CAN COGNITIVE RADIO TECHNOLOGY HELP SOLVE SOME DIFFICULT SPECTRUM MANAGEMENT ISSUES BY CREATING "VIRTUAL GUARDBANDS"?

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The fundamental goal of spectrum management is to maximize use of the spectrum. This generally is taken to mean use without "harmful interference" [1]. The first problem in avoiding harmful interference has classically been to avoid having two signals on the same frequency that can cause interference to each other at locations where interference-free use is desired. This has been the classical issue in spectrum management.

However, cochannel interference is not the only interference mechanism in practical radio systems. Adjacent channel interference, receiver desensitization, and receiver-generated intermodulation are also potential interference mechanisms and have been the underlying issues in several contentious spectrum controversies in the last decade. Realistic receivers have "near/far problems" when the desired signal is much weaker than an adjacent channel signal. These problems most seriously affects mobile receivers since cost, size, and power constraints in mobile units limit the filter performance that is practical to keep adjacent channel signals out of the receiver amplifiers and mixers where strong undesired signals can result in interference.

Guardbands can be and often have been used by spectrum regulators to prevent these near/far problems from happening. For example, analog TV in the US used only every 6th channel in order to avoid several potential interference mechanisms.

Full duplex mobile systems have all the uplinks grouped together in one band and all the downlinks in another band, often with guardbands around both. But as spectrum demand grows, guardbands become a burdensome way to avoid such problems. While it is essential to keep strong signals apart in frequency from weak signals that have to be received at a given spatial location, that does not necessarily mean that in all cases static guardbands are the only solution.

Preston Marshall has pointed out [2] while cognitive radio technology (also called dynamic spectrum access) can be used to find vacant spectrum, it can also be used to indentify which vacant spectrum will not cause interference in radios with real limitations in front end performance if the frequency selection takes into account both radio parameters and location of transmitters and receivers. In general, gathering information on equipment technical parameters and current location for real time frequency selection can be very burdensome and is not an easy evolution from today's practices.

Using cognitive radio technology it appears possible to create a "virtual guardband" in some applications that would have the interference avoidance capability of conventional guardbands but without idling a fixed guardband. This might be used by a transmitter adjacent to a mobile downlink band to find a channel in its own band that is separated in frequency from full duplex systems in the user's immediate vicinity. Since commercial full duplex systems generally use a fixed offset between uplink and downlink channels, the "hidden node problem" of detecting a receiver's presence is really the much simpler problem of detecting the transmitter paired with the receiver by looking for its emissions at the known offset from the receiver frequency under consideration.

There is significant controversy over how reliably a sensing-only cognitive radio can verify that a broadcast channel is vacant and that no receiver within its potential interfering range could receive the primary broadcast signal. The FCC's TV white space rulemaking [3] showed that this controversy exists even when the cognitive radio sensing was 30 dB more sensitive than consumer TV receivers because of concerns that the cognitive radio sensor might be located in a multipath propagation minimum and a nearby location might have a signal that is 40 dB stronger and hence usable. However, this is a classic hidden node problem where a physically nearby receiver can not be observed by the cognitive radio. The case of a full duplex mobile unit is very different since transmitters and receivers are now paired with a fixed frequency offset.

If the potential interference range to the receiver of an adjacent channel signal is less than a few hundred meters, then a paired uplink signal from the mobile unit should be readily detectable indicating both the presence of the mobile full duplex receiver and what frequency it is tuned to (since the T/R offset is known). With this knowledge, the adjacent band transmitter can move far enough in frequency from the nearby receiver to prevent interference, thus creating a "virtual guardband."

While no spectrum regulatory agency has adopted any rules dealing with virtual guardbands, this appears to be both a promising research topic and a potential solution to some vexing spectrum management problems involving adjacent channel interference.

REFERENCES

[1] M. Marcus, "Harmful Interference: The Definitional Challenge," *IEEE Wireless Commun.*, vol. 15, no. 3, June 2008, pp. 4–7.

[2] P. Marshall, "Cognitive Radio as a Mechanism to Manage Front-End Linearity and Dynamic Range," *IEEE Commun. Mag.*, vol. 47, no. 3, Mar. 2009, pp. 81–97.

[3] FCC Docket 04-186, http://fjallfoss.fcc.gov/ecfs/proceeding/view?name=04-186.

BIOGRAPHY

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