

Broadcast to Broadband

Unlicensed Access to Unused TV Channels?

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Although much public attention has focused on the US digital TV transition — and the resulting reallocation of analog TV channels by auction to wireless carriers — the US Federal Communications Commission will decide how to reallocate an even larger swath of prime TV band spectrum this year: the unused “white space” between occupied DTV channels. This reallocation of unused spectrum from broadcasting to broadband permits unlicensed access for both fixed and mobile applications. Although this policy is strongly supported by high-tech companies and consumer advocates, it’s just as strongly opposed by broadcast licensees and other incumbent users of the TV band.

When analog over-the-air TV signs off forever on 17 February 2009 — the US Congress-mandated digital TV (DTV) transition deadline — a uniquely valuable slice of the public airwaves will be reallocated to broadband and other wireless services. Recent focus has been on the US Federal Communications Commission’s (FCC’s) auction of the spectrum corresponding to UHF channels 52 through 69, which will be cleared of broadcasting nationwide. This auction began on 24 January 2008 and is expected to net the government upward of US\$10 billion in revenue paid for exclusive licenses to 62 MHz of “beachfront” spectrum. (See last issue’s installment of Public Policy, “The Spectrum Auction: Big Money and Lots of Unanswered Questions,” *IEEE Internet Computing*, vol. 12, no. 1, 2008, pp. 66–70.)

But a second and larger swath of TV channels could soon carry broadband rather than broadcast signals. This year’s most contentious spectrum policy debate focuses on whether the vacant channels between occupied DTV channels in each local market should be opened up for shared unlicensed use by smart-radio devices capable of avoiding interference with DTV reception. The increasingly fierce debate about the FCC’s proposal to free up this so-called “white space” spectrum for unlicensed access by

mobile devices pits the broadcast industry and its allies against a coalition of large technology companies (including Microsoft, Google, and Dell) and consumer advocacy groups. Meanwhile, although the FCC has led the world in promoting Wi-Fi and other unlicensed technologies, its UK counterpart, Ofcom, adopted a nearly identical proposal in December 2007 that achieves a digital dividend by opening up what it calls the “interleaved” (unused) channels on its 256-MHz DTV band for unlicensed use (www.ofcom.org.uk/consult/condocs/ddr/statement/statement.pdf).

This installment of Public Policy offers an overview of the pending FCC rulemaking and the claims of leading opponents and proponents about the proposed reallocation of unused TV band frequencies for unlicensed use.

Filling in the White Space

For nearly a decade, the FCC has implemented a slow-motion transition from its traditional “command and control” spectrum assignment to a mix of flexibly licensed and unlicensed allocations. Both licensed cellular carriers and unlicensed Wi-Fi networks have proven successful in innovatively using spectrum below 3 GHz, which includes the frequencies that propagate over longer distances and through obsta-

Table 1. Average white space as a share of the TV band in a sample of US media markets after the transition to digital TV.

Market	Average MHz available	TV spectrum vacant (%)
New York	52	18
Los Angeles-San Diego	58	20
Philadelphia	61	21
Chicago	74	25
Washington, DC-Baltimore	80	27
Boston-Providence	89	30
Knoxville	93	32
San Antonio	107	36
Portland	112	38
Phoenix	114	39
Birmingham	118	40
Atlanta	120	41
Cincinnati-Dayton	123	42
St. Louis	132	45
Milwaukee	135	46
El Paso-Albuquerque	140	48
Jacksonville	145	49
Des Moines-Quad Cities	148	50
Little Rock	152	52
Alaska	159	54
Spokane-Billings	162	55
Omaha	165	56
Wichita	176	60

cles more readily than is possible at higher frequencies.

In 2002, the FCC's Spectrum Policy Task Force recommended that spectrum efficiency and innovation could be enhanced by reallocating unused and underutilized spectrum for both flexible-use licenses (by auction) and opportunistic use by smart-radio devices capable of sharing bands on an unlicensed basis (http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-228542A1.pdf). In testimony at a public hearing, I proposed that the convergence of the DTV transition and emerging smart-radio technologies offered an opportunity to make good use of the guard band channels reserved a half-century ago to prevent interference among high-power analog TV stations. Moreover, most

local stations currently broadcast over two channels (one analog, one digital), so an even larger share of the TV band will lie fallow at the end of the DTV transition.

The vacant frequencies between occupied (licensed) TV channels have come to be known as white space – for example, the local CBS affiliate uses channel 9 in Washington, DC, so this channel isn't licensed for use in surrounding markets (such as Baltimore or Charleston), nor are adjacent channels 8 or 10 used in Washington. In fact, after completion of the DTV transition early next year, the white space spectrum in most of the nation's 210 local TV markets will exceed the amount of occupied spectrum. As Table 1 indicates, the expected vacancy rate across the 49

channels currently set aside exclusively for DTV (channels 2 through 51, except 37, which is reserved for radio astronomy and medical use) ranges from 20 to 30 percent in congested coastal markets such as Trenton, New Jersey, to 70 percent or more in small city and rural markets such as Columbia, South Carolina.¹ As Ofcom stated in its December policy statement, "Such spectrum availability would be particularly beneficial for high bandwidth services . . . such as home and business networks, community and campus networks, and municipal Wi-Fi."²

Shortly after the Spectrum Policy Task Force released its report in late 2002, the FCC surprised almost everyone by issuing a Notice of Inquiry asking for comment on the feasibility of reallocating the TV white space for advanced wireless services. In May 2004, under then-chairman Michael Powell, the FCC issued a Notice of Proposed Rule Making (NPRM), tentatively concluding that opening at least some of the vacant channels for unlicensed access would be feasible and beneficial. The FCC stated in the NPRM that opening unused TV spectrum for new unlicensed services would further its statutory mandate to promote more "efficient and intensive use of the radio spectrum." This seems particularly compelling in the TV band, where even the occupied channels are viewed by a steadily declining number of American households over the air (see Figure 1).

Although the FCC and Congress have generally preferred to reallocate spectrum by auctioning exclusive licenses, any use of vacant TV frequencies faces constraints that make it a poor fit with the business models of licensed wireless carriers. The TV white space is sometimes called "Swiss cheese spectrum" because a channel might be vacant locally but not regionally or nationally. Moreover, to avoid both co-channel

(same frequency) and adjacent-channel interference with local TV stations, white space devices must operate at very low power (the high-tech company coalition has proposed a power limit of 100 milliwatts for portable devices, well below the current 1 Watt limit for unlicensed devices operating in the 2.4-GHz band). In contrast, TV white space would meet the needs of broadband providers and consumers who currently rely on unlicensed spectrum. Today, only a tiny allocation of spectrum is accessible on an unlicensed basis in the “prime” frequencies below 1 GHz. Allocating a portion of the TV band for unlicensed use would make more prime spectrum freely accessible, boosting the ability of both wireless ISPs and device makers to deploy more cost-effective broadband solutions, particularly in rural areas where wired connections are unavailable or unaffordable.

Static and Stasis

Although making unused spectrum available for broadband and wireless innovation might appear straightforward, the reallocation of TV white space has turned into one of the most contentious proceedings this decade. The opposition is primarily led by the band’s incumbent licensees – the US National Association of Broadcasters (NAB) and wireless microphone makers and users (such as the sports leagues and entertainment venues that intermittently use white spaces). The NAB refers to white spaces as “interference zones,” and broadcasters agree because they feel mobile broadband devices, even operating at low power, would inevitably interfere with DTV reception and microphone systems. The NAB and its engineering affiliate, the Association for Maximum Service Television (MSTV), have filed studies showing that Wi-Fi-type devices could cause both co-channel interference (if they can’t reliably detect a DTV

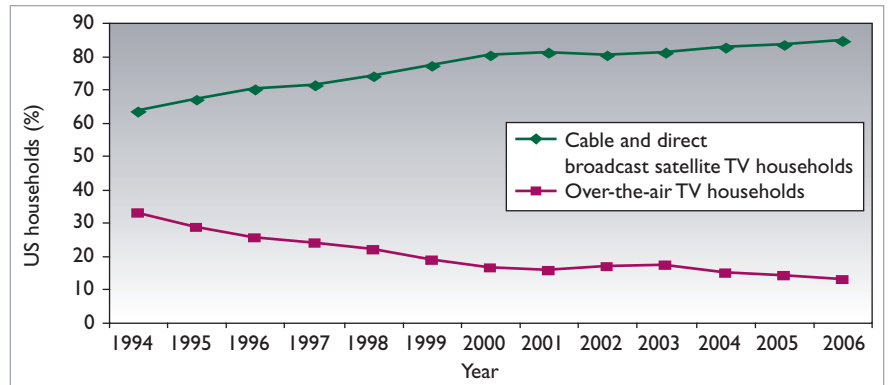


Figure 1. TV decline. The US Federal Communications Commission’s data shows the share of US households relying primarily on over-the-air reception has fallen steadily, to below 15 percent by 2006.

transmission in a given location) and adjacent-channel interference (the unlicensed device’s transmission could leak and disrupt DTV reception). On their Web site (www.interferencezones.com), the NAB and MSTV assert that “when unlicensed mobile devices operate in these zones [white spaces], they can cause interference to televisions in the area,” adding, “because the devices are not licensed, they are impossible to track down, so the interference cannot be stopped.”

The NAB believes that use of vacant TV channels should be limited to fixed-location devices operated by holders of exclusive frequency licenses. Prohibiting mobile devices and requiring these licenses, it argues, will reduce the risk of interference, increase efficiency, and – if interference occurs – allow local stations to identify the source and hold the licensee accountable. In addition, the NAB has urged the FCC to prohibit the use of channels immediately adjacent to those in use by a DTV station as well as channels used in a neighboring television market, restrictions that together would result in extremely little white space being available for new uses except in some rural areas.

The cable TV industry – led by the National Cable Television Association (NCTA) – also opposes use of vacant channels, particularly the lower channels (2 through 14), as-

serting that broadband devices used near a cable set-top box could penetrate the insulation and interfere with the digital display.

In contrast, high-tech firms and consumer groups have argued that a variety of proven technologies are capable of avoiding interference with DTV reception. Intel, Dell, Microsoft, Google, and other members of the high-tech White Spaces Coalition argue in their filings that because proven technologies exist for detecting and avoiding DTV signals, barring mobile devices represents an enormous loss for consumers and potential broadband innovation. These firms recently joined a far broader Wireless Innovation Alliance that includes national consumer, civil rights, digital divide, and education technology groups (www.wirelessinnovationalliance.net).

For its part, the FCC has consistently assumed that several technologies are capable of ensuring that white-space devices can identify vacant channels in a local market and operate without interfering with DTV reception on neighboring channels (or in neighboring media markets). In its 2004 NPRM, the FCC’s Office of Engineering and Technology (OET) described three different approaches that white space devices could use to avoid such interference (http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-04-113A1.pdf):

- *Geolocation/database.* In this scheme, the unlicensed device (such as a wireless ISP access point) would use a GPS receiver to cross-check its own location against an online database of licensed TV transmitter locations. This is the approach anticipated by the evolving IEEE 802.22 working group, which is developing a standard for fixed-location broadband networks using TV white spaces.
- *Beacon permission.* An alternative approach, aimed at allowing networks of mobile devices, would require that an unlicensed device not transmit unless it receives a “green light” signal indicating that the specific channel is free to use in that locality. The beacon could originate from the base stations of network operators or be transmitted generically by local broadcasters.
- *“Listen-before-talk” sensing.* Another approach strongly favored by the high-tech company coalition would require that each individual device scan and identify unused TV channels before transmitting (with the accuracy enhanced by sharing sensing data with other devices in range). This allows peer-to-peer and home/business networking without the extra cost of a network operator or GPS/database solution.

After Powell resigned as chairman in 2005, the debate shifted to Congress. In June 2006, the Senate Commerce Committee unanimously reported a provision – introduced initially by committee chairman Ted Stevens and four other senators from both parties – that would have required the FCC to complete the proceeding within six months and maximize the use of TV white space for unlicensed devices subject only to rules aimed at avoiding harmful interference with incumbent services. Although the legislation never

passed, it prodded the FCC’s current chairman, Kevin Martin, to reactivate the discussion.

In October 2006, the FCC reopened the proceeding by adopting an NPRM that reiterated the proposal for at least some substantial number of vacant channels being reallocated for use by fixed and portable broadband devices, presumably on an unlicensed basis. However, the new order drew a sharp distinction between fixed and portable devices. The FCC stated that while fixed-location devices definitely would be allowed on the band (presumably on a registered basis and using the geolocation/database method to avoid interference), the order sought further comment and evidence concerning the technologies and operating parameters that would let portable devices avoid harmful interference with DTV reception. OET would conduct its own feasibility testing, and outside parties were invited to submit prototype devices. Although the chairman initially proposed a one-year schedule for completing the proceeding (by October 2007), a final order is now expected no earlier than April or May of this year.

Spectrum Sensing

Because three of the FCC’s five commissioners have repeatedly stated their support for unlicensed mobile devices, the debate over the past year has shifted almost entirely to whether particular interference-avoiding technologies provide a reliable means of avoiding harmful interference from portable devices. The Wireless Innovation Alliance (WIA; www.wirelessinnovationalliance.net) insists that spectrum sensing, which relies on a detect-and-avoid capability built into each individual device, is the most proven and cost-effective method for portable devices. WIA members argue that if mobile devices must receive permission to transmit from GPS-enabled access points, an option that Motorola proposes, it

will increase costs and require the creation, maintenance, and constant updating of an online database of licensed transmitter sites. Perhaps more critically, they argue, requiring a GPS approach could prohibit or deter peer-to-peer device communication, do-it-yourself home and office networking, and an unknown variety of new applications that would be uneconomical if they had to rely on being “controlled” by a fixed-location network operator.

Advocates of opening white spaces to portable devices also point to the Pentagon’s embrace of dynamic spectrum-sharing technologies that rely on sensing. In early 2006, the Bush administration announced that the Pentagon was satisfied that 255 MHz in the upper 5 GHz band assigned exclusively for use by military radar could be opened for shared use on an unlicensed basis by cognitive Wi-Fi devices that rely on “dynamic frequency selection” (that is, on spectrum sensing and frequency hopping; <http://rcrnews.com/apps/pbcs.dll/article?AID=/20060209/SUB/602090709>).

As part of its push to exploit America’s IT edge on the battlefield, the military in recent years has invested in developing and testing other dynamic spectrum technologies as well. Darpa’s Next Generation (XG) program has already successfully tested cognitive radio technologies that could let the military rapidly establish an ad hoc mesh wireless network anywhere in the world that avoids disturbing civilian communication by sensing and selecting unused or lightly used frequencies (www.darpa.mil/sto/smallunitops/xg.html). Indeed, the electronic warfare engineer who initially directed the XG program, Paul Kolodzy, also directed the FCC’s Spectrum Policy Task Force and first counseled Powell that the dynamic sharing of spectrum white space was technically feasible.

Key Federal Communication Commission Filings

The broadcast industry's response to these technical precedents has been that sensing DTV signals – particularly at the edge of a license area where the signal is weakest – presents a unique challenge. Several high-tech companies have responded by submitting prototype devices for testing. The first two, submitted by Microsoft and Philips Electronics of North America, led to mixed results that have further delayed a decision. OET reported that although the Philips device sensed both analog and digital TV signals consistently at its designed detection threshold, the Microsoft device performed erratically. Although Microsoft concluded that the device was broken and later submitted a replacement, the NAB and its allies trumpeted the flawed prototype as proof that dynamic sensing technology for mobile devices simply couldn't be trusted.

Although chairman Martin promised to complete the proceeding by the end of 2007, he decided to invite additional prototypes and ordered OET to resume testing in early 2008. As this article goes to press, the FCC is about to begin a second round of tests on at least four devices. Motorola submitted a system based on the GPS/database approach that assumes mobile devices won't operate without permission from a fixed-location base station. Microsoft and Philips have resubmitted upgraded versions of their portable sensing device. Google and Adaptrum, a Silicon Valley startup, separately demonstrated what Google is calling "broadband spectrum sensing technologies" that both companies claim are considerably more sensitive and accurate than the Microsoft/Philips method for detecting DTV and wireless microphone transmissions. Google also demonstrated a "short-burst transmission" technology it said could substantially reduce the risk of interference to DTV and wireless microphone signals on adjacent channels.

It remains to be seen whether the

- "Comments of the National Cable & Telecommunications Association," ET Docket No. 04-186, 31 Jan. 2007; http://fjallfoss.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6518724318.
- "Comments of Shure Incorporated," ET Docket No. 04-186, 31 Jan. 2007; http://fjallfoss.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6518724353.
- "Joint Comments of the Association for Maximum Service Television and the National Association of Broadcasters," ET Docket No. 04-186, 31 Jan. 2007; www.nab.org/AM/Template.cfm?Section=Filings2&TEMPLATE=/CM/ContentDisplay.cfm&CONTENTID=8114.
- "Joint Comments of New America Foundation, Consumers Union,

- EDUCAUSE, Free Press, Leadership Conference on Civil Rights, Wireless Internet Service Providers Assn (WISPA), et al.," ET Docket No. 04-186, 31 Jan. 2007; www.newamerica.net/files/04-186EconLegalComments_Feld_FINAL.pdf.
- "Joint Comments of Dell, Google, Hewlett-Packard, Intel, Microsoft and Philips Electronics," ET Docket No. 04-186, 31 Jan. 2007; www.wirelessinnovationalliance.net/files/Comments.pdf.
- "Notice of Ex Parte Meetings of MLB, NBA, NCAA, NFL, NHL, The PGA TOUR, and ESPN as members of the Sports Technology Alliance," ET Docket No. 04-186, 27 June 2007; http://fjallfoss.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6519536217.

FCC's engineers will be satisfied that these prototypes conclusively demonstrate the feasibility of reliable sensing in consumer-grade mobile devices. Even if OET reports positively on sensing, tricky issues remain with respect to allowable power levels, the use of channels immediately adjacent to licensed frequencies, and a range of other technical rules that will set the bar for testing and certifying future devices.

Yet, despite the intense lobbying on both sides of Congress – and the scores of letters from members of Congress to the FCC seeking to pressure it to come down on one side or the other – there are refreshing signs that the FCC is determined to let engineering rather than politicking determine the final outcome. In a speech last September, commissioner Robert McDowell expressed optimism that a technical solution to the white-space debate will be found: "I am hopeful that a flexible, de-regulatory, unlicensed approach will provide opportunities for American entrepreneurs to construct new delivery platforms

that will provide an open home for a broad array of consumer equipment. ... We should let science, and science alone, drive our decisions. If we don't pollute science with politics, powerful new technologies will emerge, and American consumers will benefit as a result." □

References

1. "Comments of Charles L. Jackson and Dorothy Robyn," The Brattle Group, ET Docket No. 04-186, 31 Jan. 2007; http://fjallfoss.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6518724352.
2. "Digital Dividend Review: A Statement on Our Approach to Awarding the Digital Dividend," Ofcom, 13 Dec. 2007, pp. 44–45.

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