International Journal of Control and Automation
Vol.7, No.1 (2014), pp.227-234
http://dx.doi.org/10.14257/ijca.2014.7.1.19

Scheme using SINR for Performance Improvement of CR

Jeewon Hwang[1] and Juphil Cho[2*]

[1]*Dept. of Information Technology, CAIT, Chonbuk National University, Korea*
[2]*Dept. of Radio-communication Engineering, Kunsan National University, Korea*

[*]*Corresponding Author: Stefano@kunsan.ac.kr*

Abstract

Cognitive Radio is continually studied by many engineers and researchers. However, it doesn't still get an optimal standard proposal and technical skill. In this paper, we deal with just partial face in that field and suggest the proposed device but it doesn't state specific and physical things. This can be some problem in this scheme. However, if we use this proposed method properly, Secondary terminal (ST)'s power is flexible in the future communication of Cognitive Radio. Also, this is a good solution of power dealing with next communication of other fields.

Keywords: C*ognitive Radio, 802.22, SINR, Interference*

1. Introduction

The proliferation of wireless services and devices for uses such as mobile communications, moving the 3G and 4G, needs the usable frequency, although that is few. Actual measurements show that most of the allocated spectrum is vastly underutilized at any specific location and time [1].

As a result, the FCC's exclusive use spectrum allocation policy is being increasingly viewed as outdated. Innovative devices typically operate in the unlicensed bands, and as these bands become more and more crowded, researchers are searching for better ways to manage spectrum. A key proposal for solving this problem involves using spectrum agile, and also CRs can sense and adapt to their environment [2].

Such a device could theoretically operate in a licensed band without causing harmful interference to the primary license. All these important events created a mindset within the IEEE that culminated in the formation of the IEEE 802.22 WG for WRANs in November/2004 [3]. This 802.22 WRAN has been chartered with the specific task of developing an air interface based on CRs for un- licensed operation in the TV broadcast bands (VHF/UHF) [4].

In this paper, we target the issue which can operate practical cognitive systems even without causing excessive interference to legacy users. Also, focusing on non-interference to the primary system rather than realizable benefits for the secondary systems, and using the proposed device.

We show the existence of constraints that allow multiple cognitive radios to transmit at reasonable power levels while maintaining a guarantee of service to legacy/priority users on the same band. We do not consider achievable data rates or necessary protocols for the secondary systems.

How can we satisfy PU (Primary User)'s quality with the interference? The answer is PU's SINR. Generally, TV receiver' SINR must be satisfied 10[dB], in order to see the screen [5]. The CR's transmitted power is operated by satisfying PU's required SINR. In one word, its power (ST's power) is interference in PU. PU's measured interference is related with distance between PU and SU. And it has effect on path loss which is related to an attenuation coefficient that is between 2 and 6. For example, in free space, attenuation coefficient is 2. Attenuation coefficient is very important to determine SU (Secondary User)'s transmitted power. According to choose attenuation coefficient, SU's power is determined.

We suggest the proposed device which is determine attenuation coefficient. After a brief review of previous work and a description of our model, we consider a single SU sharing spectrum with the primary system. As an example, we imagine a cognitive radio broadcasting his signal over underutilized television bands far outside a city. We can think of the SUs as licensed users constrained to a specific power. On the other hand, it seems reasonable to allow a SU to use more power if he is further from the primary system. We examine both these cases in section 4. In section 5, we extend our analysis to multiple SUs. We consider first the case in which all the SUs are bound by the same power constraint.

2. Scenario for single ST user

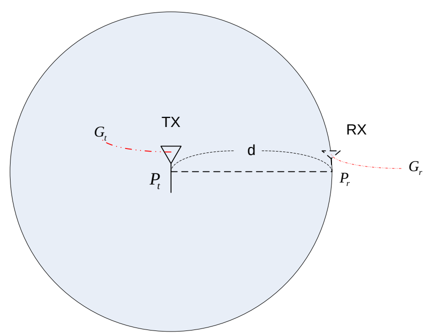

Figure 1. RX & TX in space

Figure 1 illustrates the Rx and Tx in space. Generally, received power of RX antenna in free space is:

$$P_r = \frac{G_t G_r}{\left(4\pi d / \lambda\right)^2} P_t \tag{1}$$

$$\lambda f = c \tag{2}$$

Power constraint must consider a PR and ST as close as possible, with the primary on the edge of the protected zone and the secondary on the edge of the no-talk zone.

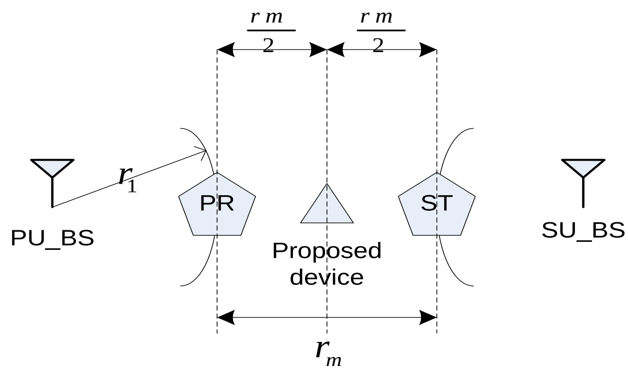

Figure 2. Single ST

First, we write PR in terms of SINR.

$$SINR_{PR} = 10\log\left(\frac{P_1 A_1 r_1^{-\alpha_1}}{\sigma^2 + fP_2 A_2 \left(\frac{r_m}{2}\right)^{-\alpha_2} A_2 \left(\frac{r_m}{2}\right)^{-\alpha_1}}\right) \quad (3)$$

$$= 10\log\left(\frac{P_1 A_1 r_1^{-\alpha_1}}{\sigma^2 + fP_2 A_2^{\,2} \left(\frac{r_m}{2}\right)^{-(\alpha_2+\alpha_1)}}\right)$$

A_1 is antenna gain of between of PT and PR antenna, and A_2 is between PR and ST. Also, f is the orthogonal factor which is related with modulation schemes and waveform design. Next, we solve for the P_2,

$$P_2 = \frac{\left(P_1 A_1 r_1^{-\alpha_1} 10^{-\frac{SINR_{PR}}{10}} - \sigma^2\right)\left(\frac{r_m}{2}\right)^{\alpha_1+\alpha_2}}{fA_2^{\,2}} \quad (4)$$

This equation (4) is maximum power of ST to guarantee PR's SINR in single user. The proposed device must have two antennas. The one is toward PU_BS(Base Station) and another is toward SU_BS. The power information which is measured by two antennas transfers SU_BS. SU_BS estimates and determines attenuation coefficient, α_1 α_2, using the received information born in SU_BS.

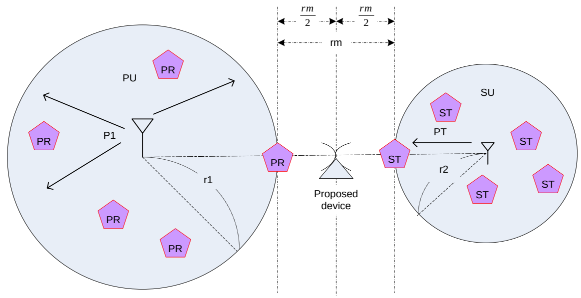

Figure 3 : Modeling and proposed device

Figure 3. Modeling and proposed device

Frequency of communication in PU and SU supposes TV's one which is the band of UHF and VHF. PR has only received power from PT(PU_BS) but not transmission power. Given an existing TV station(PU_BS) with transmission power P_1, the effective receiving range is r_1 and attenuation coefficient is α_1 in that. Also, given an SU station(SU_BS) with transmission power P_T, the effective receiving range is r_2 and attenuation coefficient is α_2. Received power from two antennas of proposed device is P_{M1}(5) and P_{M2}(6) respectively.

The idea is to guarantee service to PUs within some protected radius(r_1) by defining an additional no-talk distance(r_m) within which SUs must be quiet.

$$P_{M1} = P_1 A\left(r_1 + \frac{r_m}{2}\right)^{-\alpha_1} \tag{5}$$

$$P_{M2} = P_T A\left(r_2 + \frac{r_m}{2}\right)^{-\alpha_2} \tag{6}$$

Eq. 7 and 8 shows SU_BS get a attenuation coefficient of α_1 α_2.

$$\alpha_1 = \left(\log AP_1 - \log P_{M1}\right)\left(\log\left(r_1 + \frac{r_m}{2}\right)\right)^{-1} \tag{7}$$

$$\alpha_2 = \left(\log AP_T - \log P_{M2}\right)\left(\log\left(r_2 + \frac{r_m}{2}\right)\right)^{-1} \tag{8}$$

3. Scenario for Multiple ST Users

In this section, let's suppose that we are no longer limited to a single interferer. We assume there exist a sea of STs (Figure 4), each with power P_2. We further assume that there is a limit to how densely these transmitters are packed. Each ST uniquely occupies a footprint of area S, so this "secondary sea (radius of the r_1 and r_2 is very long, respectively)" has a power density

$$D = \frac{P_2}{S} \tag{9}$$

Integrating over this sea gives the aggregate power of the secondary transmission at a PR on the edge of the protected region(r_1).

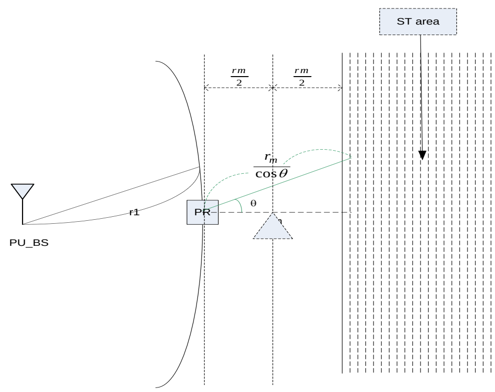

Figure 4. Multiple STs and secondary sea

In this case, SINR of PR is following this equation

$$SINR_{PR} = 10\log\left(\frac{P_1 A_1 r_1^{-\alpha_1}}{\sigma^2 + fP'}\right) \tag{10}$$

$$\begin{aligned} P' &= \int_{-\pi/2}^{\pi/2}\int_{\frac{r_m}{\cos\theta}}^{\infty} D\left(\frac{r}{2}\right)^{-(\alpha_1+\alpha_2)} r\,dr\,d\theta \\ &= 2^{\alpha_1+\alpha_2}\frac{P_2}{S}\int_{-\pi/2}^{\pi/2}\int_{\frac{r_m}{\cos\theta}}^{\infty} r^{-\alpha_1-\alpha_2+1}\,dr\,d\theta \\ &= 2^{\alpha_1+\alpha_2}\frac{P_2}{S}\frac{r_m^{\,2-\alpha_1-\alpha_2}}{\alpha_1+\alpha_2-2}\int_{-\pi/2}^{\pi/2}(\cos\theta)^{\alpha_1+\alpha_2-2}\,d\theta \end{aligned} \tag{11}$$

And, we need to simplify the equation using below one

$$\alpha = \alpha_1 + \alpha_2 \tag{12}$$

$$Q(\alpha) = \int_{-\pi/2}^{\pi/2}(\cos\theta)^{\alpha-2} \tag{13}$$

$$K = \frac{2^{\alpha_1+\alpha_2}}{S}\frac{r_m^{\,2-\alpha_1-\alpha_2}}{\alpha_1+\alpha_2-2} \tag{14}$$

$$P' = KQ(\alpha)P_2 \tag{15}$$

With using the above equation from (12) to (14), we can express (16).

$$P_2' = \frac{P_1 r_1^{-\alpha_1} 10^{-\frac{SINR_{PR}}{10}} - \sigma^2}{fKQ(\alpha)} \tag{16}$$

Eq. (16) shows the allowable ST's power as a function of the SINR measured in [dB] from the protected region.

4. Simulation

In this section, we are simulated by using the calculated information measuring proposed device and prior equation which is upper section. Simulation parameters are: $r_1 = 50000[m]$; $r_2 = 1000[m]$; $r_m = 30[m]$; $P_1 = 100[kW]$; $P_T = 10[kW]$; $\sigma^2 = 10^{-14}$; Figure 5 shows that attenuation coefficient is determined by received power in proposed device. If received power : $P_{M1} = -55[dBu]$; $P_{M2} = -70[dBu]$, the attenuation coefficients(α_1, α_2) are: $\alpha_1 = 3.5113$; $\alpha_2 = 5.6545$ by the equation (12),(14).

Figure 6 shows ST's power plot if PR need SINR value 10, 12 and 13[dB] in single user. Figure 7 also shows ST's power plot when attenuation coefficients(α_1 , α_2) are $\alpha_1 = 3, \alpha_2 = 3.5$ and $\alpha_1 = 3.5, \alpha_2 = 6$ if proposed device do not used.

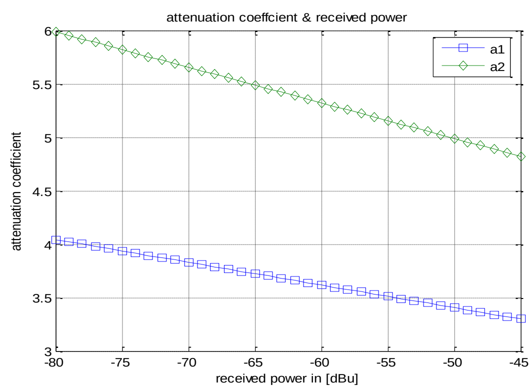

Figure 5. The attenuation coefficient of received power in proposed device

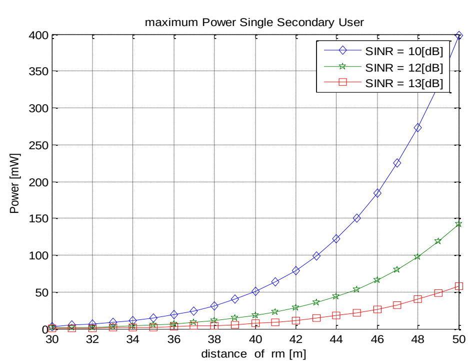

Figure 6. ST's power of distance rm[m] in single user 1

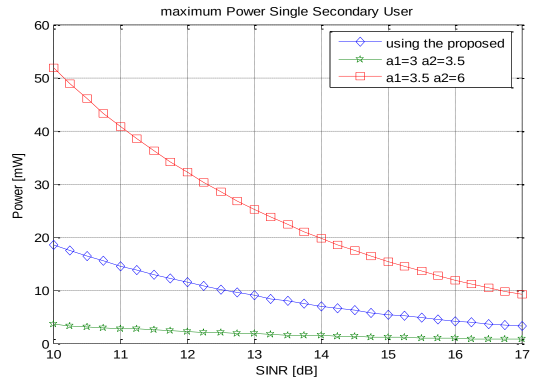

Figure 7. ST's power of needed SINR of PR in single user

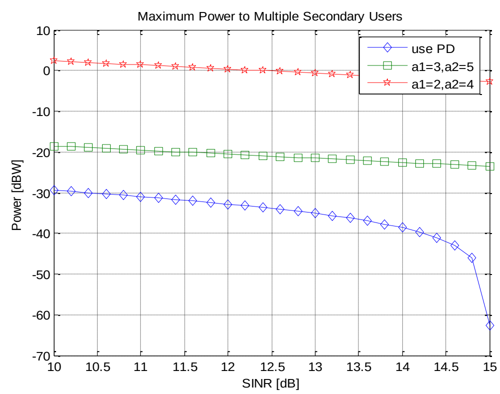

Figure 8. ST's power of needed SINR of PR in multiple users

Figure 8. shows ST's power usage in multiple users. In this result, we can see the superior performance of the proposed scheme.

5. Conclusion

A simple idea of using a proposed device in CR to reuse locally unused spectrum for their own transmissions is introduced. In this paper, the constraint which an unacceptable levels of interference to licensed systems on the same frequency can't be generated is imposed. Using received SINR as a proxy for distance, we show that CR vary its transmit power while maintaining a guarantee of service to primary users. The aggregate interference caused by single CR user and multiple CRs using the proposed device are considered.

Acknowledgements

"This research is partially supported by Institute of Information and Telecommunication Technology of KNU"

References

[1] R. W. Broderson, A. Wolisz, D. Cabric, S. M. Mishra and D. Willkomm, “White paper: CORVUS: A cognitive radio approach for usage of virtual unlicensed spectrum”, **(2004)**, http://bwrc.eecs.berkeley.edu/Research/MCMA/CR White paper final1.pdf.
[2] Federal Communications Commission(FCC), “Facilitating opportunities for flexible, efficient, and reliable spectrum use employing cognitive radio technologies”, ET Docket 03-108, Notice of Inquiry and Proposed Rulemaking and Order, (**2003)**.
[3] FCC, “Spectrum Policy Task Force”, ET Docket no. 02-135, (**2002)** November.
[4] IEEE 802.22 Working Group on Wireless Regional Area Networks, http://www.ieee802.org/22/.
[5] M. Marus, “Unlicensed cognitive sharing of TV spec- trum”, IEEE Comm. Mag, (**2005)** May, pp. 24-25.

Authors

Jeewon Hwang received the Ph. D degree from the School of Electronic Engineering, Chonbuk University in Korea in 1995, He is currently Professor at the Department of Information Technology, Engineering College Chonbuk National University, Jeonju, Korea. His research interests include Digital Signal Processing and Computer Architecture, etc.

Juphil Cho received the PhD degree in Electronics Engineering from Chonbuk National University in 2001. From 2000 to 2005, he was a Senior Research Staff at Electronics and Telecommunication Research Institute (ETRI), Daejeon, Korea, where he was involved in the development of the 4G cellular system. He was invited as a Researcher from ETRI in 2006 and stayed as an Invited Professor from University of South Florida(USF). Since 2005, he has been an associate professor at Department of Radiocommunication Engineering, Kunsan National University, Kunsan, Korea. His current research interests are the wireless communication technology including spectrum sensing, LTE Advanced, Cognitive Radio, interference detection and cancellation in the wireless local and personal area networks.

