Cory Doctorow
Electronic Frontier Foundation
454 Shotwell Street
San Francisco, CA 94110

May 3, 2004

Marlene H. Dortch, Secretary
Federal Communications Commission
445 12th Street, S.W.
Washington, D.C. 20554

RE: Facilitating opportunities for Flexible, Efficient, and Reliable Spectrum Use Employing Cognitive Radio Technologies

ET Docket Number 03-108

Dear Ms. Dortch,

Attached for filing, please find Comments of the Electronic Frontier Foundation.

Please do not hesitate to contact me should you have any questions or concerns regarding the filing, at the below stated number.

Thank you for your courtesy and assistance.

Very truly yours,

Cory Doctorow
European Affairs Coordinator
Electronic Frontier Foundation
+44.798.607.2869

Enclosure

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of: Facilitating opportunities for Flexible, Efficient, and Reliable Spectrum Use Employing Cognitive Radio Technologies	:	ET Docket No. 03108
Authorization and Use of Software Defined Radios (Terminated)	:	ET Docket No. 00-47
COMMENTS OF: Electronic Frontier Foundation	:	
May 3, 2004	:	

TO: The Commission

1. About EFF
A nonprofit, technology-oriented civil liberties organization

EFF[1] is a member-supported nonprofit organization devoted to upholding civil liberties in technology policy, law and standards. With over 12,000 dues-paying members and more than 20 staffers, EFF is one of the oldest and best-established advocates for traditional civil liberties in nontraditional, technological realms.

EFF has recently been pleased to comment upon several matters before the Commission, including the Broadcast Flag[2], Plug and Play[3], the Spectrum Policy Task Force report[4] and clearing unused UHF broadcast television spectrum for unlicensed use[5].

EFF is once again pleased to have the opportunity to present the Commission with its views concerning many of the questions raised regarding Cognitive Radio devices in this NPRM.

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1 For more information, see EFF's home page at http://www.eff.org/.

2 MB Docket 02-230, see http://www.eff.org/IP/Video/HDTV/EFF_02-135.pdf.

3 PP Docket 00-67, see http://www.eff.org/IP/Video/HDTV/20030328_fcc_cable-ce_comments.pdf.

4 ET Docket 02-135, see http://www.eff.org/IP/Video/HDTV/EFF_02-135.pdf.

5 WT Docket 03-66.

2. Introduction

Regulation should not abridge speech

EFF strongly supports removing regulatory barriers to spectrum use as a means for facilitating speech amongst the greatest number of users (speakers). Today, the speech rights of those who would use spectrum to express themselves are abridged by a regulatory policy that creates artificial scarcity in the name of preserving access.

Spectrum questions need a factual basis

EFF calls upon the Commission to inform its spectrum policy with empirical information about the actual use of spectrum in America. As was illustrated in the television underlay docket[6] and in the New America Foundation's exemplary spectral analysis of Washington, DC The Commission carefully records its own allocations to licensees but rarely follows up by considering to what use they have put those allocations. This exacerbates the scarcity in spectrum, walling Americans off from their speech rights in the name of preventing congestion where none, in fact, obtains.

Open spectrum initiatives are laudable

This Commission's inquiries into new paradigms for spectrum regulation are worthy of commendation. The future of radio is in cooperative, frequency-agile devices, based on commodity PC components and rapidly evolving software.

Regulating components is a bad idea

However, EFF is alarmed at the Commission's suggestion that the flexibility of new radio technology is grounds for regulating access to simple commodity components, such as ubiquitous Digital-to-Analog converters; and by the notion that "Trusted Computing" presents a solution to any of the Commission's enforcement problems. Denying Americans access to basic electronic components and stripping them of their ability to examine and improve upon their own property is no answer to any of the questions facing the Commission.

New technologies demand new enforcement regimes

It's clear that agile radios present unique enforcement challenges, challenges which must be met to ensure both the orderly use of the public's airwaves and the ability of emergency or public safety services to use those airwaves. Regulating access to components and mandating Trusted Computing has no nexus with effective enforcement -- such a regime could never effectively prevent malefactors from gaining access to the tools necessary to make mischief. Further, bans on the publication of software code are

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[6] Ibid

an unacceptable abridgement of the First Amendment rights of software programmers. Finally, such regulations can only act as a damper on legitimate experimentation and improvement, which impairs the ability of new technologies that further reduce spectrum scarcity to emerge.

The Commission should issue a separate notice of inquiry concerning the future of the enforcement of the Commission's rules in light of the increasing flexibility and diminishing cost of general-purpose devices that may function as emitters. Such an inquiry should include an examination of what capabilities are likely to become newly available to the general public, on what time scale, and how the Commission might respond. It should also include an examination of what new enforcement technologies and measures may help the Commission detect harmful emissions and identify who is responsible for them. Finally, it should consider in what ways critical communications services can evolve to improve their robustness against deliberate and accidental interference.

3. Regulation Should Not Abridge Speech

Spectrum and the First Amendment

The public's electromagnetic spectrum is a medium over which many ideas can be expressed, by many parties. It is a critical vehicle for conveying speech of all kinds. And while the First Amendment demands that regulatory bodies eschew limits on the public's speech, the FCC has traditionally regulated spectrum on the grounds that the inherent scarcity of the spectrum demanded that it be managed, lest congestion make *any* communication possible.[7]

Congestion is overstated

Today, there is twofold evidence that this risk of congestion may have been overstated or may no longer be as great as it once was:

1. Frequency-agile, cooperative radios are capable of increasing the capacity of spectrum by intelligently reducing power, by sensing and selecting unused spectrum, and by forming cooperative relay networks.[8]

2. Existing licensees are allocated a 24/7/365 monopoly over their spectrum, but in many instances, licensees' use of spectrum is time-bounded and space-bounded

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[7] For an extended discussion of the First Amendment issues relating to unused or underused spectrum, see Stuart Minor Benjamin, The Logic of Scarcity: Idle Spectrum as a First Amendment Violation, 52 Duke L. J. 1 (2002) at 19-20 which asserts that 2500-2690 MHz band is a "notable example" of underused spectrum.

8 See, for example, "Communications Futures," Clark, Fine, Lippman and Reed, at http://cfp.mit.edu/papers/summary.pdf

> within a smaller radius than the allocation permits -- to the point where a given licensee's use of its spectrum may not be detectable.[9]

With proceedings like the Spectrum Policy Task Force report[10], the Commission has led the world in investigating the possibility of cooperation as a means for reducing spectral scarcity, but the matter of idle existing allocations has yet to be investigated in any serious way.

4. Create a factual basis for examining how scarce spectrum really is

Spectrum allocated isn't spectrum used

As the New America Foundation amply demonstrated[11], it is dangerous to assume that spectrum *allocated* is spectrum *in use*. As the Commission investigates alternatives to its traditional command-and-control regime, it should simultaneously investigate which licensees are making best use of the spectrum they have been allocated in the public interest. It may turn out that existing licensees' exclusive rights inefficiently lead much spectrum to lie idle much of the time, a conclusion suggested, for example, by the New America Foundation's research.

A simple -- though not exhaustive -- proxy for evaluating the stewardship of spectrum is to calculate the detectable activity levels across space and time (i.e., where and when which spectrum is in use). While this metric has its limitations -- emissions do not necessarily equate to communications -- it can, at least, yield a picture of what proportion of the spectrum now sits idle and might fruitfully be repurposed.

Traditional spectral analyzers are expensive and difficult to operate: deploying these devices across the nation would cost too much to be practical. However, the selfsame technologies that enable the sunset of command-and-control could likewise enable average Americans to measure spectral activity.

SDRs and commodity hardware are the answer

The GNU Radio project[12] is a software-defined radio, implemented in "free software"[13], running on commodity PC hardware, with the addition of a few general purpose

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9 Ibid

10 00-67

11 Ibid

12 http://www.gnu.org/software/gnuradio/

13 "Free software" is a catch-all term for software that may be freely studied and modified by its users; such software underpins the GNU-Linux operating system as well as major pieces of the Internet's infrastructure, see http://www.fsf.org/philosophy/free-sw.html for more.

components for I/O and tuning. Already, GNU Radio implementations on today's high-end PCs[14] are capable of mastering such difficult tasks as demodulating an ATSC signal[15].

Relative to this task, detecting and measuring activity in the electromagnetic spectrum is trivial. Spectral analyzers built on GNU Radio can be run on the cheapest PCs in the field; moreover, these PCs would be ready to connect to the Internet and report on their findings. Through techniques such as these, in the future the Commission could cheaply and effectively review the national spectral "climate" in real time.

5. Don't regulate SDRs

The future of radio is the PC

Frequency-agile, low-cost, low-power software-defined radios are the core of the Cognitive Radio future. The potential reductions in scarcity are important benefits recognized by, among others, the Commission's own Spectrum Policy Task Force.

For these devices to flourish, they must be cheap, they must be powerful, and they must be robust. The fastest and most effective way to achieve these goals is by building our new radios out of the same basic components as commodity PCs: for nothing gets cheaper, faster than commodity PCs.

More to the point, things built out of PCs get improved upon by people who tinker with PCs. The past 30 years have been a period of unparalleled technological innovation, much of it on American soil, most of it revolving around the ability of average individuals to "hack" the equipment they lawfully acquire, understanding it and improving upon it.

The key to the PC's success was its accessibility to anyone who chose to play with it. No PC entrepreneur needed a license to acquire "professional" computing tools, nor the permission of a regulator to try new approaches to computing tasks.

Thus, PC innovation has far outstripped radio innovation. PCs got better (and more flexible and more capable and more cost-effective) a lot cheaper than radios did. The lack of regulation was key. Even though radios have seen a lot of innovation, the extensive regulations imposed by the Commission – frequently for essential policy purposes – have limited the rate of this innovation.

All PCs are potential radios

But even if we set aside the contribution that PCs can make to radios, we should consider the ways in which radio-regulation can impact PCs. A software-defined radio is a PC, an

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14 i.e., Tomorrow's landfill.

15 See http://www.gnu.org/software/gnuradio/images/hdtv-samples.html

antenna, a digital-to-analog (DAC) converter and an analog-to-digital converter (ADC). Every PC in the field today is stuffed full of DACs and ADCs, in the form of sound- and video-cards (and in the case of ADCs, in the light-sensors of high-end laptops' keyboard illumination systems, in battery-management systems, in temperature sensors, and so forth).

A PC, some software and an antenna combine to make a radio. If we are to enjoy a world in which the radio-spectrum is protected, it cannot come at the expense of Americans' access to commodity PCs: the public would not accept such a trade, nor should they.

But in order to keep Americans from converting their PCs to radios, that's precisely the kind of regulation the Commission would need to countenance: regulation over access to commodity PC hardware, regulation and licensing of operating systems, applications and drivers.

Regulating DACs is no better

If PCs shouldn't be regulated, then how should the Commission ensure that the airwaves aren't overrun by bad actors spewing noise or even intentional interference through PC-based emitters?

The current Notice asks if the proper regulation should be over DACs, for without these, a PC is mute -- they're the voicebox through which bits are converted to analog radio-waves.[16]

Such a regulation could be tailored to just DACs embedded in boards intended for use as SDRs, but this would not be effective. A VGA video-card contains DACs that can be readily repurposed to turn a PC into a tuneable emitter.

But regulation of DACs is problematic. The world is filled with DACs: There are far more DACs in the field than human beings. These are so widespread that it is a certainty that deliberate malefactors will not have any trouble acquiring a DAC regardless of the regulatory landscape.

- DACs are easy to make: undergraduates in Electrical Engineering programs are frequently assigned the task of making a fast DAC out of a few resistors. A 1 GHz DAC can be built for a few dollars from parts. Even if the installed base of DACs were somehow brought under regulation, the ability of a moderately skilled bad guy to make her own DACs can't be likewise checked.

- DACs are everywhere, and a regulation over DACs will limit academic freedom, scientific inquiry, and turn the Commission into the de-facto designer of many non-radio devices.

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16 Thankfully, no one is proposing that the Commission seek charge over the nation's scrap-metal supply through a mandate to police the creation and acquisition of antenna!

6. Trusted Computing: more problem than solution

What Trusted Computing is(n't)

"Trusted Computing" describes a variety of computing techniques that, among other things, allow remote parties to assure themselves that a computer's owner cannot override the remote party's wishes.[17] That is, if I run your software on my "trusted computer," you may be relatively[18] assured that I cannot peer into its workings or act on its data.

EFF has been privileged to meet at length with representatives from all major Trusted Computing initiatives, to have published the definitive white-paper on TC[19]: what it can and can't do, and what risks it presents.

How Trusted Computing could(n't) help

The reference of the NPRM to Trusted Computing is oblique, but in order for Trusted computing to effectively curtail malefactors and the merely clueless from turning their PCs into malignant emitters, it would have to restrict PC owners' ability to run software that addressed either integrated SDR devices or the components that make them up, such as DACs. The Commission did not specify exactly how Trusted Computing would do this and it is not clear whether the Trusted Computing implementations currently contemplated could serve this function in the PC environment. "Trusted Computing" should not be used as a catch-all term for "tamper-resistance", not least because the actual amount of tamper resistance included in Trusted Computing systems may vary widely.

Even if they could, such a regulation would be problematic because it would strike at Americans' ability to manipulate, improve upon, and execute software code running on their lawfully acquired property, regardless of the outcome (and that dishonest or malicious parties would still have access to the tools necessary to attack the spectrum and its users).

Regulate outcomes, not devices or behavior

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17 Trusted computing has other properties, such as acting as a vehicle for encrypting user information and communications, but these are tasks to that "untrusted" computers are handily capable of performing and are not the capabilities that the Commission would employ in respect of a Trusted Computing enforcement regime over agile radios.

18 Trusted Computing does not seek to secure itself against skilled individual attackers, but rather aims at preventing "class breaks" where a single attacker can propagate a tool for breaking all instances of the system, as with the worms that move from machine to machine, repeatedly attacking the same vulnerabilities in Windows.

19 See http://www.eff.org/Infra/trusted_computing/20031001_tc.php

The components necessary to create a spark-gap generator are for sale in every modest-sized town in the nation. The Internet has many pages of detailed schematics for High-Energy Radio-Frequency "guns"[20] that can zap a laptop into senescence at a hundred paces, through its RF shielding. The Commission does not seek to regulate the parts that go into these devices, nor does it chase those who merely build or acquire these devices.

When the FCC chases down someone operating a spark-gap generator, it is because he is interfering (or is likely to interfere) with one or more licensed users of a band. When the FCC brings an enforcement action against an unlicensed FM broadcaster, it is because she is interfering (or is likely to interfere) with licensed FM stations. Even enforcement actions far removed from actual interference reports ultimately seek to support a world of predictable and regular spectrum use in which interference is relatively unlikely. The Commission does not, finally, seek to regulate the *behavior* -- learning about spark-gap generators, building spark-gap generators, operating spark-gap generators -- but rather, the *outcome*: harmful interference to a licensed user.

7. Effective enforcement against undesirable outcomes
SDRs are unstoppable

This is the crux of the matter. User-controlled, user-programmable SDRs built out of PCs are going to exist. Preventing their development would be too expensive, both in cost-of-enforcement, and collateral damage, to contemplate. No regulatory regime we can contemplate will prevent bad people from using these technologies in the worst possible way -- the technologies are simply too easy to build or acquire for the Commission to comprehensively regulate their emergence in the marketplace.

The Commission has in the past extensively regulated devices in order to achieve policy outcomes that include control of end-users' behavior. Despite the long pedigree of this approach and despite the elaborate deference which other commenters will likely show it, we suggest that this approach will not be cost-effective or practicable for PC-based SDR emitters in the near future. The Commission will not be able to limit the kinds of radios available to the general public in the future.

Nevertheless, the Commission must enforce its regulations on harmful interference -- however they may evolve -- against those who ignore them. It is clear that the Commission must re-evaluate its enforcement rules for a world in which device regulation is unavailable, or unavailing. How can it do so?

Consider enforcement separately from capabilities

EFF asks the Commission to consider the question of enforcement separately from the question of functionality. The Commission should allow this proceeding, and others like it, to consider the question of the characteristics of the best possible design and operation of flexible radios without regard to enforcement questions. It should allow American

20 See http://www.voltsamps.com/

technologists to build the devices that make most efficient use of spectrum and allow the greatest amount of speech over the public's airwaves.

As each new type of device and operational norm is approved, the Commission should ask, separately, how best to police the airwaves in light of the fact that the newly approved devices will soon proliferate. It must assume that Americans should and will acquire the best and most-capable radios possible and determine how to address the problems that may arise from this reality.

Further, the Commission should seek to backstop enforcement by hardening existing radio applications against harmful interference, spoofing and other attacks: for example, if air-traffic control signals carried cryptographically secured signatures, the risk of spoofed signals would be greatly reduced. Our government has already required that airlines install reinforced cockpit doors: reinforcing the cockpit radios is a logical next step.

An example

The Commission has sometimes relied on reports from licensed radio amateurs in initiating enforcement actions, or even in locating the source of malfunctioning devices and unlicensed radio stations. Since licensed amateurs are few and far between and have limited resources, it is hard to imagine relying solely on their co-operation for every enforcement action. But their participation in enforcement is instructive, because it shows that the public can co-operate with the Commission to help detect misbehavior in the radio spectrum.

Imagine that every American cellphone is cooperative, location-aware[21] and frequency-agile. Such phones would be more than communications devices: collectively, they would constitute a distributed sensor array capable of detecting interfering emitters, triangulating on them, logging their location and vector, and transmitting this information in real-time to enforcement authorities.

This example illustrates that by equipping the public with powerful, flexible radios, the Commission can tract the intractable. These solutions enlist Americans as active stakeholders in their electromagnetic spectrum and foster innovation and speech.

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21 i.e., equipped with E911 location-sensing capability

8. Conclusion

America's spectrum should be husbanded to maximize communications -- speech -- with minimal restrictions on speakers. Agile radios can bring us closer to this goal, and they should be encouraged. But encouraged or no, it's a certainty that the Commission will have to enforce its regulations against users of these devices. If it is to do so, it must equip itself with tools suited for the job -- not retard innovation in the hopes of keeping its tools current.

Respectfully submitted,

Electronic Frontier
Foundation
By: /s/ Cory Doctorow
Cory Doctorow
European Affairs Coordinator

May 3, 2004