Spectrum Policy 2.0

White Space, the Internet and the Public Interest

By Mitchell Shapiro

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Executive Summary

The Federal Communications Commission is in the final stages of deciding if and how to authorize use of the TV broadcast "white space," which it could make available by early 2009, when broadcasters are scheduled to return their analog channels and switch to all-digital transmission.

The so-called "white space" is comprised of channels in the broadcast band that were historically set aside as unused "guard bands." This was done to avoid interference with stations transmitting on adjacent channels in the same market and broadcasts on the same channel in nearby markets. The Commission's current proceeding reflects a growing belief that, thanks to modern technology, these channels can be made available for unlicensed use without causing harmful interference to licensed broadcasters.

Should the Commission open up the white space for unlicensed use, many parts of the country could see as much as 150-200 MHz of unlicensed spectrum become available, with more than 200 MHz potentially available in some areas. To put this in perspective, consider that: 1) the entire cellular, PCS and recently auctioned AWS bands include 50 MHz, 120 MHz, and 90 MHz, respectively and; 2) the white space spectrum has much better propagation characteristics than the 83.5 MHz of spectrum in the heavily used 2.4 GHz unlicensed band and, even more so, than the unlicensed bands above 5 GHz, which are not well suited for wide area access networks.

The white space proceeding (Docket 04-186) requires the FCC to make decisions on a number of key issues that together will determine how much and on what terms white-space spectrum will be made available and, potentially, the nature and economic viability of networks and services employing that spectrum.

Between late January and early March of this year, the Commission received two rounds of comments on these issues. We discuss these issues and comments in Part 3 of this report.

In Part 4 we present our own recommendations for how best to address the white space issues currently before the FCC. These recommendations are also intended to help address some of the broader issues that have confronted communication policymakers since Congress first grappled with them in the debates leading to passage of the Communications Act of 1934.

Public Interest IP (PIIP) networks

A fundamental premise of this report is that the white space proceeding presents the Commission and the nation with a historic opportunity to leverage the combined power of the Internet and digital technologies to:

1) more fully resolve the First Amendment conflicts that have confronted policymakers since passage of the Communication Act of 1934, which granted

broadcasters exclusive spectrum licenses while imposing on them an undefined requirement to serve the "public interest, convenience and necessity";

2) promote economic growth and efficiency, and the maximization of social value enabled by our nation's communications infrastructure.

Our analysis attempts to integrate economic, technical and legal perspectives related to the history and future evolution of the U.S. communications sector. The report's final chapter offers recommendations intended to help the Commission promote these two fundamental policy goals while simultaneously resolving the specific issues before it in the white space proceeding.

At the core of these recommendations is a proposal to encourage white space-enabled "Public Interest IP" networks that use public spectrum assets to serve the public interest more directly and fully than has been the case in the past. As their acronym suggests, these PIIP networks would serve as open-access "pipes" for transmission of Internet Protocol data packets and the nearly endless forms of IP-based content and service this would enable.

In contrast to the profit-seeking motivation of private network operators, a key financial goal of PIIP networks would be to move in the direction of providing free universal connectivity, to the extent this can be done in an economically sustainable manner. In this respect, the PIIP model is a 21st century expression of the underlying "public interest" principle shared by the 20th century policy goals of "universal phone service" and "free over-the-air television."

The need and opportunity for new policy models

In the first chapter of Part 1 we review the history of spectrum policy, starting with the 1934 Act's political compromise that attempted to balance that era's perception of "spectrum scarcity" with the recognition that electromagnetic spectrum was a valuable public asset.

Chapter 1 goes on to review how enforcement of the Act's "public interest" standard proved challenging at best and how, beginning in the 1980s, it was largely phased out in practice, as "market efficiency-based" policy models came into ascendance. Chapter 1 also reviews the migration from "comparative hearings" to auctions as a basis for granting exclusive spectrum licenses, and considers both the strengths and weaknesses of auction-based licensing.

Chapter 1 closes with a brief history of "unlicensed" spectrum as an alternative to exclusive licensing, including the evolution of interference-management technologies and standards, the proliferation of devices and applications, the expansion from LAN to WAN applications, and the FCC's slow movement toward making unused broadcast "white space" spectrum available on an unlicensed basis.

In Chapter 2 we review the broadcast industry's shift away from over-the-air reception to other modes of program distribution, and the accompanying evolution of broadcasters' business models, TV viewing habits, and the devices and applications used to access video content. A common thread throughout this discussion is that over-the-air broadcasting is an increasingly inefficient mode of content distribution and that movement in the direction of the so-called "Negroponte switch" would be desirable from the perspective of efficiency and overall social value.

While Chapter 2 acknowledges that broadcasters may always resist any reduction in the spectrum rights granted to them by Congress and the FCC, it advocates use of broadcast "white space" as an important step in what might be described as a "Negroponte migration."

In Part 2 we discuss how the common carrier regime adopted by the 1934 Act sought to promote broad public benefits by pursuing the goal of universal and affordable telephone service, and the beneficial "network effects" this policy goal would bring.

Part 2 also explains how the FCC's effort to implement the 1996 Telecom Act, in conjunction with competitive dynamics, court decisions and shifting investor perceptions, led first to a flowering of many new competitors, followed by a sharp and costly contraction of their ranks. Part 2 also reviews the FCC's decision to treat the dominant broadband access services provided by cable and telephone companies as "information services functionally integrated with a telecommunications component," and therefore not subject to the common carrier requirements of Title II of the Communications Act.

Part 2 also reviews a range of data showing that the U.S. increasingly lags behind other industrialized nations in key measures of broadband availability, capacity and value.

In Part 2 and later in Part 4, we discuss how the Internet's content-and-application-neutral "end-to-end" architecture relates to the underlying goals of both the Title III "public interest" and Title II "common carrier" policy models. We suggest that, in key respects, the evolving broadband Internet combines the best of what we've known as television and telephone, while adding to this a wide range of additional software-based and value-enhancing features and functionality.

In the early days of television, it seemed unworkable and not economically attractive (at least to broadcasters), to provide everyone a chance to speak through this new and extremely high-powered megaphone. In contrast, the characteristics of telephone technology made it more feasible to extend the ability to speak through it to large numbers of citizens, a goal that was pursued through common carrier regulation and "universal service" policies.

To the extent we can put aside the perceptual filters created by these longstanding but outdated "silo" policy models, we can recognize that the fundamental architecture and evolving technology of the Internet, coupled with ever-lower costs of video capture and editing technologies, are dramatically lowering the entry barriers that led Congress to adopt the "public interest" broadcasting compromise of 1934. We can also begin to envision how

a ubiquitous high-capacity Internet can open up more direct paths to the "public interest," by providing the kind of broad and symmetrical access to multimedia communications that was not feasible in 1934, when Congress set the television and telephone industry down two separate paths, both intended to serve the public interest.

The Internet, spectrum & free speech

A key underpinning of the "public interest" goal in communication policy is the First Amendment, which states that "Congress shall make no law…abridging the freedom of speech, or of the press."

Though this wording focuses on prohibiting Congressional acts of abridging freedom of speech, over time a body of First Amendment law has evolved that takes a broader view of the Founding Fathers' intent as applied to modern technology. Much of the impetus for this was the fact that Congress, in granting broadcasters (and other licensees) exclusive rights to use public spectrum assets, was fundamentally tilting the First Amendment playing field in their favor.

A thought exercise that can help free us from legacy-bound perspectives in evaluating current policy options is to ask what First Amendment-friendly policy options would have been available (and preferable) to Congress if, in 1934, American citizens had access to the Internet, low-cost video production technologies, and 'cognitive radio' technologies that allowed efficient-enough spectrum sharing to provide every citizen a multi-megabit symmetrical connection to the Internet--and therefore to each other.

If we take this thought exercise seriously, we can appreciate the Constitutional basis and current policy significance of the assertion in a white space filing by NAF et al. that "where technology allows users to speak through the electromagnetic spectrum without interference to the productive uses of higher powered licensed services, the FCC has no right preventing them from speaking."

Seen in this context, the pending white space proceeding is, in large measure, an attempt to answer the question of whether we have, in fact, reached this point in the evolution of communication technology and its ability to minimize harmful interference. As we discuss in Part 3, some commenters in that proceeding claim we have. If they are correct, FCC tests will presumably verify this in the months ahead.

Should that be the case, the First Amendment implications are both clear and important. It would mean that the time has come for significant portions of the broadcast spectrum—much coveted today as it was 70 years ago—to serve the public interest directly, by supporting a multiplicity of voices through the use of advanced radio technologies and the near-universal connectivity provided by the Internet. And, as the NAF et al. filing suggests, it would also mean that the FCC (a creation of Congress) would be in violation of the First Amendment if it "abridge[d] the freedom of speech" of non-broadcasters via restrictions on "electromagnetic speech" that does not cause harmful interference with licensed broadcast services.

Internet era economics

A consistent theme throughout this report is that the neoclassical market equilibrium theories that dominated 20th century economics are increasingly inadequate as a foundation for developing and evaluating communication policies in the 21st century.

In Part 1, we cite a number of critiques of spectrum auctions and the economic theories that helped convince policymakers to adopt them. In Part 2 we discuss the basic elements of New Growth Theory, as developed by Stanford economist Paul Romer, especially its application to Internet and communication policy analysis by Cardozo law professor Susan Crawford. Part 2 also considers the growing importance of Internet-enabled "nonmarket social production" and "peer production of information, knowledge, and culture," as explained by Yale law professor Yochai Benkler. We then speculate on the potential value of this "nonmarket production" from the perspective of Romer's New Growth Theory. Part 2 also examines the analysis of wireless and wireline communication sectors by Columbia law professor Tim Wu, a leading advocate of network neutrality rules.

Taken together, the work of these leading Internet-era policy thinkers highlight: 1) the need for new economic models with which to approach 21st century Internet and communication policy issues and; 2) the vital and fundamental role that ubiquitous, neutral, and symmetrical high-capacity networks can play in promoting economic growth and efficiency, as well as healthier and more vibrant political and cultural sectors.

PIIPs, local governments and public benefits

Key goals of the PIIP proposal contained in this report are to maximize: 1) the amount and efficiency of white space spectrum made available for unlicensed use and; 2) the benefits associated with harnessing that spectrum to the purposes of municipal or "community" broadband networks. These benefits include:

1) more universal and affordable Internet access;

2) providing a low-cost and Internet-friendly alternative to incumbents' vertically-integrated "gatekeeper" access models;

3) delivering cost savings and increased efficiencies to local governments and other non-market "public service" institutions;

4) increasing beneficial "externalities," including economic growth and social value driven by the Internet's ability to facilitate efficient exchange, evaluation, combination and implementation of new ideas;

5) a lessening of the First Amendment restrictions on non-licensees that result from the FCC's practice of granting exclusive spectrum licenses.

6) cost sharing and cooperation with next-generation public safety networks that will be using 700 MHz spectrum in the same timeframe that white space spectrum becomes available.

Though our PIIP proposals encompass a range of specific options, they all assume, to varying degrees, the following general roles for local governments:

1) helping to maximize the amount and efficiency of white space spectrum use while, at the same time, helping to avoid and, as necessary, resolve interference problems with broadcasters and other spectrum users;

2) providing rights of way and other resources to support efficient network deployment and operation, including cooperation and, as appropriate, coordination with public safety networks and users;

3) delivering public services and facilitating other economic, political and social benefits via white space-enabled networks that provide broadly available untethered and non-discriminatory access to the Internet;

4) through these cost savings, efficiencies, services and benefits, generating value that can help justify the cost of providing universal broadband Internet connectivity.

Impacts on incumbents

A key characteristic of the PIIP policy model is that it avoids the imposition of "common carrier" or "network neutrality" requirements on the dominant providers of broadband access service. Instead, the PIIP model offers a more direct path to the same fundamental policy goal, without the regulatory risks and costs associated with imposing such requirements on network operators that resist them and claim they would result in unforeseen problems and inefficiencies,

By avoiding network neutrality rules, this approach would not encroach on the freedom of incumbent network operators to pursue their preferred model, which they argue will provide significant value not only to their shareholders, but also to American citizens and businesses. More importantly, it would insure that the latter also have access to a "neutral network" model, and be free to choose between the two models, or to enjoy the respective benefits of both.

Though the PIIP model does not impose network neutrality requirements on incumbent network operators, the widespread deployment of PIIP networks can be expected to have significant impacts on incumbents' revenues. These potential impacts are considered in the final sections of this report, under a range of different scenarios.

While our analysis suggests that broad adoption of the PIIP model could have significant negative impacts on the revenues of both wireline and wireless network operators, we also consider possible win-win scenarios in which incumbents participate in the deployment and operation of PIIP networks. We also note recent signs that incumbents and local

governments are beginning to explore such forms of cooperation in a handful of communities, as well as the potential benefits, risks and challenges associated with such alliances.

The FCC's pending white space proceeding provides a unique and potentially irreplaceable opportunity to reaffirm that the electromagnetic spectrum is a valuable public asset with a primary purpose of serving the public interest.

By adopting the PIIP proposals described in this report, the Commission can encourage creation of a 21st century communications infrastructure that can help correct the First Amendment imbalances and economic inefficiencies tied to the limitations of 20th century technology and the tangle of outdated policies that has grown up around it over the past seven decades. In doing so, the Commission can provide a much needed boost to the health and vitality of the American economy and political system, and of the local communities that are their foundation.

Part 1: From Broadcast to Broadband

In Part I of this report we examine the evolution of spectrum policy and usage, starting with the early days of broadcasting, when exclusive licenses were granted to broadcasters in exchange for commitments to serve the "public interest, convenience and necessity."

We then consider: 1) the transition to spectrum auctions and the pros and cons of the auction-based scheme that has dominated spectrum policy since the mid-90s; 2) the expansion of the unlicensed model for spectrum use and; 3) the FCC's slow movement toward opening up unused broadcast channels ("white space") to unlicensed use.

In the final chapter of Part I we discuss the various ways in which the historical television broadcast model is outdated and inefficient. We also examine, as a desirable long-term policy goal, a migration toward what is known as the "Negroponte switch" which, in its fullest form, would shift spectrum use to mobile applications, while delivering television programming and other high-bandwidth services to American homes via high-capacity wired networks. As part of that discussion, we consider the value of white space spectrum as a transitional step in this potential long-term migration.

As discussed more fully in the final section of this report, it is the author's belief that the white space spectrum, and specifically the FCC's pending proceeding to address it, offers a historic opportunity to bring the nation's spectrum policy—and its communications policy in general—more fully into the 21st century. To appreciate the nature and scope of this opportunity, it is helpful to view it from a broader and historical context.

The Evolution of Spectrum Policy

In evaluating current and future spectrum policy options, it's useful to look back at how this arena of policy has evolved over the past 70+ years. In this chapter we do that, beginning with the initial decision to license spectrum in the late 20s and early 30s, through the adoption and evolution of spectrum auctions and unlicensed spectrum rules, to the FCC's pending proceeding on policies related to the "white space" portions of the spectrum to be returned by broadcasters in early 2009.

Spectrum scarcity and the First Amendment

The web site of NTIA (National Telecommunications and Information Administration) includes a section entitled "Spectrum Scarcity and the Public Trustee Model" that provides a brief history of early broadcast regulation:

> A recurring challenge facing Congress and the FCC has been how to reconcile the competitive commercial pressures of broadcasting with the needs of a democratic polity when the two seem to be in conflict. This struggle was, in fact, at the heart of the controversy that led to enactment of the Radio Act of 1927 and the Communications Act of 1934.

> Under the antiquated Radio Act of 1912, the Secretary of Commerce and Labor was authorized to issue radio licenses to citizens upon request. Because broadcast spectrum was so plentiful relative to demand, it was not considered necessary to empower the Secretary to deny radio licenses. By the 1920s, however, unregulated broadcasting was causing a cacophony of signal interference, which Commerce Secretary Hoover was powerless to address. The lack of a legal framework for regulating broadcasting not only prevented reliable communication with mass audiences, it thwarted the commercial development of broadcasting.
>
> Thus began an extended debate over how to allocate a limited amount of broadcast frequencies in a responsible manner. A prime consideration was how to assure the free speech rights of the diverse constituencies vying for licensure. Some groups -- especially politicians, educators, labor activists and religious groups -- feared that, under a system of broadcast licensing, their free speech interests might be crowded out by inhospitable licensees, particularly commercial interests. They therefore sought (among other policy remedies) a regime of common carriage. A common carrier system would have required broadcasters to allow anyone to buy airtime, ensuring nondiscriminatory access.
>
> Existing broadcasters, for their part, sought to maintain editorial control and to develop the commercial potential of forging individual stations into national networks. They wanted Congress to grant them full free speech rights in the broadcast medium and not be treated as common carriers.
>
> This basic conflict was provisionally resolved by passage of the Radio Act of 1927, and seven years later, by the Communications Act of 1934. The 1934 Act, which continues to be the charter for broadcast television, ratified a fundamental compromise by adopting two related provisions: a ban on "common carrier" regulation (sought by broadcasters) and a general requirement that broadcast licensees operate in the "public interest, convenience and necessity" (supported by Congress and various civic, educational and religious groups). The phrase was given no particular definition; some considered it necessary in order for the government's licensing powers to be considered constitutional. [1]

Citing a number of key court decisions *(NBC v. United States, 319 U.S. 190, 226 (1943); Fed. Radio Comm'n v. Nelson Bros., 289 U.S. 266, 285–86 (1933); Red Lion Broad. Co. v. FCC, 395 U.S. 367, 390 (1969); FCC v. Nat'l Citizens Comm. for Broad., 436 U.S. 775, 795 (1978))*, comments filed by NAF, *et al.* in the FCC's pending white space proceeding (Docket No. 04-186) make some key points about the "scarcity rationale" for spectrum licensing and its relationship to the First Amendment. [2]

> Only because unregulated use of the electromagnetic spectrum by *everyone* would make ineffective the use of the spectrum by *anyone* has the Supreme Court permitted the Federal Government to restrict access to spectrum to a handful of government-selected licensees…[B]ecause the government must suppress rights of the vast majority of Americans to speak directly through the electromagnetic

> spectrum, the scarcity rationale imposes on the government a fundamental responsibility to protect the public's "collective right to have the medium function consistently with the ends and purposes of the First Amendment."[3] The Supreme Court has found that the public interest standard underlying the Communications Act "necessarily invites reference to First Amendment principles, and, in particular, to the First Amendment goal of achieving 'the widest possible dissemination of information from diverse and antagonistic sources.'"[4]

According to *Red Lion* and other cases, the NAF filing argues, "the scarcity doctrine imposes a responsibility on the Commission to regulate those holding exclusive licenses so as to protect the "paramount" First Amendment right of the public to receive access to a diversity of views in the electronic media."

The initial conflict that led to the 1934 Act and its important but undefined policy goal of serving the "public interest," speak to fundamental issues that remain largely unresolved today. As explained more fully later in this report, it is the author's contention that the opening up of broadcast white space presents a historic opportunity to resolve this early policy conflict and, thereby, to create spectrum policies that serve the public interest more fully than at any time our nation's history.

As discussed in the following section, in the decades since the 1934 Act became law, and most notably since the 1980s, U.S. communication policy has increasingly leaned in the direction of a neoclassical economic perspective that has largely failed to address this fundamental policy conflict.

This perspective has favored auctions of exclusive spectrum licenses, deregulation and consolidation in the communication sector, and the particular forms of efficiency associated with unregulated and vertically integrated oligopolies or duopolies in communication sectors characterized by high fixed costs.

A key purpose of this paper is to highlight the limitations of this perspective, and to suggest policies for use of the broadcast white space that can help correct key distortions in our economic and political systems that these limitations have fed.

How to serve the public interest?

In the decades following passage of the 1934 Act, a number of policies were adopted by the FCC to promote a "diversity of views" and make real the requirement that broadcasters serve the "public interest, convenience and necessity." These included the Fairness Doctrine and two corollary rules, the "personal attack" rule and the "political editorial" rule.

Beginning during the Reagan Administration, these policies have been largely abandoned, beginning with the Fairness Doctrine in 1987 and the two corollary rules in 2000. An equal-time rule, which remains in effect, requires broadcasters to provide an equivalent opportunity to any opposing political candidates who might request it. But it allows for the following exceptions: if the air-time was in a documentary, interview, scheduled newscast

or an on-the-spot news event the equal-time rule is not valid. The potential political significance of these exceptions was highlighted in 2004 when, during the heat of that year's presidential campaign, Sinclair Broadcasting chose to run a documentary highly critical of John Kerry, the Democratic candidate.

In addition, since 1983, political debates not hosted by a broadcast station are considered news events. As a result, they may include only major-party candidates without having to offer air time to minor-party or independent candidates.

The demise of the Fairness Doctrine was just one element of the FCC's changing vision of the public interest since the 1980s. As the NTIA web site explains:

> In essence, the FCC held that competition would adequately serve public needs, and that federally mandated obligations were both too vague to be enforced properly and too threatening of broadcasters' First Amendment rights. Many citizen groups argued that the new policy was tantamount to abandoning the public interest mandate entirely.
>
> Pursuant to its marketplace approach, the FCC embarked upon a sweeping program of deregulation by eliminating a number of long-standing rules designed to promote program diversity, localism, and compliance with public interest standards. These rules included requirements to maintain program logs, limit advertising time, air minimum amounts of public affairs programming, and formally ascertain community needs. The license renewal process -- historically, the time at which a station's public interest performance is formally evaluated -- was shortened and made virtually automatic through a so-called "postcard renewal" process…
>
> In 1996, Congress expanded the deregulatory approach of the 1980s with its enactment of the Telecommunications Act. Among other things, the Act extended the length of broadcast licenses from five years to eight years, and instituted new license renewal procedures that made it more difficult for competitors to compete for an existing broadcast license. These changes affected the ability of citizens and would-be license applicants to critique (at license renewal time) a broadcaster's implementation of public interest obligations. The 1996 Act also lifted limits on the number of stations that a single company could own, a rule that historically had been used to promote greater diversity in programming.

The shift to spectrum auctions

Parallel to this expanding deregulation of broadcasting was a shift to using auctions as the preferred mode of spectrum licensing. Before reviewing the strengths and weaknesses of auctions, its worth considering the licensing methods that preceded it.

For much of the history of spectrum licensing, the FCC would choose between multiple license applications using a process that came to be known as comparative hearings. The primary basis for selection during these proceedings was the vaguely defined "public

interest, convenience, or necessity" standard. The process provided competing applicants a quasi-judicial forum in which to argue why they should be awarded a license over competitors, and allowed other interested parties to argue for or against an applicant.

Comparative hearings tended to be time consuming and resource intensive from the perspective of both the applicants and the Commission. The selection of licensees from a pool of applicants often took up to two years or longer to complete.

For example, according to the FCC, grants of initial licenses for cellular service based on comparative hearings resulted in over 200 requests for the first 30 licenses, many of them consisting of well over 1,000 pages of detailed argument and documentation. The next two rounds of licensing attracted 344 and 567 applicants, respectively.

Ultimately, the huge volume of applications for new licenses driven by the developing cellular industry, led the FCC to seek authority to assign licenses by lottery.

In 1981, Congress added Section 309(i) to the Communications Act to give the FCC the authority to assign a broad range of licenses by lottery. It was hoped that lottery-based licensing would expedite service and lower entry costs for applicants.

Initially, the Commission screened applicants and allowed only qualified providers to participate in the lottery. When even this minimal degree of screening was deemed too burdensome on the Commission's resources (e.g., it took 20 months for the first set of cellular applications to be screened before the lottery), the FCC decided in 1987 to abandon pre-lottery screening and open the process to all potential applicants.

The result was that "application mills" sprang up to help nearly 400,000 different entities—some of them best described as speculators--participate in lotteries for cellular, Specialized Mobile Radio (SMR) and other licenses. With speculation driving a significant portion of license winners, the result was, not surprisingly, an active secondary market in FCC licenses. This led not only to sizeable windfall profits for some lottery winners, but also to delays in making service available to the public, as licenses were sold by winners seeking windfall profits and then consolidated by companies that actually intended to use the spectrum to deliver services.

The FCC has estimated that it took, on average, about two years to award cellular licenses in comparative hearings and over one year by lotteries. According to a 1991 study by National Economic Associates, the delay in cellular licensing cost the U.S. economy the equivalent of two percent of GNP.[5]

In addition to this cost was the direct cost incurred by applicants, which a 1989 study by economists Tom Hazlett and Robert Michaels estimated to be $800 to file a cellular lottery application.[6] As a 1997 FCC report noted, this cost multiplied by almost 400,000 cellular license applications, translates into a total application cost of nearly $300 million.[7] This FCC report also cited estimates of an additional $190 million in transaction costs associated with post-lottery license resales.

This 1997 FCC report summarized the perspective on comparative hearings and lotteries that set the stage for the introduction of auctions earlier that decade:

> Both methods…encouraged wasteful use of resources, not only by the firms seeking to acquire licenses but also by the Commission. The demands associated with comparative hearings and lotteries overburdened the Commission's resources, which were not prepared for the deluge of applications. These methods also failed to capture for the public any of the monetary benefits that spectrum licenses garnered for the fortunate few who acquired them.[8]

In the 1993 Budget Act, Congress added Section 309(j) to the Communications Act, authorizing the FCC to use auctions to assign licenses. The thinking at the time was that auctions could correct key problems associated with prior licensing methods. For example, the cost of winning an auction was expected to discourage speculators, the value of the spectrum would go to the federal Treasury rather than to speculators, and the auction winners who valued the spectrum most would presumably implement services most quickly.

In the Balanced Budget Act of 1997, Congress extended and expanded the FCC's auction authority. At the time, the Congressional Budget Office cited some of the key goals of spectrum auctions:

> In designing auctions for spectrum licenses, the FCC is required by law to meet multiple goals and not focus simply on maximizing receipts. Those goals include ensuring efficient use of the spectrum, promoting economic opportunity and competition, avoiding excessive concentration of licenses, preventing the unjust enrichment of any party, and fostering the rapid deployment of new services, as well as recovering for the public a portion of the value of the spectrum.[9]

Expanding the unlicensed model

The FCC allows operation of unlicensed radio transmitters under Part 15 of its rules. A key element of these rules is that a Part 15 device may not cause harmful interference to authorized services, and must accept any interference received.

The Commission's authorization of unlicensed spectrum usage dates back to 1938, when most unlicensed devices were designed to operate in the medium frequency (0.3-3 MHz) and high frequency (3-30 MHz) frequency bands.

Over time, as the industry designed new products intended for operation on different frequencies, the FCC amended and expanded the Part 15 rules to permit the use of higher power for unlicensed operation in higher frequency bands.

In 1985, the FCC expanded its Part 15 rules to include low power, unlicensed spread spectrum technology in the 900-928 MHz, 2400-2483.5 MHz and 5725-5850 MHz bands. The power limit in this band is 1 watt.

When the Part 15 spread spectrum rules were originally developed, the Commission's primary aim was to encourage the development of unlicensed industrial, scientific, and medical (ISM) devices in these bands. Since then, the agency has modified these rules to accommodate new technologies and industry standards, including wireless-LAN (local area networks) and wireless-PAN (personal area networks) technologies employing standards such as 802.11 (Wi-Fi) and 802.15 (Bluetooth). In addition to ISM and Part 15 radio devices, location and monitoring services (e.g., vehicle tracking), amateur radio operators, licensed point-to-point microwave, and U.S. Navy fire-control radars all use the ISM bands.

Today, the lion's share of unlicensed radio activity occurs in the 2.4 GHz and 5 GHz bands, driven most recently by the proliferation of Wi-Fi and Bluetooth devices.

With the growth of unlicensed devices and applications, the FCC moved in the late 1980s to revise its Part 15 technical and administrative rules. The revised rules standardized emission limits in various bands and established a number of general usage frequency bands. They also allowed operation at very low power in any band except those where such operation was explicitly prohibited (the latter includes most of the broadcast TV band), while establishing certain bands where higher emission levels are allowed.

During the 1990s, the Commission continued to open up new spectrum bands to unlicensed operation. This included the 1993 authorization of "Unlicensed Personal Communication Services (U-PCS) devices in the 1910-1930 and 2390-2400 MHz bands, where wireless PBX systems often operate. Later in the decade the Commission opened up additional spectrum in the 5 GHz band (5.15-5.35 and 5.725-5.825 GHz) for applications including wireless local area networks (W-LANs). It also authorized unlicensed use in the much higher "millimeter wave" band (57-64 GHz) band, suggesting that these bands might be appropriate for broadband wireless computer-to-computer communications.

Among the earliest advocates of an expanded role for unlicensed spectrum was Yochai Benkler, currently a Yale Law School professor. Benkler, who coined the term "commons-based peer production," is considered a pioneer in analyzing and advocating commons-based approaches to managing resources in networked environments.

In a paper entitled *Overcoming Agoraphobia: Building the Commons of the Digitally Networked Environment* published in a 1998 issue of the Harvard Journal of Law & Technology, Benkler laid out the case for considering an expansion of unlicensed spectrum policies.

> Generally, we use market-based solutions for resource management, and therefore when posed with such a problem look for something to which we can affix property rights to be traded in the market. But there is no such "thing" as "spectrum"…no finite physical "resource" that needs to be allocated. There are simply people communicating with each other…with equipment that uses electromagnetic waves to encode meaningful communications and send them over varying distances without using a wire.

> "Spectrum management" means regulating how these people use their equipment. "Spectrum allocation"…is the practice whereby government solves this coordination problem by threatening most people in society that it will tear down their antennas and confiscate their transmitters if they try to communicate with each other using wireless communications equipment without permission. This is done so that other people—broadcast licensees or spectrum "owners"—can successfully communicate…Once we understand that the question is how to regulate the use of equipment, not of "a resource," we will be able to recognize that we have alternative regulatory models in our society.[10]

Benkler cites automobiles and roads as an example of one such alternative model. "In the case of automobiles," he explains, "we have chosen to allow anyone to buy and use the equipment, subject to certain 'rules of the road' that allow equipment users to coordinate their use and avoid interference."

"The central institutional choice regarding wireless communications," Benkler says, "is whether to rely on centralized control by identifiable organizations, or on multilateral coordination among numerous users."[11]

> On the one hand, it is possible to treat spectrum as a resource whose use must be centrally determined by someone with the power to decide how wireless communications equipment will be used in a given spectrum unit….On the other hand, it is now technically possible to rely on standards and protocols to enable multilateral coordination of transmissions among equipment owners, without identifying any person whose choices trump those of all other potential users.[12]

Benkler followed this with a 2002 paper entitled *Some Economics of Wireless Communications*, also published in the Harvard Journal of Law & Technology. It argued that unlicensed spectrum models are likely to be superior to auction-based approaches in terms of network capacity, security, innovation and consumer welfare.

Influenced by Benkler and other advocates of expanding the unlicensed spectrum model, the FCC in 2002 authorized use of ultra-wideband (UWB) technology that spread very low power transmissions over a broad range of frequencies. Given the controversy over this authorization, the Commission set very conservative standards for such usage, which was targeted primarily at imaging systems (e.g., radar, medical imaging, surveillance devices), vehicular radar systems and communications and measurement systems.

In December 2002, the FCC released a Notice of Inquiry seeking comment on the possibility of permitting unlicensed use in the TV band and in the 3650-3700 MHz band that had previously been use by the federal government and was also used for Fixed Satellite Service.

In the spring of 2005, the Commission took action on the 3650-3700 band, adopting rules for non-exclusive licensing using contention-based spectrum-sharing protocols. According to the FCC's order, its rules provided "a streamlined licensing mechanism with minimal regulatory entry requirements that will encourage multiple entrants and stimulate the rapid

expansion of wireless broadband services--especially in rural America--and will also serve as a safeguard to protect incumbent satellite earth stations from harmful interference." The Commission's 3650-3700 "non-exclusive licensing" rules appear in part to be an attempt to create a regulatory middle-ground between exclusive licensing and unlicensed operations.

Unlicensed wide-area networks

Though the history of unlicensed spectrum use has been anchored in relatively short-distance low-power applications, the geographic scope of unlicensed use has recently begun to expand dramatically, in parallel to the FCC's efforts to adapt its power limits and related rules to the propagation characteristics and interference risks of particular spectrum bands. **For example, a growing number of commercial WISPs and "muni-wireless" networks have been employing Wi-Fi (or, in some cases, proprietary) technologies in unlicensed bands to deliver wide-area Internet access services.**

In its white space comments, NAF et al. note that "more than 200 towns, cities and counties already are or will soon be completely covered with ubiquitous and free or reasonably-priced wireless Internet access over networks initiated by local governments," and that "according to Wireless Internet Service Providers Association (WISPA), there are at least 3,000 wireless Internet Service Providers (WISPs) in the U.S. serving about one million customers."[13]

A key issue related to this expansion of network coverage is the amount and type of spectrum available for unlicensed applications. **As WISP and municipal wireless deployments have found, the ability to transmit through foliage and other obstacles, and to provide in-building coverage, are key challenges in designing networks utilizing the 2.4 GHz and 5 GHz unlicensed bands. This highlights the significance of the fact that, aside from the highly congested 900-928 MHz band, there is no spectrum allocated for unlicensed use below 2 GHz. While mesh networks and other technologies have made major strides in overcoming these hurdles, both logic and evidence strongly suggest that current limitations on unlicensed spectrum—especially below 1 GHz—remain an obstacle to the growth of wide-area unlicensed networks and the business cases necessary to sustain that growth.**

The combination of mounting interest in unlicensed wireless broadband access networks—both in underserved rural areas, and as an additional competitor in other parts of the country--and the technical constraints of existing unlicensed spectrum bands, provide key elements of context for the current debate over the future of the broadcast white space. This is because the broadcast white space—especially if made broadly available for unlicensed use—has propagation characteristics much more favorable to wide-area networks than those in the currently available unlicensed bands.

In March of last year, Microsoft CTO Craig Mundie, speaking before the Senate Commerce Committee, highlighted some of the benefits his company and others see from unlicensed use of broadcast white space:

> The equipment exists today to deliver wireless broadband in coffee shops and hotels using unlicensed bands. And wireless Internet service providers (or WISPs) are attempting to use variants of that technology to bridge the last mile in rural communities. The problem is that the spectrum available today for unlicensed use does not propagate well over long distances. Signals can be obstructed by foliage and walls, and the physics of today's Wi-Fi spectrum dictate that the signal fades over distance.
>
> Spectrum below 1 GHz has excellent propagation characteristics. The same spectrum used to deliver high-quality TV and radio signals long distances to your home would do an excellent job delivering high-quality Internet services. The problem of propagation losses would be overcome.
>
> Designating spectrum below 1 GHz for unlicensed use will have many benefits. Deployment of unlicensed devices is fast; it's efficient. The technology empowers innovators and consumers. It also gets the FCC out of the job of picking technology or service provider favorites. Instead, it lets the market decide — or lets the community, or even individuals, do it for themselves. That means innovation is faster, and competition — not the Commission — pushes companies to innovate and deploy new services.
>
> Moreover, because unlicensed bands are open to anyone who buys a compliant device at a retail store and attaches it to the network, the capital investment comes when it is needed and is fueled by individuals and businesses, not by larger network operators. And because buying blocks of spectrum at auction is not required, the cost of entry for these services is lowered. Thus, the cost of providing these services is extremely low relative to the substantial benefits that can accrue as the result of broadband Internet access.[14]

Critiques of auctions

Just a few years after auctions began being used by the FCC, Columbia University professor Eli Noam published a paper that contained a harsh critique of the Commission's new approach to spectrum licensing. "The underlying objective for the auction 'game," said Noam, "was to raise revenues for government."

> This is usually denied quite heatedly, and various other considerations are cited, such as moving spectrum to the users valuing it most, etc. But the political fact is that auctions were approved, after years of Democratic opposition to them in Congress, as a measure to reduce the budget deficit. Allocating spectrum resources efficiently was a secondary goal at best…As one Senator put it, an agency ostensibly responsible for regulation could be turned into a giant cash-register. Once a certain dependency on revenues from communications has been created, it may affect substantive policy…

> The Administration's goal is to advance the national infrastructure…But are we not actually doing now the opposite of making public investments? Through auctions, we are taking money out of the infrastructure and away from telecommunications carriers and throwing it into the black hole of the budget deficit…[15]

According to a study by Gregory Rose and Mark Lloyd, published by the Center for American Progress in May 2006, the FCC had, as of that point in time, conducted 58 spectrum auctions since 1994. Rose and Lloyd estimated that, in total, these auctions had generated roughly $45 billion in revenues, which equates to an average of roughly $776 million per auction or, over the course of a dozen years, roughly $3.75 billion per year.[16]

To put these auction revenues in a context that highlights Noam's comment about "the black hole of the budget deficit," it's worth noting that as of early 2007, the U.S. government had either spent or approved more than $500 billion of taxpayers' funds on the war in Iraq. And, though the war is opposed by a majority of Americans, President Bush was expected to request another $100 billion in war-spending for 2007 and $140 billion for 2008. The additional 2007 request alone would consume more than twice the the total revenue generated by spectrum auctions in the dozen years from 1994-2005.

While an argument can be made that the Iraq war is a necessary and valuable expenditure of federal funds, there are, no doubt, many other examples that could be cited with regard to waste in federal government spending. One good candidate would be the $24 billion in "earmarked" projects in the 1996 transportation bill, which included $223 million in spending for Alaska's notorious "bridge to nowhere." These earmarked projects alone will consume more than half the total revenue generated by spectrum auctions in the dozen years from 1994-2005.

An even fuller picture of the budget deficit "black hole" is evident in the following excerpt from a report by the Center on Budget and Policy Priorities:[17]

> Estimates provided in August 2006 by the Congressional Budget Office show that the direct cost of legislation enacted since January 2001 and the resulting increases in interest on the debt amounted to $633 billion in 2006 alone — and totaled $2.3 trillion over the six-year period 2001 through 2006. This left the debt (i.e., the "debt held by the public") at $4.8 trillion (or 37 percent of GDP) at the end of 2006, rather than at the $2.5 trillion level (19 percent of GDP) it would have attained had no changes in policy been enacted.

The fact that spectrum auction revenue is just a drop in the hole-filed deficit bucket does not, of course, negate its potential value in helping to at least partly fill that bucket. The more important question, as Noam points out, is whether "useful budget policy [is] also good communications policy."

Given the potential value of ubiquitous high-capacity broadband networks for our nation's security and economic growth in the 21st century, it would be extremely unfortunate if the development of sound national communication policy was distorted in any significant way

by a desire on the part of the federal government to use auctions to offset the budget impacts of poor policy choices, mismanagement and inefficiency.

Noam also cited other elements of economic inefficiency in spectrum auctions:

> An auction payment that must be paid in advance is a barrier to entry, unless capital markets are perfect, which they are not. This especially affects small firms and unproven technologies that cannot find partners to share the risks. Therefore, an up-front payment will reduce the pool of entrants...
>
> The highest bidders will be those who can organize an oligopoly. This is facilitated by bidding "consortia" of companies which would otherwise be each other's natural competitors, and who collaborate under some rationale of synergy. Second, after the auction, the high bidders will collectively suffer from some "winner's curse" and, after some shake-out period, will collaborate, because otherwise they might not be able to support their bid price's cost… Oligopolists…will attempt to inflate opportunity cost and other means in order to recover their bid price and more. This does not require an explicit agreement, just commonality of interest, and is therefore difficult to identify. Even with multiple service providers left nationally, there would be pressures for concentration to take place, similar to the dominance by airlines of "their" hub cities…
>
> Flexibility of entry…is an excellent way to protect against oligopoly…There must also be enough spectrum auctioned off to attack oligopolistic tendencies and reduce opportunity cost. But here, the government is conflicted. Release more spectrum, and its price drops. The quantity released is affected not only by policy considerations, but also by revenue needs and stakeholder interests. Just as New York cab drivers have used politics to prevent the issuance of additional taxi cab medallions at the same level since the Great Depression in order to protect their investment, so will existing spectrum holders be united in the desire to stave off new entrants which will not only compete with them for future business but also depress the value of their past investment in spectrum. Government has a related revenue-based incentive to keep spectrum prices high by limiting supply. Thus, government could become the spectrum-warehouser and protector of oligopoly, a function it has played historically…
>
> It is argued that the auctions are not for full ownership and only for a long-term lease or business license. But this is a legal distinction without a real difference. The strong expectation is that the lease will be almost automatically renewed, just as it has been for TV broadcast licenses, where of more than 10,000 renewals between 1982-1989, less than 50 were challenged and fewer than a dozen were not renewed, virtually never for comparative reasons. In cable TV the non-renewal of franchises is similarly rare. For all practical purposes, the auctions are for permanent occupancy, though the slight uncertainty will lower the prices a bit.[18]

The 1996 study by Rose and Lloyd concludes that "analysis of the last ten years of FCC spectrum auctions reveals that these auctions have met neither the standards nor the expectations expressed by Congress in their authorization."

> They do not facilitate the development of robust markets or meet the needs of the broader public interest. Instead these auctions, as they have been conducted, appear to serve the narrow interest of dominant actors in the telecommunications industry. They have systematically resulted in market concentration and the growth of the oligopolistic market power of major actors in the telecommunications industry. They have been pervious to manipulation by tacit collusion among bidders in ways which no minor amendment of the auction process could possibility remedy. Even the often made argument that FCC spectrum auctions maximize revenue fails in the face of both FCC mispricing of licenses, reflected in the large number of licenses which fail to be auctioned because no bidder meets the reserve price, and substantial evidence that strategic behaviors like preemptive bidding can guarantee better capitalized bidders licenses at consistently lower prices than their competitors…[19]

It's worth updating the Rose and Lloyd analysis with some data from last fall's AWS spectrum auction. According to our analysis, roughly 70% of the total MHz-Pops attracting bidders in that auction went to four entities. Of these, three were among the nation's four dominant mobile carriers (T-Mobile, Verizon and Cingular, in descending order of bid totals). The fourth was an entity called SpectrumCo LLC, whose investors included four large cable operators and Sprint (the other top-four wireless provider), all of which are also involved in a joint venture aimed at developing services that integrate wireless and wireline as well as video, voice and data.

On the face of it, the AWS auction results appear to support Noam's 1995 predictions that "the highest bidders will be those who can organize an oligopoly" and Rose and Lloyd's claim that auctions "have systematically resulted in market concentration and the growth of the oligopolistic market power of major actors in the telecommunications industry."

Another issue related to exclusive licensing is that spectrum if too often warehoused or underutilized. This contrasts with the intensive use of unlicensed spectrum (discussed in the following section of the report) available in comparable bands. A good example of this is the comparison of three bands in the 2 GHz range--Wireless Communications Service (WCS), at 2.3 GHz, Broadband Radio Service (BRS, formerly known as MDS/MMDS) at 2.5 GHz, and the 2.4 GHz IMS band. The first two of these are licensed, the third unlicensed.

Though large amounts of WCS spectrum were licensed back in 1997 (with telecom giants BellSouth and Comcast among the largest winning bidders), this band has seen relatively little commercial deployment. And, in various incarnations, licenses for the BRS band have been available for decades, and have changed hands numerous times, with buyers including some of the nation's largest telecom providers. And while there were some deployments using this spectrum, they were typically limited in scope and, in many cases, proved unsuccessful in terms of long-term economic viability.

Today, the lion's share of BRS spectrum (along with commercial spectrum leases for the nearby Educational Broadcast Service band) is controlled by Sprint and Clearwire. Until AT&T agreed to sell its BRS licenses to Clearwire as part of a deal that led to FCC approval of its BellSouth acquisition, the latter had also been among the largest owners of BRS licenses.

As of late 2006, Clearwire had deployed broadband networks in only 33 mostly smaller markets. And Sprint, which had agreed to certain BRS deployment milestones to win approval for its Nextel merger, will only be launching its first commercial markets in 2007.

This tendency toward warehousing of licensed spectrum in the 2 GHz band contrasts sharply with the intensive use of the nearby 2.4 GHz IMS band by an ever-expanding variety of unlicensed devices and applications. And, even though the band was already being used intensively for wireless LANs and other low-power applications, it has seen, in recent years, a wave of wide-area deployments by WISPs (mostly in relatively rural areas) and, more recently, muni-wireless systems.

Spectrum warehousing was one of the issues address by Simon Wilkie, Director of the Center for Communications Law and Policy at the University of Southern California, in a March 2007 paper entitled *Spectrum Auctions Are Not a Panacea: Theory and Evidence of Anti-Competitive and Rent-Seeking Behavior in FCC Rulemakings and Auction Design*.

According to Wilkie, "incumbent…providers of fixed and mobile as well as wired or wireless telecommunication services, have strong incentives…to limit or delay entry of potential competitors who might make use of the spectrum."

> [This] incentive may be even stronger today than in the past if potential entry into the national market using new technologies with significantly lower marginal costs of network deployment and/or the possibility for product differentiation (such as nomadic broadband services) could accelerate depreciation schedules of existing incumbent's network infrastructures.
>
> Firms with such powerful incentives to delay or deter new entry find the means to do so through the current spectrum allocation rulemaking process managed by the FCC and, in cases where there is competitive bidding, through the auction process itself. There are four key tactics whereby firms can potentially influence the process and outcome in anti-competitive ways:
>
> • Strategically warehousing spectrum in order to prevent entry for potential competitors;
> • Delaying the decision-making process through long-drawn debates over service rules, un-specifiable and unquantifiable arguments of technical interference and other means;
> • Outbidding new entrants in unfettered auctions that do not expressly address the risk of incumbent carriers' potentially anti-competitive tactics;

> • Slicing new available bands for private commercial use in ways that make it more costly or impossible to build out upon such license a viable national competitive business plans.[20]

In his paper, Wilkie presents empirical evidence and theoretical arguments to support his contention that "where there exist strategic incentives to use the rulemaking process and auction process anti-competitively by incumbent carriers seeking to curtail or slow entry, auction mechanisms can result in socially suboptimal outcomes and even constitute a *de facto* barrier to entry that impairs competition."

Rose and Lloyd take the view that U.S. spectrum auction policy reflects of a fundamentally misplaced enthusiasm for a particular approach to economic analysis.

> What has principally driven the adoption of spectrum auctions by the FCC and Congress has been ideologically-libertarian economic theory, captured in simplistic models which ignore inconvenient facts. Game theory is a powerful tool for analysis of economic behavior. However, a game-theoric model is only as good as its assumptions. Assumptions about information, bidder resources, risk-acceptance and -aversion, and the structure of bidder preference all matter, because they imply things about how the real world operates. All modeling is along a continuum between analytical tractability and empirical verisimilitude: the more mathematically tractable the model is, the less it resembles the real thing being modeled…
>
> The past ten years of FCC spectrum auctions have amounted to such an experiment, and the experiment demonstrates that the models on the basis of which Congress and the FCC were persuaded to adopt spectrum auctions fail dramatically in their prediction of real-world outcomes. When tested by the actual performance of such auctions, the chasm between the outcomes predicted by theory and the outcomes observed is immense. In sacrificing the public interest in pursuit of hypothesized market efficiencies and greater revenue we have arrived at the worst of both worlds: FCC spectrum auctions neither serve the public interest nor realize the promised economic efficiencies and revenue maximization touted by their advocates.[21]

In a later section of this report we will revisit the question of what economic models and analytical approaches are best applied to 21st century communication policy.

Spectrum sharing and the First Amendment

In an article published in the December 14, 1998 issue of The New Republic magazine, Yochai Benkler and then Harvard Law professor Lawrence Lessig questioned the constitutionality of FCC spectrum allocation policies in the face of technological change allowing efficient spectrum sharing.

> Our argument is straightforward: The FCC regulates speech. It says that, if you want to speak on 98.6 FM in Boston, you must get a license (or, now, buy one). If you

> speak on 98.6 without a license, you will have committed a crime. The FCC will prosecute you and seize your transmitter. All this despite the fact that the First Amendment to the Constitution says, "Congress shall make no law ... abridging the freedom of speech." What gives?
>
> The traditional rationale goes something like this: 98.6 is part of the radio spectrum; radio spectrum by its "nature" must be allocated for it to be useable...Nature makes it so, the government says, and government must respect nature…But what if "nature" changed?..What if the spectrum could be shared by all rather than set aside for a narrow class of licensees?.. Instead of a market in spectrum, we would have a market in efficient wireless modems.[22]

"If shared spectrum is possible," argued Benkler and Lessig, "then the First Amendment would mean that allocated spectrum--whether licensed or auctioned--must go."

> The First Amendment…is strongly opposed to a system of licensing or prior restraint…When the state creates a regime where all speech must be licensed; when it establishes monopolies over valuable speech resources; when it erects a framework that concentrates, rather than decentralizes, opportunities for speech, then the state needs a very strong justification.
>
> Necessity would be such a justification. If the only architecture for broadcasting that could work were the architecture of allocated spectrum, then spectrum allocation would be justified. But, when technology advances such that this concentrated architecture is no longer required, then "necessity" disappears and…the reason for this state-sponsored monopoly--abridging the freedom to speak without a license from the state—vanishes.[23]

Recent comments filed by NAF *et al.* in support of unlicensed white space highlight the First Amendment issues related to spectrum auctions and exclusive licensing in general. These comments argue that, even if the promised efficiency gains were fully realized through such auctions, neither these gains, nor the scarcity doctrine, give the government "unlimited authority to curtail speech."

> [W]here technology allows users to speak through the electromagnetic spectrum without interference to the productive uses of higher powered licensed services, the FCC has no right preventing them from speaking. Economic grounds alone are not a substantial government interest, and thus cannot support exclusive licensing where the threat of interference does not exist.[24]

Citing *City of Los Angeles v. Preferred Communications*, NAF et al. argue that "The Supreme Court has explicitly found that the First Amendment prohibits the government from granting exclusive rights in communications media unless the physical characteristics of the medium require exclusivity as a precondition of productive use."

In that case, the Court ruled that the City of Los Angeles, which had auctioned an exclusive cable franchise, could not deny an application of another company unless physical limitations required the city to limit the number of franchises.[25] As the NAF filing put it:

> The Court explicitly held that the desire of the city to maximize revenue or maximize economic efficiency did not permit limiting the ability of citizens to speak through the new medium any more than the city could limit, in the name of economic efficiency, the number of newspapers circulated. In other words, where the laws of physics no longer require exclusivity, exclusivity cannot be justified on economic or efficiency grounds alone.[26]

NAF et al. draw an analogy to the legal principle that the government may impose reasonable time and place restrictions on First Amendment activities on public property, but may not exclude speakers more than necessary.

> The Constitution would not tolerate an auction for rights to protest in a town square on the grounds that an auction would increase government revenue, or to ensure that only those who "most value" the right to speak publicly have the opportunity to do so. Such a scheme could not circumvent the First Amendment by arguing that winners at auction would resell or rent to other speakers if it were genuinely more efficient to allow just anyone to speak…
>
> It makes no sense as a matter of First Amendment jurisprudence, therefore, to posit that the First Amendment rights of the vast majority of citizens to speak directly to one another, rather than through a government-licensed intermediary, can arbitrarily be circumscribed in the name of economic efficiency.[27]

Slow progress on unlicensed white space

Though the FCC had established rules for opening up the 3650-3700 band by the spring of 2005, its progress toward authorizing operation in the broadcast white space—which had also been the subject of its 2002 NOI--has been much slower. In a recent white space comment, NAF et al. provided a brief history of the FCC's halting progress toward arriving at a white space policy.

> The Commission first considered the question of whether to permit unlicensed operation in the broadcast bands as part of its reexamination of its Part 15 Rules in 1987, but declined to do so in 1989 for fear that an unlicensed underlay in the television broadcast bands would interfere with the anticipated change to analog high-definition television…
>
> In 2002, the Commission created a Spectrum Policy Task Force (SPTF) for the express purpose of conducting a comprehensive reexamination of all aspects of the Commission's spectrum policy…[The SPTF] delivered a set of reports and

> recommendations...[that] included finding new spectrum for unlicensed use, such as the broadcast white spaces.
>
> The Commission…concluded that… permitting unlicensed operation in the broadcast bands appeared both feasible and desirable as a means of facilitating numerous public interest benefits. Nevertheless, out of an abundance of caution, the Commission chose to issue an initial notice of inquiry rather than proceed directly to a rulemaking.
>
> In 2004…the Commission commenced [a "white space"] rulemaking…Once again, the Commission concluded that the arguments raised in favor of unlicensed operation in the broadcast white spaces outweighed the interference risks or purported advantages of licensing use of the broadcast white spaces. Accordingly, the Commission adopted a "tentative conclusion" to allow unlicensed operation in the broadcast white spaces.[28]

Facing opposition from broadcasters, and with the replacement of Michael Powell by Kevin Martin as chairman, the FCC subsequently put the white space proceeding on the back burner. This lack of movement led to the early 2006 introduction of bipartisan House and Senate bills directing the FCC to move forward with its rulemaking and to make white space spectrum available for unlicensed broadband access.

In September 2006, more than 2 years after its 2004 NPRM, the Commission finally announced a schedule for resolving outstanding issues in that proceeding. About a month later it released a First Report and Order and Further Notice of Proposed Rulemaking. As the Commission said at the time, its First Report and Order concluded that fixed low power devices can be allowed to operate on TV channels in areas where those frequencies are not being used for TV or other incumbent licensed services."

But the Order disappointed unlicensed white space advocates in several key respects. As expected, it did not allow unlicensed operation on TV channel 37, which is used by radio astronomy and wireless medical telemetry services, nor on TV channels 52-69, which had previously been reallocated for public safety and commercial mobile services. But it also declined to permit operation of unlicensed personal/portable devices on TV channels 14-20, which are used by public safety service in 13 cities. It also left open several spectrum-related issues, seeking comment on these in its FNPRM. These included:

> 1) whether personal/portable devices can operate in any of the TV channels without causing harmful interference;
>
> 2) whether low power devices should be permitted on TV channels 2-4, which are used by TV interface devices such as VCRs;
>
> 3) whether fixed low power devices can be permitted on TV channels 14-20.[29]

Also disappointing to advocates of unlicensed use of the white space was the Commission's decision to invite comment on the desirability of requiring licensing for

devices operating in the TV bands, in spite of its original NPRM's proposal favoring unlicensed use and the fact that a majority of the proceeding's commenters have expressed interest in such unlicensed uses.

The FNPRM also sought comment on the proposed mechanisms for avoiding interference with broadcast signals, including the use of geo-location technology, control signals, and spectrum sensing. As discussed later in this report, issues related to these interference control mechanisms are closely tied to questions about what white space channels should be opened up for use, and whether such use should include personal/portable devices.

In a later section of the report we will revisit the FCC's white space FNPRM, including analysis of the comments and reply comments filed by interested parties during the first two months of this year.

Moving Toward the Negroponte Switch

The TV broadcast spectrum which, because of its propagation characteristics, is considered prime spectrum real estate, is, by virtually any measure, used very inefficiently.

For one thing, much of this band is unused, being set aside as "guard bands," (a.k.a. "taboo channels" or "white space"), whose purpose is to avoid interference with stations using nearby channels in the band or stations in adjacent TV markets using the same channel.

A vast spectrum wasteland?

While different estimates of broadcast white space have been developed based on somewhat different methodologies, they all suggest there is a large amount of high-value spectrum sitting fallow. For example, a 2005 study done by Shared Spectrum Company for the National Science Foundation found that, on average, only 23% of spectrum was being used for TV channels 14-51. Another study by Free Press and the New America Foundation found that an average of seven full-power stations operate in local TV markets. For the 22 markets included in the study, the number of vacant channels after the DTV transition ranged from 15 (90 MHz) to 41 (246 MHz), the equivalent of 30-82% of total spectrum in the TV band.[30]

A more recent and comprehensive study conducted by the Brattle Group and consulting engineer Charles Jackson, with support from Qualcomm, found generally similar results. It estimated that the average amount of unused spectrum in the nation's 52 Major Trading Areas ranged from 140 MHz in the New York MTA to 252 MHz in Wichita, with the majority of MTAs averaging more than 200 MHz, the most concentrated MTAs averaging around 150 MHz, and a national average of 188 MHz. The Brattle Group study also estimated the minimum amount of unused spectrum across all areas within an MTA. This measure ranged from a low of 78 MHz for New York, San Francisco and Philadelphia, to a high of 222 MHz for Wichita, with only 17 MTAs having minimum availability of less than 150 MHz.[31]

On a nationwide basis, the Brattle study found that there was at least 108 MHz of unused spectrum covering 95% of the nation's total population, with at least 78 MHz available nationwide. For more than half of the country's population, unused broadcast spectrum amounted to at least 192 MHz.

While there remain key questions about how much of this unused spectrum can be used without risking interference to broadcasters, the above studies suggest that the potential pool of high-quality spectrum that currently lies fallow in the broadcast band is quite substantial. The studies also show that, in general, there is more unused spectrum in smaller broadcast markets.

Fewer homes served by TV spectrum

Another aspect of inefficiency that characterizes the broadcast spectrum band is the percentage of the population that actually makes use of it. In an October 2005 policy paper, Jim Snider of the New America Foundation used data from NCTA, SBCA, the FCC and the Census Bureau to compare the percentages of U.S. TV households that subscribe to cable or satellite TV services versus those that rely on over-the-air signals to receive their TV service. According to Snider, the latter declined from roughly 33% (31.5 mil.) in 1994 to less than 15% (16.1 mil.) in 2004, while the former increased from 67% (63.9 mil.) to 85% (92.3 mil.).[32]

While this trend is dramatic when viewed over the course of a decade, it is even more so when we consider that the percentage of homes depending on OTA broadcasting has declined from nearly 100% in the early 1970s.

From a public policy perspective, it's important to keep in mind that the grant of TV broadcast licenses was made: 1) at a time when over-the-air broadcasting was the only method to bring TV service to the nation's homes; 2) without broadcasters paying for the privilege of being the sole user of extremely valuable spectrum and; 3) contingent on broadcasters serving "the public interest, convenience and necessity, a requirement that, to a large extent, has been scaled back over the years to become arguably meaningless.

Some useful reference points for considering the relative efficiency of broadcast spectrum use in terms of trends in the number of end users served are:

> 1) According to the FCC, during the six year period from 1999-2005, mobile subscribers increased from less than 80 million to more than 200 million.
>
> 2) Data from the Telecommunications Industry Association shows annual sales of unlicensed wireless home networks skyrocketing from 7 million to 45 million units in the three year period from 2003 to 2006. This rapid ramp of technology adoption suggests that American consumers perceive a very high value-to-cost ratio in this application of unlicensed spectrum.

Clearly, the large amounts of unused spectrum and the low and declining percentage of households dependent on over the air broadcasting translate into very inefficient use of broadcast spectrum in terms of the number of end users per MHz of spectrum.

The increasingly clear nature of these inefficiencies is reflected in the perspective sometimes referred to as the "Negroponte switch," named after Professor Nicholas Negroponte of the MIT Media Lab who, along with George Gilder, was one of its earliest proponents.

The "switch" reflects two parallel trends: 1) increasing numbers of mobile devices require connectivity and; 2) the bandwidth of wired networks expands at relatively rapid rates, thanks in large part to more intensive use of high-capacity fiber optics.

Given these two dynamics, it becomes increasingly inefficient to deliver broadcast signals to fixed locations via wireless. The Negroponte switch refers to a point in time when the more limited bandwidth of wireless would (or at least should) be reallocated to mobile applications, while delivery of video and other high bandwidth services would be delivered to homes and other fixed locations via wired networks.

While the Negroponte switch makes compelling sense in theory, it confronts significant challenges in terms of real-world execution. As discussed more fully later in this report, the development of sound policies related to the broadcast white space can play a key role in moving the country more quickly and smoothly in the direction of this "switch," and its promised benefits.

Broadcasters as content providers

A key characteristic of the television broadcast sector as it has evolved over the decades is that stations' core business is essentially to produce and schedule programming and package it with advertising. As noted above, this programming has, over time, been delivered to an increasing share of its viewers via non-OTA distribution outlets.

As noted earlier, most non-OTA distribution today occurs through cable and satellite networks. While cable has played this role for decades, satellite providers have moved in recent years to expand their delivery of local broadcast stations to roughly 95% of the country. And, most recently, they have also begun to add local HDTV broadcast channels to their satellite lineups, with plans to offer both standard and HD resolution local channels to most if not all of the country by the time broadcasters complete their transition to all-digital transmission in early 2009. As a result, households in most of the nation have at least two other options for receiving local TV programming beyond OTA broadcasting.

Broadcast networks are also beginning to make some of their programming available via broadband Internet connections, either on their own web sites, or via independent services developed by Apple, Google, AOL, Yahoo and an expanding assortment of smaller entities. And, as they move in this direction, they are, to varying degrees, working with their local affiliate stations to develop new business arrangements that allow these stations to share in the revenue streams generated by broadband distribution.

For example, ABC began last fall to allow local affiliates to stream the network's primetime shows, including an opportunity to retain a portion of advertising slots packaged with the web-delivered programs.

About a month earlier, Fox began streaming programs on the web sites of its owned and operated stations. This was followed in late February by an expansion of this streaming to Fox's entire base of more than 200 affiliates. Under the new deal, affiliates will be able to stream ad supported programs, or download programs for a fee. For streamed content, affiliates will be able to sell nearly a third of ad inventory. For downloaded content, affiliates will retain a portion of revenues, with prices of single episodes expected to be in the $1.99 range and full seasons selling for $30-$40.

Broadcast programming has also begun showing up on mobile devices, including newer generations of cellular phones, which are typically upgraded every two years, as well as Apple's hugely popular iPods. With new "cellular broadcast" technologies like Qualcomm's MediaFlo being deployed by major carriers, this trend is likely to accelerate in the future.

Charging for carriage

Inherent in this expansion of distribution platforms is a migration by broadcasters away from the free OTA model that originally justified their spectrum grant, to one in which they negotiate deals with non-OTA distributors for carriage of their programming. While this is already typical for emerging platforms like the Internet and cellular, and also for satellite broadcasters, it is also becoming the case for what has long been the dominant mode of broadcast distribution—cable carriage.

In recent months this trend can be seen in increasingly aggressive negotiations by broadcasters seeking "retransmission consent" payments from cable operators that carry their programming. An example of this is Sinclair Broadcast Group's recent hard-ball negotiations with Mediacom, a mid-sized cable operator. According to news reports, it was ultimately the threat of having its subscribers lose access to the Super Bowl that forced Mediacom to give Sinclair all of or most of what it sought in the negotiations.

Shortly after the dust settled on its face-off with Mediacom, Sinclair negotiated a four-year carriage deal with Comcast, the nation's largest cable operator. Financial terms of that deal were not disclosed by the companies. Sinclair had previously struck a retransmission deal with number-two MSO Time Warner that is believed to have included at least some cash payments. A range of other broadcasters and cable operators have also either struck or are negotiating retransmission consent deals that involve some payment by cable operators.

Satellite providers already pay broadcasters retransmission fees, and Verizon is believed to be paying CBS $0.50 per month per subscriber to carry the latter's TV stations on Verizon's FiOS TV service. It's worth noting that this is an amount comparable to what is paid for some non-broadcast (a.k.a., "cable") channels carried by satellite and cable operators.

In discussing the trend toward retransmission payments, CBS CEO Les Moonves last year predicted that his company will earn hundreds of millions of dollars in extra revenue from retransmission fees paid by cable, satellite and telecom companies.

To the extent retransmission payments proliferate in the industry—something that seems likely to be the case—every household that switches from OTA reception to some other mode of program delivery could actually yield an increase in revenue for local broadcasters.

This suggests that, over time, broadcasters may have a financial incentive in seeing an expansion of the longstanding migration from OTA delivery. This has significant implications for a potential "Negroponte switch," in that broadcasters, while presumably

always reluctant to limit their spectrum rights, will at least have an offsetting benefit for every lost OTA viewer that continues to view their programming on an alternative delivery platform.

The shift to end-user control

Another related and important trend is the migration of television viewing away from the traditional broadcast model where programmers are in control of viewers' access to content by means of linear scheduling in a broadcast architecture. This trend is tied to expansion of non-OTA distribution options, including Internet and cellular delivery and cable video on demand (VOD) offerings. It is also tied to the growing market adoption of devices like digital video recorders (DVRs).

While some of this change reflects a shift to "on-demand" delivery technologies by service providers, the use of DVRs and similar "intelligent reception and storage" devices can provide end users with increased control over their viewing schedules even if content is delivered via traditional linear broadcasts. These devices eliminate the need to watch programs when they are broadcast, by allowing viewers to schedule recordings in advance and watch them at their convenience, in a manner far more user-friendly than what was previously available from VCRs. Though estimates vary, it seems likely that DVR penetration hit the double digit range by yearend 2006, with some projections showing this increasing to a third of total homes in the 2008-2010 timeframe.

While DVR-based viewing is more accurately described as "time-shifted" rather than true "on-demand" viewing, it represents an increasingly popular approach to providing viewers more control over content management and scheduling. And, because DVRs and similar devices can be married to either broadband or broadcast distribution networks, they can help facilitate a migration to an overall content delivery architecture that makes most efficient use of both types of networks.

For example, a broadcast architecture might be the most efficient way to deliver broadly popular and widely viewed content to end user-controlled "intelligent reception and storage" devices. But the most efficient architecture for these same devices to access "long-tail" content (i.e., content sought by relatively small numbers of viewers) might be to use a broadband network.

Another aspect of efficiency aided by these devices is that they allow content distribution to be scheduled in ways that balance network traffic. To the extent viewers are willing to accept time delays between their requests for content and their viewing of it, content can be delivered during off-peak periods. This can help balance traffic loads and thereby reduce the peak capacity a network must be designed to support.

The long-term significance of the shift to increased end-user control is demonstrated by an anecdote reported in a January 22, 2007 article on CNET News.com.

> Jonathan Steuer, a researcher at Iconoculture, has a 5-year-old daughter who recently asked to watch one of her shows while they were visiting a friend's house.

> Because the friends didn't own a TiVo, "I had to explain to her the show wasn't on there," he said. "You've got a generation of kids who've had an unprecedented amount of control of their media and they're not going to give it up," Steuer said.[33]

This story suggests a future in which the longstanding practice of watching television shows when they are broadcast will eventually become relegated to sports programming and other live events, which many viewers will continue to want to watch at the time they occur.

One implication of all these related trends is that there will likely come a time when most viewers will prefer to watch video programming in a real-time or prescheduled on-demand mode on the screen of their choice, whether it be a large flat panel monitor in their living room, a widescreen laptop or desktop computer, a cellphone, or any number of video-capable mobile devices.

What we are seeing today with RSS (Really Simple Syndication) and similar technologies on the Internet is an indicator of where this trend is headed. RSS allows Internet users to "subscribe" to web sites, blogs and publishers of web-delivered audio and video. These subscriptions enable them to receive automatic updates when new content becomes available from these sources.

To the extent broadband and broadcast distribution systems become better integrated, it will become increasingly feasible to harness a variety of "ordering" modalities (e.g., RSS/subscription, on-demand, linear scheduling, etc.) to a mix of broadcast and broadband delivery platforms in ways that provide high levels of both network efficiency and consumer choice, control and convenience.

New advertising models

Another related trend that could help push the video industry in the direction of a Negroponte switch is the increased dissatisfaction of advertisers with the large but unknown amount of waste in broadcast advertising (as reflected in the old saying "I know I'm wasting half my advertising budget, I'm just not sure which half).

As the better-targeted and more accountable advertising technologies developed by Google and others expands into the video realm (a process already underway on multiple fronts), both advertisers and broadcasters may find it in their interests to see this model displace the traditional mode of buying TV ad time. And while targeting can be applied in a "scheduled viewing" broadcast mode, it can become even more refined and specific in on-demand, broadband and mobile modes, which can take into account viewer intentions, locations and other factors.

While this transition in the video advertising market will take time and may face significant bumps in the road, it does seem likely to happen, given that it will be supported by the other related trends discussed above.

White space and a Negroponte "migration"

Though there may never be a single moment in time where the Negroponte switch occurs en-masse, the intense and growing demand for expanded broadband coverage, capacity, mobility and end-user control—coupled with the woefully inefficient use of prime spectrum for TV broadcasting discussed above--cries out for policies that can expedite that shift.

As discussed more fully later, one initial and important step in what might be described as a "Negroponte migration" would be to employ white space spectrum as much and as quickly as possible to the task of delivering universal, high-capacity Internet connectivity.

The combination of trends discussed above suggests possible further steps in a Negroponte migration, including the possibility that broadcast spectrum beyond the white space channels could eventually be reclaimed without causing significant harm to broadcasters' business models.

For example, it seems fairly likely that, after the digital conversion, OTA viewership will continue to decline and that the programs carried on broadcasters' new "digital multicast" channels will attract an even smaller share of this declining OTA audience. It also seems likely that, parallel to this continued erosion of OTA audiences, there will be increased amounts of on-demand and time-shifted viewing (in some cases coupled with targeted advertising) that employs a range of distribution platforms and end-user devices.

In such a world, it will become increasingly inefficient for each local broadcast station to control a full 6 MHz of spectrum. While broadcasters will presumably always be reluctant to reduce their claims to valuable spectrum, it seems possible that the industry shifts described above could reach a point where it becomes clear to policymakers that broadcasters' business models are evolving in ways that can justify a consolidation of primary digital signals from multiple broadcasters onto a single 6 MHz channel.

Other things being equal, one would, of course, expect broadcasters to fight such a move with the same aggressive protectiveness they've shown in past policy debates over spectrum rights. But, to the extent this "reclaimed" broadcast spectrum was used in ways that benefited broadcasters, they would presumably fight less hard, and perhaps even choose to cooperate with such reallocation of broadcast spectrum.

One benefit to broadcasters from a consolidation of local stations' primary digital feeds on fewer 6 MHz channels would presumably be a reduction in each station's operating costs. It is also possible that, after such a consolidation, viewers would be able to access local stations' content in a variety of ways that enabled the latter to achieve healthy revenue growth from an expanded mix of sources, including traditional and targeted advertising, carriage fees and end-user fees.

As noted above, it seems highly likely that broadcasters will remain very reluctant to give up any of the spectrum rights granted to them by Congress and the FCC. But the scenario described above could provide a basis for these same policymakers, in concert with

interested parties, to craft workable solutions for expanding the Negroponte migration to include more and more of the broadcast band.

Later in this report we discuss the possibility of establishing "Public Interest IP" networks that would provide Internet connectivity using broadcast "white space" spectrum. Given their focus on community service and their experience managing a wireless network, these entities would seem well suited and appropriately motivated to work with broadcasters in planning and executing a win-win Negroponte migration.

Part 2: Broadband Internet Demands New Policies

The FCC is considering the options for use of broadcast "white space" at a critical time in the evolution of this nation's communications industry.

Though there is widespread agreement that the Internet is a powerful facilitator of economic growth and value, there is intense debate over public policies related to the next phase of its evolution, and its increasingly central role in the communications sector and the economy as a whole. It is the author's contention that the FCC's pending white space proceeding provides a unique opportunity to move this debate toward a constructive resolution, and the final chapter of this report outlines some proposals designed to take advantage of that opportunity.

To help set the stage for these proposals, this section of the report considers a range of policy issues related to broadcasting, spectrum, the Internet, broadband networks and communications in general.

Telephone, TV & the Internet

While the history of telephony and broadcasting predate the Communications Act of 1934, this legislation, written in the days when television was a new technology but not yet an industry, created the basic foundation upon which today's electronic communications industries have been built.

The 1934 Act created the FCC, which took on from the Interstate Commerce Commission (ICC) responsibility for regulating the telephone and telegraph industries. The newly created Commission was also given responsibility for regulating broadcasting, which had previously been the job of the Federal Radio Commission (FRC), which had been established seven years year earlier, by the Radio Act of 1927.

The basic regulatory model adopted for telephone service, as reflected in Title II of the 1934 Act, was one of common carriage, where service is provided to all comers at regulated rates, and where the direct and indirect (i.e., network effect) benefits of adding users to the network led to regulatory policies favoring universal service, including a structure of subsidies to support such service. Over the years, the latter has grown quite complex, political and, in the view of some critics, inefficient and subject to abuse.

As discussed earlier in this report, the model adopted for broadcasting, expressed in Title III of the Act, reflected an expedient but unwieldy compromise between those who favored a common carriage model (including politicians, educators, labor activists and religious groups) and existing broadcasters. The latter, who sought to maintain editorial control and develop the commercial potential of national broadcast networks, pushed for Congress to grant them full free speech rights in the broadcast medium and to avoid common carrier requirements.

As explained on the NTIA's web site:

> The 1934 Act, which continues to be the charter for broadcast television, ratified a fundamental compromise by adopting two related provisions: a ban on "common carrier" regulation (sought by broadcasters) and a general requirement that broadcast licensees operate in the "public interest, convenience and necessity" (supported by Congress and various civic, educational and religious groups). The phrase was given no particular definition; some considered it necessary in order for the government's licensing powers to be considered constitutional.

When originally adopted by Congress, both regulatory models were logical approaches to the technical constraints of the relatively young industries to which they were applied. In broadcasting, this included the scarcity of spectrum, the high cost of transmitters and national networks and, for the still-nascent television sector, the significant financial and technical resources required to produce program. In wireline telephony it involved the high fixed costs and low variables costs that led many to view it as a natural monopoly. That view was reflected in the guiding principle espoused by AT&T's early president, Theodore Vail, that "one system, one policy, universal service" would maximize the network's efficiency and overall value.

Old regulatory models grow obsolete

In the decades since 1934, the shortcomings of both models have become apparent. As discussed earlier, the undefined "public interest" compromise set in law for the broadcast sector remained a chronic source of tension between broadcasters and other interests who sought, among other things, access to the media, more balance and diversity in programming, or to eliminate content they viewed as indecent or harmful to children or to the overall public interest.

The challenges of trying to define and implement the public interest standard were compounded by a number of factors. These included the legal truism that "possession is 90% of the law" (broadcasters had control of the spectrum), the realities of "regulatory capture" (i.e., a dynamic that leads regulatory bodies to primarily serve the interests of the entities they are intended to regulate), and the growth of unregulated cable TV channels as an alternative source of video "voices" (which, in the view of some, weakened the "scarcity" argument that helped justify broadcasters' public interest obligations). As a result, the compromise was at best an uneasy and challenging one to implement and, at worst, a pro forma charade designed to minimally satisfy the vaguely worded letter of the law.

Given this, it is not surprising that, as deregulatory theories and policies came into ascendance in the 1980s, the Fairness Doctrine—one of the core strategies for implementing the public interest requirement—was abandoned, along with other requirements related to "public interest" programming, advertising time and various elements of the license renewal process.

On a parallel track to broadcasting's struggle with and eventual migration away from the 1934 Act's public interest requirement, was the slow evolution of the telephone industry and its body of regulation and related case law.

Since, as a common carrier, its rates were set by the FCC (for interstate communications) and state regulatory bodies (for intrastate communications) on a cost-plus basis, the telephone industry became notorious for its inefficiencies (as a seriously underworked temporary employee of Mountain Bell many years ago, the author can vouch anecdotally for such inefficiencies).

And while Ma Bell become known for gold-plated reliability standards, she also became notorious for seeking to control every aspect of her network, to the detriment of technology and service innovation. The 1956 Hush-a-Phone v. FCC court case and the FCC's 1968 Carterphone decision were two key turning points in the loosening of that control. Whereas AT&T had previously claimed the 1934 Act allowed it to "forbid attachment to the telephone of any device 'not furnished by the telephone company,'" these two rulings made it clear that devices could legally be connected to the AT&T network, as long as they did not cause damage to the system. Over time, this opened up new markets for devices like answering and fax machines, cordless phones and computer modems and, in key respects, the rise of the dialup Internet.

Even with the telephone network opened up to new devices, the realities of monopoly power, cost-plus rate regulation, and the growing complexity and costs of the associated regulatory systems, compounded by the realities of "regulatory capture," continued to take their toll on industry efficiency, competition and innovation.

For example, the inherently arbitrary nature of cost allocations in the high-fixed cost telephone industry made for extremely long and expensive price setting proceedings in which political influence was too often reflected in regulators' decisions. And, because it owned the network and the data concerning its internal operation and costs, the incumbent telcos enjoyed inherent advantages in these regulatory proceedings. And, as one would expect, they developed well-staffed regulatory and government relations units, whose salaries generally proved to be very good investments for AT&T.

The days of Ma Bell ended in 1984, with the AT&T divestiture, the culmination of a 10 year old antitrust suit. The case was finally settled by a Modified Final Judgment that split the company into a long-distance company and seven regional operating companies (RBOC), often referred to as Baby Bells.

The 1996 Telecom Act

About a dozen years after the AT&T breakup, Congress passed the Telecommunications Act of 1996. In broad terms, the intent of Congress in passing the Act was to update what was viewed as a largely outdated regulatory structure in the telecom and media industries.

The immense task of implementing specific rules and rule changes mandated by the Act was given to the FCC.

The Act's primary mode of achieving its goals was to lessen regulation in and across the effected industries, with the hope that deregulation would lead to increased efficiencies, innovation and competition. The latter was expected to include increased competition between cable and telephone companies, who would be free to invade each other's core markets (video for cable and voice for telcos). Also foreseen was the prospect of competition among the major ILECs, through entry into each others' service areas. The Act also sought to promote competition from new market entrants in the telecom arena, including both facilities-based and non-facilities-based service providers.

On the broadcasting side, the Act moved to broadly lift or loosen ownership restrictions, based on the belief that this would generate increased efficiencies and that there was enough diversity of "voices" in the market to protect the First Amendment right of the public to have access to a diversity of views, even with additional concentration in the electronic media.

It's worth noting that, as the provisions of the Act were being drafted, the World Wide Web was still in its infancy, following the release of the Mosaic browser in 1993, which was followed by the more commercially-oriented Netscape Navigator in 1994, and the high-profile IPO of Netscape Communications in 1995. At that time, few could have predicted the Internet's evolution and impacts on the telecom and media sectors.

While the Act may have had lofty goals, its final provisions largely reflected the hard-nosed and hard-fought compromises struck among major industry players, all of which sought deregulation for themselves, but not for competitors who might encroach on their markets. It's also worth noting that, while it was a bipartisan bill, some of its final revisions reflected the notably more deregulatory leanings of the Republicans that took control of the House in 1994.

The law included changes impacting broadcasting, cable and telecommunications. On the broadcast and cable side it:

1. Removed the limits on radio station ownership.
2. Removed the limit on the number of TV stations a company could own and expanded the limit on audience reach to 35%.
3. Deregulated rates for non-basic cable services and allowed the FCC to relax bans on broadcast-cable telephone-cable cross-ownership.
4. Provided broadcasters with digital TV licenses at no charge, subject to the later return of their analog spectrum. The FCC subsequently set a 2006 date for return of the spectrum but, in 1997, broadcasters won Congressional language allowing them to keep the analog spectrum until 85% of viewers in their markets are receiving digital signals. Then, in February 2006, roughly a decade after the law was passed, Congress finally established February 17, 2009 as a firm date for return of the analog spectrum.

5. Provided telcos two options for entering the video market: a common carrier-like approach dubbed "open video systems," or as a conventional cable operator.

On the telecom side, Section 271 of the 1996 Act provided a process for the RBOCs to enter the in-region long distance market. This entailed requirements for interconnection agreements and a number of other steps and conditions that must be met and that became known as the "competitive checklist." To facilitate competition in the local telephone market, the Act imposed mandatory requirements on the RBOCs, including interconnection, unbundling and number portability.

While a key goal of the Act was to encourage telco entry into video and cable entry into the voice market, this did not occur on a wide scale for nearly a decade following its passage.

Though Cox and AT&T began offering voice service in some markets during the late 1990s, cable's voice footprint remained relatively small until operators began deploying VoIP-based services a few years ago.

And while RBOCs took a number of initial steps geared toward offering on-network video services (including relatively modest investments in FTTH, FTTN, HFC and wireless broadband), they ended up not pursuing any of these network strategies with a long-term program of investment. Instead, they spent most of the decade following passage of the Act focused on large scale mergers, the pursuit of long-distance entry, DSL deployments to counter cable's early edge in broadband, and the regulatory battles related to these new markets and to the maintenance of their core voice business. As with cable's broad entry into the voice market, it took nearly a decade for the nation's two largest RBOCs (which by then encompassed six of the seven original Baby Bells, GTE, AT&T and MCI) to get serious about upgrading their networks to support a serious assault on cable's core video business.

The squeeze on new entrants

One of the more controversial outcomes of the Act from the RBOC's perspective was the imposition by the FCC of requirements that ILECs provide an unbundled network element-platform (UNE-P) service to competitors at rates set by state regulators. The RBOCs claimed that these UNE-P rules, especially the relatively low rates set in some states, effectively forced them to subsidize their competitors. These competitors countered that UNE-P was a part of the bargain the RBOCs had struck during the negotiations that led to passage of the 1996 Act that had opened the door for them to enter the much-coveted long-distance market.

In the wake of the 1996 Act, competitive local exchange carriers (CLECs) began to sprout up around the country, offering service through a mix of their own facilities (typically in areas with high concentrations of large business customers), a combination of their own switches and ILEC loops, or resale of ILEC lines, mainly through UNE-P arrangements. Then, beginning in 2000, investors began to sour on what became viewed as an "over-exuberant" competitive telecom sector, in what came to be known as "The Telecom

Meltdown." The result was a rash of CLEC bankruptcies and survival-focused mergers. According to one source, approximately 20 telecom companies sought bankruptcy protection in 2000, followed by 77 more in 2001. In 2002, the bankruptcies continued to expand, reaching some very large and high-profile players, including Worldcom, Global Crossing, Williams Communications, 360networks, XO Communications, Winstar and Genuity.

As large numbers of facilities-based players in the CLEC and IXC sectors (and some of their equipment vendors) struggled to survive in the early years of the decade, UNE-P emerged as a major driver of CLEC growth, especially in those states with the most heavily-discounted UNE-P rates.

But, even as UNE-P was driving substantial RBOC retail line losses, the latter's legal challenges were winding their way through the courts, with the U.S. Court of Appeals in D.C. rejecting the FCC's UNE-P rules multiple times. This prolonged legal fight culminated in a December 2004 party-line vote by the Commission to phase out its UNE-P requirements over the course of the following year. In the wake of the FCC's decision, AT&T and MCI stopped selling UNE-P lines, then stopped actively marketing mass market long distance service and, most recently, were acquired by the nation's two largest RBOCs--AT&T by SBC and MCI by Verizon. Then, not too long after acquiring AT&T, SBC announced it would do the same with BellSouth, in a deal that closed in the final days of 2006. As that year drew to a close, there remained only three Baby Bells—AT&T, Verizon and the much smaller Qwest, each of which was evolving into an increasingly integrated combination of ILEC and IXC operations.

On a parallel track to the multi-phase evisceration of the CLEC market was a similar trend in the still-young broadband ISP market.

The first major step on this front was a 2002 FCC ruling that the broadband services offered by cable operators are "information services" (as distinguished from telecommunication services that are subject to Title II common carrier regulation). This meant that cable operators were not required to allow competing ISPs access to their networks. The decision attracted an immediate challenge from a California-based ISP named Brand X. In 2003, the 9th Circuit Court of Appeals overturned the FCC in favor of Brand X. The FCC, supported by the Justice Department, appealed the decision. In a June 2005 decision, the Supreme Court, in a 6-3 decision, overturned the Appeals court

The majority decision, written by Justice Thomas, did not speak directly to the substance of the FCC's ruling. Instead, it relied mainly on what is sometimes know as the "Chevron deference" doctrine. As Justice Thomas put it, "If a statute is ambiguous, and if the implementing agency's construction is reasonable, Chevron requires a federal court to accept the agency's construction of the statute, even if the agency's reading differs from what the court believes is the best statutory interpretation."

The Court's Brand X ruling left a clear imbalance between the regulatory treatment of cable-delivered broadband services and competing services delivered by ILECs, which remained subject to Title II common carrier requirements. In August 2005, the FCC

removed this imbalance by ruling that ILEC-delivered broadband services, like their cable counterparts, were "information services functionally integrated with a telecommunications component."

"Neutrality" and "Internet Freedoms"

Accompanying its ruling on ILEC broadband services was a "policy statement" by the FCC that echoed the four "Internet Freedoms" first enumerated in February 2004 by the agency's former chair Michael Powell. The Commission also issued a Notice of Proposed Rulemaking seeking comments on "whether it should develop a framework for consumer protection in the broadband age."

The policy statement laid out the following principles (the corresponding "Internet freedom" proposed by Powell is provided in parentheses):

> 1. Consumers are entitled to access the lawful Internet content of their choice (Freedom to access content).
>
> 2. Consumers are entitled to run applications and services of their choice (Freedom to run applications).
>
> 3. Consumers are entitled to connect their choice of legal devices that do not harm the network (Freedom to attach devices).
>
> 4. Consumers are entitled to competition among network providers, application and service providers, and content providers (Freedom to obtain service plan information).

The policy statement said that, while the Commission did not adopt rules to enforce these "consumer rights", it would "incorporate these principles into its ongoing policymaking activities." It also noted that all the principles "are subject to reasonable network management" on the part of broadband network operators.

From a practical perspective, the FCC's regulatory treatment of incumbents' broadband services was a tacit acceptance of a vertically-integrated duopoly market structure for broadband access service, with the possibility left open that the Commission might, at some future date, adopt rules reflecting the "network neutrality" principles in its policy statement.

More recently, the Commission took another small step toward dealing with the network neutrality question, which appeared to reflect a compromise between its Republican majority and Democratic minority. On March 22, it began a Notice of Inquiry seeking information on "broadband market practices," including how broadband providers are managing Internet traffic on their networks and price and package their services. The NOI also invited comments on whether the FCC's earlier policy statement should incorporate a new principle of nondiscrimination and, if so, how this principle would be defined. When the NOI was announced, Democratic Commissioners Copps and Adelstein expressed

frustration that the Commission had not taken the more active step of issuing a Notice of Proposed Rulemaking.

During the past year or so, the definition and desirability of network neutrality rules have become perhaps the most hotly debated issue tied to telecom and Internet policy. In the author's view, the intensity of this debate reflects a growing sense among many Americans--including some in Congress and at the top levels of the FCC, and from both liberals and conservatives--that there is a fundamental conflict between the open-access, neutral design of the Internet, and a vertically integrated duopoly access market in which broadband Internet access is treated as an unregulated "information service functionally integrated with a telecommunications component."

The coalition that emerged in support of network neutrality was similar in its breadth and bipartisanship—and apparently in motivation--to the coalition that in 2003 had challenged proposed FCC rule changes that would have further loosened the Commission's media ownership rules. In 2004, a federal appeals court rejected most of the Commission's proposed rule changes, saying the agency had "not sufficiently justified its particular chosen numerical limits for local television ownership, local radio ownership, or cross-ownership of media within local markets." The court's decision left open the possibility that the FCC could change the rules if it could more fully justify such changes.

Public opposition to the Commission's proposed loosening of media ownership rules reportedly included nearly 3 million letters sent to the FCC and Congress, many of them expressing much of the same fundamental concern that later helped fuel the Internet-focused network neutrality debate. That concern harkens back to the initial First Amendment debates that led to the 1934 Communications Act's largely-failed compromise seeking to grant exclusive spectrum licenses in exchange for vaguely-worded public interest requirements. In key respects, the current uproar over network neutrality is an Internet-era version of those earlier heated debates.

Though the question of imposing network neutrality rules on incumbent network operators is not the focus of this report, the value of "neutrality" in the provision of broadband access is a core element of the proposal contained in the report's final chapter, and of the policy analysis presented later in this section of the report. But before delving into these policy questions, we first consider some statistics on how the U.S. broadband sector has performed in comparison to its counterpart in other industrialized nations.

U.S. a broadband laggard

As many commentators--including FCC Commissioner Michael Copps--have noted, the U.S., though the birthplace of the Internet and still a high-tech leader, has become a broadband laggard. As discussed further below, the nation's ranking is disappointingly low and, in most cases, has declined, in terms of service penetration, availability, bit rates and the monthly price per unit of capacity.

Broadband penetration

Data published by both OECD (Organization for Economic Cooperation and Development) and ITU (International Telecommunications Union) show that the U.S. ranking in broadband penetration has fallen significantly since early this decade. OECD data, for example, shows the U.S. ranking fourth in 2001, then falling to eighth in 2002, tenth in 2003 and even further to 12th in 2004, where it remained through mid-2006. Recently released OECD data for yearend 2006 showed the U.S. rank falling even further, to 15th.

Similarly, ITU data has the U.S. ranked 11th in 2002, 13th in 2003 and 16th in both 2004 and 2005. And, according to a November 2006 Washington Post column by FCC Commissioner Michael Copps, the U.S. ranked 21st, right after Estonia, on the ITU's "digital opportunity" index. According to the ITU's web site, this index is based on 11 "Information Communication Technologies" indicators, grouped in three clusters: opportunity, infrastructure and utilization.

While these various metrics may be calculated somewhat differently and apply to a somewhat different mix of countries, their trend lines and ranking of the U.S. are very similar and also very sobering.

Some have suggested that our country's low ranking on broadband penetration metrics is a function of low population density, income and age. In a recent article in Information Week, Richard Hoffman challenged such rationales, based on a review of the mid-2006 OECD data and other sources. As he noted, "five of the 11 nations that lead the U.S. in per capita broadband penetration, including Iceland, Finland, Norway, Sweden, and Canada, have significantly lower population densities than the U.S." As to income, noted Hoffman, OECD ranked the U.S. 12th on broadband penetration, even though it ranked second on the OECD's measure of per capita gross domestic product (GDP). As he put it, "As a rule, prosperity clearly correlates with broadband access, but the United States is comparatively more affluent than most of the nations it trails in the broadband arena."[34]

Hoffman also considered age, which is also believed to be related to broadband penetration:

> A third demographic possibility which could affect the analysis of broadband adoption rates is median age of the population. There are indications that lower age tends to correlate with heavier Internet use in general, and broadband use specifically, as younger users tend to be more likely to be early adopters of new products and technologies. Yet the latest data from the U.S. Census Bureau indicates that the U.S. has a statistically younger population based on median age than all the countries -- except Iceland and Korea -- that are ranked higher for broadband adoption.

Hoffman concluded that, while the U.S. "is still a powerful innovator and test bed for advanced research and development…[it] isn't even close to being the leader in widespread broadband availability and usage and, in fact, may be dropping further behind the 'first tier' of broadband-rich countries in Northern Europe and Asia."

Broadband availability

One reason for the relatively low broadband penetration in the U.S. relates to the availability of broadband service.

For a number of years, the FCC has released semi-annual reports on the status of broadband deployment and competition. Since it began this practice it has reported broadband availability in terms of the percentage of zip codes in which service providers reported at least one broadband customer. In the wake of widespread criticism of this methodology as too crude and too likely to overstate the real extent of broadband availability, the Commission began including (starting with mid-2005 data), a more precise measure of the availability of DSL and cable modem service. These two modes of broadband access together account for more than 95% of total broadband subscribers counted by the FCC, when we exclude customers served by 3G mobile networks. Though the Commission recently began including the latter in its broadband counts, their data rates are typically far below those offered by DSL and especially cable modems.

On the mobile front, it's also worth noting that, according to World Bank data, the U.S. ranks only 49th in the world in terms of per capital penetration of mobile phones, and has tended to lag behind European and especially Asian markets in terms of deploying 3G-enabled broadband services.

The table below provides the FCC's most recent DSL and cable modem availability data (as of mid-2006) on a state-by-state basis. The column providing "xDSL" availability data includes both asymmetric and symmetric DSL.

According to the FCC, the estimates in both columns are weighted averages of the availability percentages that ILECs or cable system operators report for the areas they serve. Reported xDSL availability is weighted by ILEC end-user switched access lines, while reported cable modem availability is weighted by cable TV subscribers. The weighted averages include ILECs or cable system operators that report no availability.

Availability of DSL and Cable Modem Service by State (as of mid-2006)

State	DSL (1)	Cable Modem (2)
Alabama	78%	91%
Alaska	78%	*
Arizona	67%	91%
Arkansas	66%	77%
California	86%	97%
Colorado	82%	96%
Connecticut	*	0.84
Delaware	*	*
District of Columbia	*	*
Florida	88%	96%
Georgia	87%	89%
Hawaii	*	*
Idaho	76%	83%
Illinois	78%	97%
Indiana	74%	94%
Iowa	83%	89%
Kansas	80%	86%
Kentucky	85%	91%
Louisiana	87%	87%
Maine	67%	89%
Maryland	75%	98%
Massachusetts	*	0.99
Michigan	66%	92%
Minnesota	81%	91%
Mississippi	73%	79%
Missouri	72%	96%
Montana	76%	83%
Nebraska	86%	91%
Nevada	85%	*
New Hampshire	59%	83%
New Jersey	88%	100%
New Mexico	75%	79%
New York	78%	99%
North Carolina	83%	95%
North Dakota	86%	79%
Ohio	81%	95%
Oklahoma	75%	88%
Oregon	81%	90%
Pennsylvania	82%	94%
Rhode Island	*	*
South Carolina	78%	84%
South Dakota	76%	58%
Tennessee	81%	95%
Texas	75%	95%
Utah	82%	*
Vermont	60%	*

Virginia	66%	96%
Washington	80%	94%
West Virginia	68%	88%
Wisconsin	76%	96%
Wyoming	77%	*
Nationwide	79%	93%

* Data withheld to maintain firm confidentiality.
(1) % with DSL availability where ILECs offer phone service, includes both asymmetric and symmetric DSL;
state average weighted by ILEC access lines
(2) % with cable modem availability where cable systems offer cable TV service;
state average weighted by cable operators' basic subscribers

Because these estimates are based on the areas in which the two companies provide their core service, they are likely to be overstated as a percentage of total homes in each state. And, given that a state's cable networks are likely to pass a smaller percentage of total homes than its telephone networks, this overstatement is likely to be greater for the cable modem availability percentages. For example, if cable network passed only 95% of the nation's homes, the reported 93% national "cable modem availability" figure would actually represent only 88.4% of the nation's total homes.

The FCC's data shows that, nationwide, as of mid-2006, DSL service was available in 79% of homes to which ILECs were providing phone service, up from 76% as of mid-2005. This included eight states with coverage levels below 70%, nine states with coverage of 85% or more, and none above 90%.

On the cable side, overall broadband availability within cable's service footprint was 93% (up from 91% in mid-2005), with South Dakota the lowest at 58%, and four others (Arkansas, Mississippi, New Mexico and North Dakota) below 80%. Another dozen states had broadband availability below 90%.

While the data in this table does not include other broadband service providers, including WISPs (wireless ISPs) and satellite-delivered broadband, it does suggest that more than 20% of U.S. homes do not have a choice of cable modem or DSL service. The data also suggests the likelihood that perhaps one in ten U.S. homes do not have access to either cable modem or DSL service.

Another caveat in interpreting FCC data on broadband availability and penetration is that the Commission defines a "high-speed" line as one delivering service of at least 200 Kbps in at least one direction. This minimum threshold is far below what is today considered a true broadband connection, and what is required for reliable delivery of some of today's fastest growing broadband applications, including streaming video. As a result, it is reasonable to assume that the FCC's broadband metrics are overstated to some unknown but potentially significant degree.

Also worth noting in terms of U.S. broadband availability are the plans of Verizon and AT&T to deploy next-generation fiber-rich architectures in parts of their service territory.

Their network upgrade plans reflect the conflicting pressures faced by the nation's two largest telcos and many of their smaller peers. On one hand, to better compete with cable operators in the triple-play bundled service market, they feel pressure to invest in network upgrades that allow them to deliver video on their own networks, rather than rely on marketing deals with satellite TV providers. On the other hand, they face pressures from Wall Street to restrain capital spending and increase profits and dividends.

As a result, both companies have so far announced plans to deploy their next-generation networks to only a little more than half of their service footprints. AT&T is deploying a relatively low-cost, low-capacity fiber to the node (FTTN) architecture, while Verizon has committed to a more capable but also more costly fiber to the home (FTTH) network. Because its preferred architecture is less expensive and quicker to deploy, AT&T aims to reach 19 million homes by 2008, while Verizon is targeting 18 million by 2010.

Given their financial structure and Wall Street's expectations, both companies have decided that the remainder of their service footprint cannot financially justify deployment of their next-generation networks.

For example, when AT&T (then SBC) announced its Project Lightspeed FTTN plans in 2004, it said it would extend the network to 90% of its highest-value customers, 70% of its medium-value customers, but only 5% of its low-value customers. The company explained that the high-value target group accounts for about 25% of households and 34% of revenue, and spends an average of $160 to $200 per month on services that Lightspeed will be able to deliver. The medium-value segment, it said, accounts for 40% of total households and 41% of revenue, with an average monthly ARPU of $110-$160.

Verizon, meanwhile is in the process of selling off some of the access lines it doesn't believe can justify the expense of its FTTH upgrades. For example, in 2004 it sold roughly 700,000 lines in Hawaii to private-equity firm The Carlyle Group for an estimated $1.65 billion. And in January of this year it announced the spinoff and sale of roughly 1.5 million lines in Maine, New Hampshire and Vermont to FairPoint Communications, in a deal valued at $2.7 billion. It's worth noting that these three states have among the nation's lowest levels of broadband availability, with New Hampshire at 59%, Vermont at 60% and Maine at 67%. Verizon has also reportedly been looking to sell an estimated 3.4 million lines in Indiana, Illinois, Ohio and Michigan.

The network upgrade plans of both AT&T and Verizon highlight the challenges of bringing next-generation broadband services to all of American homes by relying strictly on a model of private investment. We will revisit this issue more fully later in this report.

Bang for the buck

Hoffman notes that, while downstream and even upstream bit rates available in Korea and Japan are often in the 100 Mbps range, "[m]ost current U.S. customers are lucky to get one-tenth or even one one-hundredth of that speed, particularly for uploads -- and they pay more for the lower speed." He also points out that "[b]y OECD estimates, the U.S. price-per-megabit of connection speed is more than 10 times as high in the U.S. as in Japan."

The following table, published on the IP & Democracy blog, and based on data from the ITU, compares the price per 100 kbps of a sampling of broadband services in various countries. Though Comcast's service ranks tenth on this list, it is important to note that the table appears to be based on Comcast's promotional price of $20/mo. which, when offered, is typically available for only 3-6 months.[35]

Lowest Broadband Prices Globally

Rank	Economy	Company	Speed Kbit/s	Price/Mo. US $	US$/100 Kbit/s	Change 2005-2006
1	Japan	Yahoo BB	51200	$ 31.19	$ 0.07	-13%
2	Korea	Hanaro	41200	$ 40.59	$ 0.08	0%
3	Netherlands	Internet Access	20480	$ 27.97	$ 0.14	-81%
4	Taiwan	Chunghwa	12288	$ 22.67	$ 0.18	0%
5	Sweden	Bredbandsbolaget	24576	$ 56.08	$ 0.23	-7%
6	Singapore	Starhub	30720	$ 73.17	$ 0.24	-85%
7	Italy	Libero	12288	$ 37.23	$ 0.30	-74%
8	Finland	Elisa	24576	$ 85.64	$ 0.36	-51%
9	France	Free	10240	$ 37.29	$ 0.36	-90%
10	U.S.	Comcast	4096	$ 20.00	$ 0.49	0%
11	Germany	Freenet.de	18287	$ 30.95	$ 0.52	0%
12	U.K.	Pipex	8128	$ 50.89	$ 0.63	-54%
13	Hong Kong	Netvigator	6144	$ 51.17	$ 0.83	0%
14	Portugal	Sapo	8128	$ 75.82	$ 0.93	0%
15	Canada	Bell Canada	4096	$ 41.26	$ 1.01	-4%
Average			18287	$ 44.33	$ 0.42	-51%

Source: ITU

If the table used Comcast's standard price, the U.S. MSO would have been ranked at or near the bottom of the list with Canada, putting all of North America pretty far behind most of Asia and Western Europe in terms of delivered bandwidth per dollar of subscription fees. Also notable is the fact that both countries' absolute bandwidth measures are also the lowest of the group, in some cases by a very sizeable gap.

Time to rethink universal service?

To properly evaluate the significance of the United States' relative shortfalls in broadband availability, penetration and value (i.e., price per bit), it's important to keep in mind how broadband services have been evolving and expanding.

For example, voice over IP (VoIP) technology is rapidly developing and is already to a point where it is being sold by cable operators as a full replacement for telco primary line voice service. And, as noted earlier, the Internet is increasingly being used to deliver video content, including some prime-time network programs, and to compile and disseminate information about natural disasters, local, state, national and international public affairs, health-related matters, and a host of other important areas of life. And, in ways that telephone and TV service cannot match, the broadband Internet is rich in both interactivity and multimedia content.

This rapidly evolving capability to inform and connect citizens raises new and important policy questions, especially when considered in light of some of the FCC's most long-cherished policy goals, particularly the notion of universal telephone service and free over the air TV.

The key question seems to be: if the broadband Internet can deliver the equivalent of telephone service, the video content delivered by free TV broadcasting, plus a huge and expanding array of additional content and communication functionality these other platforms cannot deliver, should we, as a nation, begin thinking about broadband Internet connectivity—rather than telephony and television--as the cornerstone of a 21st century "universal service" policy?

The author believes the answer to this question is clearly "yes" and, in the final chapter of this report, outlines a proposal that would use the broadcast white space as a key building block to help move in that direction. But first, to prepare the theoretical and policy groundwork for that proposal, we consider some key characteristics of the Internet as they relate to emerging and important industry trends and economic theories.

Economic & Policy Issues

While most industry participants and knowledgeable observers would agree that legacy regulatory policies developed decades ago are poorly suited to manage a 21st century communication sector, there is much less of a consensus as to what policies should replace them. In this section of the report we consider key issues related to this important national policy challenge, in order to set a foundation for the final chapter's white space-related policy proposals.

Cost structure and competition

The first issue we consider is cost structure, as it relates to the feasibility and health of competition in the broadband sector.

A fundamental characteristic of the telecommunications industry—especially the wireline access sector—is that it is very capital intensive, with capital and operating costs that are largely fixed. This, in turn, translates into high barriers to entry, since a new market entrant must take on large amounts of fixed costs just to get a foothold in the market.

A simple model of costs and pricing can highlight the impact that the high-fixed-cost nature of telecommunications has on the fundamental economics of facilities-based competition. To keep things simple, we'll assume the extreme case that 100% of the costs to build and operate a network are fixed.

Under this assumption, adding a facilities-based competitor in a single-provider market would double total network costs, while adding a third and fourth network would increase total costs by 50% and 33%, respectively.

Based roughly on real-world experience, we'll assume that end-user prices decline by 25% with the addition of the second network, another 15% (from the original monopoly price level) due to the additional competition provided by a third network operator, and a further 10% following the entry of a fourth competitor.

This simple model leads to the following results: a second competitor increases total costs by 100%, but reduces prices by just 25%; a third competitor leads to total costs 200% higher than in the monopoly scenario, with prices only 40% lower, while a fourth competitor results in a 300% increase in costs and a 50% reduction in competitive pricing.

If we assume that new entrants offer roughly the same set of services as incumbents, and that total penetration does not increase with the introduction of additional competitors, these scenarios would translate into dramatic increases in total network costs that would need to be financed through steadily declining total revenues. In the four-network scenario, for example, total capital and operating costs would be four times what they were in the single network model, even as total revenues—which now need to be shared by four rather than one provider—would be cut in half.

The economic inefficiencies—and severe challenges faced by new entrants--in this simple model of facilities-based competition are clear, and would exist in proportion to the real-world ratio of fixed to total network costs. New entrants' challenges would also be impacted by other factors, including the extent to which: competitors' services are not highly differentiated; service innovation is relatively modest; end-user willingness to spend is relatively stable and; incumbent service penetration rates are high. All of these, to varying degrees, tend to be the case in the telecommunications sector.

Though the 1996 Telecom Act was intended to encourage competitive market entry by removing regulatory barriers, its impact over time was actually to introduce new forms of regulatory uncertainty, as FCC rules attempting to implement the Act were constantly challenged and dragged through the courts.

As a result, after being thrown wide open to new facilities-based entrants in the wake of the Act's passage, the floodgates of investment capital were abruptly slammed shut as the ensuing regulatory uncertainty ended up aggravating rather than ameliorating the fundamentally challenging economic hurdles to successful market entry. The painfully high percentage of bankruptcies in the CLEC and "overbuild" (a.k.a. "competitive broadband service provider") sectors over the past decade are a testament to this dynamic.

Thanks in large part to this combination of regulation and market dynamics, the mass market telecom sector has migrated to a duopoly model, and a good number of once-highflying CLECs and overbuilders have ended up in bankruptcy

As demonstrated by the bankruptcy-laden history of the CLEC and "overbuild" sectors earlier this decade, private capital can become quickly spooked as the realities of facilities-based market entry begin to sink in. These realities can include intense and arguably-predatory price competition during and after construction phases, lack of cooperation with regard to interconnection and other regulation-mandated requirements, and, in the case of cable operators, use of exclusivity as a competitive weapon (most often related to terrestrially-distributed sports programming, often owned by the cable operator itself). In the CLEC and overbuild sector, these dynamics have been compounded by relentless regulatory and legal challenges, typically at the state and national level in the telecom sector, and at the local franchise level in the multichannel video market.

Somewhat ironically, the fixed cost nature of telecom networks works largely in reverse for incumbent network operators. Since so much of their costs are either sunk capital costs or fixed operating costs, it is relatively easy for them to cut prices in areas targeted by new competitors and, if needed, offset these with price hikes levied in other geographic or service markets where they do not face comparable competition. And, as our simple modeling exercise suggested, incumbents have strong incentives to nip competitive entry in the bud, if at all possible.

To the extent new facilities-based competitors introduce innovative services, their prospects can be improved, since they have more to offer customers than just lower prices than incumbents. Such services can also give them some degree of immunity from price competition from incumbents seeking to leverage their own fixed cost structure in order to retain customers and increase the strains on competitors' business models and investor confidence.

The evidence of the past decade suggests, however, that such innovation has not occurred very much in the facilities-based mass market sector over the past decade. Even today, for example, the primary focus of cable operators, telephone companies and, where they exist, "competitive broadband service providers" (e.g., RCN), is pretty consistently on the delivery of triple play (voice, video and high speed Internet access) and, more recently

quad-play services (which include wireless) and incrementally "converged" services (e.g., integrated voice mail and email; access to TV program guides and DVR control via mobile handsets, etc.). For the most part, even the newer "converged" services are fairly similar to each other, with price, combined with broadband data rates, remaining the primary differentiating factors that drive consumer buying decisions.

The point here is not to deny any technological and service-oriented innovation on the part of the cable and telephone industry and new facilities-based entrants into their markets, but to note that such innovation is limited in scope and variety, and most dramatically so when compared to the massive and multi-sourced innovation characteristic of the Internet.

This last point leads into a discussion of another form of competition—from service providers that haven't taken on the massive costs and risk associated with the facilities-based strategy discussed above.

Even a cursory review of the Internet's history provides dramatic evidence that its "application layer," has consistently supported extraordinarily high levels of competition, innovation and value creation. Among the most notable examples are the rise of Google, Yahoo, eBay, Amazon, Skype (acquired by eBay), YouTube (acquired by Google) and MySpace (acquired by News Corp.).

The Internet's history stands in sharp contrast to the track record of UNE-P based competition from CLECs in the circuit-switched voice market. This is due to key differences in technology, regulation and industry structure.

Since its inception, the rules of the UNE-P road were subject to a complex multilayered regulatory process under constant legal challenge from incumbent ILECs. So, while a UNE-P-based competitive sector was able to thrive for a short period of time, particularly in some states, its business model came crashing down when the courts struck down the FCC's UNE-P regulations and the Commission finally chose to phase them out. In contrast, the early growth of the Internet was marked by a fairly competitive ISP sector in which the basic regulatory rules and cost structure remained relatively clear and stable.

The other key difference is tied more to technology and business structure. Whereas the UNE-P sector was predominantly a market for the resale of incumbent's circuit-switched voice service, Internet access is best viewed as a portal to a virtual world containing an ever-expanding selection of electronic services and modes of communication and connection, and an equally expansive and fluid exchange and manipulation of information, ideas and multiple forms of media content.

Due to its open-access nature and the fact that its services are mainly enabled by an ever-expanding, largely standards-based and relatively low cost (and in some cases free) software, barriers to entry are much lower in the Internet sector than they ever were in the telecom, cable or broadcast sectors.

In key respects, the net neutrality debate can be viewed as a collision of two very different business, technology and regulatory models.

The first, based on the relatively slow evolution of legacy regulations and business models in the telecom and cable TV sectors, is premised on the provision of service combined with transport, and the expansion of competition through facilities-based market entry (or, in the case of UNE-P, through regulation-controlled wholesale pricing subject to persistent legal challenges by incumbents and the uncertainty this engenders).

In contrast, the newer Internet model, based on open hardware and software standards and open access principles, separates transport from service provision. This accomplishes a number of things. Importantly, it removes the financial hurdles, risk and inefficiencies associated with investments in redundant and high-fixed-cost network facilities for companies seeking direct relationships with customers, but focused mainly on the provision of services rather than transport.

As noted, above, the value of this removal of entry barriers is dramatically reflected in the massive innovation taking place on the Internet, and in the relatively high stock valuations of leading Internet-based service providers.

In key respects, the Internet serves the same role in the electronic world as the public road network serves in the realm of physical transport. It provides a simple, shared transport infrastructure open to any and all entities seeking to use it to exchange goods and services. Importantly, this exchange can be done without the owner of the road network being party to it (or even being aware of it). Instead, all that's needed is for each entity using the network to adhere to certain rules of the road, which are applied equally to all users, independent of the nature of the market or non-market transactions being facilitated by the availability public road-enabled transport.

In this collision of business models driven by the Internet's explosive growth, it is not surprising that network operators, whose core competitive strength is their control of bottleneck access facilities, would see the Internet model as a threat and even a distortion of what they view as healthy market functioning from the perspective of their legacy business models. It would also not be surprising if these companies' executives were somewhat envious of the dramatically higher valuations investors place on Internet growth stocks compared to their own.

But the fact that the Internet's open model is not preferred by incumbent network operators does not seem like a sound basis for public policy in what most would agree is one of the nation's most important economic sectors. At the same time, however, resolving this business-model clash by imposing neutrality rules on network operators seeking to pursue a model more akin to their legacy business models, strikes this author as a strategy likely to face prolonged legal challenges and perhaps, as network operators predict, to trigger unintended and undesirable consequences. In the final chapter of this report, an alternative path to addressing this conflict is suggested. But first, it's worth examining its nature and implications more fully.

The issue of market power

The tendency of private network operators to seek and exercise market power manifests in large part as a pursuit of control over the introduction (and directly or indirectly the development) of services, software and CPE, the latter being a key point in the network for enabling (or disabling) new applications. It also manifests as a preference for imbedding intelligence and control mechanisms in the network, rather than at end points controlled by end users. Put another way, the dominant providers of wired and wireless network facilities seek to avoid becoming providers of commodity "bit transport" network services. Instead, they want to deliver services that combine "transport" with "applications" and "content," and thus to capture, as much as possible, the added value of whatever services are delivered on their network.

Many have argued that this strategy is fundamentally at odds with the basic architecture that has enabled the Internet to become what most would agree is the fastest-growing communication and service platform and value-creation mechanism in human history.

The understandable tendency among dominant network operators to seek a gatekeeper role over key bottleneck facilities has been a key driver behind the "network neutrality" and "municipal broadband" movements. Both movements seek to retain the "end-to-end" openness of the Internet as it migrates to broadband and mobile platforms. Network neutrality advocates seek to do so by imposing some form of "non-discrimination" requirements on dominant (or all) providers of Internet access facilities. Supporters of municipal broadband projects seek to accomplish similar goals through deployment by local communities of wireless and/or fiber optic networks that provide an "open-access" alternative to the vertically-integrated network strategy preferred by dominant providers of access service. In describing the value and purpose of such networks, muni-broadband supporters often use a "public road" metaphor, citing parallels between the transport of motor vehicles on public roads and data packets on the Internet.

Data compiled by the FCC shows clearly that today's wireline broadband industry is largely a duopoly in which the vast majority of customers are served either by cable or telephone companies. For example, according to the FCC's most recent report on broadband Internet access, which contained data as of mid-2006, alternative technologies like fixed wireless, satellite and broadband over powerline (BPL) accounted for less than 2% of total broadband customers.

While less concentrated, the wireless sector, following waves of consolidation, is in most areas an oligopoly dominated by four major players. Of these, the two largest have sister companies that are the nation's largest wireline telephone companies (AT&T and Verizon), while the third largest (Sprint) is aligned with the dominant players in the cable industry. The market and policy significance of these intra- and inter-company links between dominant wireline and wireless players can be expected to increase as the process of "fixed-mobile convergence" moves forward.

As noted above, it is in the perceived self-interest of these dominant providers of bottleneck access facilities to avoid becoming commodity transporters of IP packets and to instead

play a role as vertically integrated providers of broadband services that combine transport, applications and content. Since this vertically-integrated service model is fundamentally at odds with the Internet's original design, it is incumbent on policymakers to understand its implications, and to do so from a broad perspective that takes into account the importance and central role of communications in our economic, political and social systems.

VoIP provides one example of a market where access provider enjoy, and have leveraged, significant market advantage by virtue of owning and controlling the networks over which VoIP signals travel. In this case, cable operators' control over the nation's only widely available network that can deliver multichannel video, high-speed Internet access and relatively reliable VoIP service is translating into accelerating growth in service penetration and revenue.

While this is clearly good for cable operators, and arguably good—at least in the short term--for consumers who enjoy discounted bundle pricing, there are already signs that it is beginning to threaten the health and potentially the survival of independent VoIP providers. Among these signs are key metrics in the Q4 06 earnings report of Vonage, the nation's largest independent VoIP provider. In the author's view, these metrics—including subscriber growth, churn, ARPU and SAC—raise serious questions about whether Vonage can survive as an independent entity.

The implications of this apparent squeeze on independent VoIP providers merit careful analysis by policymakers, not only with regard to competitive trends in the VoIP market, but also in terms of what they suggest for the evolution of competitive dynamics in other broadband service sectors.

Another reflection of broadband access providers' preference for vertically integrated service delivery models is AT&T's allocation of the roughly 25 Mbps of capacity provided by its next-generation Lightspeed network. The company's current plans call for maximum speeds for its Internet service of 6 Mbps downstream and 1 Mbps upstream. The remaining two-thirds or so of network capacity is dedicated to the company's IPTV service which, while technically different than traditional cable TV service, is similar to the latter in that it positions AT&T as a gatekeeper, with whom programmers and other service providers must negotiate financial arrangements in order to serve the network's end users.

This allocation of next-generation network capacity is especially important since AT&T, following its late-2006 BellSouth acquisition, is, by far, the nation's largest telco. It means that the next-generation ILEC networks serving large portions of the nation may for many years deliver Internet capacity only roughly comparable to what has been widely available in the market for the past few years, and that falls short of what some cable operators are already offering in markets where they face more capable telco broadband offerings (e.g., Verizon's FiOS).

This, along with AT&T's last minute pre-merger agreement to adhere to network neutrality rules for its Internet access service, but not for its IPTV service, strongly suggest that the RBOC's investment priority will focus on the latter, where it will be better able to exert market power with regard to products, services and the capture of value-added revenue

streams. While this makes good business sense from AT&T's perspective, it leaves unanswered and looming increasingly large the broader policy question of whether it is good for our economy and society as a whole.

While its all-fiber FiOS network does not face the capacity constraints that have led AT&T to limit its next-generation Internet data rates to current-generation levels, Verizon is taking steps to exert control over the applications that ride on its network and the method by which end users access those applications. One manifestation of this is the company's introduction of a number of in-home devices, including "home gateway" broadband routers, a "Verizon One Home Communication Center" device, and a Home Media multi-room DVR that allows customers to access photos and music from their computers and play them on their entertainment center.

Clearly, these devices and the services they deliver provide value to FiOS customers. But, at the same time, they tend to increase the vertical market power that Verizon—which operates as a duopolist in the wired broadband market and a dominant oligopolist in the wireless sector—can exercise in the emerging market for advanced broadband and converged services.

In a recent paper, Bob Frankston, a pioneer in software and in-home networking, an outspoken critic of what he calls the FCC's "Regulatorium," and a strong advocate of publicly controlled open access networks (or "end to end connectivity," as he might put it), offered some comments on his recent experience of becoming a FiOS customer.

> The complex protocols of traditional telecommunications are a breath of dank air by contrast with the transparency and simplicity of the Internet…. You can…see this in the router Verizon provides for FiOSTV.
>
> When I was doing home networking the details of the router were under-specified so we could experiment and innovate. The evolution continues – new routers may support IPV6. But in order to get FiOSTV I must use Verizon's router. I cannot take advantage of new technology until Verizon does. There is no reason for this – in fact they have a simpler bridge – the Motorola NIM100 but they refuse to release any documentation on it and they even claim it is not available. These problems are endemic to broadband.
>
> Verizon is now installing RG-6 they control rather than using my existing Ethernet wires. This is reminiscent of the old days when they owned my phone wires. It seems profligate to run new RG-6 cable rather than using my existing network. RG-6 is the thick cable that is necessary to preserve analog video signals – it is clumsy. For those without networks 802.11 can work fine and requires essentially no installation…why does Verizon insist on spending large amounts of money to take back control of the wires inside my house and turn it back into a service?[36]

In key respects, these FiOS network devices are similar to AT&T's decisions regarding capacity allocations between IPTV and Internet access on its Lightspeed network. Both are vertical extensions of market power by duopoly access providers over the evolution of the

broadband services market and the interactions between services delivered on the open Internet and those more directly under the control of these access providers. While these extensions of market power can provide consumer benefits, they raise important policy questions about the balance of their costs and benefits, in both the short and long term. It is especially important to address these policy questions if no viable alternatives to the dominant duopoly/oligopoly market structure are broadly available to the American people.

A development in the content sector that has links to these AT&T and Verizon network and device strategies is the move by leading access providers to offer video services that include user-generated content and deliver "best of the web" programming to devices other than the PC, including the television and mobile phone.

Leaders in this area are two of the nation's largest access providers, Comcast, which has launched a service called Ziddio, and Verizon, which has a deal with Revver.

Ziddio is a user-generated-content video site that offers prizes, including the possibility of having one's video featured on Comcast's Video on Demand service, which delivers on-demand content to the MSO's digital cable customers.

The Verizon deal with Revver includes distribution of selected Revver content on the Verizon Wireless V CAST mobile service, and, later this year, on the carrier's FiOS TV platform. According to one news report, Verizon is expected to retain at least 20% of advertising revenue from Revver videos distributed via FiOS, with Revver sharing the remainder with content creators, as it does with its web-based service.

As with the previous examples of access providers' leveraging of their market power into the application and device space, these moves by Comcast and Verizon have potential to deliver real value to end users, and also to content creators. But, also like these other examples, this leveraging of market power has the potential to generate direct and opportunity costs—in both the short and long term.

Columbia Law professor Tim Wu is among those who believe such costs are considerable and who has advocated some form of network neutrality rules in both the wireline and wireless sectors.

> Today…you can start a business on the internet with relatively little capital. But in a world where AT&T or Verizon decides who gets priority access, entrepreneurs get a different message. Its not who has a better product: it's who can make a deal with AT&T, Verizon, Comcast or Time-Warner.[37]

While the market dynamic Wu describes may be a desirable one from the perspective of access providers, its costs could outweigh the benefits provided by carrier-controlled services from the perspective of end users, other service providers, device makers, and the economy and society as a whole.

In an April 2006 testimony before the House Committee on the Judiciary Telecom & Antitrust Task Force, Wu laid out his basic case for network neutrality.

In any discussion of neutrality rules, the Bells and even the cable companies will always turn back to their one big argument: we need more money to build the infrastructure, and if you don't give it to us, we won't build it…What we have here in truth is a tradeoff. **The Bells want permission to discriminate in exchange for a promise that they'll use any money earned to build more infrastructure.** But even if the Bells make more money, and even if that money is actually invested in infrastructure deployments, that doesn't mean the tradeoff costs don't exist. **The tradeoff is a distortion, a tax, on the healthy markets that are on top of the basic network.**

It is inevitable that a discriminatory infrastructure will affect competition and innovation in the markets that depend on it. Imagine, for a moment, that private American highway companies reserved a lane for Ford cars. That would be good for Ford, but obviously would affect competition as between Ford and General Motors. It would also slow innovation—for it would no longer be the best car than wins, but the one that signs the best deals and slows down their competitors. The race is no longer to build a better car, but to fight for a better deal with the highway company.

That's the threat to innovation on the internet…That's a different kind of market, one more like the old days of telecommunications [and cable TV]. That's when starting a network business meant making a deal with a big Telco [or big cable operator], or forget it.

In short, the long-term costs to the economy of allowing a discriminatory internet are real. Encouraging infrastructure investments is a serious challenge, but in the end one only tangentially related to the Network Neutrality debate. The real spur to network deployment and innovation will be market entry—whether municipal broadband, or otherwise, that scares today's providers into offering something better. Indeed, even given the limited competition we have today, it is the superiority of the cable network that has goaded the Bells into beginning fiber optic deployments. For these deployment decisions, facilities-based competition is the strongest answer, and letting gatekeepers tax application competition is really a sideshow. Taxing innovation is hardly the only, and probably the most expensive way to encourage infrastructure deployment.[38]

The role of IMS

A key component of the telco long-term vision of multi-service and multi-platform integration is IMS, which stands for IP Multimedia Subsystem. A June 2005 article by John Waclawsky discusses IMS in terms of how it relates to carrier technical and business strategies. At the time, Waclawsky was a technical leader for Cisco Systems' Mobile Wireless Group involved in standards activities and developing wireless architectures. A few months after the article was published in Business Communications Review, Waclawsky was hired as Motorola Software Architect, where he is responsible for software development that delivers converged end-to-end solutions.

> The IMS standards promise an operator-friendly environment for real-time, packet-based calls and services that not only will preserve traditional carrier controls over user signaling and usage-based billing, but also will generate new revenue via deep packet inspection of protocols, URI and content. IMS was conceived for the evolution of cellular telephony networks, but the benefits of user signaling and billing controls have attracted the endorsement and involvement of wireline network operators and standards makers.[39]

Waclawsky notes that mobile and wireline carriers are not the only ones interested in IMS's potential:

> In the U.S., cable multiple systems operators (MSOs) are also showing interest in IMS as part of the recent CableLabs PacketCable initiative, and network operators recently approached the WiMAX Forum's Network Working Group, asking that IMS be included in its forthcoming reference architecture.

Waclawsky suggests that a big factor behind incumbents' support for IMS is their desire to assert more control over service development and monetization in the IP space at a time when "over-the-top" web-based services pose a threat to existing and future revenue streams:

> ...**IMS is part of a grand plan of sorts by incumbent network operators and supported by entrenched telephony vendors...This is the emerging, consensus view: That IMS will let broadband industry vendors and operators put a control layer and a cash register over the Internet and creatively charge for it. It is this monetization of the Internet that makes IMS extremely appealing to all communications operators.**

But Waclawsky is among those involved with IMS standards and product development that also harbor doubts about its ability to achieve the goals carriers have set for it:

> ...**IMS is complex and costly, provides very little (if any) end user value, offers little (if any) in the way of new applications**...and plans to use several new and unproven technologies...on a grand scale. There are performance concerns already. Perhaps most ominously for IMS, there is no end-user (consumer) pull similar to what the market experienced with cell phones or WiFi. In other words, IMS is a VERY high-risk strategy.

If Waclawsky is correct that IMS is a very high-risk strategy for carriers, this raises the question of how risky (in terms of their own prospects) these carriers perceive a future in which the do not have technologies like IMS to "put a control layer and a cash register over the Internet and creatively charge for it." While the answer to this question speaks to carrier motivations and business strategies, it does not shed much useful light on public policy questions concerning the desirability of allowing this model of "carrier control and monetization of the Internet" to become the dominant or potentially even the only model available in our increasingly Internet-dependent economy.

Market power in wireless

In a recent paper entitled *Wireless Network Neutrality: Cellular Carterfone and Consumer Choice in Mobile Broadband*, Wu analyzes market dynamics in the wireless sector, which today is dominated by four major carriers, following the October 2004 acquisition by Cingular Wireless of AT&T Wireless and the August 2005 of merger of Sprint and Nextel.

Wu's bottom line conclusion was that "wireless carriers [are] aggressively controlling product design and innovation in the equipment and application markets, to the detriment of consumers." As Wu puts it:

> The carrier oligopoly controls an important part of the national infrastructure, namely the public's licensed spectrum that carries digital wireless signals. **The relevant question is how the spectrum caretakers interact with the relevant vertical markets: namely, the equipment and application markets which depend on the wireless spectrum.**[40]

Wu cites four key areas where carrier control is being exercised in ways that harm consumers:

> 1. **Network Attachments**. Carriers exercise excessive control over what devices may be used on the public's wireless spectrum. The carriers place strong controls over "foreign attachments," like the AT&T of the 1950s. These controls continue to affect the innovation and development of new devices for wireless networks.
>
> 2. **Product Design and Feature Crippling**. By controlling entry, carriers are in a position to exercise strong control over the design of mobile equipment. They have used that power to force equipment developers to omit or cripple many consumer-friendly features, and also forced manufacturers to include technologies, like "walled garden" internet access, that neither equipment developers nor consumers want. Finally, through under-disclosed "phone-locking," the U.S. carriers disable the ability of phones to work on more than one network. A list of features that carriers have blocked, crippled, modified or made difficult to use, at one time or another include:
>
> - Call timers on telephones
> - WiFi technology
> - Bluetooth technology
> - GPS Services
> - Advanced SMS services
> - Internet Browsers
> - Easy Photo file transfer capabilities
> - Easy Sound file transfer capabilities
> - Email clients

- SIM Card Mobility

> 3. **Discriminatory Broadband Services** – In recent years, under the banner of "3G," carriers have begun to offer wireless broadband services that compete with WiFi services and may compete with cable and DSL broadband services. However, the services are offered pursuant to usage restrictions that violate basic network neutrality rules, and pursuant to undisclosed bandwidth limits.
>
> Most striking is Verizon Wireless, which prominently advertises "unlimited" data services. However it and other carriers offer broadband service pursuant to both bandwidth limits, and contractual limits that bar routine uses of the internet, including bans on downloading music from legitimate sites like iTunes, the use of Voice over IP, and on the use of sites like YouTube.
>
> 4. **Application Stall** – Mobile application development is by nature technically challenging. However, the carriers have not helped. They have imposed excessive burdens and conditions on application entry in the wireless application market, stalling what might otherwise be a powerful input into the U.S. economy. In the words of one developer, "there is really no way to write applications for these things." The mobile application environment is today, in the words of one developer, "a tarpit of misery, pain and destruction."
>
> Most of the carriers adopt similar practices. However, in each area, there are variations between the four largest carriers: AT&T, Verizon Wireless, Sprint-Nextel, and T-Mobile. Speaking generally, Verizon Wireless and AT&T offer the most restrictive policies; Sprint is slightly less restrictive. The fourth and smallest competitor, T-Mobile, tends to be the least restrictive of consumers and application developers.[41]

It's worth noting that the two carriers Wu says have the most restrictive policies are the two largest and the two with affiliated wireline telco units. And Sprint, with the third-most restrictive policies, is aligned with the other (cable) side of the broadband duopoly.

According to Wu, wireless carriers have "an obvious interest" in extending their market power up and down the wireless value chain: maximizing revenue.

> Usually but not always, maximizing revenue is a useful motive, for it suggests making the wireless networks and wireless services as useful to consumers as possible. Vertical integration or controls placed on the equipment and equipment market may represent efforts to maximize the utility of the overall platform for consumers. For example, in some instances, careful "hand-in-glove" cooperation between the carrier and equipment may yield a better product or service. That's arguably the case, for example, for the voice that is the carriers' main offering. [42]

But in other cases, says Wu, carriers' pursuit of their perceived self-interests in the oligopolistic wireless market conflicts with the interests of end users. As an example, he cites the development of mobile software and new applications.

> Given standardization and more openness, software developers might develop a range of applications at the rate seen in Web development. But the carriers seem hesitant to allow such development to occur, possibly out of the idea that if any new services come into existence, it should be "theirs." Analyst Andrei Jezierski describes the carriers' behavior as follows. "It's not clear if the carriers will make money from these value-added services. So if the economic model is still unclear, why give away more control earlier than you have to?"[43]

The problem with this attitude, says Wu is it can stifle innovation and impose significant costs on consumers and equipment manufacturers.

> A…plausible explanation for [such] behavior…is this: carriers believe it makes sense to block a feature to protect an existing revenue source, or to keep its own costs low, even if that behavior is bad for actors in the equipment and application markets, and hurts innovation. For example, again, many carriers cripple Bluetooth's media transfer capabilities. Bluetooth makes it easy to communicate between a computer and cell phone, so blocking helps preserve an existing revenue source—the prices the companies can charge for songs, ringtones, wallpapers, and other content. In other words, with a more open system, a consumers could get what she wanted without passing the carrier's "tollbooth."
>
> Unfortunately, protecting tollbooths comes at a price. Crippling Bluetooth also retards any market for Bluetooth compatible devices, and makes it that much more difficult for users of cell phones to coordinate their phones and computers. This kind of problem is a spillover, or externality problem. It may be that the money a carrier makes on ringtone downloads is more than it can expect to make from providing consumers with fully functioning Bluetooth. For that reason, it may narrowly make sense for a wireless carrier to block Bluetooth. But the carrier will not be taking into account the externalized costs of such action -- the costs to consumers, and equipment manufacturers who would like to make Bluetooth-compatible devices other than headsets.[44]

Wu's arguments were echoed in a February 2007 petition filed with the FCC by Skype Communications, asking the Commission to "confirm a consumer's right to use Internet communications software and attach devices to wireless networks." Skype claimed that:

> [M]anufacturers are poised to equip handsets with Skype features, but are reluctant to do so if such features threatened wireless carriers' established business models. Such a "permission-based" approach to innovation creates an innovation bottleneck, as equipment manufacturers are forced to design equipment based on what carriers will allow, not necessarily what consumers want and the state-of-the-art will permit.[45]

Skype noted that the FCC decided in 1992 to permit cellular carriers to bundle CPE and service, but only if "cellular service is also offered separately on a nondiscriminatory

basis." According to Skype, the FCC would not have accepted "the risks of bundling wireless service with handsets…without the safety valve of the unfettered availability of wireless service only." But since then, argued Skype, key characteristics of the wireless industry "have changed in a way that calls the Commission's analysis into question."[46]

One key change relates industry concentration, said Skype, noting that "the average Herfindahl-Hirschman Index values in the mobile telephony market are 2706, well above 1800, which the FTC and DOJ consider 'highly concentrated,'" The VoIP provider claimed this level of concentration has given wireless carriers too much power over the devices and applications wireless customers can access.

> In permitting carriers to bundle cellular service and handsets in 1992, the Commission observed a market in which most wireless carriers were smaller and operated in local markets, making it unlikely that they could "possess market power that could impact the numerous CPE manufacturers operating on a national…basis." This situation has changed dramatically, as the market is now dominated by four large nationwide carriers with large enough subscriber bases to exert significant influence on handset manufacturers. The simple truth is that manufacturers depend on carriers to market their devices, and no manufacturer can afford not to "play ball" with the largest wireless carriers."[47]

The Skype filing cited a recently introduced Nokia "smartphone" as an example of this industry dynamic.

> The Nokia E61, a high-end e-mail device and phone…was released in Europe in the summer of 2006 and received favorable reviews. In the United States, however, Cingular (now AT&T) was the exclusive vendor of a stripped-down model known as the E62—a crippled model which lacked, among other things, Wi-Fi connectivity, a feature that is increasingly popular among on-the-go consumers…Intentionally removing Wi-Fi functionality from the Nokia E62 interferes with consumers' ability to place Internet calls, thereby harming innovation and price competition."

"Neutrality" and "externalities"

Increasingly, developers of applications and end-user devices, as well as end-users themselves, are finding themselves aligned on one side of Internet-related policy debates. On the other side are typically found the companies that control distribution networks in duopolistic or oligopolistic markets.

Two such policy debates with relevance to the FCC's white space proceeding relate to the principle of network neutrality and the deployment of municipal (a.k.a., community) broadband networks. To a large extent, both are characterized by the alignment of interests described above, and reflect a fundamental difference in perspective between the two sides of the debate.

On one side we typically find private network operators, their investors and, to varying degrees, their equipment suppliers. Facing a business with high fixed costs and barriers to entry, broadband network operators—very rationally from their perspective--pursue their interests through a strategy of aggregating and protecting market power by positioning themselves as vertically-integrated bottleneck gatekeepers. These operators, as well as some economists, argue that this aggregation of market power through vertical integration provides the financial incentives operators need to invest in building and upgrading their networks.

One of the problems with this approach, according to those on the other side of the debate, is that operators will make investment, service-related and other decisions based in large part on their perception of their ability to internally monetize the value of services and interactions delivered over their network. To the extent there exists potential network value that cannot be readily monetized in this manner, or is not apparent to network operators, the latter may choose to avoid investments that yield such value. And, should such value creation be perceived as detrimental to an operator's interests, it may even take conscious actions to squelch it. All of this would be very rational behavior by network operators, and has been observed in historical and current contexts.

Governments differ in key respects from private network operators seeking to internally monetize network-enabled value. To a large extent, it is this difference that drives today's "municipal broadband" movement. The key difference is that governments are far more concerned with what economists refer to as "externalities," those elements of value that are external to the economic actor. This is, in fact, a fundamental role of government, typically applied to arenas such as public health and safety, economic growth, education, transportation, access to basic necessities and services, and overall quality of life.

As a result, local governments pursuing municipal broadband projects, while generally seeking to create economically self-sustaining networks that support operating and capital costs, are more concerned with maximizing externalities than with internal measures of profitability. The opposite tends to be true of private network operators. While they may invest modest amounts to support externalities (e.g., to engender good will in local communities, or as required by franchise or "public interest" obligations), their dominant short and long-term priority is to capture and monetize network-generated value. For companies with publicly traded stocks, this priority tends to be particularly acute, often characterized by an urgency focused on relatively short term financial performance.

To the extent externalities loom large in the overall value equation associated with communication networks, the policy significance of arguments made by network neutrality and municipal broadband advocates increases accordingly.

The "externalities" typically cited by network neutrality advocates tend to focus on issues related to innovation and open market entry in the technology and service sectors, as well as First Amendment issues, and how these benefits can be reduced by the kinds of exertions of market power discussed above.

While municipal broadband advocates are also inclined to cite these same factors, they tend to focus heavily on potential efficiencies, cost-savings and other "internal" or "public" benefits captured by local governments and other public institutions, and local communities as a whole (e.g., attracting businesses, tourism, education, bridging the "digital divide," etc.).

In an earlier report we examined these claims and concluded that "[while] there remains a shortage of real-world data to fully evaluate the extent to which cost-savings and other "public" benefits can cost-justify muni-broadband deployments…the potential for such benefits is suggested by anecdotal evidence and preliminary studies."

The muni-wireless network in St. Cloud, Florida, is a good example of how these "public" externalities can impact network economics and business models. After a year of operation, the St. Cloud network, which provides Internet access service at no charge, had attracted more than 77% of the city's 11,000 households as registered users.

According to Jonathan Baltuch, president of MRI, a consultant on the project, capital costs for the St. Cloud network were financed through the local economic development fund, with operational expenses funded through internal savings to city operations, which he says exceed the annual cost of operations.

In response to questions about the St. Cloud project posted on the Muniwireless.com web site, Baltuch explained that a key source of these savings is "cash savings to [city] operations through a variety of methods including cell phone replacement, mobile data card replacement, Internet connectivity to facilities etc. In many cities the conversion from cell phones to mobile VOIP phones can save a small city $100,000 a year or more." A second source of savings, he said, is increased productivity. As an example, he cited the fact that a muni-wireless network enabled the city of Corpus Christi, Texas to implement a program of remote meter reading that allowed it to go from 29 meter readers to just five, generating more than $1 million in annual savings.[48]

In the following section we examine a related but distinct form of beneficial externality, one tied to the value of neutral Internet access as a driver of economic growth.

The Internet and New Growth Theory

Much of the argument favoring "neutral networks" has focused on the "end to end" principle of the Internet and a related view that regulation should be tailored to the various layers of the Internet protocol stack. Typically this "layer" perspective argues that the Internet's local transport layer is insufficiently competitive and therefore should be subject to some non-discrimination regulation similar in principle to "common-carriage" regulation. In contrast, the "application" layers of the Internet (i.e., services and content) are typically viewed as sufficiently competitive, and thus should be left largely unregulated.

In a recent draft paper entitled *The Internet and the Project of Communications Law* and slated for publication in the UCLA Law Review, Susan Crawford, Associate Professor,

Cardozo School of Law, attempts to provide a somewhat different—and arguably more fundamental-- underpinning for policies supporting neutral, ubiquitous, high-capacity and symmetrical Internet access.[49]

Crawford's arguments are grounded heavily in the relatively new growth-focused school of economics, particularly the work of Paul Romer, considered the primary developer of what has come to be known as "New Growth Theory." Romer is a Professor of Economics at Stanford University's Graduate School of Business and a Senior Fellow of the Hoover Institution. He received his PhD from the University of Chicago, which may be best known for being home to Milton Friedman's brand of "free market" economics.

New Growth Theory differs in key respects from the dominant neoclassical approach to economic analysis, which is often used as a basis for telecommunications public policy, including spectrum auctions. Whereas the latter focuses heavily on market optimization via price-based supply and demand equilibriums, New Growth Theory focuses on an area largely ignored by neoclassical economists--"the economics of ideas." As Crawford argues in her paper, the relationships between ideas, the Internet and economic growth have direct and major relevance to communication policy, and to the role such policy can play in strengthening the U.S. economy as it confronts an increasingly interconnected, competitive and, in some cases, hostile world.

A bottom line conclusion of Crawford's analysis is that the Internet should be at the center of communications policy and that laws affecting Internet access should be evaluated in terms of whether they further U.S. economic growth by facilitating increased online diversity, interaction, innovation and generation and proliferation of ideas.

Crawford criticizes the nearly exclusive focus of current communications policy on the private economic success of infrastructure and "application" providers, and suggests that communications policy be focused more on facilitating communications themselves, and on the Internet's unprecedented ability to provide a highly efficient mechanism for generating, evaluating, expanding, synthesizing, proliferating and applying ideas. The logic of New Growth Theory (discussed more fully below), as well as real-world experience in the early years of the 21st century, would suggest that the Internet, by providing such a mechanism at unprecedented levels of scale and efficiency, is an extremely powerful and valuable driver of economic growth.

Crawford sees a problem in realizing the Internet's powerful growth-promoting potential if Internet access networks are controlled by vertically-integrated, profit-maximizing service providers in a duopoly or oligopoly access market. As her analysis suggests, the fluid nature and often indirect and unpredictable impacts of the open Internet's idea- and growth-promoting conditions are likely to be viewed as not-readily-monetizable externalities by these network operators. This means that, absent very strong competitive pressure--which is lacking in oligopolistic and especially in duopolistic markets--these network providers are not likely to make support for these conditions a high priority. And, as Wu's analysis of the wireless sector suggests, should they see such conditions as disruptive or otherwise threatening to a business model they can more reliably manage, they may even take steps to stifle them.

Ideas vs. objects

A key component of New Growth Theory that distinguishes it from traditional economic theory is how it treats the distinction between "ideas" and "objects." This distinction—and its implications—underscore the Internet's uniquely powerful potential to drive economic growth, and the need for communication policy to be geared toward realizing that potential. As Crawford explains:

> Traditional economics assumes implicitly that the economy as a whole is a closed system that will eventually reach equilibrium…In the view of an equilibrium economist, ideas are exogenous…
>
> [I]n recent years, traditional economics has had to open its doors to work that rigorously examines the sources of increased productivity and focuses on the centrality of new ideas to economic growth. This research has transformed economics from a dismal science, preoccupied with the scarcity of land, labor, and capital (and concerned about the diminishing returns these resources will generate as markets perfect themselves) into a field that spends much of its time focusing on abundance, increasing returns, and the power of new ideas.
>
> Robert Solow's breakthrough work fifty years ago showed that "technological progress" allows economies to add to their outputs without the addition of more labor and capital. But Solow called this key technological-change element responsible for eighty percent or more of economic growth the "residual," and dealt with it as an unexplained exogenous influence.
>
> Beginning in the mid-1980s Paul Romer seized the challenge of transforming the "residual" of technological change into an endogenous element of his model explaining economic growth. Since then, Romer has pointed out in a series of papers that (1) nonrival but (2) partially excludable ideas can prompt increasing returns when they are (3) exploited on a large scale. We are beginning to understand that the growth in social wealth per capita in terms of real income per person over the last millennia is deeply related to the increase in the diversity of new ideas that has occurred over the same time...[50]

As Romer explains in one of his early papers entitled *Endogenous Technological Change*, "a purely rival good has the property that its use by one firm or person precludes its use by another [while] a purely nonrival good has the property that its use by one…in no way limits its use by another." Excludability, explains Romer, is "a function of both the technology and the legal system. A good is excludable if the owner can prevent others from using it."[51]

As traditional economics tells us, "objects" are rival goods subject to the law of diminishing returns. In contrast, as Romer and others have pointed out, ideas and technology designs (which Romer sometimes refers to as "new recipes" for using or combining objects, or "discovery of better ways to do things"), are nonrival goods that "can be used by many people at the same time," without being subject to the law of diminishing returns.[52]

As Romer put it in a December 2001 interview published by Reasononline, "[t]here's no problem of overuse or overgrazing or overfishing an idea. If you give an idea away for free, you don't get any of the problems when you try and give objects away for free."[53]

In fact, rather than diminishing returns, ideas are characterized by increasing returns, since ideas can generate new ideas and new and better ways of doing things, ad infinitum. As such, they don't fit very well within traditional economic analysis which, to retain its internal consistency and ability to generate seemingly meaningful mathematical calculations, has tended to ignore their significance

Romer has described "the combinatorial explosion of ideas" as a key source of economic growth. To exploit this potent source of growth most effectively, he says, "[y]ou have to have systems which explore lots of different paths, but then those systems have to rigorously shut off the ones that aren't paying off and shift resources into directions which look more promising." Another key ingredient, he says, is "freedom," which he suggests "may be the fundamental hinge on which everything turns."

Since the large-scale and highly efficient sharing, evaluation, interaction, expansion and implementation of ideas is an essential element of the Internet's value, function and basic design, it makes sense that Romer's New Growth Theory would provide a more solid foundation for analysis of Internet policy than traditional economic analysis, which has relatively little useful to say about the economics of ideas. And since the Internet has become central to virtually every sector of the communications industry (and arguably to most every sector of our economy), this would also apply to communication policy in general and, potentially, to a range of economic policy issues, especially those tied to industries that make heavy use of the Internet.

The Internet, ideas and economic growth

A key contribution of Crawford's paper is that it links Internet and communication policy to Romer's New Growth Theory approach to economic analysis.

> In the last 200 years or so, technological progress and concomitant economic growth have been particularly dramatic. Romer and others suggest that this may be happening because more people and more (and better) institutions are out looking for new ideas and new technologies. The freedom to look for these ideas is fundamental to economic growth...
>
> The new growth theorists put scale in the foreground as a fundamental aspect of modern economic understanding, because larger markets induce the creation of more new ideas and hence faster growth. The human communications made possible by the internet have the greatest scale of any communications modality we have known thus far. …

> The internet provides a particularly fertile environment for the development of [the] diverse new thoughts that will drive growth. It supports the development of groups and other forms of online communication that are potentially highly responsive to the feedback of human beings and highly likely (given the enormous scale and connectivity of the internet) to trigger exponential development of unpredictably diverse new ideas that are nonrivalrous…
>
> Thus, there is something new about the internet that separates online communications from all former communications modalities...The internet can do more than just transport bits and facilitate momentary person-to-person communications. It can also provide a substrate that enables new ideas and new forms of social organisms to emerge, created by many different decisions to pay attention…[I]nvestment of our attention in these collaborative efforts has a greater payoff than investment of attention in either the one-to-many transactions made possible by broadcast or the one to one (peer) transactions made possible by telephony…[54]

Crawford sees New Growth Theory economics having important policy implications for the communications sector:

> [E]conomic growth theory, with its emphasis on new ideas, diversity, and scale producing increasing returns, combines with our newfound understanding of communications complexity in a fruitful way. Our national economic policy, which looks for opportunities for increased economic growth, should be closely tied to communications policy that facilitates the interactive, group-forming attributes of the internet. …
>
> Online communications are not just like any other form of economic activity. Ideas are not like goods; they are potentially far more valuable. The online world enables the creation of new relationships and thus new ideas that are key to our future economic growth. Communications law can no longer afford to ignore this central fact and its radical implications for policy.
>
> **The key organizing principle for communications law must be to support the emergence of diverse new ideas online because that is where economic growth for society as a whole will come from.** This form of diversity support is not the same as the kind of quota-driven artificial "diversity" that has been used to force broadcast content regulation to reflect minority viewpoints. Rather, **this kind of online diversity stems from allowing the end-to-end, content-neutral, layer-independent functions of the internet to flourish** and allowing groups and human attention to pick and choose from among the bad ideas presented online, enabling good ideas to persist and replicate…[55]

A networked non-market growth sector

As Romer explains in the 2001 interview cited above, New Growth Theory raises important policy questions related to an idea-driven growth model. While the equilibrium price

models of traditional economics work reasonably well for analysis of markets for "objects," Romer says these market-clearing pricing models cannot accurately be applied to "ideas."

> The miracle of the market system is that for objects, especially transformed objects, there's a single price which does two different jobs. It creates an incentive for somebody to produce the right amount of a good, and it allocates who it should go to. A farmer looks at the price of a bushel of wheat and decides whether to plant wheat or plant corn. The price helps motivate the production of wheat. On the other side, when a consumer has to decide whether to buy bread or corn meal, the price allocates the wheat between the different possible users. One price does both jobs, so you can just let the market system create the price and everything works wonderfully.
>
> With ideas, you can't get one price to do both things. Let me give an extreme example. Oral rehydration therapy is…a simple scientific insight about how you can save the life of a child who's suffering from diarrhea. Literally millions of lives have been saved with it. So what price should you charge people for using it?
>
> Because everybody can use the idea at the same time, there's no tragedy of the commons in the intellectual sphere…If you give an idea away for free, you don't get any of the problems when you try and give objects away for free. So the efficient thing for society is to offer really big rewards for some scientist who discovers an oral rehydration therapy. But then as soon as we discover it, we give the idea away for free to everybody throughout the world… So with ideas, you have this tension: You want high prices to motivate discovery, but you want low prices to achieve efficient widespread use. You can't with a single price achieve both, so if you push things into the market, you try to compromise between those two, and it's often an unhappy compromise.[56]

Romer's own analysis of this unique element of the "economics of ideas" appears to be focused largely on the need to strike a healthy balance between the costs and benefits of patents and copyrights, and between publicly-sponsored basic research and market-driven applied R&D.

While these are important areas for growth-economic policy analysis, Crawford's analysis suggests that the Internet can play a key role in bridging the apparent conflict between the value of high prices as motivators of "idea creation" and the social value of low (or no) prices for idea dissemination. One way it does this is by facilitating the free, fluid and efficient exchange and "combinatorial explosion" of ideas that Romer's theories identify as key drivers of economic growth.

The work of Yale Law School professor Yochai Benkler builds on this notion, adding to it a dynamic he refers to as "nonmarket social production." As noted earlier, Benkler is considered a leading thinker on commons-based approaches to economic production, including peer-based production, open source software and creative commons copyright. The following discussion is based on his May 2006 book entitled *The Wealth of Networks: How Social Production Transforms Markets and Freedoms.*[57]

The book's basic premise is that the Internet's technology and structure is enabling increasingly efficient "nonmarket social production." This development, Benkler suggests, promises significant and potentially dramatic benefits in economic, social and political spheres.

Benkler's focus on "nonmarket social production" speaks to Romer's observation in the Reasononline interview that "because the economics of ideas are so different from the economics of markets, we're going to have to develop a richer understanding of non-market institutions, science-like institutions. This is going to be a new endeavor for economics."

More specifically, Benkler's arguments suggest that "nonmarket social production" can help bridge the gap found in market-based production between the high price that motivates high levels of "idea creation" and the low price that makes economic sense from the perspective of disseminating ideas that are nonrival and exhibit increasing returns to scale.

As Benkler explains:

> [W]e are seeing the emergence of a new stage in the information economy, which I call the "networked information economy." It is displacing the industrial information economy that typified information production from about the second half of the nineteenth century and throughout the twentieth century.
>
> The most advanced economies in the world today have made two parallel shifts that, paradoxically, make possible a significant attenuation of the limitations that market-based production places on the pursuit of the political values central to liberal societies. The first move, in the making for more than a century, is to an economy centered on information…and cultural…production, and the manipulation of symbols…The second is the move to a communications environment built on cheap processors with high computation capabilities, interconnected in a pervasive network—the phenomenon we associate with the Internet.
>
> It is this second shift that allows for an increasing role for nonmarket production in the information and cultural production sector, organized in a radically more decentralized pattern than was true of this sector in the twentieth century. The first shift means that these new patterns of production—nonmarket and radically decentralized —will emerge, if permitted, at the core, rather than the periphery of the most advanced economies. It promises to enable social production and exchange to play a much larger role, alongside property- and market-based production, than they ever have in modern democracies.
>
> **What characterizes the networked information economy is that decentralized individual action—specifically, new and important cooperative and coordinate action carried out through radically distributed, nonmarket mechanisms that do not depend on proprietary strategies—plays a much greater role than it did, or could have, in the industrial information economy.** The catalyst for this

> change is the happenstance of the fabrication technology of computation, and its ripple effects throughout the technologies of communication and storage.[58]

Benkler offers three key observations about "the emerging information production system."

> First, nonproprietary strategies have always been more important in information production than they were in the production of steel or automobiles, even when the economics of communication weighed in favor of industrial models. Education, arts and sciences, political debate, and theological disputation have always been much more importantly infused with nonmarket motivations and actors than, say, the automobile industry. **As the material barrier that ultimately nonetheless drove much of our information environment to be funneled through the proprietary, market-based strategies is removed, these basic nonmarket, nonproprietary, motivations and organizational forms should in principle become even more important to the information production system.**
>
> Second, **we have in fact seen the rise of nonmarket production to much greater importance.** Individuals can reach and inform or edify millions around the world. Such a reach was simply unavailable to diversely motivated individuals before, unless they funneled their efforts through either market organizations or philanthropically or state-funded efforts. **The fact that every such effort is available to anyone connected to the network, from anywhere, has led to the emergence of coordinate effects, where the aggregate effect of individual action, even when it is not self-consciously cooperative, produces the coordinate effect of a new and rich information environment.** One needs only to run a Google search on any subject of interest to see how the "information good" that is the response to one's query is produced by the coordinate effects of the uncoordinated actions of a wide and diverse range of individuals and organizations acting on a wide range of motivations—both market and nonmarket, state-based and nonstate.
>
> **Third, and likely most radical, new, and difficult for observers to believe, is the rise of effective, large-scale cooperative efforts—peer production of information, knowledge, and culture.** These are typified by the emergence of free and open-source software. We are beginning to see the expansion of this model not only to our core software platforms, but beyond them into every domain of information and cultural production—and this book visits these in many different domains—from peer production of encyclopedias, to news and commentary, to immersive entertainment.[59]

Benkler suggests that 20th century economic analysis largely--and mistakenly--ignores this growing sector of the 21st century economy. The implication is that strictly market-based analysis will become less and less relevant to the extent social production increases its share of value creation.

> It is easy to miss these changes. They run against the grain of some of our most basic Economics 101 intuitions, intuitions honed in the industrial economy at a time when the only serious alternative seen was state Communism —an alternative

almost universally considered unattractive today…**Human beings are, and always have been, diversely motivated beings. We act instrumentally, but also noninstrumentally. We act for material gain, but also for psychological well-being and gratification, and for social connectedness. There is nothing new or earth-shattering about this, except perhaps to some economists.** [60]

While the above is one hand a humorous commentary on the limitations of traditional economics, it also points to a serious and potentially radical transformation in how human beings will create and exchange value in the 21st century.

In the industrial economy in general, and the industrial information economy as well, most opportunities to make things that were valuable and important to many people were constrained by the physical capital requirements of making them. From the steam engine to the assembly line, from the double-rotary printing press to the communications satellite, the capital constraints on action were such that simply wanting to do something was rarely a sufficient condition to enable one to do it. Financing the necessary physical capital, in turn, oriented the necessarily capital-intensive projects toward a production and organizational strategy that could justify the investments. In market economies, that meant orienting toward market production. In state-run economies, that meant orienting production toward the goals of the state bureaucracy. In either case, **the practical individual freedom to cooperate with others in making things of value was limited by the extent of the capital requirements of production.**

In the networked information economy, the physical capital required for production is broadly distributed throughout society. Personal computers and network connections are ubiquitous. This does not mean that they cannot be used for markets, or that individuals cease to seek market opportunities. It does mean, however, that whenever someone, somewhere, among the billion connected human beings, and ultimately among all those who will be connected, wants to make something that requires human creativity, a computer, and a network connection, he or she can do so—alone, or in cooperation with others. He or she already has the capital capacity necessary to do so; if not alone, then at least in cooperation with other individuals acting for complementary reasons. **The result is that a good deal more that human beings value can now be done by individuals, who interact with each other socially, as human beings and as social beings, rather than as market actors through the price system.**

Sometimes…these nonmarket collaborations can be better at motivating effort and can allow creative people to work on information projects more efficiently than would traditional market mechanisms and corporations. The result is a flourishing nonmarket sector of information, knowledge, and cultural production, based in the networked environment, and applied to anything that the many individuals connected to it can imagine. Its **outputs, in turn, are not treated as exclusive property. They are instead subject to an increasingly robust ethic of open sharing, open for all others to build on, extend, and make their own.**[61]

Benkler appears to be describing an Internet-enabled dynamic that facilitates the "combinatorial explosion of ideas" that, according to Romer, drives economic growth. It does this by using the Internet to leverage the idea-generating power of "decentralized individual action," "nonmarket collaborations," and "cooperative and coordinate action carried out through radically distributed, nonmarket mechanisms that do not depend on proprietary strategies."

One thing these nonmarket mechanisms can do is reduce the "idea-price" gap discussed above, which Romer cites as one of the key challenges facing economic growth policy. Whereas, as Romer notes, patents, copyright and government-funded research are important arenas for addressing this market-clearing price gap, Benkler's analysis suggests that the expansion of Internet-enabled nonmarket production offers a lower cost means to address this price gap, since it neither requires government funding (though it can amplify the benefits of such funding), nor entails the legal and administrative costs and potential market distortions associated with managing patents and copyright.

While the extent to which these nonmarket interactions will contribute to growth remains unknown, Benkler's point is that their contribution is already significant and shows clear signs of expanding. But he also warns of a conflict that threatens to stifle this expansion. Driving this conflict, he says, is the challenge such expansion poses to the perceived interests of incumbent entities that have aggregated significant power in what he calls the "industrial information economy."

> We see this battle played out at all layers of the information environment: the physical devices and network channels necessary to communicate; the existing information and cultural resources out of which new statements must be made; and the logical resources —the software and standards—necessary to translate what human beings want to say to each other into signals that machines can process and transmit. **Its central question is whether there will, or will not, be a core common infrastructure that is governed as a commons and therefore available to anyone who wishes to participate in the networked information environment outside of the market-based, proprietary framework.**[62]

A central message of Benkler's book is that much future value will be lost if public policymakers miss the opportunity to promote the "core commons infrastructure" he refers to, by adopting policies that excessively favor industries and companies whose financial interests lie with "proprietary, industrial models of information production."

Benkler doesn't limit himself strictly to economic matters. He also claims that "the diversity of ways of organizing information production and use opens a range of possibilities for pursuing the core political values of liberal societies—individual freedom, a more genuinely participatory political system, a critical culture, and social justice."

In essence, what Benkler is saying is that, just as a neutral, high capacity, symmetrical Internet empowers new forms of nonmarket production that in turn drive idea-driven economic growth, it also supports vibrant and healthy growth in the political, social and

cultural spheres, where decentralized nonmarket production and exchange of ideas have always played a central role.

The value of neutral, symmetric networks

Comments by Crawford bring us back to the choice we now face as a society regarding Internet and communication policy and, specifically, with regard to the value of neutral high-capacity networks.

> …To generations accustomed to centrally-controlled entertainment modalities like television and cable, this limitation to "channels" provided by network providers may not seem important. Surely there will be vast amounts of digitized material to absorb online. Why should it matter whether some of it is prioritized? The reason this prioritization matters is that we do not know what new forms of group-oriented collaborative interactions (social, commercial, or cultural), or what kinds of new ideas, will emerge from this network of networks.
>
> Prioritization will make a difference because network providers will cease to be commodity transport-providers and will instead become gatekeepers, pickers-of-winners, and controllers-of-experiences on a massive scale. The diversity of online experiences, and thus the range of freedom of human connection, human relationships, and the diverse generation of new ideas will diminish.
>
> **Neutrality of symmetric high speed access is important for a host of reasons: it will enable diverse new applications to emerge that are not controlled by network providers; it will cause new forms of interaction to grow, even apart from the introduction of applications; and it will enable diversity in various real-time communications that otherwise will be controlled and monetized by the network providers. All of this diversity has great potential to be positively associated with economic growth.** [63]

One can certainly argue that the comments cited earlier by Bob Frankston do not represent the attitude of the typical Verizon customer. Frankston is, after all, a long-time expert in software and networking, with both the motive and capability to take direct responsibility for his home network and make heavy use of a symmetrical high-capacity network. His "empowered citizen" attitude is evident in statements like "the marketplace is really us creating our own solutions" and "if we provide opportunity rather than just narrow solutions, demand can create supply." But, as Crawford points out, the fact that not everyone is an independent-minded technologist like Frankston does not weaken the basic case for neutral, high-capacity networks.

> One frequent argument against network neutrality is that users want simplicity. Verizon representatives talk animatedly about the need for an interface for online broadcasts that can be controlled in the dark with one hand -- because the other hand will be busy holding a beer. But this conception of user behavior shows a lack of imagination. People do want to relax and be entertained, and Americans have great

strengths in this domain, but **network neutrality is not incompatible with either simplicity or high entertainment value. The key question is who will be in a position to control access to simple and highly-entertaining activities and engagements provided online. If network providers act as gatekeepers, deciding which new ideas will fail and which will succeed, then they will be artificially amplifying particular ideas. Instead of the internet, we will have a broadcast television network, in which success is decided on "from above" rather than emerging from the interactions of agents.** [64]

Part 3: Key White Space Issues

As noted in Part 1, the FCC is in the final stages of deciding if and how to authorize use of the broadcast white space, which could potentially be made available by early 2009. Depending on what the Commission decides, many parts of the country could see 100-150 MHz of white space spectrum freed up for new uses, with more than 200 MHz potentially available in some areas.

In Docket 04-186, the Commission must make decisions on a number of key issues that together will determine how much and on what terms white space spectrum is made available and, potentially, the nature and economic viability of networks and services employing that spectrum.

In late January and early March, the FCC received two rounds of comments from interested parties in the white space proceeding. In this section of the report we examine the key issues before the Commission, the views expressed in these recent comments, and the potential implications of alternative white space policies that could be adopted by the Commission.

First Report and Order and FNPRM

In October 2006, more than 2 years after issuing an initial 2004 NRPM under previous chairman Michael Powell, the FCC, under pressure from Congress, released a First Report and Order and Further Notice of Proposed Rulemaking in its white space proceeding (Docket 04-186). Though the First Report and Order "concluded that fixed low power devices can be allowed to operate on TV channels in areas where those frequencies are not being used for TV or other incumbent licensed services," it left much to be resolved in the FNPRM. Comments on the FNPRM were due at the end of January, 2007, with reply comments due in early March.

The Order disappointed unlicensed white space advocates in several key respects. As expected, it did not allow unlicensed operation on TV channel 37, which is used by radio astronomy and wireless medical telemetry services, nor on TV channels 52-69, which had previously been reallocated for public safety and commercial mobile services. But it also did not permit operation of unlicensed personal/portable devices on TV channels 14-20, which are used by public safety service in about a dozen major markets cities. It also left open several spectrum-related issues, seeking comment on these in its FNPRM. These included:

1) whether personal/portable devices can operate in any of the TV channels without causing harmful interference;

2) whether low power devices should be permitted on TV channels 2-4, which are used by TV interface devices such as VCRs;

3) whether fixed low power devices can be permitted on TV channels 14-20.

Also disappointing to advocates of unlicensed use of the white space was the Commission's decision to invite comment on the desirability of requiring licensing for devices operating in the TV bands. The Commission chose to revisit this question even though its original NPRM's proposal had favored unlicensed use and, as the Commission noted, a majority of the proceeding's commenters had expressed interest in such unlicensed uses.

The FNPRM also sought comment on the proposed mechanisms for avoiding interference with broadcast signals, including the use of geo-location technology, control signals, and spectrum sensing. As discussed more fully below, issues and options related to these interference control mechanisms are closely tied to questions about what white space channels should be opened for use, and whether such use should include personal/portable devices.

The Commission also ordered that marketing and sales of unlicensed white space devices could begin February 18, 2009, after the digital television (DTV) transition is complete and all TV stations are in operation on their permanent DTV channels.

The Commission also "reaffirmed its commitment to developing a complete record to ensure that the final rules will protect TV broadcasting and other service against harmful interference." Toward that end, it invited parties to submit test results showing that TV band devices will not cause harmful interference and indicated that it plans to conduct its own extensive testing in this area before adopting final rules.

The First Report and Order laid out a schedule for further steps, including: 1) a report on interference rejection capabilities of DTV receivers by March 2007; 2) a test program, including field tests, "to assess the potential for interference from low power devices operating in the TV bands," with a report on test results to be completed by July 2007 and; 3) a Second Report and Order "specifying final requirements for devices in the TV bands in the fall of 2007."

Interference issues

Probably the most contentious issue in the FCC's white space proceeding is how to avoid harmful interference to licensed users in the TV band.

Protecting broadcasters

Not surprisingly, joint comments by the Association for Maximum Service Television (MSTV) and the National Association of Broadcasters (NAB) argue that interference risks are substantial if unlicensed use is authorized in the white space. Accordingly, they advocate severe limits on white space usage, including: prohibitions on so called "adjacent channels" and potentially other channels as well; requirements for interference protection methods that unlicensed advocates claim are too costly and inefficient—perhaps to the

point of economic non-viability--and; prohibitions on use of unlicensed personal/portable devices.

Also not surprising is that broadcasters preferred approach to the white space, as reflected in a separate "Joint Comments of Broadcasters" filing, would be a primarily licensed-based scheme in which the first step was to allow incumbent broadcasters to expand the geographic scope of their existing licenses. Following this step, broadcast licenses would be available in white space channels, also on a DMA basis.

Under the broadcasters' plan, "to the extent any unlicensed uses are adopted for available TV spectrum, they [would] occur only in certain limited DMAs and frequencies on a geographic, market-by-market, secondary basis, for fixed use by low-power devices so long as those devices do not cause harmful interference to incumbent broadcasters or to other services."[65]

Leading the charge to open up the white space to unlicensed use are two main coalitions. One is spearheaded by New America Foundation (NAF), a DC-based non-partisan policy think tank that has been a longstanding advocate of spectrum reform, with a particular focus on opening up the white space to unlicensed use. Most of NAF's recent white space filings have included the backing of a range of community and consumer groups and unlicensed spectrum advocates, including: Media Access Project, Common Cause, Educause, Public Knowledge, U.S. PIRG, Center for Digital Democracy, National Hispanic Media Coalition, Wireless Internet Service Providers Association, Association for Community Networking, CTCNET, Cuwin Foundation, Ehos Group, NYC Wireless, Tribal Digital Village, Newburyopen.net, Acorn Active Media and Freenetworks.org.

The other leading advocate of unlicensed use of white space is a coalition of high-tech companies, including Dell, Google, Hewlett-Packard, Intel, Microsoft and Philips Electronics. As discussed further below, this coalition offered fairly detailed technical proposals for unlicensed use of the white space, and is also taking the lead in developing prototype devices for testing.

A full analysis of technical interference issues related to the white space is well beyond the scope of this report and will, in any event, be subject to extensive testing by the FCC. But a review of comments filed in the proceeding suggests that some claims by broadcasters have significantly exaggerated interference risks. An example of this was cited in reply comments filed by the high-tech coalition:

> MSTV…contends that harmful co-channel interference from unlicensed devices presents a potential interference problem for miles. For example, in an exhibit, MSTV…initially speculates that "to keep the free space interference field 20 dB below the desired DTV signal would require a separation of 600 miles" for a 4 watt device…As the Commission surely knows, the 600 mile figure is nonsensical even as a starting point. Megawatt full power TV stations operate on the same channel at much closer distances than six hundred miles, usually about 150 miles. To suggest that six hundred mile separation from a 4 watt device should be considered in any

> way only demonstrates the embarrassing lengths some will go to in an attempt to "protect" spectrum for which they do not have a license (i.e. the white spaces).[66]

Broadcasters' claims of very wide area interference from low power unlicensed devices appear to be in direct conflict with the apparent technical assumptions underlying the licensing model proposed in their "Joint Comments" filing. That plan appears to support licensing of new "full power" TV stations on white space channels, a proposal that is difficult to reconcile with broadcasters' claims that low-power 4 watt unlicensed devices could cause interference for up to 600 miles.[67]

The high-tech coalition also cited a number of other "unrealistic assumptions about how real-world devices," such as those it was proposing, will operate. These included incorrect assumptions regarding power levels and antennas, and seeming disregard for the fact that devices would employ transmission power control (TPC), which is a fundamental component of the coalition's proposed approach to interference control.[68]

According to the coalition, broadcasters' claims of 600-mile interference risks for low-power unlicensed devices, along with other technical claims in their comments, "demonstrate the need for an objective, independent Commission assessment of harmful interference risks."[69]

Reply comments by NAF, which sponsored its own series of white space interference tests, "urge[d] the Commission to set performance goals consistent with the need to protect licensed users from interference based on long standing precedents." NAF went on to explain:

> We believe the Commission should simply define objective criteria for measuring harmful interference, and for detecting and avoiding use of a licensed frequency, and then allow technology and industry to evolve to meet this challenge through the FCC's traditional device certification process.
>
> Can DTV detection at, say, -114 dBm be made to work in a consumer device? At what power level can an efficient transmission mask allow an unlicensed device to operate on an unused DTV channel without causing harmful interference to DTV reception on the first or second adjacent channel? These are fascinating questions, but not the right policy questions here. They are certainly not questions the Commission should strive to resolve now for all time. While the opponents may be well-intentioned in trying to prevent multibillion-dollar corporations such as Microsoft and Google from spending R&D resources to develop innovative technology, **a better government role is to say "how high the bar is" and tell such corporations they can sell products if they can "get over the bar." The "bar" should be set high enough to prevent harmful interference, and the challenge to show feasibility left to the proponents.**[70]

Like the high-tech coalition, NAF's reply comments take aim at some of MSTV/NAB's more aggressive claims about the potential range of interference from low-power unlicensed devices, describing them as "misuse of free space propagation models."

NAF cites the 1979 precedent of Docket 20780 that it says "successfully set limits on home computer emissions to protect television reception and other licensed services." "In Docket 20780," NAF explains, "the Commission based its emission limit for digital devices/personal computers on the assumption that 'the home computing device is at least 10 meters from the receiver.'" In that proceeding, the Commission had said it was "most interested in protecting an individual who is receiving interference from his neighbor's computer," and "concerned about devices in the same household…to a lesser extent."[71]

Broadcasters comments seemed to be arguing that virtually all potential interference must be foreseen and forestalled in order for unlicensed use of white space to be authorized. In contrast, NAF argued that the proper standard to be used is one that attempts to balance potential costs and benefits, as the Commission sought to do in Docket 20780.

> MSTV/NAB has stated, "whenever any device is in proximity to any television receiver, the risk of interference will increase." While this is technically true, it ignores the longstanding approach of Docket 20780 and the fact that many regulated and unregulated devices "in proximity to any television receiver" will and do cause interference…
>
> MSTV/NAB…and other opponents seem not to be aware of the Docket 20780 precedent and the success it has had in virtually eliminating interference complaints from digital devices. They advocate an impractical protection standard that, if implemented consistently among electrical and electronic products sold for home use, would escalate consumer costs and restrict spectrum and product availability for no real benefit. This is not the approach the Commission has taken in the past 28 years...
>
> Considering the enormous opportunity cost of losing any channels that could be used for low-power home, enterprise, and neighborhood networking, it would be unproductive and paternalistic to set an emission limit at any distance that was not considered essential to protect the use of licensed services in neighboring households or businesses – certainly not those on the consumer's own premises.[72]

As NAF notes, in setting home computer emission limits, the Commission considered the value provided by these emissions in relation to the risks of interfering with licensed operations.

> We believe that in most cases interfering radiation from computing devices is a less valuable use of spectrum than the radio and television services that would be interfered with. Therefore, we consider it appropriate that our regulations deny to computing devices an interfering use of the spectrum (except where the interference is to other equipment of the computer owner). We have made this judgment by comparing the benefits of allowing current uses of spectrum to continue without interference from computing equipment with the costs of denying interfering use of the spectrum to computers. [73]

Building on this "balancing" approach to potential interference, NAF argued that the FCC should consider higher emission levels for white space radio devices than for the unintentional radiation from home computers:

> [S]ince the communications signals of the TV band devices under consideration are not unintentional noise without content as referred to in Docket 20780, the same logic would indicate that higher emissions would be appropriate [for these TV band devices].[74]

Interference protection options

As noted earlier, the FCC's FNPRM requested comments on the proposed mechanisms for avoiding interference with broadcast signals, including the use of geo-location technology, control signals, and spectrum sensing.

The high-tech coalition was the strongest advocate of using spectrum sensing technologies as a means to avoid interference. According to its comments:

> Spectrum sensing will protect incumbent licensees and facilitate spectrum sharing with other low power devices in the white spaces, while avoiding the operational difficulties and economic burdens associated with the other interference avoidance mechanisms identified in this proceeding. In addition, since spectrum sensing does not depend on third party "assisting" technologies (such as databases of available channels and/or broadcast beacons) to implement, **a spectrum sensing approach will better facilitate the creation of a mass market for devices – resulting in more affordable consumer products and more attractive prospects for wireless broadband, including in rural areas. In fact, it may be the single most significant action taken by the Commission to bring broadband access to rural America.**[75]

The coalition challenged claims by broadcasters and others that spectrum sensing is an unproven approach to avoiding harmful interference:

> Wi-Fi devices operating in the unlicensed bands have been employing spectrum sensing technology for over 10 years. Moreover, as the Commission has recognized, the authorization of U-NII devices employing dynamic frequency selection ("DFS") in the 5 GHz band provides a valuable precedent for the Commission to consider when determining the appropriate approach for interference avoidance in this proceeding…
>
> Although the Commission correctly notes that differences between incumbent military radar in the 5 GHz band and TV broadcast signals will require modifications to the U-NII DFS approach, most of these differences make the case for spectrum sensing in the TV bands even more compelling. Unlike military radar, TV signals are designed to be detected. While differences between the bands will require different technical standards, the Coalition is confident that the

> Commission's prototype device testing will confirm that the Coalition's proposed operating parameters will protect licensees from harmful interference.[76]

Tropos Networks, a leading supplier of WiFi-based mesh networks in the muni-wireless sector also argued that spectrum sensing, combined with dynamic frequency selection (DFS) would be sufficient to protect broadcasters from harmful interference:

> [T]he strength and reliability of current contention based sensing protocols, which have expanded enormously since the commencement of these proceedings, will provide adequate protection to broadcast operations while avoid costs that provide no additional protection. The detection capability of a device can be enormously more sensitive than a DTV receiver, a reality that should be recognized in examining the ability of contention based technology to protect broadcast operations.[77]

Tropos' comments also echoed those of NAF, in cautioning that "[t]he Commission's rules should be directed not toward particular operating parameters, but the criteria to evaluate whether a device adequately protects broadcast operations."[78]

Motorola's comments expressed a more conservative view of the role of spectrum sensing in interference control. "It is premature," the company said, "to rely on spectrum sensing as a spectrum access method because of the difficulties involved in implementing sensing technology in this environment."[79] Instead, said Motorola:

> A system employing spectral sensing in combination with some form of geolocation or database look-up appears to be necessary to insure protection of authorized licensed users. Rules regarding spectral sensing could be relaxed at a later date as the technology becomes more proven.[80]

> There are still technical issues with relying only on spectrum sensing, particularly in outside applications, that only real world environments will identify. This includes not only the ability of devices to accurately sense in the TV environment where the location of receivers relative to the desired transmitter is unknown, but also the need to ensure adaptability to not only detect current, but future waveforms. Inflexible implementations may detect today's waveforms but once devices are deployed, there will be no way to modify sensing requirements. Accordingly, the Commission would have to require some software defined capability to provide future adaptability.[81]

Adjacent channels

An important question in terms of the amount of available white space is whether channels immediately adjacent to actively used broadcast channels can be used in the same service area.

Broadcasters, using propagation models and test assumptions the high-tech coalition and NAF claimed were unrealistic, concluded that "any operation of a TV band device on a television station's first adjacent channel will harm reception…[and] should be avoided within a TV station's protected contour."[82]

The high-tech coalition had a totally different view of this question. Noting its "plans to utilize TPC combined with over-the-air sensing to achieve Commission-mandated adjacent channel D/U (desired to undesired) signal ratios," it expressed "confiden[ce] that Commission testing of the Coalition's prototype will verify that this approach is more than adequate to project incumbent licensees on adjacent channels."[83]

> The Coalition's own testing strongly suggests that the FCC laboratory will be able to confirm that an outright ban on adjacent channel usage by low power devices is not necessary or advisable, and will serve only to create an artificial scarcity of white spaces in congested areas. The ability to offer devices that will work in both urban and rural areas will create a substantially more robust market—with resulting economies of scale and scope—than would a market made up of devices that could operate only in rural areas.[84]

Data presented in comments filed by the Brattle Group (cited earlier in this report) provide some useful perspective on the extent to which the exclusion of first adjacent channels would impact the availability of white space spectrum.

The Impact of Excluding First Adjacent Channels

	White Space Bandwidth Including First Adjacent Chs.		White Space Bandwidth Excluding First Adjacent Chs.		Bandwidth Lost by Excluding First Adjacent Chs.	
	Minimum	Average	Minimum	Average	Minimum	Average
San Francisco-Oakland-San Jose	78	149	0	67	78	82
New York	78	140	18	54	60	86
Philadelphia	78	162	12	63	66	99
Puerto Rico-U.S. Virgin Islands	96	125	18	26	78	99
Tampa-St. Petersburg-Orlando	96	171	18	60	78	111
Los Angeles-San Diego	108	152	12	60	96	92
Boston-Providence	108	163	48	91	60	72
Chicago	114	181	18	74	96	107
Detroit	120	190	24	92	96	98
Washington-Baltimore	120	164	30	81	90	83
Buffalo-Rochester	126	193	42	98	84	95
Milwaukee	126	222	24	138	102	84
Miami-Fort Lauderdale	132	161	36	67	96	94
Cleveland	138	196	24	85	114	111
Knoxville	144	197	42	96	102	101
Denver	144	203	48	124	96	79
Richmond-Norfolk	144	214	48	121	96	93
Charlotte-Greensboro-Greenville-Raleigh	150	200	30	102	120	98

Seattle	150	210	36	123	114	87
Tulsa	150	206	42	94	108	112
Dallas-Fort Worth	156	205	54	125	102	80
San Antonio	156	207	48	121	108	86
Houston	156	187	54	98	102	89
Pittsburgh	162	197	66	122	96	75
Oklahoma City	162	219	54	130	108	89
Jacksonville	162	230	72	152	90	78
Phoenix	168	211	84	121	84	90
Atlanta	168	209	36	123	132	86
Birmingham	168	216	54	121	114	95
Indianapolis	168	210	54	120	114	90
Nashville	174	219	54	124	120	95
Louisville-Lexington-Evansville	174	227	66	145	108	82
Cincinnati-Dayton	174	209	72	124	102	85
Salt Lake City	174	220	54	129	120	91
Portland	180	215	72	122	108	93
New Orleans-Baton Rouge	186	219	72	121	114	98
Kansas City	186	236	66	150	120	86
Alaska	186	244	72	176	114	68
Columbus	186	226	84	141	102	85
El Paso-Albuquerque	186	229	72	150	114	79
Des Moines-Quad Cities	192	237	72	153	120	84
St. Louis	192	233	66	138	126	95
Little Rock	192	237	72	157	120	80
Minneapolis-St. Paul	198	238	84	164	114	74
Memphis-Jackson	198	236	96	157	102	79
Honolulu	198	220	78	126	120	94
Omaha	204	243	108	170	96	73
Spokane-Billings	216	249	102	182	114	67
Wichita	222	252	138	189	84	63
Average (unweighted)	150	201	69	128	81	73

The table above is based on the Brattle Group data, which includes breakouts by Major Trading Area (MTA). As it clearly shows, the reduction in usable white space is fairly dramatic when first adjacent channels are excluded.[85]

Including adjacent channels, the minimum amount of spectrum available per MTA ranges from 78 MHz to 222 MHz, with an overall unweighted average of 150 MHz. In contrast, with adjacent channels not available for use, this range drops to 0-138 MHz, with the unweighted average cut by more than half to just 69 MHz.

Similarly, the average amount of spectrum including adjacent channels ranges from 149 MHz to 252 MHz, with an average of 201 MHz, but falls to 26-189 MHz and an average of 128 MHz when adjacent channels are excluded.

The final two columns in the table show the bandwidth that would be lost if first adjacent white space channels are not available for use. In terms of minimum available bandwidth per market, this loss ranges from 60 MHz to 132 MHz, with a per market average of 81

MHz and 30 of 49 markets losing more than 100 MHz of usable bandwidth. The average amount of bandwidth lost due to exclusion of adjacent channels ranges from 68 MHz to 112 MHz, with an average loss of 73 MHz per market.

Wireless microphones

A number of comments were filed by manufacturers and users of wireless microphones, who use broadcast spectrum at low power levels under Part 74 Subpart H of the FCC's rules. Licensed wireless microphone users in this band include broadcasters, cable operators producing local programs, film and TV program producers, and MMDS licensees.

In approaching this issue, the high-tech coalition began by pointing out that "many—if not most—wireless microphone users in the TV band operate illegally."[86] As evidence to support this claim, NAF cited "a recent Internet posting by a wireless microphone group" that cited an estimate that "only about 10 to 15 percent" of unlicensed microphone system in use today are properly licensed."[87]

In their comments, microphone interests requested protection mainly in the form of white space channels set aside solely for their use, and/or a beacon system to create a "bubble" around areas where wireless microphones are transmitting.

The high-tech coalition rejected the beacon system proposal, arguing that it would mainly serve to protect the "scofflaws" that engage in "unauthorized wireless microphone transmissions." The coalition predicted that, "[j]ust as sales of wireless microphones have not been restricted only to licensed users, sales of beacons would surely spread to these same scofflaws, who would then create 'bubbles' around their unauthorized wireless microphone transmissions."[88]

More fundamentally, the coalition argued that beacons would not be needed because "Commission testing will confirm that the Coalition's proposed detection threshold of -114 dBm will provide wireless microphone licensees with the interference protection to which they are entitled."[89]

Motorola, which was in favor of higher power limits than proposed by the coalition, favored use of a disabling beacon to avoid interfering with wireless microphones. As one option, it cited an approach being developed by the IEEE 802.22 standards group, which has been developing a standard for fixed operation in the white space band.[90]

NAF suggested that "a long-term solution to the wireless microphone issue would be to migrate present users, both legal and illegal, to alternative technologies that can share spectrum efficiently with the greater spectrum-user community." It went on to propose a detailed plan to achieve this.[91]

Acknowledging that its plan was a "complicated" one, NAF predicted that it "will no doubt be unpopular among the wireless microphone users who have exclusive free access to a valuable block of 'beachfront property' spectrum under anachronistic rules adopted in a

different technical and spectrum policy era." But it also claimed that the proposal was "crafted to respect the equity of existing users, provide for reasonable protection of ongoing operations in the short term, and give enough time for a reasonable transition to a better long-term policy."[92]

Public safety and channels 14-20

According to the Land Mobile Communications Council (LMCC), from one to three channels in the 470-512 MHz band (channels 14-20) are used by Private Land Mobile Radio Service (PLMRS) licensees in eleven major U.S. markets: New York, Los Angeles, Boston, Philadelphia, Washington D.C., Pittsburgh, Chicago, San Francisco, Dallas, Houston, and Miami. Channels had also been authorized for land mobile usage in another two markets, but are not used due to treaty restrictions with Canada.[93]

As LMCC noted in its comments, "land mobile base and mobile stations are subject to strict limitations on operating areas."[94] These strict geographic limits would presumably simplify the process of avoiding interference.

This potential for avoiding interference was reflected in the FCC's May 2004 NPRM, which proposed allowing low power devices to operate on channels 14-20 in parts of the country where they are not being used by land mobile licensees.

In spite of its earlier proposal, the Commission's October 2006 First Report and Order, adopted a more conservative stance with regard to channels 14-20, which account for 42 MHz of the roughly 300 MHz in the TV band that contains the white space.

Most notably, the Order prohibited personal/portable TV band devices from operating on those channels in all areas of the country. In the accompanying FNPRM, the Commission sought additional comments on whether fixed TV band devices should be allowed on channels 14-20 in those areas of the country where these channels are not used by public safety.

The Commission's rationale for imposing a nationwide ban on personal/portable devices in the 14-20 band appeared to reflect a concern that these devices could be transported to and used in areas in which land mobile licensees operate.

> Because personal/portable devices are easily transported and used anywhere, we believe that the most prudent approach to protecting public safety and other PLMRS/CMRS operations on channels 14-20 is to prohibit personal/portable low power TV band devices from operating on those channels in all areas of the country.[95]

In a Petition for Reconsideration filed in December, NAF and the Champaign Urbana Wireless Network argued that the Commission's ban on personal/portable devices in the channel 14-20 band reflected "far too cautious an approach."[96]

> As explained in the FNPRM, the Commission will continue to investigate the technical requirements for mobile devices, as well as for fixed use on channels 14-20 (and fixed and mobile use in channels 2-4). The Commission will therefore have more than sufficient opportunity to determine whether or not to permit mobile use on channels 14-20.[97]

NAF's petition argued that the likely impact of the Commission's decision would be to prematurely and unnecessarily foreclose potentially beneficial uses of the 14-20 band.

> If this Commission makes a decision at this stage to foreclose mobile devices on channels 14-20, no one will conduct the necessary studies to determine whether mobile devices can coexist safely with the [land mobile] operations on these channels. This will foreclose the use of valuable spectrum not merely to the broader community, but to public safety operators as well…
>
> The Commission can, and should, defer a final decision on whether to permit mobile operation on Channels 14-20 until it becomes more familiar with the available technologies for mobility generally through the processes outlined in the FNPRM. Requiring interested parties to start an entirely new proceeding at some undefined future date will only increase the cost in time and money while needlessly depriving the country of much needed spectrum.[98]

In separate comments, NAF, et al. urged the FCC to authorize unlicensed fixed operation in channels 14-20, based on the use of geolocation and control signal technologies to avoid interference with land mobile systems. They also encouraged the Commission to consider a technical approach that could allow the use of portable devices as well (underline in original).

> [G]iven that fixed station use is practical in these channels using geo-locational or control signals, mobile use would also be safe if such use in channels 14-20 were conditioned on the use of the master-client relationship discussed in ¶46 of the FNPRM. As the FNPRM notes, this concept has already been used in U-NII and is a noncontroversial aspect of the new 3650 MHz rules, where it protects sensitive satellite earth stations.[99]

NAF estimated that, even with "an excessively-protective 200-mile radius" around the cities in which land mobile licensees needed to be protected, less than 45% of the nation's area would fall within this protected zone. In addition, said NAF:

> A more detailed calculation using a smaller and more realistic protection radius that takes into account overlaps between protection areas and accounts for coastal cities, where much of the protection area is in the ocean, would yield a small fraction of the country where TV band devices on channels used for TV/land mobile sharing would be unacceptable under any circumstance.[100]

NAF concluded that:

> [I]t would be incredibly inefficient and disproportionately harmful to rural areas and constituencies for the Commission to prohibit all use of channels 14-20 if they can be used safely in the majority of the land mass of the country and the rules can be crafted to prevent harmful (or any) interference in the 13 metropolitan areas subject to TV/land mobile sharing. In view of the challenges in getting broadband to rural areas, the total denial of channels 14-20 to our rural citizens is especially burdensome.[101]

Motorola agreed with NAF that the FCC should not close the door to personal/portable use in the 14-20 band. But it suggested such use be limited to "public safety and other critical users."

> Such devices will be required to rely on appropriate mechanisms that ensure interference protection to incumbent broadcast and land mobile services. This will contribute valuable information on the capabilities and requirements of spectrum access methods, such as control signal beacons. **As further experience with the technology is applied, the Commission can review whether these eligibility restrictions [i.e., allowing only "public safety and other critical users] continue to be warranted.[102]**

According to Motorola, its proposal would insure that "[u]se of the 470-512 MHz band by public safety and other critical users [w]ould be monitored," while also being "consistent with the Commission's decision in the First Report and Order to prohibit unlicensed portable use on these channels."[103]

> While Motorola does not recommend individually licensing users and agencies for these devices given the relatively low power allowed, users should be required to register and coordinate unlicensed use with an appropriate Commission frequency coordinating committee. Also, similar to the authorization "by rule" of…"radar guns,"…authority to operate these low-powered devices can be provided through the entity's general land mobile license.

In its reply comments, the high-tech coalition said it was "pleased to learn that Motorola advocates the use of personal/portable devices for public safety and first responders in channels 14-20."[104] The coalition also some implications for device design in the Motorola proposal.

> Allowing public safety agencies to supplement their existing operations with unlicensed personal/portable devices…will allow public safety agencies to obtain the benefits the general public will receive from unlicensed devices…[C]onsumer personal/portable devices can easily be modified by the manufacturer to accommodate public safety operations on channels 14-20. Thus, by allocating the use of channels 21-51 for unlicensed personal/portable use by the public, the Commission can ensure that prices for counterpart public safety devices will

> decrease dramatically, providing both the general public and public safety users with affordable access to the benefits that these devices will provide.[105]

The white space proposal laid out in a later section of this report will refer back the above comments by NAF, Motorola and the high-tech coalition with regard to uses of the channel 14-20 band in ways that augment potential benefits while minimizing potential interference risks.

Cable also seeks protection

The National Cable & Telecommunications Association (NCTA) also weighed in with some interference concerns related to white space use. It submitted a technical paper it claimed "demonstrated… that television receivers and VCRs directly connected to cable systems are highly susceptible to 'direct pickup' ('DPU') interference from unlicensed devices operating in close proximity because of inadequate shielding in TV receivers." As it noted in its reply comments:

> NCTA urged the Commission to limit the power output of new personal/portable devices to a range of 10-20 mW and prohibit their operation on channels 2 - 4 in order to preserve cable's ability to cure any interference that occurs through the use of a well-shielded set top converter.[106]

NCTA also asked the Commission to prohibit operation of fixed devices on any VHF channels "because of the increased potential for DPU interference and reduced path loss at lower frequencies which requires very long distances between fixed devices and the cable headend," which it claimed would make it "very difficult to protect reception or coordinate with fixed unlicensed VHF transmitters."[107]

Not surprisingly, the high-tech coalition opposed this sharp reduction in transmit power limits, which was well below the 100 mW cap it favored. NAF was also skeptical regarding NCTA's claims of DPU interference:

> It seems more than odd that this does not seem to impact cable subscribers living near high-power TV transmitters today, nor cable users in communities with TV/land mobile sharing on channels 14-to-20. Indeed, interference to a cabled system from a low-power device in another household (or even more than 10 meters distant) seems implausible.[108]

NAF said it "expect[s] the FCC labs will rigorously test this under realistic conditions" and noted that it is also "undertaking additional testing at the University of Kansas to explore this issue." NAF also pointed out that VCRs and cable and satellite set-tops are regulated as Part 15 devices that are not protected against interference. [109]

NCTA also expressed concerns that unlicensed devices might cause interference to cable headend antenna reception of "distant" broadcast signals in "unprotected" areas beyond their protected Grade B contours. Based on this concern it "urged the Commission…to not

only restrict operation of personal/portable devices within the Grade B contour but require spectrum coordination before any unlicensed devices (fixed or portable) are permitted to operate outside the Grade B boundary."[110]

NAF countered that "[t]he Commission has generously provided the CATV industry with access to Cable Television Relay Service, Part 78, spectrum independent of auctions and other marketplace forces." [111]

> It is ironic to limit TV band device spectrum availability for broadband access for rural residents over a wide area – and at tremendous opportunity costs to those communities – in order to protect an isolated CATV headend that has access to Part 78 spectrum. Cable operators are certainly able to take self-help measures to protect their reception in those handful of circumstances where they may be vulnerable.[112]

The coalition also had something to say on this issue:

> As a threshold matter, cable headend antennas are usually mounted far off the ground and out of the way of populated areas, and typically are highly directional. These factors make off-axis interference generated by a low power personal/portable device highly unlikely. More fundamentally, by setting up headends beyond the Grade B Contour, cable companies have accepted the risk of relying on transmissions that are not protected from harmful interference. Arguments that the Commission should not take into account "whether the broadcast signal received is inside or outside of a defined contour" do not help determine how best to enable use of the white spaces, but merely seek to expand impermissibly the rights of broadcasters beyond the scope of their licenses.
>
> The NCTA implies that the restrictions it has proposed are necessary to allow cable companies to meet their "must carry" obligations under Part 76 of the Commission's rules, but this is simply not so. If a broadcaster wishes to invoke its must carry rights, it has the obligation to provide a "good quality" signal (which the Commission has determined to be -61 dBm or better for digital signals) at the cable system's principal headend. Indeed, cable companies routinely refuse to carry broadcasters' signals based on their failure to provide a good quality signal to their principal headends. As the NCTA concedes, signals are often delivered terrestrially rather than over-the-air, and there is no reason that broadcasters cannot do so if they cannot deliver a -61 dBm signal to areas where they are not entitled to interference protection.[113]

A spectrum grab by incumbents?

In their reply comments, NAF et al. urged the Commission to reject what they claimed was a "spectrum grab" by incumbents. "With few exceptions," they said, "prominent representatives from each major incumbent interest group have made major new claims [in their comments] on the TV white space, seeking a vast enlargement of their spectrum rights."[114]

[Incumbents] frame this spectrum grab as protecting their existing users. But no one should be fooled by this framing. Now that they know the FCC is serious about allocating the white space, they want to claim as much of it as possible for themselves. And since they cannot baldly ask for such a momentous giveaway of spectrum rights (the Communications Act bans spectrum "windfalls"), they are, for the most part, framing their spectrum grab as a ratification of the status quo rather than the radical departure from the status quo which it is.

Taken individually, each incumbent's spectrum grab may seem reasonable. But taken collectively, a much clearer perspective of what is going on becomes evident. For if all the incumbents get what they want, it is clear that there will be virtually no spectrum left for any market entrant or future innovator, whether unlicensed or licensed. Moreover, with so many underutilized channels inaccessible, any unlicensed devices that are allowed would be so expensive or otherwise crippled that an unlicensed allocation, to the extent there is any, could be pyrrhic.[115]

Incumbent (comments)	Spectrum Sought	Substitutes
Cable (NCTA)	Cable headends outside of the Grade B contour; channels 2-13	Direct Broadcast Satellite TV, Cable TV, Telco TV, Internet TV, Commercial Satellite TV, point-to-point microwave [or fiber] links; set-top boxes;
Public Safety (Motorola)	Channels 14-20; two additional vacant channels each from 7-13 and 21-25.	700 MHz spectrum, 800 MHz spectrum, 4.9 GHz spectrum, federal interoperable spectrum
Wireless Microphones (Shure)	Six to 20 vacant channels	3G, MSS, WiMax, WiFi, Bluetooth
Medical Telemetry (GE Healthcare)	Channels 36, 38; delay white space use of channels 33-35	Channel 37, Unlicensed rights with trespass laws
High Power Broadcasters (Joint Comments of Broadcasters, NAB/MSTV)	New spectrum rights between the Grade B and DMA contours; First adjacent channels	Satellite TV, Cable TV, Telco TV, Internet TV
TV Translators and LPTV (Community Broadcasters Association and National Translator Association)	New spectrum rights between the Grade A contour and the farthest edge of a household that can receive a TV signal outside that contour by employing high antennas directed at the broadcast transmitter	Satellite TV, Cable TV, Telco TV, Internet TV

Source: Economic/Legal Reply Comments of NAF, et al. (Docket 04-186, March 2, 2007)

NAF et al. also argued that "there are close economic substitutes for the services the incumbents want to provide at a huge opportunity cost to society." To illustrate this point, their reply comments included the following table entitled "Incumbents' White Space Spectrum Grab."[116]

In the view of NAF et al., incumbents' arguments reflected "[t]he unstated assumption… that the long-term interests of the many should be sacrificed for the short-term interests of the few."[117]

> [Incumbents] are saying, in essence, that to potentially protect the spectrum uses of a small fraction of the public, for a small fraction of the time, they are willing to sacrifice spectrum uses that could benefit the vast majority of the public in an abundance of different ways, including to facilitate broadband deployment, affordability, and ubiquity at a time when our nation has fallen to 16th in the world in broadband adoption (and with prices ten times higher, per Mbps, than other advanced economies). With rare exception, the spectrum incumbents have been completely unwilling to explicitly deal with this objection, implicitly asserting that if even a single potential user of their service would be inconvenienced, they have the right to absolute protection. Their arguments, therefore, are completely at odds with the FCC's mission to manage the public airwaves in the public interest, which, in economic terms, means to maximize social welfare, as well as to facilitate robust and diverse communication based on First Amendment principles.[118]

Personal/Portable Devices

The high-tech coalition took issue with what it viewed as the FCC's overly cautious approach to personal/portable devices compared to its treatment of fixed devices.

> Those opposing the use of personal/portable devices maintain that insufficient information is available for personal/portable devices as compared with fixed devices. In fact, the very opposite is true. While the Coalition has submitted a personal/portable device prototype for the Commission to test, no group has submitted a prototype of a fixed device. Thus, the only information available on fixed devices consists of theoretical analyses based on hypothetical models. This information pales beside the concrete data the Commission can obtain by testing an actual device.[119]

The coalition also urged the Commission to avoid becoming too dependent on the work of the IEEE 802 standards group, which has focused solely on fixed applications and whose work seems to have received at least grudging acceptance from the broadcasting industry.

> IEEE 802.18 and MSTV suggest that because IEEE 802 has not developed standards for personal/portable devices, the FCC should not yet authorize such devices, but rather should initiate another proceeding to examine personal/portable devices. IEEE 802's failure to promulgate standards in a timely manner cannot be allowed to dictate spectrum policy—the Commission's role is to establish protection

> standards, not to mandate particular implementation approaches. The Commission sought information about personal/portable devices in the initial NPRM at the same time that it proposed the use of fixed devices. Because the IEEE made the deliberate choice to address only the latter, it should not be heard on the former. More fundamentally, established standards are not and should not be a prerequisite for Commission authorization. In fact, spectrum allocation often precedes standardization, as in the cases of Wi-Fi, Bluetooth, Ultrawideband and myriad other innovative services. Spectrum allocation is a task for government, not for private parties working to develop technology standards which may—or may not—advance the *public* interest.[120]

The coalition also took issue with broadcasters' suggestion that the Commission delay authorization of personal/portable devices until it and the industry "gain experience" with fixed devices.

> Such an argument is a non-sequitur: fixed devices do not operate under the same parameters, nor function in the same way, as personal/portable devices. Experience with fixed devices will add only to the knowledge of fixed devices. In fact, with the operating parameters chosen by the Coalition, personal/portable devices pose less risk than fixed devices. The Commission will be able to obtain sufficient information to authorize personal/portable devices, and should do so at the same time as fixed devices, if not before.[121]

Notwithstanding its concerns about relying solely on spectrum sensing as a means to avoid interference, Motorola argued that personal portable devices "should be allowed with the same due diligence afforded to proposed designs for fixed deployment." It expressed support for:

> …development of an "anchor" personal/portable/fixed device that would use geo-location and database techniques to determine its location and transmit a beacon signal to identify the channels available for use in the nearby region. Any associated personal…would…either operate under authority of the device that has knowledge of the clear channels or its own knowledge of channels that would not interfere with broadcast TV operations.[122]

And while it was relatively conservative about reliance on spectrum sensing as an interference protection scheme, Motorola had an even more aggressive stance than the coalition in terms of maximum power levels that should be allowed in the white space:

> Motorola supports limiting the power levels for personal portable devices to 400 milliwatts EIRP. This will provide for enhanced penetration through foliage and buildings and serve to increase coverage of portable devices in rural areas. Comments filed by Dell, Google, HP, Intel, Microsoft, and Phillips would limit such power to 100 milliwatts for protection of wireless microphones. In contrast, Shure [a wireless microphone manufacturer] would limit power to 10 milliwatts. In Motorola's view, neither of these proposals provides enough power to support any meaningful deployment of broadband devices.[123]

Though the Wireless Internet Service Provider Association (WISPA) expressed enthusiastic support for unlicensed use of the white space, it opposed the authorization of personal/portable devices at this point in time. Its views on this question appeared to reflect the experience of its members using the 2.4 GHz WiFi band to deliver commercial wide-area broadband access.

> While we firmly believe that a distributed sensing model would be more than capable of protecting the broadcasters, we do NOT wish to see a spectrum issue similar to the current 2.4 GHz WiFi band. In the 2.4 GHz band channel 6 has become all but useless for large-scale, wide area deployments. Almost all consumer grade WLAN gear defaults (fortunately) to channel 6. Because a very high percentage of our customers are also running WLANs (40 to 50% and climbing fast)…most WISPs have had to abandon the middle 1/3rd of the band! 22 MHz of spectrum gone, buried under its own massive success. We do not wish to see this situation played out in any new bands.
>
> Also, we believe that it is NOT in the consumers' best interests to have personal portable devices with propagation properties that would naturally allow them to pass through interior walls but also exterior ones. We believe that personal portable devices, especially in urban and suburban, markets would be best left to the higher frequency bands. The likelihood of massive amounts of interference are far more likely, on an indoor basis, with bands that carry greater distances through construction and foliage. We believe that this issue should be revisited when technology changes allow for much greater frequency reuse or in the event that outdoor only Whitespaces were greatly underutilized over time.[124]

While WISPA's opposition to white space portable devices reflect the particular business priorities of its members, it does raise valid issues about the interactions between unlicensed LAN and wide-area applications in the white space. As WISPA's comments suggest, managing these interactions in the white space could in some ways be more challenging than in the 2.4 GHz band, whose propagation characteristics seem to allow for an easier segregation between indoor and outdoor applications.

FCC Testing Will Be Key

Though, as noted above, there are sharp disagreements among commenters regarding interference risks, there was broad agreement among the parties that it is crucially important for the FCC to conduct its own objective and independent testing.

A key element of that testing is likely to be a prototype TV band device the high-tech coalition plans to submit to the FCC for testing.

This device, a description of which the coalition submitted to the FCC in February, has already become a focus of controversy, as reflected in reply comments submitted in early March. For example, MSTV/NAB reply comments claim that:

> The Device Coalition's description of its device suggests that it will not be at all representative of a typical TV band device, despite the Commission's express desire to test the interference characteristics of devices that are likely to actually be placed in the band…this so-called "prototype" cannot form a basis upon which to craft rules capable of protecting the public's television service from the actual devices intended for the TV band. In light of these and other substantial shortcomings, MSTV and NAB urge the Commission to require that an adequate prototype for testing be developed, and found not to cause harmful interference, before any TV band devices are authorized to operate.[125]

The broadcasters' reply comments do not appear, however, to define the parameters of what would comprise an adequate testing device.

Another element of controversy surrounding the coalition's prototype which was developed by Microsoft, is the request by broadcasters that the device be available for inspection "by the public." The Coalition's response to this request was that it "should be rejected out of hand."[126]

> The Coalition already has invested a substantial amount of time and money on its TV band device program, and its prototype contains confidential information that could place the Coalition's members at a competitive disadvantage if released prematurely. MSTV does not offer a rationale for inspection of the device.[127]

This comment suggests that coalition members will be at least somewhat protective of such "confidential information," and that broadcasters and other opponents of unlicensed white space may attempt to exploit this protectiveness in ways that discredit or delay tests of the device that support the coalition's view of interference risks and other pending technical issues.

The cacaphony of interference-related claims and counterclaims contained in the various white space comments underscores the importance of the FCC's ability to design and conduct objective and accurate tests.

This, plus the agency's belated but aggressive schedule for testing and decision-making suggests that it will be under substantial pressure to navigate technical issues and political minefields as it tries to meet that schedule.

Though it is important to avoid further delays in this too-long tabled docket, it is perhaps more important—especially from the long-term perspective--that the Commission make informed and thoughtful choices that balance justifiable claims for caution and interference protection with the value of opening up as much white space as possible as expeditiously as possible, and under rules that inhibit device and service innovation as little as possible and that allow for an ongoing and efficient expansion of value from white space usage. We will have more to say about this later in the report.

Licensed or Unlicensed?

As noted above, the FCC's October 2006 FNPRM requested comments about whether devices operating in the TV white space should operate on a licensed rather unlicensed basis, even though the Commission's 2004 NPRM had adopted a "tentative conclusion" to allow unlicensed use in this band.

In a Petition for Reconsideration filed in December 2006, NAF and the Champaign Urbana Wireless Network argued that "the Commission's decision to reopen the 'licensed' v. 'unlicensed' question was arbitrary in light of the record."[128]

> Given the extensive argument that has taken place on this very issue for the last four years, and the tentative resolution of the Commission in favor of unlicensed use in the broadcast white spaces two years ago, the failure to explain why the Commission has reversed its tentative conclusion is arbitrary and counterproductive…For the Commission to determine that something has caused it to change its mind about its tentative conclusion in 2004, but to fail to explain precisely what, is the essence of arbitrary decision making.[129]

In spite of the FCC's reopening of the licensing question, it seems likely at this point that the Commission will continue down the road to authorizing unlicensed operation in the white space. As NAF, et al. pointed out in their reply comments, FCC Chairman Kevin Martin recently had this to say at a Senate Commerce Committee hearing, when asked by Senator John Sununu about this issue:

> It would be more difficult and potentially actually even delay a little bit the full utilization of the white spaces to try to actually license off the white spaces, because it would first require us, from a technical standpoint, to identify exactly what all the white space was. Whereas, if we could adopt general rules which said, "We think you can operate under these parameters without causing interference, and then you can do so as long as you're not causing interference," it would be more easily able to allow the technological innovations that are occurring in unlicensed to more fully utilize that spectrum.[130]

The benefits of unlicensed

As evidence that the use of unlicensed bands has produced an ever expanding stream of positive social and economic benefits, and that there is "no evidence of a 'tragedy of the commons'" due to the sharing of unlicensed spectrum, comments by NAF, et al. cited a range of statistics.[131]

- at least 3,000 U.S. WISPs serve roughly a million customers using mainly unlicensed spectrum in rural areas;
- of the approximately 1,200 small, independent telephone companies in the U.S., 61% use unlicensed spectrum to provide wireless service to their customers;

- as of December 2006, roughly 240 U.S. towns and cities were already operating or had announced plans to deploy wide area municipal, countywide or even multi-county Wi-Fi networks, with many more offering Wi-Fi hotspots in libraries, schools, parks, downtown business districts and other public spaces;
- according to TIA, U.S. Wi-Fi hotspots have increased in number from 23,600 in 2004 to 53,000 in 2006, with U.S. spending on public hotspots increasing from $35 million in 2001 to $410 million in 2006;
- from a base of "essentially zero" in 2000, an estimated 60% of U.S. corporations now provide some type of wireless networking using unlicensed spectrum;
- 45.8% of university classrooms have unlicensed access and the average number of hotspots at the nation's 100 largest public colleges has increased from zero at the end of 2000 to 2,000 at the end of 2006, with Ohio State alone now having more than 10,000;
- the estimated 200,000 wireless base stations at just these top 100 colleges is roughly equivalent to the total number of cell towers in the U.S.
- there are at least 500 manufacturers of unlicensed 2.4 GHz devices, compared to just 25 equipment manufacturers active in the mobile telephone bands, even though the latter encompasses roughly twice as much spectrum;
- there are more than 25 times as many equipment authorizations in the unlicensed 2.4 GHz band as in the mobile telephone bands;
- since 2000, the Bluetooth and Wi-Fi trade associations have certified more than 4,000 unlicensed products, with the great majority in the last few years;
- the mid-2006 installed base of unlicensed cordless phones (188.7 mil.) exceeded the installed base of licensed cellular phones (181.8 mil.)
- annual sales of wireless routers expanded from seven million units in 2003 to 45 million in 2006, a three year increase of 500%;
- more than 1,000 unlicensed devices were on display at the 2007 Consumer Electronic Show

According to NAF, if the added capacity and improved propagation characteristics of white space spectrum were made available to wide-area networks operated by municipalities, WISPs and others:

> [T]here can be little doubt that within five years, a majority of Americans will have an option to communicate and access the Internet—any time, from any location—through networks operating over unlicensed spectrum. The benefits for local economic development, education, government and personal productivity, and particularly for bridging the broadband deployment gap in rural and in low-income urban areas, are quite literally incalculable.[132]

In addition to highlighting the benefits and rapid growth of unlicensed devices and applications, NAF et al. argued that the "swiss cheese" nature of broadcast white space was much better suited to unlicensed rather than licensed operation. As evidence, they cited the failures of licensing schemes targeting similar "swiss cheese" bands, including the 700 MHz "guard bands" and the 900 MHz M-MLS service, which was created and auctioned by the Commission in the late 1990s.

> Rather than guaranteeing efficiency, the high transactional costs and divergent economic interests of the licensees — to say nothing of other stakeholders — makes deployment and use of licensed systems in such bands extremely difficult and time consuming, if not impossible. By contrast, the low cost of unlicensed deployment, coupled with the ability of unlicensed operators to take advantage of the dynamic opportunities offered in such bands, makes unlicensed spectrum the clear choice for success in the broadcast white spaces.[133]

NAF, et al. also argued that "uncertainty associated with the final spectrum assignments of incumbents in the TV band" would create problems for a white space licensing scheme.

> The consequence of this uncertainty would either be to dramatically depress the value of the white spaces sold at auction or postpone the use of the white spaces for many years as the future license areas of the incumbent license holders were clarified in a host of different FCC proceedings.[134]

License advocates make their case

Comments filed by The Brattle Group and Charles Jackson, with backing from Qualcomm, argued that a licensed approach to the white space was superior to the unlicensed model supported by the majority of commenters. One of the key benefits of licensing, they contended, was that it would provide stronger incentives to invest:

> The incentives for investment in white space systems would be far weaker in an unlicensed regime compared to a licensed one…For short-range data transfer, unlicensed TV spectrum would be inferior to the existing unlicensed bands at 2.4 GHz and 5 GHz. A combination of limited data rates, network externalities, and the added costs to avoid interference with incumbents would impede adoption of this band for the market needs served by today's wireless local area networks (LANs).
>
> Investment in long-range applications in the white space would be impeded for a different reason—the threat of interference, primarily from short-range wireless LAN operations in that spectrum. (More generally, unlicensed spectrum is a poor home for long-range services because of the tendency for short-range services to crowd them out.) Long-range systems typically require significant infrastructure and corresponding investment. Unlicensed operation provides no protection from interference from competitors or consumer-owned devices. The risks of interference raise the cost of capital for such systems and reduce the level of investment.[135]

While the Brattle Group comments correctly note the significant differences between propagation characteristics of the TV band and the 2.4 GHz and 5 GHz bands, their conclusion that this would discourage investment in an unlicensed environment seem rather speculative, and even inconsistent with today's realities.

For example, while WISPs may complain about their wide area services being crowded out of some WiFi channels by low-power LANs, the fact is that more than 3,000 WISPs have invested in such wide area networks. And while interference issues may "raise the cost of capital" for wide-area networks, the same is true of auction fees.

The most accurate description of the typical WISP perspective is probably that, like any other network operator, they would prefer to avoid both the costs of spectrum licenses and the need to manage interference (like all of us, they want their cake and to eat it to). But the fact that the vast majority of WISP deployments have thus far used unlicensed rather than licensed spectrum suggests that, if they must choose between the two, WISPs prefer the cost-benefit tradeoffs provided by unlicensed operation.

The fact that the Computing Technology Industry Association (CompTIA) supports unlicensed use in the white space also raises questions about the Brattle Group's pessimistic view of investment incentives with unlicensed white space. CompTIA claims to have more than 22,000 member companies, "including nearly every major IT hardware, software or services company" and a mix of manufacturers, distributors, resellers, solution providers, ISPs, ASPs, software developers, e-commerce and telecom companies. In its comments, CompTIA had this to say:

> The Commission initially determined that the "significant growth of and consumer demand for unlicensed wireless broadband applications" supported opening up the white spaces for unlicensed use. This was the right decision for consumers and small businesses alike. The tremendous success that this nation has witnessed in wireless data services is in part due to the use of what was once deemed a "junk" band. Creative allocation and use of this spectrum lowered infrastructure costs and provided widespread, flexible broadband access, improving the productivity and performance of many small businesses. The success of existing unlicensed operations may well be a prelude to the benefits the country can expect from making the TV white spaces available on an unlicensed basis…[136]
>
> CompTIA's members report that the availability of additional wireless spectrum will boost the productivity and efficiency of small business in every sector. CompTIA's members play a crucial role in enabling America's small businesses to take advantage of information technologies, and they stand ready to help small businesses and consumers alike reap the enormous benefits that access to the white spaces can provide…[137]
>
> CompTIA urges the Commission to reaffirm its initial determination that the unlicensed model is appropriate for the TV white spaces—and to do so in a way that will allow CompTIA members to provide the nation's small businesses with the most robust wireless networks possible.[138]

The high-tech coalition also challenged the Brattle Group's analysis of investment disincentives in an unlicensed white space model:

> Licensed advocates by and large have acknowledged the inherent desirability of TV spectrum due to its superior propagation characteristics, but nevertheless suggest that unlicensed users may actually be better off with the spectrum allocations at 2.4 and 5 GHz with their inferior propagation characteristics. This argument presupposes that future unlicensed use would merely mimic existing unlicensed deployments, but this will not be the case. **For example, in addition to short range applications such as media distribution (which will be far more robust than they are at 2.4 or 5 GHz), the Coalition envisions a number of "medium range" applications based on neighborhood self-organizing mesh networks. These types of applications simply are not possible at the existing higher frequencies allocated to unlicensed devices.**[139]

The Brattle Group comments also sought to make the case that there was already more than enough unlicensed spectrum to satisfy demand. It estimated that "approximately 11 GHz of spectrum is available for unlicensed use, which represents more than ten percent of the entire spectrum below 100 GHz" and that "760 MHz of the spectrum below 6 GHz—or about 13 percent—is available for unlicensed use."[140]

What the Brattle Group deemphasized, however, was the fact that only 26 MHz (902-928 MHz) of unlicensed spectrum is below 2 GHz, with anything close to the propagation characteristics found in the white space spectrum. This contrasts with the roughly 170 MHz in the cellular and PCS bands currently available to licensed mobile service providers, plus the hundreds of MHz licensed in other relatively low frequency bands, including the underutilized WCS, BRS and AWS bands located in the upper 1 GHz and lower-to-mid 2 GHz ranges.

The Brattle Group also argued that "licensing would be a superior way to minimize harmful interference."

> One of the key purposes of licenses and call signs is to facilitate the tracking down of interference. Every day, co-channel wireless carriers work with one another to control interference between their systems. Consider a viewer located at First and Main Streets who reports interference to her local broadcaster. In a licensed environment, the broadcaster can look in the FCC's database and determine who the white space licensee is; depending on the service rules that the FCC adopts, the broadcaster may even be able to see where the white space licensee's transmitters are located. Alternatively, the TV station could call up the white space licensee and ask, "Hey, are you guys doing anything new over near First and Main? We have a report of interference there."
>
> Contrast that with an unlicensed environment. In response to a call from the viewer at First and Main, the broadcaster can ask the FCC's Enforcement Bureau to track down the interference; but the FCC would face a near impossible task—especially if the interference is caused by a mobile device, which moves around constantly. Alternatively, the broadcaster can try to track down the source of interference itself, which would require sending out a team of technicians equipped with the appropriate measurement devices—an expensive proposition.

> In sum, the licensed regime provides multiple mechanisms to control interference that do not exist in the unlicensed regime. Furthermore, licensees have stronger incentives to limit interference than do unlicensed users.[141]

While the Brattle Group may be correct that a licensed regime can provide additional methods to control interference, the above discussion does not really answer the question of whether such methods are necessary and cost-effective. Clearly, the high-tech coalition believes they are not, and that harmful interference can be avoided through advanced technologies like TPC and "listen before talk" algorthims, without requiring the traditional--and often costly and time-consuming--enforcement mechanisms referenced in the Brattle Group's comments. The ability of unlicensed WiFi technologies to steadily expand capacity, performance and availability in the face of ever-more-intensive use of unlicensed spectrum gives at least some measure of empirical credence to the coalition members' claims.

WiFi's history notwithstanding, the Brattle Group contends that the coalition's "logic flies in the face of a century of spectrum management experience." But this seems to beg the question of whether--in light of the accelerating innovation taking place in wireless communication technology--it is necessary and desirable for the next century's "spectrum management experience" to rely on the same interference control strategies as the last century.

If all goes according to plan, the FCC will soon get the chance to rigorously test the validity of the coalition's claims regarding their proposed approach to interference control.

The Brattle Group also predicted economic efficiency benefits from licensing the white space. These would occur because a licensed scheme would provide "both the incentive and the opportunity for white-space licensees and broadcasters to engage in negotiations to expand licensed service."[142]

> Such negotiations (what economists refer to as "Coasian bargaining," after Nobel Laureate Ronald Coase) would allow spectrum users to improve on the starting point defined by FCC interference standards to achieve a more efficient use of the white space…[143]
>
> Perhaps the key advantage of licensing is that it would put in place a mechanism whereby the TV bands could transition to more productive uses (the process referred to as "the Negroponte Switch"). If broadcasters were given flexible use rights, over time, broadcasters and white-space licensees would reengineer the broadcast system, freeing up most of the spectrum for higher value applications.[144]

The high-tech coalition described The Brattle Group's "negotiation" scenario as "the ability to bribe incumbents to accept interference and injure their customers." It said the scenario's "underlying premise—that broadcasters should be entitled to sell portions of the TV channel spectrum the Commission has assigned them—is well beyond the scope of" the

Commission's pending FNPRM, which "certainly did not ask whether the longstanding licensing regime for TV broadcasters themselves should be revised."

The coalition went on to suggest that the Brattle Group's "negotiation" scenario was at odds with the fundamental rationale justifying free broadcast licenses, which broadcasters have used as a shield to deflect criticism of their industry's long-favored position in the spectrum licensing and media worlds:

> This proposal may disenfranchise some TV viewers who would otherwise receive acceptable TV pictures today. It may also cause the broadcasters to violate the public trust the Commission has bestowed on them, and to reap inappropriate profit from the free spectrum they have been given. This proposal is even at odds with the broadcasters' insistence throughout this proceeding that the "public's free over-the-air television service" is sacrosanct even at the outer limits of the contour where a television signal cannot be decoded.[145]

It is the author's view that the pro-licensing arguments presented by the Brattle Group and a handful of others responding to the FCC's FNPRM are unlikely to convince the FCC to adopt an exclusive licensing model for the white space spectrum.

NextWave Broadband, which said it has acquired "a nationwide spectrum footprint…covering 247 million people in the 2.3 GHz, 2.5 GHz and 1.7/2.1 GHz bands," also filed comments in support of a licensing scheme. Unlike the Brattle Group, however, NextWave favored a licensing scheme modeled after the "hybrid" licensing approach the Commission recently adopted for the 3.65 GHz band.

According to NextWave, "the streamlined licensing approach used in the 3.65 GHz band can be easily adapted to meet the requirements of the TV bands, and represents a simplified, but effective approach that would obviate the need to pursue many of the other technical proposals under consideration in this proceeding."[146]

More specifically, NextWave suggested that the FCC issue nationwide, non-exclusive licenses that require:

> 1) registration of higher-powered fixed/access stations;
> 2) use of technologies to incorporate spectrum sensing and other contention-based protocols;
> 3) reception and decoding by a portable/mobile station of an enabling signal transmitted by a registered fixed/access station and;
> 4) recognition of a "smart beacon" transmitted when legally operated wireless microphones are in use.[147]

Such a hybrid licensing scheme, NextWave claimed, would "enable efficient and widespread use of the unused TV bands and…and serve as a safeguard to protect incumbent services from both higher-power fixed/access stations as well as from lower-power portable/mobile TV band devices."[148]

> Requiring a mobile/portable device to…receive and decode an enabling signal transmitted by a base station will limit the geographic area in which mobile/portable devices can operate to a reasonable distance around a registered fixed/access device. Thus, as long as the fixed/access station is located sufficiently far enough away from the edge of the protected contour of the TV station, operation of the mobile/portable devices controlled by that fixed/access station also can be maintained sufficiently distant from protected incumbents.[149]

Several things about the NextWave proposal are noteworthy. One is that, unlike the auction-based exclusive licensing model that has dominated U.S. spectrum policy for the past few decades, the licenses it would authorize would not be exclusive.

This suggests that licensees under this model would need to rely on technology solutions such as contention-based protocols to efficiently share spectrum. And, in fact, a version of the 802.11 Wi-Fi standard (802.11y) is being developed for the 3.65 GHz band, along with a version of the WiMAX (802.16h) standard designed for non-exclusive operation.

It is also worth noting that the NextWave "smart beacon" proposal is similar in principle to the "master-client relationship" cited by NAF as a possible approach to using portable devices on channel 14-20 without risking harmful interference to public safety users operating in that band in other markets.

Part 4: The White Space Opportunity

Some will argue that to achieve the goal discussed above of ubiquitous, symmetrical and neutral broadband networks, policymakers should impose some form of "network neutrality" rules on incumbent wireline service providers and possibly also on their counterparts in the wireless sector. That is not the position advocated here.

Rather than imposing such requirements on carriers that resist them, and are likely to continue doing so, and who claim they would result in unforeseen problems and inefficiencies, this final section of the report outlines what the author believes is a more effective way to move toward the same fundamental goal.

By avoiding network neutrality rules, this approach would not encroach on the freedom of incumbent network operators to pursue their preferred model, which they argue will provide significant value not only to their shareholders, but also to American citizens and businesses. More importantly, it would insure that the latter also have access to a "neutral network" model, and be free to choose between the two models, or to enjoy the respective benefits of both.

While the proposals discussed below would not impose network neutrality rules on incumbents, they do call on policymakers to take proactive steps to enable a different model. This model would deploy the kind of neutral, ubiquitous and symmetrical IP networks that, as prior chapters have explained, are particularly well suited to facilitating positive externalities and growth-promoting ideas and nonmarket social production.

More specifically, a later section of the report outlines a proposal for making broadcast white space spectrum available on an unlicensed basis in which local governments play key roles in: 1) making efficient use of white space spectrum while avoiding and resolving interference problems with broadcasters; 2) providing rights of way for network deployment; 3) delivering public services and other economic, political and social benefits via white-space enabled networks; 4) creating value through these services and benefits and internal cost savings that can help justify the cost of delivering universal Internet connectivity.

This proposal will refer to white space-enabled networks as "Public Interest IP" (PIIP) networks. This label directly links universal IP connectivity to a 21st century vision of using public spectrum to serve the public interest. And its acronym (pronounced "pipe") suggests its basic "dump pipe" function of providing connectivity and transporting packets.

The PIIP proposal also calls for coordination and, where possible, cost-sharing with next-generation public safety networks to be deployed in spectrum in the 700 MHz band that will be returned by broadcasters in early 2009. And, to the extent Congress or the FCC choose to encourage or even mandate private-public partnerships in the deployment of new 700 MHz public safety networks, this coordination and cost sharing could be extended to these public-private partnerships.

The Broader Policy Context

In prior chapters we analyzed a range of issues and trends linked in various ways to potential use of the broadcast white space. To set the stage for the next chapter's proposals for moving ahead with such use, we briefly review this broader context.

Internet access and the public interest

As discussed in Part 1, the initial grant of spectrum licenses by the Communications Act of 1934 was subject to the requirement that broadcasters serve the "public interest, convenience and necessity." And in Part 2, we discussed how the common carrier regime adopted by the Act sought to promote broad public benefits by pursuing the goal of universal and affordable telephone service, and the beneficial "network effects" this policy goal would bring.

These two early policy models both aimed to maximize the value of relatively new communication technologies, but chose different paths to that goal, each reflecting the particular technical and economic constraints of the industry to which they were applied. In broadcasting, this included the scarcity of spectrum, the high cost of transmitters and national networks and, for the still-nascent television sector, the significant financial and technical resources required to produce programs. In telephony it involved the very high fixed and low variables costs that led many to view it as a natural monopoly.

In Part 1 we also discussed how enforcement of the "public interest" broadcast-license standard proved challenging at best, and was largely phased out in practice over the past two decades.

In Part 2 we reviewed how the 1996 Telecom Act and the FCC's effort to implement and enforce it, in conjunction with industry dynamics and court decisions, led first to a flowering of many new competitors, followed by a sharp and costly contraction of their ranks. This contraction impacted both CLECs and ISPs, the latter most fully as Internet access began migrating to broadband platforms operated by cable and telephone companies.

And, as we also noted in Part 2, the FCC has chosen to treat the broadband access service provided by cable and telephone companies—which have operated in a predominantly duopolistic (and in some areas monopolistic) market—as "information services functionally integrated with a telecommunications component." As such, they are not subject to the common carrier requirements set forth in Title II of the Communications Act.

Parallel to this migration away from the "public interest" and "common carrier" policy models has been the dramatic expansion of the Internet. As we discussed, that evolution has been based largely on the Internet's "end-to-end" and "content and application neutral" architecture.

A helpful question to consider as we analyze today's major communication policy issues is "what policies would have made the most sense to pursue if the Internet had existed in

1934, when Congress was trying to maximize the public benefits promised by new communication technologies?" This thought exercise can help us consider current policy issues from a fresh perspective built more on fundamental principles and less on legacy-bound thinking tied to the decades-long evolution of communication policy and industry structure.

From that perspective, we can recognize the evolving broadband Internet as a platform that, in key respects, combines the best of what we've known as television and telephone, while adding to this a wide range of additional software-based and value-enhancing features and functionality.

In the early days of television, it seemed unworkable and not economically attractive (at least to early broadcasters), to provide everyone a chance to speak through this new and extremely high-powered megaphone. In contrast, the characteristics of telephone technology made it more feasible to extend the ability to speak through it to large numbers of citizens, a goal that was pursued through common carrier regulation and "universal service" policies.

Television was a relatively "rich" media in terms of content and, at the time (and for decades to come), could not be cost-effectively delivered over the twisted-pair network that had been deployed by telephone companies. Far more economically attractive was to transmit a relatively small number of television "channels" via high-powered RF transmitters employing portions of the electromagnetic spectrum large enough and separate enough to reliably deliver signals to antennas feeding devices that combined RF tuners and video displays.

As we noted in Part 1, many parties aside from existing broadcasters wanted access to those frequencies and the greatly expanded "speech" opportunities it enabled. But, the realities of existing technology and political dynamics at that time led in another direction—the "public interest" compromise contained in Title III of the 1934 Act.

The evolving technology and fundamental architecture of the Internet, coupled with very low cost video capture and editing technologies, has gone a long way toward removing the technology and cost barriers that led Congress to settle on the "public interest" compromise of 1934.

In doing so, the increasingly high-capacity Internet is opening up more direct pathways to the "public interest," by providing the kind of broadly available access to video communications that did not seem feasible in 1934, when Congress set the television and telephone industry down two separate paths, both intended to lead to the goal of "serving the public interest."

The Internet, spectrum & free speech

A key underpinning of the "public interest" goal in communication policy is the First Amendment.

First Amendment issues have arisen time and time again in relation to broadcast and communication policy. The amendment states that "Congress shall make no law…abridging the freedom of speech, or of the press."

Though this wording focuses on prohibiting Congressional acts of abridging freedom of speech, over time a body of First Amendment law has evolved that takes a broader view of the Founding Fathers' intent as applied to modern technology. Some of the impetus for this was the fact that Congress, in granting broadcasters (and other licensees) exclusive rights to use public spectrum assets, was fundamentally tilting the First Amendment playing field in favor of these licensees. In key respects, the insertion of the "public interest" standard for broadcast licensing was an attempt (one that, over time proved relatively feeble) to offset the impacts of this government-mandated imbalancing of free speech capabilities.

This basic thread of broadcast-related First Amendment law is reflected in the following passage from a white space filing by NAF, et al.:

> [B]ecause the government must suppress rights of the vast majority of Americans to speak directly through the electromagnetic spectrum, the scarcity rationale imposes on the government a fundamental responsibility to protect the public's "collective right to have the medium function consistently with the ends and purposes of the First Amendment." The Supreme Court has found that the public interest standard underlying the Communications Act "necessarily invites reference to First Amendment principles"…[T]he scarcity doctrine imposes a responsibility on the Commission to regulate those holding exclusive licenses so as to protect the "paramount" First Amendment right of the public to receive access to a diversity of views in the electronic media."[150]

Going back to our thought exercise, we can ask the question, what policies would be most respectful of First Amendment rights if, in 1934, American citizens had access to, not only the Internet and low-cost video production technologies, but also 21st century "cognitive radio" technologies that allowed efficient-enough spectrum sharing to enable each citizen to enjoy multi-megabit symmetrical connectivity to the Internet (and therefore to each other)?

From this clear-slate perspective, one can appreciate the import of the assertion by NAF et al. that "where technology allows users to speak through the electromagnetic spectrum without interference to the productive uses of higher powered licensed services, the FCC has no right preventing them from speaking."

This suggests the possibility that when technology has evolved to a certain point, exercise of First Amendment rights via wireless video communications by non-broadcasters will no longer depend on attempts by the government to indirectly redress the imbalancing of First Amendment "megaphones" created by that government when it issued exclusive broadcast licenses.

Rather, what the First Amendment would require at that point in time would be for the FCC (a creation of Congress) to "not abridge the freedom of speech" of non-

broadcasters by not imposing rules that restrict "electromagnetic" speech that does not cause harmful interference with licensed broadcast services.

Seen in this context, the pending white space proceeding is, in large measure, an attempt to answer the question of whether we have, in fact, reached this point in the evolution of communication technology. As discussed earlier, some commenters in that proceeding claim we have. If they are correct, FCC tests will presumably verify this in the months ahead.

Should that be the case, the First Amendment implications are both clear and important. It would mean that the time has come for the broadcast spectrum—much coveted today as it was 70 years ago—to serve the public interest directly, by allowing it to support a multiplicity of voices through the use of advanced radio technologies and the near-universal connectivity provided by the Internet.

Internet-era economics

While First Amendment issues are fundamentally important in evaluating communication policy options, another thread of analysis is tied to economic theories, goals and policies.

At various points in this paper we have cited critiques that highlight the limitations of traditional economic analysis as applied to the communication sector. In Part 1, we cited a number of critiques of spectrum auctions and the economic theories that helped convince policymakers to adopt them. Among these was an analysis by Gregory Rose and Mark Lloyd, published by the Center for American Progress in May 2006. It concluded that:

> What has principally driven the adoption of spectrum auctions by the FCC and Congress has been ideologically-libertarian economic theory, captured in simplistic models which ignore inconvenient facts…When tested by the actual performance of such auctions, the chasm between the outcomes predicted by theory and the outcomes observed is immense. In sacrificing the public interest in pursuit of hypothesized market efficiencies and greater revenue we have arrived at the worst of both worlds: FCC spectrum auctions neither serve the public interest nor realize the promised economic efficiencies and revenue maximization touted by their advocates.[151]

In Part 2 we discussed the basic elements of New Growth Theory, as developed by economist Paul Romer, and its application to Internet and communication policy analysis by law professor Susan Crawford. As Crawford explains:

> Traditional economics assumes implicitly that the economy as a whole is a closed system that will eventually reach equilibrium…In the view of an equilibrium economist, ideas are exogenous…[I]n recent years, traditional economics has had to open its doors to work that rigorously examines the sources of increased productivity and focuses on the centrality of new ideas to economic growth… Robert Solow's breakthrough work fifty years ago showed that "technological progress" allows economies to add to their outputs without the addition of more

> labor and capital. But Solow called this key technological-change element responsible for eighty percent or more of economic growth the "residual," and dealt with it as an unexplained exogenous influence…Beginning in the mid-1980s Paul Romer seized the challenge of transforming the "residual" of technological change into an endogenous element of his model explaining economic growth… We are beginning to understand that the growth in social wealth per capita in terms of real income per person over the last millennia is deeply related to the increase in the diversity of new ideas that has occurred over the same time...[152]
>
> The key organizing principle for communications law must be to support the emergence of diverse new ideas online because that is where economic growth for society as a whole will come from. This form of diversity support is not the same as the kind of quota-driven artificial "diversity" that has been used to force broadcast content regulation to reflect minority viewpoints. Rather, this kind of online diversity stems from allowing the end-to-end, content-neutral, layer-independent functions of the internet to flourish and allowing groups and human attention to pick and choose from among the bad ideas presented online, enabling good ideas to persist and replicate…[153]

Later in Part 2 we noted some of the contributions law professor Yochai Benkler has made to the evolution of economic thinking as it relates to Internet and communication policy.

> As the material barrier that ultimately…drove much of our information environment to be funneled through the proprietary, market-based strategies is removed,…nonmarket, nonproprietary, motivations and organizational forms should in principle become even more important to the information production system…[And] we have in fact seen the rise of nonmarket production to much greater importance…[including] effective, large-scale cooperative efforts—peer production of information, knowledge, and culture…
>
> It is easy to miss these changes. They run against the grain of some of our most basic Economics 101 intuitions, intuitions honed in the industrial economy at a time when the only serious alternative seen was state Communism —an alternative almost universally considered unattractive today…Human beings are, and always have been, diversely motivated beings…We act for material gain, but also for psychological well-being and gratification, and for social connectedness. There is nothing new or earth-shattering about this, except perhaps to some economists.[154]

Taken together, these various threads of economic and policy analysis highlight the need for new economic models with which to approach Internet and communication policy issues. By clarifying key failings of traditional equilibrium economics as a tool for analyzing these issues, they help explain why there seems to be such a fundamental disconnect between those who see great value in maintaining the Internet's neutral end-to-end architecture, and those who view Internet access as merely another service to be sold at a market-clearing price in an access market characterized by high fixed costs and, therefore, a small number of competing facilities-based service providers.

As the work of Romer, Crawford and Benkler reveal, the two sides of the policy debate are focused on fundamentally different economic models and sources and measures of value. **The central questions for policymakers then become: 1) which set of models does a better job describing how the world actually works; 2) which measures of value are most worth pursuing and; 2) which policies are best suited to realize that value?**

A clash of models

The disconnect cited above is reflected not only in different economic and policy models, but also in a clash of business models. On one side are the relatively small number of dominant vertically-integrated access providers. On the other are the many entities, large and small, that use the Internet to communicate and exchange an ever-expanding variety of goods, services and other forms of value.

The model pursued by access providers is one in which they sell services to end users that closely couple applications with connectivity. This resembles the classic "cable TV" model, in which customers subscribe to a "basic" cable service and can also purchase various "premium" services on top of the basic package. While customers can choose which premium services to purchase, they typically cannot subscribe to premium services without first purchasing a basic package. And, more importantly, they are not able to access video content that cable operators have not chosen to make available to them.

In the "cable TV" model, end-users' service options are limited by the network operator, who engages in separate negotiations with the providers of content and service delivered on its network. If these two parties do not agree on terms, the content or services in question is not available to end users. In the Internet model, the network operator does not have this power to limit service options available to end-users of its network, except to the extent they may be constrained by the data rates for which the end user is paying.

A similar model dominates the mobile telephone space, where voice and other services (e.g., text and picture messaging, ringtones, limited video selections and Internet access), are offered by the same companies that control the physical networks. As in the cable model, mobile operators serve as gatekeepers for the introduction of new services delivered on their network.

As discussed in Part 2, the mobile industry is also marked by strong carrier control over the features provided by end-user equipment. This historically has also been the case in the cable industry. And, while the FCC, as directed by the 1996 Telecom Act, has attempted to open up the cable set-top market through its CableCARD initiative, that program has been very slow to evolve. This is due in large part to the fact that it is a government-mandated requirement that is not fully aligned with the preferences of cable operators to control the services delivered to their customers and the technologies used to do so.

In Part 2, we also discussed the FCC's decision to treat broadband service as an "information service functionally integrated with a telecommunications component," and thus not subject to Title II common carrier requirements. This was a key step toward extending the vertically-integrated service model to broadband access and services.

Most recently, this vertically-integrated service model has expanded to include so-called "triple-play" and "quad-play" bundles, which feature Internet access as one of three or four services packaged together, usually at a discount (the others being voice, video and mobile

services). In this model, access to the Internet is only one of multiple "services" provided by the same companies that provide network connectivity.

The basic nature of this model is reflected in a term sometimes used to describe video and voice services delivered by independent service providers to customers via the Internet—"over the top." A similarly descriptive term, "walled garden," aptly describes services pre-selected by network operators and sold to end users in conjunction with network connectivity.

As discussed in Part 2, becoming a competitor in this vertically-integrated, facilities-based market is very capital intensive and risky, which is why in most communities, the bundled service market is dominated by two wireline players, the largest of which are closely aligned with dominant wireless operators. It is also why we have seen relatively high percentages of bankruptcy in the CLEC and "overbuild" sectors over the past decade.

The model of service provision to end-users that has dominated the Internet is very different. In this model, connectivity is functionally and financially distinct from the provision of applications and services. And, since so many of the services are built around low-cost, standards-based software and relatively modest and scalable variable costs for connectivity and storage, the barriers to entry are relatively low. With entry barriers low, the aggregation of sustainable market power is relatively difficult to achieve. This contrasts sharply with the sustainability of market power in the cable, telephone, cellular, broadband access and bundled services markets, thanks largely to the latter's high fixed costs and barriers to entry.

Certainly a company like Google can be said to exert significant market power in its core search and advertising business. But even there it faces several well-heeled competitors and a larger number of smaller players—including a fairly steady stream of new entrants. And should any of these competitors develop a better search and/or advertising mouse trap than Google, it is quite conceivable in the Internet world that Google could lose significant market share relatively quickly.

Whereas the market power of broadband access providers is predominantly derived from duopoly market structure and high barriers to entry, Google's market power is largely derived from its having introduced a high-value innovation and its ability to continue attracting users to its services by adding enough value to its stock of innovation to avoid losing market share to a host of hungry competitors, including giants like Microsoft and Yahoo.

Market power & power politics

One often hears communication policymakers and those seeking to influence them—regardless of on which side of the debate they stand— express a desire to promote "level playing fields," "open markets" and "fair competition." The reality, however, is that a key driver of communication policy has, over the decades, been the preservation of market power by entities who, at some time and in some manner, have been granted access to that

market power by some agency of federal, state or local government. This applies particularly to the television and telephone industries regulated by the 1934 Communications Act, but also to cable operators who were granted franchises by local governments and became partially regulated by the federal government.

As these companies have learned, a key enabler of success in the public policy arena is access to policymakers, which in turn is fueled by money, whether it be in the form of expenditures on lobbying and legal staffs, campaign contributions, or public relations and advertising campaigns aimed at influencing public opinion and increasing political pressure on lawmakers.

Broadcasters, with their control of the airwaves that reach into nearly every American home, have historically been among the masters of these political arts. The same is true of the RBOCs—at both the national and state levels—having inherited much of Ma Bell's know how, staff and political connections. As a locally franchised industry, cable has been more focused on dealing with municipal governments, where it has faced ongoing battles over public access, pricing, customer service, franchise renewals and other issues. Cable's influence in Washington has also expanded over the years, as it has faced several cycles of rate regulation and deregulation and issues related to consolidation, program access and other matters.

While the cable and telephone industries are largely at odds at both the federal and state level regarding the terms of telco entry into the video market, they stand united in their opposition to proposed network neutrality requirements and, perhaps to a lesser degree, support for placing hurdles on the path of municipal broadband projects.

During the past few years, the RBOCs have pushed hard in Congress and in the states to win approval for their preferred models of video franchising. Not surprisingly, the cable industry has pushed back, at least with regarding to certain provisions. Amidst this battle over the balance of power in the duopoly bundled-service market, the two dominant access providers found themselves facing a potential new force in the regulatory arena, one they both viewed as a potential threat to the execution of their preferred business models in the emerging broadband and bundled service sectors. This new force went by the name "network neutrality."

Not surprisingly, major Internet-based service providers like Google and Amazon were among those advocating some form of net-neutrality rules. In some respects, the net neutrality fight was a wake-up call for them to invest more time and money in moving up the lobbying and issue-advocacy learning curves.

More important, in key respects, was the fact that net neutrality rules were supported by a wide range of groups from both the left and right sides of the political spectrum, with particularly intense support among Internet-savvy and increasingly influential sectors of the political and technology blogosphere. A simple but politically potent belief shared by these groups is that the Internet has provided their members with an unprecedented ability to communicate, interact, learn and do business, and that these new capabilities have

something to do with the Internet's openness and accessibility in comparison with industries like broadcasting and cable TV.

The coalition that emerged in support of network neutrality was similar in its breadth, intensity and bipartisanship to the coalition that in 2003 had challenged proposed FCC rule changes that would have further loosened the Commission's media ownership rules. And its goal of maintaining a neutral, open-access Internet as a means to serve the public interest is largely the same as that of municipal broadband advocates, though they may focus on different means to achieve that goal.

The concerns expressed by net neutrality and muni-broadband supporters and opponents of further media consolidation harken back to the initial First Amendment debates that led to the 1934 Act.

As we've noted, the Act attempted to address these concerns by means of a compromise that granted exclusive spectrum licenses in exchange for vaguely-worded public interest requirements that proved very difficult to implement.

What is different today is that the Internet and advanced technologies offer new paths for policy and market development that were not available when the FCC was first created by Congress. As discussed further below, the broadcast white space presents our nation with an opportunity to more fully resolve the policy dilemma that confronted Congress in 1934, and which has remained a source of conflict, inefficiency and troublesome First Amendment questions ever since.

21st century spectrum policy

In key respects, the FCC's pending white space proceeding brings us full circle on the relationship of spectrum policy to the public interest.

Back in 1934, policymakers and citizens generally believed that the electromagnetic spectrum was a public asset. But, at the same time, the technologies available then were not well suited to operationalize this "public" nature of spectrum usage rights. The result was a policy based on the "scarcity doctrine" and the "public interest" standard. It was hoped that, together, these two principles could chart an indirect path to the "public interest, convenience and necessity," by way of an exclusive licensing scheme that acknowledged both the practical constraints of spectrum management in the 1930s, and the nature of spectrum as a public asset.

As this model proved difficult to manage and clearly far from ideal, the U.S. shifted to a market-based approach to spectrum policy. The basic rationale was that, because spectrum would be assigned via auctions, its use would generate the greatest value because market forces would put spectrum in the hands of those who were best able and motivated to deliver that value.

As discussed in earlier sections of this report, the auction approach to spectrum policy also had its flaws, which were noted early by Eli Noam and others, and have become evident over the years. To its credit, however, the auction policy did increase efficiencies and reduce delays relative to comparative hearings and lotteries, while also generating government revenues. But beyond this, its relationship to the public interest in terms of First Amendment issues, industry concentration, and emerging Internet-centric economic growth models has been tenuous at best.

As we discussed in Part 1, the unlicensed approach to spectrum management had its roots in low-power short-range applications. In many respects, the history of unlicensed spectrum is a testament to the aphorism that "necessity is the mother of invention." Unlicensed spectrum, unlike its more plentiful and "protected" licensed counterparts, needed to be shared and did not involve spectrum fees or administrative hurdles and expenses. As a result, the main focus of investment and inventiveness in the unlicensed space became the development of technologies and applications that could operate reliably and efficiently in this shared-use environment.

The history of Wi-Fi is probably the most significant chapter of the unlicensed spectrum saga for the purposes of this report. First developed in the late 1990s, the 802.11 standard was initially targeted at short-range applications, and most particularly, the wireless local area network (WLAN) market. It employed contention-based protocols and other techniques to operate efficiently in an unlicensed environment.

Growth in demand and technical innovation continued to drive up the value-price ratio of Wi-Fi technology, and it eventually became included in virtually all new laptop computers, with Wi-Fi "hotspots" available at a rapidly expanding number of locations, including hotels, airports, businesses, schools, restaurants, coffee houses and homes.

Though designed as a "short-range" technology, the ubiquity and low cost of Wi-Fi devices and the "free" spectrum they used began to gain the attention of entities interested in wide-area networks. Initially these tended to be relatively small companies and communities in less economically attractive areas, with limited access to capital and unlikely to participate in spectrum auctions.

The first wave of these "wide-area Wi-Fi" enthusiasts were mainly wireless ISPs (WISPs) providing Internet access to businesses and, to a lesser extent, households, in relatively rural areas underserved by incumbent service providers. Today, these WISPs are believed to number more than 3,000, and to serve roughly a million customers.

Municipal wireless networks represent a second major wave of wide-area Wi-Fi networks. While many of these are in smaller towns, some active and planned networks are located in major cities like Philadelphia, San Francisco, Portland and Houston. At the end of 2006, roughly 240 U.S. towns and cities were already operating or had announced plans to deploy wide area municipal, countywide or multi-county Wi-Fi networks.

Like the mainly rural WISP deployments, muni-wireless networks reflect a sense that some American homes and businesses are underserved (and/or overcharged) by incumbent

broadband service providers. And, as discussed in Part 2, municipal networks are also motivated by potential cost savings for local government agencies and positive externalities for their local communities (e.g., economic growth, education, tourism, bridging the digital divide).

Among the assets a municipality brings to such projects are public rights of way for mounting radios, and the ability to serve as a sizeable "anchor tenant" to help reduce financial risk. Some also have public utility or public works departments that can provide staff and other resources to a muni-wireless project. Some also have fiber in the ground that can support network backhaul needs.

While the muni-wireless model has evolved to include a fairly wide range of variations, it generally is focused on expanding broadband access (and in some cases reducing its cost), delivering public services, and facilitating economic growth and other positive externalities.

In most cases and to varying degrees, muni-wireless projects also tend to avoid the vertically-integrated "gatekeeper" model preferred by incumbent network operators. For example, while some muni-wireless networks are owned and operated by private companies like Earthlink, cities generally require these companies to offer wholesale service that allows other ISPs to also offer retail services on the network.

For all these related reasons, muni-wireless networks offer a fundamental alternative to the access model preferred by incumbent network operators.

As discussed in Part 2 and earlier in this chapter, incumbents prefer to position themselves as gatekeepers, delivering broadband services in a vertically-integrated mode. In keeping with their private, profit-seeking nature, they are far more focused on value that can be internally monetized than on promoting externalities that cannot.

But, as we explained in Part 2, this realm of "externalities" is potentially very large and valuable, including new and powerful drivers of economic growth, and the political and social benefits of expanded opportunities for free speech. As "publicly-focused" modes of local connectivity, muni-wireless networks (and unlicensed spectrum in general) are particularly well suited to supporting these externalities.

To better adapt the technical characteristics of Wi-Fi and the spectrum it uses to wide area network environments, equipment vendors have developed mesh network architectures, along with other advanced technologies like Multiple-Input Multiple-Output (MIMO).

In spite of these technical improvements, the capacity and performance of wide-area Wi-Fi networks are constrained by the amount and propagation characteristics of the spectrum on which they rely. The white space offers an opportunity to move well beyond these technical constraints.

In the report's final chapter we consider potential strategies for combining and maximizing the benefits of unlicensed spectrum and muni-wireless networks. We also consider

potential impacts on and responses of incumbents, should such strategies be widely adopted.

"Public Interest IP" (PIIP) Spectrum

In this section of the report we consider white space policy options in light of the analysis presented in earlier chapters. As noted above, our focus will be on maximizing the benefits associated with harnessing unlicensed spectrum to the purposes of municipal or "community" broadband networks. These benefits include:

1) more universal and affordable Internet access;

2) providing a low-cost and Internet-friendly alternative to incumbents' vertically-integrated "gatekeeper" access models;

3) delivering cost savings and increased efficiencies to local governments and other non-market "public service" institutions;

4) increasing beneficial "externalities," including economic growth driven by the open Internet's ability to fuel "the combinatorial explosion of ideas" (see earlier discussion of Romer and Crawford) and the expansion of new forms of non-market production (see earlier discussion of Benkler);

5) a lessening of the First Amendment restrictions on non-licensees that result from the FCC's practice of granting exclusive spectrum licenses.

6) cost sharing and cooperation with next-generation public safety networks that will be using 700 MHz spectrum in the same timeframe that white space spectrum becomes available.

Though we consider a number of different options, they all assume, to varying degrees, the following general roles for local governments:

1) helping to maximize the amount and efficiency of white space spectrum use while, at the same time, helping to avoid and, as necessary, resolve interference problems with broadcasters and other spectrum users;

2) providing rights of way and other resources to support efficient network deployment and operation, including cooperation and, as appropriate, coordination with public safety networks and users;

3) delivering public services and facilitating other economic, political and social benefits via white space-enabled networks that provide broadly available untethered and non-discriminatory access to the Internet;

4) through these cost savings, efficiencies, services and benefits, generating value that can help justify the cost of providing universal broadband Internet connectivity.

We will refer to the proposed white space-enabled networks as "Public Interest IP" (PIIP) networks. This label directly links universal IP connectivity to a 21st century vision of using public spectrum to serve the public interest. And its acronym (pronounced "pipe") suggests its basic "dumb pipe" function of providing connectivity and transporting data packets.

Maximizing value, minimizing interference

Two key but potentially conflicting goals that need to be balanced in any approach to using the white space spectrum are to: 1) maximize the value extracted from that spectrum and; 2) avoid harmful interference to licensed users of the broadcast band.

As explained in our earlier review of pending issues in the FCC's white space proceeding, there are a number of interrelated factors involved in this balancing act. These include: 1) the number and type of white space channels available for use; 2) the extent to which use of personal/portable devices are allowed and; 3) the method(s) used to avoid harmful interference. Together, the FCC's decisions on these interrelated issues will play a key role in setting the foundation upon which white space networks and services will be built.

As we noted earlier, the FCC has so far expressed a particularly (some would argue overly) cautious view with regard to authorizing use of: 1) channels 14-20 and 2-4; 2) the use of "adjacent" channels by higher-powered fixed devices and; 3) personal/portable devices, both in general and most particularly on channels 14-20.

A related technical issues is that, as of the October 2006 release of its First Report and Order and FNPRM, the Commission had yet to be convinced that harmful interference could be avoided by relying solely on spectrum sensing-based approaches (vs. use of methods based on GPS or control signals).

To the extent the FCC's final white space rules restrict these various uses, the opportunities opened up by the white space spectrum will be more constrained than if the Commission concludes such restrictions are not needed. It is even possible that, under the most "restrained-use" scenarios, the white space could become widely viewed as an economically unattractive opportunity from the perspective of both device makers and potential service providers.

The Commission would no doubt prefer to avoid this latter fate, even as it seeks to adopt rules that can minimize risks of harmful interference to licensed users. Similarly, it is reasonable to assume that the Commission would prefer to maximize the availability of white space spectrum and the mix of white space devices and services as much as possible, again within the constraints of its other primary goal of minimizing harmful l interference.

In the months ahead, the FCC will be reviewing the various comments filed in response to the FNPRM, while also conducting its own testing and reviewing test results submitted by interested parties. Based on this, the agency will decide how to deal with the above issues. Those decisions will have a significant impact on the amount of white space spectrum

available to both fixed and portable devices, the means by which harmful interference will be avoided and, to a significant extent, the nature and costs of white space devices, networks and services.

One of the key concerns expressed by some commenters--and by the FCC itself--is the perceived lack of accountability and enforcement mechanisms with regard to interference control in an unlicensed scheme, especially in relation to personal/portable devices that would rely on spectrum sensing techniques. The most extreme versions of this concern were reflected in filings by broadcasters and wireless microphone interests, but it was also reflected to varying degrees in comments filed by others, including The Brattle Group, NextWave, Motorola and others. The basic point of these arguments is that, if harmful interference to broadcasters or other licensed uses did occur, it would be difficult or, in some cases, impossible, for these licensees or the FCC to identify the interfering portable device and remedy the situation, especially if spectrum sensing was the only means of interference control.

Though WISPA strongly supports unlicensed use of white space and believes spectrum sensing can control interference to licensed users, it was nevertheless among those expressing concerns about interference from portable devices. In its case, however, the concern was about potential conflicts between unlicensed portable local area network (LAN) devices and the type of wide-area networks (WANs) WISPA members hoped to deploy in the white space. These concerns led the trade association to oppose authorization of personal/portable devices in the white space band.

As WISPA's comments explained, its members have already experienced interference-related constraints on 2.4 GHz spectrum available for their WAN services. Given this, they are concerned these problems would be even more pronounced in the white space, since white space LAN signals will pass through walls far more readily than 2.4 GHz signals.

In evaluating WISPA's concerns in this area it is important to remember that the constraints on wide-area use of 2.4 GHz spectrum was the result of what WISPA itself acknowledged was the "massive success" of unlicensed use of this band by wireless LANs. While the impacts of this success may be unfortunate from WISPA's perspective, this does not necessarily mean it is, on balance, an undesirable outcome from a broader policy perspective. In fact, such tradeoffs and constraints are inherent in situations where unlicensed WANs and LANs share the same spectrum or, for that matter, in any spectrum sharing situation. But, as unlicensed advocates are quick to point out, these constraints tend to be far more flexible and First Amendment-friendly than those of exclusive licensing regimes, which typically foreclose (or dramatically limit) spectrum use by anyone but licensees.

While some might dismiss WISPA's concerns as too self-serving to be considered in determining white space policies, they do highlight important technical differences between unlicensed use of the 2.4 GHz and white space bands and their implications with regard to the coexistence of white space WANs and LANs. And, especially when viewed in light of the other pending issues noted above, they may also have implications for the FCC's effort to strike the right overall balance in its white space policies.

It is suggested here that, to the extent the FCC, at the conclusion of its planned test program, determines that some of the restrictions cited above are needed to insure unlicensed white space users do not interfere with licensed users of the TV band, the Commission consider approaches in which local governments can help achieve the following goals:

1) minimize the risks of interference from white space use, including portable devices, and enhance capabilities to correct interference problems should they occur;
2) maximize the amount of white space spectrum available for use;
3) facilitate efficient and beneficial coexistence of white space WANs and LANs

One of the key ways this would be done is through the deployment of community WANs under the control of citizens through their elected local governments or agents of that government. The latter could be public agencies akin to municipal utilities, private network management contractors, or potentially even private firms that own and operate networks under a local franchise that provides them with access to public rights of way for mounting antennas on utility and light poles and other public assets. All of these models are currently being considered, deployed and evaluated in muni-WAN networks throughout the country, a process that will help local decision-makers choose the option that works best for their communities.

For example, let's say that after testing and further deliberation, the FCC continues to harbor serious concerns about allowing portable unlicensed devices to operate in the 14-20 MHz band. Rather than prohibiting such use completely, the Commission could allow portable devices to operate in a master-client mode that only allowed them to use these channels when in communication with muni-WAN networks. This approach is similar to that proposed by Motorola and NAF, and to the approach the Commission has taken for the 3.65 GHz band.

Since it would be quite manageable to authorize muni-WAN use of channels 14-20 only in areas outside the "protection zones" of land mobile licensees (which is located in about a dozen U.S. metro markets), this could provide a workable mechanism for insuring that portable white space devices did not operate within these protection zones and cause interference to land mobile licensees.

Such an approach would be functionally similar to what NAF and Motorola proposed for allowing fixed and portable use on channels 14-20. In Motorola's case, it proposed that this use be restricted to "public safety and other critical users." What is being proposed here might be considered a more inclusive but still controllable "public interest" version of Motorola's proposed "public safety" restriction on users.

A similar approach could be taken with regard to use of channels 2-4, which broadcasters and cable operators warn may cause direct pickup (DPU) interference to TVs, VCRs, set-top boxes and other consumer electronic devices. If use of these channels was also controlled by (and potentially limited to) communications with muni-WANs, potential

interference problems could be reported by citizens and addressed by muni-WAN operators.

For example, upon being informed of a potential DPU problem, muni-WAN operators could remotely (and perhaps automatically) troubleshoot it to determine whether in fact it was caused by transmissions on channels 2-4. Should this be the case, it could address the problem by reducing power levels to and from the base stations closest to the device suffering the interference problems or, if need be, halt use of such channels in the areas served by those base stations. Should these steps not fix the problem, it would be reasonable to assume that it was caused by something else, which would be useful information to the citizen or business using the device, which could then search for other potential causes and solutions.

A similar approach to interference control could be applied if the FCC continues to harbor concerns about authorizing adjacent channel use by relatively high-powered fixed devices operating in an unlicensed mode. Rather than exclude such operation from the large number of adjacent channels, the Commission might reserve some or all of them for use by muni-WANs, which would serve as the "responsible party" in terms of working with affected broadcasters to remedy any interference problems that might arise.

Since the type of interference control described above would be most directly and fully applicable to channels 14-20, where geographic separation is the key goal, it seems clearly beneficial to apply such control mechanisms to at least these channels. Use of these channels would then be limited to muni-WAN base stations and the devices with which they communicate and can therefore authorize to use these channels. This use could be limited to areas of the country safely outside the protection zones provided for land mobile licensees in a small number of major metro markets.

While this approach could involve exclusive use of these channels by muni-WANs, this need not be the case. An alternative and less restrictive approach would be to also allow non-muni-WAN base stations (e.g., home or office wireless LAN routers) to operate on these channels as long as they are able to receive an authorization signal from a fixed muni-WAN base station whose location and use had been authorized as outside the land mobile protection zones.

It is also possible that, even in markets with protected land mobile licensees, local governments could work with public safety users to coordinate their use of channels in the 14-20 band (the latter use only 1-3 channels in each market). Over time, this cooperation could be extended to include the migration of public safety communications from its current use of channels 14-20 (470-512 MHz), much of which employs older analog technology, to a more advanced platform that employs the 700 MHz spectrum that will become available to the public safety community once broadcasters return their analog TV channels in early 2009. Since local governments are ultimately responsible for public safety in their communities, it is assumed they would be very respectful of public safety needs in negotiating such spectrum "coordination" and "migration" scenarios. As discussed further below, this would be one of multiple modes of mutually beneficial cooperation involving the management of "public safety" and "public interest" spectrum use.

Whether exclusive use or some form of interference control by muni-WANs for channels 2-4 and adjacent channels would be desirable would be largely a function of what the FCC decides about other means of controlling interference from unlicensed use of these channels, especially the spectrum sensing approach favored by the high-tech coalition.

For example, should the FCC decide spectrum sensing was sufficient to avoid harmful interference from these channels, any additional interference control capabilities provided by muni-WANs would be a less significant factor. But, even in this case, it seems likely that pole-mounted antennas would, in some (perhaps many) cases, be better able to detect licensed signals than ground-level end-user devices. In such instances, these muni-WAN devices could communicate the existence of such licensed signals to end-user devices, to assist the latter in their interference management tasks.

In essence, what is being proposed here is a role for muni-WAN base stations to serve as interference-protection mechanisms that, depending on the FCC's determination of the need for such mechanisms, can range from exclusive muni-WAN use of some channels, to less restrictive "master-client" relationships that authorize and, as needed, control "local" WAN and LAN devices, to "backup" support for primary interference control mechanisms built into end-user equipment.

In communities where local governments opted not to deploy or authorize muni-WAN networks, these functions could potentially be handled by WAN networks deployed by private companies. In communities with neither a public nor private WAN, these channels might have to remain unused, unless the Commission authorized other methods of achieving the same level of interference control.

The central purpose of this interference control role for muni-WANs would be to achieve the twin goals of maximizing white space spectrum availability while avoiding harmful interference to licensed users.

A potential secondary goal could be to provide muni-WANs with some amount of white space spectrum (e.g., channels 14-20), they could exclusively use, at least for some period of time. This exclusive use would have two related purposes. One would be to facilitate the deployment of higher capacity muni-WANs by providing them with some spectrum to which they had exclusive access. A second would be to avoid the type of WAN-LAN interference issues that WISPA expressed concerns about for future white space operation. As WISPA noted in its comments, this issue of exclusive muni-WAN use of these channels could be revisited as technology changes allow for greater frequency reuse and more efficient sharing, and to the extent channels assigned exclusively to muni-WANs are underutilized.

The value of this second goal is tied to the perceived value of muni-WANs. It is the author's view that such networks can provide substantial value, as explained in earlier sections of this report.

As such, it is recommended that the Commission initially limit use of channels 14-20 to muni-WANs, subject to later evaluation of this policy based on the evolution of technology, networks and applications using the white space and these channels in particular.

It is also recommended that these muni-WANs be required to operate their networks in a manner consistent with the four Internet Freedoms laid out by ex-chairman Michael Powell and reiterated in somewhat watered-down language in a later policy statement issued by the Commission under Powell's successor, Kevin Martin.

And, depending on what the Commission decides regarding interference protection on channels 2-4, adjacent channels, and for personal/portable devices, the agency might want to encourage (or potentially even require) muni-WAN network devices to include detection and control functionality for these channels. As with channels 14-20, the goal would be to minimize interference risks while maximizing the availability of white space spectrum, as well as the efficiency of its use and the variety of devices able to use it.

The cost of adding such functionality should, of course, be considered in decisions regarding any requirements for vendors and operators to incorporate them into muni-WAN devices and networks. While initial conversations with equipment vendors suggest that some such functionality would not add significant costs, a full analysis of this issue is beyond the scope of this report.

Another possible approach would be to initially assign channels 2-20 (all the VHF channels plus UHF channels 14-20) to muni-WAN operation. In this scenario, the lower 40% of white space channels would be initially dedicated to muni-WAN operation, with the upper 60% (channels 21-51) available for unlicensed LAN use.

A few things are worth noting about this approach. One is that the strong propagation characteristics of VHF channels (54-216 MHz) are, in some ways, especially well suited for WAN operation, given their ability to penetrate foliage and walls. Another is that the high-tech coalition does not appear to view the VHF channels as necessary to create an economically attractive market for low-power portable and LAN devices. In fact, in its reply comments, the coalition said it "does not oppose restricting personal/portable devices from all VHF channels."

Extending PIIPs via end-user LANs

Another factor in considering such a scenario is the fact that one of the primary goals of a muni-WAN would be to maximize coverage, access and effective data rates while minimizing costs, and that these goals would be pursued from the perspective of the community as a whole.

In contrast, a privately operated WAN (as reflected in WISPA's white space comments) would be inclined to focus on optimizing its profits and other internal financial metrics, and to target value it can internally monetize rather than positive externalities it cannot. What this means is that a muni-WAN would probably be more inclined than a private operator to

approach questions of channel use and spectrum sharing and coordination from a perspective that sought to optimize the total network capacity available to a local community, regardless of how that capacity was provided.

An industry development that can help us understand how this "community-networking" concept might evolve is the emergence of entities like FON, Meraki and Netequality. Both FON and Meraki have developed low-cost wireless routers with intelligence to support user-created mesh networks that can be expanded to cover entire communities. FON has also developed a business model to support growth of such networks, while Netequality is testing use of Meraki routers to allow multiple low-income households in San Francisco share a single DSL connection.

While many believe these technologies and the user-developed community mesh networks they enable have great potential to expand broadband availability at low cost, they face a significant hurdle in winning cooperation of existing broadband access providers. While sharing of a single DSL connection by multiple households may be an attractive proposition from the perspective of these households, it may not be so for the DSL provider and, in many cases, may be a violation of that provider's service agreement.

But if we view these technologies from the perspective of a non-profit muni-WAN whose primary goal is to maximize community-wide coverage, access and throughput while minimizing overall costs, the probability of such WAN-LAN financial conflicts shifts from very likely to very unlikely. From the perspective of a non-profit muni-WAN provider, FON and Meraki technologies would most likely be welcome additions to the achievement of its overall goals. And, because end-users would presumably be paying for their "mesh-capable" in-home routers, the result would be increased coverage and capacity without the need for additional investment by the muni-WAN operator.

In this kind of scenario, it is fairly easy to imagine that, over time, both the technical (e.g., coverage and data rates) and economic efficiency of a community's wireless connectivity (including a muni-WAN and meshed and standalone LANs) could be optimized to levels not possible (or at least less likely) in a situation where the WAN was operated by a profit-seeking entity.

It also seems likely that this optimization would involve: 1) a migration to an increasingly integrated community-wide PIIP network encompassing both WAN and LAN devices and; 2) the increasingly efficient use of all available spectrum, regardless of whether and how the FCC assigned it to muni-WAN or LAN operation, as long as the goal of avoiding harmful interference to licensed users remained a top priority for decision-making related to spectrum use and network design and operation.

The value of universal access

As the above discussion suggests, white space-enabled PIIP networks have the potential to deliver unique advantages in relation to cost, efficiency and social value.

As we consider the implications of these advantages, it is useful to remember our earlier discussion of positive externalities and economic growth as key elements of value that can be derived from the expansion of broadband Internet access provided on a non-discriminatory basis consistent with the Internet's end-to-end, content-neutral architecture.

Given the potential scope and significance of these benefits, as described earlier and in the work of Crawford, Romer, Wu and Benkler, it is appropriate to view the PIIP model as more akin to a public utility than a mode of access that relies on market-based equilibriums between access providers and end users. In that sense it provides a fundamental alternative to the existing access model, which is based primarily on duopoly-based market equilibriums and vertically-integrated gatekeeper service models that combine access and applications.

In fact, the analyses of these leading thinkers points to a PIIP model based, as much as possible on universal access by all citizens and organizations, regardless of their ability to pay a market price set by an access provider,

From the perspective of New Growth Theory, free or very low cost Internet access can be viewed as a tool to help maximize the Internet's demonstrated ability to facilitate the growth-promoting and increasingly valuable "combinatorial explosion of ideas" and "nonmarket social production" discussed by Romer, Crawford and Benkler, as described earlier in this report.

In a discussion of patents, Romer notes the problems with using price-based allocation mechanisms when dealing with the realm of idea creation, dissemination and application:

> Because everybody can use the idea at the same time, there's no tragedy of the commons in the intellectual sphere…If you give an idea away for free, you don't get any of the problems when you try and give objects away for free…[W]ith ideas, you have this tension: You want high prices to motivate discovery, but you want low prices to achieve efficient widespread use. You can't with a single price achieve both, so if you push things into the market, you try to compromise between those two, and it's often an unhappy compromise.

As Benkler explains, there are signs this compromise can be made less "unhappy" through the Internet's ability to support "nonmarket social production," as evidenced by "the rise of effective, large-scale cooperative efforts—peer production of information, knowledge, and culture."

> In the networked information economy, the physical capital required for production is broadly distributed throughout society. ..The result is that a good deal more that human beings value can now be done by individuals, who interact with each other socially, as human beings and as social beings, rather than as market actors through the price system.
>
> Sometimes…these nonmarket collaborations can be better at motivating effort and can allow creative people to work on information projects more efficiently than

> would traditional market mechanisms and corporations. The result is a flourishing nonmarket sector of information, knowledge, and cultural production, based in the networked environment, and applied to anything that the many individuals connected to it can imagine. Its outputs, in turn, are not treated as exclusive property. They are instead subject to an increasingly robust ethic of open sharing, open for all others to build on, extend, and make their own… Human beings…act for material gain, but also for psychological well-being and gratification, and for social connectedness. There is nothing new or earth-shattering about this, except perhaps to some economists.

By reducing the overall costs of exchanging ideas and information, and facilitating and leveraging non-market-based creativity and collaboration, the Internet can help reduce the "price gap" that Romer cites as a fundamental hurdle constraining growth in the realm of ideas. Reducing this gap is especially valuable in the modern world, since new ideas have become so central to driving growth in economic and social value.

Crawford adds to this analysis the value of the Internet's scale in supporting and expanding these dynamics:

> The new growth theorists put scale in the foreground as a fundamental aspect of modern economic understanding, because larger markets induce the creation of more new ideas and hence faster growth. The human communications made possible by the internet have the greatest scale of any communications modality we have known thus far…

By extending broadband Internet access to all, regardless of ability to pay a market price set by an access provider, free PIIP networks can extend the scale and efficiency by which networked communications and nonmarket production can reduce the "idea" price gap and therefore drive economic growth and value production.

Synergies with public safety

A key element of the PIIP model—and yet another potential source of cost savings and efficiencies—is the potential for administrative, operational and technical coordination between "Public Interest" and "Public Safety" networks.

As mentioned above, the public safety community will be receiving additional spectrum in the upper 700 MHz band once broadcasters return their analog spectrum. The details of this transition are still being decided by the FCC in a pending rulemaking. The original plan called for public safety users to get access to 24 MHz, with the FCC having recently proposed using half of that for interoperable broadband IP connectivity.

Two key challenges confront the current plans for next-generation public safety networks--how to finance their capital and operating costs, and how to insure they have enough capacity to support advanced broadband applications.

In December 2006, the FCC proposed a "national, centralized approach to maximize public safety access to interoperable broadband spectrum in the 700 MHz band" and to "promote the deployment of advanced broadband applications, related radio technologies, and modern, IP-based system architecture."

Specifically, the December *Ninth Notice of Proposed Rulemaking* proposed that the Commission:[155]

> (1) allocate 12 megahertz of the 700 MHz public safety spectrum from wideband to broadband use;
> (2) assign this spectrum nationwide to a single national public safety broadband licensee;
> (3) permit the national public safety broadband licensee also to operate on a secondary basis on the narrowband public safety spectrum in the 700 MHz band;
> (4) permit the licensee to use its assigned spectrum to provide public safety entities with voluntary access to a public safety broadband service on a fee-for-service basis;
> (5) permit the licensee to provide unconditionally preemptible access to its assigned spectrum to commercial service providers on a secondary basis, through leases or in the form of public/private partnerships;
> (6) facilitate the shared use of CMRS infrastructure for the efficient provision of public safety broadband service; and
> (7) establish performance requirements for interoperability, build-out, preemption of commercial access, and system robustness.

The Commission indicated a preference for the "national public safety broadband licensee" to have experience with public safety management, a not-for-profit status, and an "ability to directly represent all public safety interests." It also proposed that commercial interests not have any financial interest in the national license or licensee, nor participate in the latter's management.

The Commission's December proposal is not the only one on the table that tries to address the cost and spectrum questions confronting the planned deployment of public safety networks in the upper 700 MHz band. Several others are notable in that they would allocate spectrum scheduled for commercial auction to public safety, while also encouraging cooperation between public safety and commercial interests. And, like the FCC's proposed plan, these alternatives all attempt to strike the potentially delicate balance between insuring sufficient control by local public safety entities; achieving efficiencies through nationwide interoperability and coordination; and attracting participation by commercial entities in ways that help fund the network's costs but retain the primacy of public safety applications, especially in times of crisis.

In April 2006, Cyren Call Communications, headed by Nextel founder Morgan O'Brien, introduced a plan that would assign 30 MHz of spectrum scheduled for auction to a Public Safety Broadband Trust (PSBT). As explained on the Cyren Call web site:

> The Public Safety Broadband Trust (PSBT) would hold the license for this 30 MHz block and structure innovative arrangements for its shared use, placing the needs of public safety first and commercial usage second.
>
> The PSBT would allocate long-term access to this spectrum to private sector entities that would agree to build and maintain the nationwide, next-generation network for public safety. In exchange, the private sector entities would gain the right to share the network and sell excess capacity for commercial purposes.[156]

In a white paper, Cyren Call said "the PSBT will pay the federal government with [$5 billion in] borrowed funds raised in the private capital markets backed by federal loan guarantees, under arrangements just like those that have been made available to other industries (e.g., airlines, shipping companies and pipeline operators). The PSBT in turn would lease spectrum usage rights to commercial operators, who will build out a secure national broadband network meeting public safety specifications."[157]

Cyren Call claims its plan would balance the needs and priorities of public safety and commercial interests:

> The PSBT will hold and exercise control over the license to the 30 MHz spectrum and will determine the network's technology, build requirements and operating rules. Although such control would assure that public safety users would have priority access to the network capacity then need whenever they need it, the formidable capacity of such a network also would provide commercial subscribers with a high degree of confidence that the resources of this highly reliable, secure and redundant broadband network would be available to meet their reasonable communications needs except in times of true public emergency, when their access to the network would be interrupted in favor of public safety's urgent communications requirements.[158]

While the Cyren Call plan would disrupt current auction plans and would apparently require Congressional action, this does not appear to be the case with a competing proposal that emerged in late February from Frontline Wireless LLC. Frontline is led by CEO Haynes Griffen, the founder of Vanguard Cellular (later sold to AT&T Wireless); chairman Janice Obuchowski, former NTIA director and U.S. Ambassador to the 2003 World Radiocommunication Conference; and vice chairman Reed Hundt, a former FCC chairman during the Clinton Administration.

Whereas Cyren Call would remove 30 MHz of spectrum from the planned auction, Frontline's "Public Safety Broadband Deployment Plan" is designed to work within the auction process. It would have the FCC restructure the spectrum to be auctioned next year to include a 10 MHz nationwide "E" Block. The auction of this 10 MHz would be subject to certain conditions:

> The E Block licensee will accept the legal obligation to build out to specific milestones a nationwide broadband network that meets public safety requirements for interoperability, security and robust platforms.

> In exchange, the E Block licensee will gain access to excess capacity on the 12 MHz of broadband spectrum allocated to public safety – ensuring that the licensee's business incentives track its legal obligations.
>
> The E Block licensee will be required to operate the network according to open access principles, allowing consumers freedom to connect devices of their choosing. Also, it will provide commercial operations solely as a wholesale network "utility", producing capacity that can be resold to retail-oriented service providers, including rural telephone companies and cellular companies not adequately served by the current roaming regime.[159]

According to Frontline's recent FCC filing, in addition to providing funding to build out a nationwide public safety broadband network and making an additional 10 MHz available to public safety users when needed, its proposal would provide other benefits tied to its architecture:

> The E Block will be allocated for IP-based, open access architecture, ensuring that public safety agencies can use any equipment they choose subject to a minimum, "do-no-harm" requirement.
>
> Because it will be built using flexible, IP-based technology, the nationwide broadband network will allow local, regional, and national public safety agencies to create localized, virtual private networks or Intranets to suit their unique communications needs.
>
> By its nature, the IP-based, open access network built by the commercial licensee will ensure that first responders and other public safety officials can communicate interoperably when and how they choose.[160]

Consistent with the FCC's own proposal, the Frontline plan calls for single public safety licensee that would hold the nationwide license for the public safety broadband block. This licensee would be "representative of the public safety community, and would work with the E Block licensee to ensure the network is designed to meet public safety needs."

The national public safety licensee would be authorized to charge public safety agencies a fee for use of the broadband network. The licensee would, in turn, pay the E Block licensee "a reasonable network management fee…to cover those reasonable costs of maintaining or upgrading the network that are attributable to public safety's use of the network infrastructure."[161]

Frontline claims this fee would be "much lower than the public safety spectrum usage fee" under the FCC's own proposal because, under its plan "public safety would not be funding the up-front costs of constructing the nationwide infrastructure, and the commercial operator would share in the costs of operating and maintaining the broadband facilities."[162]

Like Cyren Call, Frontline highlights the challenges to financing a public safety broadband network, and its proposal's ability to address them:

> The [FCC's proposal]…explores whether a usage fee charged by the national licensee of the public safety broadband spectrum could viably fund the construction of the network. The network, however, must be constructed and operational before the usage fees can be generated, and it is unclear how this usage fee program would afford the national licensee the means to raise the amount of capital necessary to fund the up-front construction costs.
>
> Compared to a commercial entity, a non-profit, national public safety licensee is less likely to have the expertise and ability to raise capital efficiently through the private capital markets, absent a significant government subsidy to investors. More importantly, attempting to finance network construction with usage fees means that public safety will be saddled with the up-front cost of the build-out – precisely the primary obstacle that has to date undermined the deployment of a nationwide, interoperable public safety network. IACP [International Association of Chiefs of Police] Committee Chairman McEwen is right that the funding issue is just as critical as the spectrum problem, and therefore the Frontline Plan gives the Commission a clear path to finance a public safety broadband network.[163]

In Congress, Senator John McCain (R-AZ), has been among the most active legislators in terms of pushing for more spectrum and funding to support public safety communications. In early March, McCain introduced a "Spectrum Availability for Emergency-Response and Law-Enforcement to Improve Vital Emergency Services (SAVE LIVES) Act" that appears to combine aspects of the Cyren Call and Frontline proposals.

McCain's bill would have 30 MHz of the planned 60 MHz in the 700 MHz band auctioned under a conditional license. The winning bidder for that 30 MHz license would have to meet public-safety specifications to operate a national, interoperable public-safety broadband system. According to a press release issued by McCain's office, "[i]f there is no winning bidder, then the license to the 30 MHz will revert to public safety, which could then use the spectrum for a national, interoperable public safety broadband network and work with the FCC to auction excess non-emergency capacity." The bill would also require the FCC, the Department of Homeland Security and public safety interests to review the possibility of moving most public safety communications to the 700 MHz and 800 MHz bands, in order to enhance interoperability.[164]

According to news reports in the wake of McCain's announcement, the public safety community prefers an approach more akin to the Cyren Call proposal, where control of the network is more unambiguously in the hands of that community rather than any commercial entities.[165]

There is also public safety-related network project underway involving the Departments of Justice, Treasury and Homeland Security (DHS). Using spectrum controlled by the federal government, this "Integrated Wireless Network" (IWN) is intended to provide improved technical and operational integration for these three federal agencies. According to the

Justice Department web site, IWN will utilize a packet switched IP backbone, "will be designed to facilitate interoperability with other federal, state and local public safety partners" and "may be complemented by commercial wireless service solutions."[166]

Regardless of how the FCC and Congress ultimately decide to deal with public safety spectrum, there would likely be opportunities for coordination and cost savings between next-generation public safety networks and the "public interest" networks discussed here. And, to the extent public safety networks were built out with commercial funds, integrated with commercial network capabilities, and based on an open, standards-based IP-based architecture, the potential for cost savings and technical and operational efficiencies would presumably be even greater.

A related element of potential cost savings in the construction of community PIIP networks is tied to the revenues the federal government will be collecting from next year's auction of the 700 MHz spectrum to be returned by broadcasters.

The February 2006 legislation that set a firm date for the return of that spectrum also earmarked $1 billion of auction revenues to a grant program to help pay for public-safety interoperable communication systems. It also called for at least $990 million and as much as $1.5 billion to support a program of subsidies for consumer purchases of digital-to-analog converters that will allow analog TVs to receive off-air digital signals once broadcasters shut off their analog signals. The bill also allocated $156 million in auction proceeds for national alert and tsunami warning systems and $43.5 million to help fund E-911 upgrades.[167]

In the wake of the Democrat's takeover of Congress and the NTIA's mid-March release of its plans for the digital converter program, House Energy and Commerce Committee chairman John Dingell (D-MI) and House Telecommunications and Internet Subcommittee chairman Edward Markey (D-MA) have both expressed concern that the NTIA plan is inadequate and may have to be revisited by Congress.[168]

Given this, and the growing debate over how best to deal with public safety spectrum and, potentially, the 700 MHz auction, it is suggested here that any effort by Congress to revisit these issues include consideration of PIIP network deployment as a goal worthy of some support from the auction of publicly owned spectrum.

Though resolution of the public safety debate could significantly impact auction revenues, under the current plan these are expected to exceed $10 billion, perhaps by a substantial amount. From this total, Congress could consider allocating some additional amount to an expanded "interoperability" grant program that would encompass both "public safety" and "public interest" networks. A primary goal of these additional funds would be to promote technical, financial, operational and service-oriented coordination and efficiencies between these two networks, whose common purpose would be to serve the public interest in 21st century America.

"Smart grid" utility applications

Another potential contributor to PIIP economics is the provision of communication services to electric utilities.

For more than a decade the utility industry has been considering options for providing what have come to be known as "smart grid" applications. These communication-dependent services include automatic meter reading (AMR), outage detection, preventive maintenance, remote disconnect/connect, time-of-use metering and load management.

Utility interest in deploying such applications has increased in recent years, due in part to regulatory pressures at both the federal and state levels to improve the industry's efficiency, reliability and security, especially as the nation has become more focused on the risks associated with natural disasters and terrorist threats.

While a small number of utilities have dipped their toe into the water of "broadband over powerline" (BPS) technology, there remain real questions about BPL technology, economics and business models.

Against the backdrop of these lingering questions about BPL, a small number of municipal wireless networks, including one in Corpus Christie, Texas, have begun delivering AMR services for local electric and water utilities. While these tend to be in communities with municipal utilities, it seems reasonable to assume that some privately owned utilities might consider similar arrangements attractive. This seems all the more likely given that private utilities are feeling increasing pressure to deploy "smart grid" applications even as they remain ambivalent about deploying their own communication networks.

A PIIP-utility relationship could include upfront payments by utilities to help support PIIP network deployment costs, and/or ongoing payments in exchange for access to network capacity and services. It might also include the involvement of utility staff in deploying and maintaining the PIIP network, the use of utility poles for mounting antennas, and electricity to operate the network. And getting utilities involved in PIIP planning could also help to minimize the kinds of delays some muni-wireless networks have faced in getting access to poles owned by the local utility company.

The addition of "smart grid" applications to the PIIP service mix could also increase the potential for planning and operational synergies with public safety networks discussed above. This is because the maintenance of utility networks and services is a key element of homeland security and public safety functions.

Phasing in fiber PIIPs

Before leaving the subject of network buildout, design and costs, it's worth considering the potential role of fiber in deploying PIIP networks. In a recently published book entitled *America at the Internet Crossroads: choosing the road to innovation, wealth and a supercharged economy*, author Mike Bookey laid out a phased approach to deploying what

he calls “Internet fiber roads.” Using this report’s terminology, these might also be referred to as “fiber PIIPs.”

The first stage in this process, Bookey explains, would be for a local community to create an Internet Road Utility (IRU) and a "fiber infrastructure plan."

> For communities wanting to build Internet roads now or possibly in the future, a well-planned and well-structured fiber infrastructure plan is critically important... Unfortunately, the typical practice is for public and private organizations to install fiber infrastructure without fully considering the long-term needs of the community... [169]

> The first stage in building a community Internet road network is to form an [IRU]. Strictly speaking, it does not have to be a utility. It can be a separate agency, public development authority, or some other form of public organization. This organization can outsource the building and running of the network to private companies or run the network itself. The important point is that it needs to be a self-contained entity with a focused mission of producing Internet road service… [170]

> The IRU should use a phased approach for the build-out of the community's Internet road network. A phased approach carries the least risk of catastrophic failure and minimizes the amount of taxpayer dollars at jeopardy. It also ensures the community is solidly behind building the Internet road network… [171]

> The IRU uses whatever community fiber infrastructure is already in place. The initial focus is to aggregate the intra-community connection requirements of municipal government, public schools, libraries, police and fire departments, courthouses, hospitals, and if applicable, the publicly owned energy utility. The aggregation of municipal government and public agencies is necessary for the IRU to establish sufficient critical market mass to sustain its business. The goal is to develop this basic infrastructure without subsidizing it by raising taxes. The expense to build and operate this first phase of the Internet road network is paid for by cost savings and improved efficiencies… [172]

Bookey goes on to explain a series of evolutionary stages in this "smart-build" strategy:

> The IRU's initial development phase is small and focuses on providing Internet service to government and public agency sites within the community… [173]

> Connecting municipal government and public agency sites to the Internet road service is an important initial step for two reasons. First, it gives these public organizations the ability to leverage the Internet road service’s capabilities to operate better, faster, and cheaper. In this time of reduced taxes (income) and increased demand for services, government and public agencies must find new ways to produce more with less. Second, municipal government and public agencies must have time to develop new electronic services for delivery over Internet roads when

> the utility extends service into the residential and business areas of the community.[174]

Bookey goes on to list examples of the kinds of government and public agency services a fiber-based Internet road network could deliver to business and residential customers:

> • Live video broadcasts from local parks, highways, and traffic intersections
> • Police alerts to every retail merchant when a check forger is passing through town
> • Video on demand curriculum from local schools and colleges available twenty-four hours a day, seven days a week
> • Videophone calls to teachers, government sites, and public agencies
> • Remote home health care services provided by the community hospital
> • Real-time price signals and energy-management services provided by the community-owned electric utility
> • Live broadcasts of public meetings[175]

While some of the services may not be fully supportable by wireless PIIPs, others would. And the wireless network would have the added benefit of supporting mobility. As Bookey notes:

> Though wireless cannot deliver the capacity of fiber, and some services available on the fiber portion of the Internet road network cannot be delivered over wireless, it is quick and relatively inexpensive to deploy…When the fiber infrastructure is eventually expanded to serve these consumers, the wireless service can be repurposed to serve just the mobile service needs of the community. In this way, the IRU uses wireless to extend Internet road service to sites not yet served by fiber and provides for the future delivery of mobile services.[176]

According to Bookey, the combination of the new services not available from incumbents, combined with a highly-competitive "triple-play" service, both of which would be enabled by an all-fiber network, could drive sufficient business and residential demand to justify expanding the Internet road service into "areas immediately surrounding the already served government and public agency sites."[177]

> Because the Internet road network incrementally expands based on consumer demand, and does so in close proximity its existing fiber infrastructure, it reduces the cost of expansion and generates revenue…[178]
>
> As the business and residential consumer market served by the IRU grows larger, more service providers are attracted to the environment of the community's Internet road network. These can include broadcast television entertainment and news service providers. The addition of more providers increases the number of services available to consumers on the Internet road network.
>
> As a result, more business and residential consumers are attracted by the usefulness of the IRU's Internet road service. A virtuous cycle begins. More service providers attract more business and residential consumers, and more business and residential

> consumers attract more service providers. On it goes until equilibrium is struck between the size of the government, business, and residential consumer market in a community and the number and type of service providers it can support…[179]
>
> As consumer demand increases, a tipping point is reached when demand exceeds the IRU's ability to expand service fast enough. When this happens, the municipal government can decide to place a bond issue before its voters to fund a rapid community-wide build-out of the Internet road network.[180]

Bookey's discussion suggests the possibility that the design and deployment of wireless PIIP networks could be managed by the same Internet Road Utility he envisions managing the evolution of a community's "fiber infrastructure plan."

This would seem to make sense administratively and also technically. Together, these two initiatives would comprise the design, deployment and operation of a community's PIIP infrastructure. White-space enabled wireless would serve as the relatively low cost, quick-to-deploy and ubiquitous mode of connectivity, with the more costly fiber links being phased in if and when they proved themselves to be cost-effective for delivery of higher-capacity services.

Part of this integrated approach to PIIP planning would be to consider backhaul needs of the community's wireless PIIP network as a factor in the evolution of its fiber infrastructure plan. This would benefit the wireless network and its end users by helping to cost-effectively deliver very high levels of network capacity closer to those end users. At the same time it would help cost-justify further extensions of the community's fiber infrastructure to more locations, which in turn would effectively reduce the net cost of further incremental fiber extensions. As total fixed and mobile PIIP traffic expanded, the IRU would have the option of investing in further expansion of wireless capacity and/or fiber coverage, depending on the nature of that traffic and the IRUs ability to justify such network investments.

Incumbents' response

As we noted earlier, comments filed by NAF, et al. suggested that, if the added capacity and improved propagation characteristics of unlicensed white space spectrum were made available to municipal wide-area networks:

> [T]here can be little doubt that within five years, a majority of Americans will have an option to communicate and access the Internet—any time, from any location—through networks operating over unlicensed spectrum. The benefits for local economic development, education, government and personal productivity, and particularly for bridging the broadband deployment gap in rural and in low-income urban areas, are quite literally incalculable.[181]

In this report we have presented a range of arguments in general support of this vision of a potential future, adding to it the possibility these networks, which we refer to as PIIPs, could provide broadband access at no charge to end users by supporting network costs through a range of savings, efficiencies, other revenues and positive externalities.

The prospect of this model proliferating as suggested by NAF et al., leads logically to questions about impacts on the wireline and wireless broadband access models currently dominant in this country. As we've discussed, these two models today: 1) operate, respectively, in a predominantly duopoly and oligopoly mode and; 2) have a strong tendency toward vertical integration of access, application and end-user devices.

We consider below several different scenarios that could arise in a world of free PIIP access, as described earlier in this report. These, in turn, are built around several combinations of the following assumptions regarding PIIP and incumbent access networks.

1. **Strong PIIP** scenarios assume that the potential technical and operational benefits discussed above manifest strongly. These could include: propagation and capacity improvements from white space spectrum; efficient use of end user-created mesh extensions; synergies with public safety and; strong development of high-value PIIP-delivered services.

2. **Weak PIIP** scenarios assume the opposite, that these potential benefits manifest only weakly, with the result being an overall less capable and valuable PIIP access service.

3. **Strong Incumbent Response** scenarios would have incumbents respond to the availability of free PIIP networks by investing in network upgrades to deliver bit rates well beyond what they offer today (e.g., by deploying 4G and FTTH networks), and developing high-value services through their more vertically-integrated model of service development. From the perspective of end-users, this PIIP-induced competitive response by incumbents would be a positive development.

4. **Weak Incumbent Response** scenarios would have incumbents avoid or otherwise fail at achieving these positive steps toward retaining and attracting customers and delivering

increased value they can internally monetize. This might manifest as decisions to slow investment in network upgrades and new services and, instead, to focus resources and management attention on defensive efforts to place regulatory, legal or other roadblocks on the path to widespread deployment of PIIP networks. While the latter could be considered a "strong" response, it would be a "strong negative" response, in sharp contrast to the "strong positive" response reflected by an incumbent's decision to invest in network upgrades and new services.

5. **Cooperative Incumbent Response** scenarios would occur to the extent incumbents come to the conclusion that "if you can't beat 'em, join 'em." This could take the form of cooperation with PIIPs in the delivery of services and/or incumbent participation in the deployment and operation of PIIP networks. We briefly discuss this type of incumbent response in a final section of this report.

Scenarios reflecting combinations of these assumptions include:

Strong PIIP, Strong Incumbent Response: This scenario assumes that the proliferation of strongly functioning PIIPs spurs significant incumbent investment in network upgrades and services. The result seems likely to be a substantial increase in overall economic and social value, reflecting the combined impacts of the relative strengths and benefits of both models. At the same time, however, it is not clear what impact this would have on Wall Street perceptions of incumbent prospects. Current Wall Street models of incumbent financials do not appears to factor in significant impacts from widespread availability of free or even low-cost municipal networks.

Strong PIIP, Weak Incumbent Response: This assumes strongly functioning PIIPs but lacks the proactive incumbent response featured in the first scenario. In this model, incumbents would avoid significant investments in network upgrades and new services and would, instead, adopt a strongly defensive posture focused on cutting costs and what would probably be an ever-shrinking arena in which they could exploit their market power in ways that allow them to generate high margin revenues. This response would be particularly likely to the extent the dominant view on Wall Street was that it was too risky for incumbents to boost investments in network upgrades and new services in response to expanding PIIP deployments.

Strong PIIP, Cooperative Incumbent Response: This assumes much of the same dynamics as the prior scenario, with the key difference being that incumbents decide to pursue cooperative relationships with PIIPs in the delivery of services and/or by participating in the deployment and operation of PIIP networks. We discuss this scenario briefly in a final section of this report.

Weak PIIP, Strong Incumbent Response: This scenario assumes that the strengths and benefits actually delivered by PIIPs fall well below the more optimistic scenarios suggested in this report. It also assumes that incumbents invest aggressively in network upgrades and new services. The result would be some relatively modest degree of basic connectivity provided by PIIPs. Against this backdrop would be significant upgrades of incumbent wireline and wireless networks and services. These would be driven by the internal

dynamics of these sectors' duopoly and oligopoly market structures and also by the expanding availability of free PIIP access.

In this scenario, the impact of PIIPs would be less likely to emerge as a major factor in Wall Street perceptions of incumbents' prospects than it would in the "strong PIIP" scenarios. This is because the level of connectivity and range and quality of services delivered by PIIP networks would pose less of a threat to incumbent revenues than in the "strong PIIP" scenarios.

Assuming incumbents continued to prefer vertically integrated service models, the analysis presented in this report suggests this scenario would not generate the degree of positive externalities (i.e., those not readily internalized monetarily by incumbents) and Internet-enabled economic growth (e.g., from large-scale unencumbered "free flow of ideas" and "nonmarket social production") that would be expected in either of the Strong PIIP scenarios.

Weak PIIP, Weak Incumbent Response: From the perspective of broader social value, this scenario represents the worst of all possible worlds. It assumes incumbents' response to early signs of PIIP network growth are defensive in nature, focused on placing regulatory, legal and other hurdles in the path of that growth. This would be accompanied by a relative lack of investment by incumbents, perhaps due to pressure from investors who see such investment as too risky, especially in the face of a nascent PIIP movement. In a sense, this scenario represents a decision by incumbents to invest in lawyers and lobbyists rather than in networks.

Ironically, this final "weak PIIP-weak response" scenario could be among the more desirable outcomes from the perspective of incumbents' shareholders. This could occur because they might view incumbent investment in an increasingly competitive market as unacceptably risky. While this is understandable from these investors' perspective, it is unfortunate from the broader perspective of social value delivered by 21st century communication networks, technologies and services. From this broader perspective, this scenario would result in the least total value (including externalities and economic growth) being delivered by the communication sector as a whole, accompanied by an increase in the economic friction and distortion associated with prolonged legal fights and lobbying battles.

Impact on incumbents' revenue

As a final exercise, we briefly consider the potential impact of free PIIP access on incumbents' revenues, using a simple model that calculates these revenue impacts based on assumptions about market share and ARPU under two of the scenarios described above. To provide a sense of the range of these possible effects, we use two contrasting scenarios: "Weak PIIP, Strong Incumbent Response" and "Strong PIIP, Weak Incumbent Response."

The model considers market share and ARPU impacts on the four general service types that comprise a typical "quadruple play" offering provided by incumbent service providers. Though, over time, these four services will become less distinct and more integrated, for the

purposes of this simple model, they provide a useful framework for considering the impacts of universal free PIIP access.

While the numbers in our model are admittedly speculative, they can help provide a general sense of how the combined impacts of declines in their market share and ARPU could impact incumbent revenues.

To help derive assumptions about potential PIIP impacts on market shares we refer to a user survey taken in St. Cloud a few months after the city launched its free Cyber Spot Wi-Fi service.

In the survey, nearly half (48.9%) of respondents said they used Cyber Spot as their only connection to the Internet, with 15.2% using it as their primary mode of access, while also retaining a backup service. Another 35.9% used Cyber Spot as their secondary mode of access. Of those retaining a backup service, 68.3% said their ultimate plan was to use the free muni wireless service as their only form of access.

In terms of the primary access service used before signing up for Cyber Spot, 32% of respondents cited dial-up, while DSL and cable-delivered broadband were the primary modes of access for 21.1% and 41.3%, respectively.

At the time of the survey, 55% of homes had registered to use the Cyber Spot service, a figure that had risen to more than 77% a year after launch.

A first step in estimating potential market share shifts based on the St. Cloud data is to estimate the percentage of homes that had already switched from DSL or cable modem service at the time of the survey. We estimate this by multiplying the 48.9% "Cyber Spot-only" number by the 55% Cyber Spot registration figure and the 21.1% "previously-DSL" and 41.3% "previously cable modem" percentages. This calculation leads to an estimate that, after a few months of service, 16.8% of St. Cloud's homes had chosen to drop DSL or cable modem service to use Cyber Spot as their only source of broadband access.

If, in addition to this, we apply the 68.3% "future switcher" figure to the 15.2% for whom Cyber Spot was the primary access mode (but not to the 35.9% for which it was their secondary access mode), the percentage of St. Cloud homes that would eventually switch from an incumbent broadband service to Cyber Spot is 20.3%.

If we assume that, over time, a community's total broadband penetration would reach 60% without Cyber Spot, this would translate into incumbents losing a third of their potential broadband customers to the free Cyber Spot service. If total penetration without Cyber Spot would have reached 80%, the share loss to Cyber Spot would be roughly 25%. And if total broadband penetration had reached only 40% without Cyber Spot, incumbents would have lost roughly half their potential market to Cyber Spot.

If we applied the survey results to the more recent 77% Cyber Spot registration population, the 20.3% figure would rise to 28.5% of total homes. This would equate to a market share loss for incumbents of 36%, 48% and 71%, assuming total broadband penetration would

have reached 80%, 60% and 40%, respectively, without the introduction of the free Cyber Spot service.

The survey also asked users how they felt about the city providing Cyper Spot as a free service. Nearly 94% were supportive or very supportive of the service, while more than 87% said they would encourage other communities to provide this type of service.

The St. Cloud survey also found that, when asked to rate Cyber Spot's reliability, 68% rated it as "good or better," versus a comparable rating for cellular service by only 51.8% of respondents. And, as we noted earlier, the St. Cloud network ranked first overall in a late-2006 test of network performance, service availability, ease of use and value. That test included both muni-wireless networks and cellular networks.

Using the St. Cloud results as a reference point, we assume that, in the "Weak PIIP, Strong Incumbent Response" scenario, 20% of high-speed Internet access customers (note that this is a percentage of broadband customers, not of total homes) would choose to rely on the free PIIP service rather than pay incumbents for access. Based on our analysis of the St. Cloud survey results, this would seem to be a very conservative number, since Cyber Spot appears to have attracted well more than 20% of St. Cloud's broadband market in just a few months.

We double this percentage share loss to 40% for the "Strong PIIP, Weak Incumbent Response" scenario. This also is arguably a conservative estimate given that, in this scenario, a white space-enabled PIIP could be expected to deliver a substantially stronger combination of coverage and throughput than the current St. Cloud network.

The percentages of fixed voice and mobile customers opting to replace their existing service with those available via the PIIP network are assumed to be 5% and 10%, respectively, in the "Weak PIIP, Strong Incumbent Response", increasing to 15% and 30% in the "Strong PIIP, Weak Incumbent Response" scenario.

We assume that bandwidth and performance constraints of "weak" PIIP networks make video services delivered on these networks unable to compete in any significant way with incumbents video services. As such, we assume no decline in the latter's share of video customers in this scenario.

In the "Strong PIIP, Weak Incumbent Response" scenario we assume the PIIP network provides enough bandwidth and reliability to deliver a range of web-based video services that, over time, can collectively offer enough value to induce 10% of incumbents' video customers to drop their existing service.

While it seems highly unlikely that a PIIP network could deliver (or even try to deliver) a set of video services directly comparable to that delivered by cable operators, our assumption is that, over time, a small but growing percentage of multichannel video subscribers—particularly younger viewers—will spend increasing portions of their TV viewing time on web-delivered content. At the same time, we assume that this type of content will continue to grow in number, variety and quality, thanks in large part to the

continued evolution of web-based video distribution platforms like AppleTV, AOL, Brightcove, MSN, Veoh, Yahoo, YouTube, etc., and increasing amounts of online content available from the major networks, studios and other content owners. We also assume that, while some PIIP-delivered video may be viewed in real-time streaming mode, much of it (particularly longer-form and higher-resolution content) will be viewed offline after being downloaded based on viewer requests in the form of RSS-like subscriptions or on an a la carte basis.

We also assume that the presence of free PIIP access and the services it delivers leads incumbents to cut their prices, which in turn reduces their ARPU. For the "Weak PIIP, Strong Incumbent Response" scenario we assume incumbent price cuts leading to a 15% reduction in their Internet access ARPU and 10% declines in their fixed voice and mobile ARPU, with no negative impacts on their video ARPU.

For the "Strong PIIP, Weak Incumbent Response" scenario, we assume these price and ARPU reductions are even steeper, due to the higher value delivered by a "strong" PIIP network. We double incumbents' ARPU reduction to 30% for Internet access and 20% for fixed voice and mobile service. We also assume that the increased performance of a "strong" PIIP network allows it to deliver video services that pressure incumbents to cut prices and reduce their video ARPU by 10%.

PIIP Impacts on Incumbent Service Provider Revenues

	Internet Access	Fixed Voice	Mobile Services	Video
"Free PIIP" Capture of Market Share (%)				
Weak PIIP, Strong Incumbent Response	20%	5%	10%	0%
Strong PIIP, Weak Incumbent Response	40%	15%	30%	10%
ARPU Reductions Driven by Free PIIP Availability (%)				
Weak PIIP, Strong Incumbent Response	15%	10%	10%	0%
Strong PIIP, Weak Incumbent Response	30%	20%	20%	10%
Reduction in Incumbent Revenue from Free PIIP Availability (%)				
Weak PIIP, Strong Incumbent Response	32%	15%	19%	0%
Strong PIIP, Weak Incumbent Response	58%	32%	44%	19%

We then carry these market share and ARPU assumptions through to calculations of incumbent revenue declines. In the "Weak PIIP, Strong Incumbent Response" scenario, these range from a 32% decline for Internet access to 19% for mobile services and 15% for fixed voice, with no impact on incumbents' video revenue.

These impacts become far more significant in the "Strong PIIP, Weak Incumbent Response" scenario, including the loss by incumbents' of well more than half (58%) the Internet access revenue they would have attracted in the absence of a free PIIP access service. Their revenue declines in mobile and fixed voice are also substantial, at 44% and 32%, respectively. And, in this scenario, even incumbents' video revenue experiences a double-digit hit, losing 19% due to share and ARPU impacts of PIIP-delivered video services.

While the assumptions in these scenarios are admittedly speculative, they do point to some important implications for incumbents. The most obvious is that incumbent's existing revenue base and business models could be significantly at risk if the addition of white space spectrum helps the free PIIP model achieve new levels of functionality and economic feasibility that triggers a snowballing of adoption rates in communities around the country.

To get a sense of how different PIIP adoption rates might impact incumbent revenues, we've extended our model to consider the extent of these impacts under a range of assumptions regarding the percentage of U.S. households covered by PIIP networks.

PIIP Availability and Nationwide Loss of Incumbent Revenues

Nationwide Coverage of PIIP Networks	10%	25%	50%	75%	100%
	Incumbent Loss of Revenue (%)				
Internet Access					
Weak PIIP, Strong Incumbent Response	3%	8%	16%	24%	32%
Strong PIIP, Weak Incumbent Response	6%	15%	29%	44%	58%
Fixed Voice					
Weak PIIP, Strong Incumbent Response	1%	4%	7%	11%	15%
Strong PIIP, Weak Incumbent Response	3%	8%	16%	24%	32%
Mobile Services					
Weak PIIP, Strong Incumbent Response	2%	5%	10%	14%	19%
Strong PIIP, Weak Incumbent Response	4%	11%	22%	33%	44%
Video					
Weak PIIP, Strong Incumbent Response	0%	0%	0%	0%	0%
Strong PIIP, Weak Incumbent Response	2%	5%	10%	14%	19%

The table above considers future scenarios in which PIIP networks are available to 10%, 25%, 50%, 75% and 100% of the nation's households. For each of these it lists our model's projected incumbent revenue loss for both the "Weak PIIP, Strong Incumbent Response" and "Strong PIIP, Weak Incumbent Response" scenarios.

As the table shows, in the "Strong PIIP" scenario, our model shows incumbent losses of Internet access revenues reaching double-digit levels (15%) by the 25% PIIP coverage mark (actually this first occurs at less than 18% PIIP coverage). Incumbents' loss of mobile service revenues has reached double digit levels (11%) by this point as well.

At 50% PIIP coverage in the "Strong PIIP" scenario, incumbents have lost 29% of Inernet access revenue, 16% of fixed voice revenue, 22% of mobile revenue and 10% of video revenue.

These figures are substantially lower in the "Weak PIIP, Strong Incumbent Response" scenario, with 50% PIIP coverage yielding a 16% loss in incumbent Internet access revenue, 7% and 10% declines, respectively, in fixed voice and mobile revenues, and no negative impact on incumbents' video revenue.

We would assume that incumbent revenues would also suffer less in the "Strong PIIP, Strong Incumbent Response" scenario than in the "Strong PIIP, Weak Incumbent Response" scenario. This is because incumbents in this "Strong-Strong" scenario will have responded by investing in new and valuable services that the PIIP network could not match. The extent to which they would be able to maintain or even increase their revenues and cash flows would be determined in large part by the quality of their investment decisions, execution and fundamental strategies and business models.

Incumbents as allies?

Given the potentially severe impact on their revenues, incumbents may individually or collectively seek to preempt the proliferation of "strong" PIIP networks by blocking or hobbling PIIP deployments through legal and regulatory challenges and anti-PIIP PR campaigns. To the extent such efforts are attempted and succeed, one unfortunate result would be that they would probably also block some of the positive externalities and economic growth that could be facilitated by a thriving PIIP sector.

Though we do not attempt to model revenue impacts of a "Strong PIIP, Cooperative Incumbent Response" scenario, this scenario seems more desirable than a "PIIP blocking" scenario from the broader perspective of social value. And, if approached creatively and with good will, it could end up benefiting incumbents and PIIP network operators, as well as our nation's citizens, businesses and public institutions.

There are already signs that some local communities are beginning to think along these lines. Most notable among these are the recent deals struck by AT&T to deploy muni-wireless networks in Riverside and Napa, California; Springfield, Illinois; and St. Louis, Missouri.

Available information suggests these communities have ceded significant control to AT&T in exchange for avoiding the expense and risk associated with owning the network. At the same time, AT&T has agreed to provide some level of free access and to sell wholesale services to other ISPs. It is also providing a range of services to city agencies, typically for a fee. In at least one city, AT&T intends to provide its DSL customers with discounts for service offered on the Wi-Fi network, a move which could help its competitive position vis-à-vis its cable competitor.

The extent to which the benefits of the PIIP model and the goals of incumbents like AT&T can be reconciled remains to be seen. Since incumbents will presumably want to protect, expand and otherwise benefit their existing services, revenue streams and margins, a key question is the extent to which these motivations would conflict with the goals of maximizing a PIIP network's coverage, throughput and take rates, and insuring the

network's neutrality and openness with regard to applications, services and end-user devices.

The evolution of AT&T's current muni-wireless projects will be an important indicator as to how this reconciliation might be achieved, and of potential roadblocks it might confront.

The range of models being pursued and considered today in the muni-wireless sector underscores the tradeoffs and uncertainties cities face when deciding how to proceed with relatively capital intensive network deployments. While there are some clear differences among these models, to some extent the devil will be in the details of the contracts they negotiate with private service providers, particularly incumbent network operators already providing service in their community.

A key focus of this report has been to underscore the value of the Internet's end-to-end content-neutral model and the potential of white space spectrum to enable that model to retain the strength and flexibility it has thus far shown, regardless of how incumbent service providers proceed in developing their own business models. While city governments often face challenging financial constraints, we would encourage them to move cautiously in negotiating muni-wireless deals with incumbents, even if the short-term financials seem very appealing.

For incumbents to embrace the PIIP model on a large scale may require a shift in their thinking about their role in the communications sector and the structure of their business models. The likelihood and extent of this shift in strategic thinking would, in turn, be influenced by how the investment community viewed incumbents' options and prospects.

Among the factors likely to influence these incumbent and investor attitudes are:

1) the evolution of market dynamics in the wireline, wireless and bundled service space, including competitive and financial impacts of investments in next-generation networks as well as incumbent and investor expectations regarding these impacts;

2) legislative and regulatory developments at the federal and state level;

3) the evolution of web-based services and service providers, and their interactions with and impacts on services provided by network operators;

4) developments in the muni-wireless sector, including the handful of projects involving incumbents, as well as those involving non-incumbent service providers like Earthlink, and those more akin to the "free access" St. Cloud and PIIP models discussed above;

5) the extent to which white space spectrum becomes available and the impacts this availability has on overall industry dynamics and, in particular, on developments in the muni-wireless sector.

Regardless of how incumbents view PIIP networks, the pending white space proceeding provides the FCC with a unique and potentially irreplaceable opportunity to reaffirm that the electromagnetic spectrum is a public asset whose primary purpose is to serve the public interest.

While the transition from the era launched by the 1934 Communications Act will continue in the years ahead, the white space proceeding, taking place as it does amidst a heated battle over the Internet's future, marks an important crossroads on that journey.

As this report has explained, a public policy that encourages local communities to deploy PIIP networks can help resolve both the longstanding conflict over spectrum policy and the more recent conflicts over Internet policy. And it can do so without imposing requirements on incumbent service providers who are likely to resist them at every step of the way. We have walked that regulatory road before, and while it may be necessary in some cases, it tends to be an indirect and friction-filled route to the public interest.

By embracing the Internet-friendly "Spectrum Policy 2.0" described in this report, Congress and the FCC can set our nation's communications sector on a more direct course to the public interest. And, in doing so, they can also provide a much needed boost to the health and vitality of the American economy and political system, and of the local communities that are their foundation.

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