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Energy Efficient Cooperative Spectrum Sensing Method for CRAHNs Using Clustering with LLR

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ABSTRACT: Cognitive radio (CR) technology is invented to solve the problems in wireless networks resulting due to the scarcity of spectrum and due to the ineffciency in the spectrum usage by making use of existing wireless spectrum opportunistically. The cooperative spectrum sensing schemes exploit spatial diversity of the Secondary Users (SUs), to detect an unoccupied licensed spectrum. A Soft energy combining scheme provide optimal detection performance by aggregating the actual sensed information from SUs. Alternately, a hard energy combining scheme offers lower cooperation overhead in which only local decisions taken by SU are reported to the fusion center (FC). A Log-Likelihood Ratio (LLR) based cooperative spectrum sensing scheme in which each SU performs a local LLR based sensing test employing two threshold levels. Indeterministic region with two threshold level along with LLR is used to reduce the computational overhead. The detection performance of the proposed scheme is close to the soft combining techniques. In this work a energy efficient LLR based cooperative spectrum sensing method for CRAHNs with clustering is proposed. Clustering organizes nodes into clusters in order to provide network-wide performance enhancement. Generally there are three main advantages of clustering to CR networks , scalability, stability, and supporting cooperative tasks, such as channel sensing and channel access, which are essential to CR operations, and these advantages have led us to use the clustering in CR networks. Effectiveness of proposed strategy will be verified through simulation study on the basis of signal to noise ratio (SNR), probability of detection and energy consumption.

KEYWORDS: Cognitive Radio, Spectrum Sensing, Log Likelihood Ratio, Clustering

I. INTRODUCTION

In order to address the emergent problem of spectrum scarcity, the Federal Communications Commission (FCC) has recently approved the use of unlicensed devices in licensed spectrum. Dynamic spectrum access (DSA) techniques can be used to solve this current issue of spectrum inefficiency. This new area of research resulted in development of cognitive radio (CR) networks to further improve spectrum efficiency [2]. The basic idea of CR is that the unlicensed devices (also called cognitive radio users or SUs) needs to vacate the band once the licensed device (also known as a primary user (PU)) is detected. CR networks face unique challenges due to the high fluctuation in the available spectrum as well as differing quality of service (QoS) requirements. Basically the SUs look

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information ($s[k]_1^k$), and wireless channel effect (α_m) experienced by a particular SU m. These considerations make the system model very realistic, since in real CRAHNs these parameters are not known to the SUs. In addition, to the hypothesis H0 and H1, a SU uses a third hypothesis H2 which
represents the non-deterministic region, i.e.,

$$H2 : r_m[k] = \phi \alpha_m s[k] + n_m[k] \qquad (3)$$

here ϕ is the uncertainty factor which can have a value of 0 or 1. Assuming that the observations by all SUs are independent and identically distributed, and the channel conditions remain constant for a SI (K samples), the received energy measurements (E_m) by the mth SU can be given as:

$$E_m = \sum_{k \to 1}^{K} |r_m[k]|^2 \qquad (4)$$

For SNR calculation Let Es represents the symbol energy for a PU signal, then the SNR value of the PU signal that is experienced by the mth SU can be given as:

$$\gamma_m = \frac{E_s|\alpha_m|^2}{\sigma_n{}^2} \qquad (5)$$

Througout the work SNR means the SNR of the PU signal. Accordingly, each SU experiences distinct and independent SNR level of the PU signal, i.e., m = 1,2,…..M. The probability of false alarm (P_{fa}) and the probability of miss-detection (P_{md}) are vital metrics based on which the detection performance of a spectrum sensing scheme is evaluated. P_{fa} (P_{md}) is the probability of wrongly detecting the presence (absence) of a PU signal when it is actually absent (present). The preliminary goal of dynamic spectrum access is to improve the spectrum utilization; however a false alarm results in under utilization of the spectrum. Interference between the SUs and the PU is another crucial issue, which takes place as a result of a miss-detection. There is a tradeoff between P_{fa} and P_{md}, which is why the P_{md} is minimized for an acceptable level of P_{fa}.

$$P_{fa} = P(decision = H1|H0) = P\{d > \eta|H0\}$$
$$P_{md} = P(decision = H0|H1) = P\{d < \eta|H1\}$$

where*d* represents the decision (H0 or H1) based on a specific threshold value η , satisfying certain level of detection performance.

II. LITERATURE SURVEY

"CRAHNs: Cognitive radio ad hoc networks"Ian F. Akyildiz , Won-Yeol Lee, Kaushik R. Chowdhury.

Ian F. Akyildiz , Won-Yeol Lee, Kaushik R. Chowdhury.

This work showed that the Cognitive Radio (CR) technology is solution to the problems in wireless networksresulting from the limited available spectrum and the inefficiency in the spectrum usageby exploiting the existing wirelessspectrum opportunistically. In this paper, the properties and current research challenges of the CRAHNsare presented. Firstly some novel spectrum management functionalities such as spectrum sensing,spectrum sharing, and spectrum decision, and spectrum mobility are introduced from theviewpoint of a network requiring distributed coordination. More emphasis is givento distributed coordination between the CR users by the establishment of a common controlchannel. Moreover, the work studied the influence of all the functions above on the performance of the upperlayer protocols, such as the network layer, and transport layer protocols are investigatedand open research issues in these areas are also outlined.

"Implementation Issues in Spectrum Sensingfor Cognitive Radios"

DanijelaCabric, ShridharMubaraq Mishra, Robert W. Brodersen

In the paper, the new field of cognitive radios is explored witha special emphasis on one unique aspect of these radios spectrum sensing. The work motivated the strong need forsophisticated sensing techniques and established sensing to bea cross-layer function. Firstly, two key issuesare identified related to the cognitive radio- dynamic rangereduction and wideband frequency agility. The work also showed that the primary userdetection can further be improved by using advanced featuredetection schemes like cyclostationary detectors which also make use of the inherent periodicity of

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modulated signals. Further, it is shown that individual sensing is not adequate for reliable detection ofprimary users because of shadowing and multipath effects faced by the users. In sucha case cooperative decision making is shown to be the effective key to reducing theprobability of interference to primary users.

“A Weighted Linear Combining Scheme for Cooperative Spectrum Sensing"
SheerazAkhtarAlvia, Muhammad ShahzadYounisa, Muhammad Imranb and Fazal-e-Aminb
In wireless communication environment, SS can be affected by multiple issues like path loss, multipath fading,interference, shadowing, and receiver uncertainty. These issues make the detection performance unreliable whenSS is done individually. In cognitive radio ad hoc networks (CRAHNs), SUs are distributed in space experiencingdifferent environmental conditions due to spatial diversity. Thus, if sensing data from multiple SUs is combined then the detection performance can be improved significantly. The improvement achieved in DSA performance by exploiting spacial diversity of SUs is called cooperative gain. Comparatively, cooperative SS requires much lessertime for same performance than individual SS. Thereby, in cooperative SS SUs get more time for transmissions as a result the throughput is increased. The sensing data of every SU is not reliable, since in CRAHNs SUs do not experience same channel conditions. Thus, the sensing data should be combined based on the reliability factor of a SU that is referred as its weight. The received signal-to-noise ratio (SNR) of a SU strictly depends upon the wireless channel conditions. Thus, SNR can be an excellent candidate to evaluate the reliability of a SU’s sensed data. With keeping mind the reliability factor this work proposed soft energy and hard energy combining methods for spectrum sensing. In soft energy combining SUs report actual sensed data to the fusion centre (FC), which combines the data and estimate individual weight of each SU. In hard energy combining only one bit data depending on sensed result is sent to FC for combining.

“Cooperative Sensing among Cognitive Radios"
ShridharMubaraq Mishra, AnantSahai and Robert W. Brodersen
Cognitive Radios have been advanced as a technologyfor making the opportunistic use of under-utilized spectrum sincethey are able to sense the spectrum and use frequency bands if noPrimary user is detected. But the sensitivity is verydemanding while spectrum sensing since any individual radio might face a deep fade due to shadowing,multipath fading,path loss etc. A lightweight cooperation is proposed in sensing which is based on harddecisions to mitigate the sensitivity requirements on individualradios.The work show that the “link budget”, system designers have toreserve for fading is a significant function of the required probabilityof detection. Even a few cooperating users facingindependent fades are enough to achieve practical threshold levelsby drastically reducing individual detection requirements. Harddecisions perform almost as well as soft decisions in achievingthese gains. Cooperative gains in an environment where shadowingis correlated, is limited by the cooperation footprint (area inwhich users cooperate). With enough trusted cooperation, users only need to besensitive enough to deal with the nominal path loss. However,this requires cooperation among users facing more or lessindependent fading. Shadowing is likely to be correlated acrossspace. When correlation is distance-dependent, cooperation isdesired among more distant users.

III. METHODOLOGY

A. Clustering

Clustering is a technique to arrange the no of nodes in form of groups depending on different factors like distance of users from each other or the energy available or received at each secondary user. From each cluster one of the user is selected which acts as the clusterhead for that particular cluster. As the figure shows there may be different no of PU in the clusters formed whose presence is to be decided by SU. The formed cluster structure depends on the underlying network, like the location and channel availability (or whites paces) of the nodes. The SUs form three clusters (i.e. C1, C2, C3). The cluster heads (i.e. CH1, CH2, CH3) shown in the fig.1 acts as a information conveyer to the fusion centre for spectrum sensing, which is used in the Cognitive radio. Cluster head and the member nodes communicate with each other in every sensing interval among themselves.

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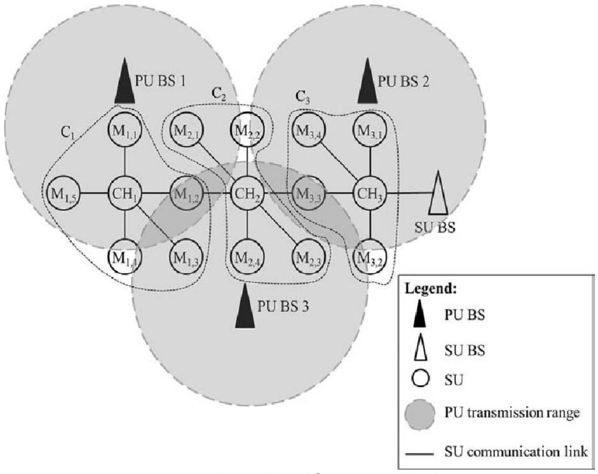

Figure 1Clusterheadformation[14]

of calculations to be done by the FC. As the FC is one of the nodes in the network with finite battery power supplied so it was not a feasible method.

Therefore to migrate the calculations from FC the LLR method is to be introduced. The LLR method is to be used at the cluster heads only. Depending on the indeterministic region the results which clearly show presence or absence of PU are reported to the FC. The local sensing calculation formulae at the clusterhead is given as follows

$$L_m = \begin{cases} -1 & LLR_m \leq \eta_{md} \quad or\ H_0 \\ +1 & LLR_m \leq \eta_{fa} \quad or\ H_1 \\ 0 & \eta_{md} < LLR_m < \eta_{fa} \quad or\ H_0 \end{cases} \tag{6}$$

At the FC results from every cluster heads are combined and final decision of presence of PU is taken and reported back to every SU. The decision criteria used is as follows

$$R_{SCH} = \frac{1}{M}\sum_{m=1}^{M} w_m L_m \underset{<H2}{\overset{>H1}{}} \eta_{SCH} \tag{7}$$

In this process the calculations to be done by the FC are migrated to clusterhead as shown in fig. 3 which ensures larger lifetime to the FC. The fig. 2 shows computational information flow from SU to the FC,

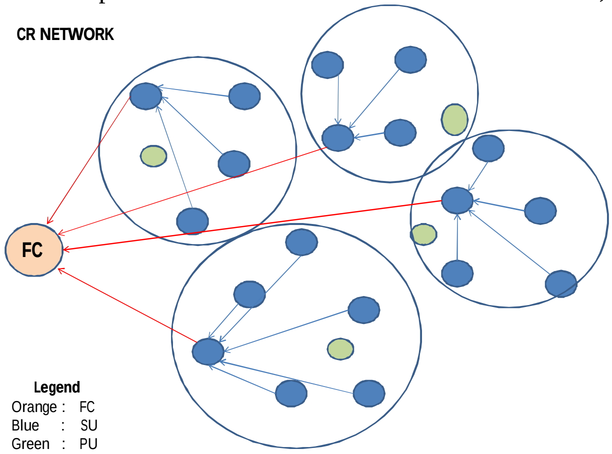

Figure 2 Computational overhead reduction (information flow)

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IV. SIMULATION RESULTS

Below fig.3 shows the graph between received power at the secondary receiver and probability density function

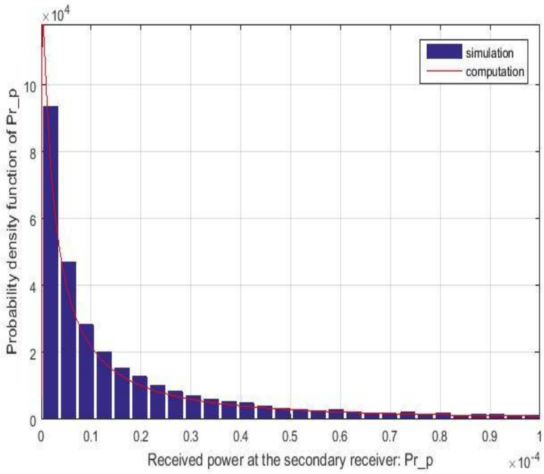

Figure 3 Probability density function

The SNR variation with respect to the probability of detection of secondary user is varied as shown in fig. 4 given below. The value os SNR is varied from -15 to 5.clearly from the graph it is observed that the method LLR with clustering(energy efficient cooperative) gives the improved result.

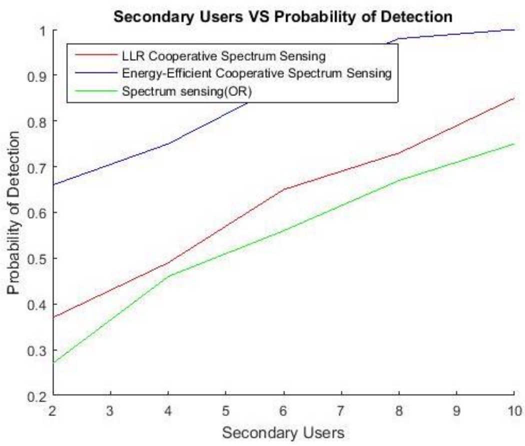

Figure 4No of Secondary usersvs Probability of detection

The simulation results also show that with the use of LLR the probability of detection is also improved because with LLR the extra overheads required for weight determination depending on the SNR are reduced.As a result of that energy efficiency is achieved.Fig. 4.shows that the energy efficient method shows better results for probability of detection than LLR only and OR method of cooperative Spectrum Sensing.

V. CONCLUSION

The time interval used to sense information for parameter estimation is reduced which further reduces the processing overhead.Fig 2. Shows that the parameter estimation process is migrated from the Fusion Centre to the clusterheads distributing the processing overhead among the clusterheads, as a result the Fusion Centre sustains for

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longer period.Making use of clustering the overall network is divided into clusters, a cluster headis selected among them, only that clusterhead from every cluster reports to the FC reducing the overall control channel overhead. The local data is only reported to the FC when the clusterhead is confident about its sensed information, which further reduces the control channel overhead. Fig. 4.shows that the proposed method better performance than the earlier one for same no of SU in the CRAHN.

REFERENCES

[1] S. A. Alvi, M. S. Younis, M. Imran, Fazal-e-Amin, and M. Guizani,"A Near Optimum Log Likelihood Ratio Based Cooperative Spectrum Sensing forCRAHNs",IEEE Transactions on Wireless Communication, Vol. No. 14, pp.7,3877-3887,2015.

[2] I.F.Akyildiz,W.-Y.Lee and K.R.Chowdhry. "Crahns:Cogntive Radio Ad-Hoc networks",Ad Hoc networks,Vol. No. 7, pp.5,810-836,2009.

[3] D. Cabric, S. M. Mishra, and R. W. Brodersen. ,"Implementation Issues in Spectrum Sensing for Cognitive Radios",38th Asilomar Conference on Signals & Systems andComputer, pp.1,772-776,2004.

[4] S.M.Mishra, A. Sahai, and R.W.Brodersen,"Cooperative Sensing Among Cognitive Radios ",Procedings of IEEE ICC, pp.4,1658-1663,2006.

[5] M. I. B. Shahid and J. Kamruzzaman,"Weighted Soft Decision for CooperativeSensing in Cognitive Radio Networks",procedings of 16th IEEE ICON, 1-6, 2015.

[6] I. F. Akyildiz,B. F. Lo, and R. Balakrishnanm,"Cooperative Spectrum Sensing inCognitive Radio Networks: A Survey",Physical Communication,Vol.no.4,pp.1,40-62,2011.

[7] S. S. Jeong,W. S. Jeon, and D. G. Jeong,"Collaborative spectrum sensing for multiuser cognitive radio systems",IEEE Transaction Vehicular Technology,Vol.no.58,pp.5,2564-2569,2009.

[8] S. A. Alvi, M. S. Younis, M. Imran, and F. Amin," A weighted linear combining scheme for cooperative spectrum sensing", Procedia Computer Science,pp.32,149-157,2014.

[9] Punchihewa, A. and Zhang, Q. and Dobre, O.A. and Spooner, C. and Rajan, S.and Inkol, R," On the Cyclostationarity of OFDM and Single Carrier Linearly Digitally Modulated Signals in Time Dispersive Channels:Theoretical Developments and Application", IEEE Transactions on Wireless Communication, Vol.no.9,pp.8,2588-2599,2010.

[10] Al-Habashna, A. and Dobre, O.A. and Venkatesan, R. and Popescu," SecondOrder Cyclostationarity of Mobile WiMAX and LTE OFDM Signals and Applicationto Spectrum Awareness in Cognitive Radio Systems,IEEE Journal on Selected Topics in Signal Processing, Vol.no. ,pp.1,26-42,2012.

[11] Rebeiz, E. and Fang-Li Yuan and Urriza, P. and Markovic, D. and Cabric,"Energy-Efficient Processor for Blind Signal Classification in Cognitive Radio Networks,IEEE Transactions on Circuits and Systems,Vol.no.61,pp.2,587-599,2014

[12] Kok-Lim AlvinYau, Nordin Ramli, Wahidah Hashim, Hafizal Mohamad,"Clustering algorithms for Cognitive Radio networks: A survey", Journal of Network and Computer Applications,pp.45,79–95,2014.

BIOGRAPHY

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