Cooperative Clustering Performance Enhancement Using Genetic Algorithm in CRNs

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Abstract

Cognitive radio (CR) is a substantial technology for spectrum utilization in wireless communication networks. Cooperative Spectrum Sensing (CSS) has been ensured to enhance the performance of detection for cognitive users in the existence of spectral variation, moreover, it tends to be an essential section in Cognitive Radio Network (CRN) due to being fit for decreasing the probability of bumble in blurring channels. Generally, cooperative clustering in spectrum detection is consolidated to limit Jostle of revealing channel, update execution of sensing and decrease the computational use. In this research, the proposed co-operative clustering in CRN using optimization scheme (Genetic) constrains the total power wasted by CRN and time delay. Therefore, the simulation analysis demonstrates that the proposed scheme able to accomplish preferred energy gains less over the traditional cooperative scheme, lessen delay time and upgrade the total performance of CRN.

1. Introduction

CR is a versatile, intelligent radio system innovation that can consequently recognize accessible channels in a wireless spectrum and exchange the sending parameters empowering more communications to run simultaneously and furthermore enhance radio working behavior [1, 2]. CR clients are named as Secondary Users (SUs) that can access the authorized spectrum at the same time but transiently unexploited range [3]. From this point of view, system throughput is improved and also the spectral efficiency is upgraded.

Spectrum Sensing (SS) is environmental awareness capability enabling for cognitive radio to detect temporarily vacant spectrum bands. Energy Detection (ED), Matched Filter Detection (MFD) and Cyclo stationary Detection (CD) [4,5] are the most substantial spectrum detection algorithms. They had been introduced for a solitary SU to locate the PU.

Even though ED isn't ideal contrasted with others, it is applied because of not requiring predefined data of the PU and easy to implement. consistent with propagation troubles like fading, mutilation, and shadowing that are addressed as an issue in wireless communication, the detecting performance of a single SU isn't regularly extraordinary. Subsequently, CS in radio spectrum had been presented [6].

CSS can be overcome the fading and shadowing issues because it has a massive effect a single CR user and promotes the performance of SS [6,7]. Therefore, CSS can be used to enhance the reliability of the detection of PU signals, but CSS cause a huge transmission overhead connection [8]. Hence, the clustering approach based on CSS is applied in CRN in order to improve the performance of sensing. The SUs are parted into small groups called clusters so, the highest user power is chosen as the cluster head (CH). CH job is to report final cluster results to the FC [9]. This approach gives less time overhead and improvement in detection probability, also, lessen packets disputation in the channel.

The main contributions of clustering in CRNs [10] are scalability, stability and supplying co-operative tasks, like sensing and accessing the channel. The co-operative clustering tasks are essential to CR executions. Though there are found many advantages of using clustering in CRNs, challenges of clustering are found.

In [11], clustering is done using distributive clustering algorithm. An optimal number of groups is obtained using “K out of N rule” [12]. The largest control channel gain sensor is selected as the group head. The only total error rate of the CRNs is improved but power consumption is still high. The weighted based cluster in [13] without utilizing the regular control channel. The execution of this protocol is assessed by different parameters as message overhead and number of bunches. The contributions of this manuscript can be summarized as follows:

- Cooperative clustering scheme in CRNs is analyzed and discussed.
- Closed formulas for co-operative clustering dissipated energy are used with applying GA.
- The proposed scheme enhances the performance of the SS and minimizes the total consumption energy and delayed time the CRNs.

Whatever is left of this paper is sorted out as follows: In Sec. 2, the cooperative SS in CRN is introduced. In Sec.3, proposed cooperative clustering using GAin CRN approach is presented. The simulation and analysis results are discussed in Sec.4. Finally, conclusions are made in Sec. 5.

2. The COOPERATIVE SS in CRN

It means that data from several Cognitive radio users have cooperated for PU detection. Practically a lot of factors, for example shadowing, multiple paths fading, and the uncertain detection problem [14] can cause a big effect in the detection performance of SS. The essential objective of cooperative SS is to improve detection performance. CR users work together with one another and share their detecting data, therefore a joined decision is done to be more exact than the individual choices [15].

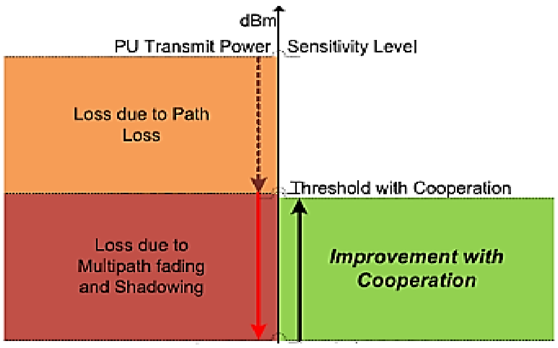

Fig. 1 The Sensitive enhancement in CSS[16].

The CSS is classified into three main categories based on how cooperating CR users share their sensing data in the network: centralized [16], distributed [17], and relay-assisted [18]. These major types of co-operative sensing are illustrated in Fig.2

The CRs energy consumption is given by,

$$E_R = \begin{cases} S\,E_e + S\,E_{fs} L^2 & if\ L \leq R \\ SE_e + S\,E_{mp} L^4 & if\ L > R \end{cases} \quad (1)$$

where L represents the transmission distance between FC and the SU, E_e is the power for sending or receiving a signal, Sis the signal length. L^2 and $L^4$are the path loss, and the multipath fading loss respectively. Finally, R is calculated from,

$$R = \left(\frac{E_{fs}}{E_{mp}}\right)^{0.5} \quad (2)$$

E_{fs} and E_{mp} are defined as the transmission power amplifier to getthe bestsignal to noise ratio (SNR). The energyconsumed by co-operative CRs is

$$E_{coop} = N \times (E_{sensing} + E_R)$$

$$= N \times (SE_e + SE_{fs} L^2 + E_{sensing}) \quad (3)$$

where $E_{sensing}$ is the sensing energy for PU and N is the number of CRs.

3. Proposed CO-OPERATIVE CLUSTERIN in CRNs using GA.

All cognitive nodes of the whole cognitive network are partitioned into several clusters. So as to choose the Cluster Head (CH) in each cluster [10,19], firstly the cognitive radio distance nodes are determined in every cluster to FC, after that the CRs with the highest power and the shortest distance from FC is selected to be the CH. The main job of CH is to send the co-operative sensing result of the cluster to the FC. The importance of the clustering approach not only ensuring the accuracy of the information sent but also saving the channel transmission bandwidth.

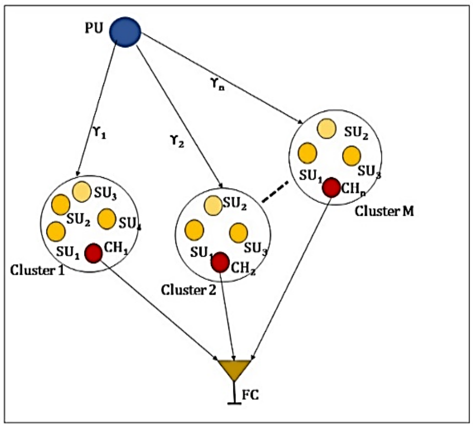

Fig. 3 Generalco-operative clustering SSmodel.

Clustering Co-operative Sensing (CCS) technique is shown in Fig.3where one PU exists alone in the proposed CRN. Also, certainly one fusion focus (Fusion Center-FC)and The N of SUs are assumed to be distributed consistently in a squared area.In fact, different fading characteristics and several reporting channel gain cause a big problem to the CR users. Therefore, the channel among CRs can be viewed as an ideal as they are closed from one another and in the same cluster. The final dissipated energy in the clusteringCRN is denoted by:

$$E_{TOTAL} = E_{SETUP} + NE_{Cluster} \quad (4)$$

$$E_{TOTAL} = E_{SETUP} + (N + M)E_{sensing} + (2N)SE_e + NSE_{dc} + MSE_{mp} L^4 + 0.159(N)SE_{fs} \frac{L^2}{M} \quad (5)$$

In which, E_{dc} determines the consumed power in data collection.

The closed energy formula in culster for co-operation in CRN is denoted by:

$$E_{TOTAL} = \alpha + (N + M)E_{sensing} + MS\,E_{mp} L^4 + L^2(N)S\,E_{fs} \quad (6)$$

where $\alpha = E_{SET\ UP} + (2N)S\,E_e + NS\,E_{dc} = Const$

The primary thoughts of Genetic Algorithm (GA)based on Darwin's hypothesis of development. These thoughts are then grasped to the computational calculation to find answers for given target work in an improvement issue[20]. The flowchart shown in Fig. 4 summarizes the steps of the GA algorithm. Our objective is to limit E_TOTAL to spare battery life, minimize power consumed and enhance the both of lifetime and the CRN performance. Therefore, the cost function to minimize the total energy consumption in the CRN using GA can be written as,

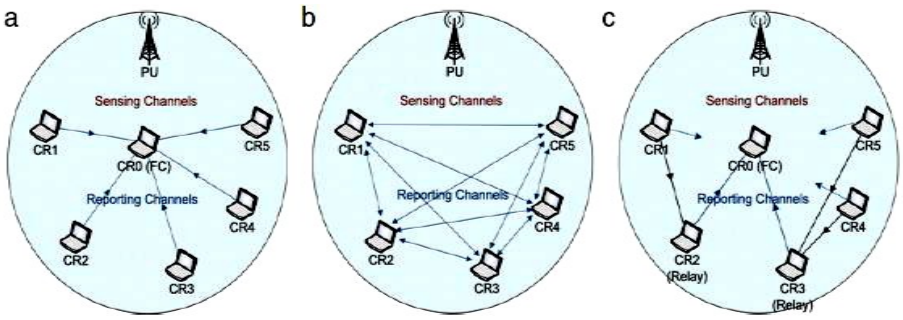

Fig.2 Classification of SS : (a) centralized, (b) distributed, and (c) relay-assisted.

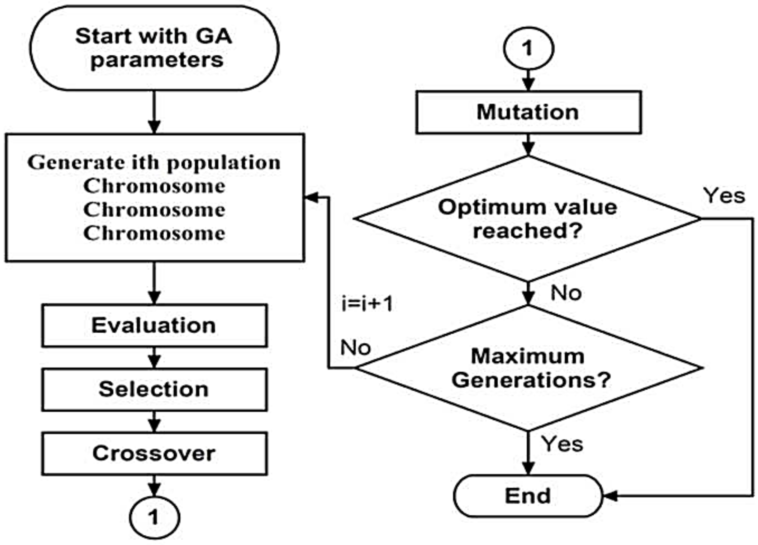

Fig. 4 the G-A flowchart.

TABEL 1 Simulation Parameters

Parameter	Value
No of SU users	100
No of clusters(M)	10
No of users per cluster(N)	10
electronic energy (E_e)	50 nJ/ bit
length of the signal (S)	1 bit
e_{fs}	10 pJ/ bit/ m^2
e_{mp}	0.0013 pJ /bit/ m^4
dissipated energy in data collection. (E_{dc})	50 nJ/ bit

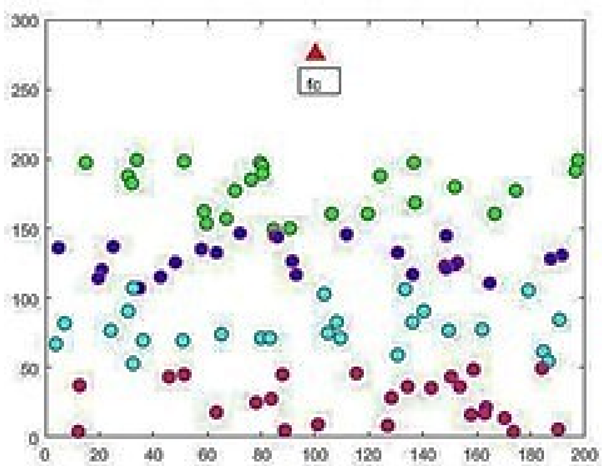

Fig. 5 CRN distribution

$$minmize\{E\ (R\ ,M)\}$$

Subjected to $\sum_{m=1}^{M} E_{TOTAL}$ for all m (7)

Sensing agility is an important metric in CSS because of the cooperation between CRs and the FC leads to more delay so it must be considered. Total detection time of CSS T_(co-op) according to TDMA schedule time can be counted by:

$$T_{co-op} = T_{local} + N * T_R \tag{8}$$

where T_{local} is sensing local time, T_R is the reporting time for one user. The purpose of clustering based scheme is reducing the overall head time and minimizing the sensing time (ST) [21]. So the sensing time of cluster based on CSS $T_{cluster}$ according to TDMA schedule time can be given as:

$$T_{clustr} = T_{setup} + T_{local} + \left(\left(\frac{N}{K} - 1\right) + K\right) * T_R \tag{9}$$

4. Simulation Results

This section presents the simulation parameter and analysis. Also, MatlabR2017a simulator is used for the simulation. The simulated CRN consists of CRs and their distributions, the CSS energy performance and the clustering cooperative scheme improvement with the uniformly distributed CRs. We use in our analysis the same energy module in [21, 22] and they are given in Table 1.

Fig. 5shows the distributed CRs in the network area (x=200, y= 300) m., they are uniformly distributed with one FC. Also, each group of users has a unique color. The FC locates at (x=100, y = 275). In Fig. 6, The performance of clustering approach based on CSS is better than the conventional CSS scheme. From the results shown below it can be seen that in the case of a group of SUs (100 CRs), a massive reduction in the elapsed energy in the clustering model is found with comparing to conventional cooperation scheme where the total number of CRs are distributed into organized groups. Hence clustering based on CSS can tool up an energy efficient model and enhance performance of SS.

Fig.7 explains the dissipated energy at different numbers of co-operative clusters. Firstly, the dissipated energy at the CSS approach is less than that is used by traditional cluster CSS mode. Also, it can be shown that with using energy closed formula under the constraints of the number of cooperated clusters, the energy performance is enhanced and the energy consumed is decreased. As is seen in this figure increasing number of clusters causing a decrease in energy consumption through CRN.

Fig. 8 demonstrates the energy dissipation at GA clustering scheme, which is less than that used by cluster CSS mode. Where, it is observed that with increasing the number of CHs that are transmitting results to FC, the energy performance of GA clustering approach is better than traditional clustering scheme. In other words, GA clustering approach can provide an energy efficient transmission scheme. The optimized values of energy are obtained based on GA in Equation (7).

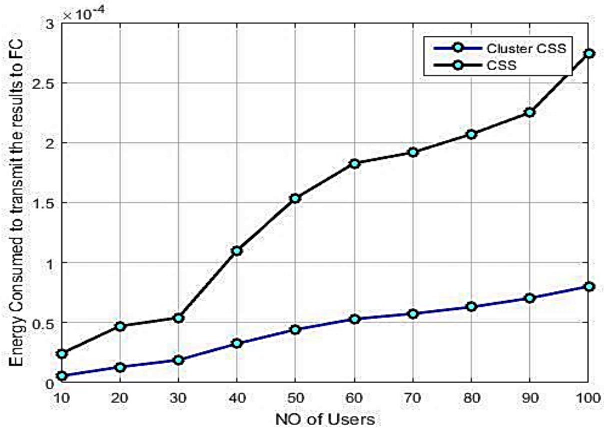

Fig. 6. Energy wasted in CSS&CCSS.

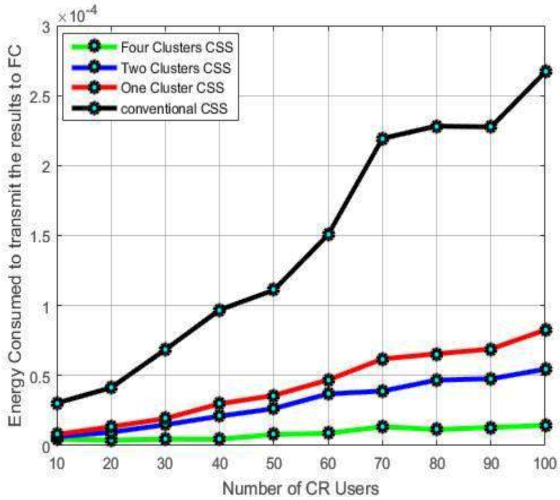

Fig. 7. Energy consumed per clusters.

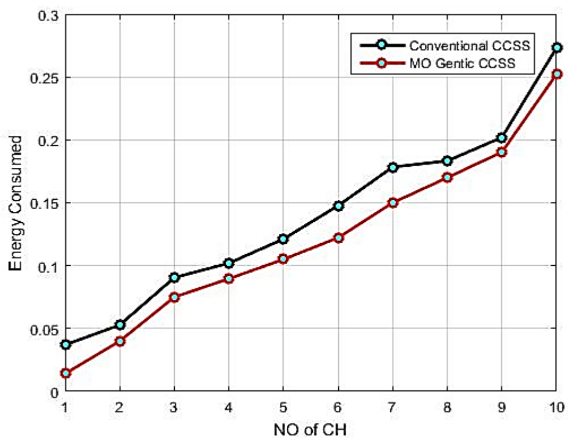

Fig. 8 Energy consumed in CCSS&GA-CCSS.

Another enhancement that can be realized by usage of our approach is the sensing delay time. As shown in Fig. 9, the normalized detection time ST of clustering CSS is very small. Hence, the performance of clustering CSS is generally better than conventional CSS and total elapsed delay time for SS in the CRN is decreased.

Fig.10 demonstrates the energy consumed in different models where using optimization technique like GA gives minimization in energy consumed in the co-operative clustering network, hence GA-CCSS (our proposed scheme) gives better performancewith compared to the CCSS and CSS.More over, using GA-CCSS provides an efficient scheme in minimizing the total consumed energy in the CRN.

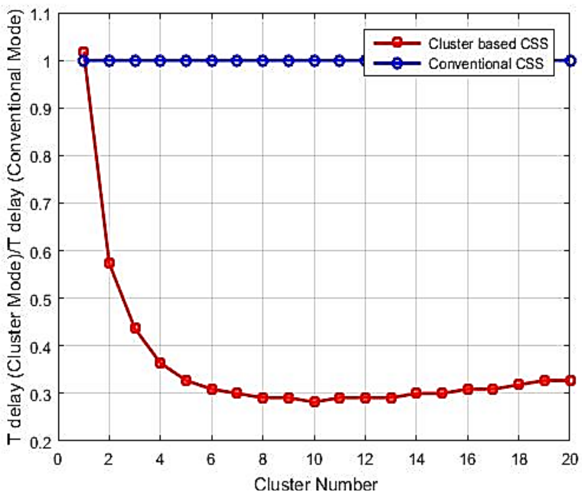

Fig. 9 Delay time CSS&CCSS.

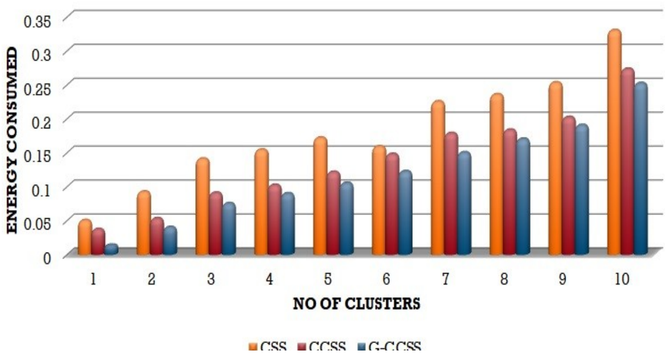

Fig. 10 Comparsion between CSS, CCSS and G-CCSS.

5. Conclusions

In this manuscript, a proposed GA clustering approach for CSS was discussed. Also, the conventional CSS was introduced. The simulation analysis shows that the performance of the proposed approach is enhanced taken N of CRs in consideration and is better than the traditional scheme. Moreover, using GA-CCSS provides an efficient scheme in minimizing the total consumed energy in the CRN. Further, it reduces delay time and enhances the lifetime of the CRN network.

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