

Position Statement

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IMPROVED SPECTRUM USAGE THROUGH COGNITIVE RADIO TECHNOLOGY

IEEE-USA strongly encourages the Federal Communication Commission (FCC) to continue the innovative thinking evidenced by its encouragement of the development and implementation of Cognitive Radio (CR) technology, which offers the possibility of making significantly more efficient use of the finite radio spectrum resource.

A Cognitive Radio is a radio frequency transmitter/receiver that is designed to have the ability to intelligently detect whether a particular segment of the radio spectrum is currently in use, and to jump into (and out of as necessary) the temporarily-unused spectrum very rapidly without interfering with the transmissions of other authorized users. CR is a relatively new technology, so we recognize that there are both technical and policy questions that must be answered before full implementation of CR can proceed.

Given the increasing demand for radio spectrum -- a finite resource -- and the potential for CR technology to facilitate sharing of otherwise unused spectrum (temporally and geographically), IEEE-USA strongly recommends that the FCC, with the cooperation of other government agencies and private sector entities:

- Determine, through industry/government sharing studies, in which bands CRs can be used with confidence, and validate the results of those sharing studies through initial field trials;
- Confirm the technical reliability and practicality of CR, by resolving technical issues including:
 - What are suitable “behaviors” and the minimal technical restrictions necessary to assure that CRs will operate without causing harmful interference to licensed users?
 - How is a licensed user of a frequency to determine that any interference received is actually the result of cognitive radio operation, rather than from some other source?
 - What is the cumulative effect of very large numbers of CR users? (and)
- Create a regulatory environment that permits the implementation of CR technology while providing a method of redress and resolution for instances where interference might occur.

This statement was developed by the IEEE-USA Committee on Communications and Information Policy and represents the considered judgment of a group of IEEE-USA members with expertise in the subject field.

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BACKGROUND

The Federal Communications Commission (FCC), in May 2003 sponsored a Cognitive Radio (CR) Technology Workshop to discuss the potential for more efficient use of the radio spectrum, based on the emerging CR technology, and the issues of how to best apply that technology for better spectrum usage.

Studies have indicated that much of the available spectrum lies fallow much of the time, on a geographic, time, and frequency basis. CRs can not only utilize spectrum that is not otherwise in use; but they can potentially use lower power than would otherwise be required to reach from point A to point Z, by sending lower-power (or even different frequency) signals to other CRs at points B, C, D, and so on, between the points A and Z.

In the past, radio transmitters and receivers have been hardware-based. Once built, devices were only usable for the purposes for which they were designed. Now, however, a technology called "software defined radio" (SDR) has been developed by which a given radio transmitter or receiver can be dramatically updated and modified on the basis of only changes in the software installed within the device.

CRs are "smart" in that they can "learn" about current use of spectrum in their operating area, make intelligent decisions on that basis, and react to immediate changes in the use of spectrum by other authorized or CR users.

Thus, any radio spectrum can, in principle, be opportunistically used by CRs on a non-interfering basis. CR technology offers the opportunity for efficient use -- without interference to authorized/licensed users -- of currently unused or underutilized spectrum.

The rights and obligations of primary users are raised, since many licensed users have the perspective that they have exclusive control of the spectrum that corresponds to their licenses, whether the license was issued by comparative hearings or bought at auction. The Commission needs to address these issues.

For example, if the CR can detect "on frequency" use by incumbent users that it should not interfere with, what is to prevent existing users from just "keying up" when CR activity is detected (or even just periodically as a "defensive measure") causing the CR to move? Would this become illegal and under what penalty? CRs should be, by definition, inherently non-interfering on a completely independent basis. Therefore, incumbents should be prohibited from deliberately blocking CR access to otherwise unused spectrum.

Of course, the full potential and practicality of CR technology has yet to be fully demonstrated. IEEE-USA suggests that CRs first be proven effective in spectrum that could be considered to be "low hanging fruit." That is, spectrum that has a relatively low percentage of actual usage by the authorized users, and for which the actual occurrence of limited amounts of interference would not be catastrophic.

For example, there may be some bands that are not currently in use, or some bands which have low average usage, and there are even some TV broadcast channels which are not used at all in some geographic areas in which CR could be tried.

Clearly, initial trials should not be implemented in spectrum used by the Department of Defense or law enforcement agencies and fire departments. In those cases, the spectrum is often used only a small amount of time on average, but sometimes when it is needed it is vitally important for it to be clearly available with no interference. After significant trials and experience, perhaps CRs could even be used in those spectrum ranges; but surely not in the initial trials of the CR technology.

Even in the end, there may well be some spectrum bands that should not be used by CRs. For example, spectrum used for global positioning satellite (GPS), or spectrum used by satellites for observing weather patterns. In such cases, the CR would likely not detect any competing use of the spectrum, but could interfere with the authorized use of such spectrum.

While unlicensed spectrum may appear at first glance to be a good candidate for initial testing of CR, it is necessary to consider the number of consumer and industrial devices that have been developed that use that spectrum. In fact, some of the unlicensed bands (e.g., 2.4 GHz) are already extremely crowded with devices sharing the band. Thus, experiments with CR in the unlicensed spectrum bands would not fully answer the issues of how CR should be used in licensed/authorized spectrum bands - issues that must be addressed in order to

take full advantage of the potential of CR to allow increased sharing of otherwise unused spectrum.

Clearly there are technical issues that must be answered before any large-scale implementation of CR can proceed, even though it has been demonstrated in limited trials that CR technology can work effectively. However, at least as important is the challenge of creating a regulatory environment that permits the implementation of CR technology while providing a method of redress for instances where harmful interference might occur, and provides for their resolution.

IEEE-USA strongly encourages the FCC and other government agencies, as well as the private sector, to pursue the development and application of CR technology as vigorously as possible with the goal of relieving the overcrowding of much of the radio spectrum-which is actually a lack of access/full utilization of the radio spectrum.

Although the FCC must surely recognize and address all of the pertinent issues, we suggest that the FCC's major efforts at this time should focus on the following major issues:

- Deciding, through sound and equitable sharing studies, conducted cooperatively between industry and government agencies, which bands would be available for initial trials of CR, confirming the results of such sharing studies through field trials, and then opening up other bands for CR as the technology proves effective and further sharing studies and field trials confirm the ability of CRs to coexist in those other bands.
- Defining the rights of the licensed users of bands of spectrum in which CR technology is authorized. Certainly licensed users should be protected from interference from CRs (largely a technical issue), but on the other hand, if the benefits of CR are to be realized, they should not be permitted to deny CRs the right to operate on a truly non-interfering basis, to charge fees for such non-interfering use, or to employ active techniques to deliberately block access by CRs to spectrum that would otherwise be unused temporally or geographically.
- Defining "harmful interference" within the bands in which CR is authorized.
- At least in the beginning, not implementing a complete set of absolute rules as to how CR technology should be experimented with, but rather, putting in place "guidelines" or "policies" which CR users and the primary users should follow in good faith.
- Establishing a method by which the incumbent spectrum user may register evidence of interference to his/her systems and achieve resolution.

It is also important, in the interest of realizing the potentially significant benefits of CR technology as rapidly as possible, that FCC should act as quickly as possible to put in place guidelines/policies for trial and long-term implementation of CR technology.

This is important, not only from the point of view of rapidly implementing this technology to solve problems of inadequate access to unused or underutilized spectrum, but also from the point of view of worldwide technological leadership of the United States of America.