인지 라디오 네트워크에서 다이버시티 게인을 얻기 위한 협력 스펙트럼 센싱 기법

최시영* · 황태원*

*연세대학교

Cooperative spectrum sensing scheme to obtain a diversity gain in cognitive radio networks

Siyoung Choi* · Taewon Hwang*

*Yonsei University

E-mail: crazysct@gmail.com, twhwang@yonsei.ac.kr

요 약

본 논문에서는 부사용자들의 공간 다이버시티를 이용한 협력 스펙트럼 센싱 기법을 제안한다우리의 기법에서는 부사용자가 다른 부사용자들로부터 신호를 받아 주사용자의 존재 여부에 대한 측정을 한다. 우리는 모의 실험 결과를 통해 부사용자의 수가 증가할수록 발견 실패 확률의 다이버시티 오더가 증가함을 알 수 있다

ABSTRACT

In this paper, we propose a cooperative spectrum sensing scheme using the spatial diversity of secondary users (SUs). In our scheme, a SU makes an estimation whether the primary user (PU) is active or not using the signals from the other SUs. We know that the diversity order of miss detection probability increases as the number of SUs increases from the simulation result.

키워드

cognitive radio, cooperative spectrum sensing, hypothesis testing, diversity order

Ⅰ. Introduction

In cognitive radio (CR), spectrum sensing requires the detection of possibly-weak signals of unknown types with high reliability, because it is hard to distinguish between a white spectrum and a weak signal attenuated by deep fading [1].

In order to improve the reliability of spectrum sensing, cooperation among SUs has been proposed [2]-[4]. In [2], one SU performs spectrum sensing with one SU-relay by using a energy detection technique. Compare to [2], [3] proposed the spectrum sensing scheme with multi-SU-relay (more than one) by using a energy detection technique. However, the proposed scheme in [3] obtains only signal-to-noise ratio (SNR) gain through cooperation. [4] quantifies the diversity order for various cooperative spectrum sensing schemes under the impractical assumption that the channels between SU and SU-relays are perfect.

In this paper, we propose the cooperative spectrum sensing scheme to obtain a diversity gain for a given target false alarm probability under practical assumption that the channels between SU and SU-relays are Rayleigh fading.

Ⅱ. Proposed Spectrum Sensing Scheme

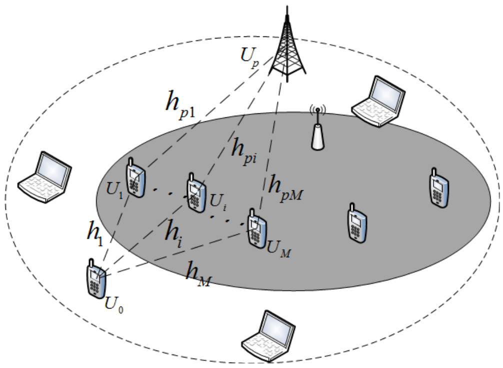

Fig. 1. Cognitive radio network with one SU and M SU-relays.

We consider the cognitive radio network with one SU U_0 and M SU-relays $\{U_i\}_{i=1}^{M}$ as shown in Fig. 1. We assume that SU and SU-relay operate in a fixed time division multiple access (TDMA) manner. The spectrum sensing phase consists of two time slots T_0 and T_1. In T_0, all the U_i's listen in the desired band and receive the signal from PU U_p. Next, in T_1, each SU-relay U_i works according to a strategy: U_i directly relay the square of its received signal during T_0 to U_0. Finally, using the received signal from U_i's during T_1, U_0 makes its own decision by maximum likelihood (ML) detection. We assume that PU signal x_p is distributed as zero mean and variance E_s. Further, we assume that the channel between U_p and U_i, h_{pi}, and the channel between U_i and U_0, h_i, are distributed as zero mean and variances $\sigma^2_{h_{pi}}$ and $\sigma^2_{h_i}$, respectively.

The received signal y_i at U_i during T_0 is

$$y_i = \theta h_{pi} x_p + n_i,$$

where $\theta = 1$ denotes U_p is active, otherwise U_p is idle, and n_i is the complex white Gaussian noise with zero mean and variance N_i. When $\theta = 1$, the received SNR at U_i is $\gamma_i = E_s / N_i$. We assume that U_i know the channel information h_i by the pilot signal from U_0. Then, U_i transmits $x_i = h_i^* |y_i|^2 / |h_i|^2$ to U_0 in T_1, where h_i^* is the complex conjugate of h_i. Note that $|y_i|^2$ is exponentially distributed with mean $\theta E_s + N_i$. The received signal y_0 at U_0 during T_1 is

$$y_0 = \sum_{i=1}^{M} h_i x_i + n_0,$$

where n_0 is the additive white Gaussian noise (AWGN) with zero mean and variance N_0. Finally, U_0 determine the state of U_p between the following two hypothesis.

$$H_0, (\theta = 0): \ y_0 = \sum_{i=1}^{M} |n_i|^2 + n_0,$$

$$H_1, (\theta = 1): y_0 = \sum_{i=1}^{M} |h_{pi} x_p|^2 + n_0.$$

Then, the false alarm probability and the miss detection probability can be defined by

$$P_f = \Pr\{y_0 > \eta \mid H_0\}$$

and

$$P_{md} = \Pr\{y_0 < \eta \mid H_1\},$$

respectively, where η is the threshold for ML detection. Let α be the tolerable false alarm probability. Then, η can be determined by solving the equation $P_f = \alpha$.

Ⅲ. Numerical Result

In this section, we present the numerical result for the miss detection probability P_{md} of the proposed scheme. We assume that $\sigma^2_{h_{pi}} = 1$, $\sigma^2_{h_i} = 1$, $N_i = 1$, for all $i = 1, \cdots, M$, and $N_0 = 1$. Under our assumption, γ_i's are all the same, i.e., $\gamma_1 = \cdots = \gamma_M = \gamma$. The number of channel generation is 1000, and the tolerable false alarm probability α is set to 0.1.

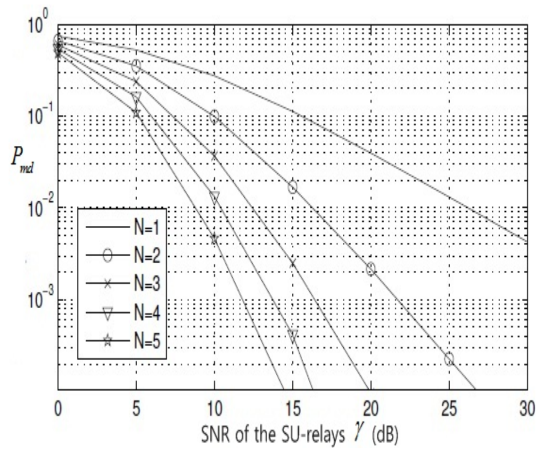

Fig. 2. Miss detection probability: $M = 1,2,3,4,5$.

Fig. 2 shows P_{md} for different M. It is clear that P_{md} decreases with the increase in γ. The diversity order of P_{md} is defined in [4], which is given by

$$d = -\lim_{\gamma \to \infty} \frac{\log P_{md}}{\log \gamma}.$$

The diversity order of P_{md} can be interpreted as the slope of log-scale P_{md} with respect to log-scale γ. As shown in Fig. 2, d increases as M increases. However, from Fig. 2, we can know that d is smaller than the number of SU-relays M, i.e., $d < M$. The reason for this phenomena is that the AWGN at U_0 degrades P_{md}. If there is no AWGN at U_0, then d is equal to the number of SU-relays M [4].

Ⅴ. Conclusion

We have proposed the cooperative spectrum sensing scheme to obtain a diversity gain in CR networks. Our proposed scheme is summarized that one SU determine the state of PU by collecting the signals from the other SUs (SU-relays). The numerical result show that our scheme obtains the diversity gain.

References

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