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Energy Efficient LLR based Cooperative Spectrum Sensing Method for CRAHNs using Clustering

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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 inefficiency 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 centre (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. In deterministic 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 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, Cooperative spectrum sensing, LLR, 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 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) need 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 that is unknown to the SUs represents the PU signal samples that are deterministic and unknown. The combined effect of fading, path loss and carrier phase, on the PU signal that is received by the m^{th} SU is represented by a complex variable m that is also unknown.

Thereupon, at each SU there are three unknown parameters: the noise variance (σ_n^2), signal data 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 whichrepresents the non-deterministic region, i.e.,

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

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 m^{th} SU can be given as:

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

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 m^{th} SU can be given as:

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

Throughout 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 underutilization 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}.

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

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

II. 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 cluster head 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.

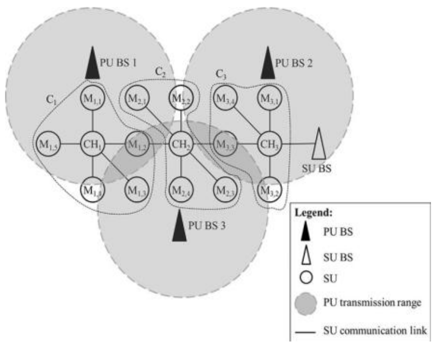

Figure 1Cluster head formation

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 cluster head is given as follows

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

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

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

In this process the calculations to be done by the FC are migrated to cluster head which ensures larger lifetime to the FC. The fig. 2 shows computational information flow from SU to the FC,

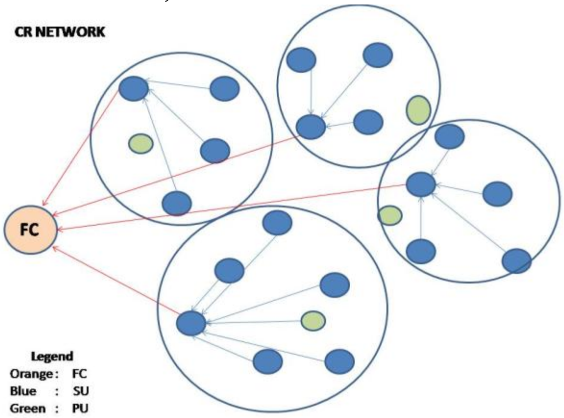

Figure 2 Computation/overhead reduction (information flow)

III. SIMULATION RESULTS

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

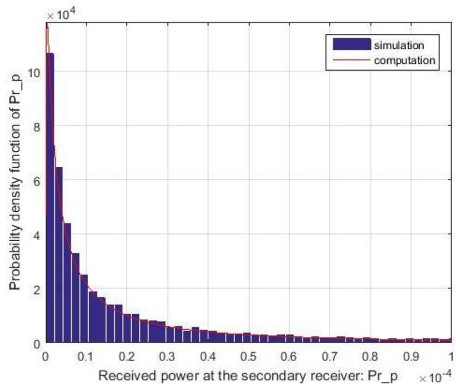

Figure 3 Probability density function

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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.

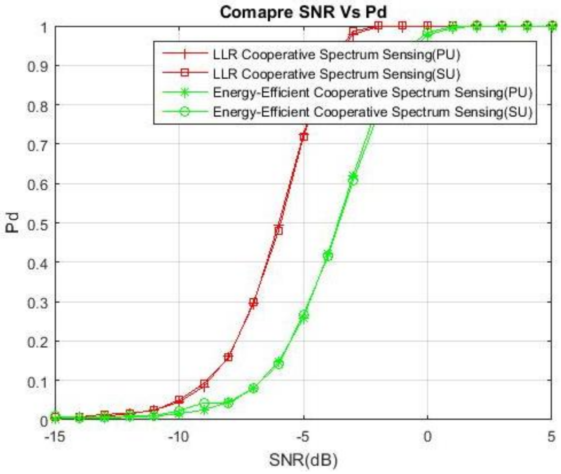

Figure 4 SNR vs Probability of detection

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. Finally the cluster formation is done based on the distance of each SU from the cluster-head and LLR is applied to cluster-heads so the overall calculation is reduced to small extent. As a result of that energy efficiency is achieved.

IV. CONCLUSION

The conclusions drawn from the implemented scheme are as follows

- First, time interval used to sense information for parameter estimation is reduced which further reduces the processing overhead.
- Second, the parameter estimation process is migrated from the FC to the Cluster head to distribute the processing overhead among the Cluster head, as a result the FC sustains for longer duration.
- Third, the network is divided using clusters, only the cluster head from every cluster reports to the FC reducing the overall control channel overhead.

Fourth, the local data is only reported to the FC when the cluster head is confident about its sensed information, which further reduces the control channel overhead.

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BIOGRAPHY

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