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The Policy Origins of Wi-Fi

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Wi-Fi technology has become a necessary foundation of modern economic and cultural life. This Article explains its history. Specifically, it argues that Wi-Fi owes its existence and widespread adoption to federal policy choices that have been underexplored in the literature. Wi-Fi's development is often portrayed as an unexpected and lucky accident following the FCC's initial decision in the 1980s to allow more unlicensed and experimental uses. This view, however, obscures the more fundamental role that federal policy played. For one, the rise of modern Wi-Fi was the product of a series of policy decisions spanning decades. In addition, the FCC's policy design itself is also an underappreciated part of Wi-Fi's story. These policies were (eventually) crafted in ways that maximized innovation and leveraged the generative power of the unlicensed spectrum "commons." Specifically, the policy designs featured technical rules that lowered entry costs by being administratively simple and generic and by rejecting specific technological requirements despite incumbent pressure. Understanding this history has implications for modern spectrum policy debates as well. In particular, it helps illustrate why Wi-Fi succeeded while other efforts to encourage unlicensed technologies have failed. It also provides normative justification for the FCC's most recent efforts to significantly increase unlicensed spectrum.

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INTRODUCTION

The COVID-19 pandemic has been one of the greatest disruptions in American history. The disruption, however, would have been even worse without Wi-Fi technology. As Federal Communications Commission (FCC) Chair Jessica Rosenworcel explained in the early days of the pandemic, "I . . . know there is a technology my household is relying on like never before. That's Wi-Fi. Because in this crisis, work, school, healthcare, and so much more have migrated online. Keeping connected is essential."[1] Former FCC Chair Ajit Pai echoed these same themes: "For many of us, Wi-Fi has helped keep us connected to our families and friends . . . . In short, sheltering in place would be a lot more difficult without Wi-Fi."[2]

As the pandemic has illustrated, Wi-Fi technology has become a key foundational infrastructure of our modern economic and social lives. It also represents one of the FCC's greatest policy successes. Globally, the adoption of Wi-Fi has been staggering. By some estimates, Wi-Fi now carries over half of internet traffic, helping relieve burdens on cellular networks.[3] The economic value of these technologies is expected to reach nearly one trillion dollars in the coming years.[4] The growth of high-speed Wi-Fi also provides a critical input for content and equipment markets served by companies such as Netflix, Disney+, and Roku.[5] Wi-Fi

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1. Unlicensed Use of the 6 GHz Band, Expanding Flexible Use in Mid-Band Spectrum Between 3.7 and 24 GHz, 35 FCC Rcd. 3852, 3992 (2020) [hereinafter 2020 6 GHz Order] (statement of Jessica Rosenworcel, Comm'r) (report and order and further notice of proposed rulemaking).

2. *Id.* at 3986 (statement of Ajit Pai, Chairman).

3. Unlicensed Use of the 6 GHz Band, Expanding Flexible Use in Mid-Band Spectrum Between 3.7 and 24 GHz, 33 FCC Rcd. 10496, 10497–98 (2018) [hereinafter 2018 6 GHz Notice] (notice of proposed rulemaking).

4. 2020 6 GHz Order, *supra* note 1, at 3986 (statement of Ajit Pai, Chairman).

5. Cisco Sys., Inc., Comment Letter on Unlicensed Use of the 6 GHz Band 5–6 (Feb.

technologies also generate positive externalities that are difficult to quantify. As the past two years have shown, Wi-Fi technologies have allowed us to stay connected with friends, jobs, and schools using multiple devices in our homes. At the same time, the lack of access to reliable Wi-Fi and hotspots imposes strong costs on families, further exacerbating racial and class divides.[6] In short, much of modern life relies upon Wi-Fi technologies.

As important as Wi-Fi has become, we should remember that it could easily not exist. In this Article, I argue that Wi-Fi technology is the result of specific policy choices that led to its creation and expansion. It thus challenges the more common narrative that Wi-Fi's development was a lucky and unforeseen accident.[7] I further argue that understanding this history can inform modern spectrum policy debates. Descriptively, the history helps explain why some unlicensed spectrum policies have succeeded while others have failed.[8] Normatively, the history provides both guidance and support for recent policy initiatives—particularly the 6 GHz initiative, which is the largest expansion of unlicensed spectrum in history.[9]

Part I of the Article describes the initial policy decisions that created the foundation for Wi-Fi's development. Beginning in the early 1980s, the FCC began exploring proposals to open additional spectrum for certain unlicensed and experimental uses.[10] In 1985, the FCC adopted regulations to this effect.[11] While unforeseen at the time, this decision would ultimately give rise to a range of innovative, new unlicensed technologies including Wi-Fi and Bluetooth.[12] The initial

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15, 2019) [hereinafter Cisco 6 GHz Comments] ("Most of these streaming applications will rely on Wi-Fi to deliver content to a consumer's television . . . .").

6. *See, e.g.*, Dan Levin, *In Rural 'Dead Zones,' School Comes on a Flash Drive*, N.Y. TIMES, Nov. 13, 2020, at A6; Erin Richards, Elinor Aspegren & Erin Mansfield, *A Year into the Pandemic, Thousands of Students Still Can't Get Reliable WiFi for School. The Digital Divide Remains Worse Than Ever*, USA TODAY (Feb. 4, 2021, 2:35 PM), https://www.usatoday.com/story/news/education/2021/02/04/covid-online-school-broadband-internet-laptops/3930744001/ [https://perma.cc/J4L3-P6W9].

7. *See*, *e.g*., Philip J. Weiser & Dale N. Hatfield, *Policing the Spectrum Commons*, 74 FORDHAM L. REV. 663, 673, 694 (2005) (characterizing unlicensed technologies development as a "happy historical accident" and an "initial, unexpected success"); Susan P. Crawford, *The Radio and the Internet*, 23 BERKELEY TECH. L.J. 933, 1002 (2008) ("The explosion of Wi-Fi surprised almost everyone.").

8. *See infra* Part III (providing examples of unlicensed policy failures).

9. *See* Ry Crist, *FCC Unlocks a Massive Amount of Bandwidth for Next-Gen Wi-Fi Devices*, CNET (Apr. 29, 2020, 5:15 AM), https://www.cnet.com/home/internet/the-fcc-voted-6-ghz-wi-fi-6e-here-we-come [https://perma.cc/J4L3-P6W9] (citing FCC statement that decision would increase available unlicensed spectrum by a "factor of five"); Jim Salter, *Wi-Fi 6 E Becomes Official—The FCC Will Vote on Rules this Month*, ARS TECHNICA (Apr. 2, 2020, 12:31 PM), https://arstechnica.com/gadgets/2020/04/fcc-will-vote-on-rules-for-1-2ghz-of-new-wi-fi-6e-spectrum-on-april-23 [https://perma.cc/CD3Y-F99W] (noting that the 6 GHz spectrum "offers roughly six times the *total* spectrum currently available" on currently used Wi-Fi bands).

10. *See infra* Section I.B.

11. Authorization of Spread Spectrum and Other Wideband Emissions, 101 F.C.C.2d 419, 426–28 (1985) [hereinafter 1985 Spread Spectrum Order] (first report and order).

12. MICHAEL MARCUS, JIM BURTLE, BRUCE FRANCA, AHMED LAHJOUJI & NEAL MCNEIL,

decision itself is noteworthy in that it challenges what traditional public choice theory would predict.[13] The FCC was acting on behalf of technologies and industries that did not yet exist and could not lobby for regulatory benefits. However, the more important—and less appreciated—aspect of the 1985 decision was its *design*. In authorizing new unlicensed uses, the FCC adopted "technical rules"—the technical requirements and operating specifications that devices must follow—that were structured to maximize innovation.[14] The accidental success of Wi-Fi depended upon these policy designs in ways the literature undervalues.

Part II explores what happened next. Beginning in 1989 and continuing for the next two decades and a half, the FCC took additional actions that helped nurture the growth of Wi-Fi and other unlicensed technologies in their formative years.[15] These policies included expanding the amount of unlicensed spectrum and modifying the technical rules to encourage innovation. Wi-Fi's growth should therefore be understood not as a happy accident following a single decision but instead the product of a series of policy decisions spanning decades. In this Part, I also examine the policy designs of how these additional measures evolved over time. After initially imposing too many limits and burdensome technical rules, the FCC gradually embraced the simpler policy designs and principles of the original 1985 decision.[16]

Part III explores precisely why these policy designs successfully generated so much innovation. Spectrum policy has long been dominated by debates between property- and commons-based approaches to governance.[17] Property approaches favor more exclusive licenses and excludability, while commons approaches favor more shared unlicensed uses. While both have their costs and benefits, one key feature of the commons approach is facilitating market entry and lowering transactions costs by removing the need to obtain permission from either the government or incumbent users.[18] I argue that the FCC's policy designs—specifically, its technical rules—became a catalyst for innovation in precisely this way. By creating simple and generic certification rules that were technology agnostic, the policy reinforced and maximized the most generative features of the

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FED. COMMC'NS COMM'N, REPORT OF THE UNLICENSED DEVICES AND EXPERIMENTAL LICENSES WORKING GROUP 6–7 (2002), https://transition.fcc.gov/sptf/files/E&UWGFinalReport.pdf [https://perma.cc/6MHB-65B8]; Ellen P. Goodman, *Spectrum Rights in the Telecosm to Come*, 41 SAN DIEGO L. REV. 269, 360–62 (2004).

13. *See infra* notes 93–94 and accompanying text.

14. Goodman, *supra* note 12, at 283–84.

15. *See generally infra* Part II.

16. *See infra* notes 228–230 and accompanying text (explaining how FCC proceedings ultimately simplified technical rules through time).

17. *See* Olivier Sylvain, *Wireless Localism: Beyond the Shroud of Objectivity in Federal Spectrum Administration*, 20 MICH. TELECOMM. & TECH. L. REV. 121, 123–24 nn.3–4 (2013) (surveying literature on property and commons disputes); Yochai Benkler, *Open Wireless vs. Licensed Spectrum: Evidence from Market Adoption*, 26 HARV. J.L. & TECH. 69, 81–83 (2012) ("Over the course of the past fifteen years, substantial literature has developed addressing the basic choice between a 'spectrum property' model of exclusive licenses . . . and a model based on equipment and services that do not depend on exclusive access . . . ."); *see also infra* notes 235–239 and accompanying text.

18. *See infra* notes 240–250 and accompanying text (outlining policy costs and benefits of each approach).

commons.[19] In other contexts where the FCC's policies did not embrace these principles, its efforts to spur unlicensed innovation largely failed.[20]

In Part IV, I examine the relevance of this history to more modern spectrum policy debates. Specifically, I apply these insights to defend the FCC's approach in the recent "6 GHz" proceeding, which is the largest expansion of unlicensed spectrum in decades and is already giving rise to exciting new "Wi-Fi 6" technologies.[21] Like the rules that gave rise to Wi-Fi, many of the 6 GHz technical rules were simple, standardized, and free from exceedingly technical requirements designed to prevent interference. However, the Article also critiques aspects of the 6 GHz order that deviated from the earlier, and successful, design principles.[22]

My Article contributes to the literature in a number of ways. First, it provides a comprehensive account of the various policy decisions that led to Wi-Fi's development and growth. While the literature often recognizes the importance of one or more of these proceedings, the examination is often cursory and ignores important details.[23] Specifically, it underestimates how much Wi-Fi depended on an ongoing process that spanned many years. The literature also undervalues the critical role of the *structure* of the policies in generating growth.[24] The simplicity of the FCC's rules and their rejection of unnecessary interference protections played a key role in Wi-Fi's success. The failure to make these same choices helps explain why other policies to promote unlicensed technologies have often failed.

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19. One of the first scholars to recognize the importance of technical rules to unlicensed policy success was Professor Yochai Benkler in *Overcoming Agoraphobia: Building the Commons of the Digitally Networked Environment*, 11 HARV. J.L. & TECH. 287, 332 (1998) ("The most important institutional attribute of unlicensed operations is that regulation focuses on general specifications for equipment design and use."). This Article expands upon this insight and applies it more specifically to recent proceedings involving Wi-Fi technologies.

20. *See infra* Part III (providing examples of unlicensed policy failures).

21. 2020 6 GHz Order, *supra* note 1, at 3853 ("[W]e are adopting rules to make 1200 megahertz of spectrum available for unlicensed use . . . ."); Jacob Kastrenakes, *Wi-Fi Is Getting Its Biggest Upgrade in 20 Years*, VERGE (Apr. 23, 2020, 11:08 AM), https://www.theverge.com/2020/4/23/21231623/6ghz-wifi-6e-explained-speed-availability-fcc-approval [https://perma.cc/F2RM-EZ44].

22. *See infra* Part IV (reviewing the benefits and problems with the 6 GHz Order).

23. It is not new to say that federal policy played a role in the creation of Wi-Fi. My departure from the literature is to examine this policy history far more closely in several respects. In particular, I argue that Wi-Fi's rise depended upon many more proceedings than is generally acknowledged and upon the specifics of the policy design throughout this history. For examples, however, of these acknowledgements of federal policy's role, see, e.g., INNOVATION JOURNEY OF WI-FI: THE ROAD TO GLOBAL SUCCESS 41 (Wolter Lemstra, Vic Hayes & John Groenewegen eds., 2011) (noting importance of FCC policy shift); Shane Greenstein, *Economic Experiments and Neutrality in Internet Access* 14 (Nat'l Bureau of Econ. Rsch., Working Paper No. 13158, 2007) ("Federal spectrum policy cooperated with these technical initiatives – indeed, nothing would have succeeded in its absence."); Weiser & Hatfield, *supra* note 7, at 672 (noting role of FCC's Part 15 rules); *A Brief History of Wi-Fi*, ECONOMIST (June 12, 2004), https://www.economist.com/technology-quarterly/2004/06/12/a-brief-history-of-wi-fi [https://perma.cc/SYE8-FHPY] (noting Wi-Fi "was, in effect, spawned by an American government agency").

24. *See infra* Part III (detailing how the policy structure of technical rules generated innovation).

To conclude, FCC Chair Jessica Rosenworcel recently stated, "You may not know it, but your life runs on unlicensed spectrum . . . . No matter who you are or where you live, the odds are good that you have benefited from unlicensed airwaves and Wi-Fi."[25] She added that "[t]hese conveniences are not the gifts of the spectrum gods. They are the byproduct of wireless policy choices . . . made at the [FCC] more than three decades ago."[26] This Article explains why she is right.

I. THE BEGINNING—THE INITIAL APPROVAL

A. An Introduction to Wi-Fi and Spectrum

In the popular mind, Wi-Fi means wireless internet service. Technically, Wi-Fi is a shorthand for a set of shared network protocols that enable wireless data communications between devices. These protocols—which consist of the larger 802.11 family of protocols—essentially allow wireless devices to "speak" to one another.[27] The protocols are developed by a standards-creating institution, the Institute of Electrical and Electronic Engineers (IEEE).[28] The term "Wi-Fi" itself is a certification mark administered by the nonprofit Wi-Fi Alliance.[29] The mark certifies that devices comply with the IEEE standards.[30]

Wireless communications themselves essentially consist of three components—a transmitter, a receiver, and electromagnetic radio waves.[31] These waves can transmit information by being modulated (i.e., altered) in ways that receiving devices can understand and translate.[32] These signals are transmitted at certain frequencies (or wavelengths) within the electromagnetic spectrum, which refers to the collective range of all frequencies upon which wireless communications may operate.[33] In this sense, "[s]pectrum is the lifeblood" for wireless communications in that it provides

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25. 2018 6 GHz Notice, *supra* note 3, at 10547 (statement of Jessica Rosenworcel, Comm'r).

26. *Id.*

27. Thomas Carroll, A History of Wi-Fi (In the Context of) Cellular Telecommunications 3 (Dec. 3, 2018) (publication to partially satisfy Ph.D. in telecommunications) (analyzing specific 802.11 standards through 2014).

28. Greenstein, *supra* note 23, at 13. For a more detailed look at the engineering history that led to these standards, see Kai Jakobs, Wolter Lemstra & Vic Hayes with Bruce Touch & Cees Links, *Creating a Wireless LAN Standard: IEEE 802.11*, in INNOVATION JOURNEY OF WI-FI, *supra* note 23, at 66–82.

29. Carroll, *supra* note 27, at 3.

30. *See* Matthew Bierlein, Note, *Policing the Wireless World: Access Liability in the Open Wi-Fi Era*, 67 OHIO ST. L.J. 1123, 1128 n.29 (2006).

31. Kevin Werbach, *Supercommons: Toward a Unified Theory of Wireless Communication*, 82 TEX. L. REV. 863, 883 (2004) ("In any wireless communications system, there are only three elements: transmitters, receivers, and electromagnetic radiation passing between them.") (footnote omitted).

32. STUART MINOR BENJAMIN & JAMES B. SPETA, INTERNET AND TELECOMMUNICATIONS REGULATION 52–54 (2019); JONATHAN E. NUECHTERLEIN & PHILIP J. WEISER, DIGITAL CROSSROADS: TELECOMMUNICATIONS LAW AND POLICY IN THE INTERNET AGE 86 (2d ed. 2013).

33. BENJAMIN & SPETA, *supra* note 32, at 47.

the "roads," or infrastructure, upon which all electromagnetic transmissions must travel.[34] Without adequate spectrum, functional wireless communications are impossible. Wi-Fi technologies, like all other wireless communications, therefore, require access to adequate spectrum to function properly.

Spectrum access, in turn, is governed by federal law. The Communications Act of 1934 delegates comprehensive regulatory authority over spectrum governance to the FCC.[35] As a result, the agency has wide discretion in determining how spectrum will be used and by whom. The primary justification for the FCC's broad role is that spectrum is a scarce resource that requires management.[36] There simply isn't enough space for everyone's communications. In the absence of regulatory limits, communications would crowd each other out and create harmful interference that dramatically reduces the functionality of wireless devices (thus threating research and development).[37] In addition, not all spectrum is created equal. Because of basic physics, certain spectrum frequencies are more valuable than others. For instance, low-band frequencies assigned to broadcast television are considered "beachfront" spectrum because of their superior propagation characteristics and ability to penetrate buildings.[38]

The combination of spectrum's scarcity and varying quality ensures that the FCC's spectrum decisions are both high-stakes and contested affairs. These decisions include resolving questions of allocation and assignment.[39] Allocation refers to *how* spectrum may be used. Assignment, by contrast, determines *who* may use a given spectrum frequency. With respect to allocation, the FCC effectively has power to "zone" different bands of spectrum frequencies much like land can be zoned for different types of uses.[40] For instance, spectrum can be allocated for different services, such as satellite and terrestrial radio, broadcast television, or cellular and data services.[41] With respect to assignment, the FCC (subject to statutory constraints) has power to decide how parties will obtain usage rights. Spectrum can, for instance, be assigned through various mechanisms, such as license applications or auctions,

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34. Charles M. Davidson & Michael J. Santorelli, *Seizing the Mobile Moment: Spectrum Allocation Policy for the Wireless Broadband Century*, 19 COMMLAW CONSPECTUS 1, 6 (2010); *see* Jeffrey A. Eisenach, *Spectrum Reallocation and the National Broadband Plan*, 64 FED. COMMC'NS L.J. 87, 99 (2011).

35. NUECHTERLEIN & WEISER, *supra* note 32, at 89–90.

36. BENJAMIN & SPETA, *supra* note 32, at 66–67; NUECHTERLEIN & WEISER, *supra* note 32, at 87–88.

37. NUECHTERLEIN & WEISER, *supra* note 32, at 90 (noting FCC's authority to prevent "harmful interference").

38. Stuart Minor Benjamin, *Spectrum Abundance and the Choice Between Private and Public Control*, 78 N.Y.U. L. REV. 2007, 2065 (2003); *see* BENJAMIN & SPETA, *supra* note 32, at 49.

39. *See* NUECHTERLEIN & WEISER, *supra* note 32, at 90–96 (providing overview of allocation and assignment).

40. Goodman, *supra* note 12, at 282 ("The allocation of spectrum is much like the zoning of land.").

41. *See* BENJAMIN & SPETA, *supra* note 32, at 75; NUECHTERLEIN & WEISER, *supra* note 32, at 90.

that create exclusive rights.[42] Alternatively, the FCC can designate certain bands of spectrum as unlicensed, thus assigning shared usage rights to the public as a whole.[43]

To better understand allocation and assignment, assume there is a radio station operating at 90.7 FM. The radio station itself is transmitting modulated radio waves at the frequency 90.7 MHz. It can do so because this range of spectrum frequencies has been allocated for FM radio use. In addition, the FCC has assigned the spectrum to this individual radio station, which has an exclusive license to transmit communications at that frequency for a given area. Unless statutes require otherwise, the FCC must make similar decisions about allocation and assignment for different frequencies all across the electromagnetic spectrum.[44]

In addition to its allocation and assignment powers, the FCC must also make additional technical decisions that govern spectrum usage. These are often known as "technical rules" or "service rules" (I will use the former). Technical rules refer to the specifications and requirements that devices must follow to operate in a specific spectrum band—essentially, the rules of the road.[45] These rules can include power and emission limits, channel sizes, technological features to prevent interference, and other requirements about equipment and transmission operations.[46] While these technical rules are not the most glamorous subject in the world, they are absolutely essential. Indeed, one of the Article's central arguments is that these technical decisions often determine whether the FCC's policy goals will be achieved. If technical rules are relatively simple, it lowers the costs of entry. Conversely, as the complexity of technical rules increases, the more costly development and market entry become.[47]

The larger point is that the FCC has wide discretion over matters of spectrum governance. It can generally decide how a band of spectrum may be used, who may use it, and what technical rules will apply. For our purposes, one key question is whether a given spectrum frequency will be authorized for licensed or unlicensed use. Prior to the 1980s, the FCC had authorized very limited unlicensed uses, particularly in the more valuable frequencies.[48] Instead, the most valuable parts of the spectrum were generally licensed exclusively to specific private users for specifically defined uses, such as broadcast television. In 1985, this would begin to change.

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42. *See* Ellen P. Goodman, *Spectrum Auctions and the Public Interest*, 7 J. ON TELECOMMC'NS & HIGH TECH. L. 343, 352–53 (2009).

43. STUART MINOR BENJAMIN, HOWARD SHELANSKI, JAMES B. SPETA & PHILIP J. WEISER, TELECOMMUNICATIONS LAW AND POLICY 105–06 (2012).

44. PETER W. HUBER, MICHAEL K. KELLOGG & JOHN THORNE, FEDERAL TELECOMMUNICATIONS LAW § 10.3.3 (3d ed. 2021) ("As the ultimate owner of all spectrum, the FCC has broad authority to 'zone' wireless licenses for specific uses.").

45. *See* Weiser & Hatfield, *supra* note 7, at 667–68; Goodman, *supra* note 12, at 283–84 (comparing "service and technical rules" to "structural requirements, such as lot size and building design, that zoning boards impose on landowners").

46. Goodman, *supra* note 12, at 284.

47. *See infra* notes 251–262 and accompanying text (arguing why technical rules can determine success of policy goals).

48. These authorizations consisted generally of very low-power devices under its Part 15 regulations. NUECHTERLEIN & WEISER, *supra* note 32, at 113.

B. The Initial 1985 Order

The story of Wi-Fi begins, like so much of the internet, with the military.[49] More precisely, it begins with the rise of a technology called spread spectrum, which was originally used by the military for wireless communications.[50] Interestingly, one of its key co-inventors was Hollywood actress Hedy Lamarr, who helped develop it for radio communications during World War II.[51]

Traditionally, most wireless communications were "narrowband," which means that the communications occupied a fairly narrow band of frequencies—similar to cars confined to a narrow lane of the highway. Narrowing the bandwidth in this way helped increase spectrum efficiency.[52] Spread spectrum, by contrast, improved communications efficiency by doing exactly the opposite. Instead of narrowing the bandwidth, spread spectrum technologies transmitted their signals over a wider set of bandwidths; again, imagine adding more lanes to the highway and expanding their width.[53] By spreading the signal widely, these communications were more resistant to interference and more difficult to detect and jam.[54] Such characteristics had obvious military benefits.

Spread spectrum technology remained a largely specialized niche interest until the late 1970s, when engineers started exploring whether spread spectrum could have civilian applications as well.[55] This was a promising possibility because spread spectrum possessed several technological characteristics that could dramatically increase spectrum efficiency.[56] For one, spread spectrum transmissions could operate at lower power levels, thus reducing interference concerns. By spreading the signal more widely and transmitting at lower power, these technologies caused less interference while simultaneously being more resistant to it.[57]

At the same time, spread spectrum also allowed multiple users to communicate simultaneously using the exact same spectrum frequencies. It would be as if two people at a crowded party could suddenly communicate to each other from across

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49. JANET ABBATE, INVENTING THE INTERNET 5 (Wiebe E. Bijker, W. Bernard Carlson & Trevor Pinch eds., 1999); *see generally* KATIE HAFNER & MATTHEW LYON, WHERE WIZARDS STAY UP LATE: THE ORIGINS OF THE INTERNET 54–64 (1996) (explaining how military necessities drove research into decentralized networks).

50. Authorization of Spread Spectrum and Other Wideband Emissions, 87 F.C.C.2d 876, 878 (1981) [hereinafter 1981 Spread Spectrum Notice] (notice of inquiry) ("[Spread spectrum technology] was originally developed for military applications concerning covert communications and/or resistance to jamming.").

51. *See* RICHARD RHODES, HEDY'S FOLLY: THE LIFE AND BREAKTHROUGH INVENTIONS OF HEDY LAMARR, THE MOST BEAUTIFUL WOMAN IN THE WORLD 141–52 (2011).

52. 1981 Spread Spectrum Notice, *supra* note 50, at 877.

53. *Id.* at 878 ("Wideband modulation techniques in certain applications may actually increase spectrum efficiency over narrowband techniques . . . ."); *see also* ALEX HILLS, WI-FI AND THE BAD BOYS OF RADIO: DAWN OF A WIRELESS TECHNOLOGY 79–82 (2011).

54. 1981 Spread Spectrum Notice, *supra* note 50.

55. *Id.*; *see* Wolter Lemstra with Donald Johnson, Bruce Tuch & Michael Marcus, *NCR: Taking the Cue Provided by the FCC*, *in* INNOVATION JOURNEY OF WI-FI, *supra* note 23, at 25.

56. 1981 Spread Spectrum Notice, *supra* note 50, at 880–85 (outlining potential advantages of spread spectrum technologies for civilian uses).

57. *Id.*

the room despite all the other voices in the air that were being "transmitted" at the same frequencies.[58] To accomplish this, spread spectrum communications rely on encoding methods that allow both the transmitter and receiver to identify specific signals within a crowd and ignore others.[59]

Collectively, these features created the tantalizing opportunity that more users could use the same scarce spectrum simultaneously. More specifically, the combination of low-power and encoding techniques potentially allowed secondary users to operate devices on spectrum currently assigned to another user, also known as an "overlay."[60] In simple terms, it means allowing unlicensed uses on other people's spectrum.[61] It would be roughly equivalent to allowing neighborhood children to play in someone's yard so long as they didn't damage anything. The potential efficiency gains were staggering. For instance, instead of reserving 90.7 exclusively for a specific radio station, that frequency could simultaneously be used not only by the radio station but also by millions of low-power devices operating in people's individual homes and workplaces. The low power allowed additional communications to occur beneath the noise floor—that is, below the threshold that would cause interference with existing devices.[62] In simpler terms, it means that these communications were too quiet to cause interference. The idea is similar to groups of people whispering to each other quietly enough to avoid interrupting anyone else in the room. With these technologies, spectrum would suddenly be much less scarce. This was all very exciting.

It was also, however, illegal. Under the Communications Act, the FCC had to authorize new uses of spectrum.[63] Given the relatively obscure nature of spread spectrum, there was little demand for the FCC to open spectrum for experimentation. In addition, among those who did know about these technologies, there was skepticism that they could work. In 1980, the FCC commissioned the first major engineering report on spread spectrum, which ultimately concluded that civilian uses for these technologies were unlikely to succeed.[64] Specifically, this report—the MITRE report—concluded that "many potential spread spectrum applications are likely to be economically unattractive."[65] From the perspective of 1980, it thus seemed unlikely that spread spectrum would ever amount to anything, thus

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58. THOMAS W. HAZLETT, THE POLITICAL SPECTRUM: THE TUMULTUOUS LIBERATION OF WIRELESS TECHNOLOGY, FROM HERBERT HOOVER TO THE SMARTPHONE 249–50 (2017).

59. *Id.*

60. 1981 Spread Spectrum Notice, *supra* note 50, at 882 ("The low power density and interference suppression capability of spread spectrum systems suggests a unique application, that of band overlay.").

61. Thomas W. Hazlett & Sarah Oh, *Exactitude in Defining Rights: Radio Spectrum and the "Harmful Interference" Conundrum*, 28 BERKELEY TECH. L.J. 227, 330 (2013) (describing spectrum overlays as creating "secondary rights to use the spectrum" licensed to incumbent users).

62. Werbach, *supra* note 31, at 919, 946–47 (discussing and defining ambient "noise floor").

63. 1981 Spread Spectrum Notice, *supra* note 50, at 876 ("[O]ur present rules implicitly forbid the use of some new technologies in this area.").

64. Lemstra, *supra* note 55, at 25.

65. *Id.* (quoting WALTER C. SCALES, MITRE CORP., POTENTIAL USE OF SPREAD SPECTRUM TECHNIQUES IN NON-GOVERNMENT APPLICATIONS 6-1 (1980)).

endangering the existence of the future technologies it would eventually spawn such as Wi-Fi, Bluetooth, and certain Code Division Multiple Access (CDMA) cell-service technologies.[66]

Despite this skepticism, the FCC nonetheless opened a regulatory proceeding in 1981 to explore potential civilian uses for spread spectrum.[67] It is no exaggeration to say that Wi-Fi owes its existence to this decision. Although Wi-Fi itself (a specific type of spread spectrum technology) was still years away, this proceeding set the ball in motion for its ultimate development.

In retrospect, the FCC's decision to open this proceeding was unusual in various respects. For one, the FCC itself—as opposed to industry—initiated the proceeding. The agency later noted that it "usually authorized new technologies only in response to petitions from industry."[68] In this case, however, "the [FCC] initiated the [i]nquiry on its own."[69] The specific impetus for the 1981 decision came from a group of engineers within the FCC who were eager to explore the new technology. One of these engineers, Michael Marcus, characterized the decision as consistent with broader contemporary efforts to deregulate certain new technologies.[70] Framing experimentation as deregulatory was likely appealing to the political appointees of both the Carter and Reagan administrations at the time and might have helped the proposal overcome initial skepticism.[71] Even this initial step, however, caused some skepticism. FCC Commissioner Abbott Washburn, for instance, tentatively concurred with the decision but emphasized his concern that authorizing new technologies "should not be at the price of interference."[72]

At this point, accounts of Wi-Fi's history usually jump forward to 1985, when the FCC officially authorized limited spread spectrum usage. These accounts, however, miss what happened in between—specifically, the FCC's initial proposal one year earlier in 1984.[73] This proposal offers a fascinating glimpse into what could have been. The literature, however, has generally ignored this earlier proceeding.[74]

In 1984, the FCC released a more detailed—and ambitious—proposal to authorize spread spectrum technologies.[75] The centerpiece of the proposal involved creating an overlay for unlicensed uses.[76] The specific proposal would have allowed

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66. *Id.* at 27–29 (outlining spread spectrum's role in development of CDMA cellular technologies).

67. 1981 Spread Spectrum Notice, *supra* note 50, at 876.

68. Authorization of Spread Spectrum and Other Wideband Emissions, 98 F.C.C.2d 380, 380 (1984) [hereinafter 1984 Spread Spectrum Notice] (further notice of inquiry and notice of proposed rulemaking).

69. *Id.*

70. *See* Carroll, *supra* note 27, at 6; Lemstra, *supra* note 55, at 21–23; HAZLETT, *supra* note 58, at 249–51.

71. *See* Lemstra, *supra* note 55, at 21–23; HAZLETT, *supra* note 58, at 250.

72. Amendment of Parts 2 and 97 of the Commission's Rules and Regulations to Authorize Spread Spectrum Techniques in the Amateur Radio Service, 87 F.C.C.2d 972, 982 (1981) (concurring statement of Abbott Washburn, Comm'r) (notice of proposed rulemaking).

73. 1984 Spread Spectrum Notice, *supra* note 68, at 380–81.

74. As of March 1, 2022, Westlaw indicates not a single citation to this notice. One exception is Lemstra, *supra* note 55, at 24–25.

75. 1984 Spread Spectrum Notice, *supra* note 68.

76. *See id.* at 387–88; Hazlett & Oh, *supra* note 61, at 329–30. For a fuller definition of

spread spectrum devices to be used on a secondary basis (to be "overlaid") on any spectrum frequency above 70 MHz so long as the transmissions were sufficiently low power and complied with requirements to prevent interference.[77] In effect, this proposal would have opened up virtually the entire range of federal spectrum to experimental low-power uses. Because spectrum is scarce—and good spectrum is especially scarce—this proposal would have dramatically expanded the spectrum ranges available for experimentation.

The second part of the 1984 proposal was far more limited. It would have authorized secondary spread spectrum usage at higher power levels in a few specific spectrum bands that—at the time—had more limited use.[78] These bands were called the "ISM bands" because they were allocated for industrial, science, and medical uses.[79] Colloquially, these same bands had been referred to as "junk" or "garbage" bands because of their perceived limited usage and value.[80] Interestingly, the 1984 proposal treated this second part of the proposal almost as an afterthought. Instead, the agency spent far more time discussing the broader overlay that was the heart of their initial proposal.[81] As an interesting aside, one supporter of these new spread spectrum technologies was Lucasfilm, which cited problems transmitting C3PO's voice with existing wireless microphones.[82]

In 1985, the FCC officially approved the use of spread spectrum technologies.[83] However, the ultimate decision was far more limited than the proposal from the previous year. The 1985 decision only approved new technologies in the so-called junk bands of 2.4 GHz, 5 GHz, and 900 MHz.[84] As you may have noticed, the Wi-Fi routers often visible on your phone and television to this day still use the first two frequencies.[85] The FCC thus abandoned its more ambitious overlay proposal, which

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spectrum overlays, see *supra* text accompanying notes 60–61.

77. 1984 Spread Spectrum Notice, *supra* note 68, at 388 ("[W]e are proposing to allow spread spectrum systems to operate on any range of frequencies above 70 MHz . . . ."). This type of spectrum-sharing arrangement would likely be referred to today as an underlay but was originally called an overlay. Goodman, *supra* note 12, at 318 n.148.

78. *Id.* at 389.

79. *Id.* at 385; *see also* Wolter Lemstra & John Groenewegen with Vic Hayes, *The Case and the Theoretical Framework*, *in* THE INNOVATION JOURNEY OF WI-FI, *supra* note 23, at 3.

80. *E.g.,* Werbach, *supra* note 31, at 958 ("Before WiFi, this was known informally as the 'junk' band, because it was so heavily congested with uses such as cordless phones, baby monitors, and microwave ovens."); Carroll, *supra* note 27, at 6 (noting they were "supposed 'garbage bands'"); Lemstra & Groenewegen, *supra* note 79, at 4 ("[T]he ISM bands were often referred to in the jargon of some professionals as the 'garbage bands.'"); *A Brief History of Wi-Fi*, *supra* note 23 (noting that ISM spectrum was called "garbage bands").

81. The agency's ISM proposal comes only after a more extended discussion of the more extensive overlay proposal. *See* 1984 Spread Spectrum Notice, *supra* note 68, at 388–90.

82. *Id.* at 384.

83. 1985 Spread Spectrum Order, *supra* note 11, at 426–27.

84. *Id.*

85. The 900 MHz—though arguably better spectrum—never took off in part because the available channel size was too small. Peter Anker & Wolter Lemstra with Vic Hayes, *The Governance of Radio Spectrum: License-Exempt Devices*, *in* THE INNOVATION JOURNEY OF WI-FI, *supra* note 23, at 299. Alex Hills has also noted that the 900 MHz band was congested. HILLS, *supra* note 53, at 106.

would have opened far more—and far better—spectrum more quickly, albeit at lower power.[86]

The FCC's more limited decision was the product of intense industry opposition to the broader 1984 proposal.[87] While most commenters expressed general support for spread spectrum technologies, that support did not extend to allowing the technologies to be used secondarily on the commenters' own allotted spectrum.[88] In particular, the FCC noted strong resistance to the more general overlay proposal: "[T]he majority of the respondents were firmly against a general overlay of spread spectrum systems upon existing services."[89]

The FCC's decision to limit spread spectrum to the ISM bands was less controversial because the established industry did not use those frequencies.[90] Instead, some of the most common uses at the time were microwaves, baby monitors, and cordless phones.[91] However, even this more limited proposal triggered some industry backlash. One of the engineers originally involved in the decision, Michael Marcus, has claimed that his department endured retaliation within the FCC following the decision because of industry pressure. He further alleged that some of the engineers involved were soon fired.[92]

The 1985 decision itself is important in several respects. First, it is of course true that the original decision was both groundbreaking and courageous given the hostility that followed it. The history of this initial decision also shows the contingent nature of the decision. It could very easily not have happened. The fact that the FCC proceeded at all presents challenges to what public choice theory would have predicted. One central foundation of public choice approaches is that agencies generally respond to interest group pressure.[93] Here, however, the FCC acted on behalf of an industry that did not exist. To the extent there were public choice pressures at all, they were pushing in the opposite direction. As the FCC had noted in its 1984 notice, "[t]he topic that caused the most concern was the potential interference that spread spectrum systems might cause to existing services."[94]

In addition, there is strong evidence that the 1985 order led directly to private research and development. Contemporary FCC databases show approval of the first

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86. *See* 1985 Spread Spectrum Order, *supra* note 11, at 428.

87. *Id.* at 420 ("The remaining issues in the *Further Notice* raised significant controversy in the Comments . . . ."); *see also* HAZLETT, *supra* note 58, at 250; Lemstra, *supra* note 55, at 26–27.

88. *See* 1985 Spread Spectrum Order, *supra* note 11, at 420.

89. *Id.*

90. *See id.* at 423 ("No serious objections were raised to the authorization of spread spectrum systems in the . . . ISM bands . . . .").

91. Werbach, *supra* note 31, at 958; Lemstra & Groenewegen, *supra* note 79, at 4.

92. HAZLETT, *supra* note 58, at 250–51; Lemstra, *supra* note 55, at 26–27.

93. *See* Gregory S. Alexander, *Takings, Narratives, and Power*, 88 COLUM. L. REV. 1752, 1771 n.111 (1988) ("Public-choice theorists conclude that we should expect regulators to forebear from regulating when regulation would disadvantage a well-defined interest group."). Though the definition is disputed, public choice theory generally implies that policy ultimately reflects interest group pressures rather than the public good. Jill E. Fisch, *The "Bad Man" Goes to Washington: The Effect of Political Influence on Corporate Duty*, 75 FORDHAM L. REV. 1593, 1611 (2006).

94. 1984 Spread Spectrum Notice, *supra* note 68, at 385.

spread spectrum devices in 1988, followed by strong growth rates.[95] One of the only comprehensive works on the history of the Wi-Fi technical standards documented the effects of the FCC approval on specific companies who then began devoting resources and feasibility studies to these technologies.[96] Indeed, it is no accident the IEEE standards were crafted on these specific frequencies—and that the Wi-Fi technologies in your house today use these very same frequencies. The authors note, "The FCC decision to allow . . . spread spectrum in the ISM bands can be considered a landscape change, opening up a new avenue of wireless LAN [local network] development based on spread-spectrum techniques."[97] The authors further note that the FCC's impact extended internationally to foreign regulators who would eventually follow the FCC's lead and open these same frequency bands to unlicensed technologies.[98]

The 1985 order is also noteworthy for its policy design—and, more specifically, for the structure of its technical rules. Indeed, these technical rules are an important and undervalued part of the story. As noted above, "technical rules" refers to the various specifications and requirements that the FCC adopted with respect to new spread-spectrum devices.[99] The structure of these rules was an important reason why the 1985 order was able to successfully generate such vast and unexpected innovation.

One common theme of the FCC's technical rules was their simplicity, which minimized entry costs for new equipment developers.[100] For instance, one important aspect of the policy design was the FCC's decision to import spread-spectrum technologies into a pre-existing policy regime known as the "Part 15" rules.[101] These rules governed unlicensed devices.[102] As background, the FCC first addressed the issue of unlicensed communications devices several decades earlier.[103] In 1938, the FCC approved the use of very low-power devices in specific bands of spectrum. These technologies included devices such as early remote controls and wireless record players.[104] The FCC regulations approving these devices—whose extremely weak signals posed little interference threat—became known as the Part 15 rules, in reference to the regulatory section in which the rules were codified. Over the next few decades, the FCC gradually expanded its Part 15 rules, extending approval to

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95. *See* Lemstra, *supra* note 55, at 27–28.

96. *See generally id.* at 21–52.

97. *Id.* at 41.

98. *See* Anker & Lemstra, *supra* note 85, at 301–02, 305–07.

99. *See supra* text accompanying notes 45–46.

100. *See* HAZLETT, *supra* note 58, at 250.

101. *See* 1985 Spread Spectrum Order, *supra* note 11, at 426 ("Spread spectrum systems are also being authorized under Part 15 for general usage . . . .").

102. 47 C.F.R. §§ 15.1–.717 (2021).

103. KENNETH R. CARTER, AHMED LAHJOUJI & NEAL MCNEIL, UNLICENSED AND UNSHACKLED: A JOINT OSP-OET WHITE PAPER ON UNLICENSED DEVICES AND THEIR REGULATORY ISSUES 6 (2003), https://www.fcc.gov/reports-research/working-papers/unlicensed-and-unshackled-joint-osp-oet-white-paper-unlicensed [https://perma.cc/FQ8Z-V3X2]; MARCUS ET AL., *supra* note 12, at 7–9. Both of these FCC white papers provide an excellent overview of the early Part 15 history.

104. MARCUS ET AL., *supra* note 12, at 7–8.

devices such as electronic garage door openers, cordless telephones, VCRs, and alarm systems.[105]

The Part 15 rules worked largely through a certification process. Instead of requiring manufacturers to obtain permission for a proposed new use or business model, the FCC only required that the device being used complied with standardized operational requirements that were relatively generic and easy to satisfy (and more on those below).[106] As Professors Philip Weiser and Dale Hatfield have explained, "[t]he traditional Part 15 regime, which governs the use of unlicensed devices, is a paradigm of regulatory minimalism."[107] The certification approach thus enabled significant flexibility for manufacturers. New market entrants could pursue whatever service they believed the market would support without needing to obtain approval from the FCC or to address objections by incumbent users. As Part II will explain, the FCC would further simplify the Part 15 rules in 1989 in significant ways.

Another important aspect of the 1985 order's technical rules involved power limits. Earlier Part 15 devices operated only at very low power to avoid interference concerns.[108] As we all know from experience, if our own remote controls sometimes struggle to send a signal from the couch to the television, there is little risk in creating interference with existing licensed users. These weak limits, however, limited the utility of unlicensed devices and confined them to very limited spaces and uses.[109] The 1985 order raised the power limits of spread spectrum devices up to a maximum output of one watt. Relative to existing Part 15 devices, this was a significant increase in power.[110] Importantly, the 1985 order largely relied on this power limit to prevent interference.[111] It did not impose other more complex technical requirements to prevent interference. The importance of this decision will become clearer in later proceedings when incumbents lobbied for more extensive and burdensome technical rules in the name of interference prevention.

One final aspect is that the FCC also provided relatively broad channels for spread-spectrum transmissions. This was another important decision because higher-power transmissions require wider spectrum channels.[112] Specifically, the FCC authorized nearly 250 MHz for spread-spectrum transmissions (225 excluding the 900 MHz band, which was never widely adopted).[113] For our purposes, the relevant

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105. CARTER ET AL., *supra* note 103, at 6–7; MARCUS ET AL., *supra* note 12, at 7–8.

106. Weiser & Hatfield, *supra* note 7, at 671–72.

107. *Id.* at 672.

108. MARCUS ET AL., *supra* note 12, at 7–8.

109. *See* CARTER ET AL., *supra* note 103, at 6–7.

110. 1985 Spread Spectrum Order, *supra* note 11, at 426–27 (noting that "1 watt . . . [was] still much higher than the level of power that we would normally authorize for devices"); Benkler, *supra* note 17, at 79–80 ("The FCC also substantially increased the permissible power level of spread spectrum systems to one watt.").

111. Philip J. Weiser & Dale Hatfield, *Spectrum Policy Reform and the Next Frontier of Property Rights*, 15 GEO. MASON L. REV. 549, 599 (2008) ("To date, the FCC manages [interference] concern by requiring all commons wireless devices to be low powered, which lessens the possibility of interference.").

112. BENJAMIN & SPETA, *supra* note 32, at 49 ("More bandwidth means more capacity for data transmission.").

113. *See* Anker & Lemstra, *supra* note 85, at 299 (noting the benefits of the wider channels available on the 2.4 GHz band than the 900 MHz band).

bands included 2400-2483.5 MHz ("2.4 GHz") and 5725-5875 MHz ("5 GHz").[114] That said, it is important to note that the wide channels were only available because this spectrum was viewed as less valuable. However, one lesson for the future would be that wider channels are necessary for higher-data transmissions.

In sum, the 1985 order establishes the policy design principles that would help fuel the growth of Wi-Fi. The rules were simple. They were also generic in that any type of device for any type of service could be introduced so long as it stayed within the power limits. And finally, the FCC also allocated additional capacity to handle the higher-power and higher-data transmissions over wider channels. The 1985 order, however, is not—as some histories suggest—the end of the story. The rise of Wi-Fi also depended on what happened next.

II. THE RISE OF WI-FI: POLICY DESIGN AS FOUNDATION

The actual technology now known as Wi-Fi would not fully emerge until the late 1990s, roughly a dozen years after the FCC's initial 1985 decision.[115] In this Part, I explore some of the policies that the FCC pursued after this decision that also helped fuel the development of unlicensed technologies such as Wi-Fi. Rather than merely summarizing the policies chronologically, I also examine them thematically to emphasize several larger points about the evolution of the FCC's policy efforts.

Most notably, this history demonstrates that Wi-Fi and related unlicensed technologies depended on a series of ongoing policy decisions and not merely a single initial approval. Extending from the late 1980s to the mid-2010s, these decisions collectively provided a critical foundation for new unlicensed technologies in these bands. The FCC did not simply approve experimentation in 1985 and allow things to develop from the sidelines. Instead, it continued to monitor the technologies and made regulatory changes as needed. The proceedings also created a dynamic feedback effect between the FCC and standards-creating bodies such as the IEEE.[116] The FCC's policies helped create new and improved Wi-Fi protocols, which in turn inspired more expansive spectrum authorizations and more generous technical rules. In this respect, the policies gave rise to a continuing virtuous cycle of innovation and policy improvement.

Second, the FCC's technical rules in these proceedings incorporated many of the design principles of the 1985 order.[117] To be more precise, the policies evolved over time to incorporate the key aspects of what made the 1985 policy design so successful in that they became simpler and more generous. Such measures included increasing power limits, expanding channel and bandwidth capacity, and harmonizing conflicting certification regimes. This design, in turn, encouraged the development of higher-data communications and protocols.

Third, and related to the previous one, the FCC resisted efforts to impose excessive interference protections at the behest of incumbents. To do so, the FCC

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114. 1985 Spread Spectrum Order, *supra* note 11, at 420.

115. *See* Carroll, *supra* note 27, at 8–9.

116. For a more technical explanation of the IEEE's development of the standards following the FCC decision, see generally Jakobs et al., *supra* note 28.

117. From this point forward, references to the "1985 order" or "original order" are referring to the 1985 Spread Spectrum Order, *supra* note 11.

often had to resist considerable political pressure from these spectrum users. Instead, the FCC generally—though not always—relied on general technical rules, such as power limits, to prevent interference rather than more specific and burdensome technological requirements. As Part III will illustrate more clearly, approval of new devices can be effectively worthless if manufacturers must comply with overly complex interference requirements before introducing them to the market.

To be sure, the FCC decisions did not always follow these principles initially. Even today, several aspects of the FCC's policies ignore the design principles of the 1985 order and impose excessive requirements to prevent interference in ways that arguably limit development.[118] The larger trend, however, is clearer. As time went on, the FCC's policies became more favorable for unlicensed technologies operating within these spectrum bands. The policies incorporated simplicity, expanded channel capacity, and liberalized restrictions that were preventing development.

A. Expanding Part 15—the 1989 Order

Following the 1985 initial decision, the FCC's next major proceeding occurred a few years later in 1989 when it completely overhauled its Part 15 rules. As explained above, the Part 15 regulations governed unlicensed low-power devices operating across a wide range of spectrum frequencies, including the ISM bands where new spread-spectrum uses had been authorized.[119] These regulations, however, had become complicated and burdensome. Although the Part 15 rules had expanded over the years to cover new devices such as cordless phones, remote controls, and VCRs, it had proceeded on a device-by-device basis. The FCC thus had to approve new devices individually and sometimes through specific rulemaking proceedings.[120] The resulting regime was therefore not only slow and burdensome, but it was also crafted for specific types of devices and network uses.

The 1989 order, however, adopted a "comprehensive revision" of the Part 15 rules that drastically simplified them.[121] The FCC explained that its actions were designed to "achieve more effective use" of spectrum "while providing additional technical and operational flexibility in the design, manufacture and use of non-licensed devices."[122] To do so, the FCC adopted an entirely new regulatory framework that divided the world into intentional and unintentional radiator devices. "Intentional" simply means that the radiation—that is, the transmission—is intended and not a byproduct of some separate process unrelated to communications.[123] Instead of

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118. *See infra* text accompanying notes 202–205 (noting limitations of FCC's rules).

119. 17 C.F.R. § 15.1(a) (2021) ("This part sets out the regulations under which [wireless devices] may be operated without an individual license.").

120. Revision of Part 15 of the Rules Regarding the Operation of Radio Frequency Devices Without an Individual License, 2 FCC Rcd. 6135, 6135 (1987) [hereinafter 1987 Part 15 Notice] (notice of proposed rulemaking).

121. Revision of Part 15 of the Rules Regarding the Operation of Radio Frequency Devices Without an Individual License, 4 FCC Rcd. 3493, 3495 (1989) [hereinafter 1989 Part 15 Order] (first report and order).

122. *Id.* at 3494.

123. 1987 Part 15 Notice, *supra* note 120, at 6136. For our purposes here, the relevant devices are all intentional radiators.

requiring device-specific approvals, Part 15 devices would now be authorized so long as they complied with more generic and technology-agnostic technical rules such as power and emission limits.[124] In addition, the FCC clarified that very low-power devices could now be used on virtually any frequency, unless the frequency was specifically designated as restricted.[125] To achieve this goal, the agency would allow "non-licensed use on almost any frequency with minimal restrictions," and it would also "clarify[] and simplify[] . . . administrative requirements."[126] The result was that Part 15 devices could now be developed and introduced at a much lower cost.[127]

The relevance of all of this to Wi-Fi is that the FCC also expanded the range of devices that could operate on the ISM spectrum bands (the "junk" bands).[128] Recall that the 1985 order had given spread spectrum technologies greater privileges than traditional Part 15 devices by allowing them to operate at significantly higher power.[129] Under the 1989 order, any unlicensed device could now operate on these spectrum bands and take advantage of the same technical rules.[130] In doing so, the FCC emphasized the policy objectives of simplicity and flexibility. Certification requirements would not "entail restrictions on channelization, bandwidth, type of modulation, or type of operation."[131] Instead, the standards-based approach would allow innovators "to introduce new equipment . . . and to take advantage of new technologies without the need for Commission rule making."[132]

The 1989 order also went forward in the face of objections that the new devices could cause interference to established users. The FCC noted that "[a] number of commenters object to permitting the operation of Part 15 devices on ISM frequency bands."[133] Some of these skeptical parties included General Electric and the Federal Aviation Administration.[134] The FCC, however, concluded that the interference claims were unfounded. The agency "believe[d] that the probability that Part 15 operations will cause interference to authorized services in the ISM bands . . . is

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124. *See id.* at 6136–37; *see also* Harold Feld, *From Third Class Citizen to First Among Equals: Rethinking the Place of Unlicensed Spectrum in the FCC Hierarchy*, 15 COMMLAW CONSPECTUS 53, 64 (2006) ("Critically, the manufacturer would not need to explain the purpose of the device, or even limit the device to a single purpose."); Goodman, *supra* note 12, at 360–62 ("The FCC later gave unlicensed transmitters greater ambit by permitting them to operate in many different bands, provided that they maintained their low power levels.").

125. 1989 Part 15 Order, *supra* note 121, at 3494.

126. *Id.* The 1987 Part 15 Notice echoes these themes of "flexibility." *See* 1987 Part 15 Notice, *supra* note 120, at 6137 ("[W]e are proposing to permit Part 15 intentional radiators to be operated without restriction as to bandwidth, duty cycle, modulation technique or application.").

127. *See* 1987 Part 15 Notice, *supra* note 120, at 6136–37.

128. 1989 Part 15 Order, *supra* note 121, at 3502; 1987 Part 15 Notice, *supra* note 120, at 6137.

129. *See* 1985 Spread Spectrum Order, *supra* note 11, at 426–27.

130. Weiser & Hatfield, *supra* note 7, at 672 (noting that 1989 decision helped "set the stage for the explosive growth of Wi-Fi systems").

131. 1989 Part 15 Order, *supra* note 121, at 3502.

132. *Id.*

133. *Id.* (summarizing comments that expressed objections to the proposed rules).

134. *Id.*

low," and the agency would not stifle these technologies based merely on the "possibility of interference."[135] The FCC justified its policy decision by emphasizing the potential for innovation. It explained, "We believe that manufacturers, if given the opportunity to use the ISM frequencies, will develop many new and practical uses of Part 15 devices."[136]

Following the 1989 order, there was a sharp increase of unlicensed devices introduced into the market as illustrated by FCC certification databases.[137] Over the next few years, companies increasingly entered the market and began to advocate for additional spectrum and rules modifications. In this way, the FCC approvals helped create new industry forces that could then, in turn, argue for even greater expansion of unlicensed technologies and policies. These new dynamics would be evident in one of the next regulatory decisions a few years later.

B. Protecting the New Market—the 1995 Order

The FCC acted to protect unlicensed technologies again in 1995 when it released a new order regarding spectrum reallocations.[138] This order is significant in several respects, particularly for what it reveals about the state of the contemporary market for unlicensed devices. The origins of this order, however, begin with Congress. In 1993, Congress passed a budget bill requiring the Commerce Department to identify spectrum allocated for federal use that could be transferred to the private sector.[139] After the Commerce Department identified the spectrum, the FCC initiated rulemaking proceedings to consider various proposals to reallocate the spectrum for different commercial uses.[140] One band of spectrum that the Commerce Department identified was 2402-2417 MHz (i.e., 2.4 GHz), which was a significant section of the ISM bands that unlicensed spread-spectrum devices had also been able to use on a secondary basis since 1985.[141]

The FCC's ultimate decision is notable for what it chose not to do. Specifically, it made no changes to this spectrum band, opting instead to keep it available for spread-spectrum (and Part 15) devices.[142] In doing so, the FCC rejected proposals by some commenters to repurpose the band for other uses. While a few parties wanted

135. *Id.*

136. *Id.*

137. *See* Lemstra, *supra* note 55, at 27–28 (providing table illustrating growth of spread spectrum device certifications following the FCC's decisions).

138. Allocation of Spectrum Below 5 GHz Transferred from Federal Government Use, 10 FCC Rcd. 4769 (1995) [hereinafter 1995 Reallocation Order] (first report and order and second notice of proposed rulemaking).

139. Omnibus Budget Reconciliation Act of 1993, Pub. L. No. 103–66, 107 Stat. 379, 380. The specific statutory provision regarding spectrum allocation is in 47 U.S.C. § 923.

140. 1995 Reallocation Order, *supra* note 138, at 4772; Allocation of Spectrum Below 5 GHz Transferred from Federal Government Use, 9 FCC Rcd. 2175, 2177 (1994) [hereinafter 1994 Reallocation Notice of Inquiry] (notice of inquiry).

141. 1995 Reallocation Order, *supra* note 138, at 4773–74, 4783–84; 1994 Reallocation Notice of Inquiry, *supra* note 140, at 2176.

142. 1995 Reallocation Order, *supra* note 138, at 4787 ("We decline to allocate the band for other uses proposed by commenters.").

to use the band for "licensed commercial services," the FCC explained that "there was significant concern expressed about maintaining use of the band by Part 15 devices."[143] For instance, several commenters wanted the band reallocated for "licensed use by private radio services."[144] Rejecting those efforts, however, the FCC "preserve[d] the status quo regarding use of this band."[145]

The 1995 order also provides a revealing snapshot of the contemporary market developments, which influenced the FCC's decision to maintain the status quo. In particular, the FCC noted the tremendous growth and diversity of Part 15 devices that had occurred in recent years. The agency explained that "since the [FCC] encouraged development of unlicensed spread spectrum systems . . . the industry has responded with a wide variety of products, including digital cordless telephones, electronic article surveillance equipment, utility metering devices, fire and security alarm devices, wireless bar code readers, collision avoidance systems, and wireless [local area networks]."[146] Reallocating this band of spectrum, however, "would severely reduce the amount of spectrum available to Part 15 devices," and essentially force them to be squeezed into narrower bands that would impact their capabilities.[147]

Most important for our purposes, the 1995 order explained that one of the most promising new uses of the spectrum was to create wireless local area networks (LANs)—essentially, wireless internet service.[148] As the agency explained, "[o]ne of the principal Part 15 uses being implemented . . . is wireless LANs," and the order went on to note the "rapidly expanding market for wireless LAN equipment" and cited the growing revenues.[149] The FCC also noted that the IEEE was developing a new standard (IEEE 802) specifically for wireless LANs.[150] The IEEE would succeed, and the first standard (802.11) would be introduced to the public in 1997.[151] As noted earlier, this family of standards is actually what the term "Wi-Fi" represents.[152] The IEEE's work had built upon earlier work by the NCR Corporation and AT&T to develop standards for wireless communications using the same 2.4 GHz spectrum the FCC had initially allocated for unlicensed use.[153] The FCC's spread-spectrum policies had also influenced international regulators. The 1995 order notes that these same frequencies were "increasingly available internationally for Part 15 type use."[154] Indeed, the IEEE standard being developed on the old "junk" bands would soon become the international norm.[155]

Another interesting aspect of the 1995 order is that it revealed the feedback dynamics that its earlier proceedings had created. The orders from the 1980s had

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143. *Id.* at 4786.
144. *Id.* at 4785–86.
145. *Id.* at 4787.
146. *Id.* at 4785.
147. *Id.* at 4786.
148. *Id.* at 4786–87.
149. *Id.* at 4786.
150. *Id.* at 4785.
151. Carroll, *supra* note 27, at 10.
152. HILLS, *supra* note 53, at 105; *A Brief History of Wi-Fi*, *supra* note 23.
153. Lemstra, *supra* note 55, at 58–67, 103 n.26.
154. 1995 Reallocation Order, *supra* note 138, at 4785.
155. *See* Anker & Lemstra, *supra* note 85, at 301–02, 305–07.

created a favorable policy environment that encouraged new innovations such as wireless LANs. The FCC, in turn, cited these developments to justify additional measures to support unlicensed technologies.[156] Similar dynamics can be seen with respect to the new industries the FCC's orders had helped develop. Those industries, in turn, became an independent lobbying force to protect and expand unlicensed spectrum policies. In the 1995 order, for instance, the FCC noted that companies such as Motorola, normally "strong proponents of allocating spectrum for private radio services," opposed reallocating the spectrum in this way.[157] Instead, these companies wanted it to "remain available for use by Part 15 devices because of [their] broad utility."[158] The FCC's earlier decisions had therefore not only introduced a technology but had given rise to new self-sustaining industry forces that could advocate for even more unlicensed opportunities.

C. Opening 5 GHz Spectrum—1997–2014

In addition to 2.4 GHz, the other major Wi-Fi band is the so-called "5 GHz" band. In reality, this band is a mixed collection of noncontiguous spectrum bands that fall between 5 and 6 GHz.[159] The original 1985 order had approved part of this range (the 125 MHz between 5.725-5.850 GHz) as one of the three original ISM bands.[160] Today, it is commonly used on modern Wi-Fi devices in both residential and enterprise markets.[161]

Technologies using this band, however, got off to a slow start. Initially, most of the initial research and development occurred on the lower-frequency 2.4 GHz band.[162] Part of the reason is simple physics. Radio waves have different characteristics at different frequencies. The radio waves at 5 GHz are higher frequency than those at 2.4 GHz. Therefore, they are higher energy and capable of transmitting more information but operate at a much shorter range.[163] In particular, they are less likely to penetrate walls and floors. The 2.4 GHz waves, by contrast, are longer range and more resilient, but also slower.[164] Partly due to these reasons,

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156. 1995 Reallocation Order, *supra* note 138, at 4786 ("Considering the universal benefits provided by part 15 equipment, [and] the potential growth for new technologies in this area . . . we find that the public is best served by providing for the continued availability of this band for Part 15 equipment.").

157. *Id.* at 4785.

158. *Id.* at 4785–86.

159. *See infra* text accompanying note 190 (providing an overview of the different segments of the 5 GHz band).

160. 1985 Spread Spectrum Order, *supra* note 11, at 426.

161. Monica Alleven, *Apple, Cisco Dis 2.4 GHz, Favor 5 GHz for Enterprise Wi-Fi*, FIERCE WIRELESS (Feb. 7, 2016, 2:56 PM), https://www.fiercewireless.com/tech/apple-cisco-dis-2-4-ghz-favor-5-ghz-for-enterprise-wi-fi [https://perma.cc/4R5Y-PKBW]; Cisco 6 GHz Comments, *supra* note 5, at 9 (noting that "successful" 5 GHz bands have a "highly developed equipment ecosystem").

162. Carroll, *supra* note 27, at 8–10.

163. *See* NUECHTERLEIN & WEISER, *supra* note 32, at 90–91 (discussing different propagation characteristics of higher and lower-frequency waves).

164. Matt Klein, Nick Lewis & Walter Glenn, *What's the Difference Between 2.4 and 5 GHz Wi-Fi (and Which Should I Use)?*, HOW-TO GEEK,

the initial efforts to develop the 802.11 Wi-Fi standards focused initially only on the 2.4 GHz band. In fact, the earliest 802.11 standard did not include communications at the higher-frequency band at all.[165]

Beginning in 1997, the FCC attempted to help this process along. In a series of proceedings extending from 1997 through 2014, the agency allocated significant amounts of additional spectrum in the 5 GHz band for unlicensed uses. In this Section, I will focus on orders from three separate proceedings in 1997,[166] 2003,[167] and 2014.[168] In doing so, I will examine how the technical rules evolved over time to adopt more of the design principles of the initial 1985 order.

I will, however, also examine the shortcomings of these orders. Interestingly, the failure of the FCC to spur development on certain unlicensed bands provides empirical support for my argument. On the bands with simpler and more generic policy designs, innovation flourished. On the bands weighed down with more technical requirements to prevent interference, developers have avoided them. The 2014 order, however, would recognize these problems and remedy many (though not all) of them. The 2014 order thus illustrates the overall trend toward policy designs of greater simplicity and increased capacity.

1. The 1997 Order

In 1996, the FCC initiated a proceeding to allocate more spectrum for new types of digital unlicensed devices as part of the larger effort to create what was called the Unlicensed National Information Infrastructure (U-NII).[169] The hope was that these unlicensed "U-NII devices" would "support the creation of new wireless local area networks" and "facilitate wireless access" to the internet more broadly.[170] These devices had particular promise for "educational institutions, health care providers, libraries, businesses, and other users."[171] Today, U-NII devices include a wide range of unlicensed wireless communications including local networks and routers, as well as larger outdoor broadband equipment used by wireless internet service

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https://www.howtogeek.com/222249/whats-the-difference-between-2.4-ghz-and-5-ghz-wi-fi-and-which-should-you-use [https://perma.cc/B749-YZ8A] (Oct. 21, 2022, 9:45 AM).

165. Carroll, *supra* note 27, at 11 ("Note that there is no 5 GHz range determination in the first 802.11-1997 standard.").

166. Amendment of the Commission's Rules to Provide for Operation of Unlicensed NII Devices in the 5 GHz Frequency Range, 12 FCC Rcd. 1576 (1997) [hereinafter 1997 5 GHz Order] (report and order).

167. Revision of Parts 2 and 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band, 18 FCC Rcd. 24484 (2003) [hereinafter 2003 5 GHz Order] (report and order).

168. Revision of Part 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band, 29 FCC Rcd. 4127 (2014) [hereinafter 2014 5 GHz Order] (first report and order).

169. Amendment of the Commission's Rules to Provide for Unlicensed NII/SUPERNet Operations in the 5 GHz Frequency Range, 11 FCC Rcd. 7205 (1996) [hereinafter 1996 5 GHz Notice] (notice of proposed rulemaking).

170. 1997 5 GHz Order, *supra* note 166, at 1577.

171. 1996 5 GHz Notice, *supra* note 169, at 7205.

providers.[172] The FCC's proceeding was a response to growing industry requests for additional unlicensed spectrum to develop these technologies. For instance, Apple—whose AirPort in 1999 was many people's first introduction to Wi-Fi devices—had petitioned the FCC for additional 5 GHz spectrum in 1995.[173] Despite some continuing objections, there was much stronger industry support by 1996 for providing more unlicensed spectrum, further illustrating the dynamic feedback effect the early proceedings had set in motion.

In 1997, the FCC authorized new unlicensed devices on three separate bands of 5 GHz spectrum that became known collectively as the "U-NII bands."[174] The FCC's order was notable in several respects. The most important was the sheer size of the spectrum allocation. The FCC reallocated approximately 300 MHz of spectrum, which was significantly larger than the original 1985 order's allocation.[175] One benefit of such large amounts of spectrum is that they allowed the creation of larger channels, which is critical for higher-bandwidth transmissions (i.e., transmissions that can carry more information).[176] Just as wider roads can carry more traffic, wider channels allow more data to be transmitted over strong signals. In supporting such large allocations, Apple had argued that the current ISM bands did not "include sufficient spectrum to accommodate high speed connections."[177] The FCC thus justified the decision by noting that higher-speed and higher-data transmissions "must use broad bandwidths" and so "must have access to a substantial amount of spectrum."[178] While it would take several years, the wider channels ultimately provided the foundation of what became known as "Wi-Fi 5," which allowed significantly larger data transmissions.[179]

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172. *DRSC and U-NII-4 Prototype Device Testing*, FED. COMMC'NS COMM'N, https://www.fcc.gov/oet/unii-4banddevice [https://perma.cc/XP72-GWD9] (defining U-NII devices and noting their use for "Wi-Fi-enabled radio local networks, cordless telephones, and fixed outdoor broadband transceivers used by wireless internet providers"); *see also* 2014 5 GHz Order, *supra* note 168, at 4127–28 ("U-NII devices are unlicensed intentional radiators, which use wideband digital modulation techniques to provide a wide array of high-data-rate mobile and fixed communications used by individuals, businesses, and institutions, particularly for wireless local area networking – including Wi-Fi – and broadband access.").

173. *See* 1997 5 GHz Order, *supra* note 166, at 1577–78. On the AirPort, see Wolter Lemstra with Cees Links, Alex Hills, Vic Hayes, Dorothy Stanley, Albert Heijl & Bruce Tuch, *Crossing the Chasm: The Apple Airport*, *in* INNOVATION JOURNEY OF WI-FI, *supra* note 23, at 110, 128–31, 134.

174. 1997 5 GHz Order, *supra* note 166, at 1577. The specific spectrum bands were 5.15-5.25, 5.25-5.35 and 5.725-5.825 GHz, which totaled 300 MHz. *Id.* The order uses the terms "U-NII band" later in the order. *See*, *e.g.*, *id.* at 1591.

175. The earlier order had allocated 250 MHz. *See* 1985 Spread Spectrum Order, *supra* note 11, at 420.

176. BENJAMIN & SPETA, *supra* note 32, at 49 ("More bandwidth means more capacity for data transmission.").

177. 1997 5 GHz Order, *supra* note 166, at 1582.

178. *Id.* at 1583–84.

179. CISCO, 802.11AC: THE FIFTH GENERATION OF WI-FI 1, 1 (2018), https://www.cisco.com/c/dam/en/us/products/collateral/wireless/aironet-3600-series/white-paper-c11-713103.pdf [https://perma.cc/SN3S-9M7T] ("802.11ac is a 5-GHz-only technology . . . .").

The 1997 order's technical rules also reflected many of the successful design principles of the earlier order. For instance, the FCC incorporated U-NII devices into the broader Part 15 regime described above.[180] Devices operating on this spectrum would therefore be subject to the less rigorous certification process already in place for Part 15 devices. In some of the bands (though not all—more on that below), the technical rules also prevented interference by relying upon more generic and technology-agnostic measures such as power and emission limits.[181] The FCC specifically noted that it was "adopting the minimum technical rules necessary to prevent interference."[182]

The technical rules, however, are also significant for what the FCC rejected. While commenters generally supported expanding unlicensed spectrum, "several incumbent and potential users . . . express[ed] concern about the feasibility" of sharing this spectrum with new entrants.[183] In its initial notice, the FCC therefore asked whether it should include additional technical measures to prevent interference to current users.[184]

In the end, however, the FCC rejected these concerns. Instead, it concluded that the more general power limits were sufficient to prevent harmful interference. This simplified approach would provide "maximum technical flexibility in . . . design and operation."[185] It therefore declined to adopt more specific technical requirements such as "rigid" channelization plans or modulation efficiency standards. Such restrictions, the FCC believed, would have "several undesirable effects, such as increasing costs and delaying the benefits" of new devices "at this early stage in the technological development."[186] It also declined to adopt its proposed "spectrum etiquette" that would have required devices to include "listen-before-talk" protocols.[187] It concluded that such requirements could "preclude some technologies that may be desirable."[188] The net effect of all this was to make the device certification more generic and less tied to any one specific technological format.[189]

That said, the 1997 order was far from perfect. Many aspects of this order ignored the policy design lessons of the earlier decisions. For one, the spectrum bands themselves were not subject to uniform rules. The 1997 order effectively created three noncontiguous spectrum bands located at different frequencies. The first band

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180. 1997 5 GHz Order, *supra* note 166, at 1613–14 (rejecting special regime and concluding that they "will regulate these devices in the same manner that we regulate other low-power unlicensed devices").

181. *Id.* at 1589 (addressing interference concerns with "transmit power and out-of-band emission limits").

182. *Id.* at 1577.

183. *Id.* at 1578.

184. *See* 1996 5 GHz Notice, *supra* note 169, at 7224–25.

185. 1997 5 GHz Order, *supra* note 166, at 1592.

186. *Id.* at 1603.

187. *Id.*

188. *Id.* at 1605.

189. One early observer of this policy was Professor Yochai Benkler, who praised the order's policy design a year later in 1998 both for the adoption of "general specifications" and the rejection of "mandated spectrum etiquette" and other more specific requirements. *See* Benkler, *supra* note 19, at 331–37. I discuss more of Prof. Benkler's arguments infra in Part III.

("U-NII-1") extended from 5.15-5.25. The second ("U-NII-2") extended from 5.25-5.35. The third band ("U-NII-3") extended from 5.725-5.825, which overlapped with the older unlicensed ISM band.[190] The problem, however, was that each spectrum band had its own distinct set of technical rules. This complexity made it difficult to create devices that took advantage of all three bands.

In addition, some of the spectrum bands faced more restrictive technical rules than others. To make a long story short, the FCC imposed more limitations on the first two bands than the third one. The policy governing the third band (U-NII-3) most closely resembled the original 1985 order in that it featured similarly high power limits and few additional technological requirements to prevent interference.[191] The first two bands, by contrast, were far more restricted. Devices using the first band (U-NII-1) could only operate indoors and were subject to extremely low power limits.[192] The second band's power limits were higher, but still significantly lower than the third one.[193] Unsurprisingly, and as illustrated more fully below, the band with the fewest restrictions—and thus the one most closely resembling the 1985 policy regime—would ultimately prove the most successful in generating development.

2. The 2003 Order

The FCC continued expanding unlicensed spectrum in 2003 by reallocating an additional 255 MHz for unlicensed devices within a different part of the 5 GHz spectrum.[194] In doing so, the FCC cited the "tremendous growth in demand for unlicensed wireless devices," including sharply increasing "[s]ales of wireless local area network equipment."[195] The FCC also noted the rise of wireless "hot[]spots"—putting the term in quotes in an indication of how novel the concept was at the time.[196] Wi-Fi had now officially entered the public consciousness.

The 2003 order provides an interesting study in contrast. Some of the FCC's technical rules supported its policy goals, while others undermined them. On the positive side, several aspects of the order's policy design incorporated the principles of the earlier 1980s orders. Most notably, the 2003 order further expanded the amount of available spectrum by a significant amount—one that also exceeded the size of the original allocation in 1985.[197] Here too, the large allocation enabled the development of wider channels that can deliver higher-bandwidth transmissions. In addition, the FCC also imported these spectrum bands into the Part 15 policy regime,

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190. *See* 1997 5 GHz Order, *supra* note 166, at 1595–1600 (outlining various technical rules for the three different bands).

191. *See* 1997 5 GHz Order, *supra* note 166, at 1596 (authorizing "similar peak power and antenna gain parameters" as currently exist for spread spectrum devices under Part 15).

192. *Id.* at 1595–96.

193. *See id.* at 1596.

194. 2003 5 GHz Order, *supra* note 167, at 24485.

195. *Id.*

196. *Id.*

197. The earlier order had allocated 250 MHz. *See* 1985 Spread Spectrum Order, *supra* note 11, at 420.

which offered the numerous policy advantages described above.[198] The FCC's decision also promoted further growth by harmonizing its rules with international regimes that were increasingly using these bands for unlicensed technologies.[199]

In other respects, however, the 2003 order was a step back. Several aspects of the decision were inconsistent with the policy design principles of the earlier orders from the 1980s. For one, the FCC continued splintering the 5 GHz spectrum by essentially creating an entirely different band—5.47-5.725 GHz—with its own distinct set of technical rules.[200] Officially, the new spectrum would be considered part of the second U-NII-2 band. However, the technical rules splintered this band so significantly that the FCC ultimately adopted different classifications for different parts of it: U-NII-2A and U-NII-2C.[201]

The order's technical rules for this new band were also quite different from earlier orders. The FCC required users of the U-NII-2 band to adopt various technical specifications designed to prevent interference to existing users of this spectrum.[202] One requirement was that devices throughout the U-NII-2 band had to employ dynamic frequency selection (DFS) functionality. This feature "dynamically instructs a transmitter to switch to another channel" when certain conditions are detected (e.g., interference levels).[203] In addition, new devices also had to implement transmit power control (TPC), which is a "mechanism that regulates a device's transmit power" when it detects certain other signals.[204] The FCC did not, however, impose these requirements on the first or third band (although the first band remained subject to very low power limits and indoor use).[205]

Interestingly, there is evidence that these various restrictions limited development on the specific bands subject to these requirements. In this way, the FCC's 2003 order unintentionally provides dependent variables to help us assess their policy effects. For instance, nearly ten years later, Comcast explained to the FCC in a different proceeding that it had avoided developing its Xfinity services on the former two bands specifically because of the more extensive restrictions.[206] Its entire quote is worth reading:

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198. 2003 5 GHz Order, *supra* note 166, at 24494 ("We therefore are adopting our proposal to modify the Part 15 rules to allow U-NII devices to operate in the 5.470-5.725 GHz band . . . .").

199. *Id.* at 24485, 24545 (statement of Kathleen Q. Abernathy, Comm'r) ("[T]oday's order makes available an additional 255 MHz of spectrum on an unlicensed basis – spectrum that has the potential to be used for broadband networks on an internationally harmonized basis.").

200. *See id.* at 24485, 24498–99 (outlining distinct technical rules for the band).

201. 2014 5 GHz Order, *supra* note 168, at 4128–29 ("The Commission [has] established rules for the 5.15-5.25 GHz (U-NII-1 band), 5.25-5.35 GHz (U-NII-2A band), and 5.725-5.825 GHz (U-NII-3 band). In 2003, the Commission made an additional 255 megahertz of spectrum available for U-NII devices at 5.47-5.725 GHz (U-NII-2C band).").

202. 2003 5 GHz Order, *supra* note 167, at 24485 ("In addition to making more spectrum available for use by U-NII devices, we are taking steps to minimize the potential for these devices to cause interference to existing operations.").

203. *Id.* at 24495.

204. *Id.* at 24498.

205. *See supra* text accompanying note 189.

206. Comcast Corp., Comment Letter on Revision of Part 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band

> The existing technical rules for the U-NII-3 band set a 1 watt maximum transmit power limit, permit indoor or outdoor operation, and do not impose DFS listen-and-avoid technology. These rules make the U-NII-3 band attractive for investment and deployment; consequently, U-NII-3 is the only 5 GHz band that Comcast currently can use in all locations where it deploys Xfinity WiFi. But the U-NII-3 rules govern access to just 100 megahertz of the 555 megahertz potentially available for use in the 5 GHz band. In each of the other existing U-NII bands – the vast majority of the frequencies – a combination of indoor-only restrictions, low power levels, and/or DFS requirements limit the bands' usefulness for many Wi-Fi operations, including cable Wi-Fi systems. As a consequence, there has been far less investment in and development of these other bands.[207]

The lack of development, according to Comcast, stemmed from both the various restrictions and the fragmented nature of the 5 GHz band. As the next Section illustrates, Comcast was not alone in raising these concerns.[208] Indeed, these complaints helped convince the FCC to address the problem ten years later in its 2014 order.

In sum, the FCC's 5 GHz policy was a mixed bag following the 2003 order. On the one hand, the FCC had dramatically expanded the amount of spectrum available for unlicensed uses, thus creating the possibility of larger channels for higher-bandwidth uses. In some parts of this spectrum, the FCC's policy design closely mirrored the principles of the earlier 1980s orders. Unsurprisingly, development became more common on those bands. At the same time, however, the 5 GHz spectrum was a bit of a mess. The spectrum itself was carved up into at least four different sections with different technical rules applying to each section. In addition, some parts of the spectrum were subject to strict interference requirements that limited development. A decade later, the FCC would attempt to address many of these concerns by returning to its earlier and simpler policy designs.

3. The 2014 Order

The FCC's 2014 order is, in many ways, a return to basics.[209] Although it has received very little attention in the literature, it should.[210] It provides one of the clearest reflections of the policy design principles that I argue helped give rise to Wi-Fi and other unlicensed technologies in the first place. The 2014 order also goes a long way to clean up many of the problems and inconsistencies of the earlier 5 GHz

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21 (May 28, 2013) [hereinafter 2013 Comcast Comments], https://www.fcc.gov/ecfs/file/download/7022418913.pdf?file_name=7022418913.pdf [https://perma.cc/X3PG-WJXJ].

207. *Id.* It added that "for this proceeding to succeed, the Commission . . . must also update the technical rules that govern the existing 5 GHz U-NII bands." *Id.*

208. *See infra* text accompanying notes 232–233 (noting parties' observation that development was limited on the more restricted bands).

209. *See* 2014 5 GHz Order, *supra* note 168.

210. As of March 1, 2022, Westlaw indicates only one subsequent citation in a law review article.

proceedings. Despite the problems of the earlier 5 GHz orders, the 2014 order illustrates that the overall trend of the FCC's policy designs has been positive.

To understand the benefits of the 2014 order, it is first necessary to understand the problems it aimed to address. The most basic one was that the 5 GHz spectrum was not providing the necessary foundation for new higher-speed wireless communications. Both the FCC and commenters noted the continuing strong demand for wireless services and the possibility of congestion on the existing spectrum.[211] In addition, the IEEE was developing a new standard—802.11ac—that would enable much faster and higher-bandwidth transmissions. Critically, the new standard could also operate using multiple bands simultaneously (including the various U-NII bands) to facilitate faster and better transmissions.[212]

The problem, however, was that the various technical rules for the different spectrum bands were an obstacle to these developments. Most generally, the bands themselves were fragmented and subject to diverse certification requirements. For instance, the first band, U-NII-1, was limited by very low power limits and indoor-only restrictions.[213] Motorola noted that, even though the U-NII-1 band was one of the first 5 GHz unlicensed bands, development had been stymied by "strict power limits and unnecessary restrictions on outdoor operations."[214] The cable trade association, NCTA (formerly the National Cable & Telecommunications Association), complained that the band's technical rules had made it "all but unusable" for several Wi-Fi operations.[215]

The technical rules for the most-used band—U-NII-3—also had several problems. The most significant problem was the inconsistency of the rules for U-NII devices (which used digital modulation) and the older rules for traditional spread-

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211. 2014 5 GHz Order, *supra* note 168, at 4179 (statement of Tom Wheeler, Chairman) (discussing "growing problem of congestion on Wi-Fi-networks"). For commenters, see, e.g., Cisco Sys., Inc., Comment Letter on Revision of Part 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band *i* (May 28, 2013) [hereinafter 2013 Cisco Comments], https://www.fcc.gov/ecfs/file/download/7022418886.pdf?file_name=7022418886.pdf [https://perma.cc/T29B-D2DU] (noting that the 5 GHz band is the "best choice" for addressing "capacity constraints" and "expanding demand").

212. *See* Revision of Part 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band, 28 FCC Rcd. 1769, 1775–76 (2013) [hereinafter 2013 5 GHz Notice] (notice of proposed rulemaking) (explaining new 802.11ac standards).

213. 2014 5 GHz Order, *supra* note 168, at 4133.

214. Motorola Sols., Inc., Comment Letter on Revision of Part 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band 4 (May 28, 2013) [hereinafter 2013 Motorola Comments], https://www.fcc.gov/ecfs/file/download/7022418846.pdf?file_name=7022418846.pdf [https://perma.cc/6W2S-PAXB].

215. Nat'l Cable & Telecommc'ns Ass'n, Comment Letter on Revision of Part 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band 13 (May 28, 2013) [hereinafter 2013 NCTA Comments], https://www.fcc.gov/ecfs/file/download/7022418914.pdf?file_name=7022418914.pdf [https://perma.cc/UXW9-FAK6].

spectrum devices operating on the original ISM bands.[216] The procedural history here is a bit complicated, but it helps illustrate the problems that the FCC sought to address. The original 1985 order had authorized spread-spectrum devices on the upper part of the 5 GHz spectrum—5.725-5.875 GHz.[217] A later proceeding in 2002 had allowed devices using digital modulation to be certified under the same rules applicable to spread-spectrum devices.[218]

The 1997 order, by contrast, applied an entirely different certification regime for U-NII devices (which used digital modulation) under a separate section of Part 15.[219] Thus, digital device manufacturers had to choose whether to certify their devices under the older or more recent policy regime.[220] The problem, however, was that the two regimes were inconsistent in several respects. For one, the range of spectrum was different. The 1997 order had authorized devices in some but not all of the spectrum range that the 1985 regime authorized.[221] In addition, each regime had different technical rules. This complexity made it more difficult and costly to certify devices. It also encouraged the development of devices that could be easily altered to comply with different requirements, which led to greater interference concerns.[222]

The 2014 order addressed all these problems by harmonizing and liberalizing the governing technical rules. With respect to the first band, the 2014 order raised transmission power limits to one watt, which harmonized power level requirements between the first and third bands. It also removed the indoor-use-only limitation.[223] Increasing the utility of the U-NII-1 band was a top priority of the proceeding, as evidenced by the Commissioners' statements following its adoption. Chairman Tom Wheeler noted that the FCC is "taking 100 MHz of unlicensed spectrum[, the U-NII-1 band,] at 5 GHz that was barely usable – and not usable at all outdoors – and transforming it into spectrum that is fully usable for Wi-Fi."[224] Commissioner Jessica Rosenworcel (now chair) echoed the sentiment, noting that this decision would "doubl[e] the unlicensed bandwidth in the 5 GHz band overnight."[225]

The original limitation had come from overprotecting the band from interference. The severe restrictions—the ones that had made the band "barely usable"—were adopted in 1997 to prevent interference to certain licensed incumbent industries that were expected to develop the band.[226] By 2014, however, those industries had not

216. *See* 2014 5 GHz Order, *supra* note 168, at 4151 (outlining rule disparities).

217. 1985 Spread Spectrum Order, *supra* note 11, at 420.

218. Amendment of Part 15 of the Commission's Rules Regarding Spread Spectrum Devices, 17 FCC Rcd. 10755, 10755 (2002) (expanding Part 15 rules governing spread spectrum devices to devices using digital modulation techniques). The specific Part 15 rule governing the older spectrum devices was 47 C.F.R. § 15.427.

219. 1997 5 GHz Order, *supra* note 166, at 1622–23. The specific Part 15 rule governing these power limits was 47 C.F.R. § 15.407.

220. *See* 2013 5 GHz Notice, *supra* note 212, at 1776–77.

221. *See id.* at 1777 (noting different spectrum ranges).

222. *Id.* at 1777–78; *see* 2014 5 GHz Order, *supra* note 168, at 4153–55.

223. 2014 5 GHz Order, *supra* note 168, at 4128, 4137.

224. *Id.* at 4179 (statement of Tom Wheeler, Chairman).

225. *Id.* at 4181 (statement of Jessica Rosenworcel, Comm'r).

226. *Id.* at 4133–34 ("The Commission adopted technical rules for U-NII devices in this band to protect the nascent NGSO/MSS [satellite] industry which had gained an international [fixed-satellite service] allocation at 5 GHz in 1995.").

developed. The FCC explained that its licensing databases showed that some of these industries did not use the spectrum at all, while others did so in a very limited manner.[227] As explained more fully in Part III, the problem is that the FCC had tied this spectrum to a specific technological model. Although these industries were nascent, just as spread spectrum devices were once nascent, the technical rules were more specific. The early unlicensed orders, by contrast, were far more generic and technology agnostic.

The 2014 order also made important reforms to the third band. The most important change is that it unified and harmonized the rules for digital unlicensed devices operating in the U-NII-3 and ISM bands.[228] It did so, however, in an interesting way. It merged the older (and more generous) spread-spectrum rules into the U-NII-3 regime but kept many of the most favorable spread-spectrum rules, including higher and more consistent power levels.[229] This unification not only made development less costly but also had the added benefit of preventing interference by simplifying the certification process.[230] That said, the final rules contained some additional restrictions as well. The overall trend, however, was for greater liberalization.

There is also evidence that these proceedings helped spur development. In proceedings a few years later, commenters noted that development had now occurred on both the first and third bands, instead of only the third one. In 2018, NCTA noted that the two bands without restrictions are more commonly used. It stated, "U-NII-1 and U-NII-3 channels are used far more often than other unlicensed sub-bands, chiefly due to a combination of higher power limits and the absence of DFS requirements."[231] The second band, by contrast, still was often ignored. This band—U-NII-2—included the most restrictive interference requirements and specifications, such as DFS.[232] Microsoft explained that the DFS requirements "substantially increase[d] [the] cost and limit[ed] [the] utility for certain important Wi-Fi use

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227. *See id.* at 4134.

228. *See id.* at 4128, 4152.

229. *See id.* at 4152 ("[W]e consolidate the Section 15.247 technical rules . . . with the Section 15.407 U-NII rules, while maintaining many of the technical rules that currently make equipment authorization under Section 15.247[—the original spread spectrum regime—]more attractive for equipment manufacturers.").

230. *Id.* at 4153.

231. NCTA – The Internet & Television Ass'n, Comment Letter on Unlicensed Use of the 6 GHz Band: Expanding Flexible Use in Mid-Band Spectrum Between 3.7 and 24 GHz 10 (Feb. 15, 2019) [hereinafter NCTA 6 GHz Comments], https://www.fcc.gov/ecfs/file/download/DOC-5a3cbcf2a1c00000-A.pdf?file_name=2019-02-15%20As%20Filed%20NCTA%206%20GHz%20Comments.pdf [https://perma.cc/2MT7-8UAB].

232. *See supra* text accompanying note 203.

cases."[233] Accordingly, the "vast majority of Wi-Fi usage in the 5 GHz band is limited to the U-NII-1 and U-NII-3 bands."[234]

The FCC's 5 GHz policies thus illustrate many of the larger themes of this Article. Most importantly, they show the importance of technical rule design. It is not enough to adopt the policy goal of encouraging unlicensed technologies. To be successful, policymakers must follow through with accompanying technical rules to make the goal a reality. In this respect, the FCC's 5 GHz policy history provides a telling example. On bands where the FCC adopted simpler and more generic technical rules, development followed. The more restricted bands, by contrast, have not witnessed similar development despite the FCC's efforts (including a relatively large allocation of spectrum) to encourage unlicensed use on those bands. Despite these limitations, the clear trend of the FCC's technical rules in this context has been toward the original policy design of the 1985 order. In the next Part, I examine more precisely why they worked.

III. THE THEORY OF POLICY DESIGN

This Section focuses more closely on why the FCC's initial policy design was able to successfully generate innovation. To do so, I explore how the FCC's policy design intersects with property and innovation theory. I ultimately argue that the FCC crafted its technical rules in a way that reinforced and amplified the benefits of the spectrum commons that the unlicensed regime had created. In particular, the policy design dramatically lowered the cost of entry in several respects, which is one important key to stimulating innovation.

Turning first to property, spectrum policy debates for decades have focused on the optimal way to allocate and assign spectrum frequencies.[235] Although there are multiple dimensions to these debates, one central fault line is between "property" and "commons" approaches.[236] In general, property-based approaches rely more

233. Microsoft Corp., Comment Letter on Unlicensed Use of the 6 GHz Band: Expanding Flexible Use in Mid-Band Spectrum Between 3.7 and 24 GHz 3 (Feb. 15, 2019) [hereinafter Microsoft 6 GHz Comments], https://www.fcc.gov/ecfs/file/download/DOC-5a3cb30069000000-A.pdf?file_name=6%20GHz%20Band%20NPRM%20--%20Microsoft%20Comments%20--%20FINAL%20(as%20Filed)%20--%2002.15.19.pdf [https://perma.cc/CR5V-VC3V].

234. *Id.*

235. *See* Werbach, *supra* note 31, at 865 (listing different approaches of spectrum governance since its beginnings in 1927).

236. Significant literature exists introducing and addressing different aspects of this debate. *See, e.g.*, Sylvain, *supra* note 17, at 123–24; Benkler, *supra* note 17, at 81–84 (noting "substantial literature . . . addressing the basic choice between a 'spectrum property' model of exclusive licenses" and an "unlicensed/open commons approach"); Kevin Werbach, *The Wasteland: Anticommons, White Spaces, and the Fallacy of Spectrum*, 53 ARIZ. L. REV. 213, 216–17 (2011) (noting "two potential models: property rights and commons"); Weiser and Hatfield, *supra* note 7, at 670–71 (introducing "property-like" and "commons" approaches); Goodman, *supra* note 12, at 270–74 (distinguishing between "private and common property" models); Werbach, *supra* note 31, at 868, 871–77 ("There are three major approaches to managing spectrum. I will refer to them as 'government licensing,' 'property,' and 'commons.'"); FED. COMMC'NS COMM'N, SPECTRUM POLICY TASK FORCE REPORT 35 (2002),

heavily on exclusive licenses and markets for allocation and assignment.[237] With spectrum licenses, private parties have the right to exclude others from the same frequency (and to prevent interference, which could be considered a type of trespass). Under this approach, users also have greater freedom to buy or sell spectrum rights and to use spectrum in flexible ways.[238] Commons-based spectrum policies, by contrast, rely more on shared unlicensed approaches. Unlicensed spectrum frequencies can generally be used by any party so long as they comply with certain rules of the road, such as power and emission limits, to prevent interference with other users.[239]

The "property versus commons" disputes have a rich history in the literature, one that extends well beyond spectrum policy.[240] For purposes here, it is important to know that each approach has its own costs and benefits, and each performs better or worse in specific contexts. With respect to property-based approaches, one key benefit is to ensure spectrum is allocated to its highest-valued use.[241] Exclusive licenses mimic property ownership and assigning property rights can help facilitate the transactions necessary for optimal value to be realized. Exclusive licenses also prevent a "tragedy of the commons" where the lack of exclusive rights creates overuse or exhaustion of the resource. In this context, the "tragedy" would be created by excessive interference and congestion if too many devices were using the same spectrum frequency, rendering it unusable.[242] Property rights also create incentives for capital investment by establishing certainty and reliance interests.[243] The widespread adoption of smartphones and wireless data services in the United States arguably demonstrates that exclusive licenses are a necessary part of optimal spectrum policy.[244]

Some traditional critiques, however, of property approaches in the spectrum context are that they can stifle innovation and entry.[245] Specifically, property approaches systematically favor existing incumbents and parties with greater

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https://www.fcc.gov/document/spectrum-policy-task-force [https://perma.cc/BL4K-QMT5] (outlining various spectrum governance models).

237. *See* Thomas W. Hazlett & Matthew L. Spitzer, *Advanced Wireless Technologies and Public Policy*, 79 S. CAL. L. REV. 595, 603–04 (2006).

238. *See* NUECHTERLEIN & WEISER, *supra* note 32, at 96–99.

239. FED. COMMC'NS COMM'N, *supra* note 236, at 35; *see* Werbach, *supra* note 31, at 874–77.

240. For an excellent overview of the literature on both sides of the property and commons debate, see Sylvain, *supra* note 17, at 123 nn.3–4 (documenting literature on each side of the debate).

241. Dale B. Thompson, *Of Rainbows and Rivers: Lessons for Telecommunications Spectrum Policy from Transitions in Property Rights and Commons in Water Law*, 54 BUFF. L. REV. 157, 159 (2006).

242. Weiser & Hatfield, *supra* note 7, at 674.

243. Anker & Lemstra, *supra* note 85, at 294.

244. *See In re* Commc'ns Marketplace Rep., No. 20-60, 2020 WL 8025117, at *4–5, *7–10 (F.C.C. Dec. 31, 2020) (providing data on continuing growth in mobile wireless markets as measured by users and data usage).

245. Daphne Keller, *A Gaudier Future that Almost Blinds the Eye*, 52 DUKE L.J. 273, 274–75 (2002) (reviewing LAWRENCE LESSIG, THE FUTURE OF IDEAS: THE FATE OF THE COMMONS IN A CONNECTED WORLD (2001)).

resources while limiting the ability of nascent industries to enter the market. In the spectrum context, this occurs because the initial historical allocation of spectrum has rewarded incumbents and raised transaction costs in a way that undermines Coaseian bargaining.[246] As a result, entry costs can become too high for new industries.

For instance, imagine the obstacles to developing spread-spectrum devices if the ISM bands had been licensed exclusively. It is difficult to say that developers could simply have purchased spectrum rights given that those industries (and the engineering standards governing them) didn't even exist until after the policy had helped stimulate research and development. It is also difficult to imagine licensed spectrum incumbents developing these technologies themselves. As Part I explained, the consensus at the time was that spread spectrum could not be used for civilian technologies.[247] And as the pandemic has illustrated all too clearly, Wi-Fi and unlicensed technologies create enormous positive externalities that are unlikely to be fully captured by incumbents—and thus unlikely to be fully developed.

The alternative approach—commons governance—also has its costs and benefits. On the positive, commons-based approaches avoid many of the entry costs associated with the property regime. Because commons are shared and generally open to all, parties can avoid the transaction costs of negotiating entry with incumbent owners.[248] Commons also reduce compliance costs because spectrum users do not need to obtain permission from the government. This inclusivity allows for greater flexibility of use at a lower cost. The traditional critique, however, of the spectrum commons approach is that it will ultimately lead to underutilization and investment.[249] As explained above, critics have claimed that spectrum commons could give rise to a tragedy of the commons because too many users will be crowded onto scarce spectrum, thus causing interference that prevents development.[250]

The point here is not to argue definitively for one model or the other. Most people recognize today that optimal spectrum policy must necessarily include and balance both approaches. Instead, my narrower purpose is to focus on why some unlicensed approaches have proven more successful than others. The common thread throughout the policies described above is that the FCC was attempting to encourage more unlicensed uses. Some unlicensed policies, however, were more successful than others. The question is why.

One important reason, I have argued, is policy design. More specifically, success stemmed from the way in which the policy design intersected with the spectrum commons and amplified its benefits. Many of the FCC's technical rules were crafted in ways that reinforced the theoretical benefits of the commons approach by lowering entry costs and facilitating shared uses. Most importantly, the technical rules were generic and technology agnostic. Instead of requiring approvals or drafting

246. *See* Werbach, *supra* note 31, at 232.

247. *See supra* text accompanying notes 64–65.

248. *See* Mark Cooper, *Why Growing Up Is Hard To Do: Institutional Challenges for Internet Governance in the "Quarter-Life Crisis" of the Digital Revolution*, 11 J. ON TELECOMM. & HIGH TECH. L. 45, 98 (2013) (explaining how unlicensed spectrum "removes the spectrum barrier [of] entry," "lowers the hurdle of raising capital," and "lowers transaction costs"); Benkler, *supra* note 17, at 88–89.

249. *See* Thomas W. Hazlett, *Spectrum Tragedies*, 22 YALE J. ON REGUL. 242, 246 (2005).

250. Weiser & Hatfield, *supra* note 7, at 674.

requirements for specific technologies, the FCC imposed a certification regime that relied most heavily on general power limits.[251] As Mark Cooper has observed, "[t]he FCC's approach . . . exhibit[ed] several characteristics that accomplish the task of managing the common-pool resources" including rules that "were simple and established an easy set of conditions" for compliance.[252] The more generic approach was also more "future proof" in that it could more easily accommodate the unpredictable new technologies that would emerge without needing to alter regulations.

One early observer of these dynamics was Professor Yochai Benkler, one of the earliest and most enthusiastic supporters of a shared commons-based approach to spectrum usage. Writing after the first U-NII order in 1998, he observed that "[t]he most important institutional attribute of unlicensed operations is that regulation focuses on general specifications for equipment design and use."[253] He further noted the importance of "generic" requirements.[254] These generic easy-to-satisfy requirements not only reduced the cost of development; they also removed both the government and incumbents from a gatekeeping function. As Benkler would later note, the FCC "impos[ed] minimal rules of the road . . . and then [mostly got] out of the way."[255] In this way, the crafting of the technical rules reinforced the intended benefits of the commons. On an aside, however, one of my central arguments is that the FCC did not merely get out of the way but continued monitoring and revising its policy regime to help Wi-Fi develop over several years.

Another way that the technical rules reinforced and amplified the commons was through the reduction of scarcity. As noted above, one critique of commons-based approaches was the risk of overconsumption, which often leads to the infamous tragedy of the commons.[256] The reliance on power limits, however, largely addressed this concern. The FCC's primary method for preventing interference was to impose limitations on power (in short, limiting how loud a device could talk). In effect, this approach dramatically expanded the amount of spectrum available to use—in some senses, it eliminated scarcity altogether. So long as unlicensed transmissions remained under the power limit (and the noise floor), one person's use had little to no impact on existing licensed uses.[257] In this respect, the technical rules helped create a "supercommons," a term coined by Professor Kevin Werbach.[258] Rather than

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251. The FCC achieved this by relying on the Part 15 certification rules. *See* 47 C.F.R. § 15.1 (2017) ("This part sets out the regulations under which [wireless devices] may be operated without an individual license.").

252. Cooper, *supra* note 248 (adding that the rules "did not require intensive . . . monitoring" and "[a]nyone could enter").

253. Benkler, *supra* note 19, at 332.

254. *Id.*

255. Benkler, *supra* note 17, at 91; *see* Weiser & Hatfield, *supra* note 7, at 672 ("The traditional Part 15 regime, which governs the use of unlicensed devices, is a paradigm of regulatory minimalism."); *see also* Cooper, *supra* note 248, at 98–99.

256. *See supra* text accompanying note 242.

257. Werbach, *supra* note 31, at 960 ("Spectrum below the noise floor is therefore not scarce, at least from the perspective of high-power systems above it, because these systems ignore radiation at that level.").

258. *Id.* at 866–67.

causing spectrum to be underutilized, the unlicensed shared uses increased spectrum efficiency exponentially by enabling vast simultaneous use for a diverse range of devices on the exact same spectrum frequencies.

The FCC's technical rules can be further justified by innovation theory. Barbara van Schewick, for instance, has argued that one of the best ways to stimulate innovation—in the face of uncertain demand—is to lower the costs of entry.[259] This is essentially what "openness" means in the context of the open internet—permission-less entry.[260] The internet's network protocols (e.g., Transmission Control Protocol/Internet Protocol) were consciously designed to avoid the need to seek others' approval or permission.[261] Anyone today can introduce a new website, a new technology, or a new device without needing permission from others. Collectively, these characteristics lower the cost of entry. Although van Schewick's work focuses on internet network technologies, the same principles apply more broadly to technologies such as unlicensed spectrum. When the costs of entry are lower, capital becomes cheaper and more parties can more easily introduce their innovations.[262] In a sense, low entry costs allow more people to throw more inventions at the wall to see what sticks. The FCC's technical rules followed these principles by dramatically lowering entry costs and thus removing any need to seek permission. Their simplicity and flexibility enabled new and unpredictable development in ways that would have been difficult with licensed spectrum.

The FCC's policy history, however, also illustrates another lesson. When the FCC strayed from these more basic policy design features, it was less successful in encouraging new technologies.[263] The evolution of the 5 GHz policies offers a telling example. Among the various U-NII bands, some had more generic and simple certification requirements, while others were subject to much more specific technological requirements to prevent interference. As noted in Part II, the band with those extra requirements (U-NII-2) has been far less utilized than the other two.[264] This result tends to vindicate arguments of those who—nearly twenty years ago—supported unlicensed approaches. It also undermines many of their contemporary critics who expressed serious concern that commons approaches would lead to policy failure and thus advocated for greater technological protections for interference.[265]

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259. *See* BARBARA VAN SCHEWICK, INTERNET ARCHITECTURE AND INNOVATION 301 (2010).

260. Preserving the Open Internet, Broadband Industry Practices, 25 FCC Rcd. 17905, 17907 (2010) (report and order).

261. Jason Oxman, *The FCC and the Unregulation of the Internet* 5 (FCC Off. of Plans & Pol'y, Working Paper No. 31, 1999) (discussing "openness" of IP protocols), http://www.fcc.gov/Bureaus/OPP/working_papers/oppwp31.pdf [https://perma.cc/7LMQ-3R5W].

262. *See* VAN SCHEWICK, *supra* note 259, at 301 ("[A] large and diverse group of potential innovators will discover a larger number of opportunities for innovation . . . .").

263. *See* Werbach, *supra* note 236, at 238 ("An unlicensed band can also be choked by excessively restrictive regulation."); *see also* Benkler, *supra* note 17, at 72 (noting lack of success of "narrowly tailored unlicensed allocations" as opposed to "general purpose open wireless bands").

264. *See supra* text accompanying note 206.

265. *See*, *e.g.*, Weiser & Hatfield, *supra* note 7, at 688–691 (implying that the FCC should consider additional interference protections, such as spectrum etiquette and registration

These lessons also help explain the failures of several of the FCC's other efforts to encourage unlicensed technologies outside of the Wi-Fi spectrum bands. Encouraged by the success of their spread-spectrum regime, the FCC in 1993 attempted to encourage the development of unlicensed personal communication devices (U-PCS) on a different part of the spectrum.[266] The initiative, however, was a complete failure. The FCC's policy design largely doomed this initiative.[267] Specifically, the FCC subjected these devices to very different technical rules than those that applied to devices on the ISM bands. The bands were also balkanized similarly to parts of the unlicensed 5 GHz spectrum, with different segments of bands being allocated for specifically designated purposes.[268] Making matters worse, the FCC required any user wishing to use these bands to pay existing incumbent users and clear the spectrum beforehand.[269] As Benkler has observed, one lesson is that "an allocation that is too narrow, balkanized, and saddled with incumbent protection requirements will fail to thrive."[270]

Another policy failure was the FCC's effort to encourage "ultrawideband" (UWB) devices in 2002. Interestingly, the FCC used similar rhetoric in authorizing these devices, noting that UWB technology "holds great promise for a vast array of new applications that we believe will provide significant benefits . . . ."[271] The problem, however, is that the policy design was inconsistent with the policy goal. Out of fear from incumbent users that the devices would cause interference, the FCC imposed significant and "extremely conservative" restrictions that doomed the technology from the start.[272]

One harmful requirement was that the technologies were subject to very low power restrictions. The FCC's order also included a byzantine array of technical rules for various specific operations at different spectrum bands.[273] Even the FCC Commissioners at the time realized the limits of the 2002 UWB order. Commissioner Kevin Martin noted he was "disappointed" that the agency did not "adopt more flexible limits."[274] Commissioner Michael Copps complained that the approach was "ultra-conservative" and the limits imposed on UWB technologies were "far below those placed on [other] technologies" and exceeded what engineers "believe[d]

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requirements); Thomas W. Hazlett, *The Wireless Craze, the Unlimited Bandwidth Myth, the Spectrum Auction Faux Pas, and the Punchline to Ronald Coase's "Big Joke": An Essay on Airwave Allocation Policy*, 14 HARV. J.L. & TECH. 335, 498 (2001) (criticizing unlicensed allocations and noting that "[w]hen unlicensed entry thrives, the characteristic pattern is that over-crowding ensues").

266. *See* Amendment of the Commission's Rules to Establish New Personal Communications Services, 8 FCC Rcd. 7700, 7702 (1993) (second report and order).

267. Werbach, *supra* note 236, at 238 (noting that U-PCS was "choked by excessively restrictive regulation").

268. *See* Benkler, *supra* note 17, at 133–35.

269. *Id.* at 134.

270. *Id.* at 135.

271. Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems, 17 FCC Rcd. 7435, 7436 (2002) [hereinafter UWB Order] (first report and order).

272. *Id.* at 7437.

273. *See id.* at 7437–38 (summarizing various technical rule regimes).

274. *Id.* at 7552 (statement of Kevin J. Martin, Comm'r).

necessary."[275] Instead of developing successfully, UWB technologies were ultimately defeated in the market by technologies using Bluetooth standards.[276] Quite tellingly, Bluetooth standards use the 2.4 GHz band and are thus (like Wi-Fi technologies) direct descendants from the original 1985 order and its policy design.[277]

A similar story could be told about the FCC's efforts to open the "white spaces" of the TV broadcast spectrum for unlicensed use.[278] Largely for historical reasons, broadcast television received some of the most valuable spectrum that exists. This spectrum is considered "beachfront property" because of the strong propagation characteristics of radio waves at these frequencies.[279] In many parts of the country, however, large portions of this spectrum lie fallow.[280] One goal of the FCC's white spaces policies over the years has therefore been to encourage the development of unlicensed devices that could use this spectrum to provide extremely robust Wi-Fi service.[281]

Like UWB, however, the FCC's white spaces policies have been a failure.[282] While the proceedings themselves are complex and have witnessed many iterations over the years, the common theme is that there are simply too many complex technical requirements to justify the effort to fully develop these new technologies. Professor Thomas Hazlett has noted that earlier white spaces rules were "highly restrictive."[283] In response to the interference concerns, the FCC put "special restrictions on mobile white space devices, giving them less power and more interference-avoiding responsibilities."[284] Until the technical rule design matches the policy goals, it is likely that this valuable spectrum will continue to be wasted, much like an undeveloped field in the middle of valuable downtown real estate.

IV. IMPLICATIONS FOR MODERN POLICY

In the Sections above, I have outlined the history of the policy foundations that helped fuel the rise of Wi-Fi and other unlicensed technologies. In this Part, I explore

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275. *Id.* at 7551 (statement of Michael J. Copps, Comm'r).

276. HAZLETT, *supra* note 58, at 257.

277. *See* Jonathan A. Messier, *"Too Legit to Quit:" Free Speech Clause Protection for Frequency Hopping Spread Spectrum Broadcasters*, 9 U. PITT. J. TECH. L. & POL'Y 1, 36 (2008).

278. *See* Unlicensed Operation in the TV Broadcast Bands, Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band, 23 FCC Rcd. 16807, 16808 [hereinafter 2008 White Spaces Order] (second report and order and memorandum opinion and order). One of the earliest efforts was in 2008. *Id.* at 16807.

279. John H. Cook IV, *Public Interest in the Digital Age: Towards a 21st Century Spectrum Policy*, 13 COLO. TECH. L.J. 71, 75 (2015).

280. HAZLETT, *supra* note 58, at 255–56.

281. *See* 2008 White Spaces Order, *supra* note 278, at 16925 (statement of Kevin J. Martin, Chairman) ("Opening the white spaces will allow for the creation of a WiFi on steroids.").

282. David J. Redl, *Closing Keynote Address at the Spectrum Hall of Shame: The Worst (and Best) Radio Policy Decisions*, 17 COLO. TECH. L.J. 275, 279 (2019) ("Despite best efforts, mass-market [white spaces] services have failed to emerge from this effort.").

283. HAZLETT, *supra* note 58, at 256–57.

284. *Id.* at 256.

the implications of this history to modern spectrum policy. To do so, I focus on the FCC's recent 6 GHz proceeding, which is arguably the most important unlicensed proceeding since the 1980s.[285] After introducing the proceeding, I argue that the policy history described above provides normative support for most but not all of the FCC's approach in this proceeding. In particular, I illustrate that the FCC has adopted many of the original policy designs that have proved successful. There are, however, some aspects of the decision that could be improved by more closely tracking these earlier policy designs.

A. The 6 GHz Proceeding—Background

In many respects, the success of the FCC's unlicensed spectrum policy has created its most pressing problem. Demand for additional unlicensed spectrum is exploding. In 2021, the FCC noted the "phenomenal pace"[286] of this ever-increasing demand. Citing studies from leading device manufacturers, the FCC explained:

> [M]obile data traffic [is expected to] more than double between now and 2022 . . . . [T]he average amount of data per month used by a smartphone will increase from 7 gigabytes in 2018 to 39 gigabytes by 2024. A large proportion of this mobile data traffic is delivered on an unlicensed basis through Wi-Fi, Bluetooth and similar protocols. In fact, according to Cisco, 59% of mobile data traffic will be offloaded to Wi-Fi by 2022.[287]

Even though the FCC has authorized additional amounts of spectrum for unlicensed uses over the years, the lack of adequate spectrum to meet this growing demand remains a problem.[288] Both residential and business users increasingly need capacity to handle modern bandwidth-intensive services, such as high-definition video streaming and video conferencing. As we increasingly rely on these services for both work and school, we need Wi-Fi to be faster and more reliable. One reason it is not, however, is because much of this higher-data traffic still depends on the relatively narrow spectrum bands that the FCC first opened in 1985.[289] These bands remain the most commonly used and thus experience congestion.[290] In short, the old roads need more lanes.

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285. *See generally* 2020 6 GHz Order, *supra* note 1.

286. *Id.* at 3853.

287. *Id.*

288. Wi-Fi All., Comment Letter on Unlicensed Use of the 6 GHz Band, Expanding Flexible Use in Mid-Band Spectrum Between 3.7 GHz and 24 GHz 1 (Feb. 15, 2019) [hereinafter Wi-Fi Alliance 6 GHz Comments] ("[T]here is simply insufficient spectrum capacity to support the growing demand for Wi-Fi.").

289. *See* 2018 6 GHz Notice, *supra* note 3, at 10545 (statement of Michael O'Rielly, Comm'r) ("[T]he exponential growth of wireless data, especially over unlicensed networks, has led to severe congestion in our highly-prized unlicensed spectrum bands, primarily 2.4 and 5 GHz.").

290. *See* Microsoft 6 GHz Comments, *supra* note 233, at 3 ("Wi-Fi operations in the 2.4 GHz band experience congestion in many locations during 'busy hours.'"); Open Tech. Inst. at New Am., Am. Libr. Ass'n, Consumer Fed'n of Am., Consortium for Sch. Networking, Pub. Knowledge & Access Humboldt, Comment Letter on Unlicensed Use of the 6 GHz Band,

Meeting this demand is important for reasons that go beyond merely ensuring fast connections in our homes and offices (which is itself very important, as the pandemic has taught us). Modern cellular networks increasingly rely on Wi-Fi technologies to help carry the ever-increasing load of data on their networks, thus enabling our phones (and the data networks powering them) to work faster and better.[291] Better wireless service, in turn, also helps relieve the digital divide, which refers to the social and economic disadvantages faced by people who lack access to adequate internet service. The pandemic and its effect on schoolchildren has illustrated all too clearly that internet access is an important part of broader debates about equity. One particularly heart-wrenching example involved stories of schoolchildren being driven to fast-food restaurant parking lots to attend online school because of the lack of adequate internet access at home.[292] Looking further ahead, many new emerging devices—including the vast range of innovations collectively known as the Internet of Things (IoT)—will depend upon access to unlicensed spectrum.[293]

Recognizing these needs, the FCC has taken steps to address several of these problems by further expanding unlicensed spectrum. Specifically, the FCC recently opened the "6 GHz band" for unlicensed use.[294] This wide band of higher-frequency spectrum extends from 5.9 GHz to 7.125 GHz.[295] It also has several characteristics that make it an appealing choice for relieving overburdened Wi-Fi frequencies. First, the band itself is massive—spanning some 1200 MHz.[296] To compare it to earlier proceedings, this band contains roughly four times the amount of spectrum as the initial allocation in 1985.[297] Such large amounts of spectrum facilitate the creation of significantly wider channels suitable for the high-volume, data-intensive applications.[298]

In addition, the location of the 6 GHz band makes it an enticing choice. The 6 GHz is adjacent to the 5 GHz bands discussed above that are currently used by unlicensed devices to provide Wi-Fi and wireless internet service.[299] Because these frequencies are next-door neighbors, their wavelengths have similar propagation characteristics. The combination of proximity and wavelength similarity allows developers to create standards that can more easily combine spectrum channels across the 5 and 6 GHz bands to allow for faster and higher-volume transmissions.[300]

Expanding Flexible Use in Mid-Band Spectrum Between 3.7 GHz and 24 GHz 14 (Feb. 15, 2019) [hereinafter Public Interest Organization 6 GHz Comments].

291. *See* 2020 6 GHz Order, *supra* note 1, at 3986 (statement of Ajit Pai, Chairman).

292. Petula Dvorak, *When 'Back to School' Means a Parking Lot and the Hunt for a WiFi Signal*, WASH. POST (Aug. 27, 2020, 4:47 PM), https://www.washingtonpost.com/local/when-back-to-school-means-a-parking-lot-and-the-hunt-for-a-wifi-signal/2020/08/27/0f785d5a-e873-11ea-970a-64c73a1c2392_story.html [https://perma.cc/N8Y2-Y39P].

293. 2020 6 GHz Order, *supra* note 1, at 3992 (statement of Jessica Rosenworcel, Comm'r).

294. *Id.* at 3853.

295. *Id.*

296. *Id.* at 3854.

297. *See supra* note 174 and accompanying text.

298. *See id.* at 3992 (statement of Jessica Rosenworcel, Comm'r).

299. *See* 2018 6 GHz Notice, *supra* note 3, at 10501–02.

300. Cisco 6 GHz Comments, *supra* note 5, at 10; Wi-Fi Alliance 6 GHz Comments, *supra* note 288, at 8–9.

There is, however, one catch. While not as congested as some of the lower-frequency 5 GHz bands, the 6 GHz band is currently used by a variety of incumbents for various licensed operations. Some of the more common incumbent uses include common carrier (i.e., telephone) backhaul services, public safety networks, energy pipeline networks, and mobile communications by local television broadcast stations and news vans.[301] Making things even more complicated, the 6 GHz band is itself fragmented and subdivided. These various incumbent services occupy different positions all across the different segments of the 6 GHz band.[302] In this sense, the term "6 GHz band" is somewhat misleading to the extent that it implies that there is a solid block of contiguous spectrum available to be used for unlicensed services. In reality, and just like any neighborhood street, there are multiple individual property owners all with different amounts of property being used in different ways. The transaction costs of clearing the spectrum for different uses are therefore politically problematic and likely cost prohibitive.

After considerable debate, the FCC in 2018 proposed opening the 6 GHz band to unlicensed use on a secondary basis.[303] It specifically proposed authorizing two separate types of technologies. The first was so-called "standard power" devices.[304] These are higher-powered devices that create networks and hot spots in larger settings, such as stadiums and theaters. They can also provide wireless internet service in rural areas.[305] The second—and more important—technology consisted of "low-power" indoor (LPI) devices.[306] This latter category is the foundation of the wireless networks we rely upon in our homes and offices. Similar to the original spread-spectrum proceeding, the FCC's proposed rules for these operations relied on a shared overlay allowing unlicensed use on a secondary basis within these spectrum bands.[307] The FCC did not propose removing existing incumbents or diminishing their status as primary users. It thus avoided the significant costs—legal, political, economic, and technological—that clearing the spectrum and moving incumbents would otherwise require.

After nearly two years of considering it, the FCC in 2020 unanimously adopted rules opening the 6 GHz band to unlicensed use for these operations.[308] Advocates of unlicensed spectrum immediately hailed the decision as one of the most significant in the history of spectrum policy.[309] A spokesperson for the Wi-Fi Alliance claimed it was "the most monumental decision around Wi-Fi spectrum in its history."[310]

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301. *See* 2018 6 GHz Notice, *supra* note 3, at 10499–501 (detailing incumbent services).

302. *See id.*

303. *Id.* at 10497.

304. *Id.* at 10504.

305. *See* AT&T Servs., Inc. v. FCC, 21 F.4th 841, 845 (D.C. Cir. 2021).

306. *Id.*

307. *See* 2018 6 GHz Notice, *supra* note 3, at 10497.

308. *See* 2020 6 GHz Order, *supra* note 1, at 3853–54.

309. *See* Howard Buskirk, *Despite Continuing Concerns from Incumbents, FCC Opens 6 GHz for Wi-Fi*, COMMC'NS DAILY (Apr. 24, 2020), https://communicationsdaily.com/issue/view?i=28783 [https://perma.cc/ME7W-YALB] (quoting Broadcom official who described it as the "most substantive decision" on unlicensed spectrum in twenty-five years and a Microsoft official describing it as "unprecedented").

310. Kastrenakes, *supra* note 21 (quoting Kevin Robinson).

One reason for the excitement was the sheer volume of spectrum made available. The 6 GHz order more than quadrupled the amount of available spectrum for unlicensed and Wi-Fi devices.[311] In his statement supporting the order, FCC Commissioner O'Rielly specifically emphasized the importance of wide spectrum channels. To obtain high-speed unlicensed capabilities, "160 megahertz channels, or eventually 320 megahertz under Wi-Fi 7, are absolutely necessary."[312] These new channels could also "be combined with the 5 GHz frequencies already in use."[313] Commissioner O'Rielly was making reference to the fact that the IEEE had already finalized new Wi-Fi standards that could make use of the combined frequencies in the 5 and 6 GHz ranges to offer large channels for bandwidth-heavy services.[314] Following the order, devices incorporating these standards—known as "Wi-Fi 6"—are already being introduced into the market and promise to provide dramatically faster and more reliable connections.[315] In short, the 6 GHz order was a big deal.

It was, however, also controversial. Several powerful incumbents objected to various aspects of the entire proceeding.[316] Some objected to opening any part of this spectrum to unlicensed uses for fear of the interference it would cause. Other parties wanted unlicensed uses limited to more specific and narrower bands within the larger 6 GHz band.[317] Others argued that the FCC should, if it opened the spectrum, adopt technical rules that would require technological specifications to prevent interference.[318] Notably, these objections did not come from minor players in the spectrum world. Instead, some of the strongest objections came from some of the most politically powerful organizations in spectrum policy, such as AT&T, the National Association of Broadcasters (NAB), and public safety organizations.[319] In fact, AT&T (supported by others) even sued to prevent the rules from taking effect. The D.C. Circuit, however, recently upheld the order in almost all respects at the end of 2021.[320]

B. Evaluating the 6 GHz Order

While it is too early to know if the 6 GHz order will prove successful, there are good reasons to be optimistic. As explained below, the 6 GHz order adopted many

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311. *Id.*

312. 2020 6 GHz Order, *supra* note 1, at 3988 (statement of Michael O'Rielly, Comm'r).

313. *Id.*

314. *See id.* at 3854; Microsoft 6 GHz Comments, *supra* note 233, at 4.

315. *See* Howard Buskirk, *FCC 6 GHz Rules Controversial 13 Months Later*, COMMC'NS DAILY (May 11, 2021), https://communicationsdaily.com/issue/view?i=30382 [https://perma.cc/83FT-G7RY]; Kastrenakes, *supra* note 21.

316. *See* Howard Buskirk, *Key FCC Wi-Fi Order Faces Challenges, Expected to Survive*, COMMC'NS DAILY (July 9, 2020), https://communicationsdaily.com/issue/view?i=29101 https://perma.cc/SWQ2-TMA9].

317. *See* 2020 6 GHz Order, *supra* note 1, at 3859–60 (summarizing various parties' objections).

318. *See* Nat'l Ass'n of Broads., Comment Letter on Unlicensed Use of the 6 GHz Band, Expanding Use in Mid-Band Spectrum Between 3.7 and 24 GHz 1–2 (Feb. 15, 2019).

319. *See* 2020 6 GHz Order, *supra* note 1, at 3859–60 (summarizing various parties' objections).

320. AT&T Servs., Inc. v. FCC, 21 F.4th 841, 843 (D.C. Cir. 2021).

of the policy designs and principles that successfully encouraged Wi-Fi's development and growth. In this respect, the policy history described in the earlier sections provides normative support for the FCC's approach here. There are, however, some areas where the order could have been better—and more precisely, where it could have followed its older approach a little more closely.

Before examining the policy design, one interesting aspect of the 6 GHz order is that it illustrates how Wi-Fi's success has become its own narrative—and one capable of exerting influence on modern policy. This dynamic is not unique to the 6 GHz proceeding. Several of the proceedings described above seemed to be self-consciously attempting to replicate the success of the 1985 policy.[321] This narrative, however, is particularly prominent in the 6 GHz proceeding in which the FCC Commissioners emphasized the earlier success of Wi-Fi as a rhetorical justification. For instance, the initial notice opened by citing the original 1985 order: "When the [FCC] first made the [ISM] bands available for unlicensed use under our Part 15 rules in 1985, few could have anticipated the explosion of innovation that followed."[322] Former Chairman Ajit Pai listed the 1989 order as one of 1989's "great accomplishments" along with the fall of the Berlin Wall and the relaunch of the Batman movies.[323] The order itself stated, "[a]s has occurred with Wi-Fi in the 2.4 GHz and 5[.0] GHz bands, we expect that 6 GHz unlicensed devices will become a part of most peoples' everyday lives."[324] While difficult to measure, one interesting possibility is that this narrative of success provided a counterweight of actual substance that helped the FCC resist the considerable pressure from powerful incumbents.

The more important issue to examine, however, is the FCC's policy design. On the positive side, the 6 GHz order incorporated several policy design principles that were consistent with the original unlicensed orders—at least with respect to LPI devices. One example is the FCC's shift from fragmentation of the bands to unification. In the initial notice, the FCC had proposed carving the 6 GHz band into four separate sections (essentially creating four new U-NII bands numbering from U-NII-5 to U-NII-8). The proposal would have allowed LPI usage on only two of the four bands (U-NII-6 and U-NII-8)—and noncontiguous ones at that.[325]

The commenters supporting greater unlicensed use strongly recommended opening the entire band—and thus all four sections—for LPI use. The merger of the four bands would create significant engineering benefits. The Wi-Fi Alliance said that limiting LPIs to two bands would "stifle innovation" and cause "unnecessary regulatory delays and complexities."[326] Microsoft noted that authorizing LPI use across the entire band would "harmonize[]" the rules and allow for significantly wider channels.[327] It explained, "[t]he [significant] increase in the number of high

321. HAZLETT, *supra* note 58, at 255 (noting that several FCC unlicensed policies were "aimed at duplicating the success of [the] 1985 reforms").

322. 2018 6 GHz Notice, *supra* note 3, at 10497.

323. *Id.* at 10544 (statement of Pai, Chairman).

324. 2020 6 GHz Order, *supra* note 1, at 3854.

325. *See* 2018 6 GHz Notice, *supra* note 3, at 10503–04.

326. Wi-Fi Alliance 6 GHz Comments, *supra* note 288, at 16.

327. Microsoft 6 GHz Comments, *supra* note 233, at 5.

throughput Wi-Fi channels would be a game changer in terms of the types of applications and on-line services that can be supported."[328]

The FCC ultimately agreed and authorized unlicensed LPI usage across the entire 6 GHz channel. In doing so, it also noted the benefits of the wider channels that harmonization would create. It emphasized that the rules were "optimizing the potential for deployment of next generation Wi-Fi that makes use of [the] 160 MHz channels."[329] The FCC's decision was also influenced by the new IEEE standard 802.11ax, which incorporates these wide 160 MHz channels and can operate in the 6 GHz band.[330]

Another important aspect of the 6 GHz order was that it kept the technical rules relatively generic and simple (at least with respect to the LPI technologies). In doing so, it rejected attempts by incumbents to codify burdensome technological requirements into the certification rules. Recall that the 6 GHz order involved both standard-power and LPI devices. The FCC's initial proposal would require standard-power devices to adopt automatic frequency coordination (AFC) systems to prevent alleged interference.[331] To simplify, the AFC system establishes coordination between an individual device and a more centralized database that identifies incumbent users. Once in operation, individual devices must communicate with the AFC system to determine which frequencies may be used.[332]

While the AFC system was relatively uncontroversial for standard-power devices, there was significant disagreement about whether to apply such requirements to LPI devices operating in the newly available spectrum.[333] Incumbents such as AT&T and Verizon had argued that the AFC requirements were necessary to prevent interference.[334] Supporters of the order, by contrast, argued that adopting service rules with these requirements would significantly limit their use. Michael Calabrese of the New America Foundation, for instance, noted that Wi-Fi 6 could only reach its potential if it were "unburdened by database control."[335] Numerous commenters echoed these concerns in the comments and offered technical arguments in support. A coalition of public interest organizations and technology companies that included Apple and Broadcom noted that AFC requirements can be complex and require professional installation. It added that low power requirements—and the FCC's limitation of operations to indoor devices—provided sufficient protection from

328. *Id.*

329. 2020 6 GHz Order, *supra* note 1, at 3888.

330. *Id.* at 3854.

331. *Id.* at 3861.

332. *See* 47 C.F.R. § 15.403 (2021).

333. *See* 2018 6 GHz Notice, *supra* note 3, at 10522 (seeking comment on whether to apply such requirements to low-power devices).

334. *See, e.g.*, 2020 6 GHz Order, *supra* note 1, at 3888 (outlining objections); AT&T Servs., Inc., Reply Comment Letter on Unlicensed Use of the 6 GHz Band, Expanding Use in Mid-Band Spectrum Between 3.7 and 24 GHz 16 (Mar. 18, 2019) ("[A]ll such devices—without exception—should be required to coordinate through . . . the AFC system."); Buskirk, *supra* note 309 (noting Verizon's preference for AFC protections).

335. Howard Buskirk, *6 GHz Band Order Seen Likely at April FCC Meeting*, COMMC'NS DAILY (Mar. 6, 2020), https://communicationsdaily.com/issue/view?i=28539 [https://perma.cc/BT36-A45J] (quoting Michael Calabrese).

interference for established users.[336] In essence, the communications that 6 GHz would enable lacked the power to extend beyond the home or office. Tellingly, the AFC requirements are already creating delays and disputes regarding the approval of these systems.[337]

The FCC ultimately rejected the AFC requirement for low-power indoor devices.[338] Instead, the FCC's technical rules relied on relatively simpler measures to prevent interference. For one, these devices were limited to indoor use and lower powers. In addition, the devices had to use a "contention-based protocol," which would prevent interference.[339] Even this requirement, however, is far simpler than it sounds. Any device that uses some form of the 802.11 IEEE protocols—which virtually all LPIs already do—would comply with this requirement.[340] Collectively, the compliance costs of these rules are dramatically less than they would be if the FCC had imposed AFC requirements that could require creating centralized databases and more expensive installation and development.

One final notable aspect of the 6 GHz order was that the FCC resisted pressure from some of the most politically powerful organizations in spectrum policy. Opposition to both opening the spectrum and adopting more flexible service rules came from larger telephone carriers such as AT&T, the National Association of Broadcasters (the trade group for broadcasters who have been a dominant political force in spectrum policy for a century), and public safety organizations.[341] AT&T would ultimately sue on various grounds attempting to overturn the 6 GHz order.[342]

Despite this pressure, the FCC proceeded to adopt policies that these organizations viewed as adverse to their interests. They included both the authorization of unlicensed use itself and the flexible service rules free from excessive interference protections. In doing so, the FCC relied heavily on its engineering staff to sort through the conflicting reports and data that different parties presented.[343] Notably, the FCC did not give broad deference to the engineering reports showing harmful interference, but instead scrutinized them closely and found their conclusions unpersuasive.

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336. Apple Inc. et al., Comment Letter on Unlicensed Use of the 6 GHz Band, Expanding Use in Mid-Band Spectrum Between 3.7 and 24 GHz 3–4 (Feb. 15, 2019); *see* Public Interest Organization 6 GHz Comments, *supra* note 290, at 3–4.

337. *See Wi-Fi Alliance Seeks FCC Action on 6 GHz Automated Frequency Control Applications*, COMMC'NS DAILY (June 8, 2022), https://communicationsdaily.com/issue/view?i=32154 [https://perma.cc/F574-AXMA]; *Questions Remain on 6 GHz AFC Proposals: APCO*, COMMC'NS DAILY (June 2, 2022), https://communicationsdaily.com/issue/view?i=32129 [https://perma.cc/H6Q4-QTDH].

338. 2020 6 GHz Order, *supra* note 1, at 3888 ("Based on the record before us, we open the entire 6 GHz band for unlicensed indoor operations without the need for AFC-controlled access.").

339. *Id.*

340. *See id.* at 3889.

341. Buskirk, *supra* note 309.

342. *See* AT&T Servs., Inc. v. FCC, 21 F.4th 841, 845 (D.C. Cir. 2021).

343. 2020 6 GHz Order, *supra* note 1, at 3987 (statement of Ajit Pai, Chairman) ("I'd also like to thank all our hardworking FCC staff. This is one of the most complicated proceedings from an engineering perspective that the Commission has encountered in many years.").

That said, the 6 GHz order has some weaknesses. While it adopted many of the principles of older, successful unlicensed policies, there are arguably too many restrictions on LPIs. One such restriction is that the power levels for these devices is arguably too low—and significantly lower than power levels in the FCC's more successful Wi-Fi bands.[344] As a result, the devices will offer less coverage and slower speeds for home and office use.[345] In addition, the LPIs are currently limited to indoor use, which further restricts the new devices' utility.[346]

The FCC is, however, currently considering removing both of these limits in a current rulemaking proceeding.[347] Specifically, the 6 GHz order included an additional rulemaking notice requesting comment on both raising the power levels and removing the indoor limitations on LPIs.[348] The history of the FCC's Wi-Fi policies suggests there are good reasons both to remove these limits and to better align the policy design with the policy goals.

Another interesting aspect of this proceeding is the FCC's proposal to authorize "very low power unlicensed devices" across the entire 6 GHz band.[349] These technologies, the agency explained, could potentially usher in a new class of wearable peripherals that could improve and expand virtual and augmented-reality applications.[350] In support of this proposal, companies and public interest groups have explained that these devices could also help improve various other applications in emerging education, gaming, and health care markets.[351] Somewhat inexplicably, however, the FCC has yet to act on these proposals.[352] History suggests, though, that the simplicity of the proposed policy design will maximize the opportunity for innovation in these technology markets.

Before concluding, however, there is one important objection to consider. Throughout the Article, I have prioritized policy design—and the technical rules, more specifically—as a key determining factor of policy success. One objection, however, is that I am overvaluing the importance of technical rules and policy design

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344. NCTA – The Internet & Television Ass'n, Comment Letter on Unlicensed Use of the 6 GHz Band, Expanding Use in Mid-Band Spectrum Between 3.7 and 24 GHz 9–10 (June 29, 2020) [hereinafter 2020 NCTA FNPRM Comments] (noting that the "significant power reduction compared to [the FCC's] most successful Wi-Fi bands [will result in] (1) reduction in coverage; (2) reduction in throughput; and (3) a loss of network adaptability.").

345. *See id.* at 10; Apple Inc. et al., Comment Letter on Unlicensed Use of the 6 GHz Band, Expanding Use in Mid-Band Spectrum Between 3.7 and 24 GHz 56–59 (June 29, 2020) [hereinafter Tech Industry Consortium FNPRM Comments].

346. 2020 6 GHz Order, *supra* note 1, at 3854.

347. *See id.* at 3939.

348. *Id.*

349. *Id.* at 3939–40.

350. *Id.* at 3939.

351. *See, e.g.*, Pub. Int. Spectrum Coal., Comment Letter on Unlicensed Use of the 6 GHz Band, Expanding Use in Mid-Band Spectrum Between 3.7 and 24 GHz 5–12 (June 29, 2020) [hereinafter 2020 Public Interest FNPRM Comments]; Tech Industry Consortium FNPRM Comments, *supra* note 345, at 1–7.

352. The FCC has only recently taken tangible steps to begin drafting an order acting on these proposals roughly two years after releasing its proposal. *See* Howard Buskirk, *FCC OET Starts Drafting Order Further Liberalizing 6 GHz Rules*, COMMC'NS DAILY (July 7, 2022), https://communicationsdaily.com/issue/view?i=32278 [https://perma.cc/Z9B3-D8GU].

more generally. The technical rules themselves might simply reflect power and political dynamics, and it is these dynamics—and the not the policy design itself—that determine which unlicensed technologies will succeed. In this sense, policy rules merely reflect an already-won battle.

Admittedly, these dynamics are surely part of the story and deserve their own exploration. For instance, the failure of the white spaces policies likely stems from the political power of broadcasters. However, this critique cannot explain the entire story. The policy history described above shows that the FCC has more agency to make contingent and discretionary decisions than its critics acknowledge. Strong public choice narratives would treat the FCC as little more than a raft tossed around by whatever the strongest political currents are. The 6 GHz order, however, poses a challenge to such accounts. The opponents of the order—AT&T, broadcasters, public safety organizations—have enormous political clout in communications policy. They even sued to overturn the order. In this respect, the 6 GHz order can be viewed as "action against interest" for the agency given the scope of the political opposition. In addition, recall that the FCC adopted its original 1985 spread-spectrum decisions on its own without industry recommending it (and with some pushback).

Another problem with this objection is that it raises the question of why go forward at all with a policy with flawed service rules if everyone knows the debate has already been decided. It seems irrational to incur the costs of drafting policies and orchestrating rulemaking proceedings that are doomed to fail. Instead, it suggests that the FCC actually believes in the policy goal enough to move forward. However, if the technical rules are structured correctly, they will undermine the policy goal and reduce the chances of success. One implication of all of this is to recognize the importance of scrutinizing technical rules whenever policymakers are drafting and adopting new policy initiatives.

CONCLUSION

In this Article, I have illustrated the policy foundations that made Wi-Fi and other unlicensed technologies possible. As FCC Chair Jessica Rosenworcel stated, these technologies "are not the gifts of the spectrum gods. They are the byproduct of wireless policy choices . . . made [by] the [FCC] more than three decades ago."[353] That said, they are not wholly the products of government policy. The FCC's policy design succeeded because it provided a foundation for new markets and private research and development. It thus complicates simplistic dichotomies between regulatory and deregulatory approaches. In reality, the FCC's policy was a successful mix of both principles. It was not deregulatory exactly, but the regulations were designed in a generic and more simple way that lowered costs and did not tie the regulations to specific technologies of the day. Success also required continued vigilance over many years to address problems and improve policy designs. Going forward, policymakers could learn a great deal from the successes—and failures—of the policy foundations of Wi-Fi.

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353. 2018 6 GHz Notice, *supra* note 3, at 10547 (statement of Jessica Rosenworcel, Comm'r).