

Local Spectrum Sovereignty: An Inflection Point in Allocation

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Abstract

Orders of magnitude changes in technology have dramatically altered the way radio spectrum is used since it was codified a “public resource” in the US in 1927.

Although some proponents of spectrum policy reform believe comprehending this technological change calls for a complete over-hall of US spectrum regulations, a wholesale re-write is neither justified nor possible.

Use of radio technology spans a huge range of human activity from the use of power drills and digital circuitry, to RFIDs on products, to satellite communications, broadcast, and radio astronomy.

Moreover domestic mission critical applications such as defense and public safety, as well as international obligations, preclude immediate changes to the rules governing some spectrum.

However this paper demonstrates that a true “disruptive event” HAS occurred in radio technology, and that this disruptive event enables and calls for an inflection point in spectrum regulation.

A fortuitous accident of propagation characteristics, pre-defined operating parameters, and the resulting products and usage models that evolved, effectively created a sphere of local spectrum sovereignty, empowering the local property owner with de facto spectrum rights.

Contrary to claims that the success of the FCC’s unlicensed regime in general and WLANs in particular, are the result and proof of a successful “commons”, it is local property owners exercising their de factor rights that have prevented a “Tragedy of the Commons”.

By recognizing and codifying this de facto right, the Commission can propagate the value of this phenomenon beyond the restrictions imposed by the aforementioned accidents, for instance enabling longer range applications such as WISPs

Accordingly this paper advocates the establishment of local spectrum sovereignty, where the right to use some frequencies, and freedom from interference in using them, is attached to the property where they are used.

The critical issue, low transaction cost dispute resolution of interference claims, can be facilitated by the FCC with an ex ante definition of a per se nuisance and minimal equipment regulations.¹

A current FCC proceeding provides a low-risk opportunity for implementing local spectrum sovereignty today in unlicensed bands, this paper propose specific regulations, which if adopted, would establish such rights.

The views expressed in this paper are those of the author, and do not necessarily represent the views of Intel.

¹ Thanks to Kevin Werbach for his insight in the role of product liability in dispute resolution in SUPERCOMMONS: Toward a Unified Theory of Wireless Communication, forthcoming in March 2004 issue of the Texas Law Review <http://werbach.com/research/supercommons.pdf>, and special thanks to Ellen Goodman whose forthcoming *Spectrum Rights in the Telecom to Come*, __ SAN DIEGO L.REV. __ (forthcoming February 2004), will be a seminal piece in spectrum management.

Introduction

Orders of magnitude changes in technology, enabling productive and novel usage and business models have dramatically altered the way radio spectrum is used since radio spectrum was codified a “public resource” in the US in 1927.

Although some proponents of spectrum policy reform believe comprehending this technological change calls for a complete over-hall of US spectrum regulations, a wholesale re-write is neither justified nor possible.

Use of radio technology spans a huge range of human activity from the use of a power drill and digital circuitry, to RFIDs on products, to satellite communications, broadcast, and radio astronomy.

Moreover domestic mission critical applications such as defense and public safety, as well as international obligations, preclude immediate changes to the rules governing some spectrum.

Accordingly reform must occur within an existing framework of commitments, and established ecosystems.

The trend to more market oriented solutions involving auctions and exclusive, flexible usage rights, should, and will likely continue.

Likewise some scenarios, such as spurious and unintentional emissions will continue to be most efficiently handled with a Pigouvian approach to pollution mitigation.

However this paper demonstrates that a true “disruptive event” has occurred in radio technology, and that this technological disruptive event enables an inflection point in spectrum regulation.

A fortuitous accident of propagation characteristics, the operating parameters defined for some frequency bands, and the resulting products and usage models that evolved, effectively limit their use to the immediate locale, empowering the local property owner with de facto spectrum rights.

Contrary to claims that the success of the FCC’s unlicensed regime in general and WLANs in particular, are the result and proof of a successful “commons”, it is local property owners exercising their de factor rights that have precluded a “Tragedy of the Commons”.

By recognizing and codifying this de facto right, the Commission can propagate the value of this phenomenon beyond the restrictions imposed by the aforementioned accidents, for instance enabling longer range applications such as WISPs.

This paper proposes exactly that, by advocating local spectrum sovereignty- where the right to use some frequencies, and freedom from interference in using them, is attached to the property where they are used.

The salient issue, dispute resolution of interference claims, can be accomplished by an ex ante definition of a per se nuisance by the FCC. Moreover that the applicability of this standard (the transaction cost in detecting and identifying an interferer) could also be enabled in current a FCC proceeding.

This paper provides the concrete steps for implementing local spectrum sovereignty today in unlicensed or license exempt bands via this proceeding.

In part 1 I show how technology has created a sphere of spectrum activity over which federal jurisdiction is no longer justified nor required.

In part 2 I describe why there is no “commons” in this sphere.

In part 3 I respond to the FCC’s current NPRM on Cognitive Radios to show how a local sovereignty solves the Commission’s objective of enabling longer-range uses for rural applications, while retaining the tremendous innovation fostering characteristics of the current unlicensed regime. I address the major concerns of dispute resolution, impact on innovation, QoS, market incentives, and possible dislocations.

1. Technology mitigation of the justification for Federal regulation

1.1. Federal Justification

1.1.1. Interstate

Prior to initial US regulation and for decades after, the perceived essence of radio was its ability to conquer distances, bridge oceans. This lack of spatial constraint, or borderless characteristic was a key element responsible for the belief in spectrum as “public property”.

In its early years “how far away” quickly became the dominant metric for users. “Advertisements for receiving sets reflected the obsession with distant radio stations”...[the] “lure of distant stations grips the radio fan”²

Compounding this early end-user “pull” for distant access (which was supplanted as the technology matured for a focus on content) was a “push” from broadcasters to reach more and more listeners. Although “localism” quickly emerged as one of the pillars of “public interest”, “distance” provided the key

² Smulyan, S. (1994), *Selling Radio*. Smithsonian Institute Press, Washington. Pg 15

driver for initial user demand and advances in receiver technology; as well as supply-side economies of scale and increases in transmitter power and range.

It was this “Interstate” feature that provided fundamental justification for federal regulation in the first place.

As Bensman puts it “here was the unique approach to the right of federal control of the air-waves, by affirming the right of authority via the commerce clause of the Constitution, which to this day underpins government control.”³

1.1.2. POLLUTION

The second classic justification for federal regulation is that in some cases because a large number of entities could be affected by emissions, it was more efficient for the government to regulate rather than allowing the parties to negotiate. A Coase himself states:

In the standard case of a smoke nuisance, which may affect a vast number of people engaged in a wide variety of activities, the administrative costs might well be so high as to make any attempt to deal with the problem within the confines of a single firm impossible. An alternative solution is direct government regulation. Instead of instituting a legal system of rights, which can be modified by transactions on the market, the government may impose regulations which state what people must or must not do and which have to be obeyed. Thus, the government (by statute or perhaps more likely through an administrative agency) may, to deal with the problem of smoke nuisance, decree that certain methods of production should or should not be used (e.g. that smoke preventing devices should be installed or that coal or oil should not be burned) or may confine certain types of business to certain districts (zoning regulations).⁴

1.1.3. FREE SPEECH

The last justification for federal intervention was the realization that broadcasting provided a powerful medium for disseminating information and shaping public opinion.

The 1920’s saw explosive growth in broadcasting, irrational exuberance applied to the stock prices of the new pioneering companies, and no known way to extract any profit. As Hoover stated in 1924 “The largest unsolved question is the entire problem of remunerations for the broadcasting stations.”⁵

Although the business model of advertisement supported entertainment, was yet to be decided, it became obvious in the early twenties that the more households you could reach with one broadcast, the more you could spread (once you figured out how) the cost of high priced entertainment.

And so the correct architecture of the system was known prior to figuring out the revenue stream. The task was to simultaneously provide the same content to geographically dispersed stations to reach a larger audience.

David Sarnoff argued that “as long as 559 broadcasting stations in this country are maintained, the situation is hopeless,” and found the solution in a few super-power stations which will reach every home in the country”⁶

The vision that Sarnoff evoked, that of a giant broadcaster, blanketing the country with a single signal, contributed to the true motivating factor for government control.

Berle and Means in their contemporary study of American business document the prevailing concern, if not apprehension, of mega corporations and their management: “the corporation has, in fact become both a method of property tenure a means of organizing economic life.” “whereby the wealth of innumerable individuals has been concentrated into huge aggregates... The power attendant upon such concentration has brought forth princes of industry, whose position in the community is yet to be defined”⁷

It was more the threat of monopoly control of voices, rather than lack of competition in the economic sphere, or a technical interference over-exploitation problem, that drove regulation of the airways.

As Hazlett pointed out in 1990 “In the event any misunderstanding had arisen that placed interference control as the primary aim of federal legislation, Dill was pointedly direct “there is much agitation and much

³ Bensman, M. (2000) *The Beginning of Broadcast Regulation In The Twentieth Century*. McFarland & Company, Inc., North Carolina. Pg 100

⁴ The Problem of Social Cost; RONALD COASE; originally published in *The Journal of Law and Economics* (October 1960).

⁵ Bensman, M. (2000) *The Beginning of Broadcast Regulation In The Twentieth Century*. McFarland & Company, Inc., North Carolina. 126

⁶ *ibid*46

⁷ Berle & Means (1933), *The Modern Corporation and Private Property*. The Macmillan Company, New York. Pg. 1

resentment to day over the chaos of the air, but that does not concern me so seriously as the problems of the future. Chaos in the air will be righted as a matter of business” “Dills concerns were devoted to monopoly and political fairness over the airwaves, both derived from his belief that radio broadcasting would become an important, powerful means of expression”⁸

Leaving a critical means of communication to the mercy of the market was unacceptable for Congress.

1.2. Mitigation, what has changed.

1.2.1. Interstate to local

In the 21st century conquering distance is as attractive as it was in 1927.

The use of radio communications via satellite, images broadcasted from mars, and radio astronomy have pushed literally to the far corners of the universe.

However technology and business models have also driven the Ether to be used for decades more and more as a short haul carrier from a few miles as in cellular, to a few yards as in remote controls and garage door openers, down to inches or feet as in Bluetooth or RFIDs.

In particular the use of radio as a means to network computing devices, Wireless Local Area Networks (WLAN), has created tens of billions of dollars of economic value.

Radio spectrum usage that is very localized to a specific property, whether a home, office building, Starbucks, Airport, or Washington Square Park appears to be entrenched on a global basis.

1.2.2. Speech

Contrasted with 1927, the public has a myriad of available ways to electronically access information and entertainment. Indeed from cable and satellite networks to the Internet., “information overload” is often cited as a problem with our vast choices.

Moreover, government regulation by restricting private use, might actually hinder free expression, rather than protect a plurality of voices as it was initially intended.

1.2.3. Pollution

As mentioned above, a Pigouvian approach is only warranted where the number of parties involved would make negotiations very costly.

In the area under discussion in this paper, where emissions are restricted to the immediate vicinity, only a small number of parties are involved, and so transaction cost would not be high enough to justify the regulatory burden.

2. Commons Myth, De Facto Local Control

The dramatic success of the FCC’s unlicensed regime, and Wi-Fi in particular, has been claimed by some as proof of a viable “commons”.

However this is a misinterpretation of the situation.

While the arbitration mechanisms of the 802.X standards allow for coexistence of a finite amount of similar devices, too many devices trying to operate simultaneously will degrade the system just like any other network.

Moreover wi-fi devices also must share the spectrum with a panoply of device that have no means of coordination such as cordless phones, baby monitors and micro-wave ovens.

The fundamental reason that a so-called “Tragedy of Commons” has been avoided for the bulk of Wi-Fi deployments, is that the corporate or campus IT department or homeowner controls the deployment of devices in their domain.

The combination of low power limits and propagation characteristics in the unlicensed bands, limit the effective range of these devices to the immediate vicinity.

The property owner, by regulating the operation of devices in the area of their control maintains a working environment for all.

This is a highly efficient mechanism. Similar to a firm internalizing transaction costs, the business, homeowner, or campus administrator trades off which devices to allow based on their utility and impact on others.

2.2. Business

In addition QoS issues, security concerns have driven corporate I.T. departments to regulate the deployment and use of WLAN equipment such as Intel’s policy on non-I.T. department deployed, or “experimental” WLANS:

Failure to fulfill the above terms and conditions [for non- IT WLANS] will result in I.T.’s

⁸ Hazlett, T. (1990); The Rationality of U.S. Regulation of the Broadcast Spectrum. Journal of Law & Economics, Volume XXXIII, No. 1, April 1990

disconnecting and or taking possession of the Experimental W-LAN Access Points.

2.3. Campus

Campus administrators regulate the deployment and use of Wi-Fi competing devices, as demonstrated by Carnegie Mellon's policy:

While we will not actively monitor use of the airspace for potential interfering devices, we will seek out the user of a specific device if we find that it is actually causing interference and disrupting the campus network. In these cases, Computing Services reserves the right to restrict the use of all 2.4 GHz radio devices in university-owned buildings and all outdoor spaces on the Carnegie Mellon Campus.⁹

2.4. Home

I had installed wired Ethernet (CAT 5) in my home and so deployed a wireless LAN only recently when my wife got a lap-top.

She discovered while using her lap-top in a room far away from the access point, that simultaneous use of our (expensive) 2.4 GHz phone would cause her internet connection to stop working. Accordingly we replaced the expensive 2.4 GHz phones with (cheaper) 900 Mhz ones, problem solved.

However later wanting the caller ID feature on the 2.4GHz phone she reconnected it in a different location, trading off a smaller amount of interference for the added feature.

This behavior is the epitome of an efficient Coasian firm- internalizing transactions costs and optimizing resources in a way neither regulation nor market transactions could achieve.

2.5. Common Mistake

Commoners erroneously believe that the way to propagate the success of this regime is for the Commission to mandate specific service requirements (broadband packet based digital transmission) for bands, and specific arbitration or sharing "etiquette" rules for equipment.

Attempting to substitute the highly efficient and successful market mechanism with an ex ante definition of "fair" spectrum use is problematic at best and probably impossible. This is because the "Digital Migration" has de-coupled service from transport, there is no longer a fixed "service" (such as voice call) or use

⁹ Airspace Guideline for 2.4 GHz Radio Frequency at Carnegie Mellon University

that can be "achieved" with some minimum spectrum use.

Devices operating in unlicensed spectrum exploit many different technical parameters in their use of spectrum, such as power, bandwidth, time, etc.

Attempting to define ex ante transmit power etiquettes are particularly problematic. Modern air interfaces maximize bandwidth as a function of S/N, which of course varies with transmit power. "Range" is no longer a simple fixed parameter: It's a given bandwidth at a certain distance, that's dependent on transmit power.

3. Practical Steps

As mentioned earlier de facto land-owner spectrum sovereignty is an accident enabled by a fortuitous coincident of the FCC power limits, propagation characteristics of the particular frequencies, and resultant physical nexus of control.

However this breaks down when different physical areas, or changes in power or frequency ranges are considered, and there is strong economic incentives to propagate the success achieved beyond these physical constraints.

In particular, the current limits severely curtail, or preclude many longer-range applications that would be very beneficial in rural environments.

The solution is to recognize and codify the de facto right into a de jure one.

The Commission is addressing this exact issue in a recently adopted Notice of Proposed Rulemaking on Cognitive Radio Technologies & Software Defined Radios¹⁰

In this proceeding the Commission recognizes that the current power limits for certain part 15 devices, unduly preclude their application in rural settings.

The lower population density and the greater distances between people in rural areas can make it difficult for certain types of unlicensed operations at the current Part 15 limits to provide adequate signal coverage. Such operations include Wireless Internet Service Providers (WISPs) and wireless LANs operated between buildings or other locations with a large separation between transmitters. These operations could potentially

¹⁰ ET Docket 03-108; In the Matter of Facilitating Opportunities for Flexible, Efficient, and Reliable Spectrum Use Employing Cognitive Radio Technologies & Authorization and Use of Software Defined Radios

benefit from higher power limits in rural areas, which would result in greater transmission range.¹¹

Accordingly this proceeding provides an excellent vehicle for the implementation of local spectrum sovereignty, where its application can achieve precisely the goal the Commission seeks.

Moreover, it would provide QoS and innovation benefits beyond what the Commission envisions.

3.1. Defining the Right

A fundamental finding of the Spectrum Policy Task Force was that spectrum policy models must be “based on clear definitions of the rights and responsibilities of both licensed and unlicensed spectrum users, particularly with respect to interference and interference protection.”¹²

Rights in the unlicensed space have heretofore been constructed as a right to act, to use certain equipment with certain operating parameters such as power, frequency, modulation etc. In fact users are specifically forbidden from claiming any interference.

In the current proceeding the Commission is again proposing to define the right as the ability to use a higher output power base on a sensing of the environment. However such a proposal may be problematic.

Fundamentally the issue is potential interference at the receiver, and so sensing the environment at the transmitter may be a poor substitute.

The Commission is attempting to guess at a universal transmit power to balance increased interference vs added utility, over a myriad of settings.

The market is the only method found successful for solving such poly-centric problems of determining what users making what trade offs, in what settings, should be made.

Simply, the solution is to tell potential operators you MAY transmit at a higher power, UNLESS you cause interference to someone.

To enable such a paradigm the key right to define is one of freedom from interference; the metric of what constitutes establish a per se nuisance.

Once established it gives parties the certainty needed to negotiate and arrive at optimum solutions.

This de-centralization of the dispute process also allows local authorities (whether the super of an apartment building, police, or even courts) to settle disputes.

Therefore rather than trying to establish a maximum output power for a transmitter, the commission should define an interference level, which when demonstrated to exist in a premises constitutes a per se nuisance, from which a user has the right to claim relief.

In order to minimize dislocation, a level should be set that closely approximates typical existing conditions.

For instance, the Commission should look at typical scenarios such as adjacent Wi-Fi users in an apartment building.

Using existing Part 15 the maximum power limits, and allowing for free space propagation loss and losses for intervening walls, a value of -50 dbm might be a viable threshold for a per se nuisance.

The FCC rulemaking process would vet all the issues with concerned parties to determine a good value

Accordingly rather than a Cognitive radio regulation, a Local Spectrum Use regulation should be codified into part 15 as followed:

§ 15.206 Local Spectrum Use

(a) Devices operating under the provisions of § 15.247 may operate with a power level greater than the maximum permitted in these sections under the conditions specified in paragraph (b) of this section.

(b) Owners of property may operate intentional radiators on their property at the higher power limits specified in paragraphs (a) subject to the following conditions:

- i. Operators must register on the FCC website www.fcc.gov.
- ii. Operators of devices must cease operation if interference is demonstrated to be caused by them on property not their own. For the purpose of this paragraph such demonstration shall be:
 1. A signal level in bands designated in 15.247 of -50dbm with a measurement bandwidth of 1.25 MHz, measured in accordance with procedure defined in xx; or
 2. An indication from a device certified under this part that incorporates a mechanism for monitoring the band and detecting and displaying a signal level in excess of -50dbm, and ID of the

¹¹ *ibid* @ 53

¹² SPTFR @ 3

interfering signal, and/or approximate location of the interfering transmitter which can be correlated to the FCC database of registered operators.

3.2. Dispute resolution

As articulated by Ellen Goodman in her forthcoming piece¹³:

neither side has examined with any degree of specificity how its proposed model of spectrum management would actually function. Interference is the eight hundred pound gorilla in the spectrum policy debate. ... despite the centrality of interference to the current administrative system, and to any legal regime in the future, surprisingly little thought has been given to the variety of interference scenarios and their relevance to the law.

Adoption of the above-proposed rule would establish a definite and verifiable metric, which would make ascertaining infringement simple and hence minimize transaction costs.

Equipment manufacturers would take advantage of the new regime to gain competitive advantage for their products.

Wi-Fi devices already have capabilities for monitoring signal level, devices that allowed users to protect their "air-space" by proving interference would have added value.

Current 802.x WLANs broadcast identifiers. A validated level about the nuisance level correlated with the ID would prove causation.

Alternately in the case where an ID was not embedded or readable in the signal, a first order approximation of the direction of the signal and its received strength, matched against the FCC registration database (all of which could be automated), should facilitate easy identification of interferers.

And so market forces would be enough to make sure devices that accurately detect and "defend" local spectrum get deployed because companies would advertise the feature as allowing consumers to protect rights.

Once an infringement was established, negotiations could then proceed at the pace dictated by the parties.

A WISP operating at a higher power, which was found to cause interference would have multiple means to settle with the claimant such as:

- They could offer to reconfigure the claimants home network to make it more immune to interference, for instance by adding access points; or
- They could offer to compensate the user with free Internet service; or
- The WISP could reconfigure its own network to eliminate or lessen the interference.

3.2.1. Market Incentives

In addition to the incentives for equipment mentioned above, a market would also develop for ancillary products that mitigate interference to allow for higher power such as directional antennas.

Likewise it might be expected, as is the case with other property, that ownership would create incentive for investment to improve the "property", for instance people might take proactive measure to make their homes more immune from noise.

3.3. QoS

Another problem with the existing unlicensed regime is that commercial entities who wish to offer a commercial service have no way to guarantee a Quality of Service to their customers. By establishing definite rights from interference, WISPs would now have a mechanism to calculate costs involved in delivering a fixed QoS. Local owners would be free to sell or lease his rights to a larger aggregator, who would then be able to guarantee a level of service.

3.4. Impact on Innovation

Perhaps one of the greatest critiques of current spectrum regulation is that new or novel uses are ex ante prohibited until they can prove non-interference to existing users.

This represents a huge cost of entry and has a chilling effect on innovation.

Establishing local sovereignty will finally create an environment for low cost experimentation by permitting innovation until an ex post interference finding.

Also to be considered is the impact of a fixed standard for RF nuisance. Unlike the standard for an audio nuisance (where human hearing isn't likely to change and 45 db will always be annoying) -50 dbm might, as technology evolves, look more and more arbitrary.

¹³ Supra 1

New uses and technology might require a greater immunity from interference, or higher power applications might generate a higher potential level of interference.

However the establishment of a level now would not preclude innovation in either case.

If a lower level of interference is of value to a property owner, a market could be expected to evolve for methods to make a property more “quiet” for instance UV coatings on windows also reduce emissions.

Likewise if a higher transmit power application appeared to have great potential, a market would evolve to contain higher emissions to the immediate vicinity, such as with directional antennas. Also the provider always has the opportunity to negotiate with claimants for the right to transmit.

The current FCC NPRM provides an excellent, low-risk opportunity, to trial local spectrum sovereignty.

3.5. Possible Dislocations and Disruptions

Giving users of spectrum in the unlicensed band a right to claim freedom from interference could invoke images of upsetting the existing equilibrium resulting in rampant interference claims overcrowding local courts. It is unlikely that the codification of the 45-decibel audio limit by New York City in 1972, created such rampant noise nuisance claims.

Regardless, in this instance the issue is moot because the new rules as I have proposed apply only to new, higher-power operation.

Operation of existing devices of lower power would constitute a safe harbor against interference claims.

Over time as the benefits accrued from innovation unleashed by the establishment of local spectrum sovereignty, market forces would develop and deploy products and architectures that would take advantage of the new regime.

In turn this ecosystem (of new products, architectures and usage models) based on local sovereignty would become the dominant force. This would allow the existing regime to be sunset with minimal dislocation.

4. Conclusion

Wi-Fi works because of de facto land-owner rights.

Recognizing and codifying these rights would propagate this success allowing its application beyond restrictions imposed by regulated physical limits, while preserving the great innovation fostering characteristics of the current unlicensed regime.