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 03-108

COMMENTS OF CISCO SYSTEMS, INC.

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SUMMARY

As the Commission considers amendments to its spectrum policies, it faces two sometimes competing sets of policy goals that have become embedded in spectrum decision-making. First, the Commission must protect licensed services from harmful interference. Second, it must also create opportunities for new technology and new wireless services. Cognitive radio technology holds much promise as a tool to assist the Commission in achieving these objectives, and in harmonizing them in those circumstances where conflicts arise.

In Cisco's view, the Commission should adopt cognitive radio as part of its policy goals for future spectrum management. Cognitive radio holds great promise for using spectrum more efficiently. But migrating from where we are today, with a large embedded base of traditional transmitters, and a few devices capable of primitive versions of cognitive radio, to ubiquitous cognitive radio devices is a significant challenge. The Commission will need to introduce cognitive radio technology on a service-specific and band-specific basis, focusing on new services first. Operational experience from these early experiences can then inform subsequent decision-making.

Cisco's comments also discuss the cognitive radio capabilities and definitions provided in the Notice, requesting some modifications to terminology. Cisco also discusses modifications to the Commissions rules for software defined radio, and the Part 15 rule changes that would allow manufacturers to equip unlicensed devices with the ability to transmit at all unlicensed frequencies, including those not authorized in the U.S., provided that such transmission could be blocked in the unauthorized frequencies in the U.S.

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I. INTRODUCTION

Cisco Systems, Inc. ("Cisco") hereby respectfully submits comments in response to the above-captioned Notice of Proposed Rule Making ("Notice").[1] Cisco is the worldwide leader in networking solutions for the Internet and is also a leading manufacturer of equipment for wireless services. Cisco offers a wide range of RF products that operate in "unlicensed" [2] frequency bands, and strongly supports spectrum-based solutions for broadband Internet access, and, more generally, wireless broadband. Cisco understands the important role the Commission has played in creating an environment that allows unlicensed bands to be widely shared, and that allows

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1 *Facilitating Opportunities for Flexible, Efficient and Radio Spectrum Use Employing Cognitive Radio Technologies*, Notice of Proposed Rulemaking, released December 30, 2003 (hereinafter "Notice").

2 As a legal matter, the use of the bands that do not require individual authorization is licensed by rule, rather then unlicensed. However, for sake of convention we will use the term "unlicensed" in this comment.

manufacturers to design and market advanced wireless devices in a reasonably cost-efficient manner. This proceeding offers new opportunities for the Commission to build on its past successes, for unlicensed as well as licensed services.

In this proceeding, the Commission is exploring how cognitive radio technologies might facilitate improved spectrum use through the ability of a cognitive device to determine its location, sense spectrum use by other devices, change frequency, adjust output power, and alter transmission parameters and characteristics. The Commission is seeking comment on both the technical capabilities of cognitive radio systems, as well as possible rule changes, including equipment authorization rule changes, which might be necessary to support cognitive radio technology. The Notice states that cognitive radio technology could: (1) increase the efficiency of spectrum use; (2) facilitate secondary markets for licensed but underused spectrum; (3) facilitate automated frequency coordination among co-primary licensees; and (4) enable unlicensed use of licensed spectrum bands and possibly allow unlicensed devices to operate at higher power. In particular, the Notice states that cognitive radio technology might be most beneficial in rural areas, where spectrum bands are most likely to be unused or underused. Cisco supports the Commission's continued efforts to address spectrum issues, including the use of technologies and concepts that promote more efficient spectrum use.

As the Commission considers amendments to its spectrum policies, it faces two sometimes competing sets of policy goals that have become embedded in spectrum decision-making. First, the Commission must protect licensed services from harmful interference. Second, it must also create opportunities for new technology and new wireless services. Cognitive radio technology holds much promise as a tool to assist the

Commission in achieving these objectives, and in harmonizing them in those circumstances where conflicts arise.

In Cisco's view, the Commission should adopt cognitive radio as part of its policy goals for future spectrum management. Cognitive radio holds great promise for using spectrum more efficiently. But migrating from where we are today, with a large embedded base of traditional transmitters, and a few devices capable of primitive versions of cognitive radio, to ubiquitous cognitive radio devices is a significant challenge. The Commission will need to introduce cognitive radio technology on a service-specific and band-specific basis, focusing on new services first. Operational experience from these early experiences can then inform subsequent decision-making.

Cisco's comments also discuss the cognitive radio capabilities and definitions provided in the Notice, requesting some modifications to terminology. Cisco also discusses modifications to the Commission's rules for software defined radio, and the Part 15 rule changes that would allow manufacturers to equip unlicensed devices with the ability to transmit at all unlicensed frequencies, including those not authorized in the U.S., provided that such transmission could be blocked in the unauthorized frequencies in the U.S.

II. BACKGROUND

Examples of cognitive radio feature functionality exist today and have some lessons to offer. For example, in the Commission's decision approving portions of the 5 GHz band for unlicensed use, the Commission's rules require that transmitters in the 5250-5350 MHz and 5470-5725 MHz bands employ dynamic frequency selection (DFS)

to avoid interference with incumbent radar systems.[3] DFS functionality requires a transmitting device to switch to another channel whenever a particular criteria is met. The Report and Order in the docket mandated that 5 GHz U-NII devices change channels if the devices detected incumbent's radar signals present in the band.[4] The Commission correctly recognized, however, that mandating DFS, and creating rules by which equipment could be built, tested, and certified, are two very different activities. In the U-NII Order, the Commission mandated a 19-month process by which the industry, NTIA, and the Commission can create final DFS measurement procedures.[5]

The lesson of this process, although it is still on-going, is humbling.[6] Reaching an agreement on just this one aspect of cognitive radio feature functionality is going to take a significant effort in order to ensure that the equipment, once certified, does what it is supposed to do – switch frequencies when a radar pulse is detected. The work is specific to the band, to the incumbent services in the band (radar), and to the frequency propagation characteristics. There is no reasonable estimate at this time for how much of the DFS "learning" that will be done in the context of U-NII will ultimately be applicable to other bands where there are other types of users and other propagation characteristics.

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3 *In the matter of Revision of Parts 2 and 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) devices in the 5 GHz band*, ET Docket No. 03-122, *Report and Order*, released November 18, 2003 (hereinafter "U-NII Order") at para. 29.

4 Devices with a maximum e.i.r.p. of less than 200mW would find a different frequency upon detecting a radar signal measuring -62 dBm, while devices with higher power would change frequencies when detecting a measure of -64 dBm. U-NII Order at paras. 23-29.

5 U-NII Order at Appendix D.

6 The development of the interim DFS test procedure in the U-NII proceeding, and the on-going work to refine the final test procedures, is being done by the U.S. workgroup made up of government and industry experts. These are the same experts that addressed DFS and other issues to allow RLANS to share the 5GHz band in the WRC2003 resolution Com 5/16. This work effort, to develop the mitigation techniques to allow sharing, and then to develop the test procedures for equipment, began more than two and a half years ago and is still in progress.

For the moment, it seems safe to conclude that implementing a broader, more robust vision of cognitive radio will take much time and effort.

In addition, the Commission itself notes that no manufacturer has yet taken advantage of software defined radio (SDR) certification rules.[7] SDR transmitters are those in which software is capable of changing various operating parameters of the device (e.g., frequency range, modulation type, or maximum output power). In sum, it is the ability of software to modify the operation of a transmitter that enables cognitive radio functionality to exist. While there are several reasons why the rollout of SDR has been slow, there are two principal ones. First, there were outstanding issues with respect to which radio features would be considered by the FCC as SDR. Recently, staff has issued several technical opinions that have clarified those issues with respect to unlicensed wireless devices.[8] Second, equipment for which SDR certification is sought can only be reviewed by the FCC Lab, and not by a telecommunication certified body. In Cisco's estimate, this adds seven to eight weeks to the equipment certification cycle for unlicensed devices, a period of time that is sufficiently large so as to discourage a manufacturer from seeking an SDR certification. As a result, although this predicate to cognitive radio technology has been part of the Commission's rules since 2001, the industry's ability to actually take advantage of the option of filing for certification as an SDR may be hampered by unintended and unforeseen issues that are wholly unrelated to the merits of the technology.

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7 Notice at para. 84.

8 For example, the FCC Authorization and Evaluation Branch recently issued an interpretation that defined a Part 15 RLAN whose operation parameter can be upgraded by the end user via software as requiring certification as a software defined radio.

III. DISCUSSION

A. The Commission Should Embrace Cognitive Radio Technology As A Policy Goal

For the reasons stated in the Notice, cognitive radio technology presents such a compelling ability to protect incumbent licensees, and to utilize spectrum efficiently, that it is destined to become part of how radio transmitters will be built in the future. The Commission is correct to identify this development now, and should embrace it as part of its policy goals for spectrum management.

However, it is a great leap from passive sensing (or passive scanning) functionality, representing the earliest examples of cognitive radio, to the much more sophisticated cognitive capabilities planned for the Defense Advanced Research Projects Agency's (DARPA) "XG program."[9] Based on Cisco's extensive involvement in the U-NII proceeding, we believe that it is important, as the Notice suggests, to first define and agree on what constitutes cognitive radio technology, and than to determine on an service-specific and spectrum band-specific basis, whether and how the technology should be deployed.

Given the large base of transmitters servicing all of the spectrum that the Commission regulates, and the potential for disruption to existing business models if embedded devices must be modified or replaced to accommodate cognitive capabilities, it is best for the Commission to proceed deliberatively, applying cognitive functionality

[9] *Compare* Notice at para. 11 (examples of passive sensing include cordless telephones operating at 43.71-44.49 MHz) *with* para. 16 (XG technology allows multiple users to share common spectrum while avoiding conflicts in time, frequency, code, and other characteristics).

first to new services.[10] This give manufacturers, users, and/or service providers notice that cognitive technology will be required in a band or for a service, so that the costs of the technology can be considered in the business case. In addition, the Commission might find that different cognitive features may be more important in some bands than in others. Most significantly, it avoids the adoption of rules that might later prove to be unworkable or that fail to protect licensees from harmful interference.

While Cisco very much appreciates the prospect of further availability of spectrum for unlicensed services, as well as greater power for unlicensed devices in existing unlicensed bands, we caution the Commission against broadly mandating new technology that is still in the development stage until the industry has some experience in demonstrating that it can work operationally. In Cisco's view, it is very important to get some operational experience in a few bands before expanding the use of this technology further. We therefore encourage the Commission to adopt cognitive radio as part of its policy goal for spectrum management, while proceeding more deliberatively in implementing the technology on a service-specific and/or band-specific basis.

B. Cognitive Radio Capabilities

The Notice provides a summary of cognitive radio capabilities.[11] In this section, Cisco discusses the need for greater precision in the terminology that would be used to create cognitive radio rules, and offers some comments on the concepts.

1. "Frequency Agility" Is the Preferred Term

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[10] *See In the matter of Unlicensed Operation in the Band 3650-3700 MHz; Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band*, ET Docket No. 02-380, and *Amendment of the Commission's Rules with Regard to the 3650 -3700 MHz Government Transfer Band,* ET Docket No. 98-237, Notice of Proposed Rulemaking, adopted April 15, 2004.

[11] Notice at paras. 20-32.

The Notice states that frequency agility "… is the ability of a radio to change its operating frequency, combined with a method to dynamically select the appropriate operating frequency based on the sensing of signals from other transmitters or on some other method."[12] The Notice also refers to the definition for DFS as "…a mechanism that dynamically detects signals from other radio frequency systems and avoids co-channel operation with those systems."[13] It is important that these two terms not be used interchangeably. DFS is a very specific term to describe the interaction between radar systems and radio local area networks (RLANs) at 5 GHz. DFS should not be transplanted to other sharing situations without rethinking all factors involved.[14] In Cisco's view, "frequency agility" is a better term to describe the more generic cognitive radio functionality of dynamically selecting frequencies.

In addition, frequency agility by itself may be insufficient to solve interference issues. The transmission aspect of frequency agility is well understood. There are multiple devices on the market today in the form of mobile phones and Wi-Fi devices that utilize some primitive form of frequency agility. However, the crux of frequency agility is the device's ability to determine the actual usage of spectrum in the area where the device will transmit. This requires that the device be equipped with a cognitive transmitter to determine the location of other receivers that might suffer from harmful interference. One of the basic engineering issues to resolve, therefore, is how to create a

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12 Id. at para. 22.

13 Id. at para. 24.

14 The current requirements of DFS as stated in the U-NII Order are for detection of certain radar systems only operating in the 5 GHz band. Although the basic concept of DFS could in theory be used in other frequency bands, it would require all new studies to determine not only if DFS could detect the various signals of other services in other bands but also to determine what detection thresholds would be needed..

mechanism whereby the cognitive transmitter can identify or sense those receivers. This is not a problem that has a ready-made, operationalized solution. As if that were not difficult enough, local propagation conditions vary significantly in time and space. These localized differences can prevent a transmitter from determining interference conditions at the receivers the transmissions might affect.[15] Frequency selection based on RF energy measurements -- even if these can detect signals below the local noise level -- may not be sufficient to determine a choice of operating frequency. Therefore, in some cases, it may be necessary to develop a service-specific sharing regime in addition to frequency agility.[16]

2. "Transmitter Power Control" Is A 5 GHz Term

The Notice states that transmitter power control is "… a feature that enables a device to dynamically switch between several transmission power levels in the data transmission process."[17] It further states that the term will be used "broadly" to refer to a mechanism that switches the output power of a device based upon specific conditions. The term "transmitter power control" is a specifically defined term in the U-NII rules.[18]

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[15] For example, in implementing DFS for 5 GHz, the operation of DFS must take into account the specific conditions in that band such as existing radar users, propagation of the signals, system density, and numerous other factors in order to ensure that DFS will function as intended.

[16] For example, band-specific sharing rules might in some cases be an equally effective means of facilitating efficient spectrum use. Listen-Before-Talk and Receiver Driven Transmission assure efficient sharing of spectrum at much smaller geographical scale than is possible with any of the above capabilities.

[17] Notice at para. 27.

[18] 47 C.F.R.§15.403(s). The definition is: "A feature that enables a U-NII device to dynamically switch between several transmission power levels in the data transmission process."

Section 15.407(h) allows transmitters to operate at 3dB above the maximum power – provided that dynamic power adjustments per transmission reduce the aggregate power level by 3dB. This requirement meets some of the protection needs of satellite-based services that are licensed in the band. In the case of a cognitive radio, however, "transmitter power control" has a different and broader meaning that will depend upon the requirements of the particular service and band in which the cognitive device will function. Cisco therefore suggests that transmitter power control remain a term defined by section 15.403(s), and that a more generic term, such as "Automatic Transmit Power Control," be used outside the 5 GHz band.[19]

3. Location Awareness May Not Be Enough

In the Notice, the Commission states that a cognitive radio could incorporate the ability to determine its location, as well as that of other transmitters, such as through GPS technology, and then accessing a database holding the GPS information. It notes that in some applications, such as receive-only satellite dishes that do not transmit signals, location technology may be needed to avoid harmful interference to receivers.[20] Cisco agrees that location awareness, in combination with access to a geographical database of frequency use, will go a long way towards assuring that "fallow" spectrum could be used. However, local conditions may change spectrum propagation characteristics. Location awareness, by itself, may not be adequate to allow spectrum sharing between different systems in the same geographical area. In Cisco's view, any geographical database of frequency use will need to be designed to allow for protective margins to ensure that

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[19] Automatic Transmit Power Control is the term used in the microwave rules to describe transmitter power adjustments. Section 101.3 of the Commission's rules, 47 C.F.R. §101.3.

[20] Notice at para. 28.

harmful interference does not occur. Nevertheless, a major advantage of such a database would be that it could reflect the actual use of spectrum rather closely. In fact, incumbent licensees could be asked to register their actual use in such a database.

4. Cognitive Devices Should Be Capable of Ceasing Transmission

As proposed by the Commission, cognitive radios will function in a much more complex and sophisticated manner than most current transmitters. While pieces of cognitive functionality are offered in various pieces of equipment in various bands, there is little operational experience with radios that offer multiple cognitive features. Moreover, one of the features that these devices will be equipped with is the ability to modify power levels. For these reason, Cisco suggests that cognitive radios have the capacity to turn off transmissions in the event that the device is causing harmful interference. This concern extends well beyond the unlicensed bands, in which an unlicensed device must cease transmissions if it is causing interference, to bands in which all transmitters are licensed. The capacity to stop transmission should be sufficient to protect other band users from devices that are not operating properly or are causing harmful interference to licensed services. Finally, Cisco believes that the specific implementation of this requirement in the radios themselves will likely vary by band and by service, and should not be mandated by a uniform rule.

C. Modifications to Part 2 of the Commission's Rules

The Notice requests comment on whether the Commission's SDR rules need revision to ensure that unauthorized changes to radios do not occur that could produce harmful interference to other users.[21] The Commission is concerned that users could

[21] Id. at para. 84.

download software from a manufacturer's web site enabling the radio to be re-programmed by unauthorized third parties to operate in non-certified modes. The Notice seeks comment on whether to require certain types of devices to be treated as SDRs for the purpose of the equipment authorization rules. Specifically, the Commission states that its goal is to require review of devices that could be modified to operate on unauthorized frequency, but to avoid imposing requirements on manufacturers whose equipment meets the definition of SDR, but for which the transmission control software cannot be easily modified.[22]

Cisco supports the Commission's view that there should be a distinction in the rules for devices where the software to control the radio configuration is not a public utility or made available to the end user. Those devices that cannot be reprogrammed by the end user should not need to be authorized as SDRs. For those devices that can be reprogrammed in the field by the end user via downloadable software or purchased software, Cisco agrees that the devices should be treated as SDRs for equipment authorization purposes. Security features should be left to the manufacturer, as today's rules permit. In fact, Cisco notes that there are actually two security issues presented by SDRs that can be reprogrammed. One issue is securing the software download path to prevent third party security issues from arising. The second is the end user permission to execute the download. However, imposing a particular solution on the manufacturer by Commission rule may simply deter the most efficient solution available from being applied.

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[22] Id. at paras. 88-89.

The Notice also asks whether higher power, high speed digital-to-analog converters could operate as radio transmitters and how the Commission's rules should be amended to prevent unauthorized use and harmful interference. We understand the Commission's concern that a generic, software-controlled digital-to-analog converter card could be configured by some remote users to operate on a frequency band not approved by the Commission.[23] However, these cases would be few in number and could easily be handled using the Commission's existing enforcement powers.

The Notice also seeks comment on whether the Commission's rules should specifically limit the liability for manufacturers in cases where the manufacturer sells SDRs, but the SDR is used in an unauthorized way, and reasonable security methods are broken.[24] Cisco has no objection to the Commission acting to limit manufacturer's liability, or even adopting a specific rule that purports to do so. But it is probably more important for the Commission to indicate that compliance with Commission rules, including equipment certification, is a defense to allegations that a manufacturer shares culpability for an unauthorized transmission. There is simply no rule that can be written that will in all cases prevent a bad actor from modifying a radio device and causing harmful interference. The best the Commission can do is to clarify current rules governing non-compliant use of transmitters to include SDR devices and software upgrades.

D. Part 15

1. Rules Should Allow Equipment To Be Manufactured For Worldwide Sale

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[23] Id. at para. 91.

[24] Id. at para. 94.

In its proposals for changes to Part 15 of the rules, the Notice seeks comment on allowing unlicensed transmitters to be certified in the United States even if those transmitters are capable of radio emissions in non-U.S. authorized frequency bands. The Notice states that manufacturers would like to equip such devices with technology that selects the country-specific band in the country where the device will be used, thereby allowing manufacturers to produce one device for a world-wide market.[25] In addition, the Notice proposes that such devices incorporate DFS, and that such devices operate only on Part 15 frequencies when operating in the U.S.[26]

Cisco strongly supports allowing manufacturers to produce one device that can be enabled on a country-specific basis to transmit unlicensed frequencies in that country's authorized spectrum bands. This is a particular issue for devices in the 2.4 GHz band, where U.S. usage of the 2.4 GHz band does not match world-wide allocations. However, the proposal to require DFS technology to be embedded into these radios "to select the appropriate frequency based on the country of operation" is unnecessary. As discussed above, DFS is a U-NII requirement for 5 GHz devices.[27] In that setting, DFS looks for an open frequency for the device to utilize. DFS has no ability to recognize what country location, and to limit the device to the appropriate frequencies.

As part of this response, Cisco is specifically addressing the issue of passive scanning or the use of "world mode" for Part 15 Wi-Fi devices as requested by Commission staff. The Notice stated that passive scanning functionality could be utilized by an end user to operate the device on an unauthorized frequency. The Notice

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[25] Id. at paras. 95-98.

[26] Id. at para. 97.

[27] Section III.B.1., infra.

raised concerns about the user's ability to automatically configure the card if in this mode the operation scan could be outside the FCC certified channel sets. Below, Cisco offers its suggestion to remedy that concern.

Currently, passive scanning, or "world mode," allows the network interface card ("NIC") to scan the 2.4 GHz band on all 14 available 802.11 b / g channels for digital transmission systems devices that operate under section 15.247. Moreover, 2.4 GHz channels 12 and 13 are within the U.S. allowable frequencies as a technical matter,[28] leaving only channel 14 out of the U.S. allowable frequency band for these devices.[29]

In "world mode," the device responds to a beacon from the access point and then starts utilizing the channel that the access point selects for communication. Significantly, the user does not control the channel selection because channel selection is made automatically by the access point. For 2.4 GHz systems sold to enterprises or service providers, we propose that these systems be equipped with a secure configuration option that will allow configuration of these access points by the system installer. Client cards running "world mode" would be then automatically configured by the installed access points without user intervention. In sum, the installer would select the country in which

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[28] Channels 12 and 13 **(**2467 MHz and 2472 MHz) are not used in most cases to avoid problems with out of band emissions in the restricted band of operation starting at 2483.5 MHz.

[29] With the Commission's recent action in the U-NII proceeding allocating additional spectrum in the 5GHz bands, 802.11a radios operating on the U.S. channel sets will be using the same frequency bands as most of the world. See U-NII Order, ET Docket No. 03-122, released November 18, 2003. Currently, the 902-928 MHz band is limited to the United States in most cases. In addition, the 5725-5825 MHz band used in the U.S. for unlicensed services was not addressed at WRC03.

the device operates, and when the user turns the device on, the device communicates with the access point to automatically select the correct channel set. [30]

2. Testing Procedures Need Modification

We support the Commission view to allow Part 15 devices to operate at higher power levels, such as in rural area operation, as long as additional mitigation and operational requirements are met. In reviewing the proposed testing requirements, we offer the following modifications.

First, in testing cognitive radio devices the testing procedures will need to take into account the effects of allowing the device to operate at higher power. With an increase in transmitter power, out of band emissions will increase. In the 2.4 GHz band, the issue of concern would be the upper channel and how the increase in power would affect compliance in the adjacent restricted band and as well as for the harmonics that fall into the restricted bands. Both the cognitive transmitters and the testing procedures would need to take these different out of band emissions into account if higher power is permitted.

In addressing receiver requirements for the Part 15 devices, the 802.11 industry standard has specific requirements. Therefore, setting regulatory receiver requirements as part of Commission rules represents a departure from past practice. In 2002, the Commission decided that it should remove processing gain receiver requirements for Part 15 RLAN devices because manufacturers had a marketplace incentive to have their

[30] Residential units are currently factory set and we propose no change to the rules would apply to these units.

devices operate properly when located near other devices.[31] We also note that Part 15 devices must accept interference, including interference that affects their operation, and that there is no safe harbor for Part 15 receivers. The above approach is practical and allows innovation and improvements in receiver design. For present purposes, Cisco recommends that the Commission rely on the industry standards-setting process to define receiver requirements for Part 15 devices.

Several of the tests proposed, such as time for listen before talk or testing to measure the detection of various standard signals, would need to be developed based on various technologies and would require the tester to adopt the worst case mode for each band of operation to ensure detection of all devices to avoid interference. We suspect that much like the work being done on DFS for 5 GHz, the process for developing tests would be lengthy.

[31] *In the matter of Amendment of Part 15 of the Commission's Rules Regarding Spread Spectrum Devices*, Second Report and Order, ET 99-231, 17 FCC Rcd 10755 (2002) at para. 20, *recon. denied*, May 30, 2003, *appeal pending Warren C. Havens v. FCC and USA*, Docket No. 03-1247 (D.C. Cir.).

IV. CONCLUSION

Cisco recommends the Commission adopt cognitive radio as part of its policy goal for spectrum management, and initially proceed on a service-specific and band-specific basis to gain operational experience in cognitive radio for new services.

Respectfully submitted,

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