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# Survey on Reporting Channel Overhead Reduction in Cooperative Spectrum Sensing For Cognitive Radio Network

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**ABSTRACT-**

*Cooperative spectrum sensing is one of the effective methods used to improve the detection performance in the cognitive radio networks. In cooperative spectrum sensing one of the most challenging issues is cooperation overhead. In this paper a survey of various methods and aspects used to reduce the overhead are presented. Various kinds of reporting methods are studied and reviewed.*

***Key words:*** *SU,CSS,PU*

## I. INTRODUCTION

The fast growing wireless communication has led to the huge demand in frequency spectrum. In all over the world the radio spectrum is controlled and allocated by the government agencies between different users. Most of the studies have shown that the allocated spectrum is underutilised .i.e. not used by the licensed users all the time. It is idle for the most of the time there are many unused spaces in the allocated spectrum and they are called the white spaces.

Cognitive radio is a promising technology which is used to manage the white spaces and used to control the radio spectrum scarcity. Cognitive radio enables the usage of spectrum by filling the spectrum holes, which are not used by the licenced user called as the primary user. Theunlicensed user or secondary users are those who opportunistically attempt to access the channel when the primary user is not using it.[1]

The major work or problem of the secondary users is to identify the white spaces or spectrum holes. The process of detection of spectrum holes is termed as spectrum sensing. The presence or the absence of the PU is observed and detected by the spectrum sensing method.

Three major techniques are extensively used in spectrum sensing theyare Energy detection method, matched filter method and cyclostationary detection method. The performance of the Spectrum sensing is determined by two factors probability of false alarm and probability of detection. Probability of false alarm is the probability of identifying the spectrum is busy when its actually free. Probability of detection is the probability of identifying spectrum is busy when its actually occupied by primary users.

In spectrum sensing the secondary user continuously monitor the frequency spectrum and detect the vacant channels for use. The spectrum sensing can be broadly classified into distributive sensing and cooperative spectrumsensing. In distributed type of sensing, the Sus performances are mainly affected by multipath fading, receiveruncertainty problems and shadowing. This will significantly affect the affect the performance and throughput of the CR system. To overcome this Cooperative spectrum sensing is used; IN this method individual secondary users identify the spectrum holes by local sensing and the secondary users exchange or sending information to the fusion centre or SU base station. The fusion centre will then make decision about the presence are absence of the Pus by using any of the decision rules. The decision rules may be hard combination rules or soft combination rules.

By this way of combined decision method more accurate sensing results can be obtained than that of the individual decision. Moreover the detection probability performance is also increased and the false alarm probability will be reduced. However the performance of the cooperative spectrum sensing is limited by the Cooperative gain and cooperative overhead. The limitation in cooperative gain may affect the user selection for cooperation in CSS.[5]

The extra sensing time, delay, and the operations that are performed for CSS are termed as cooperative overhead.

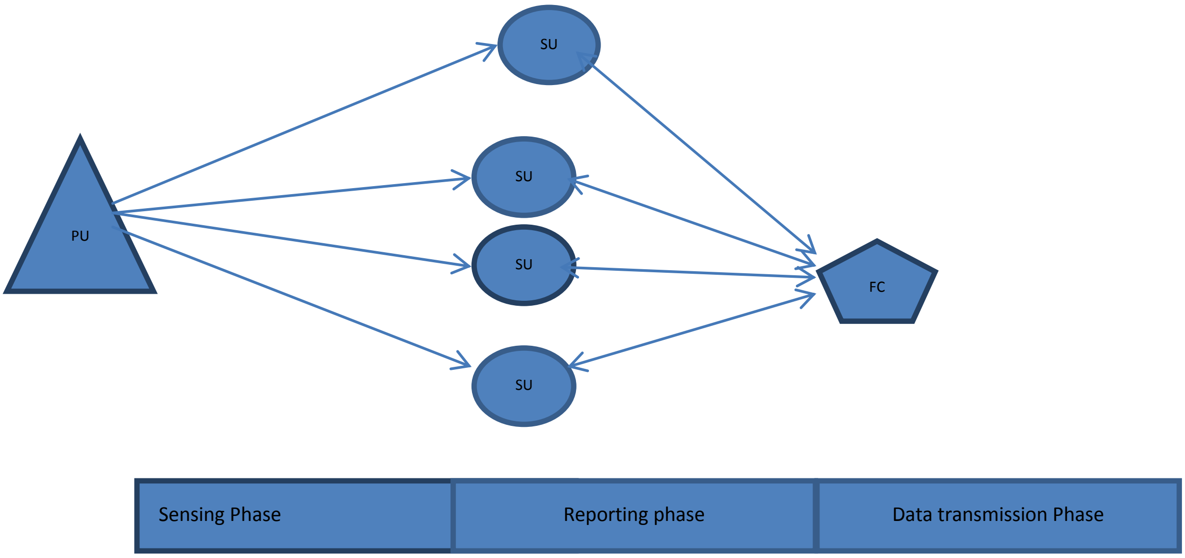
In this paper we aim to survey various types of reporting mechanisms which are tend to reduce the cooperation overheadinturn improve the energy efficiency. Energy efficiency can be achieved from sensing methods and balancing the reporting process. Here we are discussing about various methods the used to reduce the overhead and improve the energy efficiency by implementing various reporting methods.

In centralized cooperative CR network, the performance of cooperative sensing will be better if more SUs participate in reporting to the FC. But this increase in the number of reporting SUs increases the required reporting time which in turn reduces the data transmission time. Most importantly it increases the number of cooperative SUs overhead. Thus, the trade-off between reporting overhead and achievable throughput of the secondary users becomes an important research issue. In this paper we are focusing and surveying the various methods used to reduce the reporting overhead in CSS.

The remainder of the paper is organised as, Section I gives the introduction about the spectrum sensing in cognitive radio and Section II gives the concept and details about the cooperative spectrum sensing and also various methods to reduce the reporting overhead.

## II. COOPERATIVE SPECTRUM SENSING

The cooperative spectrum sensing is used to increase the sensing performance. The operation of CSS is divided into 3 major parts,Sensing,Reporting and decision makingIn the sensing phase all the nodes present in the network locally senses the PU signal, and identify the availability of PU.




Then during the reporting phase, the observed sensing results from individual nodes are sent to the fusion centre (FC) .During the decision period The FC determines the PU presence or absence by combining the results reported by the individual SUs and it's called as global decision. For making this decision the FC may use hard combination methods (eg:OR rule, ANDrule out of I rule)or soft combination method. The reporting of the decisions made by all the SU nodes may made by two ways first method is by using centralized Time division Multiple Access method and the second method is by random access reporting scheme.in the first method all the SU report their local result on its own allotted time slot. While in the case of random access method the reports were sent without any coordination.

The evaluation of the performance of the CSS may be done by using various metrics; they are detection accuracy, energy consumption, and throughput.

*Detection Accuracy*

This detection accuracy can be measured by two parameters i) detection probability and ii) false alarm probability. The complementary of the detection probability is termed as miss detection probability.The accuracy of the detection is measured by total error probability,which is the sum of false alarm and missed detection probability.

*Energy consumption*

It is defined as the average energy consumed during local sensing by all secondary users, reporting the results to FC and data transmission. It's mainly depends on the detection accuracy and sensing time.

*Throughput*

It is the measure of average successful transmission of data from each secondary users.the achievable throughput directly affects the detection accuracy

The achievement of energy efficiency may be done in reducing the sensing time or reducing the reporting time by reducing the overheads .In this paper we are focusing on various approaches towards the energy efficiency by reducing the reporting overhead.

### *A. Bayesian Detector Based Superior Selective Reporting Mechanism*

The major contribution of this paper is to detect the presence of the primary user, for local decision in the CSS, instead of energy detection which is the most common and widely used method, Bayesian detection approach is used. Simulation results shows that it has improved spectrum utilization and improved throughput.[6]

In traditional CSS reporting mechanism all the Sus has to report the decision to the FC, this will increase the reporting overhead and also time consuming. Moreover the sensing sub slots are also equally divided as $\tau$, this also leads to increase in sensing time and energy consumption .This can be reduced by the Superior selective reporting method. This method introduces two sensing time allocation factors $\eta$ and $\beta$.The sensing and reporting phase is divided into $T0$, $T1$ and $T2$. T0 and T1 uses ($\eta\beta$T) and T2 uses the remainder of the time

$(1 - 2\eta)\beta T$, $\beta T$ where $(0 < \eta < 0.5)$.

Step1:

For time T0-Only centre SU performs the Spectrum sensing, remaining Sus are are not allowed to make their decisions

Step2:

If Centre SU detects the presence within the time T0 ,then it broadcast the notifications to other Cooperative Sus.

Step3

If the Centre SU fails to detect the Primary user then each Cooperative Sus independently performs the local decision within the time T1.

Step 4:

In Random selective reporting(RSR) any one of the Sus is randomly chosen and it will report the decision to the FC.

Step5:

In Superior Selective Reporting (SSR),The SU which is having highest SNR is selected for reporting.

### *B. Two Stage Reporting Mechanism*

In this method the reporting process is actually divided into two stages as by its name, dedicated reporting with L1 channels and Contention based reporting with L2 channels.

Total no of reporting channels=L=L1+L2<=N

N-No of Sus

In the traditional method the number of reporting channel increases linearly with increase in Sus.

Step1:

The FC randomly selects L1 number of Sus for reporting by using their dedicated reporting channels.

Step2:

The remaining N-L1 Sus report their local decisions With random access probability by using the L2 contention based reporting channels.

Step3:

Based on the decisions from two reporting channels the FC makes a final decision as follows

$$\phi_{FC} = \begin{cases} 1, & \sum_{i=1}^{L_1} \varphi_i + n \geq k \\ 0, & \sum_{i=1}^{L_1} \varphi_i + n < k \end{cases}$$

From the performance analysis, it is concluded that this two stage method improves the throughput with affixed number of reporting channels.

### *C. Reporting Channel Design Based On Random Access Protocol*

This paper introduces a channel design method to improve the throughput and improve energy efficiency, which can be reduced because of collision that occurs during the reporting phase of the CSS.Introducing the random access based reporting channel for reporting the decision made by individual Sus to the FC.This protocol helps to provide a simple reporting channel with good channel utilization. A multi-channel slotted aloha protocol is used to send the Sus sensing reports and the FC uses the K out of n rule for making final decision about the presence or absence of the PU. The cooperative sensing has two phases, Detection phase and reporting phase. The channel or slots are also divided into sensing and reporting slots. If there are N reporting slots for SUS then the multichannel slotted protocol is used in the reporting slots. By the way of reducing collisions the channel utilization is improved intern improvises the energy efficiency.

### *D. Amplify And Forward Relay Assisted Cognitive Radio Network*

The system model consist of three SU nodes, Single secondary source(SUS),single secondary destination(SUD) and AF Relay node to assist the transmission between source and destination. The main objective of this method is to maximize energy efficiency and maintaining less amount of interference to the primary user.

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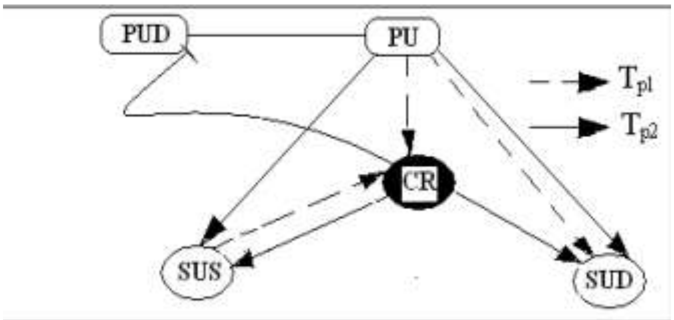


The AF relay is used to transmit the spectrum sensing information and data .SS and data transmission are done by frame basis. The entire frame is divided into equal two intervals termed as Tp1 and Tp2.

In the First phase the CRN looking for the existence of PU, If PU is not present then SUS sends its data to CR duringTp1.If PU is present then no transmission will takes place.During the second phase Tp2 amplification of the received signal at Tp1 takes place with a gain of $\sqrt{\beta}$This forwarded amplifying signal reach both SUS and SUD.

Relaying can be formulated as an optimization problem, which is used to maximise the Energy efficiency with a constraint to protect PU and maintaining a level below the predefined threshold of interference to PUD. This paper achieves the energy efficiency by amplify and forward relay assisted method.

### E. GROUP BASED MULTI BIT REPORTING METHOD

This group based CSS plays a trade-off between the sensing performance and the Reporting overhead. The reporting time is fixed regardless of the number of secondary users. Also SU send only 1 bit of information instead of sending multibit quantization information.

In general the reporting consists of dedicated reporting and contention based reporting.

When the numbers of users are very small, all their Sus report their results through dedicated channel. If there more number of Sus then the contention based channel is used for reporting.

Step1:

Among the k Sus *βd Sus* are randomly selected, and they has to report $\log_2 M$ bits through dedicated reporting channel if their signal energy level is greater than the λ0

Step2:

The remaining (K-*βd) are* classified into N groups based on their local decision values and sent via their minislots

Step 3:

The FC will capture the strongest received signal among multiple signals. The FC only counts the successful reports from each slot and each slots are mapped into each groups.

From the numerical analysis of the above scheme it is observed that the proposed CSS scheme improves the average throughput by approximately 40*:*4%, 27*:*7%, and 25*:*2% in comparison with the maximum throughput of the conventional CSS schemes based on the OR rule, *n*-out-of-*K*rule, and multi-bit combination rule, respectively.

### F. LIMITED REPORTING METHOD

This method concentrates on multi band CSS which uses soft combination method. This method mainly focuses on the reduction in overhead for multiband CRs.In the case of conventional method in multiband CSS, all the Sus has to report about all the bands to the FC.This will take total reporting time as Tr=K.N.τr;K=number of Sus;N=Number of primary bands and τr is the duration for one reporting slot.

The new limited overhead method is proposed to reduce the reporting overhead. In this new method FC selects randomly k Sus for reporting instead of K Sus .Also each Sus are supposed to sense only n number of bands instead of N number of actual bands. Now the total report time becomes Tr=k.n.τr,which is small as compared with the conventional method.

One of the crucialparts in this design is selection of k and n value,because if it is too low reduce the reporting time but Detroit the sensing performance. They are chosen adaptively under the constraint of detection probability. From the results or may be observed that the limited reporting method increases the average capacity of secondary users by 21% in comparison with that of the conventional method.

### G. EFFICIENT REPORTING AND ACCUMULATING METHOD

This is the combination of EER(Energy efficient reporting) and ERA(Energy efficient accumulating) method.ERA reduces the signalling overhead and energy consumption during the reporting period. In EER scheme the reporting reduction of overhead can be done by avoiding the uninformative local decisions In EEA scheme the total reporting can be terminated on receiving the result which shows the presence of primary user. But by the above said two methods didn't reduce the sensing time. To avoid the collision problem encountered during the reporting time GR(Gaussian retreat scheme) algorithm is proposed and to reduce the overall sensing time DSP(Differentiated signalling period) algorithm is proposed.

The principle of ERA scheme follows the following steps.

Step 1: Sensing Process

Initially DSP based sensing is performed.in that method a value $N_i$was found by considering detection and false alarm probability.Each secondary user has different sensing period and they report the results after getting all $N_i$ values.But if more than one secondary user have the same $N_i$ value ,they are likely to produce some unavoidable collisions. This can be treated by GR algorithm.

Step 2: Reporting process

A retreat time was randomly generated; after this retreat time the locally generated reports were send to the FC by adopting the EER scheme.

Step3: Decision making process

Decision can be made by EEA scheme .For making the final decision here OR rule is used.

From the simulation results it has been observed that by comparing with our conventional method. This ERA with retreat method improves its energy efficiency by 104% and the spectrum utilization is improved byb38.5 %.

## III. CONCLUSION

Cognitive Radio is one of the promising technologies to aid the demand for spectrum in various wireless communication applications. It plays a vital role in efficiently utilizing the spectrum. In this paper various methods to reduce the reporting overhead was studied. To achieve energy efficiency the reporting overhead should be reduced.it can be reduced by taking the detection accuracy as a constraint. Some of the methods were discussed above.

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