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RESEARCH ARTICLE

CENTRALIZED COOPERATIVE AND NON COOPERATIVE SPECTRUM SENSING USING ENERGY DETECTIONIN COGNITIVE RADIO

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ABSTRACT

In this paper we focus on spectrum sensing in cognitive radio to sense the presence of primary user and effectively use the available radio bandwidth. Cognitive users are allowed to share the licensed spectrum allotted to the primary user, when kept unutilized by it. Here energy detection technique is usedfor spectrum sensing overthe Rayleigh fading channel.Multiple cognitive radios actively participate to enhance the sensing capability of channel by collecting all sensed data at one central place. This collected data is processedand decision is made for the availability of spectrum, and thus can overcome the flaws of individual sensing. Comparison of cooperative and non-cooperative spectrum sensing for same number of cognitive radios is carried out under the centralized fusion procedure.

INTRODUCTION

The available radio spectrum is limited and it is getting crowded day by day as there is increase in the number of wireless devices and applications. The issue of spectrum under-utilization in wireless communication can be solved in a better way using Cognitive Radio (CR). It is a system capable of monitoring different radiofrequency bands and determines if there are unused portions. The Cognitive radio network then adapts to operate in the vacant bands [1]. The spectrum sensing mechanisms implemented by CRs should reliably detect the presence and absence of primary signals in real time. If the primary user is not using the available bandwidth then it should be allotted to secondary cognitive users, to increase the efficiency of network. Once cognitive radios detect the presence of a primary user in their operating band, they must vacate the band immediately, and must not hamper the primary users functioning. Hence, accurate spectrum sensing is an essential feature of CR systems.

The spectrum sensing can be carried out by different techniques like energy detector, cyclostationary feature detection, matched filter detection. As energy detector does not require any prior knowledge of channel under consideration and is very easy to implement at every cognitive sensing point. Hence energy detection technique has been considered over the Rayleigh fading channel [2].The individual sensing capability of any cognitive radio node may deviate from the expected outcome due to the effects of fading and shadowing.

Thus secondary cognitive radio failing to detect the presence of primary user may interrupt the transmission of primary licensed user and disturb the whole network. To overcome this problem a technique is used, where all the sensed data of each individual CR is collected at one centralized place and fused together. The output will give more precise information about the availability of vacant bands, and this information is shared throughout the network.

Depending upon the nature in which the data of each cognitive radio is fused at the central fusion center, cooperative and non-cooperative spectrum sensing techniques are considered.

Energy Detector

The sensing of signals through the radio environment which are intended for primary user is very challenging job. In this approach the energy of radio frequency channel or the received

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signal strength is measured to determine whether channel is busy or idle.

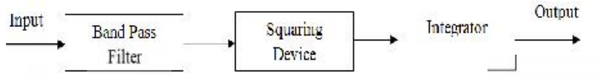

Fig. 1 Energy Detector

$$X(t) = \begin{cases} n(t)H_0 & \text{Primary user is absent} \\ h\,s(t) + n(t)H_1 & \text{Primary user is present} \end{cases}$$

Where $x(t)$ is signal received by CR, $s(t)$ is signal transmitted for primary user, $n(t)$is AWGN introduced and h is amplitude gain. In Energy detection the sensed signal is passed through band pass filter of bandwidth W and then squared to remove noise and integrated for time T interval, which gives a statistic value (Λ) this value is compared with predefined threshold value (λ). The probability of detection (P_d) = Prob($\Lambda>\lambda|H_1$) and Probability of false alarm (P_f) = Prob($\Lambda>\lambda|H_0$) can be calculated as follows [3].

$$P_f = \frac{r\left(N/2, \frac{\lambda}{2\sigma^2}\right)}{r(N/2)} \quad (1)$$

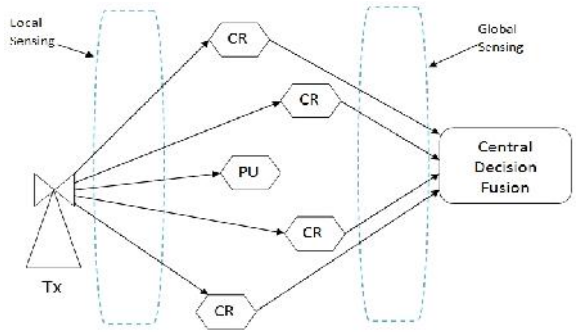

Fig. 2 Non Cooperative spectrum sensing: Cognitive Radios (CR) senses the radio channel by local sensing, intended for Primary user (PU) and sends the status of channel to central fusion block as global sensing.

$$P_{d,Ray} = e^{-\frac{\lambda}{2\sigma^2}} \sum_{i=0}^{N/2-2} \frac{\left(\frac{\lambda}{2\sigma^2}\right)^i}{i!} + \left(\frac{2\sigma^2 + a\breve{\gamma}}{a\breve{\gamma}}\right)^{N/2-1} \times \left[e^{-\frac{\lambda}{2\sigma^2 + a\breve{\gamma}}} - e^{-\frac{\lambda}{2\sigma^2}} \sum_{i=0}^{N/2-2} \frac{\left(\frac{\lambda a\breve{\gamma}}{2\sigma^2(2\sigma^2 + a\breve{\gamma})}\right)^i}{i!} \right] \quad (2)$$

Where $\Gamma(.\,,.)$ is incomplete gamma function, variance $\sigma^2 = 1$, a=1,N=2(TW) degrees of freedom and$Q_{N/2}(.\,,.)$ is generalized Marcum Q- function

Non -Cooperative sensing

To increase the sensing capability of individual cognitive radio all the cognitive radiosin the network send the sensed data to the centralized fusion center as shown in Fig.2. The transmitter is transmitting for the primary licensed user the channel is continuously monitored by all the cognitive radios for the free spectrum. When free spectrum is available all the CR's in the network send the sensed data to the fusion center and decision is made regarding the availability of spectrum.

The decision generated by each CR at local sensing is one bit decision {0, 1} is transmitted to the central decision fusion center transmitted in binary form. {0} indicated that primary user is absent and {1} indicates that primary user is present. At central fusion center one bit decisions of all the CR's are clubbed together using Eq. (4).Here H_1 and Ho is the processed decision of central fusion center whether primary user is present or absent.

$$Z = \sum_{i=1}^{K} D_i \begin{cases} \geq n, & H_1 \\ < n, & H_0 \end{cases} \quad (4)$$

In non-cooperative sensing all the CR's individually sense the radio spectrum and send the sensed data, they do not have any information of other CR's in the neighborhood. The channel is imperfect and position of each CR is different so all the CR's have different signal to noise ratio and threshold level. So there is ambiguity at the fusion center about the actual correctness of situation

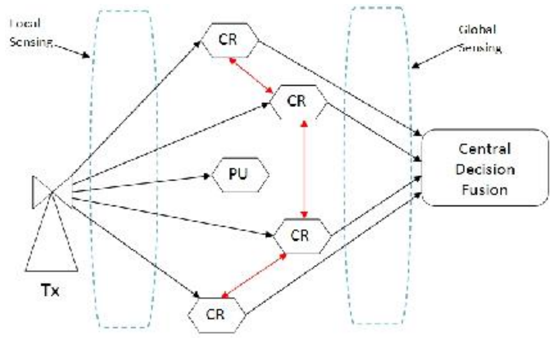

Fig. 3 Cooperative spectrum sensing: Cognitive Radios (CR) senses the radio channel by local sensing, intended for Primary user (PU) .Here each CR is sharing information with each other and then sends the status of channel to central fusion block as global sensing.

False alarm probability (Q_f) can be given as using Eq. (5) and Missed detection probability (Q_m) can be given by Eq. (6) for non-cooperative sensing [4][5].

$$Q_f = 1 - \prod_{i=1}^{K} \left[(1 - P_{f,i})(1 - P_{e,i}) + P_{f,i} P_{e,i} \right] \quad (5)$$

$$Q_m = \prod_{i=1}^{K} \left[P_{m,i}(1 - P_{e,i}) + (1 - P_{m,i}) P_{e,i} \right] \quad (6)$$

Where $P_{f,i}$,$P_{m,i}$,$P_{e,i}$ are the probability of false alarm, probability of missed detection and probability of error for local spectrum sensing of ith CR respectively.

Cooperative sensing

In cooperative sensing all the cognitive radios monitor the spectrum and send the sensed data to the centralized fusion center for processing, the same as explained for non-cooperative spectrum sensing. The difference is that here all the CR's are in synchronous with each other as shown in Fig.3.

Even though their positions are different they maintain same signal to noise ratio and threshold level, this leads to robust decision at fusion center. Considering the same threshold (λ) level at each CR, the false alarm probability (Q_f) and missed detection probability (Q_m) for cooperative sensing can be found using Eq.(7) and Eq.(8)

$$Q_f = 1 - \prod_{i=1}^{K} [(1 - P_{f,i})] \quad (7)$$

$$Q_m = \prod_{i=1}^{K} P_{m,i} \quad (8)$$

Where $P_{f,i}$,$P_{m,I}$ are the probability of false alarm and probability of missed detection for local spectrum sensing of *i*th CR respectively.

Fusion rules

The data send by all the cognitive radios in the network is collected at the central fusion center. This data needs to be processed and the fusion center has to come to conclusion regarding the availability of vacant spectrum. For this processing we are considering hard decision combining technique. In this technique one bit locally sensed data from each cognitive radio is collected and combined using k-out-of-N rule.

$$Qd = \sum_{l=k}^{N} \binom{N}{l} (P_{d,i})^l (1 - P_{d,i})^{N-l} \quad (9)$$

A. OR Rule: This rule determines the presecnce or absensce of signal when even one of of the user notifies the fusion center. This can be implemented by putting k=1 in Eq.(9) there by the Eq.(9) in the modified form is given by Eq.(10). OR rule is best when the decision threshold is very high.

$$\boldsymbol{Qd = 1 - (1 - P_{d,i})^N} \quad (\mathbf{10})$$

B. AND Rule: This rule determines the presence or absence of signal when all the users notify to the fusion center. This can be implemented by putting k=N in Eq. (9) thus the modified equation is given by Eq. (11). AND rule is preferred when the decision threshold is very small.

$$Qd = (P_{d,i})^N \quad (11)$$

C. MAJORITY Rule: This rule determines the presence or absence of signal when more than half of the users notify to the fusion center. This can be implemented by putting k= [N/2] in Eq. (9) thus the modified equation is given by Eq. (12). MAJORITY rule is preferred when the decision threshold is not known for surely.

$$Qd = \sum_{l=[N/2]}^{N} \binom{N}{l} (P_{d,i})^l (1 - P_{d,i})^{N-l} \quad (12)$$

Simulation results

A. Cooperative versus Non-Cooperative Sensing

A set of simulations is performed using energy detector for primary signal determination. The result of these simulations leads to concept of centralized fusion center, where all the data of each cognitive radio is combined together and depending upon the level of cooperation between cognitive radios the results differ. When we plot receiver operating characteristics of cooperative and non-cooperative spectrum sensing for false alarm probability (Qf) and missed detection probability (Qd), it can been seen that cooperative spectrum sensing has better performance compared to non-cooperative sensing.

It can be seen from Fig.4 that after increasing the signal to noise ratio the performance of system enhances but still cooperative sensing outperforms the non-cooperative sensing. For the Fig.4 non-cooperative spectrum sensing is carried out by using Eq.(5) and Eq.(6)by substituting $Pe = 10^{-1}$, and cooperative spectrum sensing is carried out using Eq. (7) and Eq. (8).

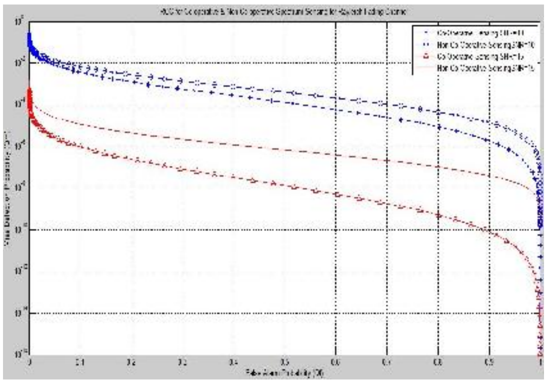

Fig.4 Receiver operating characteristics for Cooperative and Non Cooperative spectrum sensing over Rayleigh fading channel for SNR=10dB and SNR=15dB

B. Fusion Rules Implementaion

Considering the concept of centralized fusion center, we collect all the data from each cognitive radio and fuse that collected data at fusion center. The fusion is carried out by the considering the number of cognitive radios taking part in the decision process. Thus OR rule, AND Rule and MAJORITY rule is implemented using Eq. (10),Eq. (11),Eq. (12) respectively as shown in Fig.5.Here we have considered the cooperative spectrum sensing where all the cognitive radios share their sensed information with each other. Also it can be seen from Fig.5 that, OR rule has less error compared to other two. AND Rule has higher amount of error as it does not collect more data. Whereas MAJORITY rule is in between other two rules implemented but takes in to account more than half of the cognitive radio's decision for the final decision and this is best for the practical implementation even though it has some what has error compared to OR rule.

It can be seen clearly from Fig.5 that AND rules has better results when the detection threshold is low. Thus require all the neighboring radios data for the final decision. OR rule on the other hand has better results when the threshold is high. Thus only few or one neighboring radios data is considered for final decision. The MAJORITY rule is in middle of the other two rules and can work better even when the threshold is not too low or high, making this rule better than other AND rule and OR rule.

Considering the MAJORITY rule as the optimum for the practical implementation of centralized cooperative sensing, we can further analyze its working under different number of cognitive radios. This can be seen in Fig.6 that as we have more number of cognitive radios for the fusion process the total error rate goes on reducing, and we get more precise output of the presence of primary user. Thus the central fusion system has enhanced detection capability and can now assign any vacate free spectrum to secondary cognitive radios.

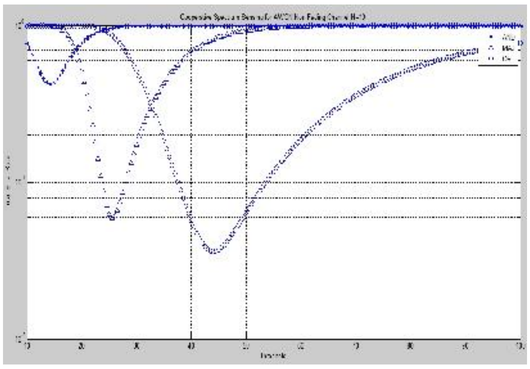

Fig.5. Plot of Threshold vs. Total Error Rate forimplementation of Fusion rules underCooperative spectrum sensing over Rayleigh fading channel for SNR=10dB and N=10

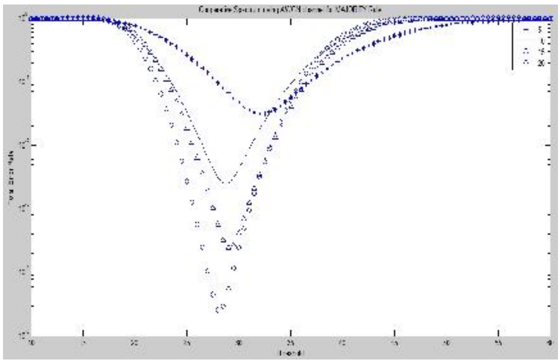

Fig.6. Majority Fusion rule implemented for Cooperative spectrum sensing over Rayleigh fading channel for SNR=10dB and N=5,10,15,20

CONCLUSION

In wireless communication spectrum is very valuable resource. Cognitive radio is one of the efforts to utilize the available spectrum more efficiently through opportunistic spectrum usage.

One of the important elements of cognitive radio is sensing the available spectrum opportunities. The new interpretation of spectrum space creates new opportunities and challenges for spectrum sensing. To overcome individual sensing issues like fading, shadowing and hidden node collaborative spectrum sensing is suitable. Cooperative spectrum sensing is considered the best for centralized spectrum sensing. Fusion rules are implemented like AND, OR, MAJORITY among them MAJORITY fusion rule is the best suitable for the practical consideration. More the number of cooperative radios the more robust the system will be.

References

1. Edward C.Y.Peh, *et. al.* , "Cooperative Spectrum Sensing in cognitive Radio Networks with weighted Decision fusion Schemes", IEEE Transactions on Wirelesscommunications, Vol.9, No.12, December 2010.
2. H. Urkowitz, "Energy detection of unknown deterministic signals," *Proc*
3. K. B. Letaief and Wei. Zhang," Cooperative communicatins for Cognitive Radio Networks", Proceedings of the IEEE,Vol. 97, No.5, May 2009
4. S.Atapattu, *et. al*, " Energy detection Based Cooperative Spectrum Sensing in cognitive radio Networks", IEEE Transactions on Wireless Communications, Vol.10,No.4,April 2011.
5. S.Chaudhari,L.Jarmo,V.Koivunen and H. Vincent," Cooperative Sensing With Imperfect Reporting Channels: Hard Decisions or Soft Decisions?", IEEE Transactions on Signal Processing, Vol.60, No.1, January 2012
6. Simon Haykin, "Cognitive Radio: Brain-Empowered Wireless Communications", IEEE Journal on Selected Areas in Communication, Vol.23, No.2, February 2005
7. Simon Haykin, "Cognitive Radio: Brain-Empowered Wireless Communications", IEEE Journal on Selected Areas in Communication, Vol.23, No.2, February 2005
8. W. Zhang and K. B. Letaief, "Cooperative spectrum sensing with transmit and relay diversity in cognitive radio networks," *IEEE Trans. Wireless Commun.*, vol. 7, pp. 4761-4766, Dec. 2008.

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