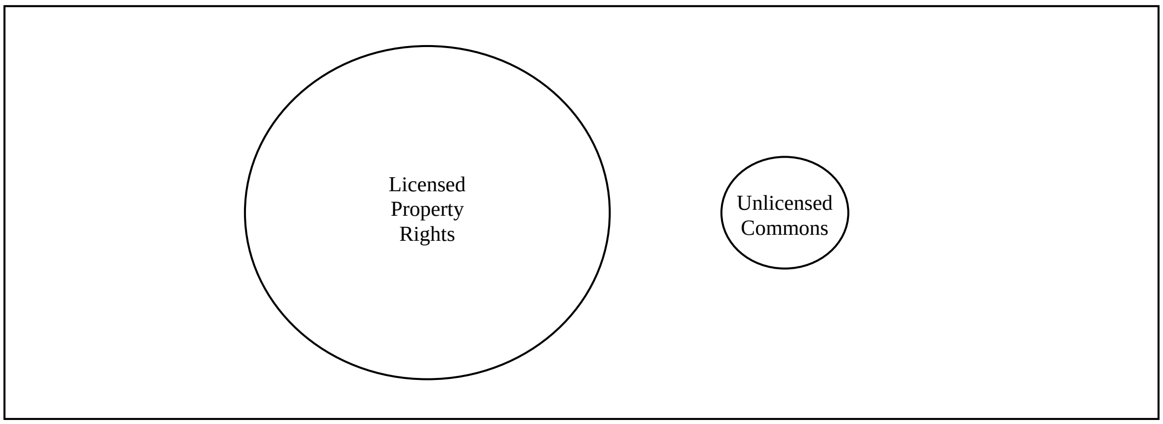
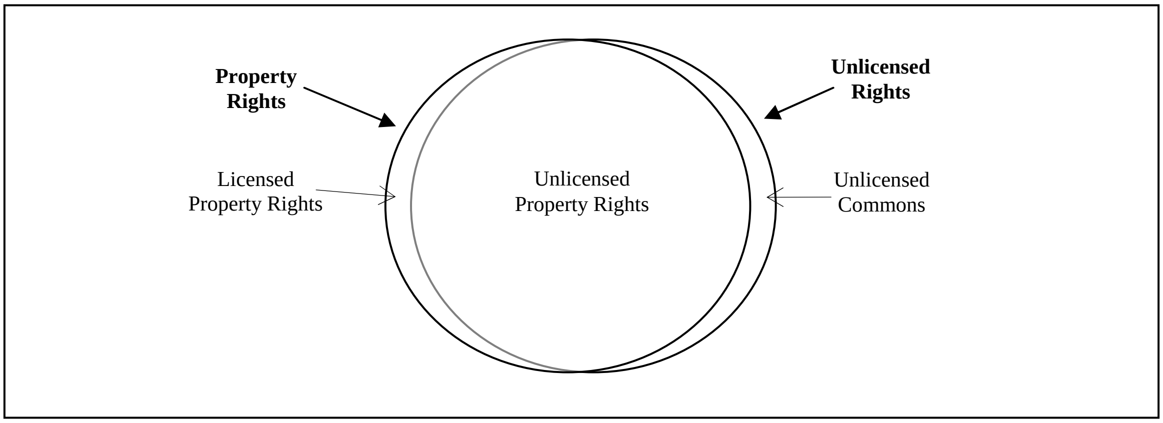


Figure 5. The Three-Model World According to Unlicensed Property Advocates



In this paper, I argue that there might be more truth to the world depicted in Figure 5 than has been previously imagined.

Does the relative size of the various social welfare circles make any difference to a public policy agenda driven only by the desire to maximize economic efficiency? The answer is yes only if the initial allocation of rights to spectrum affects the long-term efficiency of using the spectrum. Both the property rights and commons theorists agree that the initial distribution of rights between their two models has long-term efficiency implications. But some in the property rights camp have made vigorous assertions that the initial distribution of rights in a property rights model has no long-term effect on their efficient allocation. There may be an acknowledgment that this conclusion depends on minimal transaction costs and no specialized assets.[7] But it is not a point that tends to be dwelled on for long, especially by the large contingent of property rights theorists who advocate giving incumbent licensees a spectrum windfall because they will quickly put the spectrum to its most efficient use or sell it to someone who will.

Let us now frame the question more precisely. Does it have long-term efficiency implications if 1) complementary assets are initially allocated as independent assets, or 2) independent assets are initially allocated as complementary assets? Would it make any difference, for example, if a hypothetical Federal Acoustic Commission, patterned after the Federal Communications Commission, granted all rights to acoustic communication to independent entities, maybe the same companies that currently have broadcast and mobile telephone licenses, who could charge real property owners for the right to speak within their own homes? How about a Federal Plumbing Commission that licensed all rights to indoor plumbing to independent entities such as various electricians' guilds? Most people would immediately grasp that this is not only a very inefficient distribution of property rights but also that it would probably be very costly to fix. The acoustic and plumbing licensees could extract monopoly rents and negotiating a transfer of rights from the licensees to the homeowners would probably be very costly in both time and money. Conversely, imagine a world where homeowners owned air rights up to the heavens. It

[7] E.g., see "Report from the Working Group on New Spectrum Policy" (Washington, DC: Progress and Freedom Foundation, March 2006), p. 9.

would be very costly for airlines to negotiate for airspace rights with each of these homeowners. Some airspace holders, such as a county or state with a long public road in the flight path of the airplane, could also exert holdup power and thus extract monopoly rents.

The same type of reasoning applies in the context of the FCC's spectrum management. Let us imagine a world, for example, where the long-term efficient distribution of spectrum rights favors present spectrum licensees and their uses; that is, the licensed property rights model. In such a world, if tens of millions of real property owners were granted all initial spectrum rights, it would surely be very costly for the handful of today's broadcasters and mobile telephone operators to reacquire those rights. The negotiation costs alone would be astronomical; billions of hours could be wasted unnecessarily negotiating for rights. Meanwhile, the spectrum would lie fallow, possibly for decades, if the negotiations proved sufficiently costly. Moreover, just a single real property owner in a broadcast or mobile telephone service area could veto the service, thus extracting a monopoly rent for their spectrum property.

Similarly, if the most efficient long-term distribution of spectrum rights favors low power uses where spectrum rights are complements to tangible property, the economics would be reversed. Now those tens of millions of homeowners would have to acquire the right to use spectrum within their own homes from the broadcasters and mobile telephone operators. But the negotiation costs could still be huge and amount to a comparable social welfare loss. Just imagine each of 120 million American households trying to put together a large block of frequencies on their own property by negotiating with each of the hundreds of licensees with rights to tiny slivers of that block. Moreover, to the extent that there were 1) few licensees with the most desirable frequencies in a particular area, and 2) many homeowners in the same area, the licensees would have great bargaining power and be able to extract monopoly rents.

Thus, if the initial distribution of property rights between the unlicensed and licensed property rights models has a significant long-term impact on economic efficiency, it is important to assess what is the most efficient long-term distribution of spectrum property rights. The FCC has actually done a better job at making such allocation decisions than its recent rhetoric in favor of "property rights" (by which it means "*licensed* property rights") would suggest.

History of the FCC's Unlicensed Rules

Distinguishing between unlicensed and licensed property rights models may seem strange in the context of the current debate over property rights vs. commons and previous debates over command & control vs. property rights. However, such a distinction is consistent with the FCC's traditional de facto conceptualization of its Part 15 rules, which govern unlicensed devices. When the FCC's Spectrum Policy Task Force released its influential report on spectrum management models in November 2002, it adopted the reigning property rights and common theories as a way of explaining its own licensing policies. Property rights was equated with flexible use licensing and commons with unlicensed use.[8] Previously, the FCC had hesitated to engage in such theorizing about the nature of its policies. It let its policies evolve as an ad hoc adjustment to practical concerns. The FCC's recent failure to recognize its heavy reliance on the unlicensed property rights model suggests that its practical policies may have reflected deeper economic intuition than its attempt at economic theorizing.

The FCC first developed rules for unlicensed devices in 1938 in response to the evident failure of the Communications Act of 1934 to deal with the practical realities of low power electromagnetic emissions. Setting a decades long pattern, the unlicensed initiative was not based on any grand theory but a practical response to manufacturers' and users' concerns.

In the Communications Act of 1934, Congress decided that all spectrum was interstate in nature and should come under the jurisdiction of the federal government, with the FCC licensing the rights to spectrum to independent entities such as radio broadcasters and the military, each of which transmitted over an area often spanning thousands of square miles. But it turned out that a lot of devices, such as electric light switches, emitted electromagnetic energy at very low power levels. Although the most publicized and socially important spectrum using services operated at high power, manufacturers had also started building many communication devices, notably certain medical devices, that emitted energy at very short distances. As a result, the FCC decided it had to develop rules to manage such devices; thus, the unlicensed rules were born. The FCC' Chief Engineer, Ewell Jett, concisely explained his reasoning in a hearing leading up to passage of the first unlicensed rules in 1938:

> What we are concerned with immediately is the problem of interference. If certain low power devices can be used without interfering with radio communications, there would appear to be no engineering reason for suppressing their use.[9]

In formulating the unlicensed rules, the FCC was aware that unlicensed devices were most likely to be used within property lines and that protection of licensed transmissions was most important outside of property lines rather than within them. In the same 1938 hearing, this issue was addressed, admittedly in a rather muddled way, in an interchange between Chief Engineer Jett and John Potter representing the Radiograph Corporation.

> Mr. Potter: Under this proposed formula the same condition is assumed whether it be urban or rural; that is, you set up the same value—that is, the same field strength for this device whether it be used in the city or on farms. Now, that doesn't seem to follow through because naturally in rural areas there is less interference.

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[8] *See generally* "Spectrum Policy Task Force Report," ET Docket No. 02-135 (Washington, DC: Federal Communications Commission, November 2002).

[9] Informal Hearing Before the Chief Engineer In the Matter of Proposed Rules and Regulations Governing the Operation of Low Power Radio Frequency Devices, FCC Docket No. 5335, September 19, 1938, p. 5.

> Mr. Jett: Go ahead.
>
> Mr. Potter: That is my point. I wonder if you were going to put any factor in that would take care of density of population.
>
> Mr. Jett: Now, I'm a little amused here about your bringing that question up, because Mr. Ring and I gave a lot of thought to it. We thought of the case where it may be desirable to operate low power devices on the farm where the owner of the farm had control over the area, the entire area, and if we could set up a proper standard with respect to the boundary, we thought that that might be worthy of consideration. And then we thought more of that particular problem—some of the large ranches out in the West, one out on the Pacific Coast 60 miles long, I believe, and a lot of large manufacturing plants where such a rule would apply, and obviously we could not set up a standard which from a possible legal interpretation would hold that such communication was not radio, and still permit communication out to the boundary of one's premises. Then there is always the possibility of an airplane flying over, and so we finally decided on lambda over 2 pi [the power level for unlicensed devices] in accordance with the proposed rules without regard to ownership of premises.[10]

In a major 1979 rulemaking on unlicensed rules, the FCC articulated such principles more clearly.

> We are most interested in protecting an individual who is receiving interference from his neighbor's computer. To a lesser extent, we are concerned about devices in the same household. In a household, the homeowner or apartment dweller can choose which device he wants to operate. For example, if a second TV set in the same house is receiving interference from a computing device in an adjacent room, there are a number of steps he can take to remedy or minimize the problem, or as a last option, he can always choose which is most important to operate--the TV set or the computing device. One of the first and easiest corrective steps he can take is to move the two pieces of equipment further apart. Another step is to reorient the receiving antenna….
>
> [W]e are adopting minimal regulations which we consider necessary to control potential interference from computing equipment. The regulations are not intended to control interference of computing devices with other equipment owned by the same person. In this situation the competing uses of the spectrum are under the control of the same person, and private resolution of the conflict is possible.[11]

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[10] Ibid., pp. 101-2.

[11] First Report and Order In the Matter of Amendment of Part 15 to redefine and clarify the rules governing restricted radiation devices and low power communication devices, FCC Docket No. **20780**. (Adopted: September 18, 1979; Released: October 11, 1979), paras 54, 67.

One way the FCC implemented these principles was by granting higher power to unlicensed devices used exclusively in industrial applications rather than residential applications. A major consideration was that industrial users occupied plants that were much larger than a typical residence and so could be entrusted with higher power levels.

> [C]omputers are separated into two categories--Class A computing devices governing commercial computing equipment and Class B computing devices governing the computing equipment widely distributed to the general public…. [E]quipment used in manufacturing plants is not likely to cause interference because it is located within the plant and is commonly isolated by the size of the plant facility. Also factory buildings provide some shielding. Thus the Commission can expect few complaints of interference from restricted radiation devices therein.[12]

In implementing these rules, the Commission recognized that its ability to grant flexibility to unlicensed devices within property lines was limited by the primitive technology and institutional arrangements of the day, implicitly suggesting that one day such restrictions might not be needed.

> We have defined Class A and Class B equipment in a way which recognizes broad differences in the circumstances in which computers are used. This allows us to provide protection from interference while limiting both the costs of producing computing equipment which does not interfere and the costs of administering and enforcing the regulations.[13]

In developing rules for unlicensed use of the 900 MHz band in the mid-1990s, the FCC favored unlicensed devices for indoor applications--such as cordless phones and baby monitors--while favoring licensed devices for outdoor uses, notably monitoring cars, trucks, and other vehicles.[14]

In summary, my research of Part 15 rulemakings from 1938 until 2002, confirmed by conversations with senior FCC engineers with responsibility for the Part 15 rules, has not revealed the FCC resorting to any grand economic theories to justify its unlicensed rules, which were primarily developed by engineers responding to immediate and practical concerns raised by manufacturers and users. Political forces heavily constrained what the engineers could propose, but even here the tradition was to phrase concerns in technical rather than grand theoretical economic terms.[15] In addition, a search in the economics literature found no serious property rights theoretical rationale for the Part 15 rules governing unlicensed devices.

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[12] Ibid., paras 28,29
[13] Ibid., para 69.
[14] E.g., *see generally* In the Matter of Amendments of the Commission's Part 90 Rules in the 904-909.75 and 919.75-928 MHz Bands, WT Docket No. 06-49.
[15] The author interviewed long-time FCC Part 15 engineers Art Wall on August 22, 2006 and John Reed on August 24, 2006 to confirm this hypothesis.

The first person to publicly present some systematic codification of the hidden property rights assumptions behind the Part 15 rules appears to have been Mike Chartier, an Intel engineer. In the fall of 2001 he noted the discrepancy between the claims of the newly influential commons theorists and the actual application of the FCC's Part 15 rules. Chartier, however, was unable to garner much interest in this critique. One reason may be that he appeared to concede that unlicensed low power devices could not cover wide areas and thus could not provide a substitute for licensed high power devices. Thus, Chartier remained in the FCC tradition of conceptualizing unlicensed devices as bit players, little more than toys, in the grand scheme of spectrum policy.[16] The subsequent history of this idea, of which this author played a major part in the Washington, DC spectrum policy community, will not concern us here.[17]

Despite the grand rhetoric of property rights vs. commons coming out of the FCC in the early 2000s, the FCC's actual rulemakings concerning unlicensed kept within its traditional unlicensed property rights model set of parameters. It kept power levels very low. For example, it authorized a new ultra-wideband (UWB) unlicensed service that could spread its signal across a huge swath of more than 8 GHz of mostly licensed spectrum but at very low power levels so the signal didn't create harmful interference to licensed devices more than about 30 feet away.[18] The signals were also restricted to indoor use. A prime use of UWB, which could offer speeds as fast as 500 Mbps, was to replace the spaghetti like configuration of wires used in a typical home to connect computer and consumer electronics equipment. The risk of a UWB device creating harmful interference for a licensed services outside of the UWB device owner's tangible property was very low.

History of the Spectrum Property Rights Idea in the Literature

In 1959 Ronald Coase proposed the then radical idea that electromagnetic spectrum should be treated like any other scarce natural resource and allocated via markets, with the role of government limited to defining and enforcing private property rights to spectrum.[19]

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[16] Mike Chartier, "Enclosing the Commons: A Real Estate Approach to Spectrum Rights," unpublished manuscript presented at the AEI-Brookings Joint Center Conference "Practical Steps to Spectrum Markets," November 9, 2001. Chartier later developed aspects of this idea more fully in "Local Spectrum Sovereignty: An Inflection Point in Allocation," in the *Proceedings of the International Symposium on Advanced Radio Systems, March 2-4, 2004*, Boulder, Colorado: ISART, 2004, pp. 29-36.

[17] My writings on this included: J.H. Snider, "FCC Lets the Telecom Giants Steal from You: Via Eminent Domain, Fat Cat Donors Get Airwaves -- Worth Billions -- In Our Homes," *Sacramento Bee*, April 7, 2002; J.H. Snider with Nigel Holmes, "The Cartoon Guide to Federal Spectrum Policy: What if the government regulated spoken words the way it regulates the airwaves?" (Washington, DC: New America Foundation, April 2004), J.H. Snider, "The Economic Case for Re-Allocating the Unlicensed Spectrum (White Space) Between TV Channels 2 and 51 to Unlicensed Service," Issue Brief #18 (Washington, DC: New America Foundation, February 2006).

[18] First Report and Order In the Matter of Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems, ET Docket 98-153, April 22, 2002.

[19] R.H. Coase, "The Federal Elections Commission," *The Journal of Law and Economics*, Volume 2, October 1959, p. 32.

In that now famous article, Coase never considered the possibility that the primary use of spectrum in coming generations might be for very low power devices where communication was primarily within tangible property lines. Nor did Coase consider the possibility that spectrum property rights attached to tangible property rights might have much lower transaction costs and thus be more efficient than such property rights sold to independent entities, where the possession of spectrum property rights was wholly separated from the possession of tangible property. When Coase illustrated his theory with examples, he invariably granted all the spectrum property rights to independent entities. In equating property rights with licensed property rights, Coase set the terms of the property rights debate that has continued until today among both advocates and opponents (commons theorists) of property rights.

A notable recent example of this conceptual failure is the “Report from the Working Group on New Spectrum Policy,” issued by the Progress and Freedom Foundation, a major Washington, DC telecommunications policy think tank, in March 2006. The working group members who signed their names to the document consisted of many of the most prominent spectrum property rights theorists, including, alphabetically, Stuart Benjamin, Gerald Faulhaber, Dale N, Hatfield, Thomas W. Hazlett, Michael L. Katz, Thomas M. Lenard, Gregory L. Rosston, Howard A. Shelanski, and Lawrence J. White. Four of the signers were former chief economists at the FCC. Many hold distinguished economics chairs at prestigious universities.

Nowhere in this Report is there a distinction drawn between the commons and unlicensed models. Both are treated as identical. Nor is there an acknowledgment that the unlicensed model encompasses both the property rights and commons models, depending on whether the unlicensed user can use the trespass laws to control sharing. From the standpoint of property rights theory, it does not matter whether the right to exclude is enforced directly via restrictions on the use of radios or indirectly via the trespass laws. All that is necessary for the property rights model to work is that the possessor of an asset has a mechanism that can exclude others from sharing it. This conceptual confusion is remarkably ironic because the report is sprinkled with references to real estate and trespass as analogies to explain how a spectrum property rights regime would work.

Most important, there is no discussion whatsoever of 1) the extent to which the unlicensed property rights versus the licensed property rights model is the most efficient model for spectrum management, or 2) the extent to which it makes a difference whether the initial allocation of property rights is granted to one or the other of these two models. The Report acknowledges the Coasian insight that the existence of transaction costs would make the initial allocation of property rights important. But, like Coase, it does not seriously investigate the implications of this idea in the context of different property rights models.

As is typical of this property rights literature, there is an acknowledgment that the commons model appears to work fairly well in low power situations.

> Spectrum usage charges should reflect marginal congestion costs. In some cases, once a block of spectrum has been allocated to a set of uses, the marginal cost may be zero. This situation is most likely to arise with very low power uses. For example, the incremental congestion costs of a given garage door opener is very likely zero given that a low-power band has been created. One benefit of the commons model is that it can support such efficient pricing.[20]

But then the Report qualifies its praise: "we believe that the number of instances in which this is appropriate is likely to be quite small relative to overall spectrum uses."[21] From there it concludes that thanks to these low power applications, "the commons model has a limited, but not necessarily non-existent, role in spectrum policy reform."[22]

A basic fallacy of the Report authors and licensed property rights theorists more generally is the assumption that unlicensed devices cannot provide wide area coverage without a tragedy of the commons. But this is untrue. Low power devices, which individually cover only a small-area, can nevertheless be networked together to cover a wider area. Only when a single unlicensed device transmits signals over a wide area and across multiple property lines can the tragedy of the commons argument apply.

Consider municipal WiFi, the fastest growing and most high-profile type of low-powered wide area network.[23] These unlicensed networks can traverse great distances via public roads and other public rights of way. For example, Philadelphia's plan to build a franchised municipal WiFi system will network some 8,000 access points to cover the entire 135-square-mile footprint of the city.[24] And the Canamex highway WiFi network in Arizona may cover more than 500 miles before it is complete.[25]

Tens of thousands of other large spaces, including college campuses, hospitals, malls, warehouses, stadiums, K-12 schools, amusement parks and office buildings, have been building networks of small-area devices that collectively cover large areas.

Coase's conceptual omissions can be more easily explained than those of the property rights and commons theorists who followed in his wake. In the telecommunications world in which Coase lived, spectrum was primarily used for high powered communications, such as radio and TV broadcasting, which covered vast areas. Indeed, the federal government was given jurisdiction over spectrum largely on the assumption that spectrum communications was inherently interstate in nature.[26] But in the

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[20] "Report from the Working Group on New Spectrum Policy" (Washington, DC: Progress and Freedom Foundation, March 2006), pp. 6-7.
[21] Ibid. p. 7
[22] Ibid., p. 7.
[23] E.g., *see* Jesse Drucker et al., "Google's Wireless Plan Underscores Threat to Telecom," *Wall Street Journal*, 3 October 2005, p. A1.
[24] *See* "Wireless Philadelphia™ Business Plan," Wireless Philadelphia Executive Committee, February 2005, p.12.
[25] Eliot Cole, "Wi-Fi the Highway," Mobile Government, June 2005, pp. 22-25.
[26] Second Report and Order and Second Memorandum Opinion and Order In the Matter of Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems, ET Docket 98-153, December 16, 2004.

telecommunications world in which we live, Coase's assumptions about efficient telecommunications architecture are becoming increasingly untenable. The time has come for Coase's acolytes to wrestle head on with the spectrum management implications of a wireless world dominated by low power radios.

In the next section, I argue that the time has come to recognize that telecommunications architecture is undergoing a fundamental transformation, with low power devices becoming an increasingly important part of the telecommunications infrastructure.

The Role of Wireless in the Telecommunications Network

The architecture of the terrestrial telecommunications network is constantly evolving. Not only is it evolving; it is evolving in a well structured direction. I propose five major interrelated trends that will shape the network's future architecture.

1. Demand for bandwidth over the network will increase.
2. Demand for pervasive access to the network will increase.
3. Wires will dominate the network's backhaul link.
4. Wireless will dominate the network's end user link.
5. The proportion of the network link that is wireless will shrink.

1. Demand for bandwidth over the network will increase.

Driven by declining costs and increasing demand, the typical speed of consumer data connections over the telecommunications network has gradually increased from 300 bits/second in the late 1970s to over 3,000,000 bits/second (3 Mbps) today. In Japan and South Korea, millions of consumer data connection speeds now run as high as 100 Mbps. Major players in the U.S. cable and telephone industries in the U.S. are expected to provide similar service within the next five years. The Docsis 3.0 cable industry standard, for example, will support up to 1 Gbps speeds and the GPON cable industry standard will support the same speeds.

Some people today find it hard to imagine that there will be high demand for massive improvements in broadband speed; for example, to 10 Mbps, 100 Mbps, 1 Gbps, 10 Gbps, or even 100 Gbps. But given the recent track record of increasing demand for telecommunications speeds, it is hard to imagine that telecommunications history will soon come to an end. If history has taught us anything, it is that technological improvement in this area is very likely to continue and that new and valuable uses will be found for higher speeds. Thus, it is reasonable to believe that there will be a massive increase in demand for dramatically higher speed data connections in the coming generation.

2. Demand for pervasive access to the network will increase.

Users want to be able to communicate wherever they are. This helps explain the explosive growth in user centric services, such as mobile telephone service, over the last twenty years. In a user centric network, the network accommodates itself to the location of the user and not vice versa. This, in turn, requires the use of wireless communication.

Users are willing to pay a premium for user-centric services. For example, mobile telephone service may be slower speed and more expensive than landline telephone service but users are willing to pay a premium for it. Similarly, cordless phones may be more expensive than corded ones, but consumers now buy more cordless than corded phones because they value the mobility they bring.

3. Wires will dominate the network's backhaul link.

For a point-to-point link, the capacity of a single fiber optic cable is greater than the entire capacity of the radio spectrum. This is a major factor in explaining why fiber optic cable has come to dominate the telecommunications backbone and is moving closer and closer to the customer's premises. The vast majority of intercontinental, continental, and local backhaul communications is now done via wire. In every highly developed country on the earth, plans are under way to bring fiber to the premises or at least to the neighborhood. Millions of Americans already have fiber optics to their premises, and a majority already have fiber optic cable to their neighborhood. These numbers are expected to dramatically increase over the coming generation. One or more fiber optic cable connections first to every neighborhood and then to every premise is likely to be common within another generation. In the U.S., Verizon claims it already passes five million homes with fiber and will reach 18 million by 2010.[27]

Wireless does retain some cost advantages for backhaul communications. It can be upwards of $1 million to lay fiber optic in some urban areas over a ten mile stretch versus $100 to make the same link for a directional WiFi transmitter. But the growing use of fiber optic cable for backhaul communications suggests that any cost advantage wireless might have in the backbone is, except in fairly unusual cases, dwarfed by fiber optic cable's quality advantage.

Peter Rysavy, a columnist for *Mobility Loop*, nicely summarizes the advantages of fiber optic cable over wireless.

> With so much emphasis on wireless networking today, you'd think that wireless was about to displace all wire. That simply won't be the case, not because of laws of economics but due to laws of physics. When you look at speeds and capacity, you have to consider the capacity of fiber versus the capacity of radio. Fiber has a theoretical capacity in the range of 10 to 100 Tbps. That "Tbps" is terabits per second, or 1,000 Gbps. Even if you had the entire lower 10 GHz of radio spectrum available to you, and assumed a whopping 10 bps/Hz through the most advanced radio techniques available (likely breaking Shannon's law in any real world deployment with interference), you'd still only end up with 100 Gbps. So, what we have is the entire useful radio spectrum carrying one percent of the theoretical data capacity fiber. Okay, maybe you can only do 10 Gbps over today's fiber system, but remember, that's just one strand. Want more capacity; add more strands. Now, take into account the tiny sliver of spectrum available

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[27] "Verizon to Pump $18B Into FiOS by 2010," Light Reading, September 27, 2006.

> to any operator, and the ratio of wireless to wireline capacity becomes even smaller.[28]

Of course, one can imagine a world where laying fiber optic cable, or any other wire for that matter, is so expensive that the wireless cost advantage trumps all other concerns when designing the backhaul of the telecommunications network. But that does not appear to be the world in which we live. Wireless appears to retain a very important backhaul niche in rural and poor areas, but those niches appear to be getting smaller every day. As soon as an area achieves a certain wealth and population density, it switches over to fiber.

Nevertheless, none of this implies that there isn't a very important long-term role for wireless in the network of the future. It's just not in the backhaul portion of the network.

4. Wireless will dominate the network's end user link.

As the network gets closer to the end user, the comparative advantage of wired over wireless links diminishes. That is partly because wired economies of scale diminish as the network approaches the premises. The biggest cost in laying fiber optic cable is not the actual cable but the cost of laying it. Compare these costs on a major city street versus on the lawn of a house. The trench on a major city street may contain optical fiber cable serving 100,000 households; the trench on the lawn only 1 household. In this situation, the cost/household of laying a foot of fiber optic cable could be thousands of times as much under the lawn as under the city street. Thus, wired links have decreasing economies of scale as they get closer to the end user.

However, in the long-term, the dominant force preserving the role of wireless service in the end user link is that wired service is not a close substitute. Telecom network users greatly value the flexibility that comes from a wireless connection to the network. Driving in a car, for example, it is not readily conceivable how a real-time telephone call could be made over a wire. Note that the value of being untethered does not change with the length of the wireless link. The value to the end user is the same whether the wireless link is fed from a light post fifty feet away or a cell tower two miles away.

5. The Wireless End User Link Will Shrink in Length.

Longer end user wireless links have cost advantages over shorter end user wireless links. But in the long-term, the quality advantages of shorter wireless links will be the dominant factor shaping network evolution. Wireless capacity, security, battery life, control, aesthetics, and health effects are enhanced with shorter links.

More Capacity. Carriers can purchase rights to use additional spectrum. But since the supply of spectrum is not infinite, this ultimately means robbing Peter to pay Paul. The long-term strategy, then, must be to expand the information carrying capacity of spectrum. Carriers can do this by employing a variety of technologies—such as more efficient data compression and more advanced modulation—that don't involve geographic reuse of

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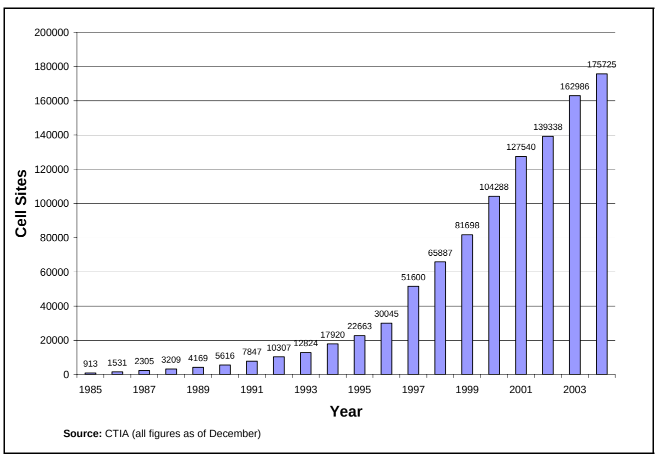
[28] Peter Rysavvy, "Wireless vs. Wireline – It's No Contest," *Mobility Loop*, March 22, 2006.

spectrum. But such strategies are highly limited, akin to trying to get a car designed to travel 100 miles/hour to travel 500 miles/hour by adding air to the tires and changing to a more aerodynamic hood.

The most efficient long-term strategy to increase the information carrying capacity of spectrum is to geographically subdivide it so that it can be reused in different geographic areas. Since each cell can reuse spectrum, the information capacity of a cellular network is directly proportional to the number of cells. A carrier can increase capacity by acquiring additional spectrum—or by investing more capital in spectrum efficiency. ArrayComm CEO Martin Cooper has estimated that more than 97.5% of the increase in spectrum capacity since 1960 has come from reducing the geographic coverage area of cells.[29] Vividly demonstrating the diminishing size of cells, New York City recently leased out its 18,000 light posts, each a potential cell site for up to a half-dozen wireless vendors. See Figure 6 for the growth of cell towers. This growth has largely been driven by the need to subdivide cells to increase information capacity. Another way to subdivide geographic coverage is with directional antennas that point signals in a specific direction and thus can reuse spectrum in different directions. However, reuse via directional antennas cannot bring the order of magnitude capacity increasing effects of reuse via smaller cells. Directional reuse is especially limited in the lower frequencies because the propagation characteristics of large electromagnetic waves don't lend themselves to the formation of narrow beams.

Figure 6 - Growth in Cell Sites



In the U.S., the capacity of wireless networks using licensed spectrum has not kept up with the capacity of wired networks. As we have seen, next generation wired networks may soon reach 1 Gbps to the household. Virtually all PCS in the United States are shipped with a minimum of 100 Mbps Ethernet connections and many are now shipped with gigabit connections. Common network interfaces such as USB and Firewire already

[29] *See* "Cooper's Law" at www.arraycomm.com. See also J.M. Vanderau et al., "A Technological Rationale to Use Higher Wireless Frequencies," (Washington, DC: U.S. Department of Commerce, February 1998), p. 10, and Toru Otsu et al., "Network Architecture for Mobile Communications Systems Beyond IMT-2000," *IEEE Personal Communications*, October 2001, p. 33.

offer speeds in the 500 Mbps to 1 Gbps range. If wireless end user links are not to become a network bottleneck, they will have to increase speeds.

The International Telecommunications Union has already set a target of 1Gbps for next generation, so-called "4G" wireless networks. No mechanism for achieving such high data rates has been specified and it may be that 1 Gbps is a blue sky number that cannot be achieved in a next generation network. What cannot be disputed is that this would be a giant leap from today's 3G wireless networks, which typically offer well under 1 Mbps, less than a thousandth as much as the new target capacity. Clearly, mobile telephone companies want to do everything possible to expand their capacity without building more cell towers, which are very expensive. But, as the foregoing analysis suggests, current cell sizes are too large to achieve these high data rate improvements. Two research engineers from AT&T's prestigious AT&T Labs have calculated that AT&T may have to subdivide existing cell sites by more than a factor of 100, with cell sizes averaging only 1000 feet in radius, to efficiently achieve 4G level bit rates. [30]

More Security. Wired communications are more secure than wireless communications because of the confined space in which they operate; it's necessary to dig up a wire to intercept a shielded, buried wired communications link. But the last wireless leg of a communications link is relatively easy to intercept with any device in its coverage area. Thus, the smaller the coverage area—for example, a corporate campus vs. an entire city—the more secure the connection.

Less Battery Usage. As portable devices grow in popularity, efficient battery use grows in importance. Physics dictates that the greater the distance a wireless device must send its signal, the greater the power it must use as well as the corresponding size, weight and cost of batteries.[31] Low power also opens up the possibility of solar-powered WiFi, which is useful for a host of military, scientific and municipal applications, as well as in disaster relief, developing countries and remote rural areas, where there is unreliable or no electricity.[32]

Similarly, physics dictates that the amount of energy required to send information is a function of the number of bits sent. Every additional bit requires more energy. When telephone-quality audio bits are the predominant type of bits sent, power usage is relatively low. But as we move into a world of CD-quality voice communication, interactive video, and other high bandwidth applications, hundreds of times more power may be needed. When the bits are coming from a battery-operated portable device, this becomes a major problem. One way to address it is with lower-power links between the transmitter and receiver.

More Control. Low power offers both more comprehensive and customized coverage. The conventional wisdom is that pervasive computing and communications requires a

[30] See slide 18 of R. R. Miller and H. R. Worstell, "4G Neighborhood Area Networks," document 802.11-05/0173r0, submitted to the IEEE, March 11, 2005.
[31] *Supra* Note 12.
[32] E.g., *see* Lumin Innovative Products at http://www.luminip.com.

high-power wireless network. But, in fact, the opposite is the case. Wide-area networks tend to miss many spaces blocked by impenetrable barriers such as hills, buildings, and elevator shafts. Mobile telephone service, for example, is frequently unavailable within commercial buildings and homes, especially in low-density areas. That's why major commercial buildings and underground public transportation systems often have their own very small local area cells.[33] J.D. Power calculates that 3 out of 100 cell phone calls has a quality of service problem.[34] But it doesn't calculate the much greater number of calls that aren't made because people have learned not to expect service.

Lower power also offers more precise coverage. Let's say a local government wants to cover its public spaces, including the public roads that link every house and business in its territory. Low-power allows it to do this without interfering with other, nearby low-power users unless those users seek access to its network. Many municipal WiFi networks, for example, are designed in default mode to focus their coverage within public rights-of-way.

Better Aesthetics. High power cell sites are associated with high cell towers. The high towers facilitate transmission over trees and other physical obstacles, which absorb energy and shorten the range of the signal. These high cell towers are widely viewed as eye sores that depress nearby property values. When cell sites are very small and can be placed inconspicuously within light posts or buildings, they don't create an eyesore and thus do not depress real property values.

Better Health. The FCC has determined that the health danger associated with electromagnetic radiation increases with its energy level. Although there is no evidence that at low power levels electromagnetic radiation poses a health hazard, many individuals who oppose nearby high power towers cite this as a concern. Small area cell sites obviate this concern. Virtually every American uses a low power, small area unlicensed device, such as a garage door opener or keyless car door opener, at least once a day without any concern for its health consequences.

* * *

Obviously, large cell sites still retain great cost savings. Otherwise, more mobile telephone operators would have shrunk their cell sites faster than they have. But the point is, the cost of small cell sites is declining.

Moore's Law of rapidly decreasing computer costs per unit of performance applies to wireless routers just as it does to other computer equipment. A single broadcast TV transmitter installed on a giant 2,000 foot high tower costs millions of dollars. Even the transmitter alone can cost several hundred thousands of dollars. Transmitters are built in relatively low volume (there are fewer than 2,000 TV transmitters in the United States),

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[33] E.g., *see* FCC Tenth Report in the Matter of the Annual Report and Analysis of Competitive Market Conditions With Respect To Commercial Mobile Services, WT Docket No. 05-71, released 30 September 2005, p. 51.

[34] Dan Meyer, "Operators Make Call-Quality Gains in J.D. Power Study," *RCRWireless*, 8 August 2005, p. 13.

each lasts for decades, and each is specially ordered because most operate on different frequencies and at different maximum power levels.

In contrast, the cost of a standalone WiFi router is in the vicinity of $40 dollars. The cost of factory-ordered WiFi chips has already dropped to $5/each in high-volume purchases and that number could drop to pennies within a few years. Other wireless devices, such as Bluetooth, have undergone similar price declines. Such declining prices helps explain why hundreds of inexpensive consumer electronics devices, such as portable game players, MP3 players, and cell phones, now incorporate wireless chips. Unlike high power broadcast and mobile telephone towers, WiFi routers are almost always placed on or within pre-existing infrastructure such as light poles, telephone poles, and buildings. In Amsterdam in the Netherlands, a city ordinance mandates that light poles be wireless ready. But even with light poles in the U.S. that weren't designed with wireless routers in mind, it can take as little as five minutes to install a WiFi router, including connecting the router to the light post's electrical wire.

Now consider this thought experiment that highlights the underlying economic logic. Assume that the cost of small area cells drops to zero while demand for bandwidth increases to infinity. The economic equilibrium derived from such assumptions would be an infinite number of infinitesimal cell sites.

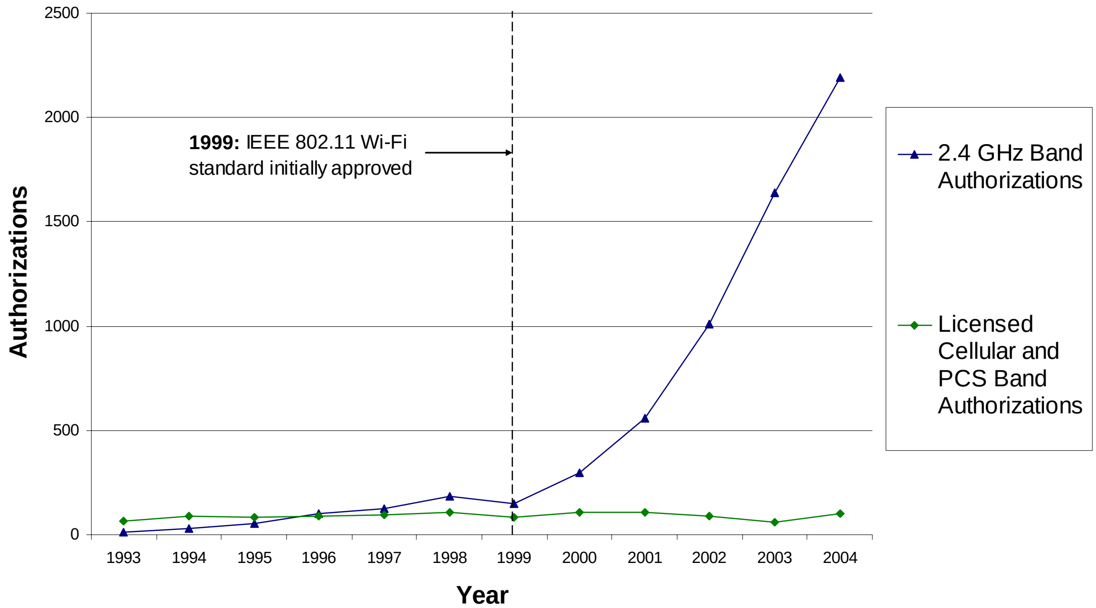
Economic Advantages of the Unlicensed Property Model

As wireless end user links shrink in size, they become a complement to possession of tangible property. In such a world, the unlicensed property model has significant advantages over the licensed property model.

The unlicensed property model fosters decentralized, local control of spectrum rights. Confidence is placed in those who possess tangible property rights—the "users," to pick a popular telecom word—to figure out how to best use the spectrum contained within their property lines. It turns out that this local control has many beneficial economic consequences in terms of increased innovation, lower costs and higher-quality service. To the extent that the Federal government has allowed such local control, it has been embraced by homeowners, businesses, and local governments on the demand side, and by venture capitalists, entrepreneurs, and manufacturers on the supply side.

Figure 7 compares the growth in devices manufactured to operate on unlicensed spectrum with mobile telephone authorizations for licensed cellular and PCS bands. Observe that the unlicensed 2.4 GHz band—the largest unlicensed band in the prime low-frequency spectrum below 3 GHz—has more than 25 times the number of authorizations as the mobile telephone bands. This is despite the fact that the mobile telephone bands occupy far more spectrum (more than twice as much) and far better spectrum (the unlicensed 2.4 GHz band occupies both a higher, less valuable frequency than the mobile telephone bands and is nicknamed the "junk" band because unlicensed devices must accept interference from a host of other devices that use that band, including licensed devices and dumb, non-telecommunications emitters such as microwave ovens).

Figure 7. FCC Device Authorizations for Licensed and Unlicensed Bands, 1993-2004



Source: Carter, Kenneth, *et al., "Unlicensed and Unshackled: A Joint OSP-OET White Paper on Unlicensed Devices and Their Regulatory Issues,"* FCC, May 2003; FCC OET Equipment Authorization Program Database.

Also note that most of the unlicensed growth has occurred since 1999. That growth is primarily attributable to the development of smart unlicensed devices, such as WiFi, in the 2.4 GHz band. Previously, dumb unlicensed devices such as garage door openers dominated the unlicensed market. It is also noteworthy that unlicensed devices, like licensed devices, are overwhelmingly located in the low frequencies. At these frequencies, the equipment is cheaper, can be positioned without regard to physical obstacles like walls, and uses less battery power.

Now let’s look more closely at the economic advantages of unlicensed spectrum, which has primarily been used in accord with the unlicensed property model.

Lower Barriers to Entry for Manufacturers. For manufacturers of wireless products, unlicensed spectrum has lower barriers to entry, leading to more competition and innovation. With licensed technology such as mobile telephone service or public safety communications, entrepreneurs must first purchase a license or get permission from a license holder before launching their innovation. This creates a number of problems. Many manufacturers consider securing rights to use licensed spectrum from private parties as comparable in difficulty to getting rights to use spectrum from the FCC. Like government license holders, private license holders may create huge bureaucratic obstacles before granting permission to use their spectrum, and the outcome may be highly uncertain. In the high-tech world, a delay of six months in getting a product to market can be the difference between success and failure.

Many licensed bands employ proprietary technologies with large license fees that discriminate against small companies. For example, license fees to use W-CDMA, a popular cellular telephone standard, may be 30% of the total product cost for a small manufacturer but as little as zero percent for a large manufacturer with more negotiating power and its own patents to barter.[35] When small players have to pay a 30% premium for the same product, it discourages innovation.

Entrepreneurs also worry about holdup problems and uncompensated appropriation of their ideas. In addition to a royalty, the licensee may insist on a cut in the profits of any successful innovation and may choose to compete with the entrepreneur if the innovation proves especially lucrative. Consider Ibiquity, the new digital radio standard for the AM and FM bands. The large commercial radio broadcasters insisted that they get a fee for any radio device sold using spectrum where they had a license. Thus, they banded together to create a company, Ibiquity, that would develop an exclusive proprietary standard for their spectrum band. The commercial broadcasters were genuinely interested in studying other companies' proposed radio standards. But the bottom line was that if the technology used their spectrum, they wanted control of it—a demand that would discourage many entrepreneurs.

In seeking negotiating leverage, a spectrum license holder may also reveal the idea to competitors, thus eliminating the entrepreneur's first mover advantage. In fast moving high tech markets, this advantage is often critical to profitability.

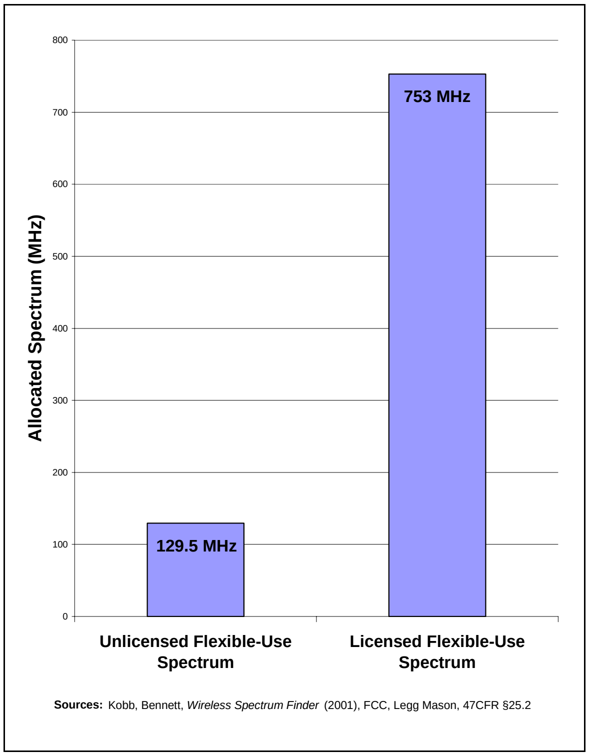
As a case study of the influence of licensing barriers to entry on market structure, compare the level of competition and innovation in the mobile telephone and unlicensed bands in the prime spectrum below 3 GHz. The mobile telephone band is a good reference case because that is where the most licensed spectrum activity takes place. In addition, the mobile telephone bands will shortly control at least five times as much spectrum as the unlicensed bands (See Figure 8).[36]

[35] Mike Dano, "Royalties Remain an Industry Mystery," *RCRWireless*, 12 August 2005, p. 1.

[36] Licensed mobile telephone bands included in this chart are WCS (2305-2320 MHz, 2345-2360 MHz); former government bands transferred to commercial use (1390-1395 MHz, 1432-1435 MHz); the Crown Castle band (1670-1675 MHz); Response TV (217-218 MHz, 219-220 MHz); CMRS (220-222 MHz), Broadband PCS (1850-1915 MHz, 1930-1995 MHz); Narrowband PCS (901-902 MHz, 930-931 MHz, 940-941 MHz); Cellular (824-849 MHz, 869-894 MHz); ESMR (817-824 MHz, 862-869 MHz); AWS (1710-1755 MHz, 1915-1920 MHz, 1995-2000 MHz, 2020-2025 MHz, 2110-2155 MHz, 2155-2175 MHz, 2175-2180 MHz); Ancillary Terrestrial Use of the MSS band (2000-2020 MHz, 2180-2200 MHz, 1626.5-1660.5 MHz, 1525-1559 MHz, 1610-1615.5 MHz, 1621.35-1626.5 MHz, 2487.5-2493 MHz), ITFS/MDS rebanding (2495-2690 MHz); and TV band auction spectrum (698-710 MHz, 722-740 MHz, 747-762 MHz, 777-792 MHz).

Unlicensed bands included in this chart are the 900 MHz band (902-928 MHz) and 2.4 GHz band (2400-2483.5 MHz).

Figure 8. Licensed vs. Unlicensed Flexible Spectrum Under 3 GHz



As in many other licensed bands, no mobile telephone handset manufacturer can sell a product within a particular band without first getting permission from the licensed carrier in that band. Getting such permission usually involves developing a unique model for the licensed carrier and selling it through the licensed carrier's approved retail channel. As a result of these and other economic incentives, fewer than ten handset makers, including Nokia, Motorola, Samsung, Sony Ericcson, and LG, control 99% of the U.S. retail handset market.

In contrast, there are hundreds and perhaps thousands of manufacturers now selling unlicensed devices, despite the fact that the mobile telephone industry is more than two decades old and the new industry of smart, unlicensed devices barely five years old. These companies include Dell, Scientific Atlanta, Intel, HP, Linksys, D-Link, Panasonic, Sony, Starkey Laboratories, Kodak, Canon, Nikon, Sony, Microsoft, Hexagram, Sharper Image, Nortel, Cisco, Motorola, Toyota, BMW, Zensys A/S, Logitech, Connexion, Lumin, Tropos, BelAir, Ember, Chipcon, Freescale, Vocera, Avaya, Colubris, Spectralink, CardioNet, Crossbow Technology, General Electric, Palm, Nintendo, and Honeywell.

A major reason these companies exist is that they sell highly differentiated products targeted at narrow market niches. Indeed, the public has never heard of most of these companies precisely because they are targeted to such narrow market niches. Consider the mobile video surveillance system developed by ODF Optronics, an Israeli company. The product consists of a ball that a public safety official (e.g., police, fire, and military) can throw into a building and on a remote screen monitor a 360-degree view of the room.

The entire worldwide market for this product may be tiny compared to the market for a mobile telephone handset. But that doesn't mean the product isn't extremely valuable and capable of saving many lives.

The additional competition among manufacturers induced by low barriers to entry may foster open standards, which in turn further reduces barriers to entry in a virtuous feedback effect. Since customers prefer not to be locked into a proprietary standard, competition may force vendors to provide open standards, which in turn reduces barriers to entry for other competitors. This may help explain why popular unlicensed standards such as WiFi and Bluetooth are more open than dominant licensed standards such as CDMA and iBiquity.

Lower Usage Costs for Consumers. An increasing number of household, business, and government entities have access to wired broadband connections via DSL, cable and fiber. When these entities look for wireless service on or near their premises, unlicensed usually becomes the obvious low cost solution. For example, why should a home or business pay Verizon Wireless $60 per month per individual (plus about 15% in taxes) for wireless data service when its premise is already linked to high speed wired service and can add a wireless component for zero dollars per month per individual?

The cost of extending a wired connection to anyone in or near the premise—using unlicensed spectrum—is the one-time cost of an off-the-shelf wireless router (as little as $30 to unwire a home). This economic logic largely explains the significant pressure on mobile telephone carriers to introduce dual mode handsets that can carry both licensed and unlicensed communications. Most of the carriers hate this idea because up to 40% of the minutes used by their customers are made in household and business premises where WiFi is likely to be used.[37] In addition, there is the threat that free or low cost WiFi will be strung on more roads, thus depriving mobile telephone companies of their bread and butter revenue. WiFi networks are also open networks whereas mobile telephone networks are mostly closed, which means that mobile telephone operators would be likely to lose content and transaction revenues that they can currently monopolize.

Finally, American carriers have been especially resistant to genuinely open dual handsets because more than 50% of the mobile telephone market is controlled by two operators, Cingular and Verizon, which also have wired networks. When consumers switch to WiFi calls, the operators will not only lose toll minutes on their wireless networks but also toll minutes on their wired networks. Still, the business pressure is becoming so great that dual mode WiFi phones are expected to become widespread within the next few years.[38]

More Product Innovation. Closely associated with lower barriers to entry is more product innovation. Many products and services wouldn't even exist without unlicensed spectrum. Today, the vast majority of wireless products are only manufactured to use unlicensed spectrum. For example, the Sony Portable Playstation video game player, the Kodak EasyShare digital camera and the Dell Axim personal digital assistant have built

[37] "Mobile and Fixed Services," *Information Week*, 10 October 2005.

[38] Amol Sharma, "T-Mobile Readies New Web Phones," *Wall Street Journal*, September 26, 2006, p. B1.

in WiFi to connect to the Internet but no mobile telephone links. The reason is obvious. Manufacturers can include a WiFi chip for about $5/device, users don't have to pay usage charges, and the speed of connection is faster. Embedding a mobile telephone in one of these products is possible, but in practice has proven prohibitively expensive for most consumer markets.

Greater Economies of Scale and Lower Transaction Costs for End Users. Unlicensed equipment tends to have greater economies of scale and lower transaction costs for on premise deployments. Consider that many markets have as many as six mobile telephone carriers. To get ubiquitous in-building coverage for all potential licensed users, a business needs to install equipment from each of these vendors. But dealing with multiple vendors for a redundant service creates unnecessary transaction costs, including installation, maintenance, billing, and negotiation costs. This may not be a serious obstacle for large, heavily trafficked entities such as sports stadiums and malls. But for smaller entities, such as the vast majority of businesses and local governments in the U.S., standardizing on a single, on-premise unlicensed standard, such as WiFi, may be more efficient. More generally, the radio communication spectrum within any entity's private property consists of hundreds of licensees with rights to different frequencies. Assuming that an on-premise user wants to aggregate the bandwidth from all these licensees, the economies of scale and transaction cost problems described above are magnified by orders of magnitude.

Higher Quality for End Users. In real world applications, unlicensed spectrum has many quality advantages over licensed mobile telephone spectrum. These are the same advantages leading to the growth of low-power devices, and include more control, more quality of service, more security, more coverage, and more capacity/faster speeds. But when spectrum is treated as a complementary asset to tangible property, those advantages are clearly maximized because possession of tangible property represents a smaller geographic unit, often by a factor of a million or more, than possession of an FCC license. Consequently, the most demanding wireless users, notably large, sophisticated businesses, are shifting to the unlicensed property model for reasons of quality as well as cost.

A major advantage of unlicensed spectrum for business is greater control, including tight integration with corporate PBXs, which are widely perceived to allow for better transferring, parking, monitoring and filtering of calls than mobile telephone networks. Businesses are increasingly seeking to have on-premise mobile employees, and they want those employees to be able to carry their work and use the same PBX features, including internal extension numbers, wherever they go. With WiFi, they can do this whether the employee is working at the corporate campus, telecommuting from home, or working out of a hotel. This is especially important in businesses, including hospitals, hotels, warehouses, retail stores and universities, where a large fraction of employees are constantly moving around.

Businesses also want more control over quality of service. A large fraction of mobile telephone calls are dropped. When the CEO of a major corporation is making a wireless call to a vital client, he doesn't want the call dropped because a teenager two miles away is chatting with his girlfriend. The mobile telephone company doesn't offer him a way to ensure his call gets through. But through integration of a VOIP WiFi phone into his PBX, he can do that.

Businesses also want more control of internal security. Both licensed and unlicensed wireless devices now have similar encryption technology to prevent unauthorized access to information. But high-power out-of-building mobile telephone signals are much more vulnerable to hackers and corporate espionage.

Businesses also want more control of coverage. Only a small percentage of businesses have complete on-premise mobile telephone coverage. Elevators, basements, nearby buildings, steel or concrete walls, and factory machines are just a few of the obstacles that typically pose barriers to ubiquitous coverage.

Businesses also want high speeds where they need it. Security, medical, and warehouse personnel may have a need for high speed images and video on the go. For example, a doctor in an emergency room may highly value the ability to download a patient MRI sixty times faster via an unlicensed (WiFi) than a licensed (mobile telephone) network. Indeed, the extra speed may be the difference between life and death for a patient.

Economic Weaknesses of the Unlicensed Property Model

A major potential problem with the unlicensed property model is that it may give those who possess tangible property monopoly power in ways we haven't seen before. But it turns out this may be more of an apparent than real threat. Consider the acoustic analogy. Municipalities, mall owners, hotels, and others could potentially ban speech on their premises. But they don't because it is not in their self interest to do so. It turns out that even strictly profit oriented private property owners provide "free" (at zero marginal cost) access to all sorts of assets on their property. For example, restaurants provide patrons with salt, utencils, and drinking water for "free." Mall owners and hotels provide access to parking, benches, and rest rooms for "free." And governments often provide even more "free" amenities, including libraries, schools, and police services. I believe this pattern will continue over to local spectrum use. I cannot imagine, for example, a mall charging for keyless car door entry any more than it charges for a parking space. Hotels might try to charge to wireless for access—as many now do—but it is hard to imagine a hotel charging its guests for wireless access solely within a room or even, ultimately, on the hotel premises. Assuming that the marginal cost of such access is zero and there is vigorous competition in the hotel market, charging for such access would be economically inefficient.

By granting spectrum usage rights based on possession rather than real property ownership, a lot of potential problems are avoided. For example, tenants in a building would have legal rights to use spectrum within their own offices without landlord approval. A cell phone user within a car could make a wireless connection to and from the car radio to use the sound system within the car. And a jogger on a public path could wirelessly connect the MP3 player on her hip to the headphones on her ears.

Another potential problem is coordinating roaming arrangements with the more than 20,000 local municipalities, fifty states, and the federal government that control public rights-of-way on everything from interstate highways down to the local neighborhood cul-de-sac. But this may not be materially different in difficulty than coordinating free access to the tens of thousands of networks that currently constitute the Internet.

Competitive vs. Monopoly Telecommunication Network Models

The vision of network evolution I have presented runs contrary to today's conventional wisdom not in its particulars but in its overall synthesis. The two major paradigms for network evolution are the monopoly and competition models. The monopoly model assumes that at least somewhere in the network there is a monopoly bottleneck that needs public regulation. The competition model assumes that all bottlenecks will be overcome as a result of emerging technologies. For several decades the competition model has been dominant.

Underlying the competition and monopoly models is a theory about the relative role of wires and wireless in the network. In the competition model, wireless can overcome the monopoly bottlenecks in the wired network and is thus viewed as a *substitute* for the wired network. In the monopoly model, it is viewed as a *complement* to the wired network—superior to wires for pervasive end user links.

Both private property and commons theorists have tended to support the competition model. The unlicensed property model fits more logically in the monopoly model, which is one reason private property and commons theorists may have been predisposed to be blindsided by it.

Policy Recommendations

> "We are called to be architects of the future, not its victims."
>
> --R. Buckminster Fuller

The changing economics and architecture of the telecommunications network requires a shift in policy orientation. The traditional rationale for giving the FCC a lock on spectrum policy—that wireless communication was inherently interstate in nature—has irreparably broken down. In an age when the most important spectrum applications increasingly occur within the confines of private property, the old one-jurisdiction-fits-all system of spectrum regulation is bankrupt.

One of the major problems with giving the federal government too much power over spectrum is that it has been too prone to corruption. In the last five years alone it has given away spectrum rights worth what I estimate to be at least $50 billion with no public compensation. Most of this giveaway has gone to some of the largest companies and wealthiest individuals in the world. Just a few of the most famous names include Disney (via ABC), GE (via NBC), Viacom (via CBS), News Corp. (via Fox), and Sprint Nextel.

But less famous names have also walked away with extraordinary windfalls, including Clearwire, Mobile Satellite Ventures LP, and the Archdiocese of Brooklyn, New York.

Even worse, the federal government has allowed incredible amounts of spectrum to be underutilized because various incumbents don't pay the opportunity cost of their spectrum rights and want to keep potential competitors from getting access to spectrum. My book, *Speak Softly and Carry a Big Stick*,[39] explains how one industry group, local TV broadcasters, has been so successful playing the spectrum windfall and economic stagnation games. But in terms of social welfare loss, the worst abuser of all is the federal government, which hogs close to 50% of all spectrum for its own internal use, classifies its assignments and uses as "classified" or "sensitive," and has a track record of grossly inefficient spectrum use. Despite endless studies and pronouncements that the federal government intends to reform its spectrum use, there has been little meaningful evidence to date that it is serious. Until there is a public inventory of exactly where and how the federal government uses spectrum, any talk about improving federal government accountability for using its spectrum is merely claptrap. [40]

The time has come to decentralize control over spectrum. Power should be taken away from both the federal government and giant corporations and shifted to local governments, homeowners, and small businesses. So far, I have suggested that the way to do this is by shifting all rights from the federal government and licensees to tangible property owners. But I don't actually believe that. I believe there will still be many applications, such as satellite services, where there will be a long-term demand for spectrum allocated according to the licensed property model.

The question then arises: how can one achieve an efficient balance between decentralized and centralized control, and between the unlicensed and licensed property models? I suggest that the obvious solution is to divide overlay and underlay rights to spectrum. In this model, each set of rights could be co-equal, just as homeowners have the right to control space within their own homes but airplanes have the right to use space 1000 feet above their homes. Similarly, sometimes the government separates ownership of resource rights below ground, such as energy and mineral extraction rights, from real property rights above ground. In both cases, the only question is where the dividing line is between real property rights and the other rights.

Figure 9 depicts one possible relationship between the various spectrum management models, including the distinction between overlay and underlay rights. Here the unlicensed property rights model is restricted to underlays and the licensed property rights and commons models are restricted to overlays. I am agnostic about the relative social value of the licensed property rights and commons models in the overlay spectrum, so I have depicted the circles as the same size. Obviously, others believe they should be of different sizes. The relative social value created in underlay vs. overlay spectrum is

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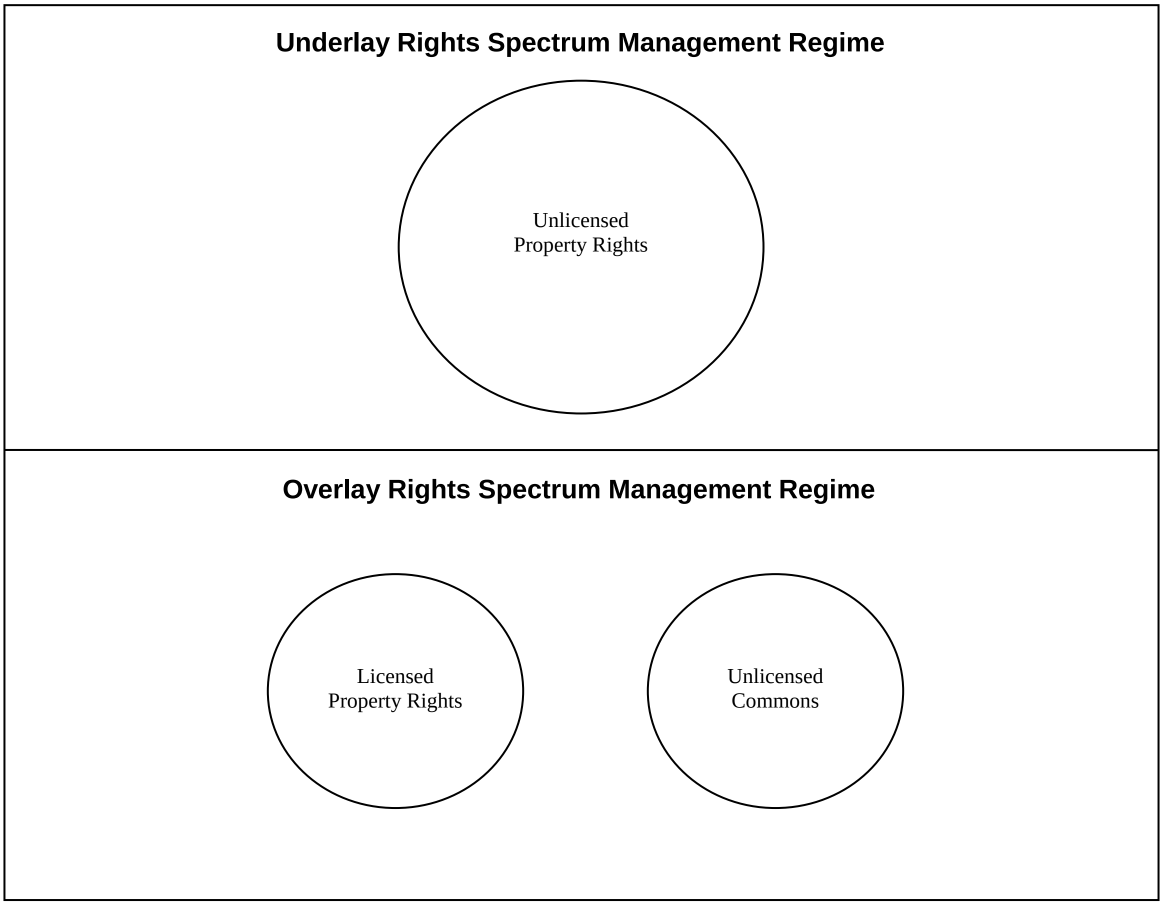
[39] J.H. Snider, "Speak Softly and Carry a Big Stick: How Local TV Broadcasters Exert Political Power," New Y ork: iUniverse, 2005.
[40] J.H. Snider, "Public Needs to Know How Government Runs Its Airwaves," *San Francisco Daily Journal*, May 10, 2006.

also a matter of potential dispute. Here I have depicted the social value in the underlay and overlay spectrum as approximately equal.

Figure 9. Underlays and Overlays in Relation to the Spectrum Management Models



To understand the difference between overlay and underlay rights, an acoustic analogy is helpful. Diners in a restaurant can talk at each table while music plays in the background. The loud music is the overlay right and the soft conversations are the underlay rights. The reason this works out is because waves—whether they are sound waves or electromagnetic waves--pass through each other. To visualize this, recall how waves pass through the wake of a boat. As they pass through the boat's wake, their shape is altered, but as they leave the boat's wake, they return to their normal shape.

Unlicensed underlay rights can be divided into jamming, incidental, and communications. Incidental underlay rights involve the discharge of electromagnetic energy at such low power as to have no discernable impact on communications. Electronic devices emit electromagnetic energy as a necessary byproduct of their operations. But as long as this energy travels only an insignificant distance, such as a few inches, nobody is harmed and nobody cares. For example, every digital wristwatch emits such energy and it is perfectly legal. Even cell phones otherwise using licensed spectrum emit such energy.

Perhaps the most common worldwide use of unlicensed underlays to affect communications is jamming, which is used to disrupt rather than send wireless communication. Jamming is technically illegal, except for federal government officials, but is nevertheless widely used. The President of the U.S., for example, rarely goes anywhere without jamming his immediate vicinity. The purpose of the jamming is to prevent eavesdropping and the remote activation of bombs. Military troops in combat, such as in Iraq, routinely use jammers when they patrol. Embassies and board rooms across the U.S. make use of them to prevent eavesdropping on sensitive communications.

At least several countries outside the U.S. now allow jamming for such public events as church services, concerts, plays, and movies. The theory is that when people attend such events they are entitled to quiet from beeping cell phones and other mobile devices. In many other countries such jammers also appear to be used, albeit illegally.

Jamming need not occur through the use of electrical signals. It can also occur by creating a "cage" to keep out electromagnetic radiation. Walls painted with metallic paint can keep out such radiation. Thick walls and underground rooms can also keep out unwanted electromagnetic radiation. Such jamming is perfectly legal and widely used in the United States in sensitive venues such as broadcast studios and corporate board rooms where the practice is to follow the letter but not the spirit of the law banning jamming.

In the U.S. there are few widely used underlay rights for communication purposes. One is FM modulators, which are used to wirelessly connect MP3 players and satellite radios to a car's radio using channels in the FM radio band. Usually, FM modulators are tuned to unused radio channels but they need not be. The allowed power levels of FM modulators are such that in ideal circumstances the signals can legally travel about 3 meters (a little more than nine feet). Ideal circumstances include transmitting in a direct line of sight from the FM modulator to the radio and on an empty channel. In practice, FM modulators can often only transmit a clear signal a few feet.

Perhaps the best publicized underlay right for communications is ultra-wideband (UWB). As noted earlier, the FCC authorized UWB service in the early 2000s. UWB spreads energy over a very large bandwidth—3 GHz to 11 GHz—and works at distances of about thirty feet under ideal circumstances. Although some outdoor uses are allowed—such as for ground penetrating radar by pointing an outdoor radio in the direction of the ground—its flexible use is restricted to indoor use. The primary consumer application for UWB is expected to be replacing with wireless links the maze of consumer electronics and computer wires found in most houses. The speed of UWB is comparable to a USB 2.0 wired connector, which is found in almost all new computers. For this reason, UWB is sometimes called "wireless USB."

Unfortunately, when the FCC issues rules for UWB, it was primarily interested in protecting incumbent licensees from worst case interference scenarios rather than maximizing the social welfare from UWB. For example, its UWB *First Report and Order* acknowledges: "We are concerned… that the standards we are adopting may be overprotective and could unnecessarily constrain the development of UWB technology…. It is our belief that the standards contained in this Order are extremely conservative."[41] One way this pro-incumbent bias played out was to ban the use of UWB as part of an outdoor municipal WiFi network. As a result, vast amounts of useful spectrum that could facilitate broadband deployment is left unused.

As a general rule, unlicensed devices authorized by the FCC are expected to be secondary to licensed devices. In practice, as a result of trespass laws, they need not be. But trespass laws are not within the FCC's jurisdiction. The one little known exception where unlicensed devices are not secondary to licensed devices is in the 900 MHz band, widely used for cordless phones, baby monitors, and other simple indoor unlicensed devices. The 900 MHz exception occurred because of a historical anomaly. Unlicensed devices were authorized first in this band and licensed services only later. Following its normal practice of protecting incumbents against newcomers, the FCC granted the unlicensed incumbents safe harbor protections against the licensed newcomers. The FCC also granted licenses only for a narrow outdoor use--vehicle monitoring--whereas the unlicensed devices were only protected for indoor use.

More recently, the FCC has sought to extend the use of unlicensed underlays through what it called the "interference temperature" concept.[42] This was a klutzy, property independent conceptualization of unlicensed service that was in keeping with the regnant unlicensed commons approach but which was also deeply muddled and went down in fiery defeat because no one could figure out a compelling way to make it work. A better approach might have been to develop an interference temperature metric with respect to tangible property rights.

Unfortunately, the technical details of such underlay interference management schemes as "interference temperature thresholds" are far beyond my intellectual grasp. The central point I want to make is that, as with any property model, spectrum emissions should be limited at the property line. What is done within those property lines is of no concern to the government unless there is an impact on those with property rights outside those lines, in which case a balancing act must be conducted. That balancing act is a staple of American jurisprudence because human activities in the real world rarely are purely self-contained within property lines. On my property, for example, the leaves from my trees fall on my neighbor's yard, the water from my yard traverses into my neighbor's yard, and my kids' playing makes noise that my neighbor can hear. The task is to use common sense reasoning to balance my neighbor's property rights with mine, and the same can be done with spectrum underlays.[43]

In conducting this balancing act, underlay rights should be given the benefit of the doubt over overlay rights, something that is completely contrary to the current spectrum

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[41] First Report and Order In the Matter of Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems, ET Docket 98-153, April 22, 2002, paras. 1, 2.
[42] Notice of Inquiry and Notice of Proposed Rulemaking in the Matter of 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, ET Docket 03-237, November 28, 2003.
[43] Ellen P. Goodman, "Spectrum Rights in the Telecosm to Come," San Diego Law Review, Volume 41, 2004: 269-404.

management regime. Overlay rights should not be ignored but when they conflict at the margin, first priority should be given to underlay rights. This, of course, is standard procedure when the government conducts any other type of eminent domain action. Spectrum should not be the lone exception.

The Communications Act of 1934 grants the federal government the authority to transition from the current system to the system I propose.[44] Under the Communications Act, no licensee can have ownership rights to spectrum. All the licenses, even those acquired at auction, are for a limited duration of years. If the government wants to reallocate spectrum and divide overlay from underlay rights or switch entirely from a licensed to unlicensed property rights regime, it can legally do so.

Even within the license terms of most licensees, the government has the right to separate underlay from overlay rights. In some cases, the disposition of underlay rights is unclear. But in many cases, they have clearly not been allocated as part of a license. For example, in the TV broadcast band broadcasters currently have the right to transmit a single signal from a particular place at a particular power level in particular directions. This leaves open the possibility that every property owner could reuse that spectrum as an underlay within his or her property. Broadcasters, of course, want those underlay rights for themselves and will fight tooth and nail against anyone else getting them. Indeed, broadcast licensees have instigated a proceeding at the FCC that, by giving them geographic service area rather that site based rights, will put them well on the road to getting such underlay rights.[45] But the FCC is currently under no legal obligation to give broadcasters such rights.

With privileges, of course, come responsibilities. Local entities should not only be given far more privileges to use spectrum locally. They also need to be given responsibility for enforcing those rights. The FCC is wholly unsuited to managing the new spectrum world we are entering. Enforcement of unlicensed property rights should be given over to local governments, which currently enforce other local nuisance and trespass laws and are far better suited than the FCC to enforce violations of unlicensed property rights.

Federal preemption of wireless tower zoning ordinances also needs to be rethought in light of the new world we are entering. It is one thing to grant federal pre-emption when a small town only has a single cell tower. But when there are thousands of cell towers, the law needs to be rethought.[46]

[44] The Communications Act of 1934, Pub. L. No. 73-416, 48 Stat. 1064 (codified as amended at 47 U.S.C. §§ 151-615b (2000))
[45] Clarification Order and Notice of Proposed Rulemaking in the Matter of Digital Television Distributed Transmission System Technology, MB Docket No. 05-312, November 4, 2005.
[46] For a discussion of tower regulation, see Charlie Lemley and Brendan Carr, "How Federal Preemption Helps Tower Owners," *Above Ground Level*, October 2006, pp. 22-25.

Conclusion

The time has come for a new, more sophisticated terminology to describe the spectrum property model. Coase made brilliant contributions to understanding the role that well defined property rights could have in enhancing the efficient use of spectrum. But he evidenced no understanding that the property rights model could encompass both licensed and unlicensed uses. Both property rights and commons theorists now need to move out of Coase's shadow and recognize the implications of the emerging era of low power wireless devices. Whether it makes any difference whether the initial distribution of property rights follows the licensed or unlicensed model is a subject for future study. But preliminary indications are that it probably does have a significant impact on social welfare.

To the extent that an unlicensed property rights regime is desirable, management of such spectrum rights should transfer from the federal government to state and local governments. One simple way to achieve a balance between licensed and unlicensed property rights is to allocate overlay rights on a licensed basis and underlay rights on an unlicensed basic. Much research needs to be done on how to efficiently allocate underlay rights and establish an appropriate balance with overlay rights. The FCC's interference temperature proceeding was a failed attempt to do this that needs to be revisited with a new conceptual model. Another important area for future research concerns how to shift enforcement of spectrum rights from the federal to local levels of government.

Licensed property rights to spectrum are hugely valuable. To paraphrase a former FCC Media Bureau Chief, most spectrum licensees would rather kill their mothers than give back their spectrum. They will thus fight unlicensed property rights tooth and nail. The fact that the public barely understands the nature of spectrum and shows almost every sign that it could care less is equally problematical. The combination of special interest zeal and public apathy is an explosive political combination that, as long as it lasts, will inevitably result in special interest spectrum politics that unduly favors the licensed over the unlicensed property rights model. To the extent that law and economics are *not* on the side of licensed property rights holders, there may be hope that these political dynamics will one day change.