Cooperative Spectrum Sensing with Selection Diversity Reception in Cognitive Radio

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Abstract - Cognitive radio (CR) is a promising technology where spectrum sensing is the key factor for the recent and future generations. Detection is compromised when a person reports shadowing or fading consequences and that's why performance of spectrum sensing is developed by cooperative spectrum sensing methods. This paper emphasizes on the performance of Cooperative Spectrum Sensing with Selection Diversity Reception in CR. Fusion rule is played at the data fusion center (FC) to take the hard decision by performing the operation of the received signal from different CR users and eventually, the paper shows that the OR rule has better performance than AND as well as MAJORITY rule in Rayleigh fading.

Keywords- cognitive radio, fusion rules, cooperative spectrum sensing, fading channels, energy detection

I.INTRODUCTION

The radio frequency (RF) spectrum is currently managed by government agencies under an exclusive usage scheme. Due to the explosive development of wireless applications, it is evident that the available frequencies cannot meet the increasing demand. Current investigations confirmed that there are present good sized underutilization of the allotted frequencies [1]. The spectral underutilization can be resolved by means ofpermitting a secondary user to entrée an authorized band whilst the primaryconsumer (PU) is absent. CR is appreciably agreed to be the maximum encouraging approach for assuaging RF spectral insufficiency. Present day investigations confirmed that there be presentsizeable underutilization of the allotted frequencies. The spectral underutilization can be resolved viaallowing a secondary person to entrée a certified band whilst the primaryuser (PU) is absent. CR is notably agreed to be the maximum encouraging technique for assuaging RFSpectral efficiency. Energy detection [2] is normallyutilized in spectrum sensing, as it has a low execution issue and does now notwant to channel kingdomrecords (CSI) [3]. Because of the a few multipath fading, a cognitive radio may additionally fail to assert the presence of the PU and then will entrée the licensed channel and purpose interference to the PU.The act of cooperative spectrum sensing with disposing of cognitive radios in Rayleigh fading channel has been expected in [7-12]. It improves the detection performance. Previouswork on cooperative spectrum sensing has shown that areadiversity can increase the chance of detection [13]–[16]. The use of most ratio combining (MRC), selection combining (SC), square-law combining (SLC), and square law selection (SLS) information fusion schemes.Rayleigh fading channels became researched in [17-20]. In this paper, we only studied selection combining (SC) data fusion schemes based in F. F. Digham by cooperating with four number of CR users.

The restof this paper is organized as follows. Firstly, in section II, the system model is presented. Secondly, in section III, detection and false alarm probability are demonstrated. Thirdly, Cooperative spectrum sensing is derived in section in IV. Eventually, the simulation result and dialogue are offered in section V as well as it is drawn in conclusion in section VI.

II.SYSTEM MODEL

The local spectrum sensing is to decide between the following two hypotheses,

$$x(t)=\begin{cases} n(t) & H_0 \\ hs(t)+n(t) & H_1 \end{cases} \quad (1)$$

Where *x(t)* is the signal received by secondary users and *s(t)* is primary user's transmitted signal, *n(t)* is the additive white Gaussian noise (AWGN) and h is the amplitude gain of the channel. The energy collected in the frequency domain is denoted by Y which serves as a decision statistic. Following the work of Urkowitz, *Y* may be shown to have the following distribution,

$$Y = \begin{cases} \chi^2{}_{2TW} & H_0 \\ \chi^2{}_{2TW}(2\gamma), & H_1 \end{cases} \quad (2)$$

where $\chi^2{}_{2TW}$ and $\chi^2{}_{2TW}(2\gamma)$ denote central and non-central chi-square distributions respectively, each with *2TW* degrees of freedom and a non-centrality parameter of 2γ for the latter distribution. For simplicity we assume that time-bandwidth product, *TW*, is an integer number which we denote by *u*.

III.DETECTION AND FALSE ALARM PROBABILITIES

In thisphase, we provide the average detection chance over Rayleigh fading channels and in closed shape [21]. In communications principle, Rayleigh distributions are used to model scattered signals that attain a receiver with the aid ofmore than one path. In non-fading surroundings the commonchance of false alarm, the commonchance of detection, and the commonopportunity of missed detection are given, respectively,

$$P_d = P\{Y > \lambda \mid H_1\} = Q_u\left(\sqrt{2\gamma}, \sqrt{\lambda}\right) \quad (3)$$

$$P_f = P\{Y > \lambda \mid H_0\} = \frac{\Gamma(u, \lambda/2)}{\Gamma(u)} \quad (4)$$

and

$$P_m = 1 - P_d \quad (5)$$

where λ denotes the energy threshold. Γ(.) and Γ(.,.) are complete and incomplete gamma functions respectively [22] and $Q_u(.,.)$ is the generalized Marcum Q-function defined as follows,

$$Q_u(a,b) = \int_0^{\infty} \frac{x^u}{a^{u-1}} e^{-\frac{x^2+a^2}{2}} I_{u-1}(ax)dx$$

where $I_{u-1}(.)$ is the modified Bessel function of ($u-1$)th order.

In this case, the averageprobability of detection can be derived through averaging (three) over fading statistics [23]

$$P_d = \int_x Q_u\left(\sqrt{2\gamma}, \sqrt{\lambda}\right) f_\gamma(x)dx \quad (6)$$

wherein f(x) is the probability distribution characteristic (PDF) of SNR beneath fading.

A. *Rayleigh fading channels*

When the received signal consists of a largequantity of aircraft waves, for somesorts of scattering environments, the receivedsignal has a Rayleigh distribution [24]. Follows an exponential PDF is given by

$$f(\gamma) = \frac{1}{\bar{\gamma}} \exp\left(-\frac{\gamma}{\bar{\gamma}}\right), \gamma \geq 0 \quad (7)$$

In this example, a closed-shapeformulation for P_d may be obtained (after some manipulation) by substituting $f_\gamma(x)$ in (6),

$$\bar{P}_{dRay} = e^{-\frac{\lambda}{2}} \sum_{k=0}^{u-2} \frac{1}{k!}\left(\frac{\lambda}{2}\right)^k + \left(\frac{1+\bar{\gamma}}{\bar{\gamma}}\right)^{u-1} \times \left(e^{-\frac{\lambda}{2(1+\bar{\gamma})}} - e^{-\frac{\lambda}{2}\sum_{k=0}^{u-2}\frac{1}{k!}\left(\frac{\lambda\bar{\lambda}}{2(1+\bar{\gamma})}\right)}\right) \quad (8)$$

B. *Selection Combining*

In the SC diversity scheme, the branch with maximum SNR, $\gamma_{\max}$, is to be selected. The PDF of $\gamma_{\max}$ for IID Rayleigh branches is known to be given by

$$f_{\gamma_{\max}}(\gamma) = \frac{L}{\bar{\gamma}}\left(1 - e^{-\gamma/\bar{\gamma}}\right)^{L-1} e^{-\gamma/\bar{\gamma}} \quad (9)$$

This PDF can be rewritten as

$$f_{\gamma_{\max}}(\gamma) = L\sum_{i=0}^{L-1} \frac{(-1)^i}{i+1}\binom{L-1}{i} \frac{1}{\bar{\gamma}/(i+1)} e^{-\frac{\gamma}{\bar{\gamma}(i+1)}} \quad (10)$$

The PDF in (10) represents a weighted sum of exponential variates each with parameter $\frac{\bar{\gamma}}{i+1}$. Hence, the average P_d for the SC diversity scheme, $\bar{P}_{dSC}$, can be evaluated as

$$\bar{P}_{dSC} = L\sum_{i=0}^{L-1} \frac{(-1)^i}{i+1}\binom{L-1}{i} \bar{P}_{dRay}\left(\frac{\bar{\gamma}}{i+1}\right) \quad (11)$$

IV.COOPERATIVE SPECTRUM SENSING

With a difficultdecision counting rule, the fusion center implements an n–out-of-M rule that decidesat thesignalgifthypothesiseach timeat leastk out of the N CR userselections indicate H_1. The probability of detection at the fusion center [25] is given by

$$P_d = \sum_{l=k}^{N} \binom{N}{l} P_{d,i}{}^l (1 - P_{d,i})^{N-l} \quad (12)$$

Where $P_{d,i}$ is the probability of detection for each individual CR user.

In AND-rule, if all the local selections dispatched to the decision maker are one, the final decision made by means of the decision maker is one. The fusion middle’s decision is calculated through logic AND of the received tough decision records. When OR-rule if someone of the local selections sent to the decision maker is a logical one, the final selection made through the decision maker is one. On the other hand, MAJORITY-rule, where half or greater of the neighborhood decisions dispatched to the selection maker are the final decision made with the aid of the selection maker is one.

V.SIMULATION RESULT AND DISCUSSION

All simulation was done on MATLAB over Rayleigh fading channel. This paper represents complementary ROC curves for different values of probability of false alarm and CR user where firstly, in Fig. 2(a) presents for complementary ROC curves with L-branch SC reception for u=5, N=4, SNR=20 as well as L=1, 2, 3 , 4 following AND rule. Secondly, Fig. 2(b) provides the complementary ROC curves with L-branch SC reception for u=5, N=4, SNR=20 in addition to L=1, 2, 3, 4 following OR rule. What's more Fig. 2(c) depicts the complementary ROC curves for L-branch SC reception where u=5, N=4, SNR=20 also L=1, 2, 3, 4 following MAJORITY rule. In this simulation, 20 dB and 5 are conserved for average SNR and U respectively. The simulated result is provided that OR rule has the betterperformance than others AND as well as MAJORITY rule.

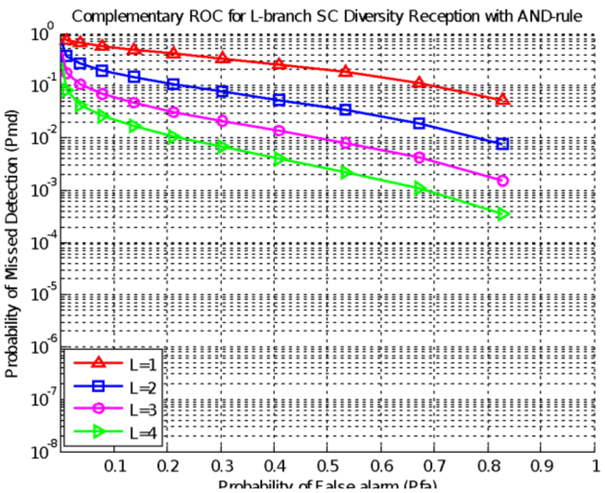

Fig. 2(a) Complementary ROC curves for L-branch SC reception (*u=5*, *N=4*, *SNR=20*, *L=1*, *2*, *3*, *4*)

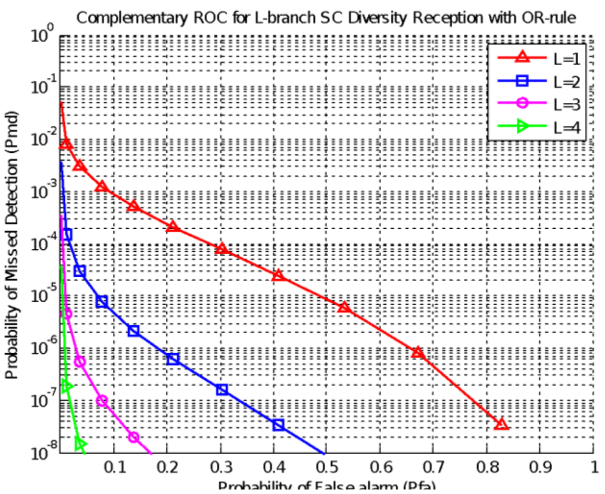

Fig. 2(b) Complementary ROC curves for L-branch SC reception (*u=5, N=4, SNR=20, L=1, 2, 3 , 4*)

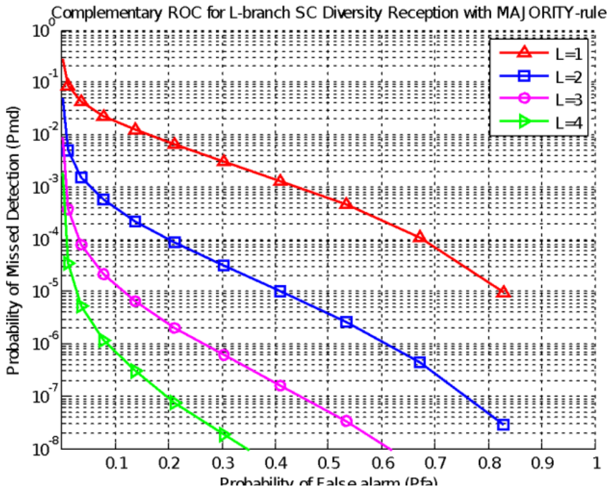

Fig. 2(c) Complementary ROC curves for L-branch SC reception (*u=5, N=4, SNR=20, L=1, 2, 3 , 4*)

Fig. 2(a), 2(b) and 2(c) show complementary ROC curves of the 4 user's spectrum sensing in Rayleigh fading following AND rule, OR rule and MAJORITY rule respectively. Fig. 2(a), it clearly depicts that the probability of false alarm increases under probability of missed detection where AND fusion rule is used for processing incoming data from the sensing element of the system. Otherwise, Fig. 2(b) indicates the probability of false rate decrease dramatically in case of probability of missed detection using the data fusion center for OR rule. Likewise, the figure clearly shows that suddenly changing the probability of false depends on several users which gives the desired results of OR rule. Eventually, in the last Fig. 2(c) presents the comparison of probability of false alarm for how much is increased with Fig. 2(a) & Fig. 2(b), Moreover in this case data fusion center uses MAJORITY rule for processing the received acknowledgement. The reason why compared among the simulated results, it is outlined that OR rule gives better performances than other fusion rules.

VI.CONCLUSION

This paper describes hard decision based cooperative spectrum sensing over Rayleigh fading channel for measuring the performance of cooperative spectrum sensing. It has been demonstrated that probability of missed detection is decreased by using different hard decision fusion rules where the OR rule has the better performance than others AND as well as MAJORITY rule in Rayleigh channels.

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