Was a Common Law Solution to Chaos in the Radio Waves Reasonable in 1927?

Draft, not for quotation or attribution

This was written a few years ago—thus it is a little out of date in places.

Please send any comments to me at chuck@jacksons.net.

7/28/2002

Charles Jackson

301 656 8716

Of Man's first disobedience, and the fruit
Of that forbidden tree whose mortal taste
Brought death into the world, and all our woe.
John Milton, Paradise Lost. Book i. Line 1.

I. INTRODUCTION

The radio spectrum is the highway that carries radio, television, satellite broadcasts, and cellular telephone calls and supports myriad other productive, even life-saving, activities. The radio spectrum provides a valuable complement to modern electronics. As electronics become more affordable, spectrum becomes more valuable. At the same time, our system of spectrum management comes under increasing scrutiny, and proposals for reform abound. History provides an important perspective for analyzing spectrum management policies and institutions — understanding the challenges and pressures that led to the creation of existing institutions informs the debate on how best to reform those institutions.

Unfortunately, myth sometimes crowds out fact. Many long for a lost Eden before a taste of the apple cast us out. Some see that as an earlier time — before the growth of federal regulatory agencies — when reason and experience governed through the wisdom of common-law judges unfettered by statutes crafted through the political process. Professor Tom Hazlett has written two papers in which he laments the substitution of federal regulation in the *Radio Act of 1927* for the common law of spectrum regulation that he believes was developing before passage of the '27 Act.[1]

His papers have been read and apparently accepted by others. For example, Chicago Law School professor Richard Epstein recently restated the view that historical evidence supports the belief that a more efficient set of property rights could have been worked out for the radio spectrum had broadcasters continued to stake out claims on a first-come, first-served basis, with disputes resolved by the courts. Although that may not be an unreasonable position for a law professor to take, it is a view that can only be held if one fails to consider the technical and historical environment that existed when radio broadcasting grew rapidly in the mid-1920s.

---

[1] Thomas W. Hazlett, "The Rationality of U.S. Regulation of the Broadcast Spectrum," *Journal of Law and Economics* . 33 (April, 1990): 133-175. <<second cite goes here also>> can't find it as I type.

Epstein wrote,

> Manifestly, broadcast signals require a new system of boundaries lest competing users of the spectrum broadcast over the same frequencies, allowing none to be heard. Although it was realized in the first quarter of this century that highways had to be created in the sky for broadcast signals as well as for airplanes, it hardly follows that some centralized system is always required to make the needed allocations. Indeed, historically, the original device for assigning frequencies imitated the patterns that had long been used for determining the ownership of unowned land: the first person who used a frequency was entitled to keep it in perpetuity. The test itself has some small wrinkles, for just as one person passing over land does not occupy it, so a person who uses a frequency once and no more does not occupy it either. Rather, one must use a frequency consistently and regularly over a period of time, with the intention to exclude others. Nor should these boundaries be more rigid that those in law: since broadcasts over nearby frequencies always interfere with each other to some degree, the live-and-let-live rule for land had to be carried over to the new medium. Some low-level interference between users of neighboring frequencies had to be tolerated and was.
>
> The historical evidence suggests that this system for allocating broadcasting frequencies, once established, would have proved stable in the long run. The basic rights could have been protected by trespass analogies. The frequencies could be used, sold, leased, or mortgaged like any other physical asset. Control over the system is decentralized so the competitive markets that arise from the practice of occupation can be maintained, if needed, by an application of the same antitrust rules applicable to other product and service markets. Small users could gain air time, not by buying an entire frequency, but by leasing it for limited periods from owners who act more like owners of rails and freight cars and less like owners of cargo. As demand shifts across areas, frequencies once devoted to radio could switch to television or telecommunications. The parties also have an incentive to narrow their broadcast bandwidths because they devote the excess to new uses. And the government can purchase what frequencies it needs in an open market or, if necessary, condemn certain frequencies under its eminent domain power. The entire field could be thus assimilated into the traditional fabric of the common law as old rules carry over to new technologies.[2]

Similarly, Peter Huber recently wrote

> A sensible solution began to materialize in late 1926. Applying common-law principles, an Illinois state court delineated rudimentary property

---

[2] Richard Epstein, Principles *for a Free Society* (Reading, MA: Perseus Books, 1998), 212-213, footnotes omitted.

> rights in spectrum. . . . Had the courts been given time to develop it methodically, this simple idea would have created property rights in the ether, much as the common law had created property rights in the land beneath it . . . But Congress had other ideas . . . The result was the Radio Act of 1927. It nationalized all wireless spectrum and placed all aspects of radio broadcasting under the ultimate control of the newly created Federal Radio Commission. The Commission was empowered to license every last transmitter in the land. It would assign frequencies for public use and decide who could use them. It would classify radio stations, prescribe service limits, assign wavelengths, approve the locations and power levels of transmitters, and regulate networks.[3]

Both Epstein and Huber cited Hazlett. Both went beyond Hazlett in expressing the view that the common law was working well in 1927. There are significant elements of myth in both Epstein and Huber's views. Epstein stated that the earlier broadcasters staked out their original frequencies — much like homesteaders — but in fact they had been assigned their frequencies by the federal government. Huber credited the 1927 Act with giving the government expansive powers over radio. The fact is Congress asserted those powers in 1912.

Hazlett's lost Eden is the use of a property-rights approach to managing use of the AM broadcast spectrum. He claimed that such an approach existed before 1927 and offered a reasonable and feasible policy approach in 1927 but was consciously rejected by Congress in favor of a public policy that gave politicians and government regulators explicit control over an important medium of public expression.[4] Hazlett criticized the development of federal radio licensing in the *Radio Act of 1927* as shortcutting the development of common-law property rights by the courts and thereby impairing the efficient use of the radio spectrum. For shorthand, I will refer to this as the *Chicago view*. Although that view may have specks of validity scattered in it, like raisins in a muffin, it is fundamentally wrong because it ignores both the technical and historical environments in which broadcasting developed.

---

3 Peter Huber, *Law* and Disorder in Cyberspace (New York, NY: Oxford University Press, 1997), 29-30.

4 For a sympathetic but skeptical analysis of the Chicago view, see Krattenmaker and Powe, Regulating Broadcast *Programming* (Cambridge MA: MIT Press/AEI, 1994), 15-17.

Although I have long believed that there is great merit to the use of property rights and market mechanisms in the management of the radio spectrum, we betray both the facts and the memory of those who had to deal with the difficult problems of radio interference in the AM band if we take the view that they easily and willfully moved away from an obvious and evident property-rights solution to an unneeded, centralized regulatory bureaucracy.

A few key factors determined — or if not determined, then powerfully influenced — the political outcome in the mid-1920s. First, systems operating on the frequencies that could be exploited with the technology then available created interference over great distances — well beyond the jurisdiction of any court. Second, the essentials of a regulatory system were in place and had been in place since 1912. Congress chose to mend the regulatory system, not to end it. Third, consumers, whose investment almost certainly exceeded that of broadcasters, were arguably at least as much exploiters, occupiers, and potential owners of any spectrum property that could be defined as were broadcasters.[5] Any reasonable view of spectrum policy or spectrum property — let alone of practical politics — should consider their rights and needs.[6] Fourth, broadcast stations are inefficient units for defining spectrum property rights.

Below, I first examine the history of radio regulation in the United States before the 1927 Act. Second, I discuss the nature of efficient property rights in spectrum. Third, I consider some characteristics of the AM broadcast band and AM broadcasting technology that make resource management in that band particularly difficult. Finally, I conclude by offering my views on the structure of sensible reform of spectrum management in this country.

---

[5] In 1926 about 5.5 million homes had radio receivers and there were about 500 broadcast stations — about 11,000 home receivers for every broadcast station.

[6] Recall that this period was before the development of the modern class-action law suit. The availability of this transaction-cost-minimizing mechanism might have made for a more efficient balance in judicial proceedings and made more likely an efficient outcome under a common-law approach.

II. RADIO REGULATION BEFORE THE 1927 ACT

Radio or wireless communications became economically important around the turn of the century. Radio permitted ships to communicate well beyond the horizon — with major implications for safety-of-life at sea and coordination of naval activities. The radios available at the turn of the century were primitive. Their signals splattered all over the dial. Receivers required strong signals in order to work. Practical radio systems transmitted their signals using the ground-wave signal — a radio wave that travels along the surface of the earth rather than through the air. The lower the frequency, the better the ground-wave propagation. Hence, there was little interest in using the higher frequencies.

The second international conference on radio was held in Berlin in 1906. The United States signed the treaty agreed to at that conference, but the Senate did not ratify that agreement until 1912.[7] The treaty dealt mostly with commercial arrangements for the exchange of telegrams between ships at sea and the wired telegraph network on land. One key element of the treaty was a requirement that radio systems interconnect — a direct slap at the Marconi Company's practice of prohibiting the interoperation of its radios with those manufactured by others.

In that treaty, the United States undertook, among other obligations, to apply the rules of the treaty to all commercial radio transmitters in the United States;[8] to require such general public transmitters to operate on either 500 KHz or 1000 kHz;[9] and to require such transmitters to meet power, bandwidth, and minimum efficiency constraints.[10]

Radio prospered. In 1910, Congress required ocean-going steamers carrying fifty or more persons to have a radio and a radio operator on board.[11] In 1912, that act was amended to apply to more ships and to require that such steamers have an auxiliary

7 International Wireless Telegraph Convention, (Washington, DC, U.S. Government Printing Office: 1907), reproduced at http://www.ipass.net/~whitetho/1906conv.htm.

8 Ibid., Article 1.

9 Ibid., Service Regulation II.

10 Ibid., Service Regulation VI. The limitation on transmitted bandwidth is weak. It only requires that the "the system employed be a syntonized system." Syntony is a term coined by Oliver Lodge to refer to the basic idea of restricting transmissions to a chosen band of frequencies. See discussion by J. A. Fleming of Syntonic Electric Wave Telegraphy in the Encyclopedia Britannica, 11th Edition, 1911, vol. 26, 537-538

11 Public Law 262, 61st Cong., 24 June 1910.

power supply for the radio capable of keeping the radio going for four hours and at least two operators, one of whom must be on duty at any time.[12]

In 1912, Congress also passed a more comprehensive statute titled *An Act to Regulate Radio Communication*.[13] That statute began with the assertion that anyone who wanted to use a radio had to have a license for such use. The statute required that the license state the location, frequency, and time during which the station would operate. The *1912 Act* was enacted in an environment in which the most significant use of radio was for communications with ships at sea and in which the safety of life at sea and defense needs, particularly the communications needs of the Navy, were major policy concerns. Commercial broadcasting had yet to be invented. The *1912 Act* contained the seeds of much of the regulatory scheme of the *1927 Act*. It required a private person who used a radio transmitter to have a license.[14] It set aside different frequency bands for different uses. Regulations included in the *1912 Act* specified limits on permissible out-of-band signal strength and on the allowed bandwidth of transmissions.[15] The *1912 Act* specified limits on the geographic location of nongovernmental transmitters in order to protect reception at government stations. Responsibility for enforcing the act was placed with the Bureau of Navigation in the Department of Commerce and Labor.

In 1912, there were basically two types of radio stations — land stations and coast stations.[16] The primary use of radio was for communications between ships and from ship to shore. Ships used radio channels much the way ships used navigational routes — channels were picked up for the duration of a call and then released. Radio operators used two frequencies (500 KHz and 1000 KHz) to set-up calls and as distress calling frequencies. The 1912 Act required all radio stations to be able to operate on these frequencies (as did the 1906 Convention). Radio stations transmitting distress signals

---

12 Public Law 238, 62nd Cong., 23 July 1912.

13 Public Law 264, 62nd Cong., 13 August 1912.

14 Licenses for shipboard radio stations and radio operators were more like driver's licenses than today's broadcast licenses. Maritime radio systems used (and still use) shared channels.

15 The third regulation of the 1912 Act required use of a "Pure Wave." Specifically, the power in any specific frequency was to be at least a factor of 10 below the power in the primary frequency. The fourth regulation imposed bandwidth constraints on transmitted signals. These bandwidth constraints were proportional to the carrier frequency being used and were specified using time-domain constraints.

16 The formal classification was to land stations and ship stations. Land stations were divided into several categories including coastal stations. See Department of Commerce Bureau of Navigation Radio Service, "Radio Communication Laws of the United States and the International Radiotelegraphic Convention, Regulations Governing Radio Operators and the Use of Radio Apparatus on Ships and on Land," 27 July 1914 (Washington, DC: Department of Commerce).

were permitted to use a "broad interfering wave" without the normal power limits when transmitting a distress signal.[17] Today, a radio transmitter transmitting a broad, high-power wave on one of the two primary frequencies of 1912, 1000 KHz, would probably wipe out nearby reception of half the AM band.

The problem Congress faced in 1912 was setting rules for a new technology that was valuable for both commerce and safety-of-life. The nature of resource use was as a commons or highway — stations had access to a pool of frequencies and chose an idle frequency to use when they needed to communicate. Many of the obligations imposed by the 1912 Act would have been reasonable even if there were an unlimited number of radio channels.[18] One cannot overemphasize two points: (1) the 1912 Act was designed to manage a commons — a shared resource, and (2) safety of life was a paramount concern.[19]

After World War I, broadcasting began. In 1921, responding to requests from Westinghouse, the Secretary of Commerce permitted broadcast stations to be licensed to operate on 833 kHz.[20] By March 23, 1923, 524 stations were operating on 833 kHz[21]. Slightly earlier, Commerce Secretary Hoover had begun authorizing broadcasts on a

---

[17] The eighth regulation of the *1912 Act* permits use of a wideband distress signal, and the fourteenth regulation limits power, except for vessels in distress. In fact, the current statute still retains this philosophy. Section 321 (b) of the *Communications Act* reads "The transmitting set in a radio station on shipboard may be adjusted in such a manner as to produce a maximum of radiation, irrespective of the amount of interference which may thus be caused, when such station is sending radio communications or signals of distress and radio communications relating thereto."

[18] For example, the 1912 Act designated specific frequencies as calling and emergency frequencies and required that shore stations keep watch on those frequencies at regular intervals. *Similarly*, the statute required use of the signal **...---...** for distress calling, required shipboard radios to have a range of at least 100 miles, required shore stations to intercommunicate with all ships without regard to the manufacturer of equipment, required that overheard messages be kept secret, and prohibited false distress signals.

[19] The Titanic sank in April, 1912. The Radio Act was approved in August.

[20] An excellent history, by far the clearest I have ever seen, of the evolution of the AM broadcasting band, "Building the Broadcast Band," was prepared by Thomas White and is available at http://www.ipass.net/~whitetho/buildbcb.htm. Much of my account of the evolution of the AM band is taken from that paper.

[21] This presentation slightly simplifies the history. Upon the recommendation of the Chief of the Bureau of Markets and Crop Estimates or the Chief of the Weather Bureau, the Bureau of Navigation authorized some stations to transmit market reports and weather forecasts reports on 618 kHz. Such stations switched their operations back and forth between 833 and 618 kHz. In addition, broadcast stations, like most other radio stations, were required to be able to communicate on the maritime emergency and calling channels of 500 kHz and 1000 kHz.

second frequency — 750 kHz. Content was regulated from the beginning — for example, transmitting mechanically reproduced music was prohibited on 750 kHz.[22] In April 1923, the Commerce Department again expanded the pool of frequencies that could be used for broadcasting. The new band consisted of 81 frequencies divided into two classes. Stations on the Class A frequencies were lower power and could be fit more closely together. Stations on the Class B frequencies were permitted higher powers and were assigned to regions of the country. The regional allocations of the Class B frequencies were announced on May 15, 1923, and stations were assigned to those frequencies by the end of July. Typically, one station was assigned to each of these frequencies.[23] Three stations still operate on the frequencies they were assigned in the summer of 1923.[24] One of the rules the Department of Commerce followed in designing those assignments was that stations in the same city had to operate on frequencies separated by at least 50 kHz.[25] In addition, six of the class B channels were reserved for use by Canada. The Commerce Department limited use of the frequencies near 1000 kHz in order to permit the orderly transfer of maritime communications away from the 1000 kHz region. The one station operating on each class B channel provided nighttime service to wide areas of the country that lacked their own local broadcast stations. Ultimately, the class B channels evolved into the so-called clear channels. Operation of additional stations on those channels would have destroyed much of this nighttime service.

In April 1926, in the Zenith case a federal court ruled that the Secretary of Commerce lacked authority to specify the time and frequency to be used by broadcasters.[26] In essence, the court, reviewing a statute designed to manage a common resource, declined to find that the statute permitted the government to assign exclusive rights to individual broadcast stations. The period referred to as "chaos in the airwaves" then ensued. Broadcasters changed channels and broadcast times, thereby creating widespread interference.

---

[22] The economic behavior of broadcast stations was controlled from nearly the beginning. Paragraph 57 of the regulation contained in the 1919 edition of "Radio Laws and Regulations of the United States" defined Class 2, or limited, commercial stations. Class 2 stations were prohibited from conducting public correspondence for hire or taking messages from other stations. Broadcast stations operated as Class 2 stations. Paragraph 57 was amended September 1, 1922, to specify the use of the frequencies 833 and 618 kHz for broadcast operations.

[23] The exceptions were that some frequencies were used on both coasts.

[24] These are WMAQ, KFI, and KSD. (The KSD call has changed to KTRS.)

[25] White, op cit.

[26] *United States v. Zenith Radio* Corp., 12 F2d 614 (N.D. IL. 1926).

The court case referenced by Hazlett and Huber soon followed. Oak Leaves Broadcasting began transmitting on a frequency located only 40 kHz from WGN's carrier frequency. WGN sued Oak Leaves in order to protect WGN's signal (or revenues), claiming that a minimum separation of 50 kHz was required. The presiding jurist, Chancellor Wilson, found for WGN. Hazlett, commenting upon that decision, stated, "What is most remarkable, perhaps, is that this common law precedent arrived at precisely the interference-separation rule adopted the following year by the Federal Radio Commission."[27] That observation exemplifies Hazlett's desire to find the superior wisdom of the common-law. However, perhaps it is not remarkable that the judge would follow the lead of the Department of Commerce, which had adopted the same separation requirement earlier when designing the channel plan for the class B frequencies. As an aside, it would have been perfectly feasible to operate AM broadcast stations with a separation of only 40 kHz. As a matter of physics and engineering, the judge was wrong. Oak Leaves's transmissions could have been separated from those of WGN. Of course, the cost of receivers might have had to be increased in order to provide the same quality service to the listening audience.[28]

The Zenith decision did not last for long. Broadcasters and consumers were irate over the interference and uncertainty. In 1927, Congress enacted the Radio Act of 1927, creating the Federal Radio Commission and giving it the authority over radio broadcasting that the Department of Commerce had been exercising up until the Zenith decision. The 1927 Act was then folded into the *Communications Act of 1934* and still governs, in large part, the use of radio technology today.

Broadcasting never lived in Eden. Radio broadcasting was born under federal regulation and thrived. Only after the court in Zenith withdrew the regulatory structure did chaos ensue. The Department of Commerce had cleared the broadcast band of the maritime users and had paved the way for broadcasting to grow. One state court decision that reaffirmed the regulatory regime of the old order hardly constitutes compelling evidence that the common law would have been superior to the federal regulatory regime.

---

27 Hazlett, JLE, 151, note 53.

28 In 1926, that probably meant four-stage TRF receivers instead of three-stage TRF receivers! Current FCC rules require a separation of only 40 kHz for stations that are close and taper off the separation in frequency as the separation in space increases. See 47 CFR 73.37.

III. DIFFICULTIES WITH BROADCAST LICENSES AS PROPERTY RIGHTS

In this section I examine factors that make broadcast stations an inefficient unit for defining property rights. I also consider some of the special properties of the AM band that make defining units or defining proper court jurisdiction difficult.

A. Broadcaster's rights are neither exclusive nor exhaustive.

One possible reason that policy makers in the mid 1920s did not choose to apply property rights to broadcast licenses is that broadcast licenses do not provide a useful set of rights for subdivision and recombination. Spectrum rights in the form of broadcast station licenses are neither complete nor exclusive. Below I use a simplified example of broadcast technology to explain this point. In this simplified model, all broadcast transmitters are identical, interference either occurs or does not occur at a specific location, the world is flat, and there are no mountains or valleys. Signals become weaker as the distance from the transmitter increases until they are too weak to provide service.

Figure 1 below shows the nature of the geographical service area and constraints associated with this technology. The transmitter is located at the center of its service region. Around that region is another larger region, labeled the blocked region, in which operation of another transmitter on the same frequency would create interference.

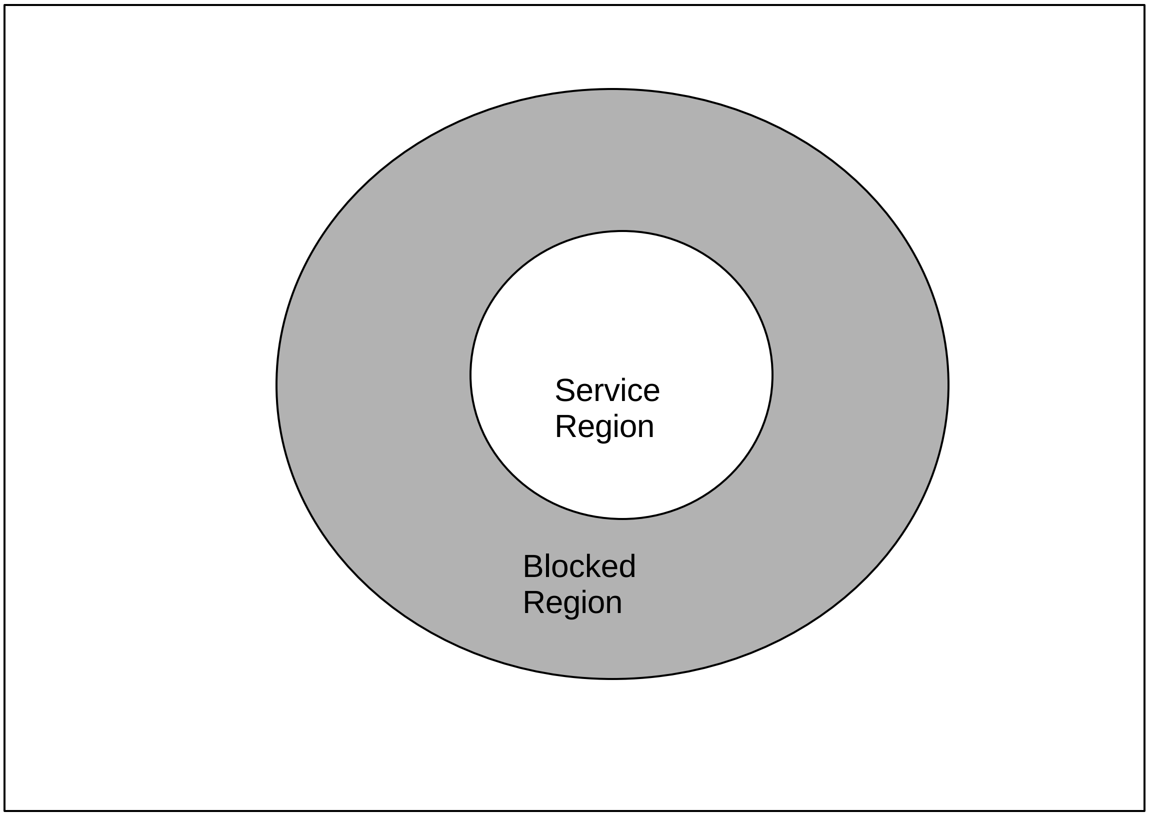


Figure 1 Served and blocked regions from a single transmitter.

So far so good. The broadcaster's property right is the right to exclude others from operating broadcast transmitters in the blocked region. But, what happens when we have two broadcasters? Figure 2 shows that situation. The blocking regions overlap, creating a region in which no one can place a transmitter without violating two sets of rights. To the extent that property is the power to exclude, property rights based upon broadcast licenses must give that power to two persons.

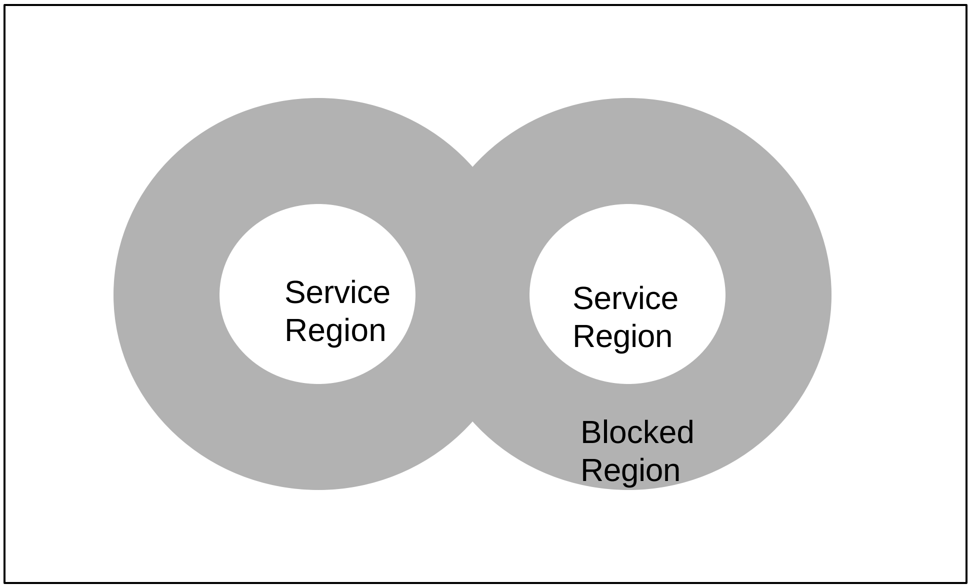


Figure 2 Blocking by two transmitters.

A parallel phenomena occurs in the frequency or bandwidth domain. Broadcast transmitters emit some energy outside their nominal band and practical receivers cannot exclude strong signals that are close to the edge of the band they are tuned to.[29] For this reason we choose not to use adjacent TV channels in the same community. Consider the two-dimensional diagram below showing how a blocked zone or exclusion region exists in distance and bandwidth about a broadcast station (see Figure 3).

[29] These statements were far more true in 1927 than they are today. Nevertheless the principal is sound.

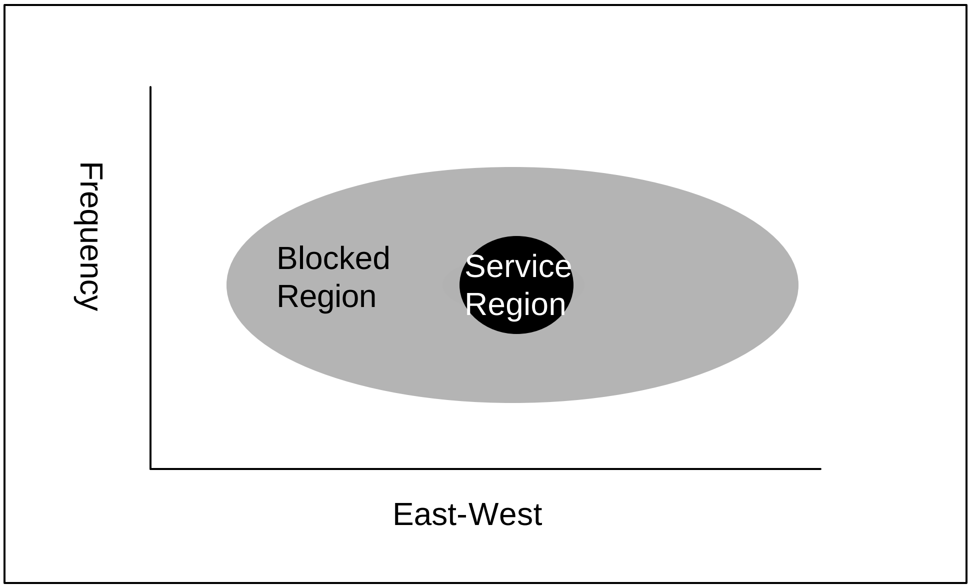


Figure 3 Combined frequency–space blocked or exclusion regions.

Of course, in the real world we must consider two or three spatial dimensions. But, that is harder to draw. As is the case with geographic separation, the frequency exclusion regions associated with two stations can overlap. For example, in Washington DC, TV transmitters operate on channels 7 and 9. Channel 8 is a buffer zone between their operations. It protects each from the other but doesn't really "belong" to either station.

To give a feeling for the magnitude of these effects, consider the FCC's current rules for television broadcasting. The FCC requires co-channel VHF TV stations to be separated by 170 miles and requires adjacent-channel VHF TV stations to be separated by 60 miles.[30] If we multiply the bandwidth blocked by the area covered we can calculate a measure of the spectrum resource blocked by a TV station. For these numbers the blockage is 680,00 MHz Mi^2.. We can compare that number with the spectrum resource inside the service area of the TV station. Assume that a TV station provides acceptable service up to 60 miles from the transmitter.[31] Then it usefully occupies 68,000 MHz Mi^2

[30] See 47 CFR 73.610. The mileage separation is for zone I, elsewhere in the country the rules require greater separation.

[31] I chose this number for illustrative purposes only — it is probably greater than the distance most people regard as the reliable service distance for television. The distance a TV station can serve is a

but blocks service by others over a region roughly ten times as big. Of course these blocked regions are shared by other stations, so the overall efficiency of broadcasting (as measured by the ratio of interference blocked regions to served regions) is much better than the 10:1 ratio in this example. However, it should be clear that the volume or region of the spectrum where multiple broadcasters would have claims of exclusivity against other broadcasters is much greater than the volume or regions where there would be undisputed claims.

The spectrum rights defined by the rights to broadcast at a specific location and have the service delivered by the broadcast protected form interference lead to the creation of wastelands where rights are undefined or where multiple entities have the ability to exclude others.

A key assumption of this model is that all stations offered the same kind of coverage. Although this assumption could be relaxed, it is not an unreasonable model for the mix of broadcast stations that were operating in the mid 1920s.

B. Consumers, not broadcasters make the big investment

A second factor that must be taken into account in defining property rights in the radio broadcast spectrum is the interest of listeners.

In the previously cited quotation, Epstein assumed that the user of the spectrum is the individual or firm that operates a transmitter on a particular frequency. But why should the property rights be assigned to those who operate transmitters? One of Coase's great insights was that efficiency is equally well served, ignoring transactions costs, whether property rights are assigned to the party that creates the externality or to the party harmed or benefited by the externality. Interference is a consequence of the use of receivers. Indeed, at the powers used in broadcasting, the radio waves of one broadcaster rarely interact with those of another — even if they are on the same frequency. Rather, if the receiving systems residential consumers can afford are unable to distinguish between two

---

function of many factors including transmitted power, the height of the transmitting and receiving antennas, and the nature of the antennas and of the receiver, as well as the consumer's standard of acceptable television.

broadcast signals, we say that interference occurs. With sufficient expenditures, we could sort out all those “interfering” signals.

Most radio broadcasting channels are used jointly by those who operate transmitters and those who operate receivers.[32] In many other situations, such as private microwave systems or cellular systems, the transmitters and receivers are controlled by the same entity. Broadcasting presents a different case. One group owns the transmitters, and another group owns the receivers. There is no reason to believe that the preferences of the consumers who own the radio broadcasting receivers perfectly match the preferences of those who operate transmitters. In most circumstances, the investment in broadcast receivers substantially outweighs the investment in transmitting equipment, so one could argue that the listening audience has a stronger claim to a property right than does the operator of a broadcast transmitter.[33] On the other hand, one could argue that it would be more efficient to assign the property rights to the broadcasters — because there are fewer broadcasters and hence the problem of making a market work would be easier. Similarly, it may be easier to identify the date a broadcaster began operating or the technical attributes of a broadcaster’s operations than to identify comparable quantities for receivers. Such transaction cost minimizations may be part of a sound approach to policy — but they are not based on any concept of homesteading or first use.

This separation of the ownership of the transmitters and receivers used in broadcasting together with the lack of any effective mechanism in the 1920s for broadcasters to charge audiences for the programming they delivered complicated the analysis of broadcasting policy. If AM broadcast stations had been auctioned off in 1925, they would have all been located in the big cities and many states and regions would have received no stations. The tenth station in New York City would have been more valuable than the first station in Boise, Idaho. The equal representation of the states in the Senate ruled out the option of such a nationwide auction.

---

32 There are uses that involve only transmitter or only receivers. For example, microwave ovens leak small amounts of microwave radiation and thus act as very low power transmitters. Radio astronomers use sensitive radio receivers to make observations but do not operate transmitters.

33 A simple, current example illustrates this principal. Direct broadcast satellite systems, such as the one operated by DirecTV, cost about $1 billion. Consumer satellite receiving equipment costs about $300 — without considering the cost of the home television set. DirecTV has more than 10 million subscribers, so the investment in subscriber equipment is about $3 billion. It is characteristic of many broadcast systems that the larger investment is in the receiving equipment, not the transmitters.

Consider a simple example of two cities — far enough apart that a radio station can effectively serve one city or the other but not both, but close enough together that a station cannot be assigned to both cities. Assume that city A has a population of 100,000, city B has a population of 40,000, and that city A already has a single radio station but station B has no radio stations. Further assume that consumers strongly value the first radio station in a community but only mildly value the second station in a community. If the new entrant goes into city A, it can reasonably expect to have an audience equivalent to that of a single station in a community of 50,000 — so advertising revenues should be higher than in city B. But, if the new station goes into city B, 40,000 people will gain something they highly value versus 100,000 gaining something they mildly value if the station goes into city A. A property-rights scheme based only upon the interests of advertising-supported broadcasters would assign the new broadcast station to market A even if the most efficient assignment were to city B.[34] In fact, we saw that the Department of Commerce procedures for the distribution of the Class B channels across the country explicitly chose to spread the channels more or less evenly across the country rather than bunching them up on the coasts. Similarly, the FCC's comparative hearing policies give great weight to providing the first service to a community. The Communications Act still contains language requiring the FCC to make a fair, equitable, and efficient distribution of radio service to states and communities.[35]

As an aside, consider that the FCC for a long time licensed additional AM broadcast stations on a first-come, first-served basis.[36] If two or more applications conflicted, that is if the requested facilities would have created interference with one another, the regulators would compare the applications and choose the application that would best serve the public. The policies adopted by the FRC and the FCC for choosing among competing applicants for a broadcast station gave substantial weight to the provision of broadcast service to previously unserved listeners.[37] It is easy to see that such a comparative policy could easily serve efficiency better than would auctions of radio licenses.

---

34 Some adjustments might avoid this outcome. If the existing broadcaster in city A were permitted to buy out the other firm's right to operate in city A, then efficiency would be served. Such a transaction might be hard to distinguish from an anticompetitive agreement harming consumers, and thus might be blocked by competition policy.

35 47 USC 307 (b)

36 And still are so licensed. See 47 CFR 73.24.

37 Cite needed.

When FM and TV came along, the FCC chose to use a tool like Hoover's initial setup of the Class B AM stations, rather than license stations on a first-come, first-served basis. The FCC chose to predetermine the distribution of licenses among cities by designing a table of allotments.[38] Creating a table of allotments avoided the difficult problems that would have been associated with trying to resolve hundreds of interlocking applications for TV stations or in trying to use trial-like comparative hearing procedures to determine the mix of TV stations among Baltimore, Washington, DC, and Richmond. Of course, once a table of allotments has been created, much of the rationale for comparative choice among applicants has been removed.

The FCC even used comparative hearings to choose among applicants for cellular licenses.[39]

C. Markets for Rights Defined by Transmitter Sites Would be Inefficient

Radio interference in the AM band is not like cattle wandering beyond broken fences to browse on grain in fields adjacent to their pasture or noise from a factory disturbing sleepers in nearby apartments.[40] Rather, the decision not to install a transmitter at location B, in order to protect receivers served by a transmitter at location A, may free up the opportunity to operate a transmitter at location C. Consequently, interference among broadcast stations, unlike some other types of external effects of activities, has an interlocking nature. Consider the operation of a TV station on Channel 4 under interference rules similar to those used today in the United States.[41] TV stations operate

---

38 The FM table of allotments is set forth in 47 CFR 73.202; the TV table of allotments is in 47 CFR 73.

39 The use of comparative hearings in cellular in the early 1980s — when demand for the service was as yet unknown and the technology permitted firms to vary their physical plant to match demand, thus eliminating almost all rational basis for comparing applicants — was the final straw that led to the abandonment of the comparative hearing process for many radio applications. Although the FCC formally designated 30 cellular licenses for hearings, only two licenses were actually granted after hearings. The FCC was authorized to use lotteries by Congress in XYZ and most cellular licenses were granted through the lottery process. In 1993, the FCC was given the authority to use auctions to choose among competing applicants for nonbroadcast licenses.

40 Cattle wandering in and trampling corn on the north side of a field will not normally make the owner indifferent to what occurs on the south side of the field.

41 See 47 CFR 73.610 which sets forth minimum milage separations for cochannel and adjacent channel television stations. Minimum cochannel separations range from 155 to 220 miles depending upon the band and the geographical location of the stations.

on Channel 4 in both Boston and New York. Operation of a station in Hartford is precluded by the interference generated by the station in Boston. But blocking the station in Hartford creates the opportunity to operate a station in New York City. Any attempt to define a market for spectrum rights must take into account this interlocking nature of interference. Many economic transactions — including many of those involving externalities — only involve two economic actors at a time. In contrast, a property-rights regime defined around radio broadcast licenses naturally involves many actors in every potential transaction.

The policy implications of the interlocking nature of interference are summarized as follows:

- There is no distributed algorithm for clearing a market in goods with the characteristics associated with broadcast licenses. Rather, if one uses a reasonable model of interference in the AM band, assuring an optimal outcome in the most general case requires simultaneous, centralized consideration of all demands for spectrum.
- The underlying problem faced by the centralized decision maker is complex and difficult to solve (in the jargon of complexity theory, it is NP-complete). The computation time of the best algorithms we know grow exponentially with the number of market participants.

In contrast, for many goods markets can be cleared with distributed processes and the underlying computational problem is simple — the computational burden of finding the optimal assignment of goods to consumers grows linearly with the number of market participants. The term *distributed algorithm* refers to methods of clearing a market that does not depend on simultaneous consideration of the demand of all consumers. As a simple example of a market that can be cleared by a distributed process, consider a good like grain that is divisible into small quantities. Assume that all producers and consumers go to the market on market day and deal in pairs. Further assume, for the sake of simplicity, that when two individuals A and B meet, they quickly and efficiently determine if there is a transaction whereby one can sell grain to the other, given the demand each has for grain. If we assume that people wander around the market randomly encountering others, then in a relatively short while, the market will clear.[42] This is not to say that in all circumstances a market in a commodity such as grain will be efficient. Rather, it is to assert that, under reasonable conditions, some markets can be cleared by distributed processes that only require interactions among pairs of consumers and suppliers.[43]

Although many goods in the economy can be efficiently allocated by such distributed markets, it is easy to construct examples of spectrum use in which no pairwise exchange can lead to an improvement in efficiency. Indeed, it is easy to construct examples in which the simultaneous consideration of all possible spectrum users is needed in order to calculate the optimum assignment of rights. The example below illustrates this.

Consider a simplified world with only one radio channel and six possible places where it can be used. (Think of Channel 4, and the locations as being Boston, Hartford, New York, Philadelphia, Washington, and Richmond). Use of the channel in one location creates interference that prevents its use at adjacent locations. Such interference potential is shown by the arrows in Figures 4-7 below.

Also shown at each location are the values associated with using the channel at that location.

.

[42] An additional assumption also needed is that individual demand functions are reasonable (e.g., continuous with negative first derivatives). And, of course there may be more efficient ways to organize the market. There could be an agreement that everybody interested in trading grain would meet in a specific location. Specialists could emerge who, by acting as brokers would reduce the time buyers and sellers spend searching out and finding efficiency enhancing exchanges. <<Offer quantitative examples from the simulation here. >>

[43] Of course, one might add conditions to this simple grain market that would slow the market or perhaps even prevent the market from clearing. Nevertheless, there is a world of difference between grain — where distributed algorithms can work and where the complexity of calculating the optimal outcome grows linearly with the number of participants — and radio stations where distributed algorithms will not work and the complexity of calculating the optimal outcome grows exponentially.

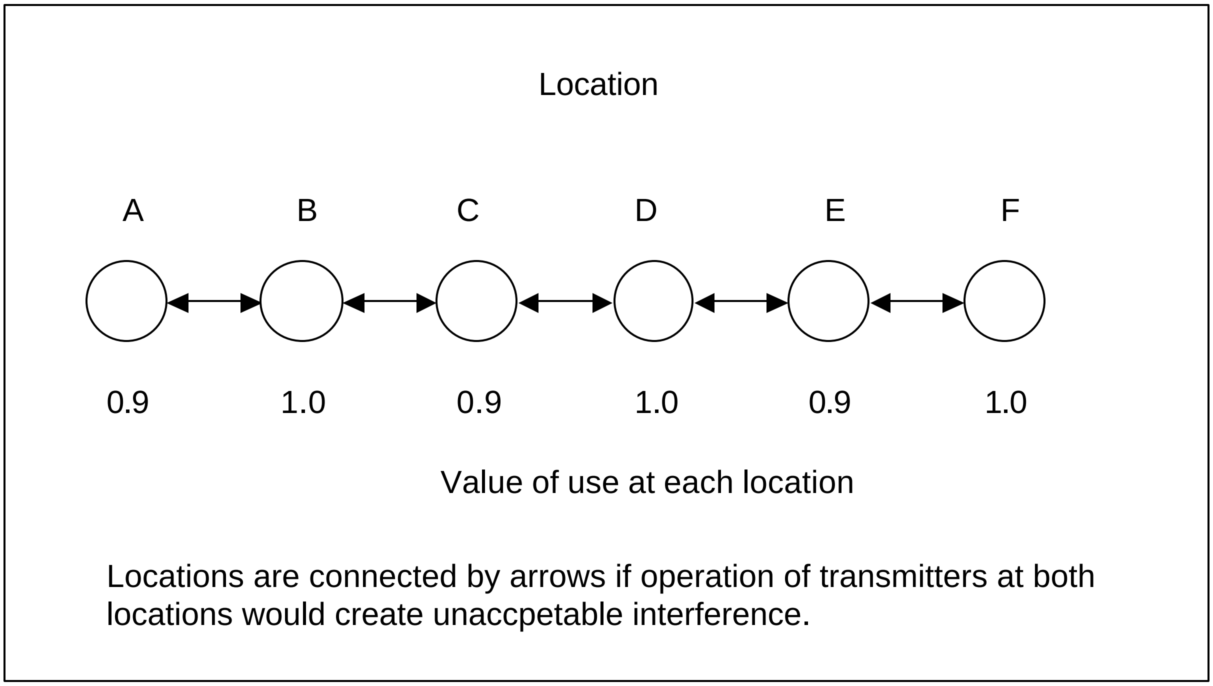
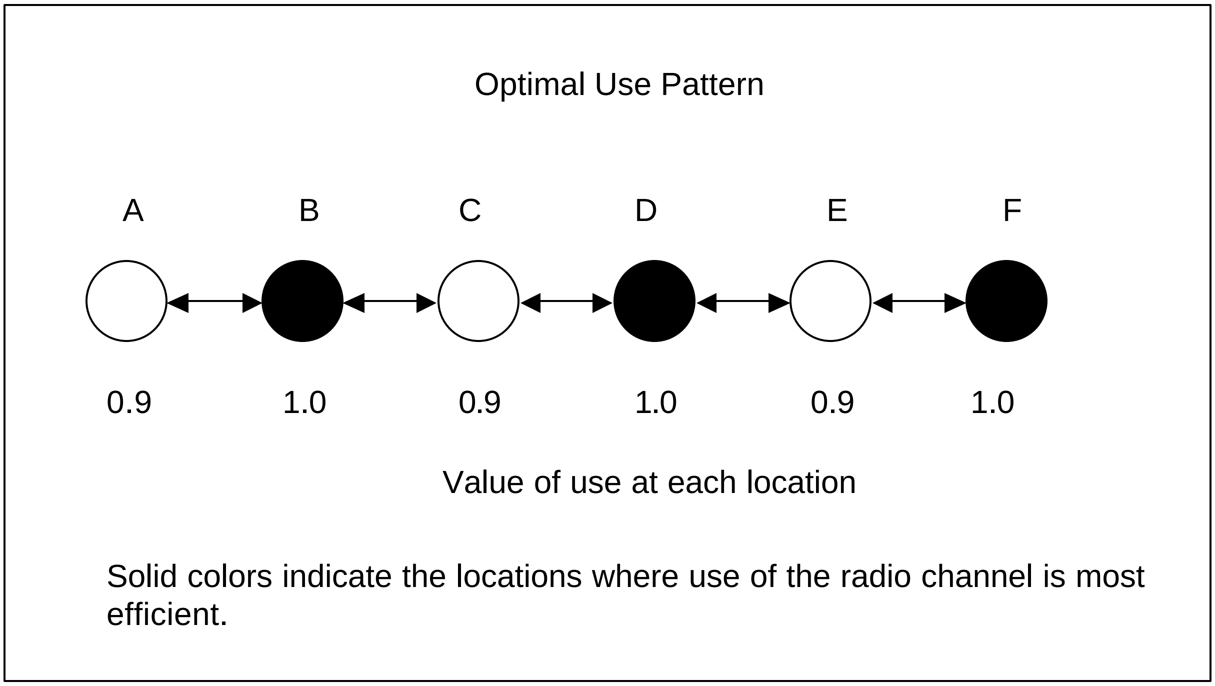
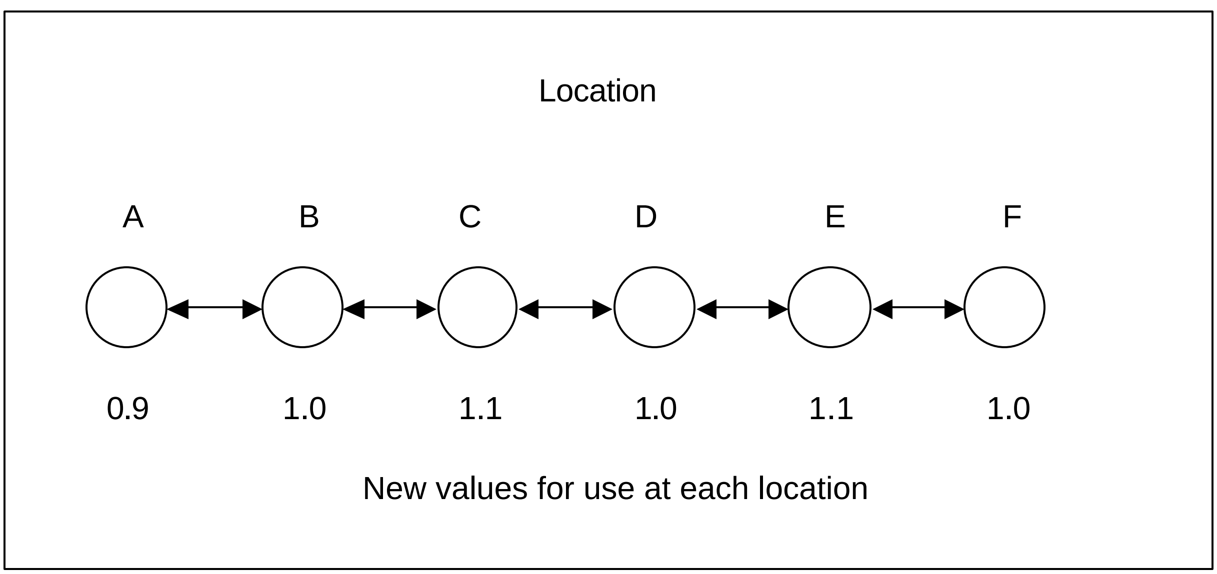


Figure 4 A set of possible transmitter locations.

The optimal use pattern, the one that maximizes the value of the permitted operations, is for operation at locations B, D, and F as shown below.



Consider now the effects of a change in demand. Suppose that the demands for use at locations D and E increases from 0.9 to 1.1 as shown below.



Notice that the user at location E values the spectrum more than does its neighbors at either location D or F. But the user at E cannot buy from the users at D and F the right to transmit because D and F together value their right to transmit at a total of 2.0 units, compared with the 1.1 units E is willing to pay. A coalition of A, C, and E, however, is willing to pay a total of 3.1 units, or 0.1 units more than the previous value-maximizing group of B, D, and F. No single user (A, C, or E) can pay enough to justify replacing those it would interfere with. Similarly, no coalition of only two members (A and C, A and E, or C and E) can afford to buy out those it would interfere with. Only with consideration of the value at all six locations can it be seen that the group of A, C, and E values the right to transmit more than the competing group of B, D, and F.

The key point in this example is that it is impossible to identify the move from one assignment of the rights to transmit (at locations B, D, and F) to the superior configuration (A, C, and E) without considering the demand at each point and all the interference constraints simultaneously. An example requiring consideration of all stations can be generated with system with arbitrarily many broadcast stations.

D. The optimal solution is difficult to calculate

In the general case, even if one does know all the needed values and interference constraints, it is difficult to calculate the optimal solution. The problem of selecting the best set of users of a frequency from a set of potential users at different locations with interference constraints among the potential users is an example of a class of problems known as *covering problems* or *vertex packing problems*. The best algorithms we have developed for finding the optimum solution to these problems are time consuming. It is generally believed that the computer resources needed to calculate the optimum answer for such a problem grows exponentially — for example, adding 10 more locations to the geography to be studied makes the computation run longer by a constant proportion. As an example of this rapid growth, if a spectrum market with 50 stations requires one minute of computation to calculate the optimum assignment of frequencies and a configuration with 60 nodes requires two minutes, then a configuration with 100 nodes would take 32 minutes and a configuration with 200 nodes would take about four weeks to calculate the optimum assignment.

We can compare this computation burden with the computation needed to clear other markets. Returning to the grain example, if one assumes that (1) the value consumers place on grain does not depend upon how much grain is consumed by others and (2) the value consumers place on grain can be described by a reasonably smooth function, then the time required to compute the market clearing assignment of grain to consumers grows at the same rate as the number of people in the market.[44] Thus, if a market with 50 participants requires one minute of computation to find the optimum assignment of grain to consumers, then a market with 200 participants would take four minutes of computation.

In the real world of frequency management, several other considerations intrude. Some of these considerations make the real world more difficult than this model. Radio stations create interference in two (or three) dimensions in space — not just one as in the example. Adjacent-channel interference ties together radio systems on different channels. Radio systems operating at the frequencies used for AM broadcasting create interference not just to the nearest possible location where a channel might be reused but also across the entire country.

Other considerations make the real world more tractable than the model might indicate. Some locations are isolated from others. At the higher frequencies, spectrum use in Salt Lake City is effectively unconnected to spectrum use elsewhere in the country. Although the computation requirements of the best known algorithms for ensuring perfect market clearance grow prohibitively with the number of points considered, there exist algorithms that can provide very good — though not guaranteed perfect — solutions to real-world-size problems relatively quickly.

To recapitulate, using a reasonable model of broadcast interference it is impossible to identify the optimal assignment of right to operate transmitters at specific locations to potential users without simultaneously considering the demand of all potential users for access to the radio band and all patterns of interference. Even then, finding the optimal solution is a difficult computational problem.

I do not claim that anyone would have articulated the problem this way in 1926 or 1927. But, smart people concerned with broadcasting would appreciate this problem even if they couldn't articulate it in modern terms.

[44] Example here maybe?

E. AM broadcasting creates difficult externalities.

Both the AM band and AM broadcasting technology create difficult externality problems that are not seen to the same degree in most other areas of spectrum use. Below I consider first the problems of the AM band; then I consider problems of AM technology.

1. The range of AM broadcast signals

Radio waves in the bands used up to and during the mid-1920s traveled great distances and could provide useful services well beyond the authority of any court. Proper consideration of radio-interference issues in the AM band necessitated international coordination. The AM stations of the 1920s could provide reasonably reliable nighttime service over most of the country if they did not share the channel with another station. A transmitter in Georgia could interfere with reception in Ohio of a transmission from Pennsylvania.

In a 1924 paper, Little described the broadcast facilities and operations of KDKA, which was then operating on 920 kHz at 1,000 watts power. He concluded

> It is believed that KDKA, as described above, is at the present time second to no broadcasting station in the world. In point of area covered, as shown by letters and telegrams received, KDKA is regularly heard at night in all parts of the United States, in England, France and Belgium. Several letters have also been received from South America and the Hawaiian Islands. The daylight range covers that part of the United States east of the Mississippi River.[45]

Similarly, experiments in 1924 showed that a relatively low-power radio (200 watts) operating in the short-wave region of the spectrum (3–30 MHz) could transmit from

---

[45] D. G. Little, "KDKA: The Radio Telephone Broadcastng Station of the Westinghouse Electric and Manufacturing Company at East Pittsburgh, Pennsylvania," *Proceedings of the IRE*, 12 no. 3 (1924): 255-276, reprinted in *Proceedings of the IEEE* 86, no. 6, (1998)): 1279-1287. Little's claims are consistent with what one would expect would have occurred in the early days of radio when there was little or no cochannel interference and few electrical appliances generating interference.

England to Japan.[46] One must ask, could a judge protect KDKA's signal in England or Belgium?

Suppose a broadcaster in France began transmitting on 920 kHz and created interference to the reception of KDKA's signal in Belgium. What would be the appropriate forum for KDKA to seek a judicial remedy? Maybe KDKA would not care about the service to Belgium, but the transmissions from France would also degrade KDKA's service in North Carolina. Of course, transmissions from southern Canada posed more of a problem to KDKA's services than did transmissions from France.

International coordination of the use of the AM band was needed to maximize the benefits derived from the radio broadcasting in the AM band. Similarly, coordination was needed inside the United States as well. As stated in the quotation above, KDKA's signal could serve most of the country. Suppose a second broadcaster had gone on the air on 920 kHz with a transmitter in Atlanta. KDKA's service in the Pittsburgh area would not have been harmed, but its service outside the greater Pittsburgh area would have been harmed.[47] A sequence of state court decisions leading to an efficient outcome is conceivable but highly unlikely.

2. The susceptibility of AM signals

AM is the acronym for amplitude modulation — a technique for transmitting information over a radio wave by varying (or modulating) the intensity of the radio wave. AM transmitters and receivers are relatively easy to build. Unfortunately, the human ear is quite sensitive to noise and static and AM is poor at rejecting interfering signals.[48] Consequently, AM signals require substantial protection from interference. If the transmission frequency of an cochannel interfering AM transmitter is not tightly controlled (at least by the standards of the mid-1920s), then the interference created by the undesired station will be much worse than would otherwise be the case. A low-power transmitter providing service to one town and operating at night on the same channel as

46 Guglielmo Marconi, "Radio Communications," *Proceedings of the IRE* 16, pp. 40-69, 1928. The test system transmitted from Chelmsford, England to Japan using omnidirectional antennas.

47 Actually, this statement is debatable. A transmitter in Atlanta would have measurably degraded the signal delivered to the audience in the Pittsburgh area by KDKA. Whether or not such effects would rise to the level of harm is a more difficult question.

48 The current FCC rules prohibit licensing a transmitter that would put a signal of 1/400 the power of the desired signal at the boundary of another AM stations service area. See 47 CFR 73.37. That rule however, is based upon the assumption that the frequencies of the two stations are well controlled.

one of the Class B stations of the 1920s could have wiped out nighttime reception of the Class B station over several states.

FM and digital modulation methods are more robust. They exhibit a phenomenon known as *capture*, where the receiver is able to decode (or capture) the desired signal if it is sufficiently stronger than the undesired signal. If radio systems exhibited perfect capture, then the blocked region in Figure 1 would shrink to nothingness — the service area and the area prohibited to others would be coincident. Property rights based upon transmitter locations and powers would become much more feasible.

IV. CONTRAST WITH CELLULAR AND PCS

The spectrum bands used for wireless telephone service (50 MHz in two 25 MHz licenses at 800 MHz and 120 MHz in six licenses in the range 1850–1990 MHz) have vastly different technical characteristics than does the AM band. Most important, radio waves in these bands usually travel along line-of-sight paths and do not go beyond the radio horizon. Typically signals in these bands create harmful interference over a range of about 5 to 15 miles.[49] Wireless telephone systems offer service over regions many tens of miles across. For example, the FCC divided the United States into 51 geographic regions for the PCS A- and B-band license auctions and issued a single license for service in each region.[50] Roughly speaking, each such license covered 60,000 square miles — corresponding to the area of a square about 250 miles on a side. If interference from neighboring systems reached in ten miles from the boundary of such a square region, only 15% of the geographic service area of a PCS license would potentially be subject to interference from PCS operators in neighboring regions. Interference problems on the region's western border would be decoupled from interference problems on the eastern border. In PCS interference externalities affect only direct neighbors and are fundamentally limited.[51]

[49] The interference range is much greater if the cellular telephone is on a mountaintop or in an airplane

[50] In many cases, firms have obtained licenses a mobile telephone band in geographically contiguous regions, thereby further internalizing interference effects.

[51] This assumes that mobile telephone operators stay within the broad technical limitations set by the FCC. For example, if a cellular operator were to start operating a television station in the cellular band, it would create interference far into the adjacent region.

In addition, cellular operators either own the transmitters and receivers operating in their band or have a contractual agreement with the consumers who operate such equipment. In cellular, there is a direct transaction between consumers and service providers that offers the potential to eliminate any market failure created by differences between the preferences of the cellular system operators and their customers.

The spectrum for mobile telephony stretches across 170 MHz. In contrast, AM broadcasting uses slightly more than 1 MHz. A PCS license 30 MHz wide and covering 1/50 of the nation's land area contains about half as much spectrum resource (measured in MHz-square miles) as does the entire AM broadcast band.

The combination of all these factors — limited signal range, systems operating over large blocks of bandwidth and over large geographic regions, and control of both transmitters and receivers by the system operator — distinguish the cellular environment from the AM broadcast environment.

The regulators and the industry treated these two services quite differently. Radio broadcasting was always licensed one transmitter at a time. Cellular was licensed over large geographic regions. Broadcasters were given specific frequencies and powers, and the tolerances on their systems were tightened up over time. Cellular operators were given great flexibility at the beginning, and their flexibility was expanded over time. The FCC has defined certain rights to operate radio systems in the cellular bands and allows the licensees to work out the details of coordination along their borders. The FCC has given licensees great technical flexibility in these bands — rather than locking them in to a specific technology. Many of the constraints that are imposed serve to set the basis for bargaining between adjacent users.[52]

It is not unreasonable to expect that a property-rights regime under the common law would have worked quite efficiently with mobile telephone technology. Interestingly enough, the FCC has created essentially such a regime in these bands.

---

[52] Many of the FCC's rules are clearly aimed at limiting or controlling interference (e.g., 22.957 requiring cellular transmitters within 45 miles of the Mexican and Canadian borders to be coordinated with use of the cellular frequencies in Mexico or Canada). The FCC's rules also contain other constraints. For example, §24.3 of the Rules prohibits PCS operators from offering broadcast services. This rule is obviously not based upon concerns about controlling interference.

V. PARALLEL DISCOVERY OF THE BENEFITS OF PROPERTY RIGHTS

The regulators, both the FCC over its 64-year history and the Department of Commerce before that, have put in place rules and procedures that have implicitly created forms of property rights in the radio spectrum. For example, broadcast licenses are almost always renewed. Radio licenses are routinely transferred from one firm to another.[53] The process of frequency coordination in the microwave bands does create a form of first-come, first-served claim staking to establish rights. However, this is homesteading with rules. The FCC has minimum performance requirements for the system installed. The rights that can be claimed are determined by predetermined procedures.

The FCC explicitly recognized a form of incumbent property rights when it reallocated 120 MHz of spectrum from microwave systems to PCS. In that reallocation, it required the PCS operator to protect the incumbent microwave system for a period of time or to obtain the agreement of the microwave operator to transmit signals that might interfere with the microwave system. In many cases the PCS operator paid the microwave incumbent enough for the incumbent to replace the microwave system with one operating in a different band or with a fiber-optic system. A careful examination of the FCC's practices would probably reveal many more instances of such bureaucratic creation of quasi property rights.

VI. CONCLUSIONS

There is an old saw that hard cases make bad law. Our system of radio licensing developed under difficult conditions to say the least. The technology available during the first three decades of the twentieth century suffered from interference at enormous ranges and could exploit only a tiny portion of the radio spectrum that can now be used. The first use of radio was for military purposes and for safety of life at sea — applications in which sensitivity to First Amendment values or concerns about the inappropriate level of government involvement were not paramount. In the period of first use, interference was

53 But, the FCC can and does intervene in such transfers when it sees the need to do so. <<Give example from primestar merger and AT&T/TCI deal.>>

a problem and scarcity was not.[54] We created our first spectrum regulatory institutions to deal with problems fundamentally different from the problems we face today in spectrum management.

Broadcasting in the AM band created interference far beyond the local service area. Broadcasting policy was also afflicted with the policy problems created by disparate ownership of the transmitters and receivers and the public goods nature of broadcast transmissions. The interlocking nature of interference in AM broadcasting made market transactions fully reflecting interference externalities unlikely to occur if they were based upon property units defined by the right to operate a transmitter at a specific location and to have the service of that transmitter protected from interference.

In the environment and with the institutional history that existed at the time of the enactment of the 1927 act, the 1927 Act appears quite reasonable.

Coase came to the study of the FCC in <<date>>. This was shortly after the FCC had licensed a large number of television broadcast stations using its comparative procedures. The creation of the television table of allotments had solved the major public goods issue associated with television licensing. The FCC therefore had to choose among the applicants for television licenses on other grounds. This process, not unexpectedly, drifted away from efficiency concerns associated with resource management.[55]

A fundamental question is whether legislative bodies, such as Congress, the Federal Radio Commission, or international conferences, would have made a more efficient initial definition of the rights in the broadcast radio spectrum than would a first-come first-served regime, supported by common law property rights enforced by the judiciary. The Chicago view appears to be that the common-law approach would be more efficient. That view may be correct, though I doubt it, but a stronger basis must be established for that proposition than citing a single case in a state court.

---

[54] To use computer science jargon, one problem in 1912 was one of address space management. There were plenty of frequencies to go around, but it was important to make sure that two transmitters did not try to use the same frequency at the same time. As an analogy, banks have no shortage of numbers to assign to accounts. However, real problems would be created if a bank assigned the same account number to two different customers.

[55] For a sometimes dismaying and sometimes amusing account of the comparative hearings see Kranttenmaker and Powe, op. cit., p. xyz.

We should not judge the 1927 Act on the basis of today's technology, our modern experience with electronic media and today's attitudes toward First Amendment values and the proper role of government regulation. Rather, we should judge that legislation on the basis of the choices and information available to the actors in the mid-1920s. On that basis, they did well.

The answer to the question posed in the title to this [chapter, essay] is that in 1927 a reasonable person, interested in serving efficiency, could have rejected a common-law, first-come first-served property rights approach to broadcaster operations in the AM band for the scheme of the 1927 act.

Epstein also wrote

> The allocation of the spectrum prior to the Federal Radio Act of 1927 took place by individual occupation of frequencies — a modern adaption of the first possession rule. But title by occupancy could not be imitated in today's assignment of the spectrum recently auctioned off for personal communications services. Every PCS band could have been occupied in a twinkling by any single provider. Given the changes in technology, only a state-run auction of well-defined spectrum could create useful property rights blessed with clear boundaries (both by frequency and by territory) and free transferability. The pace of modern life makes first possession far less valuable for newly allocated assets than in formative historical times.
>
> (Epstein, op. cit., footnote omitted)

The history recounted above shows that Epstein was wrong. Originally, all broadcasters shared the same channel. Later, broadcasters were assigned specific channels in an organized plan designed by the Department of Commerce. Radio channels were made available for broadcasting by pushing the earlier users out of the AM band.

Epstein was right in viewing the approach taken in PCS as sound. The flaw in his analysis arises from the fact that the efficient rights packages for PCS were much more like traditional real estate than were the efficient packages for AM broadcasting. The type of boundaries that are appropriate for broadcast stations are quite different from those that are appropriate for PCS. PCS was a far easier case than broadcasting and it produced a simpler solution.