Power Allocation For Cognitive Radio Network In Joint Spectrum Sensing With Primary User Outage Constraint.

K.Divya

M.E 2nd Year Communication Systems

P.R Engineering College

Thanjavur,India.

divya1093.gk@gmail.com

A.Amudha

Communication Systems

P.R Engineering College

Thanjavur,India.

Abstract---The goal of this paper is to enhance the throughput efficiency of data transmission and reduces interference between the PUs and SUs .PUs may arrive on the channel any time If the PU claims the channel, the SUs have to leave the channel immediately. Therefore, data channels should be selected intelligently considering the PU's behavior on the channel and using some Priority Based Selection algorithms. Therefore USFR has been shown to effectively improve self-coexistence jointly in spectrum utilization, power consumption, and intra-cell fairness and we can calculate the data rate, throughput, efficiency using matlab simulation. Our work presented in this paper shows an initial direction towards the future research possibilities for the implementation of the CR for self-aware and self-organized adhoc wireless networks. The spectrum is a precious resource in Wireless communication

Keyterms-cognitive radio ,spectrum sensing ,location information ,power allocation ,joint spectrum sensing

I. INTRODUCTION

Recently, the technology of cognitive radio (CR) has captured the attention of many researchers in that it promises an effective way of enhancing spectrum usage and solving the problem of heterogeneity of radio devices. For the CR network, a fundamental issue is how to identify the spectrum opportunities. To improve the sensing performance, cooperative spectrum sensing has been proposed. With the conventional sensing method, every cognitive user conducts its individual spectrum sensing by comparing the observation with a pre-fixed threshold and then sends a binary local decision to the common receiver. In the paper, we introduce a novel spectrum scheme based on the trustiness factor (TF) and fussy decision. According to the energy detection, if the energy is located in the energy region with TF=1, then the cognitive user sends 1 bit quantization for reporting its sensing result. Otherwise, the cognitive user sends 2 bits quantization. A final decision therefore is made according to the reporting results. Simulation results show that the proposed sensing scheme outperforms the conventional method in terms of missing probability without noticeable loss in quantization performance.The rapid growth of demand for wireless transmission has placed great pressure on the scarce radio spectrum. Cognitive Radio (CR), introduced by Mitola [1], is a new radio system concept. It is an intelligent radio which is able to sense its environment, and adapt its physical operating parameters accordingly, to satisfy its system requirement. Cognitive radios are promising solutions to improve the utilization of the radio spectrum [2-3]. Using CRs, unlicensed (cognitive) users can make user of under-utilized licensed frequency bands without violating the privileges of licensed (primary) users. In CRs, cognitive users do not have pre-assigned frequency bands but they dynamically sense, find and operate in an available band without constraining the primary users. However, due to the fading of the channels and the shadowing effects, the sensing performance for one cognitive user will be degraded. To enhance the sensing performance, cooperative spectrum sensing has been proposed [4]. Considering that if every cognitive radio transmits the real value of it s sensing observation, infinite bits are required and this will result in a large communication bandwidth.

Recently, censoring sensors have attracted a lot of attentions in decentralized detection [5, 6]. In their systems, only the likelihood ratios (LR) with enough information are allowed to send to the common receiver. However, in [5], the quantization of the LR was not considered. In [6], although the quantization was taken in consideration, only the special case that the number of primary user was much small was observed. Cooperative spectrum sensing with 1 bit quantization was investigated in [7]. In [7], the average number of sensing bits decreases greatly at the expense of a little sensing performance loss. It was shown that two or three bits quantization was most appropriate without noticeable loss in the performance [8]. In this paper, we attempt to solve the problem of cognitive radio spectrum sensing through energy detection—if the energy is located in the energy region with *TF*=1, then the cognitive user sends 1 bit quantization for reporting its sensing result. Otherwise, the cognitive user sends 2 bits quantization. A final decision therefore is made according to the reporting results. Performance evaluations clearly reveal that the proposed sending scheme decreases the missing probability without noticeable loss in quantization performance.

II. TECHNOLOGY OF CR

Although cognitive radio was initially thought of as a software-defined radio extension (full cognitive radio), most research work focuses on spectrum-sensing cognitive radio (particularly in the TV bands). The chief problem in spectrum-sensing cognitive radio is designing high-quality spectrum-sensing devices and algorithms for exchanging spectrum-sensing data between nodes. It has been shown that a simple energy detector cannot guarantee the accurate detection of signal presence, calling for more sophisticated spectrum sensing techniques and requiring information about spectrum sensing to be regularly exchanged between nodes. Increasing the number of cooperating sensing nodes decreases the probability of false detection.

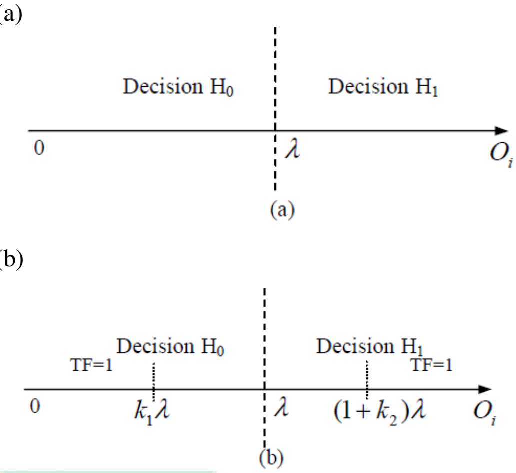
Filling free RF bands adaptively, using OFDMA, is a possible approach. Timo A. Weiss and Friedrich K. Jondral of the University of Karlsruhe proposed a spectrum pooling system, in which free bands (sensed by nodes) were immediately filled by OFDMA sub bands.

Applications of spectrum-sensing cognitive radio include emergencynetwork and WLAN higher thro ughput andtransmission-distance extensions. The evolution of cognitive radio toward cognitive networks is underway; the concept of cognitive networks is to intelligently organize a network of cognitive radio.

In wireless cellular networks, guaranteeing the user's QoS at the cell boundary usually also guarantees the QoS of all other users in the cell. Providing such QoS guarantees is usually a difficult problem to solve. Additionally, finding unused spectrum for the use of CR users is another hard problem in the design of CR systems.

III. SENSING SCHEME DESCRIPTION AND PERFORMANCE ANALYSIS

(a)



(b)

Fig.1. (a) Conventional spectrum sensing detection method (b) Proposed sensing detection scheme

In cognitive radio networks, convention cooperative spectrum sensing method is executed as follows. Every cognitive user conducts spectrum sensing individually using some detection method and then sends a binary local decision to the common receiver. Usually, the local decision is made by comparing the observation with a pre-fixed threshold. For example, the energy detection for the *i*th cognitive user is depicted in Fig.1 (a).When the collected energy *i O* exceeds the threshold λ , decision 1 *H* will be made which represents that the primary user is present.

Otherwise, decision 0 *H* will be made which judges that the primary user is absent.

In the proposed CFS Scheme, according to the energy detection, if the energy is located in the energy region with *TF*=1, then the cognitive user sends 1 bit quantization for reporting its sensing result. Otherwise, the cognitive user sends 2 bits quantization. A final decision therefore is made according to the reporting results. The scheme is illustrated in Fig.(b). Here, we introduce the concept of trustiness factor (*TF*), which means the decision trustiness extent. The spectrum sensing is conducted as follows.

Firstly, local decision is made. Every cognitive user *i*, for *i* = 1,*N* , executes spectrum sensing individually and collects the energy *i O* . When the energy *i O* satisfies ≤ ≤λ *i* 0 *O* , it means the absence

of the primary user with some value of *TF*, which satisfies

$$0 < TF \leq 1 \quad (1)$$

Then the local decision *i*,0 *D* will be made and sensing results will be reported to the common receiver. The local decision *i*,0 *D* , which is expressed by

$$D_{i,0} = \begin{cases} 0 & 0 \leq O_i \leq k_1\lambda \\ 01 & k_1\lambda < O_i \leq \lambda \end{cases} \quad (2)$$

where $0 < k1 < 1$.

Otherwise, when the energy $i\ O$ satisfies > λ $i\ O$, it means the presence of the primary user with some value of *TF*. Then the local decision i,1 D will be made and sensing results will be reported to the

common receiver. The local decision i ,1 D , which is given by

$$D_{i,0} = \begin{cases} 0 & 0 \le O_i \le k_1\lambda \\ 01 & k_1\lambda < O_i \le \lambda \end{cases} \qquad (2)$$

where $0 < k2 < 1$.

Secondly, a final decision is made. Assume that the M out of N local decisions reported from the cognitive users, it means the absence of the primary user. Then a

decision 0 H is made according to the following fussy judging

$$H_0 = \frac{\sum_{i=1}^{M} TF(i)}{M} \qquad (4)$$

Similarly, we assume that the P out of N local decisions reported from the cognitive users, it means the presence of the primary user. Then a decision 1 H is made according to the following fussy judging

$$H_1 = \frac{\sum_{i=1}^{P} TF(i)}{P} \qquad (5)$$

Then the final decision is obtained as

$$H = \max\{H_0, H_1\} \qquad (6)$$

Finally, we can draw the conclusion: the primary user is present or not..

Note that given an instantaneous

signal-to-noise

(SNR)γ , $i\ O$ follows the distribution [9]

$$f(O|\gamma) \sim \begin{cases} \chi^2_{2u}, & H_0 \\ \chi^2_{2u}(2\gamma), & H_1 \end{cases} \qquad (7)$$

where γ is exponentially distributed with the mean value γ , u is the time bandwidth product of the energy detector, 2 χ 2u represents a central chi-square distribution with 2u degrees of freedom and 2 (2)

2 χ γ u represents a non-central chi-square distribution with 2u degrees of freedom and a non-centrality parameter 2γ .

Let K represent the local decisions reported from the cognitive users and $K1$ denote the average number of sensing bits per cognitive user, i.e..

$K1 = K\ avg/N$ (8)

where $Kavg$ is the average number of sensing bits.

Then K can be expressed .by

$K1 = 1 + [P\{H0\}.\ P\{k1\ \lambda < O \le \lambda\}$

$+ P\{H1\}.\ P\{\ \lambda < O \le (1+K2)\}$ (9)

IV. DISTRIBUTED POWER ALLOCATION FOR COOPERATIVE ACCESS IN COGNITIVE RADIOS

The solutions of [4] and SDR [8] are centralized methods. They are not practical for the implementation CR systems which are decentralized. Distributed implementation of power allocation is important in CR systems for scalability reasons .Therefore, in this section, we provide a distributed algorithm for cognitive GMAG by using iterative Jacobian method. We suggest a distributed power ratio allocation for CR systems.

Lagrangian of is defined as,

$$L(\mathbf{x},\lambda) = \mathbf{x}^T(\mathbf{H} + \lambda\mathbf{G})\mathbf{x} + 2\lambda\mathbf{b}^T\mathbf{x} + \lambda\tilde{c} + z$$
$$0 \le \mathbf{x} \le 1. \qquad (10)$$

The solution of $L(\mathbf{x}, \lambda)$ exists in the following condition,

$$\frac{\partial L}{\partial \mathbf{x}} = 2(\mathbf{H} + \lambda\tilde{\mathbf{G}})\mathbf{x} + 2\lambda\tilde{\mathbf{b}}\mathbf{x} = 0. \qquad (11)$$

The problem is the same as solving linear system equation, inorder to solve this problem in a distributed fashion, we apply Jacobian algorithm

$$(\mathbf{H} + \lambda\tilde{\mathbf{G}})\mathbf{x} + \lambda\tilde{\mathbf{b}} = 0 \qquad (12)$$

$$(\mathbf{I} + \lambda\mathbf{H}^{-1}\tilde{\mathbf{G}})\mathbf{x} + \lambda\mathbf{H}^{-1}\tilde{\mathbf{b}} = 0 \qquad (13)$$

$$\mathbf{x} = -\lambda\mathbf{H}^{-1}\tilde{\mathbf{G}}\mathbf{x} - \lambda\mathbf{H}^{-1}\tilde{\mathbf{b}} \qquad 14)$$

Now, for the purpose of solving (13) in a distributed fashion,consider the following iterative power allocation procedure:

$$\mathbf{x}^{(n+1)} = -\lambda\mathbf{H}^{-1}\tilde{\mathbf{G}}\mathbf{x}^{(n)} - \lambda\mathbf{H}^{-1}\tilde{\mathbf{b}} \qquad (15)$$

Initialization

A primary MS at the cell edge broadcasts its SNR, $\gamma^{(target)}$, $g_p p_p$, and N_p.

A primary BS initializes $\lambda^{(0)}$, and $x_k^{(0)}$ and broadcasts $\lambda^{(0)}$, $x_k^{(0)}$, and $\sum_{j=1}^{N} \sqrt{g_j p_j} x_j^{(0)}$.

Secondary MS Power Allocation Algorithm:

Each MS updates power ratio until it converges.

At time (t)

$$x_k^{(n+1)} = \left[\min \left\{1, \frac{\lambda^{(t)}}{h_k p_k}\left((\gamma^{(target)} g_k p_k) x_k^{(n)} + \sqrt{g_k p_k}\Lambda^{(n)} + \sqrt{g_p p_p g_k p_k}\right)\right\}\right]^+$$

The primary BS broadcasts $\Lambda^{(n)} = \sum_{j=1}^{N} \sqrt{g_j p_j} x_j^{(n)}$.

When $x_k^{(n)}$ converges to $x_k^{(t)}$, MS transmit to primary BS with $x_k^{(t)}$.

Primary BS Algorithm:

Compute SINR with received power $x_k^{(t)}$ from all secondary MSs,

If $\gamma^{(target)} > \frac{\left(\sqrt{g_p p_p} + \sum_{k=1}^{N} \sqrt{g_k p_k} x_k^{(t)}\right)^2}{N_p + \sum_{k=1}^{N} g_k p_k (1 - (x_k^{(t)})^2)}$

Update $\lambda^{(t+1)} = \lambda^{(t+1)} + \Delta$

and broadcast $\lambda^{(t+1)}$ to each MS

Else

Stop

End

V. SIMULATION RESULTS

In the section, the performance of the proposed sensing scheme is investigated compared with the conventional method. The terms false alarm probability is denoted as *Qf* and the missing probability as *Qm* . Let *Pe i* , represent the reporting error between the *i*th cognitive user and the common receiver, for *i* = 1,□*K* . Without loss of generality, we assume *ei e P* =*P* , .

For performance comparison, here, we use *P* =0.5 Network of ten users are considered in the simulation and the average SNR between the primary user and any cognitive user is 10dB.

The average number of sensing bits per cognitive user *K1* versus the false alarm probability *Qf* is shown in Fig.2. It can be seen that, compared with the conventional detection method, there is no noticeable loss in quantization performance. Besides, for the same *Qf* , the quantization performance loss will become negligible with the probability *P* decreasing. Especially, when the value of probability *P* is near to zero, the two methods have the same quantization performance. That is, the conventional method is only a special case of our proposed sensing scheme.

The missing probability *Qm* versus the false alarm probability *Qf* is shown in Fig.3. It can be observed that, with the probability *P* decreasing, the missing probability *Qm* has a great decrease. That is because, with the probability *P* decreasing, the sensing results will become more and more credible. The missing probability *Qm* versus the false alarm probability *Qf* with reporting error is shown in Fig.4. It can be seen that the missing probability *Qm* has the similar changing trends as in Fig.3. The difference is that with the reporting error, the sensing performance becomes poor.

We consider a scenario where the primary MS employs IS-95, DS-CDMA to share a common frequency with the secondary CR system. We assume the cell structure as shown in Fig. 5, where a primary hexagonal cell covers small CR hotspots. Each MS's maximum power is assumed to be 10mW and bandwidth 1.2288 MHz. The COST 231 Hata urban propagation model is used for the channel gains between BS and MSs:

$$\begin{cases} 31.5 + 3.5\log(d), & \text{if } d > 0.035\text{ km} \\ 31.5 + 3.5\log(0.035), & \text{if } d < 0.035\text{km} \end{cases} \quad (16)$$

Table III, IV, V, and VI show some results demonstrating enhancements of cell edge user's QoS using cooperation of CRs. As Fig. 4 and 5 shows, there exists a primary MS at the boundary of the primary cell and a small secondary hotspot with secondary MSs within the primary cell. In Table III, we assume that there is only one secondary MS. Without cooperation of the secondary MS in the CR system, the primary MS's SNR is 1.7792 originally. When we set the target SNR of primary user to 1.7792, the super positioned SNR becomes 1.7792 and the power ratio of cooperation part of secondary MS is 0.2562 and data rate becomes 1.7661bps. However, if we set the target SNR to 3, which is higher than original SNR (1.7792), the super positioned SNR becomes 3.0019 but the power ratio of cooperation part in secondary MS is increased to 0.5502 to meet the primary MS's QoS improvement while secondary MS's data rate is decreased to 1.2941. Table IV, V, and VI show the numerical results when the numbers of secondary MSs are 2, 5, and 10 respectively. These numerical results illustrate that the QoS of cell edge users is improved by the cooperation of CRs.

TABLE I

THE SOLUTIONS OF POWER ALLOCATION RATIO

	Objective value
Semidefinite relaxation (SDR)	1062.8
P. Cheng's Method [4]	1062.6
Distributed Method	1061.6

TABLE II

SIMULATION PARAMETERS AND ASSUMPTION

Parameter	Explanation/Assumption
Cellular layout	Hexagonal grid
Primary Cell radius	1000 m
Cognitive Cell radius	100 m
Chip rate	1.2288 Mcps
Time slot length	0.625 msec

TABLE III

NUMERICAL RESULTS: 1 SECONDARY MS'S CASE

	Noncooperation	Cooperation
Primary SNR	1.7792	3 (Target)
Superpositioned SNR	1.7792	3.0019
Power ratio (x)	0.2562	0.5502
Secondary MS's sum data rate (bps)	1.7661	1.2941

TABLE IV

NUMERICAL RESULTS: 2 SECONDARY MSS' CASE

	Noncooperation	Cooperation
Primary SNR	1.7792	3 (Target)
Superpositioned SNR	1.7797	3.0001
Secondary MSs' sum-data rate (bps)	5.1403	4.9329

TABLE V

NUMERICAL RESULTS: 5 SECONDARY MSS' CASE

	Noncooperation	Cooperation
Primary SNR	1.7792	3 (Target)
Superpositioned SNR	1.7800	3.0002
Secondary MSs' sum-data rate (bps)	11.7319	11.7182

TABLE VI

NUMERICAL RESULTS: 10 SECONDARY MSS' CASE

	Noncooperation	Cooperation
Primary SNR	1.7792	3 (Target)
Superpositioned SNR	1.7796	3.0078
Secondary MSs' sum-data rate (bps)	17.8958	17.7004

VI. CONCLUSIONS

In this paper, we propose a novel spectrum sensing scheme for cognitive radios. We described the proposed sensing scheme and analyzed the performance characteristics of the scheme. Compared to the conventional sensing detection method,

simulation results show that the proposed scheme can decrease the missing probability without noticeable loss in quantization performance.

For further consideration, if we add one threshold or more, in some interval in fig.1 (b), then missing probability will reduce at the expense of the number of sensing bits increasing.

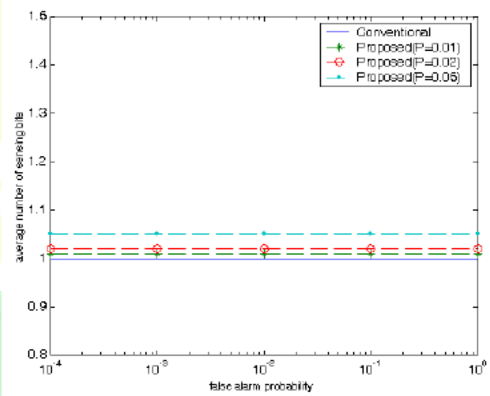


Fig.2. The average number of sensing bits per cognitive user K versus the false alarm probability Qf

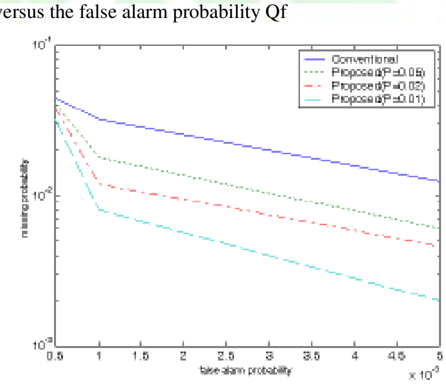


Fig.3. The missing probability *Qm* versus the false alarm probability *Qf* with no reporting error

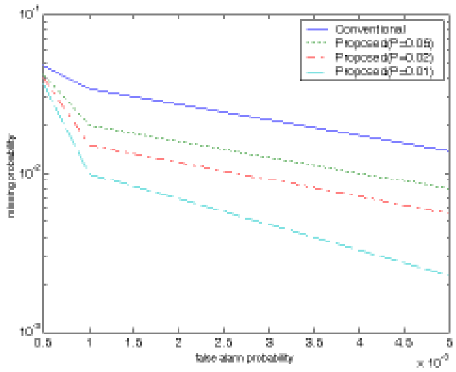


Fig.4. The missing probability *Qm* versus the false alarm probability *Qf* with reporting error = 10−5

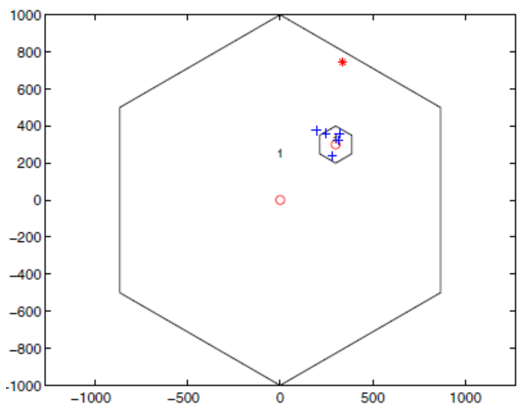


Fig 5.Simulation environment - large primary hexagonal cell covering small CR hotspots; 1 primary MS (red *) and 5 secondary MSs (blue +)

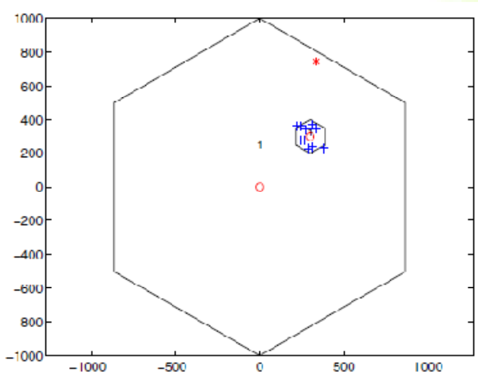


Fig6.1 primary MS (red *) and 10 secondary MSs (blue +)

.

VII. REFERENCES

[1] J.Mitola, □ and G. Maguire, Jr., "Cognitive radio: Making software radio more personal", *IEEE Personal Communications*, vol. 6, pp.13-18, Aug. 1999.

[2] S.Haykin, "Cognitive Radio: Brain-Empowered Wireless Communications", *IEEE J. Select. Areas Commun.*, vol. 23, no.2, pp.201-220, Feb, 2005.

[3] N. devroye, P. Mitran and V. Tarokh, "Achievable Rates in Cognitive Radio Channels", *IEEE Trans. Inform. Theory*, vol. 52, no.5, pp.1813-1827, May 2006.

[4] A. Ghasemi and E. S. SOUSA, "Collaborative spectrum sensing for opportunistic access in fading environments", in *Proc. Ist IEEE Symp. New Frontiers in Dynamic Spectrum Access Network*, Baltimore, USA, Nov. 8-11, 2005, pp. 131-136.

[5] C. Rago, P. Willett, and Y. BAR-Shalom, "Censoring sensors: a low communication-rate scheme for distributed detection", *IEEE Trans. Aerosp. Electron. Syst.*, vol. 32, pp.554-568, Apr. 1996.

[6] R. X. Jiang and B. Chen, "Fusion of censored decisions in wireless sensor networks", *IEEE Trans. on Wireless Commun.*, vol. 4, pp.2668-2673, Nov. 2005.

[7]S. Han, H. Kim, Y. Han, and V.C.M. Leung, "Cooperative access for cognitive radios to guarantee QoS for cell edge primary users," in Proc. of PIMRC 2009, pp. 496-500, Sept. 2009.

[8]S. Han, H. Kim, Y. Han and J.M. Cioffi, "Efficient Power Allocation Schemes for Nonconvex Sum-Rate Maximization on Gaussian Cognitive MAC," *IEEE Trans. Commun.*, vol. 58, no. 3, pp. 753-757, Mar. 2010