WIRELESS COMMUNICATIONS AND COMPUTING AT A CROSSROADS:

NEW PARADIGMS AND THEIR IMPACT ON THEORIES GOVERNING THE PUBLIC'S RIGHT TO SPECTRUM ACCESS

PATRICK S. RYAN*

* Adjunct Professor, University of Colorado at Boulder School of Law and Interdisciplinary Telecommunications Program and Guest Professor, Katholieke Universiteit Leuven. The author is most grateful to Jos Dumortier for his support to write this while in Leuven at ICRI (www.icri.be). Further, the author is indebted to the following people for feedback and critique: Carolyn Daughters, Hans Graux, Andy Johnson, Wendy McCallum, Peggy Valcke, and Phil Weiser.

I. FROM EXCLUSIVE USE TO PUBLIC RIGHT

Electromagnetic spectrum[1] enables countless variants of personal communication—person-to-person and collective, commercial and non-commercial—across many different media (*e.g.*, computers, telephones, pagers, televisions, PDAs and radios). The phenomenal growth in the Internet, mobile telephones, and many forms of video transmission demonstrates the attraction of communication, in all of its electronic forms, to very broad sectors of society. Enjoyment of the electromagnetic spectrum is now ingrained in our human character. People seek information and entertainment by talking and listening, by watching and learning, and by sending short messages, pictures, and videos to one another.

These communication forms have increasingly become wireless. For the past several decades, lawmakers have considered many options for allocating spectrum and managing wireless products, and thus far they have done so by regulating the electromagnetic spectrum itself. These laws have not been static, however, and over time they have followed—sometimes with long delay—various economic and technological principles that have sharply conflicted with each other. Although spectrum allocation policies ostensibly situate the "public interest" at the forefront, regulation is mired in thousands of pages of rules and statutes that attempt to stipulate in explicit terms what the public *cannot* do.[2] Of course, lawyers are on hand to interpret what the

1. Here, "electromagnetic spectrum" is used as a term for wireless communications, that is, all forms of communication that take place without the aid of a hard physical conduit (*i.e.*, communications that travel through the airwaves). In fact, there has been great debate as to what to call the electromagnetic spectrum and the airwaves. For example, Aristotle called spectrum "the ether." *See* Manfred Lachs, *Thoughts on Science, Technology and World Law*, 86 AM. J. INT'L L. 673, 687 (1992) (describing radio waves using Aristotle's term "ether"). Nobel Prize winning economist Ronald Coase questioned this "ether" paradigm, preferring instead to describe the electromagnetic spectrum as a "tunnel." As he observed, "[t]here is some doubt whether the *ether* exists," further noting that the spectrum's "properties correspond exactly to those of something which does *not* exist, a tunnel without any edges." Ronald Coase, *The Federal Communications Commission*, 2 J.L. & ECON. 1, 33 (1959) [hereinafter Coase, *Federal Communications Commission*]. Kevin Werbach points out that Einstein once compared the spectrum to a "cat" and then immediately removed the cat from the equation. Kevin Werbach, *Supercommons: Toward a Unified Theory of Wireless Communication*, 82 TEX. L. REV. 863, 882 (2004). Werbach quotes Einstein as follows:

> You see, wire telegraph is a kind of a very, very long cat. You pull his tail in New York and his head is meowing in Los Angeles. Do you understand this? And radio operates exactly the same way: you send signals here, they receive them there. The only difference is that there is no cat.

Id.

2. *See* PATRICIA AUFDERHEIDE, COMMUNICATIONS POLICY AND THE PUBLIC INTEREST (1999). The author describes the complexity and vagueness of the "public interest" basis for telecommunications regulation, noting that "[t]he public is endlessly invoked in communications policy, but rarely is it consulted or even defined." *Id.* at 5. She further adds

public *can* do, and they do so by reading and interpreting the thousands of pages of rules that the government has promulgated,[3] by opining on arcane procedures for obtaining licenses to transmit upon the spectrum, and even forming opinions on what can be said and who can say it. Sometimes they are famously wrong.[4] Conflating our ever-changing understanding of technology into a coherent set of regulations has proven

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that "[t]he law [related to 'public interest'] lurched and stumbled into existence, driven forward by a combination of ideological and technological changes to the terms of existing compact between big business and big government . . . government regulation evolved parochially . . . typically with a powerful allegiance to incumbents." *Id.* at 9.

3. There are thousands of pages that are relevant to wireless regulation. For example, Federal Communications Commission (FCC) Part 2 is a massive collection of technical data spawning several hundred pages. It covers international regulations, nomenclature and assignment of frequencies, and the complete table of frequency allocations. FCC Part 68 regulates the connection of terminal equipment to the telephone network. Any device that is regulated under Part 68, which sets the limits for intentional and unintentional radiation, must also comply with the provisions of Part 15. Part 68 is important for future wireless applications, because any change in FCC regulation or policy is likely to affect all of the interrelated FCC compliance regulations simultaneously. Even the most banal wireless applications (such as cordless phones) are regulated under both Part 68 (for their connection to the network) and Part 15 (for their radiation limitations in broadcasting capacity), as well as under Part 2 (for their placement in the frequency allocation zoning map). *See* FCC Frequency Allocations and Radio Treaty Matters; General Rules and Regulations, 47 C.F.R. pt. 2 (2003); FCC Radio Frequency Devices, 47 C.F.R. pt. 15 (2003); FCC Connection of Terminal Equipment to the Telephone Network, 47 C.F.R. pt. 68 (2003).

4. One of the most fascinating areas where the First Amendment clashes with FCC regulations is the legal advice associated with what can and cannot be said over the airwaves. Broadcast networks know that private citizens may bring actions to the FCC. There is an irony between what is legal and what is not, as illustrated by the 2004 Super Bowl controversy that erupted when Justin Timberlake pulled off part of Janet Jackson's bustier and exposed one of her breasts. This somewhat bizarre scene would have been legal in cable format because the signals over cable are not "public." It was perhaps illegal, however, only because it was sent over the public airwaves. While it may seem unwarranted for the FCC to police such incidents, Congress requires it to do so. This responsibility is derived from outmoded regulation that distinguishes the way the airwaves are regulated (*i.e.*, the FCC can regulate airwave content) from the way that wires and cables are regulated (*i.e.*, the FCC is prohibited from regulating wire and cable content to the same degree). In most parts of the United States, there is almost ninety percent penetration in cable or satellite (like cable, satellite content is not regulated in the same way), and most people cannot tell the difference between cable and non-cable stations. For example, when flipping through stations, there is no real way to differentiate between channel 5, an airwave-based FCC station (*e.g.*, ABC), and channel 23, a cable, non-content-regulated station (*e.g.*, MTV). Both stations come through on cable these days in most homes, and the handheld television remote control used to change channels does not differentiate between FCC-regulated material that also is transmitted over the airwaves and less-restrictive cable content. *See Transatlantic Cleavage*, THE ECONOMIST, Feb. 5, 2004, at 52 (describing the Jackson event and noting the FCC inquiry). *See also Hearing on Broadcast Decency Before the Senate Comm. on Commerce Science, and Transp.*, 108th Cong. (2004) (Statement by Kathleen Q. Abernathy, FCC Commissioner), *available at* http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-243910A1.pdf. Abernathy discusses the FCC's role in broadcasting: "The law holds that broadcasters, because they make licensed use of publicly owned airwaves to provide programming to the general public, have a statutory obligation to make sure that their programming serves the needs and interests of the local audience." *Id.*

to be nearly impossible. It is now time for the government to shift gears and to set up an overarching technology-neutral set of principles that delineate the public's *rights* to use the electromagnetic spectrum. The public already knows—for the most part—what it can not do with the spectrum. But government has never clarified the public's *rights.*

A. Dealing the Cards, and Valuing the Deal

In this article we will see that the regulation of the electromagnetic spectrum has relied upon multiple and conflicting principles that have been *de rigueur* at a given point in time, but which have been replaced by newer theories. Technology is changing so rapidly that regulators and their regulated markets are having great difficulty keeping up. Yet, more and more people want to use wireless; and counter-intuitively, government is fighting a battle of attrition. In spite of increased use of wireless products, exclusive frequencies and licenses are losing value as the world begins to recognize that new technologies shatter the concept of exclusivity. Tellingly, Gregory Staple and Kevin Werbach argue that the spectrum portfolios of incumbent operators (*e.g.*, those who paid billions for exclusive licenses) will be significantly devalued in coming years:

> Incumbent mobile operators and broadcasters will almost certainly face greater competitive pressures from both licensed and unlicensed alternatives. The spectrum portfolios of incumbent operators, especially the large cellular phone companies, may be the first to be devalued. Manufacturers, on the other hand, may see an enormous stimulus from the new spectrum environment. If nothing else, lower entry barriers mean that more service providers will want their equipment. Greater demand, in turn, may stimulate price reductions for devices and other equipment.[5]

So, assuming Staple and Werbach are right, as consumers continue to find new ways to communicate and enjoy the electromagnetic spectrum, markets and consumers will start shifting away from a focus on exclusively licensed spectrum and instead increasingly direct their attention towards new products and new forms of communication. We might, then, expect to see regulation shift from the spectrum resource itself to the devices that use it, because, as we will see, it no longer makes sense to control the resource itself. Thus far, however, the rights of the citizens who use these devices are still not set forth in any widely recognizable, overarching legal doctrine. As a result, policymakers lack

5. Gregory Staple & Kevin Werbach, *The End of Spectrum Scarcity*, IEEE SPECTRUM, Mar. 1, 2004, at 52.

the formal guidance needed to ensure the protection of the rights of the public in this burgeoning technological arena.

The idea of regulating the spectrum at the wireless device level, of course, has already been convincingly argued by many scholars and technologists.[6] As an extension of this idea, some experts even question the more fundamental aspect of whether governmental control of the spectrum may violate the First Amendment of the Constitution.[7] Nonetheless, there is still a fundamental vacuum to be filled, that of a policy or set of rights that would protect citizens' access to use the wireless spectrum. In light of this dilemma, it seems logical that we should pose and then attempt to answer the following question: Should the wireless spectrum (and the public's right to speak freely upon it) simply be protected by the First Amendment, or should it be endowed with a *sui generis* set of rights?[8]

B. Reshuffling the Deck

This article will consider one possible *sui generis* proposition—the Wireless Device Bill of Rights—and in doing so, we will expose several fundamental bases of "command-and-control" spectrum regulation that are hopelessly out of touch with current technology and scientific understanding. We will see that economists, technologists, and lawyers have had an ongoing struggle with many fundamental and conflicting questions of science and policy. For example: should computing be a

6. *See, e.g.*, Yochai Benkler, *Overcoming Agoraphobia: Building the Commons of the Digitally Networked Environment*, 11 HARV. J.L. & TECH. 287, 347 n.239 (1998) (describing "smart" versus "dumb" devices and the economic tradeoffs associated with each); Durga P. Satapathy & Jon M. Peha, *Performance of Unlicensed Devices with a Spectrum Etiquette*, 1 PROC. OF IEEE GLOBECOM, Nov. 1997, at 414, *available at* http://www.contrib.andrew.cmu.edu/usr/dsaq/globecom97.pdf (describing spectrum etiquette proposals and the role of devices in emerging wireless technologies); LAWRENCE LESSIG, CODE AND OTHER LAWS OF CYBERSPACE 184 (1999). Lessig notes the distinction between "dumb" and "smart" receivers and compares that distinction with protocol recognition in the Internet. Just as different machines have different addresses, the Internet sorts out and receives only those packets intended for a given receiver, thus requiring a network of devices of varying intelligence. *Id.*

7. LESSIG, *supra* note 6, at 182; Yochai Benkler & Lawrence Lessig, *Net Gains*, NEW REPUBLIC, Dec. 14, 1998; Stuart Minor Benjamin, *The Logic of Scarcity: Idle Spectrum as a First Amendment Violation*, 52 DUKE L.J. 1, 18-24 (2002) (offering various examples where government regulation of communication media other than the wireless spectrum—such as printing presses—would be considered unconstitutional).

8. The Bill of Rights consists of the first ten original amendments to the U.S. Constitution, which were passed by Congress on September 25, 1789, and ratified on December 15, 1791. The First Amendment protects free speech and freedom of religion. Specifically, it states that "Congress shall make no law respecting an establishment of religion, or prohibiting the free exercise thereof; or abridging the freedom of speech, or of the press; or the right of the people peaceably to assemble, and to petition the Government for a redress of grievances."

centralized public utility, or should it be subjected to a free market? Are telephone networks a natural monopoly, and should they be a government-owned public utility? Can telephone lines (and the services sold upon them) be "unbundled"? Can wireless spectrum be traded like property? The answers to most of these questions seem obvious to us today. However, they were not always so evident. Why? Because the answers depend on the evolution of economic thought and the proving of technology to support it. The Wireless Device Bill of Rights, a proposal initiated by technologist Bran Ferren[9] (and later advanced by technologist Kalle Kontson),[10] cuts through this confusing cycle by setting forth Constitutional-esque, technology-neutral protections and rights regarding the use of wireless media. These rights are intended to function irrespective of the economic, technological, or political fad *du jour*. Further, we will investigate whether the automation of the principles from a Wireless Device Bill of Rights could one day be computerized and even replace many of the functions now performed by governmental organizations like the Federal Communications Commission (FCC). As we will see, these ideas may at times seem radical, even though the FCC itself has flirted with them, just as it has begun to question other fundamental matters, such as whether or not spectrum itself is in fact scarce.[11]

If there is presently an over-arching governmental policy regarding wireless spectrum, it is that of "command-and-control."[12] This spectrum

9. *See* FCC TECHNOLOGICAL ADVISORY COUNCIL, REPORT: FIFTH MEETING OF THE FCC TECHNOLOGICAL ADVISORY COUNCIL 11 (Jun. 28, 2000), *available at* http://www.fcc.gov/oet/tac/tac_report000628.pdf [hereinafter TAC, FIFTH REPORT] (noting Bran Ferren's leadership in advancing the "Bill of Rights Initiative" through the FCC's Technological Advisory Council (TAC)).

10. *See* Kalle R. Kontson, Critical Review of the Wireless Device Bill of Rights, Presentation to the Spectrum Management Working Group (Dec. 4, 2002) (transcript available at http://www.fcc.gov/oet/tac/TAC_Examing_Bill_of_Rights_4Dec02.ppt). Many others are invariably involved in the process, mostly through the FCC's TAC, described *infra*.

11. The electromagnetic spectrum is an instantly renewable, non-depletable resource, and new digital ways of using it greatly question the "doctrine of spectrum scarcity," which has been used as a regulatory basis for governmental control of the spectrum for the past ninety years. *See generally* Jonathan Wallace & Michael Green, *Bridging the Analogy Gap: The Internet, the Printing Press and Freedom of Speech*, 20 SEATTLE U. L. REV. 711 (1997) (providing a broad overview of the doctrine of spectrum scarcity and its development under U.S. law); Benjamin, *supra* note 7 (arguing that new technologies may invalidate the scarcity rationale for spectrum management). *See also* Philip J. Weiser, *Regulatory Challenges and Models of Regulation*, 2 J. ON TELECOMM. & HIGH TECH. L. 1, 7 (2003) (describing the FCC's proactive approach to spectrum policymaking and discussing academic literature that questions the notion of scarcity).

12. *See* FCC Chairman Michael K. Powell, Broadband Migration III: New Directions in Wireless Policy, Remarks at the Silicon Flatirons Telecommunications Program, University of Colorado at Boulder (Oct. 30, 2002), *available at* http://www.fcc.gov/Speeches/Powell/2002/spmkp212.html [hereinafter Powell, Broadband Migration III] (describing the "command-and-control" philosophy behind FCC licensing).

management philosophy requires corporate "children" to be entreated by their governmental "parent" for approval of virtually anything that takes place across the spectrum.[13] Accordingly, since control is still maintained at the resource level (*i.e.*, the frequencies themselves) rather than at the device level (*i.e.*, the people and devices that use the spectrum), it is extremely difficult for corporations—or citizens—to implement changes to make better use of unused spectrum.[14] Yet, in spite of this difficulty it has become increasingly clear that "smarter" devices are helping to remedy problems arising from the government's control over the electromagnetic resource.[15]

The extraordinary growth of the kind and number of wireless devices on the marketplace prompts questions about the best way to manage conflicting needs regarding the various uses of these devices (*e.g.*, security, communications, and education). Since the spectrum is a natural and a national resource,[16] it seems fitting that the potential of

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13. *Id.* In his 2002 speech, FCC Chairman Powell describes the governmental parent analogy in the following way:

> While the wireless world has changed rapidly, government spectrum policy continues to be constrained by allocation and licensing systems from a bygone era. *Change is inhibited by the "mother may I" phenomenon*—businesses must go to the FCC for permission before they can modify their spectrum plans to respond to consumer demand.

Id. (emphasis added).

14. For example, today, a television broadcaster in Pueblo, Colorado, who does not use his allocated TV frequencies cannot choose to instead use those frequencies for delivering wireless Internet services to the community. This is the very subject of a Notice of Proposed Rule Making that the FCC has opened, which might allow for "smart" devices to use otherwise idle television frequencies. *See* Unlicensed Operation in the TV Broadcast Bands, *Notice of Proposed Rule Making*, 19 FCC Rcd. 10,018 (2004).

15. One practical example of how "intelligence" at the device level has helped to improve communications is through the proliferation of multi-mode phones. It was once believed that network operators had to make a choice, for example, between TDMA, CDMA, GSM, or other technologies; once this choice was made, consumers were then "locked in" to this chosen technology. However, multi-mode computerized phones, called "tri-band" phones and emerging "quad-band" phones, can now switch quite seamlessly between networks. Thus, the problem with using wireless phones on different standards was not resolved at the core (*i.e.*, the network), but was instead resolved through the use of more powerful, more agile telephones at the edges that are capable of adapting to their environment. *See How The Radio Changed its Spots; Smart Radio*, THE ECONOMIST, Dec. 4, 2003, at 31, *available at* http://www.economist.com/displaystory.cfm?story_id=2246155 (describing the various wireless standards that are available, and noting that software defined radio is helping to remedy the confusion).

16. In the United States, President George W. Bush has declared the electromagnetic spectrum to be "a vital and limited national resource." *See* Press Release, White House, Memorandum on the Spectrum Policy for the 21st Century (June 5, 2003), *available at* http://www.whitehouse.gov/news/releases/2003/06/20030605-4.html. Some international organizations and European countries have made an even more explicit "natural resource" argument. For example, the North Atlantic Treaty Organization (NATO) has proclaimed that "[f]rom the NATO perspective the radio spectrum has always been an extremely valuable finite natural resource of each nation." *See* NATO FREQUENCY MANAGEMENT BRANCH,

that resource should be maximized. In doing so, would it be sensible one day to completely eliminate entire governmental divisions like the FCC, just as free market systems have replaced centralized economic structures (*e.g.*, GOSPLAN, the Soviet state planning commission)[17] that once regulated farm production levels and prescribed the number of cars to be manufactured? As we will discuss in Sections III and IV, creating a mechanism that frees the spectrum from centralized government oversight and control could (and should, perhaps must) involve the assignment of straightforward rules, rights and obligations for spectrum usage—rules that are flexible enough to evolve as technology evolves and that may well require formal documentation. These rules, rights and obligations could be formed in a Wireless Device Bill of Rights.

II. THE REPEAL OF GROSCH'S LAW

In order to appreciate the potential power of Constitution-esque, device-level regulation, we might begin our discussion with a review of the ways in which our perception of computing devices has dramatically changed over the past decades. Such an inquiry will help us appreciate the feasibility of programming principles into miniature devices, as well as help us understand how it may be possible in the near future to enshrine certain principles within small but highly sophisticated computing devices.

RESPONSE TO THE COMMISSION OF THE EUROPEAN COMMUNITIES GREEN PAPER ON RADIO SPECTRUM POLICY, *available at* http://europa.eu.int/information_society/policy/radio_spectrum/docs/green_paper_all/87_nato.pdf (last visited Mar. 22, 2005). Also, the European Parliament has stipulated that the "radio spectrum is a . . . natural resource." *See* EUROPEAN COMMISSION, NEXT STEPS IN RADIO SPECTRUM POLICY - RESULTS OF THE PUBLIC CONSULTATION ON THE GREEN PAPER, (Nov. 10, 1999), *available at* http://europa.eu.int/comm/information_society/policy/spectrum/pdf/radio_en.pdf. The Irish Government has called the wireless spectrum an "international natural resource," and it manages that resource within a department entitled "Communications Marine & Natural Resources." *See* IRELAND STATE DEPARTMENT OF COMMUNICATIONS, SPECTRUM POLICY/STRATEGY FOR THE DEVELOPMENT OF DIGITAL SOUND BROADCASTING AND OTHER SERVICES: A CONSULTATION PAPER (Aug. 17, 2004), *available at* http://www.dcmnr.gov.ie/NR/rdonlyres/5B834F9B-4A9B-400F-A0A5-105C390B0244/0/dab180804.doc. The Czech Republic asserts that the wireless spectrum is a "natural resource that is, according to the Constitution of the Czech Republic, [the] property of the State." *See* CZECH REPUBLIC MINISTRY OF TRANSPORT AND COMMUNICATIONS, SUPPLEMENT TO THE NATIONAL TELECOMMUNICATIONS POLICY OF THE CZECH REPUBLIC 24 (translation from Czech, version Apr. 26, 1999), *available at* http://www.mdcr.cz/text/archiv/NTPang-appendix.doc.

17. GERALD FAULHABER & DAVID FARBER, SPECTRUM MANAGEMENT: PROPERTY RIGHTS, MARKETS, AND THE COMMONS 5 (TPRC Program Paper No. 24, 2002) *available at* http://tprc.org/papers/2002/24/SPECTRUM_MANAGEMENTv51.pdf (comparing the present spectrum regulatory process to centralized planning akin to that of the GOSPLAN era).

The scientific movement towards miniaturization not only has changed the way that we see the world, but it has also altered the important sociopolitical contexts that influence that vision. In order to understand the future of wireless communications, we must reflect on the development of computing technology that promises to change how we use the electromagnetic spectrum in the future. The history of computing is, of course, fascinating, especially considering the incredibly rapid development of computing technology over the past 50 to 60 years.

Today, we tend to believe that the smaller the technological device, the better.[18] In the past, however, the opposite was held to be true. In fact, by the middle of the 20th century, many prominent scientists thought there would be a natural tendency for computers to evolve into massive centralized units that would control the world's processing power. At the time, this concept was considered an emerging scientific "law," one that was perhaps most famously articulated by scientist Herbert Grosch, who in 1950 postulated that computer power increases by the square of its cost. Consequently, per Grosch's law, computers would *necessarily* be developed into the largest, most costly machines.[19] According to his predictions, the entire world would use fifty-five mainframe supercomputers, and these computers would allocate their processing power among "dumb" terminals and keypunch machines.[20] During the decades it took to disprove this theory,[21] however, respected pundits darkly predicted that a single organization would eventually control all of the world's data, a scenario with autocratic overtones that seemingly had the potential to harm society. Indeed, scientists and

18. Miniaturization is most often associated with the growth of personal computers that took place from the 1970s through the 1980s, and it is most often expressed in terms of "Moore's law." Moore's law, developed by Intel founder Gordon Moore in the 1970s, holds that microprocessor performance will double every eighteen months. *See Caught in the Net*, THE ECONOMIST, Mar. 27, 1997, at S16 (describing Moore's law and indicating that it has so far proven to be correct).

19. Grosch expressed his theory as follows: "I believe that there is a fundamental rule . . . giving added economy only as the square root of the increase in speed—that is to do a calculation ten times as cheaply you must do it one hundred times as fast." This argument has been interpreted to mean that natural technological evolution would lead to "supercomputing" as a norm. *See* Young M. Kang et al., *Comments on "Grosch's Law Re-Visited: CPU Power and the Cost of Computation*,*"* 29 COMM. ACM. 779 (1986) (subscription req'd).

20. GEORGE GILDER, TELECOSM: HOW INFINITE BANDWIDTH WILL REVOLUTIONIZE OUR WORLD 160 (2000) [hereinafter GILDER, TELECOSM] (describing Grosch's law and Grosch's prediction that only fifty-five mainframes would be required to meet the world's information needs).

21. *See, e.g.*, Kang et al., *supra* note 19, at 789. Taking the then-recent reevaluation of Grosch's law one step further, the authors find evidence of vastly different slopes for different classes of computers—such as PC-type computers—and the utility of an additional variable known then as the "IBM factor" or the "IBM-compatible factor." The analysis indicates that Grosch's law no longer applies to minicomputers and PCs.

journalists wrote volumes of text arguing that government regulation was needed to prevent such a state of affairs.[22] As George Gilder explains:

> Imagine . . . that it is 1971 and you are the chairman of the new Federal Computer Commission. This commission has been established to regulate the *natural monopoly* of computer technology as summed up in Grosch's law . . . the owners of these machines would rule the world of information in an ascendant information age. By the Orwellian dawn of 1984, Big Brother IBM would have established a new digital tyranny, with an elite made up of the data-rich dominating the data-poor.[23]

Fears of a "new digital tyranny" led to very real reservations about the use of this powerful new communications technology.[24] Happily, however, Orwellian predictions regarding mainframe supercomputers owned and managed by a single corporate entity have not come to pass, and Grosch's law has since been "repealed."[25] These days, minicomputers and PCs dominate the computing industry, not mainframe supercomputers. As a result, the computing power of a machine that occupied the entire

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22. In the 1960s and 1970s, Grosch's law was still highly regarded by scientists and policy analysts, and respected papers continued to espouse his centralized computing "law." While some challenged his theories, the scientific community on the whole still had great faith in them. *See e.g.*, Martin B. Solomon, Jr., *Economies of Scale and the IBM System/360*, 9 COMM. ACM 435 (1966) (concluding that larger computers offer the greatest economies of scale and indicating that "Grosch's Law, stated in the 1940s, appears to be prophetic"); A. E. Oldehoft & M. H. Halstead, *Maximum Computing Power and Cost Factors in the Centralization Problem*, 15 COMM. ACM 94 (1972) ("In addition to increases in the level of technology, one can expect for any given level, a return to scale approximated by Grosch's Law"). *But see* Charles W. Adams, *Grosch's Law Repealed*, 8 DATAMATION 38 (1962) (Adams suggests that Grosch's law may not be accurate. Adams' work was part of an early movement that ultimately led to the repeal of Grosch's law.).

23. GILDER, TELECOSM, *supra* note 20, at 160-61.

24. *See* Patrick S. Ryan, *War, Peace or Stalemate: Wargames, Wardialing, Wardriving and the Emerging Market for Hacker Ethics*, 9 VA. J.L. & TECH. 3 (2004), *available at* http://www.vjolt.net (describing the development of personal computing and discussing both the resulting public paranoia regarding computer hacking and the emerging ethical guidelines being developed by users, hackers, and industry since the 1980s).

25. Roger A. Clarke, *Information Technology and Dataveillance*, 31 COMM. ACM 498 (1988), *available at* http://doi.acm.org/10.1145/42411.42413. The author discusses trends away from centralized computing and the subsequent "repeal" of Grosch's law:

> With the repeal of Grosch's law during the 1970s, economies of scale no longer apply to processing power. Other factors that are militating against the old centralist notions are the systems software overheads of large-scale centralized processing; risks associated with single-site activities; standardization of local and site networking standards; fast-growing capabilities of network workstations and servers; decreasing cost and increasing portability and robustness of dense storage. . . . The once-obvious tendency of computers to centralize information, and hence power, is quickly giving way to the looser concepts of networking and dispersion.

Id.

floor of a building in the mid-1940s can be easily surpassed today by the computing power of an inexpensive toy.[26]

At the time that Grosch's law held rein, however, the U.S. government embraced regulatory models that dovetailed conveniently with this flawed hypothesis. As George Gilder describes in the preceding passage, it was at one time a widely-held belief that the computer industry was a "natural monopoly."[27] Furthermore, Gilder reminds us that at one time we thought that competition in that industry would *harm* consumers rather than benefit them. This was because of a bankrupt view that consumers would gain greater benefit from a single company whose economies of scale could produce the massive computing platform considered necessary under Grosch's law.[28] In fact, this rationale was applied to both the telephony industry *and* the computer industry, for in the middle of the 20th century, many saw the two as "public utilities." It was thought that telephony, like computing, required large networks and Grosch-like centralized switching; and further, that private industry could not be trusted with the public nature associated with the size and operation of these inevitably massive, monopolistic structures.[29] Bigger was better, and accordingly, to be big meant that government must impose heavy regulation, lest the consumer would be crushed by monopolistic evils.

The United States was not alone in its acceptance of Grosch's "bigger is better" hypothesis. In point of fact, some countries went a step further and actually built their own computer utilities. For example, the

26. In 1944, the first large-scale automatic digital computer began operation. Built by IBM and Harvard professor Howard Aiken, the Mark I was fifty-five feet long and eight feet high. THE WORLD ALMANAC AND BOOK OF FACTS (Ken Park ed., 2002).

27. The concept of a "natural monopoly" has been credited to John Stuart Mill. 1 JOHN S. MILL, PRINCIPLES OF POLITICAL ECONOMY 132-54 (W. J. Ashley, ed., Augustus M. Kelly 1961). In his famous work, Mill emphasizes the problem of wasteful duplication of transmission facilities that can occur in certain utility services. French economist Leon Walras, further developed the connection between natural monopoly and regulation, applying the theory to the construction and operation of railroads. *See* LEON WALRAS, ÉTUDES D'ÉCONOMIE SOCIALE: THEORIE DE LA REPARTITION DE LA RICHESSE SOCIALE (1936).

28. *See* Daniel F. Spulber, *Deregulating Telecommunications*, 12 YALE J. ON REG. 25, 31 (1995). Spulber defines a natural monopoly as a situation that exists when "a single firm can supply the market at lower cost than can two or more firms." *Id.* He further notes that a "sufficient condition for the cost function to have the natural monopoly property is for the technology to exhibit economies of scale, which are present if the marginal costs of production are less than the average costs of production over the relevant range of output." *Id.*

29. This idea is covered extensively in GERALD W. BROCK, TELECOMMUNICATION POLICY FOR THE INFORMATION AGE: FROM MONOPOLY TO COMPETITION 170, 172 (1994). The author describes the mindset of the "natural monopoly" and public utility era: "The Department of Justice and Economists viewed the industry in simple terms. There was a well-defined local exchange service that was a natural monopoly. . . . There was not a full debate between rival conceptions of the industry." *Id.*

French government, embracing the principles of Grosch's law, developed a massive, centralized, government owned and operated computer system called the Minitel.[30] The Minitel operated through the public telephone network (also owned by the government), and its databases contained information such as telephone numbers, movie listings, games, horoscopes, news articles and the like, making it much like a primitive Internet.[31] Today, the French Minitel has been replaced in large part by the Internet, and while the system is not entirely defunct, it is safe to say that the concept of a government-run computing system is.[32]

Happily, the U.S. government did not go as far as to create a Minitel-like monopoly in information systems, and in fact, Congress passed laws that forged splits within the computing and telephony industries.[33] Accordingly, once regulators realized that telephone

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30. The Minitel, operated by France Télécom, was based on a centralized computing model and offered text-only services to many (then state-run) telecommunications company subscribers. *See* Russel Carlberg, *The Persistence of the Dirigiste Model: Wireless Spectrum Allocation in Europe, á la Française*, 54 FED. COMM. L.J. 129, 136 (2001). Carlberg notes:

> The French invention of the Minitel, a computer terminal connected to the telephone that was widely available in French homes in the 1980s, is a prime example of the dirigiste tradition at work. . . . [T]he Minitel system was a dry run at an internet before the Internet was invented. When the French government introduced it as part of France Telecom's phone services, the Minitel was revolutionary.

Id.

31. *See* Mark Cooper, *Open Communications Platforms: The Physical Infrastructure as the Bedrock of Innovation and Democratic Discourse in the Internet Age*, 2 J. ON TELECOMM. & HIGH TECH. L. 177, 200 (2003). Cooper notes that the Minitel was a failed alternative to the Internet. The author explains: "The design would have been more like the French analogue to the Internet—Minitel. But Minitel is not the Internet. It is a centralized, controlled version of the Internet, and it is notably less successful." *Id.*, at 200 n.94. The failure of the Minitel, however, was not always evident. As late as 1995, there was considerable debate as to whether the Internet (a decentralized system) or the Minitel (a centralized, government-controlled one) would prevail. *See* Carlberg, *supra* note 30, at 136-37 (describing the different theories in the mid-1990s, as well as the various features of the Minitel services).

32. Even though the Minitel has migrated to the Internet, France Télécom, the French national telephone company, no longer makes the same profits that it once did—and at one time, its monopoly position earned it great profits. *See* Pierre Delaroche, *Les Bons Calculs du Minitel*, L'EXPRESS, June 26, 1997, at 71 (reporting that France Télécom made so much profit from the seven million subscribers to its home-grown online service, the Minitel, that the company chose the service over the Internet). *See also* http://www.minitel.com/, which is France's Internet version of the Minitel. Services are still sold, such as the "i-minitel" product, which can be downloaded and installed from the site.

33. Many observers in the 1950s and 1960s anticipated that this interdependence of computers and communications would inevitably result in the creation of "computer utilities." *See* D. F. PARKHILL, THE CHALLENGE OF THE COMPUTER UTILITY 153-55 (1966) (predicting that, in the future, computer utilities will bring the power of a large computer center to homes and offices). The FCC initiated a series of "computer inquiries," analyzing if (1) telephone companies would offer services that would compete with those sold by computer manufacturers and service bureau firms, while (2) these same manufacturers and firms would remain dependent on the telephone company for reasonably priced communication facilities

networks were *not* natural monopolies—a notion that has only been formally been accepted within the past couple decades[34]—competition in the telephony industry was first encouraged and later *enforced* through the government breakup of AT&T.[35]

The U.S. government did not stop with the AT&T breakup. Shortly thereafter, it promoted competition in the computer industry by *prohibiting* corporate telephone monopolies from developing computer services and equipment.[36] One scholar has convincingly argued that the government's action here is responsible for creating the conditions for the present Microsoft monopoly in personal computing operating systems.[37] In most technological markets, however, the "natural monopoly" paradigm has now been replaced by the much more powerful (and sensible) "essential facilities doctrine,"[38] and the telecommunications

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and services. *See generally* Steve Bickerstaff, *Shackles on the Giant: How the Federal Government Created Microsoft, Personal Computers, and the Internet*, 78 TEX. L. REV. 1 (1999).

34. *See* Paul Baran, Visions of the 21st Century Communications: Is the Shortage of Radio Spectrum for Broadband Networks of the Future a Self Made Problem?, Keynote Address at the 8th Annual Conference on Next Generation Networks, Washington, D.C., (November 9, 1994) (transcript available at http://www.dandin.com/pdf/baran1994.pdf) [hereinafter Baran, *Spectrum Shortage*]. Baran explains the difficult transition from a "natural monopoly" model to other models. His observations were prophetic, particularly for 1994, when many of the regulatory "unbundling" experiments had not yet been proven. The author explains:

> When a better technology comes along that allows the feasibility of multiple suppliers, it invalidates the natural monopoly argument. The end of a monopoly is rarely a swift process and it is never painless—particularly if it were well run and highly profitable. After long running anti-trust battles the US telephone monopoly, AT&T, was in part fractured into seven local area monopolies and competition was permitted in the long distance telephone and data communication field. This was an extremely controversial move at the time, and was met by all sorts of Chicken Little sky falling predictions. The sky didn't fall. Instead we saw a major increase in effectiveness in long distance services, fostered by the new competition. And this was perceived as being so successful by other countries, that similar long distance services are being deregulated throughout the world, even by those nations with a long history of sole governmental control.

Id.

35. *See* United States v. Am. Tel. & Tel. Co., 552 F. Supp. 131 (D.D.C. 1982) (judicial approval of the Modified Final Judgment and Consent Decree that broke up the Bell system).

36. The Bell companies were prohibited from manufacturing any Customer Services Equipment. *Id.* at 227-28.

37. Bickerstaff, *supra* note 33, at 6.

38. *See* Jerry A. Hausman & J. Gregory Sidak, *A Consumer-Welfare Approach to the Mandatory Unbundling of Telecommunications Networks*, 109 YALE L.J. 417, 467 (1999). The article describes the scope and purpose of the essential facilities doctrine as follows: "The essential facilities doctrine addresses scenarios in which a company owns a resource that other firms absolutely need to provide their own services. Properly understood, the doctrine is a common-law rule concerning the obligation (if any) of a vertically integrated firm to sell an input to competitors in the downstream market." *Id.* In the United States, the Federal courts first applied the essential facilities doctrine in MCI Communications Corp. v. Am. Tel. &

knot, once thought to be inevitably and permanently tied, has been (or is in the process of being) "unbundled."[39] Indeed, because of this regulatory paradigm shift, consumers have seen the price of a telephone call drop sixty percent from 1984 to 1999, while phone usage has increased almost sixty-eight percent during that same period.[40] Furthermore, studies show that the wide variety of service providers has led to much greater customer satisfaction.[41] Clearly, decentralization has directly translated into many consumer benefits.

Nonetheless, at one time we not only thought that bigger, centralized computing structures were more efficient, but we also thought that the continued growth of such structures was *inevitable.* In addition, prominent scientists like Herbert Grosch convinced us that massive-scale supercomputing was an unavoidable scientific endgame. Perhaps not unexpectedly, then, these centralized paradigms are not so easily dismissed. Even as recently as 1996, some well-respected computer scientists were still basing arguments on related aspects of Grosch's bankrupt hypothesis. For example, Bob Metcalfe, the inventor of Ethernet and the founder of 3Com Corporation, boldly declared that the public Internet could not scale, contending that it would ultimately implode in an immense cyber-collapse.[42] Of course, Metcalfe's forecasted Internet collapse has not transpired. In fact, just the opposite has occurred: Internet capabilities have expanded, and the Internet now even supports distributed computing models.[43] Put another way, the sum

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Tel. Co., 708 F.2d 1081, 1132-33 (7th Cir. 1983). The essential facilities doctrine has also been applied in Europe. *See* Commission Decision on Sea Containers & Stena Sealink, 94/19/EC, 1994 O.J. (L 15/8). *See also* Leonard W. H. Ng, *Access and Interconnection Issues in the Move Towards the Full Liberalization of European Telecommunications*, 23 N.C. J. INT'L L. & COM. REG. 1, 22-28 (1997) (describing the application of the essential facilities doctrine in European telecommunications).

39. *See* Alexander C. Larson & Margarete Z. Starkey, *Unbundling Issues and U.S. Telecommunications Policy*, 6 STAN. L. & POL'Y REV. 83 (1994) (describing unbundling and proposing where and how it should be applied in the telecommunications market).

40. Peter VanDoren & Thomas Firey, *Facts and Fictions about Deregulation*, *in* CATO REVIEW OF BUSINESS AND GOVERNMENT 1 (June 27, 2002).

41. *Id.*

42. Metcalfe thought that the Internet could not scale to the point that it has. He instead predicted its total collapse, noting that "Private TCP/IP networks are avoiding the public Internet in droves . . . . Now the nation's great research universities, the builders and first use of the internet–Harvard among them–are preparing to join the desertion of the sinking ship." Bob Metcalfe, *You Really Think That the Internet Isn't Collapsing? Universities Are Bailing Out*, INFOWORLD, Nov. 11, 1996, at 48.

43. Distributed computing is a programming model in which processing occurs in many different places (or nodes) around a network. Processing can occur wherever it makes the most sense, whether on a server, website, personal computer, handheld device, or other smart device. As early as the mid-1980s, the concept really started to take off. *See* Kenneth Kleinrock, *Distributed Systems*, 28 COMM. ACM 1200 (1985). The author states that the growth of distributed systems had "attained unstoppable momentum," describing the importance of distributed computing and calling for additional research. *Id.* He further notes the relevance

of power at the edges of a network greatly exceeds early predictions about the sum of power of immense, centralized processing "brains."[44] Thus, miniaturization has enabled these computers and devices at the edges to continue to become smaller and, at the same time, more powerful.[45]

Today, the widely supported and quite possibly unshakable theory on the future of computing is that power is derived through mesh networks.[46] Mesh networks increase capacity with each node that they add. In a wireless mesh network, each component itself becomes a wireless "base station."[47] Although centralized server-based computing[48]

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of distributed systems in nature, where there are no centralized supercomputer-like brains and where many small devices work together to perform a common task:

> How did the killer bees find their way up to North America? By what mechanism does a colony of ants carry out its complex tasks? What guides and controls a flock of birds or a school of fish? The answers to these questions involve examples of loosely coupled systems that achieve a common goal with distributed control.

Id. Interestingly, the author also suggests later in the article that Grosch's law may, in fact, not be defunct; however, the law must be thought of in a completely different context if it is to be salvaged. Kleinrock suggests that we consider Grosch's law within the framework of a "family" of computers (not unlike the Borgs seen today on the television series *Star Trek*), contending that, "Each family has a decreasing cost per unit of capacity as capacity is increased. . . once in the family, it pays to purchase the biggest member machine in that family." *Id.* at 1209.

44. One of the more fascinating examples of distributed computing is an experiment that uses thousands of computers to analyze radio waves from other planets to attempt to discover signs of extraterrestrial life. Launched by the University of California at Berkeley, the Search for Extraterrestrial Intelligence (SETI) project uses the computing power of individual users' machines that run a program downloaded from the SETI server. Specifically, SETI runs sophisticated number-crunching algorithms and data analyses when each computer activates its screen saver. Basic information can be found at the SETI website (still hosted by Berkeley). SETI@Home, *at* http://setiathome.ssl.berkeley.edu/ (last visited Mar. 22, 2005). Also, a series of articles published in THE ECONOMIST enthusiastically describes the project and its growth over the past several years. *See Aliens on Your Desktop*, THE ECONOMIST, Apr. 18, 1998, at 78; *Radio Telescopes: Thinking Big*, THE ECONOMIST, Apr. 24, 1999, at 78; *Divide and Conquer*, THE ECONOMIST, Jul. 29, 2000, at 77; *Out of This World*, THE ECONOMIST, Jan. 13, 2001, at 80; *Computing Power on Tap*, THE ECONOMIST, June 23, 2001 at 16; *The Next Big Thing?*, THE ECONOMIST, Jan. 17, 2004, at 57.

45. There are important limits to how small the microchip may become. *See generally Thus Thin and No Thinner?*, THE ECONOMIST, Apr. 8, 1999, at 80 (describing nanoelectronics and the work on electronic components whose dimensions are measured in nanometers).

46. *See* Sebastian Rupley, *Wireless: Mesh Networks*, PC MAG., July 1, 2003, at 104, *available at* http://www.pcmag.com/article2/0,1759,1130864,00.asp (noting that the core characteristic of a mesh network is that there is not a central orchestrating device; instead, each node is outfitted with radio communications gear and acts as a relay point for other nodes).

47. *See* Thomas Krag & Sebastian Büettrich, *Wireless Mesh Networking*, O'REILLY NETWORK MAG., Jan. 22, 2004, *available at* http://www.oreillynet.com/pub/a/wireless/2004/01/22/wirelessmesh.html.

48. In server-based computing, the main applications are based on a centralized server, and system managers need to update only one or two mainframes. The "terminals" can be notebooks, or they can be smaller devices with sufficient processing capacity to connect with the servers. Probably the best way to recognize the advantages of server-based computing is by reviewing the promotional materials provided by the companies that sell the technology. Hewlett Packard is one of the largest of such companies. *See* "HP Server Based Computing -

continues to hold some attraction, processing power continues to grow at the edges even while it is also growing at the core.[49] With this reality in mind, few scientists still believe that large-scale centralized computing makes sense, at least not in the same way that it did in the 1950s. These devices at the edges will take on a fundamental degree of importance in the new spectrum paradigm, especially as we let go of the centralized broadcasting model—as we now have in television and radio, where receivers of information lack a response capability—and instead embrace multiple smaller, intelligent nodes (as we have with digital cellular and Wi-Fi). These digital communications devices at the network's edge are not just passive receivers, they are also miniature computers, and with every passing year these computers can process data more efficiently.

III. THE BARAN PRINCIPLES

A. *The Kindergarten Protocol*

Proposals that embraced spectrum reform and the use of digital communications received a powerful endorsement in 1994 when Paul Baran, the inventor of packet switching,[50] spoke at the 8th Annual

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Solution Overview," *available at* http://activeanswers.compaq.com/ActiveAnswers/Render/1,1027,4737-6-100-225-1,00.htm (last visited Oct. 18, 2004).

49. There are, of course, important variants in the visions of how future computing systems will develop. For example, Larry Ellison, founder of Oracle Corporation, believes that there will be a continued and growing place for centralized computing—or, better said, centralized *sourcing* of software and data. The major difference between Ellison's and Grosch's ideas is that Ellison believes in increasingly powerful, inexpensive computers at the edges, although it may be more efficient to store the data elsewhere. Ellison explains his idea as follows: "Here's what I want. . . . I want a $500 device that sits on my desk. It has a display and memory but no hard or floppy disk drives. . . . My files are stored on a server somewhere. . . . The data I get from the network is the latest, too, and I pay for it all though my phone bill because that's what the computer really is—an extension of my telephone." ROBERT X. CRINGELY, ACCIDENTAL EMPIRES 358 (Harper Business 1996) (1992) (quoting Larry Ellison). *See also* Leslie Helm, *The Cutting Edge—Oracle's CEO Divines a New Future for Computing*, L.A. TIMES, Mar. 1, 1999, at 1 (discussing Ellison's view that the age of personal computers will soon be replaced by a new age of "[I]nternet computing").

50. Paul Baran has been credited by many as the inventor of packet switching, and he has received many prestigious awards for his efforts. *See, e.g.*, *And the Winners Were . . .*, THE ECONOMIST, Dec. 3, 2003, at T31. The article describes the world's greatest innovators in five technology categories and recognizes Paul Baran for the invention of packet switching and for the impact that his invention has had on modern technology. As the article explains:

> In 1959, Dr. Baran began to think about ways to make America's communications infrastructure resistant to a nuclear attack. He proposed using a system called "distributed adaptive message block switching", known today as packet switching. This involves breaking digital information into small chunks, or packets, and sending them separately over the network, thus doing away with centralised switching centres and enabling the network to work even when partly destroyed. His idea was initially ignored and was only given its first proper test in 1969, when

Conference on Next Generation Networks in Washington, D.C. In his speech, Baran noted that the wireless resource can be used by everyone without government-mandated restrictions on who gets to use what frequency and for what purpose. His point was that digital devices at the edge need to be smart, but they need not be geniuses. Ironically, Baran borrowed from the parent/child model that characterizes "command-and-control" today, and he flipped it on its head. For Baran, an open access policy would not require massive centralized processors, nor centralized control, and in fact it can be implemented so long as the rules that we all learned as children in kindergarten are applied. These seven rules, quoted verbatim as Baran articulated them, are as follows:

> Rule #1. Keep away from the big bullies in the playground. (Avoid the strongest signals.)
>
> Rule #2. Share your toys. (Minimize your transmitted power. Use the shortest hop distances feasible. Minimize average power density per Hertz.)
>
> Rule #3. If you have nothing to say, keep quiet.
>
> Rule #4. Don't pick on the big kids. (Don't step on strong signals. You're going to get clobbered.)
>
> Rule #5. If you feel you absolutely must beat up somebody, be sure to pick someone smaller than yourself. (Now this is a less obvious one, as weak signals represent far away transmissions; so your signals will likely be attenuated the same amount in the reverse direction and probably not cause significant interference.)
>
> Rule #6. Don't get too close to your neighbor. Even the weakest signals are very strong when they are shouted in your ear.
>
> Rule #7. Lastly, don't be a cry baby. (If you insist on using obsolete technology that is highly sensitive to interfering signals, don't expect much sympathy when you complain about interfering signals in a shared band.)[51]

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it was used as the basis for ARPANET, an experimental computer network that later grew into the Internet.

Id.

51. Baran, *Spectrum Shortage*, *supra* note 34.

Of course, metaphors and analogies used to describe wireless communications are sometimes inherently imperfect. Here, we're sharing Baran's seemingly tongue-in-cheek application of childhood aphorisms to the wireless spectrum. Moreover, later in this article we will take these metaphors and analogies a step further in order to argue that the use of computer technology can, in effect, eliminate the need for many functions of the FCC altogether. Needless to say, such contentions certainly stretch the limits of reason. It seems obvious that the application of simple behavioral maxims, the kind conveyed to young children, cannot enable spectrum reform, and the FCC cannot be replaced by a box of wires and computer chips. These ideas clearly seem somewhat extreme or, at the very least, a bit absurd.

Or are they? Let us reflect back on another "radical" concept related to spectrum management.[52] In 1959, economist Ronald Coase devised the idea of trading the wireless spectrum in the same way that all other commodities, such as real estate, are traded. At the time, all frequencies were allocated through centralized planning initiatives, and auctions were seen as an impossibility. Thus, when Coase presented his idea to the FCC, the FCC commissioners had trouble taking him seriously and accused him of making a "big joke." As Coase explains in an article written almost forty years later:

> In 1959 . . . the FCC decided to hold hearings on the future of broadcasting and I was asked to testify. You can imagine what I proposed. When I concluded, the questioning was opened by

52. It should be noted here that the ensuing discussion on R. H. Coase in this section is inspired by Thomas Hazlett's famous historical organization and subsequent recounting of the 1996 conference that he hosted at the Marconi Conference Center in California. The proceedings were published in Volume 41, Issue 2 of the JOURNAL OF LAW & ECONOMICS in 1998. Unfortunately, the conference did little to place the work of Coase and other propertization advocates within the context of simultaneous—but inseparable—developments, such as Paul Baran's packet switching initiatives and other important scientific advances that were already well established by 1998 (*e.g.*, the Internet). The one important exception was a provocative article by Eli Noam—one of nineteen contributors to the conference—who argued that "[i]t will not be long, historically speaking, before spectrum auctions may become technologically obsolete, economically efficient, and legally unconstitutional," further emphasizing that that "now, new digital technologies, available or emerging, make new ways of thinking about spectrum use possible that were not possible in an analog world . . . ." Eli Noam, *Spectrum Auctions: Yesterday's Heresy, Today's Orthodoxy, Tomorrow's Anachronism. Taking the Next Step to Open Spectrum Access*, 41 J.L. & ECON. 765, 765, 769 (1998). Noam highlighted the genius of Paul Baran and the application of packet switching to the Internet, as well as its extension to wireless, in order to alleviate scarcity problems. *Id.* at 769. Noam's article was in large part dismissed by the conference attendees. One participant brushed aside the technological developments that Noam used to support his arguments, asserting that "[t]he bottles of Chateau Coase 1959 remain eminently bold, dry and flavorful, and it is far too early to throw them out of the cellar." Timothy J. Brennan, *The Spectrum as Commons: Tomorrow's Vision, Not Today's Prescription*, 41 J.L. & ECON. 791, 792 (1998).

> Commissioner Philip S. Cross. His first question was: "Are you spoofing us? Is this all a big joke?" I was completely taken aback but I managed to reply: "Is it a joke to believe in the American economic system?"[53]

Shortly after presenting his idea to the FCC, Coase wrote a paper on the same subject upon invitation by the RAND Corporation (America's largest think tank and an important non-governmental policy organization);[54] however, RAND ultimately decided not to publish the paper. Again, in his 1998 retrospective analysis of the initial denunciation of his theories, Coase explains:

> I was invited by some of the economists at the RAND Corporation to come to Santa Monica and to help to prepare a report on Problems of Radio Frequency Allocation. This I did together with two economists at the RAND Corporation, Bill Meckling and Jora Minasian. A draft report was prepared which advocated a market solution. This draft report was circulated within RAND. The comments on it were highly critical and as a result, the report was suppressed.[55]

In the 1998 article, Coase goes on to discuss a memorandum that he received from a senior RAND fellow regarding his open market proposal. In the memorandum, the RAND fellow wrote, "I know of no country on the face of the globe—except for a few corrupt Latin American dictatorships—where the 'sale' of the spectrum could even be seriously proposed."[56] In short, the FCC did not consider Coase's proposal to be feasible, and the largest and most influential think tank in the world dismissed that same proposal as an undemocratic and disreputable scheme. It seemed that Coase's ideas were doomed to failure.

And they were, at least initially. Happily, however, Ronald Coase was able to publish his theorem in 1959-60,[57] and after economists came

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53. Ronald H. Coase, *Comment on Thomas W. Hazlett: Assigning Property Rights to Radio Spectrum Users: Why did FCC License Auctions Take 67 Years?*, 41 J.L.& ECON. 577, 579 (1998) [hereinafter: Coase, *Comment on License Auctions*].

54. RAND is a policy think tank set up after World War II, as the RAND website notes, to "further and promote scientific, educational, and charitable purposes, all for the public welfare and security of the United States of America." *See* THE RAND CORP., HISTORY AND MISSION, *at* http://www.rand.org/about/history/ (last visited Mar. 22, 2005) (discussing RAND's origins and its history). RAND claims to be four times larger than the second-largest think tank, The Brookings Institution. *See* THE RAND CORP., THE PGRS EXPERIENCE, *at* http://www.prgs.edu/experience/ (last visited Mar. 22, 2005).

55. Coase, *Comment on License Auctions*, *supra* note 53, at 579.

56. *Id.*

57. Coase wrote a series of articles, including *The Federal Communications Commission* and *The Problem of Social Cost*, published in 1959 and 1960, respectively, by the University

to embrace his ideas—over a period of several decades—the Swedish Nobel Foundation awarded him the ultimate intellectual revenge against his early skeptics: the 1991 Alfred Nobel Prize in Economics. Today, spectrum trading discussions in the United States and in Europe are heavily influenced by Coase's market theories. Further, his radio spectrum real estate model is the basis for wireless regulation in countries worldwide that auction licenses and that are now considering the implementation of trading rights.[58] (Interestingly, these countries include the United States and many European nations, not just "corrupt Latin American dictatorships.")

B. Does Baran's Protocol Repeal Coase's Theorem?

Returning, then, to our discussion of Paul Baran's "kindergarten rules," let us compare his protocol (which advocates spectrum openness) with Coase's 1959 spectrum-as-property concept (which advocates relatively closed trading rights). Both Baran and Coase had some involvement with RAND at roughly the same time (in the late 1950s), and, as we have seen, both men's theories are somewhat incongruous. Baran's kindergarten rules, which apply to the wireless spectrum the behavioral patterns taught to children, take for granted that the entire spectrum should be freely allocated for public use (just as playground equipment is intended for use by any number of children). Coase's

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of Chicago's JOURNAL OF LAW & ECONOMICS (for which Coase was the editor). The first footnote of Coase's *The Problem of Social Cost* states that "[t]his article . . . arose out of the study of . . . [b]roadcasting which I am now conducting. The argument of the present article was implicit in a previous article dealing with the problem of allocating radio and television frequencies . . . ." Ronald H. Coase, *The Problem of Social Cost*, 3 J.L. & ECON. 1, 1 n.1 (1960) (referring to Coase, *The Federal Communications Commission*, *supra* note 1). Coase again reiterated this point in his short autobiography, which appears on the Nobel Prize website. *Ronald H. Coase, Autobiography*, *in* LES PRIX NOBEL 1991 (Tore Frängsmyr ed. 1992, *available at* http://www.nobel.se/economics/ laureates/1991/coase-autobio.html. He notes that "The main points [of the Coase theorem] were already to be found in *The Federal Communications Commission*." *Id.* He goes on to explain that, "[h]ad it not been for the fact that . . . economists at the University of Chicago thought that I had made an error in my article on *The Federal Communications Commission*, it is probable that *The Problem of Social Cost* would never have been written." *Id.*

58. Within the "trading rights" and "propertization" literature, there is considerable confusion as to what these ostensibly straightforward concepts should mean. In their most liberalized sense, the terms mean that the spectrum can be leased, traded, exchanged, bought, or sold and that the underlying use of the spectrum can be altered. *See* Tommaso M. Valetti, *Spectrum Trading*, 25 TELECOMM. POL'Y 655, 656 (2001). Valetti notes:

> [Spectrum trading] means that individuals or companies should get property rights and be allowed to decide about the use they intend to make of their spectrum band, as long as they pay for it. Another consequence is that the number of licenses would not be determined by the regulator, but would arise endogenously from the working of the market place.

Id.

spectrum trading idea, on the other hand, is based on the much more complicated legal premise that exclusive or semi-exclusive rights can be traded almost as if they were real estate transactions (*e.g.*, sales, leases, and easements).

Not unexpectedly, these proposals reflect the timeframe in which they were created;[59] as such, each man's theories were formed within different technological contexts. In fact, in 1998, Coase himself indicated that he had not reviewed his original spectrum model in light of new technological developments, noting, "I have not made a serious study of the allocation of the use of the radio frequency spectrum since the early 1960s."[60] Although we will not attempt here to entirely discredit Coase's theory—such work is better left for economists—we will include the important disclaimer that Coase proposed his spectrum trading model *prior* to the introduction of digital systems, and his model was a great fit for an analog world. Baran, on the other hand, developed his model in a digital world. Further, Baran, a technology specialist, has demonstrated that he understands the marriage of computing and wireless, whereas there is no evidence that Coase had any understanding of digital technology when he presented his spectrum-as-property theory. This is not surprising, since the very technology at question was only in the early stages of development by Paul Baran.

Thus, although Coase made one of the world's leading economic arguments on transaction costs,[61] there is evidence of a massive crack in

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59. Coase's FCC article was written in 1959. *See* Coase, *The Federal Communications Commission*, *supra* note 1. Although Baran's packet switching articles were first published around roughly the same time, Baran did not actively encourage application of the principles espoused in those articles to wireless telecommunications until the 1980s and 1990s, long after the packet switching concept had been developed and proven.

60. Coase, *Comment on License Auctions*, *supra* note 53, at 577.

61. Coase's 1959 article, *The Federal Communications Commission*, *supra* note 1, argued that the government's policy of giving spectrum away for free could instead be replaced by auctions, and expanding on this study, Coase's 1960 article, *The Problem of Social Cost*, *supra* note 57, argued that economists should consider transaction costs in their theoretical modeling of pricing. Coase has told us repeatedly that *both* articles are based on the same study on broadcasting, even though the 1960 article does not discuss broadcasting directly. Specifically, the first footnote in *The Problem of Social Cost* states that the premise of the article arises "out of the study of . . . [b]roadcasting which I am now conducting. The argument of the present article was implicit in a previous article dealing with the problem of allocating radio and television frequencies . . . ." Coase, *supra* note 57, at 1 n.1. Recall that Coase again reiterated this point in his short autobiography which appears on the Nobel Prize Website (see discussion *supra* note 57). Yet, in spite of the connections that Coase has made in his work to broadcasting, the Nobel Prize did *not* mention the broadcasting piece it when they awarded the prize to him. Instead, they specifically said that the Nobel Prize in Economics was "for his discovery and clarification of the *significance of transaction costs* and property rights for the institutional structure and functioning of the economy" (emphasis added). See Press Release, Kungl Vetenskapsakademien, The Royal Swedish Academy of Sciences, The Sveriges Riksbank (Bank of Sweden) Prize in Economic Sciences in Memory of Alfred Nobel 1991 (Oct. 15, 1991), *available at* http://nobelprize.org/economics/

the Coasian spectrum theory. Would Coase endorse a spectrum property regime in 2004, a world where "overlay"[62] and "underlay"[63] technologies exist? These technologies allow wireless users to commingle and coexist in ways that technology of the 1960s never imagined.[64] If one believes that intelligence at the edges is the future, it is worth serious pause to consider whether Coase's spectrum property model is still valid; for Coase could not have considered his theory in light of packet switching (and its extension to wireless), because packet switching and intelligence at the edges had not yet been empirically proven by Paul Baran. So, it is not a stretch to propose that Coasian spectrum markets might be an outmoded relic of the era in which they were conceived, just as Grosch's theory of centralized computing is today.

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laureates/1991/press.html. Further, the Royal Swedish Academy of Sciences went out of its way to cite many of Coase's contributions as the basis for the prize, and they did *not* cite *The Federal Communications Commission* as one of them. *See id.*

62. Software-Defined Radio, for example, is called an "overlay" technology because operates in specific frequencies, at specific times, at varying levels, but in "overlay" fashion on top of existing uses. It is a "smart" product made so by software that controls it and steers through the spectrum. *See* Dan Sweeney, *Shape Changer: Software Defined Radio and the Indefinite Future*, AM. NETWORK, Dec. 1, 2000, at 75 (discussing the general concept of SDR and its "cognitive" characteristics). Former FCC Chairman William Kennard expressed enthusiasm for the technology in his published statement at the opening of a Notice of Inquiry for Software Defined Radio:

> Software defined radios are smart devices that can make good use of underused spectrum. They can operate as a cell phone one minute, a PCS phone the next, a taxi dispatch radio later on and a two-way pager after that. They can literally bridge the gaps created by differences in frequency and transmission standards. In this way, they can make all spectrum users from average consumers to police, fire, and EMS workers who need to talk to each other more productive and efficient.

Press Release, The Federal Communications Commission, Statement of FCC Chairman William E. Kennard Notice of Inquiry on Software Defined Radio (Mar. 17, 2000), *available at* http://ftp.fcc.gov/Speeches/Kennard/ Statements/2000/stwek020.html.

63. Ultra Wideband technology is often called an "underlay" technology because it broadcasts at extremely high capacity, at very low power, and across all frequency bands. It does so at the "noise floor" where it does not interfere with concurrent transmitters, and proponents of UWB technology claim that it can eliminate wireless airwave congestion, reduce power consumption requirements to a minimum, and commingle with other operators without interfering them. *See Cutting the Ties That Bind*, THE ECONOMIST, Sept. 21, 2002, at 6 (discussing UWB technology and the chipsets that are under development by various companies). *Also see* David G. Leeper, *Wireless Data Buster*, SCI. AM., May 2002, at 64 (providing an excellent overview of the history of radio and development history of UWB).

64. Ultra Wideband and Software Defined Radio, for example are two powerful "underlay" and "overlay" technologies that can potentially use the spectrum as a commons, changing the way wireless works and making electromagnetic spectrum like an ocean that is so vast that it does not need to be parceled out into individual properties. *See Freeing the Airwaves*, THE ECONOMIST, May 31, 2003, at 26 (discussing the property vs. commons debate and noting that technologies such as UWB and SDR make powerful arguments that the spectrum should be treated as a commons).

C. Packet Switching Overview

We will not write the epitaph for the Coasian spectrum trading theory here, although hopefully we will plant the seeds for a rough draft of it. Our purpose is to emphasize that it is axiomatic that the future of wireless communications is digital, not analog. Coase only knew analog, period. Moving along, before we explore the more radical idea that the FCC can be replaced by a box of electronics (or by multiple, "meshed" boxes of electronics),[65] we will first consider the principles of Paul Baran's famous packet switching invention and the ways in which those principles may be extended in the future. As we will see, his idea has been applied in many areas, and packet switching concepts have already been deployed in other wireless technologies developed within the past decade. Further, at a very high level, Baran's ideas underscore the fact that old paradigms of computing have since been replaced by new ones. Accordingly, when Baran joined the RAND Corporation in 1959, he began to outline a vision for a network of unattended—electronic, and *possibly* computerized[66]—nodes that would act as automated switches, which would route information from one node to another until that information reached its final destination. The automated nodes would use a scheme Baran called "hot-potato routing,"[67] also known as "distributed communications" (and now called "packet switching").[68] A RAND Corporation tutorial explains Baran's theory in the following simple terms:

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65. Under "mesh networking" theory, each device operates as a router for other traffic; for example, a user's Wi-Fi computer that accesses a network also acts as a router (or a "repeater") for other nearby users who would like to access data. In fact, wireless-enabled laptops can already be manually configured to act as routers to some extent. *See* Rupley, *supra* note 46 (describing mesh networking).

66. We use the term "possibly computerized" because transistors and other computer technologies were still in their infancy in the late 1950s and early 1960s.

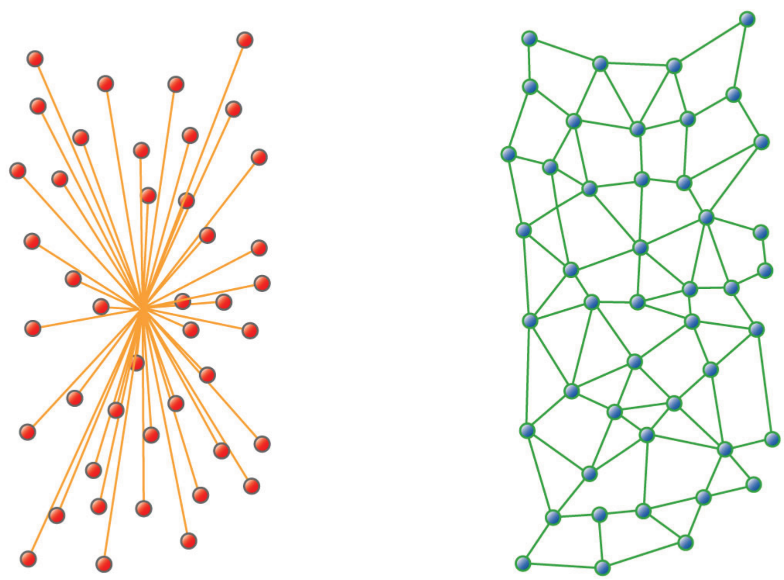
67. *See* SHARLA P. BOEHM & PAUL BARAN, ON DISTRIBUTED COMMUNICATIONS: DIGITAL SIMULATION OF HOT-POTATO ROUTING IN A BROADBAND DISTRIBUTED COMMUNICATIONS NETWORK (The RAND Corp., Memorandum No. RM-3103-PR, Aug. 1964), *available at* http://www.rand.org/publications/RM/RM3103/. Baran's "hot-potato routing" scheme was one of the earliest (and simplest) concepts for moving data from one location to another. The idea was not complicated: a "node" (a switch) would simply pass the package on to the first free node. In other words, the node passed the "hot potato" on to any other node that was ready to accept it (any system with an empty wait queue), regardless whether that node was actually closer to the final destination. Baran's hot-potato scheme was simple and fast, but it had one obvious flaw: there was no guarantee that the package would ever arrive at its destination (unless the network was very small). Thus, Baran had to perform additional studies on packet switching and associated networks in order to revise his scheme to ensure that packets would eventually arrive at their destination.

68. *See* PAUL BARAN, ON DISTRIBUTED COMMUNICATIONS (The RAND Corp., Memorandum No. RM-3767-PR, Aug.1964), *available at* http://www.rand.org/publications/RM/RM3767/.

> Baran . . . developed the concept of dividing information into "message blocks" before sending them out across the network. Each block would be sent separately and rejoined into a whole when they were received at their destination. A British man named Donald Davies independently devised a very similar system, but he called the message blocks "packets," a term that was eventually adopted instead of Baran's message blocks. . . . This method of "packet switching" is a rapid store-and-forward design. When a node receives a packet it stores it, determines the best route to its destination, and sends it to the next node on that path. If there was a problem with a node (or if it had been destroyed) packets would simply be routed around it.[69]

Thus, rather than relying upon a central node that broadcasts all information, the idea of "routing" and "switching" blocks of information was born. In fact, the Internet originated out of this very concept. Figure 1—adapted from the RAND tutorials—provides a graphical depiction of distributed communications, or packet switching:

FIGURE 1



> Figure 1: The figure on the left shows the traditional method of transferring data before Paul Baran introduced his theories. As shown in the figure, one centralized node sends, or broadcasts, data directly to its destination. The figure on the right shows how packet

69. THE RAND CORP., PAUL BARAN AND THE ORIGINS OF THE INTERNET, *at* http://www.rand.org/about/history/baran.html (last modified Jan. 13, 2004).

> switching works. Rather than broadcasting data from a single point of origin, that data can be broken into blocks, or packets, and sent individually from one node within a "mesh" to another node. The routes that these packets of data take will vary. This mesh configuration is now used as a basis for the functioning of the Internet, and Baran and others have suggested that it can also be applied to wireless communications.

Below, we will elaborate upon this distinction between traditional centralized computing and contemporary packet switching.

1. The Old Centralized Computing Model and Broadcasting

The traditional data transfer method, depicted on the left side of Figure 1, involves the broadcast of a signal at high power for many to receive. A similar method is used for broadcast radio communications and under this model listeners do not (and often cannot) respond to the broadcaster.[70] Furthermore, recall that Grosch's centralized computing concept, which is also based on this depiction, is now defunct.[71] Nonetheless, this data transfer methodology persists in radio, television, and dispatch, where broadcasters send out signals that can only be received (and that cannot be responded to) by the recipients. These remnants of the old paradigm are unquestionably based on a broadcasting notion that depends on a single, large, high-power transmitter rather than on a mesh network of lower power devices that communicate with each other. Even so, this one-to-many broadcast technology shows no sign of disappearing soon.

70. In high-power broadcasts, the receiver is a low-power, passive device. As such, it does not have the power to send signals back to the sender. Consider that a television broadcast tower can be several hundred feet tall in height and operates at several thousand watts of power. A television set, on the other hand, has an antenna that is only one or two feet in height and only passive transmission power. This differential can exist because televisions do not need to send data back to the source, they must only receive it. *See* Rob Howard, *Astute Antennas*, COMM. SYS. DESIGN, May 1, 2003, *available at* http://tinyurl.com/4srkl (subscription req'd) (describing the principles of link budgets).

71. *See* Adams, *supra* note 22, at 39.

2. Distributed Computing, Packet Switching, and Mesh Networks

On the right side of Figure 1, the "distributed" graphic depicts the way in which the Internet operates today. In fact, Internet functionality is heavily influenced by Paul Baran's ideas from the 1950s and 1960s.[72] In this mesh (or "distributed") diagram, information travels from one node to another in packets, and the path that a given packet can take will vary depending on different factors, such as congestion and processing power. For example, when a user sends an email message via the Internet, that message can take any one of many possible routes to reach its destination and can travel at a number of different speeds. All of this routing occurs in split-second intervals without the need for humans to direct traffic. Of course, humans must set up guidelines and define protocols, but once the "rules of the road" are defined, we let the computers do the rest. These computers, then, operate in a "mesh" with different servers, routers, and other computers acting as nodes to direct traffic.

When Baran suggested in 1994 that wireless devices could apply "kindergarten rules," he likely meant that wireless devices can operate in much the same way that the Internet does now. Each device can become a node and can thus be used to receive, analyze, and transfer information to other users, just as Baran's packet switching invention does today. In the wireless world, different devices must follow different rules. For example, larger devices could be required to receive wireless transmissions and to retransmit the received data (much like servers do in computing). Furthermore, smaller consumer devices will need to ensure that they enter this wireless world without disturbing the mesh. Therefore, these small devices would either need to pass data along as part of a larger system or need to operate within the system without disturbing its functionality. According to Baran, these rules can be programmed into different wireless devices, just as they have been programmed into the millions of computers, servers, switches, and routers that now constitute the Internet and the terminals that connect to it.

72. *See And the Winners Were . . .*, *supra* note 50 (describing Baran's invention and the manner in which it was applied to ARPANET, the early version of the Internet).

IV. CAN TECHNOLOGICAL RULES BE ENCODED IN CONSTITUTIONAL PRINCIPLES?

A. The Wireless Device Bill of Rights

The Wireless Device Bill of Rights is a proposal initiated by technologist Bran Ferren and later championed by technologist Kalle Kontson.[73] As its name indicates, the Wireless Device Bill of Rights endows a Constitutional character to wireless communications, shifting both rights and obligations to the devices that access the electromagnetic spectrum. According to the theory upon which this document is based, algorithms can be uploaded to devices in order to enable those devices to function cognitively in their environment. Moreover, in many cases the addition of devices can improve the functioning of the system by processing data and passing it along, just as the addition of servers and nodes increases capacity on the Internet.

The proposed Wireless Device Bill of Rights has not changed significantly since its original publication (with the exception of the addition of titles and a preamble).[74] It reads as follows:

> ARTICLE 1: THE RIGHT TO SPECTRUM ACCESS
> Any intelligent wireless device may, on a non-interference basis, use any frequency, frequencies or bandwidth, at any time, to perform its function.
>
> > *Tenet 1: Mental Competence and Moral Character*
> > To exercise rights under this Article, intelligent devices must be mentally competent to accurately determine the possibility of interference that may result from their use of the spectrum, and have the moral character to not do so if that possibility might infringe on the rights of other users.
> >
> > *Tenet 2: Good Citizenship*
> > To exercise rights under this Article, intelligent devices must actively use the wireless spectrum within the minimum time, spatial and bandwidth constraints necessary to accomplish the function. Squatting on spectrum is strictly prohibited.

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73. *See* Kevin Werbach, *Here's a Cure for Bandwidth Blues*, ZDNET.COM (Nov. 28, 2001), *at* http://zdnet.com.com/2100-1107-531165.html (describing the Wireless Device Bill of Rights and crediting Bran Ferren with its authorship). Note that the Washington D.C.-based New America Foundation has also held workshops to promote and advance some of the principles of the Wireless Device Bill of Rights. *See* NEW AMERICA FOUNDATION, INTELLIGENT DEVICE BILL OF RIGHTS (June 20, 2003) *at* http://tinyurl.com/4jz3o.

74. Note that one aspect that has changed since the original publication is the addition of titles for the articles and tenets. *See* the *infra* note 91 and accompanying text.

ARTICLE 2: THE RIGHT TO PROTECTION
All users of the spectrum shall have the right to operate without harmful electromagnetic interference from other users.

Tenet 1: Priority of Rights
Priority of rights under this Article may be determined by the proper authorities only in cases of National emergency, safety of life or situations of extreme public interest.

Tenet 2: Limit of Rights
Rights under this Article may be exercised only when the systems exercising the rights are designed, as determined by the state of the practice, to be reasonably resistant in interference.

ARTICLE 3: SUPREMACY CLAUSE
All licensing, auctioning, selling or otherwise disposition of the rights to frequencies and spectrum usage shall be subordinate to, and controlled by Articles 1 and 2, above.[75]

Like the Bill of Rights in the U.S. Constitution, the Wireless Device Bill of Rights embraces personal freedoms and records rights and responsibilities—here, the personal freedom of communications. The Wireless Device Bill of Rights then aspires to ascribe these rights and responsibilities to technical devices. The details of the document clearly need to be developed, and discussions regarding these details are underway at the FCC (at a group called the Technological Advisory Council, described in the following subsection) and at think tanks.[76] Below, we will briefly review the meaning and the import of the right to spectrum access and the right to protection, as well as the rationale behind the Supremacy Clause.

Article 1, the right to spectrum access, guarantees the rights of intelligent wireless devices to use the spectrum on a "non-interference basis," but it also requires that the devices not "infringe on the rights of other users" (Tenet 1) and that those devices use the spectrum "within the minimum time, spatial and bandwidth constraints" needed to function (Tenet 2). In short, this Article attempts to set forth the principles of cognitive radio, as well as the "listen before talking" qualities of the Ethernet. However, it does not set any restrictions on the

75. *See* Kontson, *supra* note 10.
76. The New America Foundation, a Washington D.C.-based think tank, held a conference that discussed the matter in the summer of 2003 and has addressed the topic in one of its publications. *See* KEVIN WERBACH, RADIO REVOLUTION: THE COMING OF AGE OF UNLICENSED WIRELESS (2003), *available at* http://www.newamerica.net/Download_Docs/pdfs/Pub_File_1427_1.pdf.

technologies to be used. Thus, by setting the *principles* underlying spectrum use rather than the *means* by which the spectrum will be used, the document, like the original Bill of Rights, may avoid becoming superannuated. Because the technologies that we use today may change over time, the principles in the Wireless Device Bill of Rights refrain from locking in the use of a particular technology that may become obsolete within the next few years. Said another way, the Wireless Device Bill of Rights simply protects one's right to access the spectrum resource so long as one follows general principles of good citizenship and behavior.

Article 2, the right to protection, guarantees the rights of those who already use the spectrum and prioritizes different uses of the spectrum. For example, the Article explicitly states that "National emergency, safety of life or situations of extreme public interest" may take precedence over other uses of the spectrum, as determined by "the proper authorities" (Tenet 1). It also would require the devices to be able to be rendered inoperative in order to ensure sufficient spectrum is available for emergency communications. Accordingly, just as automobiles are required by law to pull over to the side of the road to allow ambulances to move through traffic, so too electronic devices would have to be programmed to be automatically disabled in emergency situations in order to give national interest communications a first right of passage through the spectrum. Furthermore, this Article requires devices to have both an intelligent transmission capability and an intelligent reception capability. As FCC Chairman Michael Powell emphasized at the University of Colorado's Silicon Flatirons conference in 2002, one of the principle problems with receivers is that they are "dumb," meaning that they are unable to distinguish between different transmission sources.[77] Thus, regulations would need to cover receivers in addition to transmission-only devices.

Finally, Article 3, the supremacy clause, indirectly addresses the Coasian free market spectrum model by mentioning the "licensing, auctioning, selling or otherwise disposition of the rights to frequencies and spectrum usage." This Article seems to intimate that Ronald Coase's spectrum-as-property theory and Paul Baran's spectrum-as-commons theory *may*, in fact, be able to work together in spite of their seeming inconsistencies. In theory, then, a broadcasting company (*e.g.*, NBC, ABC, or CBS) could continue to "own" (or have an exclusive license to use) the airwaves to broadcast television on one or more particular channels. This right to exclusive use, however, would be subordinate to the rights of individuals to access the airwaves (Article 1) and to the

77. Powell, Broadband Migration III, *supra* note 12.

rights of others who already use the airwaves (Article 2). In other words, this Article suggests that, subject to other rights, limited property rights may be exerted over areas of the spectrum. As a point of comparison, it is like saying that a person may own the beach that connects to his or her house, but that the use of that beach by others may not be prohibited so long as designated rules are followed.[78]

B. The FCC in a Box

The discussion regarding Paul Baran's "kindergarten rules" and Bran Ferren's/Kalle Kontson's Wireless Device Bill of Rights has begun to gather steam (at least in the United States). Further, this discussion has led—perhaps indirectly—to technology lawyer James Johnston's contention that the functions performed by the FCC can instead be performed by computers. Johnston makes this argument in a 2003 piece entitled *The Federal Communications Commission in a Box*,[79] and although he does not directly mention either the "kindergarten rules" or the Wireless Device Bill of Rights, it is evident that he tacitly draws from both sources.

In the article, Johnston points out that Wi-Fi devices are based on a simple "listen before talking" principle. For this reason, he notes, sixteen million Wi-Fi devices are operational at the same time in the United States, even though there are only 1,714 television stations.[80] If as many television stations were operational as Wi-Fi devices, he argues, interference would abound, and the "cacophony of competing voices" would prevent anyone from using their televisions. However, the design of Wi-Fi ensures that this cacophony does not occur. In a statement reminiscent of Paul Baran's "kindergarten rules," Johnston reminds us that "Wi-Fi transmitters don't talk if they hear another device transmitting. It takes children about four years to learn such good manners. It has taken radio 109 years."[81]

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78. See Patrick S. Ryan, *Application of the Public-Trust Doctrine and Principles of Natural Resource Management to Electromagnetic Spectrum*, 10 MICH. TELECOMM. & TECH. L. REV. 285 (2004), *available at* http://www.mttlr.org/volten-two/Ryan.pdf (arguing that the public trust doctrine and other principles of natural resource management could be applied to the electromagnetic spectrum to protect the public's overlay and underlay rights, just as they have been used to protect similar rights in real property).

79. James H. Johnston, *The Federal Communications Commission in a Box*, 26 LEGAL TIMES, Dec. 8, 2003, at 16.

80. *Id.*

81. *Id.* In the early days of radio communications, there was competition among broadcasters, who consistently increased their transmission signal power in order to "drown out" the competition (similar to shouting louder than someone else in order to make sure that you are heard). This competition led to now famous "cacophony of competing voices" that forms the legal principle for the regulation of spectrum. Red Lion Broad. Co. v. FCC, 395 U.S. 367, 375-77 (1969). As noted in the case proceedings:

Furthermore, Johnston appears to borrow ideas advanced in the Wireless Device Bill of Rights. For example, he notes that cognitive radio technologies can do what the FCC does today—assign frequencies—and he explains that "[d]ynamic frequency selection . . . allows devices to transmit on whichever frequency is available at the moment. Thus, the FCC doesn't need to micromanage the allocation of frequencies; computer-controlled transmitters can do that."[82] In his conclusion, as the title of the article suggests, Johnston contends that the FCC could be replaced by "a box of electronics," (*i.e.*, computerized systems and associated cooperative algorithms), and he maintains that the application of computing technology to the wireless spectrum could "empower the individual, giving him the right to use the ether however he wants."[83] This conclusion is no different than that offered in Baran's 1994 proposal, nor is it any more progressive than the suggestions made by the FCC's Technological Advisory Council (TAC) in 2000, as we will see momentarily. However, spectrum stakeholders (*e.g.*, consumers, regulators, and broadcasters) have become so accustomed to the regulation and allocation of the wireless spectrum by a centralized agency that many will continue to require hard evidence in order to determine if and how a bureaucracy staffed by humans can be replaced by computer algorithms.

C. The Bill of Rights and the Technological Advisory Council

In order to investigate whether or not Johnston's *Federal Communications Commission in a Box* principles could become part of our regulatory paradigm, in 1998 the FCC created a separate group of advisors called the TAC, which comprises members of industry who provide the FCC with guidance on a wide variety of technical issues.[84]

> [B]efore 1927, the allocation of frequencies was left entirely to the private sector, and the result was chaos. It quickly became apparent that broadcast frequencies constituted a scarce resource whose use could be regulated and rationalized only by the Government. Without government control, the medium would be of little use because of the cacophony of competing voices, none of which could be clearly and predictably heard.

Id.

82. Johnston, *supra* note 79.

83. *Id.* To be fair, Johnston is asserting the position of the "open spectrum movement" as a whole.

84. *See* TAC Charter (Dec. 11, 1998), *available at* http://www.fcc.gov/oet/tac/TACCharter_112502.pdf (last visited Mar. 22, 2005). The purpose of the TAC is explained in Paragraph B (2) of the Charter, as follows:

> The purpose of the TAC is to provide technical advice to the Federal Communications Commission and to make recommendations on the issues and questions presented to it by the FCC. The TAC will address questions referred to it by the FCC Chairman, by the FCC Chief Office of Engineering and Technology

The TAC has been divided into three sessions: TAC I (1998-2001), TAC II (2001-03), and TAC III (2003 to the present). Many of the TAC's recommendations have later led to FCC rulemaking and have influenced FCC policies.[85] In 2000, TAC I suggested that Bran Ferren's proposed Wireless Device Bill of Rights be considered for further development:

> As we move into an era of software defined everything, an era where complexity and interaction are beyond the grasp of most people, we need to construct operating principles that are derived from a somewhat higher point of view than we have been considering up until now. By analogy to the Federal Constitution which provides a timeless and robust framework upon which all other laws can be tested, we need a "Bill of Rights" that would be the permanent basis for the governance of all intelligent devices. It would guide the responsibilities, obligations, rights and behavior of such devices so as to provide for both freedom of action and respect for the rights of humans and of other like devices. We need a set of high-level, overarching principles that describe how sophisticated equipment in conjunction with their human or mechanical users should behave so as to achieve the freedom and the equality of rights we desire. . . . The intent is to keep the thinking at a very high level and to use the real Bill of Rights and how people interact in real life as models.[86]

By comparing the Wireless Device Bill of Rights with the U.S. Constitution and suggesting that we take into consideration the way in which "people interact in real life," the TAC's conclusions thus take into account some of the underlying principles of Paul Baran's "kindergarten rules." After all, these rules are an extrapolation of the principles that guide the manner in which real people interact (or should interact) in the real world. The very fact that the TAC has entered into a discussion regarding these concepts seems to indicate that this bill of rights movement holds a great deal of promise.

Comments similar to those included above were reiterated at TAC II in 2001[87] and at subsequent meetings. Unexpectedly, however, a

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> or by the TAC Designated Federal Officer. The questions referred to the TAC will be directed to technological and technical issues in the field of communications.

Id.

85. For example, the FCC initiated a special inquiry to change rules in order to accommodate software defined radio based on studies performed by the TAC. *See* FCC Press Release, FCC Begins Inquiry Regarding Software Defined Radio (Mar. 17, 2000), *available at* http://www.fcc.gov/Bureaus/Engineering_Technology/News_Releases/2000/nret0004.html (describing the work of the TAC in relation to the software defined radio inquiry).

86. TAC, FIFTH REPORT, *supra* note 9, at 12-13.

87. *See* TAC, REPORT: SECOND MEETING OF THE FCC TECHNOLOGICAL ADVISORY COUNCIL II (Nov. 5, 2001), *available at* http://www.fcc.gov/oet/tac/TACII-

review of the minutes of these meetings indicates that the debate has not advanced much (at least in the TAC forum) since about 2002. However, at the December 2002 meeting, TAC II did publish the 2000 draft of the Wireless Device Bill of Rights through an FCC portal.[88] Since that time, the discussion has shifted from the TAC to other areas, such as the New America Foundation. At a June 2003 conference, the New America Foundation published the latest version of the document.[89] This version is generally unchanged from the first draft (published by TAC I), although it now contains a preamble (a Statement of Principles),[90] and the tenets have been given titles (which we saw earlier).[91]

Most importantly, however, the New America Foundation's conference included an important presentation by the Defense Advanced Research Projects Agency (DARPA), the research and development arm of the U.S. Department of Defense. This presentation showed that the kinds of wireless devices described in the Wireless Device Bill of Rights are already being developed by the U.S. government.[92] In fact, DARPA has undertaken a new communications program called neXt Generation (XG), which is building adaptive telephone technology that can operate using different frequencies in different parts of the world without causing

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Report2.pdf (proposing that the TAC continue to discuss the development of the Wireless Devices Bill of Rights under its mandate to develop new ways to manage the spectrum).

88. *See* Kontson, *supra* note 10.

89. *See* KALLE R. KONTSON, NEW AMERICA FOUNDATION, INTELLIGENT WIRELESS DEVICE BILL OF RIGHTS (June 20, 2003), *available at* http://www.newamerica.net/Download_Docs/pdfs/ Doc_File_186_1.pdf.

90. *Id.* The Statement of Principles reads as follows:

> Wireless devices are increasingly becoming the vehicle of human communication and an extension of our senses. As these devices become more intelligent, they become capable of automatically coordinating their behaviors and interactions with other such devices, just as humans would do in orderly verbal communications. To fully leverage such future technology, it may be necessary to define a universal set of rights and responsibilities for such devices. This "Intelligent Wireless Device Bill of Rights", designed for the emerging era of smart radios, takes one important step in this direction. It treats smart radios as proxies for human speech and thus subject to similar First Amendment Rights. It defines the expected behaviors, rights and responsibilities for wireless devices operating in a free environment, restricted only by the responsibility to respect the rights of others. It is technically possible to implement, as illustrated by the DoD XG program. It also supports an emerging economic model in telecommunication: one driven by unlicensed consumer products and information content, not by licensed subscriber services.

Id.

91. *Id.* The titles assign to these devices characteristics usually applied to humans. For example, Art. 1, Tenet 1, is titled "Mental Competence and Moral Character," and Art. 1, Tenet 2, is titled "Good Citizenship."

92. Preston Marshall, Beyond the Outer Limits, XG Next Generation Communications, DARPA Presentation (June 20, 2003), *available at* http://www.darpa.mil/ato/programs/xg/ index.htm (describing the DARPA XG system).

interference.[93] Since the program is being developed by the military, little information about it has been made available to the public. Nonetheless, those who support the Wireless Device Bill of Rights have cited the program as an example that demonstrates (1) that adaptive products are viable and are in the process of being developed and (2) that these products will require a different type of legal mechanism that sets forth principles that tell us not only what we cannot do, but also what we *can* do (as the Constitutional Bill of Rights does).

CONCLUSION

Over the past few decades, many paradigm shifts have changed our view of the interrelationship of science and law. Two of the more notable paradigm shifts in the computer industry have been (1) the supplantation of "Grosch's law" (a centralized mainframe and dumb terminals) by Moore's law (increasingly smaller, more powerful terminals);[94] and (2) the gradually recognized supplantation of Grosch's law by both Moore's Law and Paul Baran's principles of distributed computing (the interconnection of computers in a mesh configuration). The future promises that devices will continue to become simultaneously less expensive and more powerful.[95] As distributed mesh theories are being applied to wireless communications, we should endeavor to develop proposals that endow users of the new wireless devices with technology-neutral rights and obligations. The Wireless Device Bill of Rights is a great start.

The advantage of the proposed Wireless Device Bill of Rights is that it delineates what users of the wireless spectrum *can do* rather than what they *cannot do*. It purports to be technology neutral, and it allows users to access the spectrum so long as they abide by simple rules (rules so logical and clear cut that we learned them in kindergarten, according to Paul Baran). Others, including James Johnston, have further suggested that we can program these devices with algorithms and

93. *Id. See also* DARPA, NEXT GENERATION COMMUNICATIONS PROJECT, *at* http://www.darpa.mil/ato/programs/xg/index.htm (last visited Mar.. 22, 2005).

94. *See Caught in the Net*, *supra* note 18, at S16.

95. Even if Moore's law may reach its limits, nanotechnology promises molecular-level processing and anticipates that computers will continue to shrink beyond that which is presently available by silicon chips. *See* Jack Robertson, *Nanotechnology Expected to Extend Moore's Law*, EE TIMES U.K., Sept. 12, 2002, *at* http://www.electronicstimes.com/tech/news/OEG20020912S0039 (describing chip maker Intel's work on nanotechnology and quotes Sunlin Chou, an executive at Intel: "[t]he people who think Moore's Law will end assume that materials and structures won't change. They are constantly changing and will keep Moore's Law going for a lot longer"). *See also Small Wonders*, THE ECONOMIST, Sept. 14, 2002, at 76 (describing the limits of silicon chips and the developments of nanotechnology and molecular processing that continue the trend towards increased power and computer miniaturization).

ultimately replace the functions performed by the FCC with a set of computerized conventions that are similar to the protocols that form the basis for the way the Internet works today. Finally, the greatest strengths of the Wireless Device Bill of Rights lie in the fact that it empowers access and in the fact that, like the Constitutional Bill of Rights, it is timeless. Instead of advocating one technology over another, it instead deems as acceptable any technology that fits within its designated parameters.

The disadvantage of the Wireless Device Bill of Rights is that it is in the very early stages of development, which means that its articles and tenets still require considerable clarification. It is premature to expect that a one-page document can replace the thousands of pages of FCC wireless spectrum regulations. Further, although the Bill of Rights proposes the philosophical cohabitation of "open spectrum" theories and Coasian property rights principles, the details require a great deal of fine-tuning. Since we are only just now beginning to test property rights theories in practice, it is unlikely that these efforts will be aborted in favor of so ambitious a set of rules and principles, at least within the next few years. Finally, as rights are further developed and clarified, scholars will invariably need to turn to enforcement.[96]

For now, however, we still need a rights-based mechanism. Even though wireless communications did not exist when the U.S. Constitution was penned, since World War II the protection of such communications has become a cornerstone of European governments through the European Convention on Human Rights.[97] Furthermore, some newly democratized Central European governments have taken the opportunity within the past ten years to explicitly articulate the public's right to use the radio frequency spectrum under the umbrella of

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96. *See* Ellen P. Goodman, *Spectrum Rights in the Telecosm To Come*, 41 SAN DIEGO L. REV. 269 (2004) (discussing the emerging commons model and advocating a regulatory strategy to facilitate the effective use of commons spectrum); *also see* PHILIP J. WEISER AND DALE N. HATFIELD, POLICING THE SPECTRUM COMMONS (TPRC Program Paper No. 300, Aug. 2004), *available at* http://web.si.umich.edu/tprc/papers/2004/300/policing%20spectrum%20commons.pdf (noting that the question of enforcement in a commons regime has been underaddressed in the academic literature and proposing some models).

97. The European Convention on Human Rights was adopted in 1950. Article 10 provides the right to freedom of expression, as follows: "Everyone has the right to freedom of expression. This right shall include freedom to hold opinions and to receive and impart information and ideas without interference by public authority and regardless of frontiers. This article shall not prevent States from requiring the licensing of broadcasting, television or cinema enterprises." Convention for the Protection of Human Rights and Fundamental Freedoms, Nov. 4, 1950, art. 10, 213 U.N.T.S. 221, 230 [hereinafter European Convention on Human Rights].

constitutional free speech protections.[98] Thus, in the twenty-first century, traditional free speech principles are frequently being applied to wireless media communications, and the rights and freedoms entrenched in the U.S. Constitution now pervade democracies worldwide.

Along these lines, the Wireless Device Bill of Rights and the "FCC in a box" concept are by no means extreme, impractical ideas; on the contrary, the validity of these ideas has, to some extent, already been proven through the viability of wired devices (*e.g.*, the Internet) and of the new unlicensed wireless devices that access the Internet (*e.g.*, Wi-Fi). Broadcasters, public safety officials, and others will undoubtedly require these new technologies and the aforementioned theories to be tested for many years before these individuals are willing to forgo traditional views regarding spectrum management. That said, the Wireless Device Bill of Rights will facilitate the evolution of this discussion in coming years, and the healthy debate as to how to apply its principles should continue.

98. *See e.g.*, Bulgarian Constitution, ch. I (Fundamental Principles), art. 18, which sets forth the principle that the radio frequency spectrum belongs to the public, as do other natural resources: "The state shall enjoy exclusive ownership rights over the nether of the earth; the coastal beaches; the national thoroughfares, as well as over waters, forests and parks of national importance," (Para. 1), and "The state shall exercise sovereign rights with respect to radio frequencies and the geostationary orbital positions," (Para. 3). The Bulgarian Constitution protects freedom of speech. *Id.* at ch. II, art. 39. Also note that the 1950 European Convention on Human Rights allows for the licensing of radio frequencies, although it covers only "broadcast" media and was passed before two-way communications such as mobile telephony were widely used or even thought to be possible. European Convention on Human Rights, *supra* note 97.