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OVERCOMING AGORAPHOBIA: BUILDING THE COMMONS OF THE DIGITALLY NETWORKED ENVIRONMENT

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I. INTRODUCTION

We are in the process today of making a fundamental choice about how we will communicate with each other in the next century. We are making this choice without debating it. In fact, we are talking about the wrong thing, at the wrong time, and making this choice (which may be right) for the wrong reasons or for no reason at all. The decision to be made is deceptively "technical": how to regulate that part of the digitally networked environment that utilizes wireless or radio-communications technology. The current legal framework for radio transmission relies on administrative licensing of broadcasters. The emerging regulatory alternative replaces licensing with an exhaustive system of property rights in the radio frequency spectrum. This article analyzes a third alternative: regulating wireless transmissions as a public commons, as we today regulate our highway system and our computer networks. The choice we make among these alternatives will determine the path of development of our wireless communications infrastructure. Its social, political, and cultural implications are likely to be profound.

Most contemporary debates about how to regulate communications using the radio frequency spectrum revolve around whether to regulate through administrative licensing or by auctioning property rights "in the spectrum." For a long time, that was the right question to argue about. But it is no longer so. Technological developments in digital information processing and wireless communications have made possible an alternative regulatory approach. It is now possible to regulate wireless communications as we do the Internet — with minimal standard protocols — or the highway system — with limited governmentally-imposed rules of the road. A Federal Communications Commission ("FCC") order that became effective in April 1997 has indicated how this regulatory framework might look. But it also suggests how our present commitments to centralized control of wireless communications by licensees or owners of radio frequency bands could stunt the development of the communicative equivalent of "the open road" in the digitally networked environment.

Our capacity to think about the truly central questions concerning regulation of wireless communications is obscured by the language we use to discuss the problem. When we speak of regulating wireless communications, we speak of managing "a resource," namely, "the spectrum." Generally, we use market-based solutions for resource management, and therefore when posed with such a problem look for some*thing* to which we can affix property rights to be traded in the market. But there is no such "thing" as "spectrum." There is no ether out there, no finite physical "resource" that needs to be allocated. There are simply people communicating with each other, transmitting and receiving messages with equipment that uses electromagnetic waves to encode meaningful communications and send them over varying distances without using a wire. "Spectrum management" means regulating how these people use their equipment. "Spectrum allocation," whether it be done by licensing or auctioning, is the practice whereby government solves this coordination problem by prohibiting most people in society from operating radio transmitters, and threatening that it will tear down their antennas and confiscate their transmitters if they try to communicate with each other using wireless communications equipment without permission. This is done so that other people — broadcast licensees or spectrum "owners" — can successfully communicate.

The rhetorical effects of treating spectrum as "a resource" obscure the more important choice to be made with respect to radio communications: whether to regulate them by centralizing control of wireless communications or, alternatively, by establishing a means of allowing users to coordinate their wireless transmissions multilaterally. Once we understand that the question is how to regulate the use of *equipment*, rather than "a resource," we will be able to recognize that we have alternative regulatory models in our society. In the case of automobiles or networked computers, which involve similar coordination problems, our social choice has not been to give a small number of users an exclusive license or property right to control an input essential to effective use of the equipment. Instead, in the case of automobiles, we have chosen to allow anyone to buy and use the equipment, subject to certain "rules of the road" that allow equipment users to coordinate their use and avoid interference. In the case of networked computers, we have relied primarily on a public domain standard, TCP/IP, supplemented by industry and professional standard-setting procedures, and on competition in the equipment and service markets that rely on access to this standard.

Using traditional broadcast technology, it was simplest to coordinate transmission by defining discrete narrow channels and giving one person the right to transmit over that channel to the exclusion of all others. In that technological context, the primary critique of the institutional organization of broadcast was that rights to dominion over a channel were assigned by licensing instead of through a private property regime.[1] In recent years, this critique has gained significant support, and privatization of spectrum-use rights, initially allocated through auction,

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1. *See, e.g.*, Ronald Coase, *The Federal Communications Commission*, 2 J.L. & Econ. 1 (1959).

is becoming the new orthodoxy concerning how best to regulate radio communications.[2]

Privatization was the most important alternative to licensing in the 65 years following passage of the Radio Act of 1927. However, the case for privatization is no longer as clear.[3] Contemporary wireless communications technologies, developed primarily for mobile communications, show that sharing of broad swaths of frequencies by many users may be a better model for wireless communications than control by one party of a narrow frequency band. This new reality removes the technological imperatives and assumptions underlying both licensing and privatization. The licensing/privatization dichotomy no longer marks the most important institutional choice to be made. It is merely a sub-debate within a broader conceptual choice.

The central institutional choice regarding wireless communications is whether to rely on centralized control by identifiable organizations, or on multilateral coordination among numerous users. On the one hand, it is possible to treat spectrum as a resource whose use must be centrally determined by an entity with the power to decide how wireless communications equipment will be used in a given spectrum unit. That entity can either be "the owner" of the defined spectrum unit, if privatization is chosen, or the licensee operating within parameters set by the regulator, if licensing continues to be the rule. On the other hand, it is now technically feasible to rely on standards and protocols that enable multilateral coordination of transmissions among equipment owners, without identifying any person whose choices trump those of all other potential users. The central question then, is no longer *how to allocate spectrum channels* — how to decide who makes unilateral decisions about who may communicate using a frequency band and for what types of communications — but *whether to coordinate by defining channel allocations*. While the answer may be that we should permit a commons to develop alongside proprietary allocations, we will fail to

2. *See* 142 CONG. REC. S4928-36 (daily ed. May 9, 1996) (statement of Sen. Pressler, introducing discussion draft of the Electromagnetic Spectrum Management Policy Reform and Privatization Act); Gregory L. Rosston & Jeffrey S. Steinberg, *Using Market-Based Spectrum Policy to Promote the Public Interest*, 50 FED. COMM. L.J. 87 (1997).

3. Already in 1984, Ithiel de Sola Pool observed, "[I]ronically, now that Congress, the FCC, and the industry are gingerly edging toward payments for frequency assignments, some of the conditions that have been premises for some such scheme are changing." ITHIEL DE SOLA POOL, TECHNOLOGIES OF FREEDOM 147 (1984). De Sola Pool then continued to discuss the possible effects of spectrum sharing, or multiplexing, on the assumptions underlying the rationale of privatization. *See id.*

permit that development if we continue to misperceive the choice at hand as one between licensing and exhaustive privatization.

The choice is very real and very immediate. The Heritage Foundation[4] and the Progress and Freedom Foundation[5] are advocating exhaustive privatization of the right to control wireless communications capabilities. In the last Congress, then-Senator Pressler introduced a draft bill seeking exhaustive auctioning of perpetual property rights in spectrum.[6] More recently, extensive privatization has been advocated within the FCC.[7] Exhaustive privatization, as its name indicates, would privatize the entire usable spectrum, thereby effectively eliminating the possibility that a spectrum commons will develop.

The alternative is also at hand. Prompted by Apple Computer and WINForum (an industry group), and supported by such radical institutions as Microsoft, Compaq, Motorola, AT&T (in part), and the Consumer Electronics Manufacturer's Association, as well as the American Educational Research Association and the American Library Association, the FCC issued an order in 1997 providing for the operation of "Unlicensed National Information Infrastructure" devices (the "U-NII Order").[8] The Order permits devices meeting certain specifications to operate without a license in a 300 MHz range (as compared to the allocation of between 270 and 300 MHz for all High Definition TV licenses)[9] in the 5 GHz band.[10] This represents a significant frequency allocation. These devices will not be legally protected from interference, will share the spectrum with licensed devices, and will be required to operate so as not to interfere with these licensed devices.[11] Even under these constraints, equipment manufacturers got what they lobbied for:

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4. *See* Adam D. Thierer & Alex C. Walker, *A Policy Maker's Guide To Deregulating Telecommunications Part 6: A Free-Market Future For Spectrum*, TALKING POINTS (Heritage Found.,Washington, D.C.), Mar. 19, 1996, *available at* <http://www.atr.org/heritage/library/categories/regulation/tp11.html>.

5. FCC Working Group, Progress & Freedom Found., *Broadcast Spectrum: Putting Principles First* (Jan. 31, 1996) <http://www.pff.org/pff/pop-19.html>.

6. Pressler Spectrum Bill Discussion Draft, *supra* note 2.

7. *See* Rosston & Steinberg, *supra* note 2.

8. Amendment of the Commission's Rules to Provide for Operation of Unlicensed NII Devices in the 5 GHz Frequency Range, 12 F.C.C.R. 1576 (1997) (Report & Order) (amending 47 C.F.R. pts. 1, 2, & 15) [hereinafter U-NII Order], *available at* <http://www.fcc.gov/Bureaus/Engineering_Technology/Orders/1997/fcc97005.txt> (text); <http://www.fcc.gov/Bureaus/Engineering_Technology/Orders/1997/fcc97005.wp> (WordPerfect).

9. *See* Advanced Television Systems and Their Impact upon the Existing Television Broadcast Service, 12 F.C.C.R. 14588 (1997) (Sixth Report & Order).

10. *See* U-NII Order, *supra* note 8, at para. 27.

11. *See id.* paras. 72-97.

permission to manufacture and sell equipment that will allow users to set up high-speed, broadband data networks for local and wide area networks. These networks could potentially supplant some of the services currently offered by local telephone companies, cable companies, and cellular/PCS[12] providers.

Within the resource management metaphor, this swath of spectrum, called the Unlicensed-National Information Infrastructure band ("U-NII band"), would be considered a commons. Indeed, in the Notice of Proposed Rulemaking,[13] the FCC raised the concern that the U-NII proposal would suffer from "tragedy of the commons" effects.[14] But one of the most important implications of the U-NII Order is that it opens the possibility of stepping outside the "resource management" box as a way of thinking about radio communications regulation. The U-NII Order does not "reserve" spectrum for unlicensed use. It gives users of U-NII devices no "rights." It simply removes the prohibition to transmit that underlies the present system. It is this prohibition that necessitates an FCC license, or permission from a licensee, before one can transmit. Within this alternative institutional framework, anyone who possesses equipment capable of transmitting at the frequencies for which no license is required will be able to send anything to anyone else without obtaining a license from the FCC, without purchasing spectrum rights, and without paying use fees or deferring to the unilateral transmission control choices of anyone else.[15] The U-NII band opens a legal space for multilateral coordination of communications to develop as a mechanism for avoiding interference. It also raises the possibility that unlicensed wireless devices will provide a component of the information infrastructure that is not owned by anyone. No other communications facility currently offers that promise.

Other small allocations that were provided by the FCC for unlicensed use a few years ago[16] have already been exploited and tested as the basis for both wireless Internet access and mobile communications services, providing potential sources of insight into the workability of a

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12. "PCS" stands for "Personal Communications Services," and loosely identifies a broad range of digital personal communications services that are the current state of the art in, primarily, mobile telephony and data communications.

13. Amendment of the Commission's Rules to Provide for Unlicensed NII/SUPERNet Operations in the 5 GHz Frequency Range, 11 F.C.C.R. 7205 (1996) (Notice of Proposed Rulemaking) [hereinafter NPRM].

14. *See id.* para. 53.

15. *See* U-NII Order, *supra* note 8, at 1621-24 (to be codified at 47 C.F.R. §§ 15.401-15.407).

16. *See* 47 C.F.R. §§ 15.215-15.255 (low power unlicensed devices); 47 C.F.R. §§ 15.301-15.323 (unlicensed PCS) (1996).

variety of organizational models that could replace the prevalent centralized model.[17] These models suggest that allowing extensive deployment of unlicensed wireless devices could provide an infrastructure of first and last resort for digitally networked communications. In a communicative environment increasingly dominated by digital communications applications, such an infrastructure would serve the same role in our communicative environment as streets, sidewalks, highways, and parks play in our physical environment.

There is, however, an ecological conflict between an approach based on centralization through licensing or privatization, on the one hand, and an approach based on coordinated unlicensed use, on the other hand. Most centralized solutions operate on the assumption that interference may only be suppressed by allowing one person to transmit very "loudly" over a given channel. This strategy for avoiding interference makes use of that channel by anyone else difficult. A review of the U-NII Order provides ample insight into this conflict. Many of the constraints placed by the Order on the operation of U-NII devices derive not from the need to protect these devices from each other, but from the need to protect incumbent licensed operations using the same, or adjacent, frequency bands. If too much of the radio frequency spectrum is placed off limits for unlicensed devices that can operate in a multilaterally coordinated environment, or if too many constraints are placed on the operation of unlicensed devices to prevent them from interfering with licensed devices, then the regulatory choice to "allocate" spectrum to other uses shall have choked off development of this alternative. Once investments have been made in technology that relies on exclusive control of frequency bands, as opposed to sharing of those bands, and once companies have purchased control rights at auctions and created organizational structures to exploit these rights, we will be unable to revisit this regulatory choice.

The first four parts of this article lay the foundation for analyzing the choice between licensing/privatization and unlicensed operations. Part II describes a business history of the radio industry that suggests that our conceptualization of radio regulation is the contingent product of the 1920s. The state of technology and the actions of business and government actors during this period focused on the market in crude radio receivers as the only way to make money from radio. To serve this market, they created the system of transmission rights that has dominated thinking about radio regulation ever since. Part III outlines the

17. *See infra* Part IV.B, which describes these business models.

intellectual critique of licensing offered by economists over the past forty five years and the recent increasing acceptance of that critique as a basis for policy. Part IV explains the technological obsolescence of the licensing/privatization dichotomy and analyzes how both licensing and privatization rely on the outdated assumption that to achieve an acceptable signal-to-noise ratio, one entity must be permitted to transmit at a high power over a narrow frequency band, while interference and noise are reduced by prohibiting the emissions of others in the same frequency/space/time dimension. It then describes three current organizational approaches to creating communications networks based on unlicensed devices operating in the relatively limited frequency bands in which the FCC has permitted unlicensed operation. Part V describes the U-NII Order and how it opens up the possibility of multilateral coordination among unlicensed devices. The order is also a prime example, however, of how regulatory solicitude to the needs of incumbent licensees can constrain the development of unlicensed operations. In effect, the U-NII Order opens up the possibility that alongside telephone local loop, cable, and owned wireless local loop, there will develop a local infrastructure capable of carrying high bandwidth transmissions in an Internet-like model that will rely solely on unowned infrastructure.

Parts VI, VII, and VIII analyze the choice between licensed and unlicensed use. Part VI suggests some parameters for a microeconomic analysis of the regulatory choice. It suggests that under an unlicensed spectrum regime, the equipment market will provide the benefits sought of the spectrum market by advocates of spectrum privatization. Part VI concludes that it is at least indeterminate whether an equipment market based on unlicensed spectrum or a spectrum market based on privatization will be a more efficient means of assuring development and deployment of wireless communications technology. It offers some indications that a market in equipment for individual use — like the personal computer or automobile markets — will be better than a market in infrastructure.

Part VII offers an institutional economic analysis of the choice between unlicensed operations and spectrum licensing/privatization. It suggests that our choice between a private spectrum based system and an unlicensed/commons system is likely to affect the information that flows over the infrastructure deployed in each institutional framework. This occurs primarily because in a system based on unowned infrastructure, end-users have strong incentives to invest in developing and articulating first-best preferences as to what should be communicated, whereas in an owned infrastructure system, they seek to shift those costs to infrastructure owners and to invest only in choosing from a menu of choices determined by the owners. Part VII also suggests that under certain conditions the information flow patterns implied by a distributed model of communications may provide a better basis for economic productivity. The analysis concludes with an explanation of why, despite its potential advantages, a distributed model may not emerge through market-based allocation, due to the resistance of incumbent institutional frameworks to change.

If it is at least indeterminate whether a distributed or centralized model will be more efficient in micro-economic terms, and if the institutional economic analysis suggests that the regulatory choice will affect the patterns of distribution of control over information and knowledge production in society, how are we to think of the choice in terms of our social and political values? Part VIII suggests that for a society concerned with individual autonomy and robust public debate, an institutional choice that affects the social distribution of power to control what a choosing individual knows of the world, how perceptions of the choice set open to each individual are produced, and whether and how an individual can communicate with others has significant social-political implications. Understood in these terms, there are good reasons in terms of democratic values to support the development of a significant component of our information infrastructure that is free of centralized control by any body, governmental or commercial.

Part IX recapitulates the analysis and identifies three specific institutional measures that should be taken in light of the discussion. It suggests that at the very least there is an important role to be played by permitting a significant portion of the broadcast spectrum to be used in a commons-like model, and that such a commons will not develop if we adopt the program of exhaustive auctioning of spectrum use rights. The purpose of the measures proposed in Part IX is to reserve judgment about the institutional framework for wireless communications until after a market in unlicensed devices has had an opportunity to develop. They are intended to negate the potential institutional and technological lock-in effects of the present auctioning policy and the parsimonious introduction of unlicensed operations. The conclusion suggests (a) that the FCC revisit its decision concerning unlicensed operations, and analyze the constraints placed on unlicensed devices solely in terms of the potential interference among devices operating in an unlicensed environment, so as to avoid warping the development of the capabilities of unlicensed operations around the needs of incumbent licensees using the same frequencies; (b) that the FCC constrain its auctioning policy, rather than expand it towards exhaustive privatization, to the extent necessary to reflect the possible opportunity costs involved in devoting spectrum to privatized use that might better be employed to expand the commons; and (c) that licenses auctioned include explicit provisos tempering renewal expectations.

II. THE CREATION OF ADMINISTRATIVE CONTROL OVER WIRELESS COMMUNICATIONS: THREE BRIEF HISTORIES OF RADIO REGULATION

A. Three Histories

The core elements of the present radio regulation system were formally set forth in the Radio Act of 1927,[18] and have not changed since.[19] A large segment of the available spectrum is reserved for government use. Other parts of the spectrum are regulated by a federal commission. This Commission regulates radio communications by (a) dividing the spectrum into distinct channels, each defined over a range of frequencies; (b) assigning specific communications uses to stated sets of channels; (c) determining which private party will control transmissions over each channel; and (d) determining at what power that party can radiate on that channel for the use defined by the commission.

One might, in gross terms, identify three types of histories of the development of this system. The first is the "official" history.[20] It focuses on the period from July 1926 to February 1927, called "the breakdown of the law,"[21] as proof that the market cannot work, and that broadcast by its nature requires administrative control. Following two decisions that held he had no power to refuse a license[22] or to impose restrictions as to frequency, power, and hours of operation of a licensee,[23] Secretary of Commerce Herbert Hoover declared that he

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18. Ch. 169, 44 Stat. 1064.

19. The Communications Act of 1934, ch. 652, 48 Stat. 1064, which consolidated control over telephony and radio in the FCC, replacing the Federal Radio Commission, and the Telecommunications Act of 1996, Pub. L. No. 104-104, 110 Stat. 56 (codified in scattered sections of 18 & 47 U.S.C.A. (West Supp. 1997)) did not fundamentally alter the regulatory framework.

20. The *locus classicus* of the "official" history justifying this system of centralized federal control — some might say micro-management — of radio broadcasting is *National Broad. Co. v. United States*, 319 U.S. 190, 210-14 (1943). This history continues to be cited as the primary source for contemporary understanding of the justification of federal regulation. *See, e.g.*, Rosston & Steinberg, *supra* note 2, at 88-89.

21. *See* Comment, *Federal Control of Radio Broadcasting*, 39 YALE L.J. 245, 247 (1929).

22. Hoover v. Intercity Radio Co., 286 F. 1003 (D.C. Cir. 1923).

23. United States v. Zenith Radio Corp., 12 F.2d 614 (N.D. Ill. 1926). This interpretation was supported by the then-acting Attorney General. *See* 35 Ops. Atty. Gen. 126 (July 8, 1926).

would no longer regulate radio.[24] What followed was "confusion and chaos."[25] More than 200 new stations began operations between July 1926, when the Secretary ceased regulation, and February 1927, when the Radio Act of 1927 came into force.[26] Older stations wandered the spectrum in search of better broadcast slots.[27] "With everybody on the air, nobody could be heard."[28] Justice Frankfurter concluded this description with the following analysis of its causes:

> The plight into which radio fell prior to 1927 was attributable to certain basic facts about radio as a means of communication — its facilities are limited; they are not available to all who may wish to use them; the radio spectrum simply is not large enough to accommodate everybody. *There is a fixed natural limitation upon the number of stations that can operate without interfering with one another.* Regulation of radio was therefore as vital to its development as traffic control was to the development of the automobile. In enacting the Radio Act of 1927, the first comprehensive scheme of control over radio communication, Congress acted upon the knowledge that if the potentialities of radio were not to be wasted, regulation was essential.[29]

The first economist to tell an alternative history of radio regulation as a prelude to economic critique was Ronald Coase.[30] Coase started his story with the early attempts by the Navy to appropriate all the spectrum, beginning in 1910 and continuing through 1920.[31] In the 1920s, Hoover, as Secretary of Commerce in charge of implementing the Radio Act of 1912, gathered representatives of government departments and the radio industry for radio conferences.[32] These conferences sought greater regulation of the radio frequency spectrum.[33] Bills introduced to that

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24. *See National Broad. Co.*, 319 U.S. at 212.
25. *Id.*
26. *See id.*
27. *See id.*
28. *Id.*
29. *Id.* at 213 (emphasis added).
30. Coase, *supra* note 1.
31. *See id.* at 2-4.
32. *See id.* at 4.
33. *See id.*

effect, however, did not pass.[34] The Secretary nonetheless used his licensing authority to implement the recommendations of the conferences, until he was prevented by adverse court decisions.[35] In response, legislative action quickly followed, creating the current regulatory regime.[36]

The most important difference between this history and the "official" history is how small a role Coase assigns to the period from July 1926 to February 1927, the "breakdown of the law" or "chaos" period. For Coase, the Radio Act of 1927 was part of a long-standing drive by the federal government to regulate spectrum use — beginning with the Navy's demands before WWI, continuing with numerous bills during the 1920s, and culminating in quick action following the *Zenith* decision in 1926.[37] Coase's story, unlike the official story, is therefore not about the self-defeating excesses of unmanaged private transmissions, given the technical constraints of radio, but about the progression of choices intended to organize the use of wireless transmissions in an administrative regulation model. This theme — that cumulative institutional choices *caused* spectrum scarcity, rather than responded to it — remains the mainstay of the economists' history of radio regulation.[38]

The third type of history, not commonly told in discussions of how radio ought to be regulated, is the business history of the radio industry. This third set of stories identifies the interaction among multiple forces, and suggests that we live under a historically-contingent regulatory system, amenable to no simple conclusions about the necessity of administrative regulation or its folly. It also suggests that we take seriously the possibility that the present institutional and organizational framework is in large measure a product of the structure of the radio equipment market in the early 1920s. If one accepts this proposition, then one may have to reevaluate how the technological parameters of

34. *See id.*

35. *See* Hoover v. Intercity Radio Corp., 286 F. 1003 (D.C. Cir. 1923); United States v. Zenith Radio Corp., 12 F.2d 614 (N.D. Ill. 1926).

36. *See* Coase, *supra* note 1, at 4-6.

37. *See id.*

38. *See, e.g.*, Jora Minasian, *The Political Economy of Broadcasting in the 1920s*, 12 J.L. & ECON. 391 (1969). The most important contemporary gloss on this theme is that the administrative licensing model was not the result of misunderstanding the problem of interference, but was instead the rational choice for both industry forces and regulators who replaced an emerging common law property system in transmission rights with a system that exchanged political control over an important medium in return for protection of broadcasters from competition. *See* Thomas W. Hazlett, *The Rationality of U.S. Regulation of the Broadcast Spectrum*, 23 J.L. & ECON. 133, 138-66 (1990).

present communications equipment might change the conceptual assumptions underlying the regulatory framework and its primary alternative, privatization.

B. A Brief Business History of Radio Regulation

The world in which the Radio Act of 1912 was passed saw radio as a means of wireless telegraphy, as a means of ship-to-shore and ship-to-ship communications, with the potential of one day challenging transoceanic cable communications. Guglielmo Marconi's sales panache had sealed this perception.[39] Almost all radio communications regulated by the Radio Act of 1912[40] were wireless Morse code transmissions; there were no broadcast stations in any contemporary sense, although some amateurs tried to be somewhat consistent in offering a voice program once in a while;[41] equipment was primitive and incapable of focusing on relatively narrow frequencies;[42] time (scheduling transmissions) and space (placing transmitters far enough from each other) were the primary units to be manipulated in avoiding interference, although crude channelization of frequencies was used in the 1912 Act

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39. Marconi's chosen proving grounds in 1898-99 were yacht races and naval maneuvers. In 1898, he provided Queen Victoria with daily updates of the Prince of Wales' health, as the Prince recuperated from a knee injury on his yacht. *See* GLEASON L. ARCHER, HISTORY OF RADIO TO 1926, at 58 (1938); 1 ERIK BARNOUW, A HISTORY OF BROADCASTING IN THE UNITED STATES: A TOWER IN BABEL 12-13 (1966); PHILIP T. ROSEN, THE MODERN STENTORS: RADIO BROADCASTERS AND THE FEDERAL GOVERNMENT, 1920-1934, at 18 (1980). That same summer, Marconi contracted with the Dublin *Daily Express* to provide a minute-by-minute wireless account of the Kingstown Regatta; details of the race were radioed to a shore station, reported to the paper by phone, and in print before the yachts returned to port. *See* ARCHER, *supra*, at 58; BARNOUW, *supra*, at 13. In 1899, the *Goodwin Sands Lightship* was saved when it radioed for help from the English Channel, *see* ROSEN, *supra*, at 18, while Marconi installed his equipment on three British battleships and demonstrated its use during naval maneuvers. *See* BARNOUW, *supra*, at 13. In October 1899, Marconi arrived in the United States, where he reported on the America's Cup, *see id.* at 13, 15, while at the same time demonstrating the utility of his equipment in ship-to-ship communications to the United States Navy. *See id.* at 13; ARCHER, *supra*, at 59. By 1904, the centrality of ship-to-ship and ship-to-shore communications as *the* use of radio was so deeply embedded that the Interdepartmental Board of Wireless Telegraphy, established by President Theodore Roosevelt, determined that the Navy was the preeminent user and department responsible for wireless telegraphy; on the basis of this position, the Navy would continue to assert a right to control of radio services until the early 1920s. *See* ROSEN, *supra*, at 20-25.

40. Ch. 287, 37 Stat. 302.

41. *See* BARNOUW, *supra* note 39, at 28-33.

42. *See id.* at 31.

as well.[43] Broadcast radio as a mode of entertainment, as opposed to wireless as a mode of telegraph or telephone, was not understood as a function that radio could fulfill, except by a few visionaries.[44]

The first decade of radio saw rapid innovation and the emergence of competition. Despite his early success, Marconi lost ground in the United States when his business plan shifted from equipment sales to sales of ship-to-shore communications as a service, modeled on telephone service. In the new model, Marconi owned the equipment and charged per-message fees.[45] In 1899, Marconi offered similar terms to the U.S. Navy, for a lump sum of $10,000 and an annual royalty of $10,000. The Navy balked, opening the way to American wireless telegraphy competitors.[46] The Navy built its own shore stations,[47] and Navy contracts provided an important anchor for companies founded by competing inventors, like Lee de Forest, who invented the Audion (the three element vacuum tube) and Reginald Fessenden, the first to modulate voice over a continuous wave.[48]

The second decade of radio did little to change its role but was marked by consolidation through patent prosecutions, the wartime efforts of the U.S. Navy, and finally by the creation of the patent alliance, whose actions in the 1920s determined the organizational structure of broadcast to this day. In 1912, two of the innovators of voice radio dropped out of the picture. Fessenden's National Electric Signaling Company declared bankruptcy.[49] The patent for the alternator that Fessenden had ordered from General Electric ("GE") to generate voice transmission remained with GE, where it was developed by Ernst F. W. Alexanderson.[50] Lee de Forest's companies were in trouble that same year.[51] His United Wireless Company collapsed under indictment

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43. *See* ARCHER, *supra* note 39, at 106.

44. *See generally* BARNOUW, *supra* note 39, at 12-38.

45. *See* BARNOUW, *supra* note 39, at 17. Typically, a Marconi company would install equipment on commercial ships, and furnish an employee to maintain it. Marconi also built and maintained shore stations. Passengers and shipping company officers would pay per transmission to the Marconi company. Initially, the Marconi company also connected to ships served by competitors. Marconi shore stations soon began, however, to ignore signals from ships served by other equipment manufacturers. *See id.*

46. *See id.*; ARCHER, *supra* note 39, at 63.

47. *See* BARNOUW, *supra* note 39, at 26.

48. *See id.* at 26; ARCHER, *supra* note 39, at 93.

49. *See* ARCHER, *supra* note 39, at 86-88, 102-03; BARNOUW, *supra* note 39, at 19-20, 42.

50. *See* ARCHER, *supra* note 39, at 115-18; BARNOUW, *supra* note 39, at 19-20.

51. *See* ARCHER, *supra* note 39, at 70-71, 92-94, 106-09; BARNOUW, *supra* note 39, at 23-24, 44-45.

for stock manipulation schemes.[52] Its assets were bought by American Marconi.[53] American Marconi now had a virtual monopoly over point-to-point wireless telegraphy. De Forest's patents to the Audion were also attacked by Marconi, who owned the patents to the vacuum tube without the third element de Forest had added.[54] Under this pressure, de Forest sold his Audion patents to AT&T.[55]

In 1916, a federal district court held in *Marconi Wireless Telegraph Co. of America v. De Forest Radio Telephone & Telegraph Co.*[56] that de Forest's Audion, as a radio-transmission detector, infringed the original Fleming glass-bulb detector patent owned by Marconi.[57] The third element, or "grid," of the Audion was, however, protected by de Forest's patent. Neither Marconi nor AT&T could produce a radio receiver using the Audion without the other's consent.[58] In the meantime, GE had been perfecting the Alexanderson alternator,[59] while a Columbia University undergraduate, Edwin H. Armstrong, had developed a "feedback circuit" that reinforced the Audion. He received a patent in 1914.[60] The perfect piece of radio equipment, which would combine the Audion, the Alexanderson alternator, and the Armstrong feedback circuit, now needed the consent of Marconi, AT&T, GE, and Armstrong. No such agreement developed.

With the entry of the United States into World War I in April 1917, the government took over radio and broke the patent stalemate. In April, the Navy took over the operations of all wireless stations not under Army control.[61] The Navy issued indemnities to the manufacturers of radio equipment against patent suits arising from war production contracts.[62] War production brought GE and Westinghouse, the great light-bulb manufacturers, into the manufacture of radios around vacuum

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52. *See* BARNOUW, *supra* note 39, at 42.

53. *See id.*

54. *See id.* at 42-43.

55. *See id.* at 44-45; ARCHER, *supra* note 39, at 106-09.

56. 236 F. 942 (S.D.N.Y. 1916).

57. In 1904, J.A. Fleming had developed what was called a "Fleming valve," which was itself a development of a two-electrode tube that Edison had developed, and discarded, in search of electric light. Without the third element introduced by de Forest, however, the Fleming valve was useless as a receiving device, but it was evidently enough to give Marconi a veto power over the Audion's use for radio reception. *See* ARCHER, *supra* note 39, at 114-15.

58. *See id.* at 115; BARNOUW, *supra* note 39, at 47.

59. *See* BARNOUW, *supra* note 39, at 48-49.

60. *See id.* at 47; ARCHER, *supra* note 39, at 113-14.

61. *See* ARCHER, *supra* note 39, at 137.

62. *See id.* at 138 & n.12 (quoting, as an example, an indemnity letter to the Marconi Company signed by Acting Secretary of the Navy Franklin D. Roosevelt).

tubes.[63] General Electric also produced the most powerful Alexanderson alternators and installed them at the New Brunswick Marconi shore station, then held by the Navy. The New Brunswick station became the most powerful station in the world in 1918, enabling, among other things, President Wilson to transmit a plea to the German people to oust the Kaiser.[64]

The two years following the war saw a scramble to gain control over radio. The Navy attempted to leverage its control of shore stations and its role in technological development into a government monopoly over wireless communications.[65] The Post Office tried to create a government monopoly as part of its Air Mail Service.[66] Neither department succeeded, and in the period of 1921-22, Herbert Hoover succeeded in positioning the Commerce Department as the ally of commercial operators and amateurs, and the honest broker among the government departments.[67] The model he used relied on industry and amateur-based development, with government regulation conceived as an aid to this development.[68]

At the same time, the wireless industry was adjusting to the post-war era. American Marconi had entered the war with a near monopoly on shore stations. To sustain its position, Marconi suggested to GE that it would buy exclusive worldwide use of the Alexanderson alternator. Under the proposed agreement, Marconi would retain exclusive use of the alternator, while GE would continue to be the exclusive manufacturer.[69] An exclusive contract would deny Marconi's competitors access to transmitters powerful enough to allow them to compete, while promising GE a stable stream of orders for its wartime production facilities. The exclusivity deal raised concerns in the Navy over loss of control of wireless communications to a British company. One of Britain's early acts in the war was to cut off Germany's cable communications, which it could do because of its control over submarine cables.[70] To keep radio technology from being similarly controlled by the British-owned Marconi, the Navy acted to thwart the deal and proposed an alternative. Possibly maneuvered by then GE general

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63. *See* BARNOUW, *supra* note 39, at 48. Both Westinghouse and GE had already been enlisted by the British government to develop radio equipment for its war efforts earlier in the war. *See* ARCHER, *supra* note 39, at 128-29.

64. *See* ARCHER, *supra* note 39, at 141-42, 144-46; BARNOUW, *supra* note 39, at 51.

65. *See* BARNOUW, *supra* note 39, at 52-55; ROSEN, *supra* note 39, at 22-24.

66. *See* ROSEN, *supra* note 39, at 26.

67. *See* BARNOUW, *supra* note 39, at 94.

68. *See id.* at 94-95.

69. *See* ARCHER, *supra* note 39, at 159-60; BARNOUW, *supra* note 39, at 57.

70. *See* ARCHER, *supra* note 39, at 125; BARNOUW, *supra* note 39, at 50.

counsel Owen D. Young and perhaps even urged by President Wilson, the two top Navy radio officers, Commander S.C. Hooper and Rear Admiral W.H.G. Bullard, approached GE.[71]

To replace the Marconi deal, a new company was created in October 1919, the Radio Corporation of America ("RCA"). RCA would not be a subsidiary of GE. It would instead be a successor to American Marconi, with the British Marconi interests bought out by GE. The U.S. stockholders of American Marconi would receive shares in the new company, in return for American Marconi's conveyance of all its property, including its installed base of shore stations, patents, and goodwill, to RCA.[72] A central feature of the RCA deal was a cross-licensing agreement in which GE and RCA cross-licensed each other to use all radio technology they owned then or would develop in the next 25 years. This agreement became the template for the cross-licensing agreements around which the patent alliance would coalesce a year later.[73]

Like GE, Westinghouse found itself at the end of the war with idled production capacity. Unlike GE, which had focused on the expensive Alexanderson alternator as the central component of high-powered transmission equipment, Westinghouse had developed and manufactured smaller receivers and transmitters.[74] In response to GE's alliance with American Marconi through RCA, Westinghouse allied itself with Fessenden's almost-defunct International Radio Telegraph Company, in the hope of setting itself up as a competitor in transatlantic telegraphy.[75] RCA had, however, secured exclusive rights to communicate with British Marconi stations and with most other stations in Europe.[76] Westinghouse was America-bound.[77] To make matters worse, RCA completed a cross-licensing agreement with AT&T that would allow each to manufacture transmitting and receiving equipment using the de Forest Audion, to which each group held a partial patent. Western Electric and GE would continue to manufacture equipment, but RCA would sell it under its brand name.[78] Outflanked in international communications and blocked from competing in the production of Audion-based equipment, Westinghouse made two moves to save its

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71. *See* ARCHER, *supra* note 39, at 151-55, 160-67; BARNOUW, *supra* note 39, at 57-58.

72. *See* ARCHER, *supra* note 39, at 172-80; BARNOUW, *supra* note 39, at 59.

73. *See* ARCHER, *supra* note 39, at 180-81.

74. *See id.* at 191.

75. *See id.* at 192-93.

76. *See* BARNOUW, *supra* note 39, at 59-60.

77. *See* ARCHER, *supra* note 39 at 191-94, 195-97; BARNOUW, *supra* note 39, at 65.

78. *See* ARCHER, *supra* note 39, at 194-95; BARNOUW, *supra* note 39, at 65.

ability to compete in the radio equipment manufacturing business. The first was to acquire the Armstrong patents for the feedback circuit.[79] The second was to invent broadcast radio as a mass medium. The purchase of the Armstrong patents would lead to the inclusion of Westinghouse in the patent alliance — sealed through joint ownership of RCA by GE (30.1%), Westinghouse (20.6%), AT&T (10.3%), and United Fruit Company (4.1%) — which brought in patents for the loop antenna and crystal detectors.[80]

But in late 1920, eight months before Westinghouse was included in the patent alliance, the company had launched a different solution to its problem. Developing an idea that its chief wireless technology investigator, Frank Conrad, had pursued since 1912, Westinghouse concluded that, without Audion patents and transoceanic communications facilities, the market it should target was that of simple home receivers. In that market, it could compete using licenses it had for patents not held by the RCA-GE-AT&T alliance.[81] But to sell such equipment, there must be something for receiver owners to listen to.[82] Thus was launched KDKA Pittsburgh, whose first broadcast covered election returns from the 1920 presidential elections.[83] That same night, the *Detroit News* amateur station, 8MK (later WWJ), also broadcast the returns. But the *Detroit News* broadcast was presented as a technical fraternity event. Westinghouse advertised its coverage in terms of a social delight open to all, at their homes or clubs. Westinghouse was out

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79. *See* ARCHER, *supra* note 39, at 197-98; BARNOUW, *supra* note 39, at 65. The patents for the feedback circuit are also known as the Armstrong-Pupin patents, in reference to the name of Armstrong's professor at Columbia, where Armstrong developed the feedback loop. *See* ARCHER, *supra* note 39, at 113-14, 197-98.

80. *See* BARNOUW, *supra* note 39, at 72-73.

81. *See id.* at 65-68.

82. Westinghouse was not the first to think of the broadcast business model for equipment sales. In 1916, David Sarnoff, then with American Marconi, later the general manager and president of RCA, had proposed to Edward Nally, general manager of Marconi, a Radio Music Box that would be a home utility like a piano or phonograph. A transmitter could transmit music, and home receivers would receive it. *See* ARCHER, *supra* note 39, at 112-13. Sarnoff's idea went nowhere in American Marconi, but, as commercial manager of RCA, he revived it in 1920 in a memo to Owen Young. Sarnoff suggested that the Radio Music Box could be sold at $75 apiece, and projected sales to be $7.5 million in the first year, $22.5 million in the second year, and $45 million in the third. Again, Sarnoff was unheeded. But Westinghouse's success, followed by its inclusion in the alliance, changed the approach of the manufacturers to equipment sales. When RCA started to manufacture and sell home receivers, its actual sales were uncannily close to Sarnoff's projections. *See* ARCHER, *supra* note 39, at 189; BARNOUW, *supra* note 39, at 78-79.

83. *See* BARNOUW, *supra* note 39, at 69-70.

to sell receivers, not glorify the new technology and its operators. And it worked.[84]

RCA now controlled all equipment manufacture, except for manufacture by amateurs. Under the RCA-GE-AT&T-Westinghouse agreements ("the RCA alliance"), GE and Westinghouse would manufacture all receiving equipment (GE manufacturing sixty percent and Westinghouse forty percent of the total).[85] RCA would sell the receivers under RCA trademarks. Transmitters would be manufactured by Western Electric, and sold by AT&T. Telephony, wired or wireless, belonged to AT&T. RCA had the chief role in international communications.[86] Throughout the 1920s, equipment sales would be big business.[87]

Radio stations, however, were not generally run as profit centers. Many were run by educational and religious institutions.[88] Even stations considered "commercial" or "professional" were limited primarily to using unpaid programming.[89] Stations operated by retail businesses and newspapers hoped to increase sales through broadcast exposure.[90] The manufacturers built powerful stations like KDKA Pittsburgh, WJZ Newark, KYW Chicago (all owned by Westinghouse) and WGY Schenectady (GE), but made their money from equipment sales.[91]

Even as late as September 1926, when RCA publicly announced the creation of the National Broadcasting Company ("NBC"), which revolutionized the business of broadcasting, the business purpose of the move was explained in terms of equipment sales:

> *The market for receiving sets in the future will be determined largely by the quantity and quality of the programs broadcast.*
>
> We say quantity because they must be diversified enough so that some of them will appeal to all possible listeners.

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84. *See* ARCHER, *supra* note 39, at 208-10; BARNOUW, *supra* note 39, at 69-71.

85. *See* BARNOUW, *supra* note 39, at 61.

86. *See id.* at 81.

87. Annual sales for the years 1922-29 were: 1922: $60 million; 1923: $136 million; 1924: $358 million; 1925: $430 million; 1926: $506 million; 1927: $426 million; 1928: $651 million; 1929: $843 million. *See id.* at 123, 210, 229.

88. *See id.* at 90-99.

89. The exception was AT&T's "toll broadcasting." *See infra* text accompanying notes 126-28.

90. *See* BARNOUW, *supra* note 39, at 98-100.

91. *See id.* at 83-91, 97-105.

> We say quality because each program must be the best of its kind. If that ideal were to be reached, no home in the United States could afford to be without a radio receiving set.
>
> Today the best available statistics indicate that 5,000,000 homes are equipped, and 21,000,000 homes remain to be supplied.
>
> *Radio receiving sets of the best reproductive quality should be made available for all, and we hope to make them cheap enough so that all may buy.*
>
> The day has gone by when the radio receiving set is a plaything. It must now be an instrument of service.[92]

It was only after 1929 that commercial radio shifted towards advertiser-supported radio, making station operation, in particular in networks, the leading business of radio.[93]

The year 1922 saw radio broadcasting blossom. In November 1921, five licenses were issued by the Department of Commerce under the new category of "broadcasting" of "news, lectures, entertainment etc."[94] By July 1922, the Department had issued another 453 licenses.[95] Home receiver orders swamped manufacturers.[96] Universities, seeing radio as a vehicle for broadening their role, began broadcasting lectures and educational programming. Seventy-four institutes of higher learning operated stations by the end of 1922.[97] The University of Nebraska even offered two-credit courses whose lectures were transmitted over the air.[98] Churches, newspapers, and department stores followed suit.

The same year also saw the consolidation of Herbert Hoover's power. Appointed Secretary of Commerce a year earlier, Hoover allied himself with both commercial radio interests and the American Radio Relay League, the amateurs' organization.[99] At the initiative of

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92. *Id.* at 187 (quoting RCA advertisement announcing NBC) (emphases in original).

93. *See id.* at 237-45, 269-83.

94. *Id.* at 91 (quoting U.S. Department of Commerce, *Radio Service Bulletin*, Apr. 1, 1922).

95. *See id.*

96. *See id.*; ARCHER, *supra* note 39, at 250-52.

97. *See* BARNOUW, *supra* note 39, at 97-98.

98. *See Id.*

99. *See* ROSEN, *supra* note 39, at 31-46.

President Harding, Hoover convened a conference of radio manufacturers and broadcasters, with some representation of engineers and amateurs.[100] This forum became Hoover's primary stage, and over the next four years Hoover would use its annual meeting to derive policy recommendations, legitimacy, and cooperation for his regulatory action, all without a hint of authority in the Radio Act of 1912.[101]

Hoover relied heavily on the rhetoric of public interest and on the support of amateurs to justify his system of private broadcasting coordinated by the Department of Commerce.[102] But from 1922 on, he followed a pattern that would systematically benefit large broadcasters over small ones; commercial broadcasters over educational and religious broadcasters; and one-to-many broadcast over the point-to-point wireless telephony and telegraphy that amateurs were developing. After January 1922, the Department inserted a limitation on amateur licenses, excluding from their coverage broadcast of "weather reports, market reports, music, concerts, speeches, news or similar information or entertainment."[103] This limitation, together with a Department of Commerce order to all amateurs to stop broadcasting at 360 meters (the wavelength assigned to broadcasting), effectively limited amateurs to radio telephony and telegraphy at wavelengths shorter than 200 meters, at the time considered a relatively useless frequency band.[104] In the summer, the Department assigned broadcasters, in addition to 360 meters, another band at 400 meters. Licenses in this Class B category were reserved for transmitters operating at transmit power levels of 500-1000 watts who did not use phonograph records.[105] Class B was to become the home of broadcasters who could afford the more expensive high-powered transmitters, and could arrange for live broadcasts, rather than phonograph record playing. The success of this new frequency was not immediate, because many receivers could not tune out stations broadcasting at one frequency in order to listen to the other.[106]

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100. *See* BARNOUW, *supra* note 39, at 94-96.

101. *See* ARCHER, *supra* note 39, at 248-50; BARNOUW, *supra* note 39, at 94-95, 121-22, 174; ROSEN, *supra* note 39, at 39-41. Hoover is quoted as having emerged from the first conference with the conclusion that "this is one of the few instances where the country is unanimous in its desire for more regulation." ARCHER, *supra* note 39, at 249, BARNOUW, *supra* note 39, at 95 (quoting RADIO BROADCAST, May 1922).

102. *See* ROSEN, *supra* note 39, at 31-33, 36-37.

103. *Id.* at 37.

104. *See id.*; BARNOUW, *supra* note 39, at 151-52 (describing how the amateurs, in their short wave "Siberia," developed the long-distance communications capability of short waves).

105. *See* BARNOUW, *supra* note 39, at 100-01; ROSEN, *supra* note 39, at 38.

106. *See* ARCHER, *supra* note 39, at 291-94.

Failing to move Congress to amend the radio law to provide him with the power necessary to regulate broadcasting, Hoover relied on the recommendations of the second radio conference in 1923 to adopt a new regime. He announced that the broadcast band would be divided in three. High-powered (500-1000 watts) stations serving large areas would have no interference in those large areas and would not share frequencies. They would transmit on frequencies between 400 and 545 meters. Medium-powered stations served smaller areas without interference and would operate at assigned channels between 222 and 300 meters. The remaining low-powered stations would not, as the bigger actors wanted, be eliminated, but would remain at 360 meters, with limited hours of operation and geographic reach.[107] Many of these lower-powered broadcasters were educational and religious institutions. They perceived the allocation as a preference for the RCA alliance.[108] Despite his protestations against commercial broadcasting ("If a speech by the President is to be used as the meat in a sandwich of two patent medicine advertisements, there will be no radio left."),[109] Hoover consistently reserved clear channels and issued high-power licenses to commercial broadcasters.[110]

The final policy action based on the radio conferences came in 1925 when the Department of Commerce stopped issuing licenses.[111] The result was a secondary market in licenses, in which some religious and educational stations were bought out by commercial concerns, and in which commercial concerns like the Chicago Tribune could buy stations that a non-commercial organization like the Chicago Federation of Labor could not.[112] The result was further gravitation of licenses towards commercial ownership.[113] The pattern continued after the 1927 Act, when twenty-one of the twenty-four clear-channel stations created by the Federal Radio Commission went to network-affiliated stations.[114]

Following the boom of 1922, tensions surfaced in 1923 that would affect the structure of the industry for years to come. Receiver sales were growing phenomenally, and the RCA alliance held all the relevant patents. But RCA sales accounted for only nineteen percent of the

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107. *See* BARNOUW, *supra* note 39, at 121-22.

108. *See id.* at 122, 179; ROSEN, *supra* note 39, at 55-59.

109. BARNOUW, *supra* note 39, at 177 (quoting from RADIO BROADCAST, Dec. 1924).

110. *See id.*

111. *See id.* at 189-90.

112. *See* Hazlett, *supra* note 38, at 143-47. Hazlett ascribes to this distributive effect a primary role in driving radio regulation as we know it. *See id.*

113. *See* BARNOUW, *supra* note 39, at 174-76.

114. *See id.* at 218.

market.[115] The rest was taken up by some 200 companies that constructed partly assembled sets that lacked only the patented component — the vacuum tube. The customer could buy a vacuum tube, which the members of the alliance sold for replacement of burnt tubes and for amateur transmitter construction, and complete the set.[116] In 1923, the alliance responded. RCA sued competitors that built receivers complete but for the tubes. RCA also required tube dealers to provide it with a burnt tube for each new tube sold, and attached warnings that the tubes were not to be used in equipment not manufactured by RCA.[117]

Congressional concerns over leveraging of the tube monopoly into a receiving set monopoly and, eventually, a broadcast monopoly, led to a call for an FTC inquiry.[118] The resulting 347-page report seemed to confirm the legislators' concerns.[119] Meanwhile, AT&T considered all stations that used a transmitter not manufactured by Western Electric, its equipment-manufacturing arm, to have infringed its patent rights.[120] That meant all but thirty-five of the 600 stations then on the air.[121] Rather than risk a suit against almost all broadcasters, AT&T sought to persuade broadcasters to pay it a license fee for using equipment not manufactured by Western Electric. In return, AT&T would not sue for the use of this allegedly infringing equipment, and would grant broadcasters access to AT&T's long lines for remote broadcasts of sports or similar events.[122] Concerns rooted in these practices found their way into the 1927 Radio Act's prohibition on licensing of persons who violated the antitrust laws.[123] The fear of losing the NBC licenses under this provision apparently forced RCA in 1931 to release controls it had for years imposed on competitors.[124]

Tensions also began to emerge within the RCA alliance. The phenomenal success of receiver sales tempted Western Electric into that market. In the meantime, AT&T, almost by mistake, began to challenge GE, Westinghouse, and RCA in broadcasting, as an outgrowth of its attempt to create a broadcast common carriage facility. Despite the successes of broadcast and receiver sales, it was not clear in 1922-23

115. *See id.* at 115.
116. *See id.* at 116.
117. *See id.*
118. *See id.* at 117. The FTC Report was presented to Congress in December 1923.
119. *See* ARCHER, *supra* note 39, at 325-27.
120. *See* BARNOUW, *supra* note 39, at 117-19.
121. *See id.* at 117.
122. *See* ARCHER, *supra* note 39, at 118.
123. *See* Radio Act of 1927, ch. 169, 44 Stat. 1162.
124. *See* BARNOUW, *supra* note 39, at 256-57.

how the cost of setting up and maintaining stations would be paid for. In England, a tax was levied on radio sets, and its revenue used to fund the BBC; no such proposal was considered in the United States.[125] AT&T was the only company to offer a solution. Building on its telephone service experience, it would offer radio telephony to the public for a fee. In February 1922, it established WEAF in New York, a facility over which AT&T was to provide no programming of its own, but instead would enable the public or program providers to pay on a per-time basis.[126] Since AT&T treated this service as a form of wireless telephony, it fell, under the alliance agreements of 1920, under the exclusive control of AT&T. RCA, Westinghouse, and GE could not compete in this area.[127]

Toll broadcasting was not a success by its own terms. There was insufficient demand for communicating with the public to sustain a full schedule that would justify listeners tuning into the station. As a result, AT&T produced its own programming. In order to increase the potential audience for its transmissions while using its advantage in wired facilities, AT&T experimented with remote transmissions, such as live reports from sports events, and with simultaneous transmissions of its broadcasts by other stations, connected to its New York station. By mid-1923, AT&T found itself with the first functioning precursor to an advertiser-supported broadcast network.[128]

The alliance members now threatened each other: AT&T to enter into receiver manufacturing and broadcast, and the rest of the RCA alliance, with its powerful stations, to enter into "toll broadcasting," or advertiser-supported radio. The patent allies submitted their dispute to an arbitrator, who was to interpret the 1920 agreements, reached in a world of wireless telegraphy, to divide the spoils of the broadcast world of 1924.[129] In late 1924, the arbitrator found for RCA-GE-Westinghouse on almost all issues.[130] Capitalizing on RCA's difficulties with the FTC, however, AT&T countered that if the 1920 agreements meant what the arbitrator said they meant, they were a combination in restraint of trade

125. *See* ARCHER, *supra* note 39, at 252. The editor of *Radio Broadcast* proposed a national endowed fund, like those that support public libraries and museums. *See id.* at 252-54. In 1924, a committee of New York businessmen solicited public donations to fund broadcasters, but the response was so pitiful that the funds were returned to their donors. *See id.* at 328-29.

126. *See* BARNOUW, *supra* note 39, at 108-14.

127. *See* ARCHER, *supra* note 39, at 255-58; BARNOUW, *supra* note 39, at 105-08.

128. *See* ARCHER, *supra* note 39, at 275-77, 284-91, 313-15, 335-38; BARNOUW, *supra* note 39, at 105-14.

129. *See* ARCHER, *supra* note 39, at 327-28; BARNOUW, *supra* note 39, at 161-62.

130. *See* BARNOUW, *supra* note 39, at 182-83.

to which AT&T would not adhere.[131] Bargaining in the shadow of the mutual threats of contract and antitrust actions, the former allies reached a solution that formed the basis of future radio broadcasting. AT&T would leave broadcasting. A new company, owned by RCA, GE, and Westinghouse, would be formed, and would purchase AT&T's stations. The new company would enter into a long-term contract with AT&T to provide the long distance communications necessary to set up the broadcast network that David Sarnoff envisioned as the future of broadcast.[132] This new entity would, in mid-1926, become NBC. AT&T's WEAF station would become the center of one of NBC's two networks, and the division arrived at would form the basis of the broadcast system in the United States ever since.[133]

By the middle of 1926, the institutional elements that became the American broadcast system were, to a great extent, in place. The idea of government monopoly over broadcasting, which was dominant in Great Britain and Europe, was forever abandoned. The idea of a private property regime in spectrum, which had been advocated by commercial broadcasters to spur investment in broadcast,[134] was rejected against the backdrop of other battles over conservation of federal resources.[135] A relatively small group of commercial broadcasters and equipment manufacturers took the lead in broadcast development, with the aid of a governmental regulatory agency that, using a standard of the public good, would allocate frequency, time, and power assignments to minimize interference and to resolve conflicts that could not be resolved by contract. The public good, by and large, correlated to the needs of commercial broadcasters and their listeners. Later, the networks would supplant the patent alliance as the primary force to which the Federal Radio Commission would pay heed. But within this system, interests of amateurs (whose romantic pioneering mantle still held a strong purchase on the process), educational institutions, and religious organizations continued to exercise some force on the allocation and management of the spectrum.

The suit brought by Zenith Radio Corporation to challenge the Secretary's power laid bare the absence of a legal basis for the system

131. *See id.* at 183.

132. *See id.* at 185-88.

133. *See id.* at 185-88; ROSEN, *supra* note 39, at 90-91.

134. *See* BARNOUW, *supra* note 39, at 178 (citing HERBERT HOOVER, THE MEMOIRS OF HERBERT HOOVER: THE CABINET AND THE PRESIDENCY, 1920-1933, at 140-41 (1952)).

135. *See id.* at 195-96 (discussing conservationist impulses underlying federal ownership of spectrum).

that had evolved between 1921 and 1926.[136] Hoover's announcement that he would no longer regulate radio came after Congress had dispersed for the summer.[137] When Congress returned in December 1926, it produced the Radio Act of 1927 in about two months.[138] The fundamental institutional parameters of the system remained unchanged from those that had developed by the summer of 1926, before the "breakdown of the law." The most noticeable difference was that the federal agency was the new Federal Radio Commission, not the Secretary of Commerce.

C. A Call for Intellectual Flexibility

The lesson to be learned from the early business history of radio is twofold. First, the present system is a historically contingent arrangement, not one necessitated by either technological or economic parameters. Second, the market in radio equipment was a forceful engine of innovation and development of wireless communications technology, and was a crucial element in framing the problems associated with broadcast. In recognizing the contingency of the institutional details of the present regulatory framework, we must understand that the conceptual tools developed to explain, justify, and criticize these institutional elements are as contingent as the subject matter that gave rise to their development.

The present regulatory system was fashioned around the needs of one model of wireless communications: broadcasting. The companies that developed this model did so to make possible a consumer market in simple receivers, which were at the time the sole product appropriate for mass marketing. Consequently, the institutional problem to be solved involved allocating frequencies among powerful transmitters capable of being received by these simple receivers. Today we live in an economy powered by low-cost processors. We have learned to communicate through distributed communications networks like the Internet that rely heavily on the computing capabilities of end-user equipment. Yet we continue to use a problem definition resulting from a market in equipment whose present-day successor is still one of the "dumbest" machines in our houses. We must instead open our minds to the possibility that the important question is no longer how to allocate spectrum among a small number of sophisticated service providers, but

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136. *See* United States v. Zenith Radio Corp., 12 F.2d 614 (1926).

137. *See* National Broad. Co. v. United States, 319 U.S. 190, 212 (1943); BARNOUW, *supra* note 39, at 189-90.

138. *See* BARNOUW, *supra* note 39, at 199.

rather how to allow better coordination among a large number of end-users with sophisticated equipment.

III. THE ECONOMIC CRITIQUE OF LICENSING AND THE EMERGENCE OF SPECTRUM PRIVATIZATION

The core of the economic critique of the broadcast licensing system is that interference makes spectrum an economic good, and economic goods are best allocated by market mechanisms. The best legal solution to interference would, according to this view, be to define a set of property rights in spectrum units, and to allow market transactions to allocate spectrum to its highest valued uses, as defined by the willingness of spectrum users to pay for spectrum units. Once this point is understood, the rest of the literature consists of fine tuning the property rights, defining their content, and conceiving of a method of allocation that would produce the best-functioning market.

A. The Basic Critique: Coase on the FCC

The person credited with being the first to propose the economic critique of administrative spectrum regulation was Leo Herzel.[139] Ronald Coase was next to claim that spectrum, like all other resources, should be allocated "by the forces of the market rather than as a result of government decisions."[140] Coase argued that pricing would yield better allocation than administrative fiat, that requiring government agencies to bid for spectrum would encourage more efficient use of spectrum within government bands, and that licensing in practice partially operates as a market due to the secondary market (except that it gives initial licensees a windfall profit because they receive a valuable marketable input for free).[141]

139. *See* Leo Herzel, *"Public Interest" and the Market in Color Television Regulation*, 18 U. CHI. L. REV. 802 (1951). In proposing a market solution to the choice of a standard for color broadcast, Herzel proposed that "[T]he FCC could lease channels for a stated period to the highest bidder without making any other judgment of the economic or engineering adequacy of the standards to be used by the applicant," thereby gaining the benefits of market allocation of spectrum to its highest valued use. *Id.* at 811-12.

140. Coase, *supra* note 1, at 18. This article was where Coase first introduced the basic insight of reciprocal causation underlying his seminal article *The Problem of Social Cost*, 3 J.L. & ECON. 1, 2 (1960).

141. *See* Coase, *supra* note 1, at 18-24.

The most important element of Coase's analysis was his insight into the possibility of using property rights in spectrum to eliminate interference:

> The main reason for government regulation of the radio industry was to prevent interference. It is clear that, if signals are transmitted simultaneously on a given frequency by several people, the signals would interfere with each other and would make reception of the messages transmitted by any one person difficult, if not impossible. The use of a piece of land simultaneously for growing wheat and as a parking lot would produce similar results. As we have seen in an earlier section, the way this situation is avoided is to create property rights (rights, that is, to exclusive use) in land. The creation of similar rights in the use of frequencies would enable the problem to be solved in the same way in the radio industry.[142]

Similarly, Coase suggested that assigning a property right against interference, like trespass or nuisance, would solve the problem of interference between broadcasters on adjacent frequencies.[143] The person who values transmission more highly would pay the other to cease interference.[144]

The projects that remained after Coase's plain explanation were to identify the content of the property rights to be assigned and the most efficient way to allocate these rights, and to gain the political support to make it law. The former project was vigorously undertaken in the decade and a half following Coase's article.[145] The latter would have to wait until the 1980s for the first explicit endorsement of spectrum privatization by the then-Chairman of the FCC,[146] although it was only

142. *Id.* at 25-26.

143. *See id.* at 26-29.

144. *See id.*

145. The most comprehensive of these studies are, in chronological order, William K. Jones, *Use and Regulation of the Radio Spectrum: Report on a Conference*, 1968 WASH. U. L.Q. 71; Arthur S. De Vany et al., *A Property System for Market Allocation of the Electromagnetic Spectrum: A Legal-Economic-Engineering Study*, 21 STAN. L. REV. 1499 (1969); HARVEY J. LEVIN, THE INVISIBLE RESOURCE: USE AND REGULATION OF THE RADIO SPECTRUM (1971); and Jora R. Minasian, *Property Rights in Radiation: An Alternative Approach to Radio Frequency Allocation*, 18 J. L. & ECON. 221 (1975).

146. *See* Mark S. Fowler & Daniel Brenner, *A Marketplace Approach to Broadcast Regulation*, 60 TEX. L. REV. 207 (1982) (Fowler was Chairman of the FCC under

in 1993 that the FCC actually received authority to auction certain licenses.[147] Since then, the wisdom of applying market mechanisms to spectrum allocation seems to have emerged as the new orthodoxy.[148]

B. The Interference Problem, Licensing, and the Economic Critique

The literature analyzing property rights based solutions to spectrum allocation clarifies that it is the phenomenon of interference that makes the discussion of spectrum as an economic resource intelligible.[149] The value of wireless transmissions, like that of all methods of communication, is that they allow people to communicate with each other.[150] The baseline technical assumption of both the licensing approach and the various proposals for a property regime in spectrum is that in order for a transmission from a transmitter to be intelligible to a receiver, the signal sent by the transmitter must be "louder," by a technically sufficient degree, than the combination of all other signals received by the receiver. More formally, the ratio between the electromagnetic radiation detected by the receiver that carries the message of the sender must be high enough relative to all other sources of electromagnetic radiation similarly detected by the receiver to allow the receiver to decode the message. Interference occurs when for a given receiver, R, there are multiple transmitters, $T_a \ldots T_n$, that transmit at the same frequency, at the same time, and with such power, that given the relative spatial locations of $T_a \ldots T_n$ to each other and to R, the ratio of signal to noise for the transmissions of at least one of $T_a \ldots T_n$ makes the transmissions of that transmitter unintelligible to R.[151] What is important to remember is that, although transmitters propagate signals, interference "occurs" at the receiver.

President Reagan).

147. *See* Pub. Law No. 103-66, 6001-02, 107 Stat. 379, 379-401 (codified in scattered sections of 47 U.S.C. (1994)).

148. *See* Rosston & Steinberg, *supra* note 2; Reed E. Hundt, Spectrum Policy and Auctions: What's Right, What's Left, Remarks to Citizens for a Sound Economy (June 18, 1997) (Chairman of the FCC stating in his introduction that "for the first time ever the FCC truly follows a market-based approach to the allocation and use of spectrum"), *available at* <http://www.fcc.gov/Speeches/Hundt/spreh734.html>.

149. *See, e.g.*, De Vany et al., *supra* note 145, at 1504; Minasian, *supra* note 145, at 224-25.

150. *See* Minasian, *supra* note 145, at 224.

151. Sources of signal degradation that are not caused by radiation of other transmitters of communications are usually referred to as noise, and, while they affect intelligibility, and therefore the signal to noise ratio, they are not generally treated as interference, or as a problem that is subject to solution by anything we would consider to be spectrum allocation. *See* Minasian, *supra* note 145, at 226-27.

The traditional assumption that underlies both the licensing regime that still predominates spectrum allocation policy, and the economic critique that is emerging as its alternative, is that interference occurs *whenever* multiple transmitting devices simultaneously use the same frequency, resulting in "a reduction in the quality of the desired signal, with its actual intelligibility being determined by the (effective) radiated power of the various transmitting sources and their distances from the point of reception."[152] "Two separate communications operators cannot use the same [time, area, and spectrum frequency] without interfering with each other's service."[153] Part IV will explain why this central assumption is no longer true, but first we must see how, given this assumption (shared by both licensing and market-based approaches), a private property regime is presented as preferable to an administrative licensing regime.

It is cliché that the right to exclude is the central "stick" in the bundle of rights that is property. Similarly, the most important part of a license or property right in spectrum is that, in addition to the privilege its holder has to radiate at a given frequency/time/power dimension,[154] it protects the right holder from radiation by others in a manner that causes interference to the right-holder's transmissions. That a privilege to radiate without protection from the transmissions of others is of little avail to its holder is amply demonstrated by the period of the "breakdown of the law" in late 1926.[155]

The core difference between the licensing regime and a property regime resides in who controls the duty not to cause interference. Licensing prevents interference at point *A* (defined by frequency/time/power dimensions) by imposing obligations in the licenses of all transmitters who could technically interfere with reception of transmissions at point *A*, requiring them to transmit in a manner (at a frequency, power, or time) that will not cause such interference. The

152. Minasian, *supra* note 145, at 226; *see also* De Vany et al., *supra* note 145, at 1502.

153. De Vany et al., *supra* note 145, at 1502; *see also* THOMAS G. KRATTENMAKER, TELECOMMUNICATIONS LAW AND POLICY 39 (1994).

154. While there are other possible dimensions along which to identify spectrum use and interference, it has commonly been the practice of the economics literature to treat these three dimensions — time, frequency, and space, as determined by signal power in a geographic point — as the dimensions of spectrum, along which it can be allocated. *See* LEVIN, *supra* note 145, at 16 & n.2; De Vany et al., *supra* note 145, at 1501.

155. *See supra* text accompanying notes 21-29; *see also* Rosston & Steinberg, *supra* note 2, at 102 ("An authorization to use spectrum is of limited value without an expectation that one's legitimate use of the spectrum will be free from interference by others.").

obligations are "owed" to the government and enforceable at its choice. Private property prevents interference by giving the "owner" of the privilege to transmit at point *A* a right against other transmitters to be free of interference at that point. It is the capacity of each owner to exercise this right or refrain therefrom that creates the possibility that spectrum use rights will be reallocated by agreement among users, leading the spectrum to its highest valued use. The economic critique relies on the assumption that if *B* values the right to transmit in a manner that causes interference to the owner of an interference-free transmission right at *A* more than the owner of the right at *A*, *B* will buy out the rights at *A*. The various studies of property regimes in spectrum focus on how to assure that the rights are defined so as to clarify who must be bought out in order to transmit in a given manner, and to limit the transaction costs, primarily detection and enforcement costs, that could prevent this market reallocation.[156]

C. FCC Implementation and Proposals for Market-Based Spectrum Allocation

It is obvious from this description that the spectrum-auction system that has been implemented by the FCC in the 1990s is a far cry from market-based spectrum allocation. Under its statutory authorization,[157] the Commission may use auctions to decide *who* gets a license. But the initial determination of what part of the spectrum will be used, for which service, must be made by the FCC using traditional criteria,[158] and rights associated with the license are no different from those created by the regular licensing process.[159] In effect, auctions remedy a small part of the problem Coase identified — the windfall to initial licensees. Even that problem is solved only as to some licensees, while others, most notably television broadcasters, retain the windfall.[160] The important allocation decisions remain administrative.[161] In their present

156. *See* De Vany et al., *supra* note 145, at 1512-52; Minasian, *supra* note 145, at 227-62.

157. *See* 47 U.S.C. § 309(j) (1994).

158. *See* 47 U.S.C. § 309(j)(6)(A).

159. *See* 47 U.S.C. § 309(j)(6)(A).

160. *See* 47 U.S.C. § 309(j)(2)(A) (excluding from auctions services that do not directly charge subscribers); 47 U.S.C.A. § 309(k)(3) (West Supp. 1997) (giving broadcasters a strong presumption of renewal, and preventing the FCC from considering alternative users and uses at the time of renewal, so long as the licensee has fulfilled its past obligations).

161. In the case of PCS licenses, the definition of the license was sufficiently flexible that, although the Commission thought it was auctioning a license for mobile digital

configuration, spectrum auctions are more a user-fee for government licenses than a market-based system of spectrum allocation.[162]

To remedy the limitations of the present system, the FCC is exploring the possibility of "substantial replication in the spectrum context of the freedoms inherent in property rights."[163] The proposal will privilege licensees to (a) use the spectrum for any use they choose; (b) use the spectrum with any technology and equipment that they choose; (c) aggregate and disaggregate spectrum allocations as they choose, along the dimensions of frequency band used and power/geographic coverage; (d) leave spectrum idle for future use; and (e) transfer the preceding four privileges to control spectrum to anyone else, with Commission approval.[164] Regulation will no longer be in terms of inputs (transmission power, antenna height, etc.), but in terms of outputs — by limiting the overall interference caused by a transmitter outside his or her license area (along frequency/space dimensions).[165] The proposal suggests that licensees be allowed to negotiate variances from the output levels set by regulation, thereby opening the possibility of market-based exchanges of freedom-from-interference rights, as proposed by Coase.[166] Initial allocation would be in blocks that approximate the Commission's best judgment of the highest valued use of the spectrum, in order to avoid situations where transaction costs prevent the spectrum from moving to that use in the secondary market.[167] The spectrum would be exhaustively auctioned, in order to allow market

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communications, AT&T has declared that it will use the licenses to create a local loop with which to compete with local wire-line telephone companies. *See* Laurent Belsie, *AT&T Pulls the Wires and Tosses Down the Gauntlet*, CHRISTIAN SCI. MONITOR, Mar. 4, 1997, at 9; Thomas W. Haines, *AT&T's Secret Is Out: Wireless Plans Are Big*, SEATTLE TIMES, Mar. 2, 1997, at E1.

162. Appropriately, when the FCC presents its record on auctions, the amount of money raised, rather than the efficiencies achieved in spectrum allocation, seems to occupy center stage. *See* FCC, *Wireless Telecommunications Bureau Auction Topics* (last modified Sept. 19, 1997) <http://www.fcc.gov/wtb/auctions>; FCC, *Wireless Telecommunications Bureau Revenue Summary Pie Chart* (last modified Sept. 19, 1997) <http://www.fcc.gov/wtb/auctions/summary/revenue.gif>.

163. Rosston & Steinberg, *supra* note 2, at 99.

164. *See id.* at 99-103, 115. Oddly, the extremely important feature of (at least limited) alienability is almost hidden in the proposal, appearing as an aside text preceding the four other features of flexibility, and later as part of the discussion of the reasons to auction spectrum. *See id.* at 95-96, 107-111.

165. *See id.* at 12. The shift from input regulation to output regulation is a central part of the property regime proposals. *See, e.g.*, Minasian, *supra* note 145, at 230-32; De Vany et al., *supra* note 145, at 1513.

166. *See* Rosston & Steinberg, *supra* note 2, at 102; *see also supra* text accompanying notes 142-44.

167. *See* Rosston & Steinberg, *supra* note 2, at 95.

forces to optimize the use of as much of it as possible, as soon as possible.[168]

D. The Shared Assumptions of Administrative Licensing and Its Economic Critique

The proposals for market-based allocation of frequencies and the present system of administrative allocation share a central factual assumption about the prevention of interference. Both approaches assume that to avoid interference only one person may transmit in a given frequency/time/space dimension. The shared factual assumption translates into a shared organizational assumption. Both licensing and privatization assume that for a given band of frequencies there must be a determinable person who decides how the relevant band will be used and by whom. That person also decides when it is time to change a previous choice: by reallocating frequencies, altering the use of the same frequency, or changing the identity of the actual user at a given moment.

In order to create a centralized organizational model, the two approaches adopt a similar institutional rule. They both constrain would-be transmitters by pointing to a single entity who has the power to permit or prohibit a proposed transmission. While the property-rights approach includes no single centralized authority allocating use of the entire spectrum, as there is in theory in the regulatory system, nevertheless, for each defined portion of the spectrum, there is only one entity to whom the law points as the decision-maker. That person decides whether that channel will be used at all and for what, whether it will be divided and, if so, into which subsets, or whether it will be aggregated with other sets of frequencies, under one's own control (by buying) or someone else's (by selling to another spectrum owner). Administrative allocation bifurcates the function of making these decisions, but for each decision there is always a single entity — the regulator or the licensee — who has the power to make the decision.

Both institutional arrangements attempt to prevent the behavior that they see as causing interference — transmission by more than one person at a given frequency, time and power — by centralizing all decisions about transmission and reception at that frequency, time, and power. Coordination among putative transmitters is achieved through centralized control over the act of transmission. The difference between the two systems lies in how they allocate that control.

168. *See id.* at 93-94.

Part IV explains why the factual assumption that interference can only be avoided by permitting one person to transmit in any defined frequency band is no longer valid and why the shared organizational model is no longer the only way to prevent interference. Removing these elements raises the question that occupies the remainder of the article: whether the institutional framework within which our society will produce the good of remote wireless communications capacity should define discrete entities who have sole power over transmission at a given frequency/time/power dimension (as both licensing and property do), or whether it should foster multilateral coordination among users without assigning to any one person control over transmission at any specified portion of the spectrum.

IV. The Technological Obsolescence of the Licensing/Privatization Dichotomy

A. Overview

The core assumption underlying both licensing and privatization is an anachronism. Recall that interference is a degradation of the fidelity of *reception*, caused by transmissions from different sources that are detectable by a *receiver*, which the receiver cannot sufficiently differentiate to be able to translate into intelligible information.[169] The dominant solution to interference since the inception of radio technology has been to "focus" high transmission power in a narrow frequency band, and thereby "drown out" interference in that channel. The receiver tunes in to the channel, and comprehends the intended signal because it is much "louder" than all other competing signals (interference) and noise in that narrow channel combined. Naturally, if more than one person uses this strategy for the same narrow frequency, neither can be heard.

This "loud transmission over a narrow channel" solution is the reason that both licensing and privatization use a system of exclusive transmission rights over narrow frequency bands. It is also the reason for spectrum scarcity as we know it, because the number of clear "channels" is limited by the radio frequency bandwidth divided by the

169. Note that under this definition, "interference" relates only to that component of the total noise a signal must contend with that is the product of intentional signal-carrying radiations. While "interference" in this sense by no means covers all unwanted radiation with which a signal must contend, it does limit the discussion to those sources of competition with a signal that are solvable by institutional decisions, such as licensing, privatization, or regulation of multilateral coordination capabilities.

minimal "size" necessary for a channel to carry a particular type of signal, such as video or audio, plus the separation between signal-carrying channels (known as a "guard" band) necessary to avoid interference from the spurious emissions of adjacent channels.[170]

Information theory has for a long time questioned the necessity of the technical solution to interference that underlies the regulatory system and its privatization alternative.[171] As early as World War II, there was a proposal for military use of technologies exhibiting high resistance to signal jamming and interception that relied on radically altered baseline assumptions concerning interference-free wireless communications.[172] In the past decade the dramatic drop in the price of processing power, the increase in the sophistication of digital information technology, and the pressures on mobile telephony providers have made the theoretical alternative to the approach of "loud transmission over a narrow channel" a consumer-market reality. Increasingly, companies are using a variety of wireless communications technologies that rely on processing power and sophisticated network management, instead of raw transmission power, to prevent interference, and are allowing many users to use broad frequency bands simultaneously, without interference, instead of

170. Statements basing licensing on the necessity of limiting transmissions over a given frequency to a single person have abounded since the beginning of regulation. *See, e.g.*, General Elec. Co. v. Federal Radio Comm'n, 31 F.2d 630, 631 (D.C. Cir. 1929) (upholding FRC decision based on the necessity of avoiding interference, as "in order to avoid interference between stations when broadcasting at the same time, there should be a difference of 10 kilocycles between the frequencies respectively employed by them; otherwise they will interfere with one another and cannot be clearly distinguished by the receiver"); *see also* United States v. American Bond & Mortgage Co., 31 F.2d 448, 450-53 (N.D. Ill. 1929). Economic critics of the licensing system have similarly relied on the assumption that no two transmitters can occupy the same frequency/time/space unit without causing interference, and thus allocation was necessary. *See, e.g.*, Coase, *supra* note 1, at 25-26 (quoted *supra* text accompanying note 142); De Vany, *supra* note 145, at 1502; Minasian, *supra* note 145, at 26.

171. The two primary sources often cited for this insight are Claude E. Shannon, *Communication in the Presence of Noise*, 37 PROC. IRE 37 10 (1949) [hereinafter Shannon, *Noise*], and Claude E. Shannon, *A Mathematical Theory of Communication*, 27 BELL SYS. TECH. J. 379 (1948), 27 BELL SYS. TECH. J. 623 (1948) (published in two parts) [hereinafter Shannon, *Theory*]. These articles lay out the theoretical underpinnings of direct sequencing spread spectrum. The general approach described here was most expansively stated in a broadly accessible format by George Gilder. *See* George Gilder, *The New Rule of the Wireless*, FORBES ASAP, Mar. 29, 1993.

172. The 1942 patent issued to Hollywood actress Hedy Lamarr and composer George Antheil, is usually credited with having provided the idea of frequency hopped spread spectrum. *See, e.g.*, Fleming Meeks, *"I Guess They Just Take and Forget About a Person,"* FORBES, May 1990, at 136.

allotting use of a narrow channel to a single user for the duration of the communication.

The technological shift derives from various techniques — such as spread spectrum and code division multiple access, time division multiple access, frequency hopping, and packet switching — for allowing multiple users to communicate at the same time using the same frequency range.[173] Some of these technologies complement each other; some conflict with each other. What is crucial to understand about these technologies is that they challenge the underlying assumption of both licensing and privatization: that the only way to assure high quality wireless communications is to assign one person the right to transmit in a given frequency band.

The effect of these technologies on the elements of the institutional framework of wireless communications is to shrink (or even eliminate, in the case of direct sequencing spread spectrum) the unit size of the most efficient frequency/time/space dimension that a user must occupy exclusively in order to communicate without interference. The relevant time units might be as small as 10 milliseconds, and the relevant space no more than 50 yards or so. These units are so small as to make the transaction costs involved in negotiating allocation of exclusive property rights to them prohibitive. Similarly, regulatory control is too cumbersome a vehicle to administer spectrum that is allocated dynamically among fractions of transmissions, on a fraction-by-fraction basis. In the case of spread spectrum technology, no individual user occupies the entire relevant frequency/time/space unit, no matter how small that unit is. The spread spectrum transmissions of multiple users occupy the same frequency band, but are treated by each other as manageable noise, not as interference that causes degradation of reception. The claim here is not, then, that technology has eliminated spectrum scarcity. Instead, the claim is that the pattern of use that is emerging as the technically most efficient way to communicate does not lend itself to regulation through either a property system or a command-and-control regulatory system.

If it is no longer necessary to determine an exclusive user in clearly defined narrow channels, it is more difficult to sustain the central justification for both administrative and market-based regulation that relies on identifying who "the" exclusive user must be as well as how the narrow band will be used. Technology increasingly deployed today shifts the relevant question to how to share spectrum at any given moment among the greatest number of users without causing

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173. For a more detailed description of these technologies, see *infra* Appendix.

interference. While it is certainly possible to answer this question within the frameworks of licensing or privatization, the new technology opens up an institutional arrangement not previously available: like automobile traffic, wireless transmissions can be regulated by a combination of (a) baseline rules that allow users to coordinate their use, to avoid interference-producing collisions, and to prevent, for the most part, congestion, by conforming to equipment manufacturers' specifications, and (b) industry and government-sponsored standards. This is the nature of the "unlicensed operations" institutional arrangement, whereby individuals can use equipment to transmit and receive over a specified range of frequencies without obtaining a license.

The following section draws some flesh on the dry bones assertion that it is technically possible to provide extensive communications capabilities using wireless communications operating in an unlicensed environment. It describes three models of communication that have developed in the very limited frequencies in which the FCC has for a while permitted unlicensed operations.

B. Current Business Models Utilizing These Technologies over Spectrum in Which Unlicensed Operations Are Permitted

The FCC has, for some time, permitted low power transmitters, such as cordless phones or garage openers, to operate without an individual license in specifically defined, narrow parts of the radio spectrum.[174] Relying on the freedom to use these frequency bands without a license, a number of companies have produced equipment for high speed data transmission within the parameters set for unlicensed use, and this equipment has been used to build communications networks that operate in the unlicensed spectrum environment. The results of these initiatives provide a basis for assessing the pattern and viability of communications networks in such an environment.

1. Proprietary Infrastructure Cellular Network: Metricom's Ricochet Wireless Network

Metricom, Inc., a company founded in 1985, has developed a wide area wireless data network using frequency hopped spread-spectrum and packet-switching.[175] The company has deployed its "Ricochet" network,

174. *See* Operation of Radio Frequency Devices Without an Individual License, 54 Fed. Reg. 17,710 (1989) (codified at 47 C.F.R. pt. 2 & pt. 15 (1996)). The bands covered are 902-928 MHz, 2400-2483.5 MHz, and 5700-5800 MHz.

175. *See The Ricochet Network Wireless Overview* (visited Feb. 25, 1998)

utilizing the 902-928 MHz band, in Seattle, San Francisco, and Washington, D.C.[176] The organizational model of the Ricochet system is similar to that of a cellular service.[177] The company installs radio transceivers on street lights or utility poles, placed every quarter to half mile. A twenty-square-mile radius will have about 100 transceivers, creating a microcellular network covering the area. This network is connected to a wired access point, which can connect the wide-area wireless network to the Internet, the wire-line telephone system, or a customer's wired local area network ("LAN"). The network relays signals from one transceiver to another, packet-by-packet, employing 162 frequency hopping channels in a randomly selected sequence along the most efficient route available. This allows sharing by multiple users with little congestion and a relatively high degree of security. Users connect to the network with wireless modems. The modems can connect to the network whenever they are within the coverage area of the wireless infrastructure (the network of installed transceivers). They can also communicate to each other on a peer-to-peer basis, which means that two users of these wireless modems can connect to each other without going through the network in areas outside network coverage.

Metricom's model suggests that unlicensed spectrum could lead to the development of a service model similar to that currently used by cellular and PCS providers. It is a fixed infrastructure system, in which the backbone of transceivers and wired gateway connections is installed and operated by a private company. The owner of the backbone maintains control over communications, and users pay that owner a service fee. The difference between the Ricochet system and cellular or PCS providers is that it is provided not by a licensee or spectrum owner, but by a company that found a way to use an environment in which no one exercises unilateral control of spectrum use.

2. Ad-Hoc Network of Equipment Owned by Users: Rooftop Networks

An alternative model uses similar frequencies open to unlicensed devices in a completely different organizational pattern, relying solely on end-user owned equipment with no owned backbone.[178] In a rooftop

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<http://www.ricochet.net/ricochet/netoverview.html>.

176. *See* John Markoff, *Metricom Says New Network to Lift Speed of Its Modems*, N.Y. TIMES, May 5, 1997, at D4.

177. The following description is based on the company's own description. *See The Ricochet Wireless Network Overview*, *supra* note 175. Without relying on any self-serving claims to success of the system, the description of its design furnishes an understanding of how unlicensed wireless services could operate.

178. The company presenting these devices is Rooftop Communications Corporation.

network, each user's device is both a client of the network and part of the network backbone used to relay the communications of other users. The network uses no licensed spectrum, and no fixed backbone components, like base stations in cellular networks, that must be purchased, installed, or maintained by a service provider. Software installed in the radios coordinates the forwarding of traffic from one peer radio to another and manages congestion.[179] In this form of ad hoc networking,[180] peer radios serve as the backbone for each transmission, based on the most efficient configuration of peer radios not-then-transmitting that form a path for relaying the message from transmitter to receiver.

The user of a rooftop network would purchase a digital radio, an antenna, and a connection to a computer inside the house. The radios use spread spectrum technology and the Internet packet-switching protocol to route information. They can therefore be used to transmit and receive any information that can be sent over the Internet. The radios operate continuously, but transmit only when there is information to be transmitted. Thus the user is always connected to the network to receive transmissions, and the radio is always available to relay messages routed through it by the network. The network could be connected to the Internet through a gateway leased or owned by a group of users.

The rooftop networks model has not yet been deployed, and presents a number of difficulties. As the size of the network increases, the complexity of distributed management rises, requiring a significant amount of overhead traffic to convey network controlling information among the nodes. As use increases, collisions will have to be addressed through increasingly sophisticated means. Furthermore, the network will be formed only after a critical mass of users have purchased expensive equipment[181] that, without similar purchases on the part of their neighbors, will be worthless. Collective action problems arise.[182] The

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For descriptions of the company's products and development projects, see *Rooftop Communications Corporation* (visited Feb. 25, 1998) <http://www.rooftop.com>. As of this writing, the company does not yet offer the equipment described in the text.

179. *See* David Beyer et al., *The Rooftop Community Network: Free, High-Speed Network Access for Communities* (visited Feb. 25, 1998) <ftp://www.rooftop.com/pub/iip_web.pdf>.

180. For an explanation of differences between backbone-based and ad hoc networks, see, for example, Kwang-Cheng Chen, *Medium Access Control of Wireless LANs for Mobile Computing*, IEEE NETWORK, Sept./Oct. 1994.

181. The necessary equipment would cost $500-$750 by Rooftop Communications' optimistic assumption. *See* Beyer et al., *supra* note 179, at 9.

182. An NSF field study in which a small group of commercial users invested in a peer-to-peer network of unlicensed devices with a non-profit, unlicensed Internet access

model nevertheless indicates how unlicensed devices could develop into a wireless local loop that is not owned or otherwise centrally controlled by anyone. Such a model could be used by neighbors or a local governmental body to create a network whose use would be free of service charges once its users invested in the equipment, and whose use would be completely user-defined. In densely populated areas networks might be formed even without coordination, because even at low penetration rates a sufficient number of radios may be available to form a network.

3. Publicly-Owned Infrastructure of Unlicensed Devices: The NSF Field Tests

A number of field tests funded by the National Science Foundation have studied and aided school districts that have chosen to connect their schools to each other and to the Internet using unlicensed equipment.[183] The immediate implication of these tests is that unlicensed operations can become an important alternative solution for public schools' data connection needs, using a different approach than the long term subsidies that are at the core of current universal service efforts.[184] More broadly, these tests suggest that the economies of unlicensed wireless local loops are such that communities may choose to create a publicly funded wireless infrastructure, much as local governments maintain public streets and local roads, for the benefit of their residents.

One of the field studies involved the networking of the eight schools of the Belen Consolidated School District of Valencia County, New Mexico, which span an area over fifty square miles, with a student population of 4,800 and a staff of 250.[185] The entire school district was interlinked at DS1 signal rates, which is the benchmark for high speed

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provider, illustrates the potential for spontaneous coordination. *See* David R. Hughes, *Wireless Lariat Country: A Report on Laramie, Wyoming's Wireless Net* (visited Feb. 25, 1998) <http://192.160.122.20/lariat.txt>. Such a network might be a sufficient core to solve the collective action problems for surrounding users.

183. For a description of the project, progress reports, and reports on specific studies, see *Old Colorado City Communications and the National Science Foundation Wireless Field Tests* (visited Feb. 25, 1998) <http://wireless.oldcolo.com/> and linked sources.

184. *See* 47 U.S.C.A. § 254(h)(1)(B) (West Supp. 1997) (requiring universal service subsidies to cover local loop access costs for educational institutions and libraries); *see also* Federal State Board on Universal Service, 12 F.C.C.R. 8776 (1997) (implementing same).

185. *See* David R. Hughes, *The Connected Schools of Belen, New Mexico: A Wireless Success Story* (May 20, 1996) <http://192.160.122.20/belen1.txt>.

data connections using optical fiber,[186] by installing in the schools radios that operated without licenses, some in the 2.4 GHz range, and some in the 900 MHz range, and a number of routers and servers to manage the network. In operation, the system provided transmission rates of up to 1.22 Mbps, connecting all schools in an effective high-speed wide area network ("WAN").[187]

The cost comparison between the network implemented and a wired WAN at similar transmission rates is instructive. The cost of the wireless WAN was $108,000. Because the infrastructure the wireless network used was not owned by anyone else, there were no service fees. The initial cost (to the school district) of the equipment necessary to use a wired connection would have been only $8000, but the expected service costs for a wired network were quoted to the school district at $84,000 a year. The break-even point of the wireless network would therefore be the fifteenth month of operation. For the expected life of the equipment, assumed to be ten years, the cost of the wireless network would be about one-eighth of the cost of the wired connection.[188]

The primary drawback of the system was that the closest Internet Point of Presence was thirty miles away in Albuquerque. Radios operating within the power limits imposed on unlicensed devices by the FCC cannot reach that distance, and the school district was forced to buy a wired connection from the local telephone company. Unable to afford a high-speed wired connection, the school district spent $125 a month for a 56 kbps frame-relay connection, which was the bottleneck for its Internet access. The community's immediate plans were to make the network available for dial-up modem connections serving the local community, although the district was also investigating wireless connections to avoid the cost of maintaining telephone modem banks.

Another field study involved the wireless wide area network and Internet gateway installed by a Colorado Springs school district with 14,000 students and 3,000 staff members. This network combined unlicensed spread spectrum wireless, licensed microwave wireless backbones, and fiber components to link twenty-six of the total twenty-eight sites in the district to each other and to the Internet, at about twenty-seven percent of the cost of a wired network with similar

186. A DS1 signal is about 22 times faster than a high-end modem at 33.6 kbps, and about 12 times faster than an ISDN connection, at 128 kbps.

187. *See* Hughes, *supra* note 185.

188. *See id.* (detailing cost comparison).

capabilities.[189] The system included a hub, at the administration building, which was connected to the Internet by two T1 lines. From the hub, four licensed microwave links (using 8 microwave radios, at $16,000 a pair), operating at 10 Mbps, connected as a backbone to four clusters of schools. Within these clusters, connections were achieved by deploying thirty spread spectrum radios operating at 2 Mbps, using the 900 MHz and 2.4 GHz ranges open to unlicensed use. The licensed microwave backbone, although not necessary, was included because the budget could accommodate it and because it solved the problem of regulatory limitations imposed on unlicensed devices as backbone elements. Over one year of operation, the system had no failures, even during storms, and the slowest observed speed of Internet access was 256 kbps.[190]

The organizational model presented by these field tests suggests that unlicensed devices could allow communities to install a public infrastructure, much as they build and maintain streets and roads today. The tests were conducted in a framework that affords unlicensed devices minimal operating space, at an early stage of market development. As unlicensed devices become more ubiquitous and equipment prices drop, the cost effectiveness of wireless infrastructure will increase. Limiting the range of spectrum in which transmission without a license is prohibited (or devoting more spectrum to unlicensed use) would enhance the capacity of communications using unlicensed devices. Such solutions could be particularly appropriate for rural and suburban communities, and may involve combinations of public and private, wireless and wired, and peer-to-peer as well as fixed-infrastructure backbone networks.

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189. The following description summarizes David Hughes, *Report on Air Academy School District Microwave and Spread Spectrum System* (Aug. 28, 1996) <http://192.160.122.20/airacad.txt>. Hughes describes the cost comparison as follows:

	Telephone Company Wired T1 (1.54 Mbps)	**Vendor Installation** Wireless E1 (2 Mbps and 10 Mbps)
Installation	$1,500,000	$601,000
10 years	750,000 ($75,000/yr)	0
Total	$2,250,000	$601,000

While the cost analysis exaggerates the cost savings — because it does not reduce the cost of the wired connection to present value, and it does not include any accounting for maintenance of the wireless equipment — the difference is nevertheless stark.

190. *See id.*

V. UNLICENSED OPERATIONS AS THE INSTITUTIONAL ALTERNATIVE TO LICENSING AND PRIVATIZATION: THE U-NII ORDER

A. The U-NII Order

The U-NII Order[191] is a document both pedestrian and inspiring. Pedestrian because it revolves around defining power limits and antenna gains for as yet undeveloped equipment, in defined frequency bands in the 5 GHz range. Inspiring because it gave birth to a new industry and pointed to a new way to regulate wireless communications. It also showed how we could build an infrastructure commons that may be as central to our freedom to communicate in the digitally networked environment as are public sidewalks and streets to our freedom of movement in the physical environment.

The initiative for the Order came from equipment manufacturers. In May 1995, two petitions for rulemaking were filed, one by WINForum, an industry group, the other by Apple Computer.[192] Apple's petition suggests that the proposed band would "mak[e] possible high-bandwidth access and interaction throughout a limited geographic area . . . both on a peer-to-peer, *ad hoc* basis and through wireless local area networks," and "would provide for unlicensed, wireless, wide area 'community networks' connecting communities, schools, and other groups underserved by existing and proposed telecommunications offerings."[193] After notice and comment, the Commission adopted a final order providing for an Unlicensed National Information Infrastructure Band on January 9, 1997. Its provisions became effective on April 1, 1997.[194]

In the U-NII Order, the Commission permitted unlicensed operations in 300 MHz of the 5 GHz range — 5.15 GHz-5.35 GHz, and 5.75 GHz-5.85 GHz. Parts of these bands and frequencies immediately adjacent to them are already occupied by various licensed services.[195]

191. *Supra* note 8.

192. *See id.* para. 2.

193. *See* Apple Computer, Inc., Petition for Rulemaking: "NII BAND," Allocation of Spectrum in the 5 GHz Band to Establish a Wireless Component of the National Information Infrastructure, RM-8653 (May 24, 1995), *available at* <http://www.warpspeed.com/lovette1.html> [hereinafter Apple Petition].

194. *See* Unlicensed NII Devices in the 5 GHz Frequency Range, 62 Fed. Reg. 4649 (1997) (summary of U-NII Order).

195. *See* U-NII Order, *supra* note 8, at para. 4 (aeronautical radionavigation, aeronautical mobile-satellite, fixed-satellite, and inter-satellite services for both government and non-government operations, non-governmental radiolocation services,

The Order imposes certain constraints on the operations of U-NII devices (the radios permitted for unlicensed use in these bands), intended primarily to protect incumbent services from interference. The regulatory requirements imposed, as well as requirements proposed and rejected during the notice and comment process, provide some insight into the institutional choices involved in designing a framework for unlicensed operation. They also provide a valuable understanding of the ecological competition between licensed uses, as a class, and unlicensed uses.

B. Institutional Elements

1. Generalized Rules Applicable to Classes of Equipment

The most important institutional attribute of unlicensed operations is that regulation focuses on general specifications for equipment design and use. Unlicensed operations are intended to occur more generically than traditional licensed transmissions, without analysis of the specific effects of transmission in a given location or time. The regulatory purpose of preventing interference is therefore achieved by imposing generic requirements on equipment seeking to transmit without a license in the specified frequency band, leaving decisions about individual design and use to manufacturers and users.

The U-NII Order imposes four primary substantive requirements on devices for unlicensed operation. First, by definition U-NII devices must provide "wideband, high data rate, digital, mobile and fixed communications."[196] Given the increasing use of data transmission for all types of communication, including telephony and video programming, this limitation is minimal. Second, transmission within bands where unlicensed operations are permitted must not exceed certain specified power levels.[197] Third, transmissions must assure that spurious emissions outside the band be attenuated by a specified factor below the maximum power allowed for within-band transmission.[198] And fourth, a device must transmit only when it has information to transmit, and must cease transmission when it has no information to transmit.[199]

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amateur services, and industrial, scientific, and medical ("ISM") applications).

196. *See id.* at 1621 (to be codified at 47 C.F.R. § 15.403(a)); *id.* para. 62; *infra* Parts V.B.2 and V.D.

197. *See* U-NII Order, *supra* note 8, at 1622 (to be codified at 47 C.F.R. § 15.407(a)).

198. *See id.* at 1623 (to be codified at 47 C.F.R. § 15.407(b)).

199. *See id.* at 1623-24 (to be codified at 47 C.F.R. § 15.407(c)).

2. Peak Power and Power Spectral Density

The most important substantive constraints imposed on U-NII devices limit the power at which they may transmit. The limits are measured in terms of (a) peak power — the maximum power the transmitter may use for the duration of a transmission burst — and (b) power spectral density — the maximum power used divided by the breadth of the frequency band over which the transmission is sent at that power.[200] The peak power limits are linked to antenna gain, and transmitters are given some leeway in adjusting antenna gain and power to attain the desired output.[201] The power spectral density limits were arrived at by dividing the peak power limits by 20, reflecting the Commission's baseline assumption that U-NII devices would transmit on broad bandwidths of at least 20 MHz. Its purpose is to require devices that use less bandwidth to reduce their power.[202]

It is crucial to understand that the specific power limits imposed on U-NII devices are not based on an assessment of the power levels at which such devices can operate without interfering with each other. The limits were imposed to address concerns that U-NII devices would cause interference to incumbent licensed services operating in narrow bands within the broad band in which unlicensed operations were permitted.[203] These power limits therefore represent a clear instance of how commitment to an institutional path chosen in the past — licensed operations — resists attempts to shift course, and can prevent new developments, or at least warp their contours.[204]

200. *See id.* at 1621-22 (to be codified at 47 C.F.R. § 15.407(a)).

201. *See id.* para. 49.

202. It is unclear why power spectral density limits alone would not have sufficed, since that is the "output" of the transmitter insofar as it affects other transmitters. *Cf.* De Vany et al., *supra* note 145, at 1513-17; Minasian, *supra* note 145, at 230-32 (explaining the benefits of defining radiation rights in terms of output instead of input). This would have allowed devices using broader bandwidth, for example 50 or even 100 MHz, particularly those using direct sequencing spread spectrum techniques, to transmit at higher power without increased interference to licensed devices or to other U-NII devices.

203. For a more detailed discussion of the role of concerns over interference with incumbent licensees in determining the power levels, see *infra* Part V.D.

204. See *infra* Part VII.D for a discussion of institutional path dependency and institutional lock-in.

C. Regulatory Alternatives Not Followed

Proposals considered for inclusion in the U-NII Order but ultimately rejected are more enlightening than the U-NII Order itself, in terms of highlighting the parameters of an institutional framework necessary to allow users of unlicensed equipment to share the spectrum.

1. Mandated Spectrum Etiquette

The Notice of Propose Rulemaking ("NPRM") that preceded the U-NII Order had proposed two types of rules intended to permit U-NII devices to share the spectrum.[205] First, the NPRM proposed a "listen before talk" protocol[206] along lines similar to the CSMA/CA protocol:[207]

- A person wishing to transmit in the spectrum of frequencies allotted for unlicensed wireless must, immediately prior to the transmission, monitor the spectrum for at least fifty microseconds.
- If there is frequency bandwidth sufficient to accommodate the transmitter's intended transmission bandwidth, in which no other transmission is detected, the transmitter may emit a transmission burst.
- The transmission burst may be no longer than ten milliseconds.
- After the burst, the transmitter must wait a deference time randomly chosen from a range of 50 to 750 microseconds, and then begin the process again.
- Congestion is minimized by requiring transmitters who find no open spectrum to double the deference time each time they try to access the band unsuccessfully, up to a ceiling of twelve milliseconds between attempts. This creates a

205. *See* NPRM, *supra* note 13, at paras. 51, 52, app. A.

206. *Id.* at 7233 (to be codified at 47 C.F.R. § 15.411(a)).

207. There are, generally speaking, three transmission protocols for network traffic management that could be used for managing shared access to spectrum. These are TCP/IP ("transmission control protocol/Internet protocol"), the Internet protocol that uses first-come, first-served access, with facilities to allow systems using the Internet to sense collisions (congestion) and to slow down transmission rates of all users in order to ease congestion; CSMA/CA (carrier-sense multiple access with collision avoidance), which operates on a similar basis but prevents congestion by transmitting only after first sensing that the medium is a free and then backing off for a randomly selected time; and ATM (asynchronous transfer mode), which uses broadband transmissions of standard sized packets to prevent the potential delays of the other two modes.

feedback mechanism that limits collisions and in effect slows the rate of all transmissions in the band during peak periods.

- All transmissions must be packetized, must assume equal access to the spectrum (no transmissions have priority, and no one centrally determines who will go first when there is congestion), and must therefore be capable of accepting some delay.

This proposal would have, in effect, chosen one spectrum-sharing technique. While reasonable, it is not the sole option for operating without interference. The Commission decided to avoid technique-specific regulation, and to allow equipment manufacturers flexibility in designing their system. Should shared protocols become necessary, the Commission would rely initially on cooperative development.[208] While the Commission's concerns about locking in a single technological standard are understandable, the question of whether a specific set of minimal access-protocol rules is necessary to assure that equipment manufacturers have the right incentives to manufacture spectrum-efficient devices remains one of the central research questions raised by the U-NII order.[209] Furthermore, if standardization is required, it is unclear that awaiting market-based development is the wisest option.[210]

2. Channelization

The second proposal considered was a channel-based internal allocation of the band in which unlicensed operations are permitted. The initial idea was to divide the band into channels 20 MHz wide, and require devices to use the entire bandwidth of a channel. This would assure that the U-NII band would be used for high-rate data transmission, and would be used only by equipment within minimal spectral efficiency attributes.[211] The Commission rejected this proposal, but requested further comment on whether to impose maximum bandwidth limitations, so as to prevent devices from occupying too much spectrum.[212] The Commission finally rejected both versions of the channelization plan. It explained that determining channelization by regulation, instead of by equipment function or through cooperation

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208. *See* U-NII Order, *supra* note 8, at paras. 63-71.
209. *See infra* Part VI.E.1.
210. *See infra* text accompanying notes 241-45.
211. *See* NPRM, *supra* note 13, at paras. 40, 42.
212. *See id.* at para. 51.

among manufacturers, would impose too great a burden on innovation in spectrum use technology.[213] Instead, the Commission's definition of U-NII devices required them to provide "wideband, high data rate" communications.[214]

3. "Part 16" Operation

The last important path not taken was Apple's proposal that the U-NII band be protected from licensed services under what was termed "Part 16" status.[215] The Part 16 proposal would have allocated the band to unlicensed use and treated the band as though it were licensed to all U-NII device users, providing them collectively the same protection from interference as a licensee receives for its licensed transmissions. Although they would share the spectrum among themselves, U-NII devices would not have to be designed around the needs of devices licensed and engineered to operate on an exclusive basis. The idea was that unlicensed operations are no less important than licensed services.

The Commission rejected the Part 16 proposal.[216] Based on the experience of existing unlicensed devices operating under Part 15, the Commission determined that U-NII devices did not need the protection envisioned in Apple's proposal.[217] The language of the report, however, indicates that the Commission's focus on protecting incumbent licensees caused it to misunderstand the Part 16 proposal. For example, with respect to the higher frequency parts of the U-NII band, the Commission explained that "we believe U-NII device manufacturers and users can feel confident that their operations will not cause interference to primary operations."[218] Similarly, in the lower part of the band, the Commission

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213. *See* U-NII Order, *supra* note 8, at para. 61.

214. *See id.* at 1621-22 (to be codified at 47 C.F.R. § 15.403(a)) ("wideband, high data rate, digital, mobile and fixed communications for individuals, businesses, and institutions."); *id.* para. 62.

215. *See* Apple Petition, *supra* note 193; *see also* U-NII Order, *supra* note 8, at para. 91. The usage refers to an as-yet nonexistent part of the FCC regulations, differentiating these unlicensed operations from those permitted in part 15 of the FCC regulations. *See* 47 C.F.R. pt. 15 (1996). Part 15 devices operate on a secondary basis (share the spectrum with licensed uses to which they are junior) and are required to suffer interference from other services.

216. *See* U-NII Order, *supra* note 8, at paras. 93, 97.

217. "While we seek to encourage the important and valuable telecommunication operations which will be provided by U-NII devices, we find that the current record does not provide a compelling reason to believe that such devices require higher or more protected status than we have provided for low power unlicensed devices in the past." *Id.* para. 93.

218. *See id.* para. 94.

found that interference would be prevented by the strict limits on the power of U-NII devices and the requirement that they be limited to indoor operation.[219] The irony of finding that unlicensed devices need no protected band because they have already been limited in operation in order to accommodate competing uses seems to have escaped the Commission. The request for Part 16 status and the Commission's approach to it raise the question of how unlicensed use competes or conflicts with licensed operations.

D. Signs of Ecological Competition with Licensed Devices

Given that the U-NII Order permits equipment users to operate simultaneously, on the same frequency, without a license, with the expectation that as many as 540 million devices could be deployed in only the bottom third of the band permitted for unlicensed use,[220] surprisingly little in the U-NII Order addresses the prevention of interference among U-NII devices. Most of the institutional framework adopted for permitting use of U-NII devices addresses concerns raised by licensed services sharing the same bands, not by potential suppliers of U-NII devices seeking standards to allow them to share the spectrum. Throughout the Order, the justification for most limits on operation is the need to protect incumbent licensed services from interference.

The Commission divided the 300 MHz band into three 100 MHz sub-bands, each with different maximum peak power and power spectral density limits.[221] This separation was put into effect because each sub-band is shared with different kinds of incumbent devices.[222] In addition to different power limits, each sub-band is required to maintain different attenuation levels for out of band emissions.[223] On the band shared with the most interference-sensitive incumbent service, mobile satellite system ("MSS") feeder links, U-NII devices are prohibited from operating outdoors and are required to have a built-in antenna to enforce the peak power/antenna gain rules.[224]

The effect of this decision is to create three distinct regulatory environments, each available to different types of devices. The most powerful devices will be capable of providing all types of services: indoor LANs, short-range multi-building wireless LANs, and longer

219. *See id.* paras. 95-97.
220. *See id.* para. 75.
221. *See id.* at 1622 (to be codified at 47 C.F.R. § 15.407(a)).
222. *See id.* paras. 27, 42.
223. *See id.* para. 53.
224. *See id.* paras. 44, 50.

range communications networks for organizational WANs, community networks, local loops, and mobile communications. The operation of these versatile devices is, however, limited to the top 100 MHz of the available range. The other two sub-bands will allow only shorter-range communications services. To take advantage of the full 300 MHz, manufacturers will have to develop three different types of equipment — indoor, short-range outdoor, and longer-range outdoor devices. Customers will have to buy different equipment for each type of use, instead of buying one piece of equipment and deploying it as need arises. The reason for the creation of three types of devices, using three layers of frequency bands, is not that this division is more efficient for unlicensed wireless operations. It is simply the historical contingency that parts of the band in which unlicensed operations were to be permitted had already been allocated to certain licensed services, and that the different incumbents have different sensitivities to interference.

The conflict between incumbent licensees and unlicensed users is dramatically illustrated by a statement that could easily have replaced Coase's confectioner story:[225]

> [W]e note that it may also be appropriate to reassess the technical parameters governing U-NII devices in light of second generation MSS systems. For example, second generation MSS systems may be more sensitive and therefore more susceptible to interference from U-NII devices. On the other hand, if European HIPERLAN systems proliferate and operate at more power than U-NII devices, second generation MSS systems may of necessity be designed to be more robust and immune to interference from such devices.[226]

The reciprocity of the interference, in the economic sense, seemed to have escaped the drafters of this statement. The future choice by MSS

225. *See* Coase, *supra* note 1, at 26; Coase, *supra* note 140, at 2. Coase's classic example of the reciprocity of the problem of interference or nuisance is the confectioner who has machinery that causes vibrations, and his neighbor, the physician, whose practice is made more difficult because of the vibration. Coase explained that, while we would normally think of the confectioner's machinery as having "caused" the interference or injury, in fact the physician's decision to practice next to the machinery interferes with the confectioner's ability to continue vibrating, as the vibrations interfere with the physician. The problem does not concern one person "wronging" the other; it simply involves incompatible uses.

226. U-NII Order, *supra* note 8, at para. 96.

systems designers to make those systems more sensitive is treated independently, instead of as a form of interference with U-NII devices already designed for the procrustean dimensions of the lower 100 MHz of the unlicensed band. Manufacturers and buyers of the low-power U-NII devices must make and buy the equipment not knowing whether, at some future date, unilateral decisions of MSS systems designers will make their equipment an obsolete "source of interference."

The Order is strewn with examples of objections by incumbents that were rejected or partly accepted by the Commission. The Commission cites an objection from AT&T, for example, arguing that the higher-powered devices envisioned as the basis for community networks should not be allowed to operate without a license purchased at auction, because allowing such operations would bring unlicensed devices into competition with AT&T's purchased spectrum.[227] A local telephone carrier raised similar objections to competition from unlicensed operations as an alternative local loop.[228] Fixed point-to-point microwave licensees objected that their business of longer-range wireless relay could suffer competition.[229] The only similar objection raised by a manufacturer of unlicensed devices came from Metricom, who objected to non-spread spectrum devices in the higher-power range.[230]

The role played by licensed services in the notice and comment period of the U-NII Order indicates two broad types of conflict between licensed and unlicensed uses. First, licensed users occupy spectrum with claims to protection from interference. Their claims, their sensitivities to interference, are a direct constraint on how unlicensed devices may operate. Because of the privileged position of licensed uses within the prevailing conceptual framework, the needs of licensed users trump the needs of users of unlicensed devices. This creates conflict between a model that requires of all users robustness to interference and the capability to share spectrum, and a model that allows some users to be as "sensitive" to interference as they choose, while requiring all other users to adjust their operations to work around that sensitivity.

The second type of conflict is the conflict between two business models: one, a model based on owned infrastructure whose owners capture the value of their investment through service fees over time; the other, a system based on end-user equipment ownership. This is the

227. *See id.* para. 86.

228. *See id.* (quoting the objections of Pacific Telesis Group).

229. *See id.* para. 14.

230. *See id.*; *see also id.* para. 77 (citing Metricom's objection to non-spread spectrum devices).

conflict made clear by the objections of AT&T, PacTel, and the point-to-point microwave link licensees. The NSF field studies[231] indicate that the latter model may be more cost effective. Incumbents who have invested large sums of money in infrastructure, hoping to recoup their investment through service fees over time, have much to fear from the development of a competing business model based on relatively high-priced end-user-owned equipment and free infrastructure.

VI. SOME ECONOMIC PARAMETERS OF THE CHOICE BETWEEN CENTRALIZED AND DISTRIBUTED CONTROL OVER WIRELESS COMMUNICATIONS

The choice concerning regulation of wireless communications is who will decide who may communicate, with whom, how, and for what purposes. The traditional answer has been that the spectrum licensee will make these decisions, within bounds set by the FCC. Increasingly, the dominant answer is shifting towards preferring a spectrum owner over a licensee, and seeking to determine how wireless communications equipment will be used by exhaustively auctioning transmission rights in the entire spectrum, and allowing wireless communications to be used, or remain unused, based on the decisions of these transmission rights owners. The sophisticated spectrum-sharing techniques that made the U-NII Order possible raise a third alternative, which is that no single entity will decide how transmissions in a discrete range of frequencies will be used, but rather that many users will coordinate their transmissions multilaterally.

The question this Part addresses is whether there are systematic reasons, within conventional economic analysis, to think that decisions about wireless transmissions made by a single identifiable entity (in particular, a transmission-right owner) will necessarily be superior to decisions made by an undetermined group of users privileged to transmit and receive in a given band, in terms of maximizing the value of communications to the users of wireless equipment.[232] The analysis

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231. *See* discussion *supra* Part IV.B.3.

232. The more common definition of the value to be optimized as "the value of spectrum," rather than the value of communications to users of wireless equipment, *see* Rosston & Steinberg, *supra* note 2, at 94, suffers from the inverse problem to that identified by Coase when he criticized the use of the notion of a "public trust" in the airwaves, Coase, *supra* note 1, at 31-33. Coase argued that this notion was based on using misleading terminology concerning "the ether" or "frequencies," which created the illusion that they were things to be owned by "the people." *Id.* "What does not seem to have been understood is that what is being allocated by the Federal Communications

suggests that there are no such systematic reasons. It appears that equipment manufacturers and end-users combined, operating in an unlicensed environment, have incentives that are no worse than those driving transmission-rights owners. Furthermore, end-users are likely to have better information, at lower cost, about the most highly valued uses of wireless communication; a system geared to distributing choices about wireless communications use to end-users is therefore likely to produce better decisions.

A. Identifying the Comparison to Be Made

The cluster of decisions that determine who will communicate with whom, how, and for what purposes can be stylized as described in Table 1. Decisions may concern either the physical layer available for transmission of intelligence, or its content.[233] There is no necessary order in which decisions must be made, but once either content or physical layer decisions are made, they may constrain choices concerning the other type of decision.[234] Each type of decision is divided into primary and secondary decisions. This division is based not on any notion of inherent importance of the decision, but of which decision precedes, and hence constrains, the other.

Commission, or, if there were a market, what would be sold, is the right to use a piece of equipment to transmit signals in a particular way." *Id.*

233. I use the term "physical layer" to denote the technical means of actually transmitting the intelligence over the distance separating the sender from the recipient.

234. *See supra*, Part II, for a description of the reflexive relationship between choices about physical layer use and content layer decisions, primarily the effects of the decision of radio equipment manufacturers to use radio to offer one-to-many entertainment on the licensing policies that determined primary physical decisions concerning spectrum use.

Table 1: Decisional Elements Determining Use of Wireless Communications

	Physical Layer	**Content Layer**
Primary Decisions	Definition of frequency/power/time (which band of radio wave frequencies are available at given power/time dimension) Definition of transmission technology (AM, FM, digital vs. analog)	Medium; format (one-to-one voice; one-to-many video)
Secondary Decisions	Standards and protocols (NTSC; AM stereo; HDTV; CDMA vs. TDMA vs. CSMA/CA)	Specific content of intelligence transmitted and received (Seinfeld; "Hi Mom, it's me")

Physical layer decisions begin with the basic allocation decision regarding which clusters of frequencies will be available for use in a single emission (e.g., the FCC has decided that the 6 MHz from 54 MHz to 60 MHz can be used by a single emitter, known to us as TV channel 2). The other primary physical layer decision is what technology the emitter will be permitted to use (e.g., an emitter using the said 6 MHz channel must use frequency modulation in a manner that produces a television signal). The secondary physical layer decision concerns standards and protocols. There may be different ways of supplying similar communications services, using the same primary technology. A television signal using frequency modulation can be created using the North American NTSC standard, for example, or the European PAL standard. A decision must be made concerning which standard will be used to transmit in the stated channel. In the case of the channel between 54 to 60MHz, in the United States the emitter must use the NTSC standard. It is impossible to develop a standard without a decision about how broad a channel is available for a single emission, and thus the primary decision maker can exert control over the secondary decision. But standards are not necessary to the definition of emission units, so the decision maker of the primary physical layer decisions may decide without making or awaiting the secondary decision.

Primary content layer decisions concern the medium or format of communications using the transmission capacity made available by the physical layer decision. For example, the FCC decided that the 6 MHz band defined in the preceding paragraph be used in a one-to-many transmission mode (broadcast) of combined pictures and voice for eighteen to twenty-four hours a day. This leaves undetermined, but constrained, the secondary content layer choice, which concerns decisions of what will actually be transmitted and received over a given channel, using given standards in a given medium. So we might, for example, see Seinfeld or the local news on Channel 2 — a joint choice made by the station licensee and the viewer tuning in — but Mom could never see or hear little Johnny calling from school. The decision about the medium not only precedes the decision about the content of a particular transmission, it is also severable from it, so the primary decision maker has the option to control the secondary decision or to refrain from controlling that decision.

The value to be maximized is the aggregate value of communications using wireless transmission to all its users. This value is to be maximized by the aggregation of decisions at each layer, along both horizontal and vertical axes. Table 2 compares who makes which decision under a number of institutional arrangements: licensing, auctioning, privatization, and unlicensed operation.[235] Note that the table reflects the observation that the major difference between auctioning as currently practiced and licensing is that in an auction, the federal government appropriates the value of the license, whereas in a licensing regime, initial licensees do so in the secondary market for licenses.[236] Efficiency gains from privatization are likely to accrue if and when decisions about spectrum use are finally made by spectrum owners. Such gains are unlikely to accrue as long as government continues to decide what part of the spectrum will be used for which type of service, and uses auctioning simply to decide who will be the private organization providing that service over the allocated channels. The discussion therefore focuses on comparing exhaustive privatization, as described in Part III, to the unlicensed wireless alternative.

235. On the difference between auctioning, which uses market allocation only to determine who gets the license, but determines all else administratively, and actual privatization, which would allow reconstitution of rights so as to devolve what are termed here primary physical layer decisions, as well as content layer decisions, into the hands of spectrum purchasers, see *supra* Part III.C.

236. *See supra* Part III.C.

Table 2: Decision Makers Under Alternative Institutional Arrangements for Spectrum Allocation

	Licensing	Auctioning	Privatization	Unlicensed
Primary Physical	Government	Government	Government initially; Owner through reconstitution of rights[a]	Government as to power; Equipment manufacturers through hardwired protocols[b]
Secondary Physical	Licensees; Equipment manufacturers; Government	Licensees; Equipment manufacturers; Government	Owners; Equipment manufacturers; Government	Equipment manufacturers; Government
Primary Content	Government; Licensees	Government; Licensees	Owners[a]	End-users
Secondary Content	Licensees (TV); can delegate to users (cellular)	Licensees (MMDS); can delegate to users (PCS)	Owners; can delegate to users	End-users

a. The primary reason justifying transition from licensing to privatization is that it transfers more of the decision making from government to market-signal-sensitive owners.

b. The current U-NII band provides no special subband for unlicensed operations protected from interference by competing licensed uses in the same bands. It consists merely of permission to emit at stated powers in a broader swath of spectrum than necessary for any single unlicensed transmission. This means that for the power dimension of the unit, government makes the primary physical layer decision, but for the frequency/time dimensions, unlicensed equipment following embedded protocols (secondary physical layer decisions) dynamically makes primary physical layer decisions on a transmission-by-transmission basis.

From this table it appears that there are two central questions to be answered from a neoclassical economics perspective about the choice between the unlicensed wireless arrangement and exhaustive privatization. First, there is the question of whether there is systematic reason to believe that spectrum owners who hold allocations initially determined by government will make better physical layer decisions than equipment manufacturers operating within a range minimally defined by government regulation. The second question is whether spectrum owners will make better content layer decisions about spectrum they own than will end-users of unlicensed wireless devices. The conclusion of this Part is: (a) that there is no good reason to hold the first view, or at least that to find out whether spectrum owners or equipment manufacturers will make better decisions is probably too costly to justify using exhaustive privatization to find out whether a commons-like model develops for part of the spectrum; and (b) that it is uncertain whether owners or end-users will make better content decisions, but that there are reasons to believe that users will value more highly the ability to make their own choices about content, even at the loss of quality, than they will value high-resolution content determined by others, namely, spectrum owners.

B. Are Spectrum Owners Better than Equipment Manufacturers Operating in an Unlicensed Environment at Making Decisions About the Use of Spectrum?

1. The Incentives of Spectrum Owners

The reasons supporting the efficiency of decision making by spectrum owners were discussed in Part III, and require only brief clarification here. Spectrum owners capture the value of their right to make unilateral physical and content layer decisions about a given channel by either leasing parts of the transmission right, in the form of the right to make secondary content decisions, to users who wish to use the channel to transmit,[237] or by selling secondary content layer decision-making services (i.e. programming) themselves to those who wish to receive transmissions.[238] These owners will make physical layer decisions that will permit them to maximize the value they can appropriate from the sale or lease of these rights. If another organization believes that it can better use the physical layer owned by an owner, that organization will bid for the transmission right and buy out the inefficient owner. Since the owner can sell its spectrum, and the new purchaser can change the physical and content layer decisions made by its predecessor, at each point in time an owner will put the spectrum to

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237. Broadcasters most notably lease the right to advertisers. Network affiliates lease the right to networks. Cellular services lease the right to those who wish to transmit point-to-point voice messages.

238. Direct broadcast satellite ("DBS") is the most popular version of this model. The payment is extracted because the broadcaster can control the information flow over its channel and "physically" prevent reception by users who do not pay for a descrambler.

the use for which it can receive the highest payment from users, which is deemed to be the use most highly valued by users.

There are a series of transaction costs involved in management and reconstitution of transmission rights that affect the likely efficacy of decision making by spectrum owners. These costs are associated with deciding how to use the transmission rights, including costs of collecting information about what the highest valued use is at a given time, processing that information, and deciding to switch uses when appropriate. They are continually incurred by the transmission rights owner and by putative purchasers of transmission rights to determine what the highest value of transmissions will be.

Transaction costs also include the costs associated with switching between uses. Because, as explained below, owned transmission rights will tend to focus on higher quality provided for a narrower range of uses, the equipment that is likely to be deployed for their services will be relatively specialized. A shift in use will entail the purchase of new specialized equipment. This cost will present a barrier to shifting uses of the transmission right. Use will only be changed if its added value will be greater than the cost of retooling. Further, opportunity costs associated with the continued use of equipment after a shift would have been undertaken but for the partial lock-in effect of specialized equipment, are part of these transaction costs. In addition, there are costs of communicating the availability of a new service to purchasers of transmission rights or to purchasers of reception services, and transaction costs incurred from time to time in signing customers up for new, higher-value services, and disengaging from users of old uses.

Another cost of management of transmission rights can be viewed either as an enforcement cost or as a lost positive externality. The owner of transmission rights will offer only services for which it can internalize the benefit, because those are the only services it identifies as valuable. For example, assume two customers of *A*, *m* and *n*, where *A* is the owner of the transmission rights in a certain band and offers wireless telephony. Assume that *m* and *n* are close enough to each other (e.g., within one cell of *A*'s system) that they could use wireless phones to call each other peer-to-peer using *A*'s spectrum allocation. *A* could design its system to allow peer-to-peer calls, or it could design its system so that all calls, including intra-cellular calls, must bounce off a base station. *A* would have a preference for designing the system with a bounce, instead of without it, even though this requires additional equipment and network management costs, because this allows *A* to capture the value of the conversation between *m* and *n* while peer-to-peer communications would not. To avoid this problem, *A* might resist manufacture of equipment capable of peer-to-peer communications over its band, impose a royalty on such equipment, or raise the rates for all its users to cover the lost value of peer-to-peer communications. Services not provided because the transmission rights owner cannot internalize their value, and marginal users who drop off because of the incremental price increase to offset uncaptured value, are lost positive externalities. Costs incurred by owners to identify and capture externalities are enforcement costs.

To the extent that management costs and transaction costs will prevent an owner from identifying the highest valued use, or prevent a putative better user from acquiring the channel and changing its use, spectrum owners will be inefficient decision makers as to how spectrum should be used. In this context, it is worth noting that the distributed model does not incur the costs of centralized determination of the use of the transmission rights, because that decision is made by end-users. The distributed model also does not incur the costs of network management over time. These costs are rolled into equipment design costs, and thus into the cost of equipment capable of transmission without interference over an uncontrolled band of frequencies. Therefore, the primary cost of the distributed model is the relatively high initial investment in equipment, and that cost comes to represent the value that users attach to the capability to transmit and receive in the unlicensed environment.[239]

239. The fact that equipment costs will reflect the value both of transmitting and of receiving in this environment highlights a problem with the traditional focus on transmission as the "cause" of interference, based on the engineering fact that it is radio propagation, not its reception, that "creates" interference. It is important to remember that from an economic behavior standpoint, if there is an option to use two types of reception equipment, one that is "dumb" and requires the transmitter to use high power over a narrow frequency to drown out competing signals, and another that is smart in that it can pick up spread spectrum or otherwise multiplexed signals, then the choice to use a dumb receiver causes interference to those who would otherwise use "smart" devices, no less than Coase's physician causes the confectioner interference by being sensitive to vibrations. For example, a consumer's decision to use a device capable of receiving and transmitting analog voice (e.g., a cellular phone), which requires an exclusive channel, interferes with the use by others of equipment based on packet-switched digitized data for similar purposes (e.g., a U-PCS or U-NII device). The sensitivity of the former to interference, and the consumer's right to be free of interference, prevent users of the latter from using their equipment of choice, or imposes on them additional costs for the more sophisticated equipment necessary to utilize higher frequencies or to operate at lower transmit power levels. For the set of users *A*, *B*, *C*, and *D*, for example, if *A* wants to transmit, *B* wants to receive what *A* transmits, and *C* and *D* want both to transmit and to receive, if *B* uses equipment that can only receive *A*'s transmissions if *A* transmits but *C* and *D* do not, then *B*'s choice will interfere with *C* and *D* if it leads to the recognition of a transmission right in *A* as against *C* and *D*.

2. The Incentives of Equipment Manufacturers

The value of communications in an unlicensed environment is, then, measured primarily in the price of equipment capable of unlicensed operation.[240] To maximize the value of the equipment they produce, manufacturers must maximize the value of communications their equipment makes possible for its end-users. There are two types of investments that must be made in order to maximize the value of communications in a given range of frequencies, and which will be made by equipment manufacturers where they would have been made by spectrum owners/licensees in a privatization or licensing regime. The first type of investment involves development of standards and protocols to allow networking (secondary physical layer decisions). The second type involves investment in increasing equipment efficiency, and hence spectrum utilization efficiency, to gain an advantage over competitors in the market for equipment (primary physical layer decisions).

a. Standard Setting Incentives

Table 2[241] suggested that secondary physical layer decisions — those involving standard setting and the creation of shared protocols — will not be centralized under any of the regimes. In the traditional models of licensing, auctioning, and privatization, standards come into play in one of two ways. First, where the primary content layer decision is to offer a broadcast model service (so that secondary content layer decisions are also made by licensees), standards are necessary to allow a critical mass of equally accessible complimentary programming offered by competing licensees/owners to induce consumers to buy the equipment necessary for receiving the type of programming offered. Second, where the primary content layer decision is to produce an end-to-end communications model, like mobile phones, standards are necessary for interconnection between the services offered by competing licensees.

Firms operating under conditions of incomplete information and communication will have difficulties in establishing standards, even if establishing any given standard will be beneficial to them all.[242] The history of standard setting for wireless communications applications in the United States suggests that spectrum licensees are not exempt from

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240. *See supra* Part VI.B.3.

241. *See supra* p. 344.

242. *See* Joseph Farrell & Garth Saloner, *Standardization, Compatibility, and Innovation*, 16 RAND J. ECON. 70, 75-81 (1985).

the difficulties involved in deciding about standards.[243] The incentives and difficulties faced by equipment manufacturers in developing a standard are no different from those facing licensees/owners. They might attempt to do so, for example, by using an industry forum, like those that lobbied for the petition that resulted in passage of the U-NII Order. They might seek intervention from the FCC as a form of honest broker. Furthermore, since the market in devices of this type, like the markets for computers and faxes, will likely be typified by network externalities,[244] it is not impossible that developers will open their standards fully or partially in order to establish a favorable product ecology and capture network externalities for the developer's products, and that competitors will adopt one or another of the standards in order to gain network effects, leading to tipping that will establish a single de facto standard.[245] However standards might eventually develop for

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243. *See, e.g.*, Leo Herzel, *"Public Interest" and the Market in Color Television Regulation*, 18 U. CHI. L. REV. 802 (1951) (describing vicissitudes of color television standard setting); Bruce C. Klopfenstein & David Sedman, *Technical Standards and the Marketplace: The Case of AM Stereo*, 34 J. BROADCASTING & ELEC. MEDIA 171 (1990) (describing failure of market to settle on single standard for AM stereo).

244. Different products may have network externalities to different degrees and for different reasons. A telephone, the classic instance of a network good, is almost completely useless without other telephones, and the availability of network effects to each telephone resides in physical connection to other telephones. Faxes, while similarly pure network products, were from their creation physically connected to a widely deployed network. The barrier to achieving network effects in the case of faxes was the absence of standards necessary to permit the physical machines, which were physically connected, to communicate with each other. Computers and software are not fully network goods like phones and faxes because they have some intrinsic stand-alone value. Nonetheless, each type of product also has a network effects component to its value. When analyzing unlicensed wireless devices in comparison to these well-known network products, it is important to keep in mind that unlicensed devices are more like faxes and computers than like software or telephones. They do not have the same high initial investment costs with rapidly tapering marginal costs, which are common in full blown increasing returns markets, as software (where almost all cost is in the first copy produced, and all other copies are almost at zero marginal cost) and telephones (where almost all of the investment is in the infrastructure, and the per-customer marginal cost is very low, while for faxes this investment had already been made, and there was no equivalent entry cost). Like faxes and computers, however, there are very strong network externalities to U-NII devices in that the more people use a particular form of device, the more people can connect to each other using that device (as they can fax to each other, or share documents and programs because they use similar platforms, as in the PC/Apple case). Shared standards would help each manufacturer establish a favorable product ecology, although they raise the specter that one manufacturer will dominate the market through proprietary control of a standard.

245. *See* W. Brian Arthur, *Increasing Returns and the New World of Business*, HARV. BUS. REV., July–Aug. 1996, at 105-07; Charles R. Morris & Charles H. Ferguson, *How Architecture Wins Technology Wars*, HARV. BUS. REV., Mar.–Apr. 1993, at 86.

unlicensed wireless equipment, in the absence of evidence that one or another group has better mechanisms or incentives to collaborate in standard setting, we must be agnostic as to whether equipment manufacturers will have a harder time agreeing on standards in order to sell devices than will spectrum owners in order to sell transmission services or programming.

b. Efficient Spectrum Use Incentives

Even if there is no good reason to treat the likelihood of appropriate standard-setting as a distinguishing feature between unlicensed wireless and licensed/privatized spectrum, there remains the question of whether, assuming that necessary standards have been established, equipment manufacturers will have the appropriate incentives to invest in increasing the efficiency of spectrum use by their equipment.[246]

Manufacturers who deliver more reliable throughput more quickly will have an advantage. Users will value equipment that allows them to transmit and receive more rapidly, with higher fidelity, and so forth. Systems that provide high ratios of information sent to frequency time/bandwidth/space used (through, for example, higher compression rates) will tend to fare better in an environment operating on a first-come, first-served basis than systems that use more spectrum (i.e., more bandwidth, for more time) to send the same amount of information. Systems capable of detecting spatial or frequency band congestion points (say, a cell or frequency range with high traffic) and routing around it, will similarly fare better in an environment where congestion is the primary expression of spectrum economic scarcity than systems that do not incorporate congestion avoidance mechanisms. This is the mechanism by which unlicensed operations provide an incentive for intensive margin development of the spectrum resource.[247]

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246. Manufacturers of U-NII devices will have incentives to maximize the utility of unlicensed operations for their putative customers similar to those motivating equipment manufacturers in the early days of radio. These manufacturers "developed" the spectrum by building equipment capable of more efficient (longer range, higher fidelity, etc.) use of the spectrum than could their competitors, "invented" broadcasting as a means of selling home receivers, and then initiated and participated in the semi-voluntary licensing system prior to the Radio Act of 1927 in order to prevent the dissipation of that value through interference. See *supra* Part II.B, which discusses the role of equipment manufacturers in the development of the broadcasting medium and spectrum utilization.

247. *See* LEVIN, *supra* note 145, at 19-24, 228-30 (describing the incentives a rental charge system would create for spectrum lessees to develop the intensive and extensive margin of the radio frequency spectrum). Note that this claim ignores the history of radio, where short-wave communications were developed by amateurs "banished" there

Furthermore, government can encourage manufacturers to develop and be first to market with equipment using new, uncongested frequencies by signalling to them that unlicensed tranmissions will be permitted in as yet unused ranges of frequencies should they develop equipment for unlicensed use in those bands. By this mechanism unlicensed operations would create an incentive to develop the extensive margin of the spectrum equivalent to that sought to be achieved by exhaustive privatization of unused frequencies.

In other words, in an unlicensed environment, equipment manufacturers in general will fulfill the same role allotted to the spectrum owner in the property rights approach to spectrum management. The market in equipment will reward equipment manufacturers for producing and marketing devices that deliver the best possible transmission services in an unlicensed environment, just as the market in transmission rights rewards spectrum owners for efficient use of their spectrum allocations.[248] The question then remains of whether content layer decisions, made in an unlicensed environment by end-users, can be said to be systematically inferior to decisions made by transmission rights owners.

3. The Role of User Incentives as to Physical Layer Decisions

Before treating the question of content, there is the issue of the concern that, even if manufacturers have proper incentives as to physical layer decisions, users will not. Once a user has sunk the cost of equipment into the unlicensed device, the argument would be, marginal use of wireless transmissions with that equipment would be free, thereby causing overuse. This objection is misleading for two reasons. First, as to the choice between unlicensed wireless devices and devices based on wired or licensed wireless infrastructure, the value of communications over time using an unlicensed device is expressed in the price of the equipment. Ex ante, a consumer would compare the cost of all communications over the life of the equipment to the cost over the same period of use-priced communications.[249] If a user then uses the equipment extensively, the possibility of such use will be reflected in the

by licensing that favored broadcasters. *See* BARNOUW, *supra* note 39, at 151-52.

248. The possibility that equipment manufacturers will also use spectrum-wasting techniques when such techniques will enhance the values of transmissions using their equipment can be addressed by designing the access rules and transmission protocols to negate such incentives. *See infra* Part VI.E.1.

249. See *supra* Part IV.B.3. for a description of such a cost-benefit analysis performed by school districts comparing wired networking solutions to unlicensed wireless solutions.

initial equipment price, and will be a valued use reflected in the market for equipment, which replaces the market in spectrum in the unlicensed environment. Second, use over time is not free. A user of an unlicensed device continues to incur costs over time in terms of the opportunity cost of time not spent on activities other than communicating using an unlicensed device. Users will not use their unlicensed wireless device if the value of the time spent using the device is lower than the value of that time to them employed in some other use, whether that other use is communicating with a different method or on a non-communicative activity. Overuse expressed as congestion will lead to queuing — or higher prices — expressed in time. Queuing, in turn, is the appropriate allocation method whenever the cost of avoiding queuing — increasing capacity or instituting a price system without a queuing component — is higher than the cost of the time lost in the queue.[250]

C. Are Spectrum Owners Better than End-Users at Making Content Layer Decisions?

The difference between the unlicensed wireless and privatization models as to content layer decisions is that in the former, transmission rights owners make choices on a channel-by-channel basis, while in the latter, end-users make them on a transmission-by-transmission basis. At the outset it should be made clear that unlicensed wireless, as currently understood, would technically permit all forms of digitally-encoded information to be transmitted in a high-capacity wireless local loop, and could be connected to the Internet — or a future broadband medium — for relay or reception beyond the reach of the locally deployed wireless network. The unlicensed nature of the environment does not, therefore, in and of itself, impose constraints on the types of content it can carry.

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250. Allocation by queuing is not discontinuous with allocation by pricing. Because queuing uses a simple allocation rule — first come first serve — transaction costs associated with it are low. The amount of information necessary to administer the rule is minimal, there is no room for negotiation, and the number of parties to every allocation choice is two — for any two conflicting claims to use, the only relevant question is who came first in that pair. When the value of time lost in the queue is lower than the transaction costs associated with instituting a price-based exchange for allocating a good, we see queuing used to allocate that good. For example, in boarding an airplane, queuing is always used. Pricing is often, though not always, used for an initial gross allocation of the boarding order of clusters of customers (first class, business class, coach), but then within clusters queuing is again used. Similarly, higher-priced stores attract fewer customers and can employ more cash-register personnel per customer, replacing pricing for queuing at the register. Such a store would still revert to queuing above a certain cost per minute lost in the queue. Most prominently in our economy, we use queuing for automobile transportation and computer networks.

The question, therefore, is whether transmission rights owners have better incentives and better ability to define the highest valued use — in terms of content — of their channel, or whether end-users in an unlicensed environment do.

The comparative advantages of owners and end-users at making choices about content depend on the assumptions one makes about what is valuable in communication. The centralized system will tend to provide a higher resolution[251] signal for the communications of fewer users, while the distributed system will tend to provide a more flexible fit to the communications needs of more people, but at a cost to the resolution of the signal provided for each use. The relative value of each system will depend on the relative values of resolution and flexibility to end-users engaged in acts of communication.

The rationale for the centralized system is that it identifies an owner/licensee who decides how the equipment that transmits and receives in the frequency band is used. That arrangement is deemed efficient because it allocates the spectrum hierarchically, based on the willingness of users to pay. Once a channel owner has identified a channel use that will maximize the owner's value, the channel will be devoted to that use. The owner will then offer as high quality a service for that communicative use as necessary to increase the paying users of that use, as long as the price of adding quality is no greater than the income from marginal users. For example, over-the-air television is mostly sold to advertisers. The service they buy is the broadcast of a mix of direct advertising and programming that attracts the attention of viewers from the advertiser's target markets. Maximizing revenue depends on transmitting content that captures the attention of receiver users who tend to buy the products advertised. It therefore also maximizes the value of receiver owners most likely to purchase products based on television advertising. This business model is dominant, although the same equipment can be used to satisfy different preferences, as evidenced by public television.

The distributed approach relies on individual, moment-by-moment decisions of end-users to use the equipment for their highest valued use at that moment. The immediate cost of use is the opportunity cost to the individual's time. An individual will use an unlicensed device (whose capital cost is sunk at the moment of use) if using that device, for a

251. I use the term "resolution" broadly, to denote the fidelity of the signal to the communications need addressed. This is intended to cover a broad range of attributes, including technical fidelity, such as number of pixels in a picture, and content quality, such as that attained by using professional actors and camera crew — instead of amateurs.

particular use, at a given moment, is a higher valued use of the individual's time and attention than any alternative use. To allow this form of maximization, equipment must provide flexibility in terms of the uses to which it can be put and adaptability as the user's needs change over time. In this sense, it is likely to provide a better fit for the communications needs of more people. Because of the greater flexibility, however, there will likely be a lower incentive to invest in optimizing any given use than in a system that provides less flexibility and a smaller range of potential uses.

In comparing the utility of each of the systems of regulation, therefore, an important consideration is the relative value of flexibility and breadth of fit between equipment use and the needs of every user, versus quality of fit between the equipment use and the preferred use that the users who, as a group, are willing to pay the most. The question is whether the value of the additional "quality" achieved through centralized management is outweighed by the value of adaptability to the needs of more users made possible by the "flexibility" of a system based on distributed coordination. A contemporary choice concerning a similar tradeoff faces television and cable companies with the introduction of digital transmission. While the broadcasters' focus has been on the delivery of High Definition TV (higher quality of the narrow menu of offerings already in existence), cable companies facing competition from direct broadcast satellites are planning to use the same technology to add more channels at lower resolution.[252] These competing market trends indicate that it is not yet clear whether providing a smaller range of uses at higher resolution or greater flexibility and breadth of coverage at lower resolution will yield higher value.

D. *Comparing the Models: Examples of Similar Choices*

In the absence of good systematic reasons to prefer transmission-rights owners to equipment manufacturers and end-users, the central question is which of the two systems will more efficiently deliver the communications uses most valued by users — an empirical question that will be determinable upon the development of markets for each type of service. Should such markets develop, it will be possible to compare the value users place on communicating in an unlicensed environment to the value consumers place on communicating in a licensed environment, by

252. *See* Joel Brinkley, *As Digital TV Arrives, Cable's Picture May Not Be So Clear*, N.Y. TIMES, May 5, 1997, at D1 (describing the opposed strategies of broadcasters and cable companies on deployment of digital technology for television services).

measuring the expenditures in the relevant markets (including equipment, services purchased, and time spent). Early empirical studies comparing these systems for delivery of wide area data networks favor unlicensed operations, but those comparisons are based on distorted costs for both unlicensed and licensed systems. On the unlicensed side of the comparison, the equipment market is almost non-existent, and has not yet captured any of the scale or scope economies that it should in the future. On the licensed side of the comparison, the costs of the Internet high-speed connections were presumably artificially high, due to the service providers' market power in the heavily concentrated markets that were studied.[253] The costs of both alternatives were thus inflated in these studies, each by a factor independent of that inflating the other.

A better indication of the possible advantages of the distributed model, at least for some classes of uses, arises in two other instances where a value could be generated both by a centralized, proprietary model, and by a distributed, non-proprietary model. These examples are the transportation system and computer networks.

In the nineteenth century there developed two competing solutions to the problem of transportation. One approach was based on proprietary routes, operated and managed by a centralizing owner operating under a franchise from the state, and offered to users for a fee. These included first turnpikes, then canals, which were very shortly thereafter supplanted by railroads.[254] The alternative approach was based on privileged use for all, with no proprietary control. Use of these routes was coordinated by custom or general use rules. These included roadways and navigable waterways,[255] which were operated as a commons managed by customary norms followed by their users.[256] After the internal combustion engine equalized to some extent the capabilities of rail and road, the twentieth century has seen the parallel development of a system based on proprietary control of infrastructure and a system based on multilateral coordination of equipment users operating on an infrastructure regulated as a managed commons. In

253. *See supra* Part IV.B.3 (describing NSF field tests and the economic comparison between unlicensed devices and wired or fixed-microwave alternatives).

254. On the development of the legal framework within which the proprietary models developed, see MORTON J. HORWITZ, THE TRANSFORMATION OF AMERICAN LAW, 1780-1869, at 124-39 (1977). On the rapid deployment of railroads, and the degree to which the success of railroads is linked to their managerial form, not only their technological superiority, see ALFRED CHANDLER, THE VISIBLE HAND: THE MANAGERIAL REVOLUTION I[illegible]MERICA 81-89 (1977).

255. *See* Carol Rose, *The Comedy of the Commons: Custom, Commerce, and Inherently Public Property*, 53 U. CHI. L. REV. 711, 723-27, 730-39 (1986).

256. *See id.* at 739-49.

1992, for example, the year for which the latest numbers are available from the economic census, total revenue from rail transportation, including local and interurban passenger services, was $40,996,202,000.[257] Total revenue for the same year from local and long haul trucking services alone, excluding warehousing, was $111,912,000,000.[258] This value excludes the value of trucking performed by independent operators with no employees, private motor carriage departments within firms, and, of course, the value of local and long haul transportation of passenger automobiles. While the distributed model has not completely eclipsed the centralized/owned model in ground transportation, it seems to be the dominant model, despite the associated queuing/congestion costs, and despite the high end-user equipment costs relative to the cost of service-based payment for rail tickets or freight.

The usefulness of the roadway-railroad comparison is compromised by two objections: highways are publicly subsidized, while railroads are not; and toll highways do not fall neatly into either category. First, it is hardly surprising that people use a subsidized good more than they use another (imperfectly) substitutable good that is not subsidized. Recall, however, that the comparison of licensed and unlicensed wireless is between: (1) a service with high upfront costs, relatively low resolution, and the potential for delay or congestion, but with the benefit of flexibility of use to fit the user's specifications as they change over time; and (2) a service with costs incurred over time rather than up front, relatively high resolution, and little potential for congestion or delay, but with a more controlled menu of choices. Similarly, trucks are high-upfront-cost, low-usage-cost devices that offer congestion-prone, flexible use; trains are low-upfront-cost, high-usage-cost devices that offer congestion-free, fixed-menu use. What the subsidy to roads does is increase the usage cost differential between the alternatives. It does not affect the qualitative inference that for some given differential usage cost, consumers will prefer a high upfront cost device to a low initial cost, and that for some measure of increased flexibility (time of departure), users will accept a reduction in resolution (sitting in traffic jams). In particular, it should be noted that in the U-NII band scenario,

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257. *See* U.S. Census Bureau, *1992 Census of Transportation, Communications, and Utilities, U.S. Summary* (visited Feb. 25, 1998) <http://www.census.gov/epcd/www/uc92html.html> (value in text represents combined values for SIC 40 and SIC 41).

258. *See* U.S. Census Bureau, *Motor Freight Transportation Services and Warehousing Survey, Table 1, Motor Freight Transportation Services and Warehousing (SIC 42) — Summary Statistics, by kind of business, 1991-1995* (visited Feb. 25, 1998) <http://www.census.gov/svsd/tasann/view/tab1.pdf> (value in text derived from columns 3 and 4, and note 2).

the free usage of the common infrastructure is not the result of subsidy, because no cost is involved in developing, maintaining, or recovering the infrastructure. The low usage price reflects the shifting of the network management costs into the initial equipment cost.

The existence of toll roads, the second concern with the roadway-railroad analogy, would in fact be a significant criticism of the degree to which one can rely on the analogy, except that toll roads, as they are in fact used in the United States, fulfill a different role in the roadway network than the unlicensed spectrum would fulfill in the broadband communications network. Toll roads are limited to main artery highways or to high- cost bottlenecks like bridges and tunnels. The role of these components of the Interstate Highway System is more akin to the role of trunks (public or leased) in the Information Infrastructure, and either central office switches in the public switched network or Internet Point Of Presence ("POP") servers. The U-NII band would have its effects not as a replacement to fiber trunks or to POP servers, which, like toll roads, would continue to operate on a priced-use model, but as a replacement for local loop and small cells in cellular systems. In this sense, the relevant analogy is provided by sidewalks and small city streets, not toll roads, bridges or tunnels. We do not observe toll booths on sidewalks and city streets, either because of transaction costs or because they would be politically untenable. What we see are people relying on open-access transportation, with all its delays and problems, rather than closed-access transportation, like toll roads or railways.

While there are no similarly competent statistics for computer network use, the rapid shift towards Internet access services and away from proprietary online services in the second half of the 1990s suggests a similar dynamic. At the beginning of the 1990s, commercial computer network services, like Prodigy, CompuServe, and America Online, were the primary popular method of computer network communications. The development of the World Wide Web and of graphical web browsers, however, countered the advantage that these proprietary online services had previously enjoyed over the Internet in terms of user interface. At that point, the breadth of capabilities offered by the Internet became vastly more valuable than the value of a controlled environment offered by the online service providers. The result was that all the proprietary service providers were forced to connect to the Internet, and that by late 1995 the number of users using the Internet directly had already surpassed the number of users of all proprietary services combined.[259] The starkest consequence of this trend was the process by which

259. *See* O'Reilly & Associates, *Defining the Internet Opportunity* (visited Feb. 25, 1998) <http://www.ora.com/research/users/charts/pop.html>.

Prodigy, for years the largest online service provider, slipped out of the race as its approach of providing high quality, family oriented communications facilities met with competition from the Internet.[260] America Online, the first online service to offer Internet access, became the largest proprietary online service.[261] Similarly, even in 1995, as sophisticated a player as Microsoft had launched MSN as a proprietary online service. A year later the company reoriented its service and became an Internet access service.[262]

Both the transportation system and computer network examples suggest that a distributed model has advantages over a centralized-managed model, where the value to be maximized is the value individuals place on their communications capability (assuming equivalence between the values of transportation and communication capabilities). Greater flexibility and broader coverage, coupled with greater individual choice, seem to provide greater benefits, even at the cost of time lost queuing, than higher quality facilities satisfying a narrower range of preferences.[263] In both examples, a system for distributed coordination of infrastructure use proved to be the dominant model in direct competition with commensurate services offered in a centralized-managed model.

E. Two Microeconomic Objections

There are two intuitively forceful microeconomic objections to extending the policy represented by the U-NII Order into a broader conceptual framework that would build an important part of the information infrastructure by permitting operation of unlicensed wireless devices. The first is that the proposal treats the infrastructure of wireless communications — spectrum — as a commons. It is therefore subject to a well known critique: we expect that the spectrum will be overused and under-maintained. The second is that, if allowing unlicensed operations over a broad band of frequencies is efficient, then a market

260. *See* David J. Lynch, *Prodigy Tries To Upgrade Its Stodgy Image*, USA TODAY, Feb. 9, 1996, at B4.

261. *See* David Shaw, *World Wide Wait*, L.A. TIMES, June 18, 1997, at A18.

262. *See Microsoft Launches New MSN Version*, NEWSDAY, Oct. 11, 1996, at A65.

263. Another indication of the same phenomenon is the relative value of telephony, which provides a low resolution (voice only) connection to communications content produced in a distributed fashion, and video programming, which provides high resolution representation of content produced in a much more centralized model. In 1992, video (broadcast, cable, and videocassettes) generated $63 billion in revenue, while local and long distance telephone generated $125 billion in revenue. *See* JOHN THORNE ET AL., FEDERAL BROADBAND LAW 8-9 (1995).

in spectrum will lead to the development of such a space for unlicensed operations. All the FCC need do is consistently apply exhaustive privatization, and spectrum will be allocated to unlicensed use.

1. The Tragedy of the Commons Problem

In Hardin's classic statement, the "tragedy of the commons" to a situation where a resource is shared without rules to allocate its usage.[264] Under such conditions, every individual with access to the resource internalizes the full benefit of using whatever part of the resource the individual is capable of using, but shares the costs of depletion caused by his or her use with all other potential users of the resource. Similarly, the benefits of an individual's investment in maintenance of the resource are shared with all other potential users, while the costs of such investments are not. The individual's private cost-benefit analysis therefore leads all users of the commons to make rational personal choices that lead them, with tragic determinacy, to lose the resource.

In identifying the potential role of tragedy of the commons concerns in wireless communications, it is important to remember the heuristic limitations of treating "spectrum" as a resource. Spectrum is not a thing, like a pasture, that can be eliminated by overgrazing or that needs constant upkeep. To be precise, if one wishes to treat spectrum as a resource, one must recognize that it is a perfectly renewable resource that is an input into the value sought to be maximized — the capacity of users to send and receive communications. The spectrum is perfectly renewable in that time is one of its defining dimensions; the availability over time of a given frequency/power unit as an input for communications is in no way affected by its use at any previous time.[265] Thus, for any given band of frequencies that might be owned or operated as a commons, there are no issues associated with initial investment in creating the resource, or in maintenance, recovery, or development.

What makes frequency/time/power units an economic good, and hence defines the extent of potential tragedy of the commons effects, is the potential for interference, or conflicting uses, and, in the case of devices with the spectrum sharing capabilities, congestion. Overuse by

264. *See* Garret Hardin, *The Tragedy of the Commons*, 162 SCIENCE 1243 (1968), *reprinted in* PERSPECTIVES ON PROPERTY LAW 132 (Robert C. Ellickson et al. eds., 2d ed. 1995).

265. Even those who use the resource metaphor acknowledge that "[s]pectrum may be used more or less efficiently, but it cannot be created or destroyed. Unlike many natural resources, spectrum is inexhaustible over time; the manner or degree to which spectrum is used at one moment has no physical impact on the availability of spectrum at any other moment." Rosston & Steinberg, *supra* note 2, at 91.

a device capable of sharing spectrum consists of that device using, for a given transmission more spectrum than necessary to transmit the information it has to transmit, hence increasing its potential to conflict with other users. Under certain conditions an equipment manufacturer could increase the performance of its equipment by transmitting for longer bursts than necessary, using a broader band of frequencies than necessary, or using greater power than necessary; this behavior will likely lead to a degradation in quality of performance for all manufacturers, the defector included.[266] Such behavior, if unchecked, is in fact the equivalent of overgrazing. The question that must be answered in defense of the unlicensed regime is whether this type of behavior can be eliminated by incorporating incentives to avoid overuse into the market in equipment, or whether it must be resolved by instituting a regime based on exclusive control of spectrum allocations, such as privatization or licensing.

In an unlicensed environment, where no one controls transmission decisions, rules concerning power limits (primary physical layer decisions), in combination with transmission protocols (secondary physical layer decisions), can operate to prevent interference and avoid congestion. As described in Part VI.B, equipment manufacturers operating in such a regulated commons have incentives to tend the commons that are not demonstrably inferior to the incentives motivating spectrum owners in a property-based system. What motivates equipment manufacturers is that they will sell more devices than their competitors if their devices can deliver more reliable, faster transmissions in an unlicensed environment where allocation is attained by queuing. To avoid overuse of frequency/time/power units by unlicensed devices, the initial rules defined by the FCC for use of unlicensed devices and industry standards, perhaps to be developed under FCC supervision, should be designed to take advantage of the equipment manufacturer's incentives, by tying the access a device may gain to the unlicensed spectrum to the efficiency of that device's use of the spectrum.

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

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266. *See* Durga P. Satapathy & Jon M. Peha, *Spectrum Sharing Without Licenses: Opportunities and Dangers*, *in* INTERCONNECTION AND THE INTERNET 49 (Gregory L. Rosston & David Waterman eds., 1997).

of equipment manufacturers to design their equipment so that it suffers the least delay.[267]

For example, a device that uses too broad a band of frequencies, given its power spectral density, to convey a given amount of information may be required to scan the spectrum to find a frequency range that is free of competing transmissions for a longer time interval than that required of a device that uses a narrower band with the same power spectral density (i.e., with lower peak transmit power) to transmit the same amount of information. This would give the more efficient device — the device transmitting the same amount of information over a narrower band of frequencies at lower power — an advantage every time the two devices competed for a transmission slot.[268] Or a device could be required to wait longer deference periods between transmission bursts in some proportion to the length of its previous transmission burst, so as to make a strategy of transmitting for longer than necessary a self-defeating exercise.[269] Since overuse by one manufacturer will lead to countermeasures for similar overuse by its competitors,[270] equipment manufacturers will all benefit if standards that prevent or penalize defection are adopted; they will therefore likely adopt such standards if the familiar collective action problems involved in standard-setting are overcome. This, in turn, should focus FCC efforts on facilitating adoption of such standards.

It is important to realize that this solution to the tragedy of the commons problem does not rely on the elimination of excess demand for transmissions over the supply of frequency/time/power units available for transmission. It does not, in other words, suggest or rely upon the notion that spectrum sharing will eliminate spectrum scarcity. It suggests, instead, that just as property rules can bring into play the incentives of spectrum owners to maximize the value of their spectrum, spectrum-sharing rules can bring into play the incentives of equipment manufacturers to optimize the use of spectrum by their devices. That is not to say that the current U-NII Order imposes such rules. Rather, it is to say that an important area of study into unlicensed spectrum is to

267. For initial work identifying the possibility of using protocols for this purpose, see *id.*

268. The references in the text keep power spectral density fixed in order to limit the proposal to techniques other than direct sequencing spread spectrum ("DSSS"). With DSSS, concerns of overuse are significantly mitigated, and devices using DSSS may be advantaged by, for example, limiting the type of concerns identified in the text to transmissions whose power spectral density exceeds that of white Gaussian noise in the relevant spectrum.

269. *See* Satapathy & Peha, *supra* note 266, at § 5.

270. *See id.*

identify which rules will reward efficient devices with better access to the shared spectrum and penalize inefficient devices — whether such rules take the form of administrative regulations by the FCC or protocols and standards set by the industry to prevent defection and degradation of the quality of performance all industry members can deliver to their customers. What is important from the perspective of the tragedy of the commons objection is that the tragedy can be resolved within the framework of the equipment market, and does not require a shift to the spectrum market. Assuming the development of appropriate spectrum-sharing rules and protocols, and in the presence of an equipment market to reward investment in more efficient devices, the absence of a property system in spectrum should not result in a tragedy of the commons.

2. If Unlicensed Operations Are Efficient, They Will Emerge from an Efficient Spectrum Market

The second objection to using administrative regulation to permit unlicensed operations is that, if indeed a model of multilaterally coordinated devices using first-come, first-serve allocation is an efficient mode of communication, then an efficient spectrum market will devote frequencies to such applications. If the value of spectrum to users of devices capable of distributed coordination is higher than it is to the owners of exclusive transmission rights, then someone will aggregate enough spectrum to allow such use, and then make that spectrum available to devices of this type for a fee. Making spectrum available for unlicensed use by administrative decision would allocate the spectrum without the benefit of a market valuation that unlicensed use is indeed a more highly-valued use of this part of the spectrum.

The answers to this objection fall into three categories of well-known difficulties: collective action problems, risk of monopolization, and unnecessary transaction costs. Analysis of these difficulties leads to the conclusion that a market in spectrum rights is unlikely to produce the spectrum necessary for unlicensed-like use; that if it will produce the necessary spectrum, the process of using a market to make such use possible will likely distort the equipment market capable of utilizing that spectrum; and that the costs associated with market determination of whether spectrum should be deployed in an unlicensed model are the sort of transaction costs that are best avoided by correct initial allocation, in this case, of universal limited transmission privileges.

First, there are collective action problems associated with collecting enough spectrum to sustain a robust unlicensed operations market. To create a functioning market in spectrum, the FCC must define the initial units subject to trade. Since the market would be in rights to exclusive control of a narrow band, the units that would produce an efficient market are much smaller than the broad bands necessary to allow efficient unlicensed operations. A market actor attempting to collect a spectrum allocation equivalent to the U-NII band would have to persuade multiple licensees to sell their rights in order to form a broad contiguous band. The collector of such a band would face problems familiar in the context of infrastructure development requiring the aggregation of private land. These problems are the most universally accepted justification for the power of the state purposefully to counteract market decisions by property owners.[271]

Second, the difficulty of assembling a broad swath of frequencies would render unlikely the initial development of more than one such band. During a period during which there were only one band available, equipment manufacturers would have developed equipment for use in that band. A potential competitor to the first band would then face not only the barriers of collecting an equivalent band, but also the need to introduce new equipment capable of transmitting at its newly assembled frequencies. These attributes lead to a high likelihood that market allocation of spectrum for unlicensed-like use would result in monopoly control over infrastructure. Historically, such control has proven an effective tool for monopolization of both equipment and service markets that depend on access to the infrastructure.[272] Moreover, the most likely consolidators of spectrum would be equipment manufacturers seeking to make space for their products.[273] Without regulatory intervention, it

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271. *See, e.g.*, RICHARD POSNER, ECONOMIC ANALYSIS OF LAW 62-63 (5th ed. 1998) (explaining that high transaction costs associated with assembling a large number of contiguous parcels is a good justification for eminent domain); Richard A. Epstein, *Covenants and Constitutions*, 73 CORNELL L. REV. 906, 920 (1988) ("[T]he law does not always respect the holdout rights of an owner against the rest of the world. . . . [E]minent domain is designed, at least in cases of public use, to allow the state to force persons to surrender their private property provided it compensates them for their loss."); *see also* Louis Kaplow, *An Economic Analysis of Legal Transitions*, 99 HARV. L. REV. 509, 606 (1986) (suggesting that economic efficiency justifies a broader application of eminent domain and, especially, uncompensated takings).

272. *See, e.g.*, MCI Communications Corp. v. AT&T, 708 F.2d 1081, 1094-98 (7th Cir. 1983) (describing control over local interconnection to prevent competition in the long-distance market); United States v. AT&T, 524 F. Supp. 1336, 1351-52 (D.D.C. 1981) (describing how interconnection to the local loop was used to prevent competition in customer premises equipment); *see also* Roger G. Noll & Bruce Owen, *The Anticompetitive Uses of Regulation: United States v. AT&T*, in THE ANTITRUST REVOLUTION 291-94 (John W. Kwoka & Lawrence J. White eds., 1989) (describing how the Bell system used discriminatory interconnection to its long distance lines to re-establish its local loop monopoly when the expiration of the original Bell patents allowed the development of local exchange competition at the turn of the century).

273. *See* Kenneth J. Arrow, *Vertical Integration and Communication*, 6 BELL J.

is unlikely that these manufacturers would offer competitors nondiscriminatory access to their spectrum.

Requiring that spectrum for unlicensed-like uses be purchased by someone, to prove its value, will therefore involve either costs of lost efficiency in the equipment market, upon which the efficacy of unlicensed use relies, or costs due to administrative regulation of competition (and the failures of such regulation), given that the equipment market is systematically sensitive to monopolization by leveraging of ownership over its essential infrastructural input — spectrum. It should be recalled that the costs of the market-based approach (in terms of risk of monopolization) are not a necessary evil forced by the need to provide returns to investment in infrastructure. Spectrum, like manna and unlike twisted copper pair, falls from the heavens to those who collect it. The monopolist, if one would emerge, would therefore not be a product of a "natural" monopoly based on large initial investment in infrastructure. The monopoly would be an administrative cost of the decision to use market forces instead of a regulatory process to determine whether to allocate spectrum for unlicensed operations.

Finally, the transaction costs involved in assembling and subletting the required spectrum are likely to be high. In fact, because there are no maintenance or development costs for the spectrum itself, payments to the owner would reflect compensation solely for the effort of identifying the need for spectrum for unlicensed operations, collecting that spectrum, and making it available for unlicensed use.[274] Given these foreseeable transaction costs, if there is good reason to believe that unlicensed operations will be an efficient model for wireless communications, the better choice is to allocate spectrum for unlicensed operations by regulation. This would avoid the transaction costs involved in creating the space for such communications through the

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ECON. 173 (1975) (explaining that firms in a downstream market dependent on inputs from an upstream market will tend to integrate vertically with the upstream market and consolidate it).

274. The costs would include: (1) collecting the information necessary to assess the potential value of a broad band devoted to unlicensed-like use, where a market to exploit this value could not develop until after the frequencies have been assembled; (2) collecting the information necessary and deciding which frequencies to purchase to attain the nationwide contiguous, broad spectrum necessary; (3) getting the putative sellers and buyers of spectrum allocations together; (4) executing all the agreements necessary to collect the spectrum, and then all the agreements necessary to permit equipment manufacturers to sell equipment using that band; (5) policing against manufacturers who manufacture equipment without a license. (Note that a royalty on equipment is itself only a device to avoid the transaction costs associated with charging end users a fee for their use of the transmission right.)

market and the risk that these costs will be so high as to prevent reallocation to such use.

VII. SOME ECONOMIC IMPLICATIONS OF THE CHOICE BETWEEN CENTRALIZED AND DISTRIBUTED CONTROL OF COMMUNICATIONS INFRASTRUCTURE

A. Who Invests What in Information Collection Under Different Institutional Mechanisms for Infrastructure Management?

The primary institutional difference between licensing or auctioning, on the one hand, and unlicensed operations, on the other hand, is that the former rely on instituting asymmetric constraints on how people may communicate using wireless communications, while the latter constrain the choice sets of all wireless communications users symmetrically.[275] The asymmetry is a purposeful institutional feature. It is considered necessary to allow users to communicate, because it provides the necessary framework for a centralized organizational model. The person with the right to control becomes a clearinghouse for information about who wants to communicate at a given frequency/time/power unit and how they would like to communicate. That person also becomes the sole person with whom transactions have to be made, thereby limiting the number of transactions necessary to attain coordination. In the absence of such a clearinghouse, every potential user would have to collect this information about every other potential user, communicate his or her preferences to these others, and transact with all of them to assure coordination. The cost of coordination would be prohibitive. The alternative institutional option — imposing symmetric constraints that do not identify an organizational center — therefore presented itself only when it became technologically possible to reduce these transaction costs by instituting simple coordination rules that can be implemented through transmission control protocols and computer processing power. The question is what are the implications of the now-possible choice between the two institutional frameworks.

Organizations and individuals structure their interactions so as to take advantage of the institutions within which these interactions occur. In the case of privatized spectrum, both owners/licensees and users will tend to structure their use of wireless communications so as to exploit

275. This asymmetry is expressed in Table 2, *supra* page 344, as the difference between who makes primary and secondary content layer decisions in each of the different regimes.

the asymmetrical constraints imposed on them. The primary attribute of the asymmetry is that owners can decide how wireless transmissions will be used, by whom, and at what time. Users can then decide whether to use wireless transmissions within the parameters set by owners.[276] Expenditures on the part of end-users towards obtaining full information about how wireless communications might be used, developing and articulating their own utility function with respect to the full range of possible uses, and processing that information to identify their first-best uses of wireless communications are irrational. Unless their preferences happened to coincide with those of many others, or unless they incurred the large costs necessary to coordinate preferences with others, the costs of articulating a preference order would be wasted. The most likely benefit of their investment would be an increased capacity to identify which, among the menu of options offered by the owner, is their closest second-best.

The likely outcome of the asymmetry is therefore that users will attempt to shift the initial costs of articulating the menu of potential uses of wireless communications to the owners of transmission rights, and will limit their expenditures to choosing from the menu of options defined by owners. Owners are left to develop a menu of communications capabilities that will maximize the value of their unilateral power to determine how wireless communications will be used over a given channel, in the rational absence of articulated preferences of potential end-users.

The alternative institutional framework, which imposes symmetrical constraints on all users, creates different incentives for information collection and preference articulation. On the one hand, end-users can communicate in any fashion, at any time, and for any purpose, within set symmetrically-imposed constraints. These constraints are neutral as to the content, time, or nature of the communications. End-users, who have already incurred the capital costs of equipment, have an increased incentive to invest in accurately identifying and articulating their individual highest-valued use of a communications facility operating under the constraints of multilaterally-coordinated wireless transmission. On the other hand, there is no clear single entity with the incentive to articulate and service aggregate preferences. Organizations that cannot control how communications facilities are used will likely thrive by providing end-users with capabilities to maximize their choices within the framework of symmetrical constraints. In turn, this focus will save

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276. For a more complete statement of the decisions involved in the choice of how wireless communications are used, and who makes each of these decisions under different institutional arrangements, see *supra* Part VI.A.

the organizations the costs of collecting information about end-user preferences (representing a shift of these costs to end-users), and the costs of monitoring, measuring, negotiating, and enforcing agreements concerning appropriation of the value of communications over time.

B. Implications of Symmetric and Asymmetric Constraints for the Pattern of Information Flow and Knowledge Production

Because obtaining information is costly, we continuously act on incomplete information and make our choices under conditions of uncertainty.[277] By constraining the choices available to any individual in a given interaction, institutions (laws, norms) reduce uncertainty and the amount of information that must be collected in order to act in most routine interactions. They allow people to coordinate their behavior in a world where obtaining the information necessary to attain such coordination without institutional constraints may be too costly.[278] Nested within this general function of institutions is the fact that the specific institutional choice with which we are concerned affects the organization of our information infrastructure. In other words, institutional choices intended to solve informational deficiencies about the best way to organize our communications facilities have feedback effects on how we identify, collect, process, and communicate information, because the subject of the institutional choice is itself our facility to perform these tasks.

In the asymmetric constraints model, the costs of collecting information about how communications infrastructure would best be used are not borne by end-users, but by the owner of the right to decide how the communications infrastructure will be used. Having incurred these costs, the organization controlling the infrastructure is in the position to decide what information will be available, to whom, and in what form, as well as to what degree and to whom to to sell or license these decision-making powers. An owner of infrastructure could choose to become transparent to its users, and allow them to do as they please on its facilities. It would do so if the cost of retaining more control over the use of its facilities would be greater than the benefits of categorizing and tracking services so as to impose a more discriminating pricing scheme than possible without monitoring and control. Even if the owner chose transparency, it would retain the power to reassert active control.

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277. *See* DOUGLASS C. NORTH, INSTITUTIONS, INSTITUTIONAL CHANGE, AND ECONOMIC PERFORMANCE 16, 27-35 (1990).

278. *See id.* at 11-16, 27-35.

An admittedly stereotyped comparison between the information environment associated with television broadcast and that associated with the Internet will illustrate. In the broadcast model, the broadcaster makes all decisions about what information in the world is relevant, reliable, or truthful; about the appropriate frame of reference within which to comprehend that information; and about how to structure and articulate it. Viewers come to rely on, and value, the centralization of these functions. The broadcast model allows each viewer to minimize information collection costs, but the costs are cut at the expense of the viewer's capacity to effect the knowledge environment generated by this model of communications. We articulate this exchange through the popular images of the "boob tube" and the "couch potato."

The Internet, on the other hand, is the best model we currently have of a distributed information infrastructure. It imposes high information collection and processing costs on its end-users, and creates significant problems of identifying relevant and reliable information for users habituated to a centralized information infrastructure like the broadcast model. On the other hand, the Internet provides a broader range of communicative alternatives to its users. The distinction between the production of knowledge or information and its consumption are less clearly defined than in the broadcast model (as the rise in multiplayer online games dramatically illustrates). In this framework, the part an end-user plays in defining the information and knowledge environment within which he operates is much greater than in the centrally-controlled environment created by the broadcast model.

Whether a broadcast model or an Internet model isbetter depends on the values by which the question is measured. One approach to comparing the two models is offered in Part VIII. What is important to recognize here, however, is that the institutional background against which organizations manage a society's information infrastructure has implications for the relative role played by different actors in shaping that society's knowledge environment.[279]

C. Institutional Implications for Articulation of Demand

The effects of variations in formal institutions on economic performance are complex and in no useful sense deterministic. It is nevertheless possible to identify one likely relationship between the

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279. I have elsewhere provided a more complete statement of this proposition. *See* Yochai Benkler, *Communications Infrastructure Regulation and the Distribution of Control over Content*, *in* 22 TELECOMMUNICATIONS POLICY, (forthcoming Winter–Spring 1998).

institutional choice to adopt centralized or distributed control over communications infrastructure and the pattern of information flow in the economy. If the patterns described in the preceding section in fact represent the likely effects of such an institutional choice, then adopting a distributed model of communications should allow better articulation of end user preferences and better communication of those preferences to producers. This, in turn, would allow an upward shift in the aggregate demand curve (as perceived by suppliers) of an economy that could have been in equilibrium at a lower state due to poorer information both consumers and producers would have had about actual and potential consumer preferences.

Because information in the broadcast model flows from the center to the periphery, the model offered an obvious and "natural" point to centralize information and standardize perceptions of demand and consumer utility functions in a mass production economy. The model was originated in the mid-nineteenth century, with the introduction of a number of technological advances in printing, the development of mass circulation newspapers and magazines, railroad-based distribution, and the introduction of managed demand through advertising.[280] It was enhanced when radio broadcast combined with mass production techniques in the 1920s.[281] The organizational development of the American broadcast system into networks financed as a demand-management branch of a mass production economy was a rational response to a combination of the state of radio technology in the 1920s, the institutional parameters of the spectrum allocation system (itself largely a product of the efforts of the progenitors of the American broadcast model),[282] and the need of American mass production industries to manage the demand for their products.[283]

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280. *See* JAMES BENIGER, THE CONTROL REVOLUTION 271-74, 356-62 (1986); *see also* WILLIAM BURNELL WAITS, THE MODERN CHRISTMAS IN AMERICA: A CULTURAL HISTORY OF GIFT GIVING at xvii-xix (1993) (describing the business model of *The Ladies Home Journal* and *The Saturday Evening Post* as cost-based pricing of copies coupled with broad common denominator content, attaining high circulation, which was then translated into higher advertising rates and advertising content). Waits uses these early mass media to track the creation of Christmas gift giving culture, and the shifting production of perceptions of who men and women (gift recipients) are, and what they want, as a vehicle for demand management.

281. *See* BARNOUW, *supra* note 39, at 237-45, 264-83; BENIGER, *supra* note 280, at 362-74.

282. *See supra* Part II.B. For the introduction of advertising as the key financier and determinant of content, see BARNOUW, *supra* note 39, at 237-45, 264-83. For the role of radio in homogenization of culture and nationalization of perception, see *id.* at 125-31, 224-31.

283. *See* BENIGER, *supra* note 280, at 344-89 (describing the role radio broadcasting

This system has significant drawbacks where the production capacity of a society has developed in the direction of allowing manufacturers to respond to individually defined needs.[284] As explained in Part VII.B, a communications system responding to centrally-produced perceptions of demand, with limited feedback mechanisms based primarily on statistical sampling intended to identify average responses (e.g., the Nielsen ratings system), is a poor mechanism for allowing the development and communication of individual utility functions. The closer the production of information about an individual's needs is pushed towards the individual, the more it will tend to reflect that individual's actual then-perceived utility function. If the same communications system allows the individual to communicate that utility function to producers, these producers can begin to work on fulfilling that demand by tailoring their products ever more finely to fit the individually-generated demand. While averaging serves well the preferences of those at the peak of the normal distribution curve of consumer preferences, it will not similarly fulfill the preferences of outliers. Fulfillment of actual demand will continue to offer the former group a service that fulfills its demand, but will better serve the preferences of the outliers. As seen by manufacturers, then, the aggregate demand curve shifts upwards, since it now reflects more closely the aggregate of actual individual highest valued uses, rather than the product of multiplying an average individual utility function as perceived by a producer by the number of individuals in the producer's target market.

D. Institutional Path-Dependency and Lock-In

The potential for productivity gains from an organizational shift to distributed control over information infrastructure raises the same question for the neoclassical economist that was raised at the end of Part VI: if in fact distributed communications offer the more efficient model of organizing communication in an economy capable of mass customization, then that is the model of communication that will evolve over time. Producers who find ways to allow consumers to articulate

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played in facilitating the ability of mass producers to assert control over the mass consumption of their products).

284. The plausibility of a "mass customization" model built on flexible production as an alternative to the mass consumption, Fordist model that has dominated twentieth century production was first articulated in MICHAEL J. PIORE & CHARLES F. SABLE, THE SECOND INDUSTRIAL DIVIDE: POSSIBILITIES OF PROSPERITY 19-48 (1983); *see also* DAVID HARVEY, THE CONDITION OF POSTMODERNITY 121-97 (1991) (elaborating on this pattern of "post-Fordist" production).

and communicate their individual utility functions will thrive at the expense of those who rely on average demand articulated and communicated through mass media and thus produce below capacity.

The response suggested by institutional economics[285] is that institutional arrangements, and the adaptations developed to maximize their utility within a given institutional framework, can persist over time even if they are economically inefficient, because institutions have increasing-returns attributes and operate in imperfect markets with high transaction costs. An institutional framework acts like a product or service with network externalities,[286] in that the more contracts, transactions, and economic or political behavior is pursued within an institutional framework, the more useful the framework is for all who use it to predict the behavior of others with whom they are likely to interact. Institutions also have relatively high setup costs, in terms of resources devoted to institution-building instead of to material transformation, as well as in transactions to obtain the benefits of specialization within an already-established institutional framework. Furthermore, institutional frameworks involve significant learning effects. In an imperfect market with high transaction costs, individuals and organizations must expend time and resources to optimize their behavior in accordance with a given set of rules. Once these costs are incurred, organizations are well-tailored to fit the existing institutional framework, and a shift entails new learning costs. Finally, perceptions of what is efficient or desirable are shaped over time to reduce the perceived opportunity cost of the stable condition in which a society exists. As an institutional framework persists over time, people who live in it develop better stories to justify its continuation and filter out information whose assimilation could require the expenditure of resources on institutional transformation and involve the risk of uncertain patterns of redistribution.[287]

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285. The response here turns to institutional economics, rather than to the economic history explanations that initially established the plausibility of persistent patterns of production that are not a single best practice, *see, e.g.*, PIORE & SABEL, *supra* note 284, because it is an approach that makes the institutional framework endogenous to the model, and hence offers what may be a more satisfying answer to the model-based critique. It is not to be taken as a denial of the centrality of historical empirical evidence as the central critique of model-based observations.

286. On the concept of network externalities, see Nicholas Economides, *The Economics of Networks*, 14 INT'L J. INDUS. ORG. 673 (1996), *available at* <http://raven.stern.nyu.edu/networks/top.html>.

287. *See* NORTH, *supra* note 243, at 92-104. Note that it would be rational for an organization well adapted to an institutional framework to invest in developing perceptions of the existing institutions and their alternatives that stabilize the existing

The political decision to require the American economy to spend billions of dollars to retool its household communications equipment so as to receive higher resolution signals in the traditional television broadcast model — High Definition TV ("HDTV") — is an excellent example. The change over time in the name of the goal, from HDTV to advanced TV ("ATV") and then to digital TV ("DTV"),[288] expresses the gradual realization that HDTV is no different than all other communications today — digital transmission of a particular kind of content. But digital communications need not be chained to the traditional broadcast model. The 6 Mhz channel allocated to broadcasters in the DTV Orders can be used to carry a number of old-resolution programs, up to two high-resolution programs, or data transmissions, etc.[289] Recognizing the technological obsolescence of the idiom of high-resolution television, the FCC nonetheless persisted in requiring the continuation of the communicative model it represents. With two actions, the Commission sought to maintain the old broadcast model in new imperial cloths. First, the Commission required each broadcaster to offer one program, continuously, that would replicate old television programming at the same or higher resolution.[290] Second, the Commission required all viewers who wish to continue to view old-style television programming to purchase new digital television sets. (This requirement was formally imposed on transmitters, not viewers, by requiring that all analog broadcasts stop after a number of years.[291]) The requirement was imposed ostensibly so that the spectrum allocations used for analog transmissions could be reclaimed and auctioned. When broadcasters themselves began to resist the requirement that they use their spectrum for high-resolution delivery of the same menu, rather than

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institutions, as long as the cost of producing these perceptions were lower than the cost of an institutional transition discounted by the change in the probability of its occurrence as a result of the investment. This effect might be called the rationality of false consciousness. It also explains the rationality of loving one's chains, in that as long as the cost of a transition from one system to another is more costly to any group in a system, including its "losers," from the expected benefits from the transition, it would make sense for that group to invest in developing a set of perceptions that would minimize the probability that transition would occur, leading them to incur the costs.

288. *See* Telecommunications Act of 1996 § 201 , 47 U.S.C.A. § 336 (West Supp. 1997) (ATV); Advanced Television Systems and Their Impact upon the Existing Television Broadcast Service, MM Docket No. 87-268, FCC 97-116 (Apr. 21, 1997) (Fifth Report & Order) [hereinafter Fifth ATV Order] (DTV); Advanced Television Systems and Their Impact upon the Existing Television Broadcast Service, 12 F.C.C.R. 14588 (Sixth Report & Order 1997) (DTV).

289. *See* Fifth ATV Order, *supra* note 288, at para. 20.

290. *See id.* paras. 27-28

291. *See id.* paras. 97-100.

low-resolution delivery of a broader menu, they were quickly beaten into submission by Congress.[292]

The DTV Orders are a quintessential instance of an old institutional and organizational model resisting change and forcing a radically changed technological environment to conform to the assumptions of an old framework so as to allow its continued survival. If American consumers spend billions of dollars in the next ten years on high-definition televisions, capable of high-resolution reception of a limited menu of programs (assume even 500 channels, as compared to, for example, millions of web pages) and limited upstream communications capability, it may be difficult to persuade them to spend the same amount again to buy unlicensed broadband devices during the same time frame. This would be true even if such devices were much better (in some important sense), since the purchase of a high-definition television might have exhausted the portion of the household budget devoted to information collection and communications capability for the expected life of the television set. DTV may yet emerge as an instance of both institutional and technological lock-in operating in a feedback loop with each other.[293]

Interests created by spectrum privatization also operate to resist unlicensed operations. At a simple level, licensees who have purchased their licenses in auctions will object to competition from unlicensed operations. This can be seen in the objections of AT&T and others who could find themselves in competition with powerful U-NII devices.[294] Even where incumbent licensees (whether they bought their license in an auction or not) cannot block unlicensed operations completely, they still exert a pull on the institutional framework for unlicensed operations, as one sees in the relatively large role protection of incumbent uses played in the U-NII Order.[295] Both broadcasters and licensees who

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292. *See* Joel Brinkley, *Under Pressure, 2 Broadcasters Decide They Will Run HDTV*, N.Y. TIMES, Sept. 18, 1997, at D2 (describing how Congress forced broadcasters like ABC and Sinclair to recant their heretical plans to offer multiple programs, including pay-per-view, over their DTV allocations, rather than a single channel in high-definition format).

293. On technological lock-in, see W. Brian Arthur, *Competing Technologies, Increasing Returns, and Lock-In by Historical Events*, 99 ECON. J. 116 (1989); Paul A. David, *Understanding the Economics of QWERTY: The Necessity of History*, *in* ECONOMIC HISTORY AND THE MODERN ECONOMIST 30 (William N. Parker ed., 1986); *see also* S.J. Liebowitz & Stephen E. Margolis, *Should Technology Choice Be a Concern of Antitrust Policy?*, 9 HARV. J.L. & TECH. 283 (1996). On the similarity and ties between institutional lock-in and technological lock-in, see NORTH, *supra* note 277, at 93-96.

294. *See* U-NII Order, *supra* note 8, at para. 86.

295. *See supra* Part V.D.

purchased their licenses at auctions are examples of entities that resist transition in order to protect their investment in an incumbent institutional framework.

At a more subtle level, the cultural and organizational entrenchment of two conceptual paradigms operates to resist adoption of a distributed model of communications infrastructure regulation. First, the intellectual dominance of neoclassical economics and the cultural centrality of property rights aid the continued conceptualization of the spectrum as "a resource" and the intuitive resistance to treating spectrum as a commons.[296] Second, the cultural centrality of the one-to-many broadcast model also operates to resist the distributed model. We see this most clearly in attempts to develop "push" technologies for the Internet, in order to force the broadcast model upon our most robustly distributed remote communications facility.[297]

Considering the increasing-returns attributes of institutions, and the resistance of entrenched organizations and conceptual apparatuses to institutional transition, it is possible that an institutional framework will persist in the face of a more efficient institutional alternative. Recognizing this possibility does not militate that a transition be politically undertaken whenever it seems that a new framework will be more efficient than the last. It does, however, suggest that relying on market mechanisms to identify when an existing institutional framework is less efficient than a feasible alternative is unlikely to be an effective strategy. A polity must treat the study of institutional alternatives as though institutional transitions were a form of public good, and when a polity is persuaded of the advantages of transition, it must effectuate the transition by political decision.

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296. In the NPRM, for example, the Commission explicitly raised concerns of "tragedy of the commons." *See* NPRM, *supra* note 13, at para. 53. In the most recent FCC policy assessment, unlicensed operations are recognized as a potentially useful area for study, but embedded within a system wholly dominated by private property rights in spectrum allocations. *See* Rosston & Steinberg, *supra* note 2, at 96-97.

297. Techniques collectively referred to as "push" technologies operate on a range of models in which a provider sends information to the user's computer, much as a television broadcaster or newspaper sends to a viewer or subscriber. *See* David Bank, *Selling Pants on PointCast*, WALL ST. J., Dec. 13, 1996, at A1. While these techniques can be romanticized, *see* Kevin Kelly et. al., *PUSH! Kiss Your Browser Goodbye: The Radical Future of Media Beyond the Web*, WIRED, Mar. 1997, at 1, the basic drive behind push technology is to counteract the diffusion of power to control information collection, which is a central feature of present design of digital networks.

VIII. Towards a Political Economy of the Choice Between Centralized and Distributed Production of a Society's Information Environment

A. Individual Autonomy, Robust Political Discourse, and Medium-Specific Law

> "In an age of omnipresent radio, there scarcely breathes a citizen who does not know some part of a leading cigarette jingle by heart. Similarly, an ordinary habitual television watcher can avoid these commercials only by frequently leaving the room, changing the channel, or doing some other such affirmative act. It is difficult to calculate the subliminal impact of this pervasive propaganda, which may be heard even if not listened to, but it may reasonably be thought greater than the impact of the written word." *It is no answer to say that because we tolerate pervasive commercial advertisements we can also live with its [sic] political counterparts.*[298]

Thus, writing for the Court in *Columbia Broadcasting System v. Democratic National Committee* ("*CBS v. DNC*"),[299] Chief Justice Burger explained why broadcast licensees, in the name of protecting the openness of the marketplace of ideas, could refuse to accept paid political advertising, even though they accepted commercial advertising.[300] More recently, Justice Breyer, concurring in the Court's rejection of cable system operators' claims that their rights to be free from "forced speech" were violated by statutory "must carry" obligations, wrote: "I believe that this purpose — to assure the over-the-air public 'access to a multiplicity of information sources,' . . . — provides sufficient basis for rejecting appellants' First Amendment claim."[301] The passage Chief Justice Burger quotes in *CBS v. DNC* conveys the sense of invasion of the individual's informational environment by radio commercials, of resistance by the individual who

298. Columbia Broadcasting System v. Democratic Nat'l Comm., 412 U.S. 94, 128 (1973) ("*CBS v. DNC*") (emphasis added) (quoting Banzhaf v. Federal Communications Comm'n, 405 F.2d 1082, 1100-01 (D.C. Cir. 1968) (citations omitted)).

299. *Id.*

300. *See id.* at 121-31.

301. Turner Broad. Sys., Inc. v. Federal Communications Comm'n, 117 S. Ct. 1174, 1204 (1997) (Breyer, J., concurring).

switches channels, leaves the room, and yet cannot get the jingle out of his head. When Burger compares radio advertising to writing, the difference he focuses upon is that writing necessitates action on the part of the reader, thereby shifting control over information flow from the sender to the recipient, while the jingle can be heard even if not listened to.[302] Justice Breyer's concurring opinion in *Turner Broadcasting System, Inc. v. Federal Communications Commission* ("*Turner II*")[303] adds a layer of insight. An institutional framework that produces a lopsided distribution of access to information and communications capabilities substantially reduces the capacity of those people whose access to information is constrained to be politically self-governing citizens.

These two statements outline the importance of the choice between permitting unlicensed wireless operations and exhaustively licensing or privatizing the spectrum. Chief Justice Burger's statement emphasizes that even if we accept centralized production of the information environment when we consider its effects on us as economic actors, we must be more cautious about its effects on us as citizens in a democracy. Justice Breyer's *Turner II* concurrence suggests that, at least when a society has no option but to make an institutional choice that will produce different patterns of distribution of communications capability, important First Amendment values weigh in favor of a system that more broadly distributes "access to a multiplicity of information sources."[304] Given the analysis in Part VII of the information flow implications of distributed infrastructure organization, this Part suggests that there are good reasons to endorse unlicensed wireless operations when these effects are considered in light of our democratic values. Broader distribution of the capacity to produce and control the knowledge

302. *CBS v. DNC*, 412 U.S. at 128. Burger's opinion notes that, "[w]ritten messages are not communicated unless they are read, and reading requires an affirmative act." *Id.* (quoting *Banzhaf*, 405 F.2d at 1100).

303. 117 S. Ct. 1174 (1997).

304. *Id.* at 1204.

environment helps to maintain both robust political debate[305] and individual autonomy.[306]

The analysis progresses in two stages. First, I suggest why institutional choices regulating a communications technology can affect information flow patterns in a society in politically significant ways. Second, I suggest how the information flow patterns likely to develop, given the choice between licensed and unlicensed operations, are likely to effect the values of robust public discourse and personal autonomy.

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305. The Court has often treated the protection of political discourse as the highest function of the First Amendment. *See, e.g.*, Associated Press v. United States, 326 U.S. 1, 20 (1945) ("[The first] Amendment rests upon the assumption that the widest possible dissemination of information from diverse and antagonistic sources is essential to the welfare of the public, that a free press is a condition of a free society."); Thornhill v. Alabama, 310 U.S. 88, 102 (1940) ("The exigencies of the colonial period and the efforts to secure freedom from oppressive administration developed a broadened conception of these liberties as adequate to supply the public need for information and education with respect to the significant issues of the times. . . . Freedom of discussion, if it would fulfill its historical function in this nation, must embrace all issues about which information is needed or appropriate to enable the members of society to cope with the exigencies of their period."); Whitney v. California, 274 U.S. 357, 375-76 (1927) (Brandeis, J., concurring). The scholarly *locus classicus* of this position is ALEXANDER MIEKLEJOHN, FREE SPEECH AND ITS RELATION TO SELF-GOVERNMENT (1948) and Alexander Mieklejohn, *The First Amendment Is an Absolute*, 1961 SUP. CT. REV. 245. Robert Bork has derived from this position a claim that *only* political speech is to be protected. *See* Robert H. Bork, *Neutral Principles and Some First Amendment Problems*, 47 IND. L.J. 1 (1971). Another strand of scholarship that gained less support over time, but which also drew from this well, was the claim that the First Amendment required access rights to the press, so as to assure effective political speech, as opposed to simply freedom from government censorship. *See* Jerome A. Barron, *Access to the Press — A New First Amendment Right*, 80 HARV. L. REV. 1641 (1967).

306. As Martin Redish put it, "Free speech aids in all life-affecting decisionmaking, no matter how personally limited, in much the same manner in which it aids the political process. Just as individuals need an open flow of information and opinion to aid them in making their electoral and governmental decisions, they similarly need a free flow of information and opinion to guide them in making other life-affecting decisions. There thus is no logical basis for distinguishing the role speech plays in the political process. Although we definitely need protection of speech to aid us in making political judgments, we need it no less whenever free speech will aid development of the broader values that the democratic system is designed to foster," which Redish defines as "having individuals control their own destinies." MARTIN H. REDISH, FREEDOM OF EXPRESSION, A CRITICAL ANALYSIS 21-22 (1982). Others have focused on the importance of self-expression as a central attribute of a self-governing, rational person, *see, e.g.*, David Richards, *Free Speech and Obscenity Law: Toward a Moral Theory of the First Amendment*, 123 U. PA. L. REV. 45 (1974), or on the freedom a person must have to form his or her own judgments and not to relinquish that capacity to the state, *see* Thomas Scanlon, *A Theory of Freedom of Expression*, 1 PHIL. & PUB. AFF. 204, 213-18 (1972). *But see* Thomas Scanlon, *Freedom of Expression and Categories of Expression*, 40 U. PITT. L. REV. 519, 532-33 (1979) (recanting earlier view).

B. Communications Technology, Institutional Choices and Organizational Structure

Different communications technologies, arising at different times and subject to different institutional developmental paths, organizational structures, and social patterns of use, have very different effects on the distribution of social control over information and knowledge in the societies that adopt them.[307] Perhaps the starkest example we have of this phenomenon can be seen in the effect of print on the Reformation and, eventually, on the rise of liberal philosophy and democratic institutions. Nailing religious disputations to the doors of a church was not an uncommon practice in late medieval and early Renaissance Europe. But the printing press put over 300,000 copies of Luther's *Ninety-Five Theses* into the hands of sixteenth-century Europeans within three years of its publication in Wittenberg; the printing of both Bibles and indulgences for fifty years before Luther's tracts were published prepared the fertile ground for his attacks on indulgences and his defense of Bible-reading.[308]

The relevance of technology arises from a combination of at least three factors. First, the technology itself may have attributes that affect the flow patterns of information in a society that uses it.[309] For example,

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307. My approach relies most closely on the work of Harold Innis. *See* HAROLD INNIS, THE BIAS OF COMMUNICATION (1951) [hereinafter INNIS, BIAS]; HAROLD INNIS, EMPIRE AND COMMUNICATION (1950). Fragments relating to this part of his work can be found in HAROLD INNIS, POLITICAL ECONOMY IN THE MODERN STATE (1946); HAROLD INNIS, THE IDEA FILE OF HAROLD INNIS (1954). For an excellent brief description of Innis's work, see JAMES W. CAREY, COMMUNICATIONS & CULTURE 142-69 (1989). For assessments of Innis's work that focus more heavily on the continuity between Innis's work and McLuhan's, see MARSHALL MCLUHAN, INTRODUCTION, *in* HAROLD INNIS, THE BIAS (1964 ed.); DAVID CROWLEY, INTRODUCTION, *in* HAROLD INNIS, THE BIAS OF COMMUNICATION (1991 ed.); Joshua Meyrowitz, *Medum Theory*, *in* COMMUNICATIONS THEORY TODAY 51-52 (David Crowley & David Mitchell eds., 1994). It is important to emphasize that because of its focus on the interaction of communications technology with historically contingent institutional and organizational frameworks, this approach differs from the more commonly recognized claims about the effects of media on social relations, developed by Marshall McLuhan in the 1960s. McLuhan's approach is more deterministic and universal in its claims. *See* MARSHALL MCLUHAN, THE GUTENBERG GALAXY (1962); MARSHALL MCLUHAN, UNDERSTANDING MEDIA, THE EXTENSIONS OF MAN (1964); MARSHALL MCLUHAN, THE MEDIUM IS THE MESSAGE (1967); MARSHALL MCLUHAN & BRUCE R. POWERS, THE GLOBAL VILLAGE: TRANSFORMATIONS IN WORLD LIFE AND MEDIA IN THE 21ST CENTURY (1989).

308. *See* ELIZABETH L. EISENSTEIN, THE PRINTING PRESS AS AN AGENT OF CHANGE 303, 367-78 (paperback ed. 1980).

309. The most systematic and expansive explication of this position is found in Harold Innis's works, *see supra* note 307, and in Marshall McLuhan's works, *see supra*

the use of manuscript on parchment codex (a durable storage medium suited to large volumes, but not to smaller, more portable volumes), reproduced by hand copyists, undergirded the resilience of the monastic monopoly over knowledge.[310] With the introduction of print, the ease with which large circulation editions of identical books could be manufactured and distributed forever altered the possibility of access to sources of study and to competing perceptions of the world.[311] Combined with the introduction of paper to replace parchment, print made books ubiquitous. The increased access to books made the expansion of literacy possible, and with it a decline in the monopolistic control over interpretation of the world.[312]

The second factor involves the institutional treatment of a technology. Analysis of the first factor suggested that wide availability of inexpensive books was the catalyst for literacy and its attendant broad distribution of access to information. Institutional factors, however, can counteract, enhance, or give direction to the technological effect. The first books to expand readership in Europe from learned classes to what would become the middle class were vernacular Bibles.[313] Catholic

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note 307. Important detailed works that track the effects of the technological attributes of a medium of communications and public discourse include BARNOUW, *supra* note 39 (discussing radio broadcast); H.J CHAYTOR, FROM SCRIPT TO PRINT (1945) (discussing the effects of print on literary forms); EISENSTEIN, *supra* note 308 (discussing the effects of print on religion, political theory, and the scientific revolution of the "century of genius"); JOSHUA MEYROWITZ, NO SENSE OF PLACE (1986) (discussing the effects of electronic mass media on perceptions of childhood, gender, and political figures). A more deterministic, but very well known, statement of the social-relational effects of print technology is MARSHALL MCLUHAN, GUTENBERG GALAXY (1965). In a similar vein is WALTER ONG, ORALITY AND LITERACY (1982), on the shift from oral communications to writing.

310. *See* INNIS, BIAS, *supra* note 307, at 17, 22-23.

311. Eisenstein identifies this print-created ubiquity of consistent copies of classic information sources as one of the most important impulses underlying both the religious revolution, *see* EISENSTEIN, *supra* note 308, at 331-34, and the scientific revolution of the sixteenth century, *see id.* at 572-74 (noting that alternative medical were treatises available to students for comparison), 575-604 (noting that alternative cosmological theories were available for comparisons underlying the Copernican revolution). *See also* INNIS, BIAS, *supra* note 307, at 23-24.

312. *See* EISENSTEIN, *supra* note 308, at 353-54 (suggesting that printing, more than the specifics of the Lutheran heresy, undermined the interpretive monopoly undergirding the universality of the Church). On the interaction between print technology and the use of paper instead of parchment codex into European communications technology, see INNIS, BIAS, *supra* note 307, at 51-54.

313. Vernacular Bibles and many other works were printed for decades before Luther. *See* EISENSTEIN, *supra* note 308, at 329-30. Scholars had read and basked in the breadth of newly available sources well before Luther published his Theses. But the expansion of literacy is tied to vernacular Bible-reading, as described in the text. *See id.*

countries prohibited vernacular Bible-reading, but Protestant countries strongly supported — and in some cases mandated — it, affecting the pattern and timing of literacy expansion in Europe.[314] What is important for our purposes are not the direct effects of censorship and sponsorship, i.e., whether vernacular Bibles were or were not read. What is important is that institutional insistence on reading vernacular Bibles moved populations to become literate in their vernaculars.[315] Once literate, their capacity to access information was not limited to Bible-reading. Literacy created expanding markets for printers. Printers could produce and sell more if they expanded the range of products they manufactured,[316] and increasingly they turned out the secular, free-thinking, and hedonist literature that attracted prohibition from Rome. These unintended consequences changed the universe of perceptions of the world available to these "new" readers in a manner unimagined by either the Counsel of Trent or the theologians and monarchs who supported vernacular Bible-reading.[317]

The third factor relates to the way that organizations structure their information collection, processing, and communications in relation to technology. One of the clearest instances of self-conscious organizational determination to track a technology into one, rather than another, communications model is AT&T's choice to use telephone technology solely to provide point-to-point switched communications rather than developing it as a broadcast medium as well. Early in the development of telephony, wireline broadcast to the home was considered an important application of the technology.[318] But AT&T chose to focus on providing a point-to-point communications network. There are several circumstances that may have influenced AT&T's organizational decisions to track telephone technology in the United States toward point-to-point communications, rather than broadcast:[319]

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at 415-17.

314. *See id.* at 349-50 (describing royal sponsorship of vernacular Bibles); *id.* at 415 & n.377 (describing a Scottish law imposing a fine on householders who did not have a vernacular Bible and psalm book in their homes, and noting the duty of Elizabethan householders to teach their children, apprentices, and servants to read).

315. *See* MCLUHAN, GUTENBERG GALAXY, *supra* note 307, at 230-38 (describing how print standardized the vernacular, and how standardization of the vernacular had the dual effect of fostering nationalism and, through its increase in the audience available to individual authors, individualism).

316. *See* EISENSTEIN, *supra* note 308, at 415.

317. *See id.* at 416-20.

318. *See* BARNOUW, *supra* note 39, at 7-9. In 1890, for example, AT&T was criticized in *Electrical Engineer* for not adequately pursuing the possibilities of "furnishing musical and other entertainment by wire to the fireside." *Id.* at 8.

319. The introduction of 900 numbers is a recent, minor implementation of the

AT&T's business model was oriented towards telephony as an improvement of telegraphy;[320] the cost of providing high-fidelity entertainment services may have been too high to be supported by the low penetration rates of telephone at the end of the nineteenth century;[321] or AT&T may have perceived its relative advantage over new entrants to be in switching and long-distance amplification technology.[322] This organizational choice responded to, and was reinforced by, institutional decisions. Initially, the telephone company was treated by some legal decisions as a form of telegraph.[323] Later, as the telephone system evolved, it was subjected to regulation that solidified its monopoly in the point-to-point switched model while constraining it to operate within that model.[324]

A more subtle example exists at the end of the period of printing press dominance, and concerns the shift to modern printing press technology that gave birth to the organizational structure of the mass-mediated environment in which we live today. Newspapers in the eighteenth century were produced by hand presses, in small circulation editions, distributed over short distances.[325] Many of the papers were subsidized by political parties,[326] often through grants of postal monopoly positions,[327] and their primary role was to serve as a medium for political commentary and debate.[328] With the introduction between 1839 and 1886 of the electric press, rotary printing, wood pulp paper, the curved stereotype plate, paper folding machines, the high speed printing

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broadcast model in telephony.

320. *See* DE SOLA POOL, *supra* note 3, at 28-30; BARNOUW, *supra* note 39, at 8.

321. *See* DE SOLA POOL, *supra* note 3, at 31-33.

322. For a brief description of the Bell System's use of interconnection and long-distance services to eliminate competition in the local markets, see Noll & Owen, *supra* note 272.

323. *See* DE SOLA POOL, *supra* note 3, at 100.

324. The reference here is to the 1913 Kingsbury Commitment between AT&T and the United States Department of Justice, the first of a number of agreements arising from antitrust concerns surrounding AT&T over this century, in which AT&T agreed to accept the regulatory authority of the Interstate Commerce Commission (later shifted to the FCC), divest from Western Union, refrain from buying out competitors, and undertake to interconnect to independent companies. *See* MICHAEL K. KELLOGG ET AL., FEDERAL TELECOMMUNICATIONS LAW § 1.3.3, at 16-17 (1992).

325. *See* INNIS, BIAS, *supra* note 307, at 148-49 (describing the limits created by the hand press on circulation and format, in context of the London press); *id.* at 162 (describing how American small towns were relatively less capable than large ones of sustaining the capital costs associated with transition to newer print technology and the newspaper model associated with them).

326. *See id.* at 157-58, 162-67.

327. *See id.* at 163-64; *see also* DE SOLA POOL, *supra* note 3, at 75-79.

328. *See* INNIS, BIAS, *supra* note 307, at 162-67.

and folding press, half-tone engraving, the linotype, and distribution by rail,[329] newspapers shifted from a narrowcast medium (one-to-few with higher feedback capabilities) to a broadcast medium (one-to-many with low feedback capabilities).

The production capabilities made mass-circulation and illustrated papers possible. The capital costs associated with this machinery made mass-circulation, advertiser-supported newspapers and magazines a robust organizational method of exploiting the potential created by the technology.[330] In order to create and sustain this mass circulation, prices per copy were dropped, the newspapers and magazines themselves became the subject of advertising, as well as its medium, and the content of the publications that now surrounded the advertisements changed.[331] The genres of pulp fiction, sensationalism, muckracking, graphic illustration, and comic strips developed to provide a sufficiently broad appeal to the diverse audience necessary to sustain mass production costs through advertising fees.[332] The most important shift, however, was achieved in combination with another crucial communications development — the telegraph. The daily paper came to rely on that most universal of contents to sell its advertising — fresh factual reportage, or news.[333] Facts (unlike commentary and analysis) require relatively little shared background among readers, and can be produced anew every day. To cope with the costs of news production, newspapers developed news agencies like the Associated Press;[334] these organizations flattened and homogenized news. These organizational changes invited new institutional choices, sometimes supporting concentration,[335] sometimes working to counteract it.[336]

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329. *See* BENIGER, *supra* note 280, at 356-57; INNIS, BIAS, *supra* note 307, at 159-60.

330. *See* BENIGER, *supra* note 280, at 356-62; INNIS, BIAS, *supra* note 307, at 162.

331. *See* BENIGER, *supra* note 280, at 358-59; INNIS, BIAS, *supra* note 307, at 160-62; HAROLD A. INNIS, THE PRESS: A NEGLECTED FACTOR IN THE ECONOMIC HISTORY OF THE TWENTIETH CENTURY 13-20 (1949) [hereinafter INNIS, THE PRESS].

332. *See* BENIGER, *supra* note 280, at 359-60; INNIS, THE PRESS, *supra* note 331, at 13-20.

333. *See* INNIS, BIAS, *supra* note 307, at 161-62, 167-69.

334. *See id.* at 168, 176-180.

335. For example, the Supreme Court developed a quasi-property right in fresh news, supporting Pulitzer's efforts to leverage his control over the Associated Press into dominance in his competition with the Hearst papers. *See* International News Service v. Associated Press, 248 U.S. 215 (1918) ("*INS v. AP*"). Thanks to the time lag introduced by the Court's decision, Pulitzer had some success as to morning papers, but was unable to stem the growing success of his competitors in the evening papers. *See* INNIS, BIAS, *supra* note 307, at 179-80. These papers, in turn, refocused the medium on end-of-the-day, entertainment information — e.g., sports coverage. *See id.*

336. Thirty years after *INS v. AP*, the Supreme Court refused to read the First

The newspaper had shifted over the nineteenth century from a medium of political debate into a medium of commercial advertising. The representations of the world carried in newspapers shifted from commentary and opinion to fresh facts and sensational reporting.[337] The information environment in which these papers continuously comprised a component of central importance shifted, from one where points of view and positions expressed on the basis of assumptions about values shared by readers took center stage, to one in which commentary is secondary to the presentation of factual, and thus value-neutral or apolitical, perceptions of the world. The focus on factual reportage provides a "thin" reflection of the tastes of a broad readership, rather than a "thick" expression of the positions of authors and a small readership with shared social or political values.

The examples illustrate that the three factors — technology, institutional framework, and organizational structure — are not independent of each other, and are historically contingent, rather than technologically determined. The historical context in which a technology is introduced affects both the institutional treatment of that technology in a given society and the organizational structure through which the technology is deployed. Each vector — the institutional and the organizational — has a feedback effect on the other, and together they affect the continued development path of the technological parameters of communication. Different societies introducing similar technologies at different points in their institutional and organizational histories experience the technological shift differently, in terms of its effects on how the knowledge environment of that society is produced, controlled, and used.

C. *From Recognizing the Importance of Communications to Institutional Design of the Digitally Networked Environment*

The approval of unlicensed wireless operations currently provides the sole institutional avenue for the creation of an unowned, fully distributed component in our communications infrastructure. For this reason, the debate over unlicensed wireless devices is crucial to the future development of our information environment. Contemporary discussions usually identify five facilities for connecting individuals to

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Amendment as a blanket immunity for the Associated Press (and for that matter, news gathering in general) from antitrust liability. *See* Associated Press v. United States, 326 U.S. 1, 12-17 (1945).

337. *See* INNIS, BIAS, *supra* note 307, at 161-62; INNIS, THE PRESS, *supra* note 331, at 21-23.

public networks. Each of these facilities has its own historically contingent legal basis and incumbent physical facility with which to develop its infrastructure. These facilities are:

(1) Wires, historically copper "twisted pair," strung over telephone companies' rights of way;[338]

(2) Wires, historically coaxial cable, strung over cable companies' rights of way;

(3) Wires, including already installed electric wiring, strung over electric utilities' rights of way;

(4) Land-based wireless transmission, including one-way — television, traditional radio, MDS (wireless cable); and two-way — cellular, PCS; and;

(5) Space-based wireless transmission, including one-way models like direct broadcast satellite, and two-way facilities like Low Earth Orbit ("LEO") satellites and Mobile Satellite Systems ("MSS").

All five of these facilities are privately-owned. In each, the owner determines the best use of the infrastructure, under the same assumptions discussed in Parts VI and VII. This model is derived from the federal government's decision not to invest in building public infrastructure, but instead to rely on private initiative to lay wires or optical fibers and upgrade the switches, or deploy satellites, transmitters, and antennas.[339] As a consequence, the infrastructure will be privately owned.

For the reasons expressed in Part VII.A., owned infrastructure will tend to be used by, and for the highest valued use of, those users whose preferences cluster around the peak of the normal distribution curve of individual communicative preferences as perceived by the owner of the infrastructure. The primary force counteracting this dynamic is the historically-contingent inertial force of the common carrier model that has to date dominated one of the most important channels to the digitally networked environment — telephone lines. In the process of effecting

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338. *See* YOCHAI BENKLER, LEGAL RESEARCH NETWORK, RULES OF THE ROAD FOR THE INFORMATION SUPERHIGHWAY: ELECTRONIC COMMUNICATIONS AND THE LAW 174 (1996).

339. *See* KENNETH M. MEAD, INFORMATION SUPERHIGHWAY, ISSUES AFFECTING DEVELOPMENT 14-16 (GAO Rep. No. 94-285, 1994).

a transition to a more competitive market in telephony,[340] the Telecommunications Act of 1996 instituted a presumption (albeit with little institutional detail) that all communications services that facilitate communications of the end-user's choosing will operate as common carriage.[341]

There are three reasons why common carriage does not completely negate the phenomenon of information-environment centralization. First, the carrier still defines the range of services or communicative uses available through its service. Common carriage assures that all comers will be able to use this menu, not that they will be able to control the menu of options itself. Accordingly, it does not reverse the incentives for preference articulation discussed in Parts VII.A-B. Second, given a choice between operating as a contract carrier or a common carrier using similar facilities, organizations have an incentive to act as contract carriers in order to "cherry-pick". Given that the Act imposes carriage obligations only on services that a carrier offers that do not affect the content of messages,[342] organizations have good reasons to structure their services primarily around components that affect the intelligence carried, and thus to retain more control over the communications carried and their pricing. The model of the open video system, offered as a hybrid common carriage/proprietary video delivery system in the 1996 Act,[343] is an excellent example of the direction in which these institutions might evolve, with large portions of the networks devoted to owner-controlled content subject to more discriminating pricing, rather than to end-user-generated content. Finally, privately-owned infrastructure relates as a bottleneck or essential facility to services or communications that rely on it for carriage, and suffers from an endemic need for regulation against anti-competitive abuses. Enforcement shortfalls would lead to centralization of control over information content flowing on the infrastructure, even assuming that an otherwise-efficient market in information uses would not lead to such centralization in a common carriage model.

The only available path to develop a significant component of unowned infrastructure under present technological and organizational conditions is to permit extensive deployment of unlicensed wireless

340. For a more comprehensive description of the 1996 Act, and how it relates to the background of telephone and cable companies as primary channels to the home, see BENKLER, *supra* note 338, at 172-209.

341. *See* Telecommunications Act of 1996, Pub. L. No. 104-104, § 3(a)(49), 110 Stat. 56, 60 (codified at 47 U.S.C.A. § 153 (West Supp. 1997)).

342. *See* BENKLER, *supra* note 338, at 186-93.

343. *See* Telecommunications Act, § 302, 110 Stat. At 118 (codified at 47 U.S.C.A. § 651 (West Supp. 1997)).

devices. Because such devices require neither wires nor privately-owned spectrum allocations, there is no large initial investment to be made, and thus no single entity with investment-backed claims can demand centralized control. Moreover, since the network is coordinated in a distributed, rather than centralized, fashion, there is no organizational need for an owner to manage or monitor the flow of communications in the network. Thus, while unlicensed operations *can* be organized on an owned-infrastructure basis, as in the case of Metricom,[344] they *need* not be. The network can be deployed piecemeal, through the additions of individual network users or small network groups, organized through private enterprise or public/community organizations and working independently of each other.

Unlicensed wireless devices can offer a portion of the infrastructure to users who cannot otherwise gain effective access to the communicative environment. It can be the infrastructure of first resort for those who cannot pay for information on a continuous basis, similar to over-the-air television today. Unlike television, unlicensed devices will allow those who rely on them to be producers of information and knowledge, and not solely consumers. Unlicensed devices also offer an infrastructure of last resort for those who are refused the facilities of owned infrastructure because their views are unorthodox or offensive, or because the information they offer is valuable only to a market segment too small for infrastructure owners to consider worthwhile.

D. *Implications for Personal Autonomy and Political Discourse*

To be able to choose the path of one's life, one must be able to perceive the world, form a belief about the present state of the world and alternative possible states, and develop a preference ordering of possible states of the world among which one can then choose. The capacity to acquire information about the world, to determine for oneself what information is credible and what is relevant, to access information with which to make that judgment, and to apply the conceptual structures necessary for selecting and processing the information into an intelligible personal conception of the world as it is and as it might be, is therefore central to the capacity of an individual to be a source of commands concerning his or her way in the world. Furthermore, we do not live alone. To live one's life according to one's own decisions, one must be able to communicate his or her conception of the preferred state of the world, and must have the facility to persuade others of the validity of

344. *See supra* Part IV.B.1.

that preference and the course of conduct leading to it, so as to seek their cooperation in permitting or aiding the execution of the individual's choice. Similarly, one must have the capacity to reject the persuasive communications of others when acquiescing in their preferences would quash one's own will. The capacity to communicate or not as one wills, to choose one's mode of expression and one's audience, are therefore germane to a person's ability to effectuate his or her life plan.

An individual's communicative environment is the sum of communicative inputs and outputs with which an individual comprehends the world, chooses a course of action, and coordinates behavior in society. A system that gives individuals the power to make more of the decisions that make up their communicative environment offers them more control over the important decisions in their lives. As more of the decisions that define a person's practically-useful choice set in a given set of circumstances are controlled by the individual, a greater proportion of the determinants of the individual's action in those circumstances is self-generated. The individual is more self-governing.

A similar dynamic operates at the level of community self-governance. No less than individuals, the degree to which political communities are self-governing is affected by the extent that the views of more of their constituents, and others as well, are available to the body politic for consideration. The recognition of the importance of open information flows and robust confrontation of views to political self-governance has been a recurring theme in First Amendment decisions and commentary.[345] Privately-owned infrastructure operating in a broadcast model has tended to homogenize and standardize information content for mass appeal, and has thereby acted to smooth out differences of opinion, impoverish the competition of ideas, and, ultimately, make public debate thinner and less productive.[346] Part VII.A. offered an institutional economic explanation for this phenomenon. Its conclusions indicate that an institutional framework

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345. *See supra* note 271.

346. The poverty of public discourse in the mass-mediated environment — including the media's tendency to reflect the preferences of those who purchase advertised products and those who control the broadcasting infrastructure, to standardize viewpoints, to eliminate the unorthodox or disturbing, to professionalize public speech and to impoverish public debate — have been the basis for significant criticism of the effects of the current structure of mass media on the central values represented by the First Amendment. *See, e.g.*, Owen Fiss, *Why the State?*, 100 HARV. L. REV. 781, 785-788 (1987); Barron, *supra* note 305; R. Randall Rainey, *The Public Interest in Public Affairs Discourse, Democratic Governance, and Fairness in Broadcasting: A Critical Review of Public Interest Duties of the Electronic Mass Media*, 82 GEO. L.J. 269, 300-01 (1993).

that relies on symmetric, as opposed to asymmetric, constraints on how individuals can use the communications facilities of an infrastructure will tend to produce a more diverse range of communicative uses. This diversity of use, in turn, produces the "multiplicity of information sources" considered so valuable for the democratic process.

Unlicensed wireless devices offer the best currently-available means of maintaining an infrastructure of first and last resort whose use is controlled by individuals seeking to obtain information or opinion, or to communicate their perceptions and conceptions to others. By locating the power to decide how communications infrastructure will be used with individual equipment owners, an institutional choice in favor of permitting unlicensed operations will tend to leave actual decisions about the range of uses for that equipment in the hands of end-users. Conversely, under similar conditions, an institutional choice to give infrastructure owners the initial decision-making power will cause actual decisions to be made by these owners. The implications of these choices will reflect on both individual and political self-governance.

IX. Conclusion and Three Institutional Recommendations

A. What Is at Stake?

The implications of whether part of the information infrastructure will be unowned can be intuitively grasped by analogy to the system of roadways and sidewalks that we take for granted, and its effects on our freedom of movement. Imagine that in order to balance the budget by 2002 and to reduce congestion and tailpipe emissions, the government decided to auction all roadways and sidewalks connected to the Interstate Highway System. The owners of roadways and sidewalks would be free to offer any transportation service they chose, or none at all. They could provide public transportation or allow fee-based automobile and pedestrian use, allocate use by time slots, or rank users by their willingness to pay. Presumably, the owners of the roads would use them so as to maximize their value. If enough people wanted to use a road in a particular way, neoclassical economics suggests that those people would find an owner willing to sell them permission to use the road in that manner.

To the extent one feels discomfort at the idea of such a privatized model for roadways, I propose that this discomfort is due to what might be called the "Easy Rider" or "Thelma and Louise" effect. The central role that the open road has played in American culture as a metaphor for freedom derives from its unique importance to our physical freedom.

Because roadways are operated as commons, anyone who can walk or has the wherewithal to purchase the necessary equipment (a car, bike, or wheelchair), can choose when, where, how, and with whom to travel without needing permission from anyone else. Our entire relationship with our physical surroundings would likely be altered fundamentally if, in order to leave our homes, we had to transact constantly with others, having a superior right to decide whether we could or could not take the route of our choice, at the time of our choice, using the vehicle of our choice.

Unlicensed wireless operations provide the best currently available option to assure that our communications infrastructure, like our transportation infrastructure, has such an "open road" component. All other lines of communication to the home or office will be owned. Some of these channels may be regulated as common carriers. But non-discrimination in pricing and service can no more substitute for individual control over communications than efficient train travel can replace the freedom of the open road. Both owned infrastructure and the open road are essential to our relationship with the physical space in which we live. A similar combination for our communicative environment has much to commend it.

B. Recapitulation

In this Article, I have suggested that the primary focus of present debates over wireless communications regulation is misplaced. The present regulatory system was fashioned around the needs of one model of wireless communications: broadcasting. That model was developed in the 1920s to make possible a consumer market in simple receivers, which were at the time the sole product appropriate for mass marketing. Consequently, the institutional problem to be solved involved allocating frequencies among powerful transmitters capable of being received by these simple receivers. Today, we live in an economy powered by low cost processors. We have learned to communicate through distributed communications networks like the Internet that rely heavily on the computing capabilities of end-user equipment. Yet we continue to use a problem definition created by a market in equipment too crude to permit distributed network management. We must instead open our minds to the possibility that the important question is no longer how to allocate spectrum among a small number of sophisticated service providers, but rather how to allow better coordination among a large number of end-users with sophisticated equipment.

This Article has suggested why it may be advisable to adopt, through regulatory or legislative means, an institutional framework that will make possible the development of an unowned component of our information infrastructure based on unlicensed wireless devices. The market in equipment — computers (whether they look like desktops, televisions, or cellular phones) and software — necessary for operating in an unlicensed environment will provide the engine of innovation and deployment of this component of the infrastructure. This market, and competition from owned-infrastructure alternatives, will provide equipment manufacturers and users with the incentives to avoid overuse and underdevelopment, the primary objections to this regulatory model raised by traditional microeconomic models.

An institutional economic analysis of the effects of licensing and auctioning, on the one hand, and permitting unlicensed operations, on the other hand, indicates that the former is likely to lead to centralization of decisions about the content and nature of communications and information flows, while the latter is likely to lead to a distribution of these decisions to end-users who possess communications equipment. The high cost of information-gathering, and other transaction costs associated with articulating and communicating preferences about the uses of communications infrastructure in an imperfect market, are likely to leave the actual decisions about who may communicate with whom, about what, in what form, and to what effect, where the power to make those decisions is initially located by the institutional framework. A model that relies on distributed networks therefore is likely to result in a broader range of uses, both because users will have greater incentives to articulate their own first-best preferences, and because they will be in a position to effectuate their preferences. Furthermore, while there are reasons to think that such a distributed model may be more efficient, or more productive, in an economy that performs best with high consumer information-feedback, there are also reasons to think that the institutional framework necessary to allow this more efficient model to develop will not arise without political initiative. Institutional arrangements are prone to path-dependency, and organizations adapted to an incumbent institutional system tend to have sufficient staying power to sustain a sub-optimal institutional path indefinitely. Adopting a better path will therefore require administrative or legislative action.

The analysis of the choice between centralized control and distributed coordination of a communications infrastructure reveals its social and political implications. The distributed model is more likely to give individuals the actual power to determine the sources of information available to them, the relevancy and credibility of information, the mode for perceiving and processing information, and the appropriate response to information. Since autonomous action begins with perceptions of actual and potential states of the world, the distributed model of communications gives individuals greater control over the choice set they perceive as available to them. Because acting on personal decisions often requires cooperation or acquiescence from others, individual control over the capacity to communicate one's will to others and to persuade them to cooperate is central to the capacity of individuals to effectuate their choices. An institutional framework that is likely to afford individuals more power over their personal communicative environment is therefore likely to serve values crucial to the enhancement of individual autonomy. Moreover, the broad distribution of remote communications capacity will likely diversify the social, political, and cultural perspectives available for public conversation. Free of the tendency of the broadcast model to use communications facilities to reflect average preferences, those connected to the digitally networked environment will be better able to access this multiplicity of voices.

C. What Is to Be Done? Four Steps to Reserve Institutional Judgment

The FCC has already issued the U-NII Order, thereby providing the institutional space for an unowned component of the infrastructure. What more can be done before the results of the U-NII experiment are in? I propose one intellectual device to discipline our thinking about regulatory choices in wireless spectrum, as well as three specific institutional measures whose cumulative effect is to reserve judgment on the question of whether the best way to regulate wireless communications is through a centralized control model or a distributed coordination model.

The intellectual exercise I propose is that we stop talking about wireless communications regulation in terms of resource management. Using this terminology obscures the fact that the problem is one of coordinating the use of equipment that can cause and suffer collisions and congestion. Letting go of this heuristic device may open the discussion to new regulatory options. Collision- and congestion-prone equipment need not be regulated by assigning property rights to the infrastructure necessary for its use. Automobiles on most routes, legs on a busy street, and networked computers are the most ubiquitous examples. We should focus our attention on whether wireless communications equipment should be regulated by assigning property or other exclusive rights to an input necessary for its use, or by imposing "rules of the road," or collision-avoidance and congestion-control protocols.

The three practical institutional proposals offer a framework by which to reserve judgment on whether wireless communications will develop according to a centralized model or a distributed model until after a viable market in devices for unlicensed-wireless use has had an opportunity to develop. The first proposal seeks to free the path of technological and organizational development of unlicensed operations from the gravitational pull of incumbent licensed operations. The other proposals are intended to prevent entrenchment of licensed operations that would tie us to the transmission-rights model even if unlicensed operations prove to be a better model in the future.

First, the FCC should reopen its U-NII proceeding to consider whether its regulatory choices best serve the development of unlicensed devices, independent of considerations of incumbent services. If the U-NII band is to provide a good laboratory and seeding ground for testing the viability of an unlicensed model for a significant portion of the information infrastructure, then its institutional parameters should focus on permitting these devices to be developed and deployed so as best to facilitate multilateral coordination, not the avoidance of interference to and from transmissions operating on the competing model. The Commission should reconsider the decision not to employ a "Part 16" model, where unlicensed devices as a group are treated as a protected service vis-à-vis other uses of the spectrum. The U-NII Order treated this question as one involving protection of unlicensed devices from *claims* by licensed operations that the unlicensed devices were causing interference, instead of considering the value of providing unlicensed device users protection against *interference* from others. In other words, the Order did not consider the advantages for unlicensed devices which might accrue if the devices operated in an environment free of high-powered transmissions that are not amenable to spectrum sharing. Furthermore, the decision to divide the U-NII band into three, and to permit different power levels in different bands, was based on the needs of incumbent services, not those of unlicensed devices. The Commission thereby artificially segmented the market and limited network economies for unlicensed devices. The Commission also limited the range of frequencies available to solve the multiplexing problems associated with wide area or community networks. These effects handicap the development of the unlicensed environment as a basic component of the digitally networked environment. The Commission should seek either to relocate competing licensed services in the U-NII band or to add spectrum in which unlicensed devices will be subject only to the constraints necessitated by frequency sharing among devices designed to share spectrum.

Second, the process of spectrum auctioning should be slowed. The FCC has been auctioning the airwaves at increasing rates. This policy is made attractive by the allure of present income and short-term deficit reduction, by the pride of an agency whose auctions make it appear as a profit center rather than a cost center in the federal government, and by microeconomic predictions that rely on assumptions of perfect markets and transaction-cost-free reconstitution of rights. Each purchaser of airwaves is, however, an organizational trench dug along the path of institutional change that will haunt us if and when we decide that permitting unlicensed wireless devices is the better institutional path. While I do not suggest that the analysis offered here justifies that we halt all auctions, I think it is important that each decision to auction spectrum start with the assumption that auctioning is a high risk commitment to an institutional and technological path that may be wrong. The current background assumption that auctioning is a step in the right direction (to a market-based system) even if a specific proposed auction will have no immediate benefit, should be counter-balanced with an understanding that each auctioned frequency has a clearly defined cost in terms of lost institutional flexibility, at a time when we do not know what the best institutional framework is but have good reason to think that a privatized or licensed framework may not be best.

The third institutional proposal is independent of, but complements, the second. Current spectrum auctions involve the sale of time-limited licenses. If these licenses did not carry with them an expectation of renewal, the concern over the path-determining effect of auctions would be attenuated. In the present system, however, given the strong historical renewal expectancy broadcasters have enjoyed and its endorsement and extension in the Telecommunications Act of 1996, together with the prevailing economic wisdom — increasingly endorsed by the FCC — that licenses should evolve into property rights, those who purchase their licenses at auctions have valid expectations-based claims that their licenses *should* be renewed. The development of these claims threatens to be the most forceful argument available to incumbents seeking to prevent a shift to unlicensed operations. It is important to prevent the formation of these expectations, even at the expense of a reduction in present auction revenue. The Commission should consider including in new licenses an explicit proviso that there is no guarantee of renewal, at least to the extent that the Commission decides not to continue to allocate the frequency block auctioned to licensed use. As a corollary, the Commission should adopt the position that licenses already granted are more akin to leases without a renewal option than to fee-simple rights or long-term renewable leases. The sooner the Commission develops and publicizes a policy of reserving judgment on how wireless communications are to be regulated, the more lead time will be available to incumbent licensees to adjust their behavior accordingly, and the less forceful their settled-expectations claim against a regulatory transition will be.

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Providing an appropriate regulatory space for unlicensed wireless operations is the only available option for allowing the development of unowned information infrastructure. Such an unowned infrastructure component could provide a communicative space in the digitally networked environment functionally equivalent to public sidewalks, streets, and roads. Its implications for our individual autonomy and political culture are likely to be significant. In the absence of adequate regulatory space, such open infrastructure may not develop. While the technology for its development exists, and the economic interests to fuel its development are in place, whether such an infrastructural element will in fact develop depends on institutional choices our society will make in the next decade or so. It is the possibility of such an open and distributed infrastructure, with its social-political benefits, together with the lack of a clearly determined mechanism that will lead to its creation absent regulatory action, that provides the most important reason to strive, as a matter of legislative and administrative policy, towards the creation of a well regulated commons in our information infrastructure.

APPENDIX: PRIMARY SPECTRUM SHARING TECHNOLOGIES

A. Spread Spectrum and Code Division Multiple Access ("CDMA")

Since the 1940s,[347] it has been recognized both theoretically and practically that a signal could be received without degradation, at lower signal-to-noise ratios than previously thought necessary, if the signal is spread over a much broader channel than actually necessary to convey the information.[348] A certain minimum bandwidth is necessary to send

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347. The two primary sources often cited for this insight are Shannon, *Noise*, *supra* note 171, at 10, and Shannon, *Theory*, *supra* note 171. These articles lay out the theoretical underpinnings of direct sequencing spread spectrum. The 1942 patent issued to Hollywood actress Hedy Lamarr and composer George Antheil, is usually credited with having provided the idea of frequency hopped spread spectrum. *See, e.g.*, Meeks, *supra* note 172, at 136.

348. The following discussion is based on Jack Glas, *The Principles of Spread Spectrum Communication* (visited Feb. 25, 1998) <http://olt.et.tudelft.nl/~glas/ssc/techn/techniques.html>; Spread Spectrum Scene, *Spread Spectrum Primer* (visited Feb. 25,

any signal, given a power level at which the signal is transmitted. Spread spectrum communications use a much wider bandwidth than necessary to send the same signal. Because the signal transmitted at a given power is spread over a broader band of frequencies, the power density of the signal (watt per hertz) is lower at every point on the spectrum used for its transmission. It is so low that it "sounds" like natural background, or "White Gaussian," noise, to the casual "listener." With this approach the signal cannot, and need not, "drown out" noise, because it behaves like noise.

To spread the signal over more than the necessary bandwidth, a manufactured code is added to the information-carrying signal. This added code masks the content of the message with what is typically called a pseudo-random sequence, producing a transmission of "pseudo-noise." (Noise in general refers to anything that is not part of the intelligence intended to be sent by the sender.) But pseudo-noise, unlike noise in the channel that is not intentionally created, is manufactured according to a pre-determined code. It can therefore be recognized and differentiated from other kinds of noise by a receiver that "knows the code" used to generate the pseudo-noise. The receiver is designed with the intelligence necessary to "pick up" the noise-like spread transmission (the information carrying signal transmitted as pseudo noise), strip the signal from the pseudo-noise, and reproduce the signal as intelligible information. Metaphorically, the receiver "scans" the broad spectrum over which the signal is spread, recognizes from the range of background noises those noise-like transmissions that carry the signal transmitted by the desired transmitter, and re-translates them into an intelligible signal.

Spread spectrum technology has extensive implications for wireless communications. At a simple level, spread-spectrum techniques allow more secure communications, because the signal is "hidden" when transmitted, and a receiver must "know the code" to recognize which, among the many other noise-like waves appearing in the spectrum, carries the message that the receiver wishes to receive. They are also more robust to interference than narrowband transmissions. For these reasons spread spectrum technologies were initially developed for military uses. They also (arguably) allow more efficient use of the spectrum, because every point in the spectrum can be used without

1998) <http://www.sss-mag.com/primer.html>; Virginia Polytechnic Institute, *Spread Spectrum* (visited Feb. 25, 1998) <http://www.cwt.vt.edu/faq/ss.htm>; Andrew J. Viterbi, *Wireless Digital Communication: A View Based on Three Lessons Learned* (visited Feb. 25, 1998) <http://people.qualcomm.com/karn/viterbi_lessons.html>.

interference from spurious emissions from frequencies next to the primary frequency.[349]

But the most important implication of spread spectrum technology for regulatory purposes is that it allows many users to use the same band of frequencies simultaneously. Because every signal is noise-like, the signal of each user is, to all the others, just part of the background noise. The receiver ignores all signals but the one chosen for reception, and "receives" — translates into humanly intelligible form — only those noise-like transmissions that carry the intended signal. The code can, for example, identify a single individual, and allow person-to-person wireless telephony or point-to-point data transmission. Alternatively, it can identify a certain "broadcaster," allowing a user to "tune in" to that person's transmissions and no others. It is this aspect of spread spectrum technology that most directly challenges the continued dominance of an institutional model based on exclusive transmission rights for transmitters — whether by licensing or privatization.

When spread-spectrum techniques were developed for military applications in the 1940s, computer processing technology was decades away from the cheap processing capabilities that could make spread spectrum into a viable basis for consumer applications. But as commercially-viable processing power became available in the late 1980s, equipment has caught up, and spread-spectrum transmission techniques are fast becoming the vehicle of choice for many services. The first company to solve the engineering problems associated with implementing spread spectrum was Qualcomm, Inc.,[350] whose code division multiple access ("CDMA") standard was adopted in 1993 as one of the industry standards ("IS-95") for wireless communications.[351] The company offers both mobile phone products and equipment to use a wireless local telephone loop instead of a wired loop.[352] According to the Company's annual report, at the end of 1996, its technology had been adopted by seventy-five percent of the licensees for cellular services and by carriers who held licenses covering sixty percent of the U.S. PCS market.[353] Other major equipment manufacturers are involved

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349. *See* VIJAY K. GARG & JOSEPH E. WILKES, WIRELESS AND PERSONAL COMMUNICATIONS SYSTEMS 41-42 (1996).

350. *See* Raymond Steele, *The Evolution of Personal Communications*, 1 IEEE PERSONAL COMM. MAG. 1 (1994), *available at* <http://www.comsoc.org/pubs/surveys/steele/steele-orig.html> (visited Feb. 25, 1998).

351. *Id.* For a brief description of IS-95, see Virginia Polytechnic Institute, *IS-95* (visited Feb. 25, 1998) <http://www.cwt.vt.edu/faq/is95.htm>.

352. *See* Qualcomm Inc., *Qualcomm CDMA Home Page* (visited Feb. 25, 1998) <http://www.qualcomm.com/cdma/>.

353. *See* Qualcomm Inc., *CDMA Goes to Market* (visited Feb. 25, 1998)

in manufacture of equipment based on CDMA technology,[354] and Sprint PCS has deployed its national wireless service using a CDMA-based system.[355]

B. Time Division Multiple Access ("TDMA")

The competing digital standard for allowing multiple users to share the same frequency, primarily in the context of mobile communications, is time division multiple access ("TDMA"). TDMA was the first digital wireless telephony standard to be recognized in the United States, and its multiplexing principle is shared by the European multiplexing standard, GSM. The principle of TDMA is that the entire bandwidth of a narrow frequency band is used to send the entire signal of a number of users "simultaneously," by divided the band among those users by time. The division occurs by breaking up the message of each user who is sharing a channel into digitized packets; each packet is then transmitted in a short "burst," occupying the entire channel for a brief instance. The "simultaneous" sharing of the spectrum is achieved by establishing a cycle that sequences the transmission bursts of each of the sharing users. During each cycle, a burst from each of the sharing transmitters is sent or received, each in its turn. The cycles are sufficiently rapid that from the "real time" perspective of the participants in the conversation, the conversations occur simultaneously.[356]

TDMA is primarily a technique that allows PCS providers to achieve greater spectral efficiency. In other words, it is a method that allows service providers to accommodate more customers, speaking at the same time, over the narrow frequency band that the provider is licensed to use. Its primary corporate sponsor for this purpose is Ericsson, Inc.,[357] and there is still debate over whether TDMA, CDMA, or some combination is the most efficient method of providing that kind

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<http://www.qualcomm.com/IR/AR96/cdmamkt.html> (describing PCS as a current/next generation cellular system).

354. *See, e.g.*, Margaret Ryan, *Merge Consumer Communications Operations in $2.5B Pact — Philips, Lucent Forge Deal*, ELEC. ENG'G TIMES, June 23, 1997, at 27 (describing how Lucent Technologies is joining Qualcomm, Motorola, Nokia, and Northern Telecom in producing CDMA based equipment).

355. *See* Mark Moore, *Sprint PCS Adds Cities to National Wireless Service*, PC WK., June 23, 1997, at 131.

356. *See* GARG & WILKES, *supra* note 349, at 30-33; Steele, *supra* note 350; *see also* Parag Vora, Technological Standards in Cellular Telephony (Apr. 1995) (copy on file with author).

357. *See* Ericsson, *Digital* (visited Feb. 25, 1998) <http://www.ericsson.se/US/phones/phones/cellterm/digital.html>.

of service.[358] Because TDMA is a narrowband technique, it is not, alone, likely to provide the basis for broadband spectrum sharing of the type considered in this article. Nevertheless, the primary principle underlying TDMA, using time sharing in such small increments as to make the time division imperceptible to the human user, is likely to play a part in the technological mix that will facilitate the use of wireless communications on a multilateral coordination model, rather than one based on centralized control.

C. Cellular Networks

Cellular telephony preceded digitization of voice communications. It makes an important contribution to spectrum management, regardless of the transmission technology, by reducing the distance that each transmitter must send, thereby reducing the power necessary for transmission and allowing for frequency reuse in other cells. Cellular communications use a combination of end-user transmitters/receivers and base stations. The base stations are essentially relay stations and routers. The closest base station to a transmitter receives a signal, and relays it to the base station closest to the intended receiver through an intermediate wired network or by wireless connections.

Cell sizes can vary over tremendous ranges, from a radius of hundreds of miles to fifty to one-hundred meters. These micro- or pico-cells have the advantage that they allow for extensive frequency reuse — multiple users can use the same frequency, as long as they do so in different cells. When the radius of a cell is fifty meters, for example, users might be quite close to each other, sharing the same frequency in adjacent cells. The downside of smaller cells involves network management — the smaller the cells, the greater the number of times a given conversation must be handled by different cells (i.e., "hand-offs") as the users move from cell to cell. However, this difficulty does not arise when wireless technology is used to connect fixed locations since the user remains in a given location. Small cells therefore offer a particularly efficient solution to deploying a local loop of unowned spectrum as an alternative to current proprietary wired and emerging wireless local loops.

Cellular networking can be combined with both CDMA and TDMA, both for intracellular sharing of frequencies and for intercellular

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358. *See* Paul Walter Baier, et. al., *Taking the Challenge of Multiple Access for Third-Generation Cellular Mobile Radio Systems — A European View*, IEEE COMM. MAG., Feb. 1996, at 82; GARG & WILKES, *supra* note 356, at 41–43; Steele, *supra* note 350.

handoff.[359] This significantly increases the sharing capacity of all of these techniques by itself, because it adds space (distance between users) as an additional dimension for allowing spectrum sharing.

D. Frequency Hopping

Frequency hopping was initially developed as a means of avoiding interception of naval radio communications during WWII.[360] A transmitters operating under this principle transmits part of its message over a narrow frequency, and then hops to a different frequency to transmit the next part of the message. The next frequency can be predetermined by a "pseudo random" sequence known to the receiver, thereby allowing transmitter and receiver to hop in tandem.[361] Frequency hopping is used primarily as a spread spectrum technique,[362] but has also been adapted to TDMA systems.[363]

Other than the security advantages from fleeting hops, frequency hopping is advantageous because it avoids problems raised by geographically proximate sources of interference.[364] Given *x* users at *y* traffic rate, the use of signals transmitted over randomly sequenced narrow bands within a wide frequency range (i.e. frequency hopping) will reduce the probability that any two competing signals from proximate transmitters will collide; and any interference will likely degrade only a small portion of the message.

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359. *See, e.g.*, Graeme Woodward et. al., *CDMA Cellular Mobile System Capacity Improvement by Combination with TDMA and Adaptive Interference Suppression, in* PROCEEDINGS IEEE WIRELESS COMMUNICATION SYSTEMS SEMINAR '95, at 171 (1995), *abstract available at* <http://www.ee.usyd.edu.au/~graemew/WCSS95.html> (visited Feb. 25, 1998).

360. A copy of the patent for the communications process that invented frequency hopping, issued in 1942, is available at Chris Beaumont, *Text of the Lamarr/Antheil Patent* (visited Feb. 25, 1998) <http://www.ncafe.com/chris/patent/patent1.html>. The original patent is US Patent Office, Patent No. 2,292,387 (1942), issued to Hedy Kiesler Markey (a.k.a. Hedy Lamarr) and George Antheil.

361. *See* GARG & WILKES, *supra* note 349, at 39-41; Glas, *supra* note 348; Virginia Polytechnic Institute, *supra* note 348; *see also* NATHAN J. MULLER, WIRELESS DATA NETWORKING at ch. 1 (1995).

362. *See id.*

363. *See, e.g.*, Stuart Sharrock, *CDMA/TDMA: From Fists to Facts* (visited Feb. 25, 1998) <http://www.ericsson.com/Connexion/connexion3-93/techno.html>; Ericsson, *GSM Unlimited* (visited Feb. 25, 1998) <http://www.ericsson.com/WN/wn3-96/six.html>.

364. *See* Glas, *supra* note 348; Virginia Polytechnic Institute, *supra* note 348.

E. Packet Switching and Computer Network Management in General

An important technology developed in the context of computer networks, rather than wireless communications, is packet switching. This method of communications forms the basis for the Internet. A packet switching protocol breaks down every message into smaller "packets" of information bits, which carry small portions of the message, and information about the packet's destination and how it is to be recombined with other packets to reproduce the message sent. For example, the protocol breaks an email message sent over the Internet into short strings, and sends each packet over the network wherever there happens to be capacity. Once all packets have arrived, the receiver of the packets reconstructs them into the email message.

Packet switching is a very robust transmission technology. Routing protocols avoid areas where many collisions (interference) are likely, and when interference does occur, the receiving computer can "call" for missing packets that do not arrive at the destination to be re-sent until it receives the full complement of packets necessary to form the message. Wireless communications, using any of the transmission technologies discussed above, can use packet switching protocols to break down the size of transmission bursts into minuscule packets, which require only a fraction of a second to send. Portions of a transmission that are "lost" in collisions with other transmissions can be retransmitted without the necessity of retransmitting the entire message. Wireless communication that uses packet switching can also take advantage of cross-fertilization of technologies developed for computer networks and information management such as compression, buffering, and efficient network management concepts that can be used to manage traffic in a wireless system that, like the Internet, lacks a central controller.