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Design of clustered architecture for cooperative spectrum sensing with optimization of number of clusters

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Abstract— The main idea behind this work is to use an appropriate routing protocol for cognitive network which becomes a major necessity now a days. As the available radio frequency for wireless communication gets lesser day by day because of licensing, so we need to have some way to use these frequencies in a more efficient manner. But since the topology of ad-hoc network changes dynamically so our cognitive ad-hoc network should be capable to cope up with dynamic network topology as well as diverse quality of service. And also proper routing protocol should be there so that an efficient routing can be done apart from maintaining QoS .Spectrum is a very precious resource and thus underutilization of a large part of allocated spectrum is not affordable. Where increasing demand for wireless applications has made it difficult to manage limited spectrum, allocated spectrum utilization is found to be very low[3]. Cognitive radio is proposed as a promising solution for increasing spectrum utilization and thereby helping to mitigate spectrum scarcity.

Keywords—Spectrum sensing, Cluster ,Primary user ,Secondary user.

1.INTRODUCTION

1.1.Spectrum Allocation:

Spectrum is a group of various types of electromagnetic radiations of all feasible wavelengths, used for wireless communications. Radio frequency is a natural resource but unlike other resources it will not deplete when used. But it will be wasted if not used efficiently. Spectrum allocation is important and necessary to ensure interference free operation for each radio service. All nations share the electromagnetic spectrum and reserve their right to its unlimited use. To support compatibility of hardware set ups, trade, standardizations and interference free communication, it is essential to allocate spectrum in the common bands. In India, wireless planning and coordination (WPC) Wing of the Ministry of Communications[2], is the National Radio Regulatory Authority of India responsible for Frequency Spectrum Management,..Wireless communication systems are built based on the transmission of electromagnetic waves (or radio waves) with frequencies in the range of 3 Hz to 300 GHz[3,4]. Radio waves with different frequencies have different propagation characteristics, each of which is suitable for a specific wireless application

1.2 Spectrum Scarcity

With the rapid growth in subscribers of wireless services available now in the market, the demand for additional spectrum is steadily increasing. High data rates are needed to meet QoS for different services. The data rate requirement for various services With data applications consuming far more bandwidth than voice and with an increasing number of mobile users engaging in such applications[3], assignment of additional spectrum is imperative to continue expanding and upgrading the country's wireless internet and broadband networks. Changing pace of modern lifestyle, economic growth and technical developments, greater device sophistication and new bandwidth hungry applications

1.3.Cognitive Radio:

A cognitive radio is a transceiver which automatically detects available channels in wireless spectrum and accordingly changes its transmission or reception parameters so more wireless communications may run concurrently in a given spectrum band at a places capable of configuring radio-system parameters[4]. These parameters include "waveform, protocol, operating frequency, and networking".[2] It functions as an autonomous unit in the communications environment, exchanging information about the environment with the networks it accesses and other CRs.[2] A CR "monitors its own performance continuously", in addition to "reading the radio's outputs"; it then uses this information to "determine the RF environment, channel conditions, link performance, etc.", and adjusts the "radio's settings to deliver the required quality of service subject to an appropriate combination of user requirements, operational limitations, and regulatory constraints". These processes have been described as "reading the radio's meters and turning the radio's knobs "In context of CR, spectrum sensing refers to the detection of spectrum holes with the help of spectrum sensing techniques as transmitter/energy detection, interference based detection, matched filters and cooperative detection. The ability of a CR network to coexist with other existing networks is predicated upon being able to sense the existence of other networks. Not only must the CR detect the spectrum holes, continuous monitoring of spectrum is also necessary to lookout for the return of PU. Accuracy, time and detection range are important considerations for sensing. Some associated problems in sensing are as follows:

FALSE ALARM*:* While detecting the presence of PU in vicinity, CR detects the PU even if no PU is present. This is called false alarm.

MISSED ALARM*:* If there is a PU present in the surroundings of CR and it does not observe its presence, this is known as missed alarm.

1.4.Cooperative Spectrum Sensing:

Cooperative spectrum sensing is proposed to overcome this problem by utilizing the cooperative diversity. For cooperative sensing, the cognitive base-station acts as a centre controller to instruct the collaboration of cognitive users. However, when the number of users becomes very large, the crowding may occur on the control channel and the sensing delay may be too long to make valid decision. Cluster based cooperative sensing is proposed to tackle these problems In , a cluster-based cooperative sensing method is proposed and the performances of both decision and energy fusion schemes are investigated. However, it does not consider how many clusters are needed to maximize the efficiency of network with the guarantee of detection performance new cooperative sensing scheme with cluster-based architecture and obtain the optimal number of clusters by balancing the trade-off between efficiency and reliability. Furthermore, we propose a clustering strategy and compare it with the clustering scheme in by simulation. The operation of the cognitive radio is based on the notion of spectrum holes, i.e., bands of frequencies assigned to a primary user, but, at a particular time and specific geographic location, they are not used by that user . The objective of the cognitive radio is to identify the spectrum holes, and to provide the means for making the spectrum holes available for secondary users. This chapter discusses the foundations of cognitive radios and cognitive radio networks and provides an overview of the cognitive tasks .In addition, the cognitive radio approach can be useful in other applications such as home environment, utilization of vacant TV bands, messaging devices and other non-real time communication systems. The cognitive radio could improve communications in emergency situations when the traditional network becomes congested with calls for help due to the limited availability of Spectrum band.

2.SPECTRUM SENSING IN MULTI-USER NETWORKS:

Environment in which cognitive radios operate consists usually of multiple secondary users and primary users [5]. In addition, the cognitive radio networks can be co-located with other secondary networks competing for the same spectral resources. Secondary users can interfere each other in spectrum sensing which makes it more difficult to detect primary users reliably. In such a multi-user environment, cooperation is needed to exploit spatial diversity. The need for cooperation creates challenges to the spectrum sensing information distribution. Delays in cooperation have to be very short and the signalling overhead caused by sensing information distribution must be kept low. Otherwise there would be very few temporal resources that can be used for cognitive radio transmission. To overcome these problems, fast physical layer signalling, boosting protocol, was proposed in [5] for centralized spectrum pooling systems. However, there are several open research challenges in multi-user network operation. To mention a few: What kind of cooperation is really needed to efficiently exploit the spatial In addition to the spectrum holes, what information should be distributed (location, transmitted power and frequency of different users)? How to cooperate with other secondary networks? Do we need to cooperate with primary networks too It is clear that the interference to the PU is decreased due the cooperation. The cost for that is the increased complexity. The bandwidth of the control channel should be increased due to increased control traffic between the nodes. The delays of the combining and relaying processes reduce the time of the data transmission. In addition, independence and trust issues can affect to the performance improvement of the cooperation. Shadowing correlation occurs when two radios are blocked by the same obstacle and it degrades the performance of the co-operative sensing when SUs are close to each other. Shadowing correlation becomes less significant as the distance between two users increases. This was also shown in an experimental study performed in the Berkeley Wireless Research Centre. In the study, it was shown that the probability of detection monotonically increases as the separation between two cooperating radio increases. It is possible that the SU network has one or more malfunctioning nodes e.g., node/nodes that always report false alarms when doing spectrum sensing. Dealing with this kind of nodes is possible when the behaviour and the amount of malfunctioning nodes can be predicted. In that case, the effect can be compensated by increasing the amount of nodes. However, malicious users and the users that fail unpredictably set the upper bound on the performance of a cognitive radio.Spectrum sensing, as a key enabling functionality in cognitive radio networks, needs to reliably detect weak primary radio (PR) signals of possibly-unknown types [4]. Spectrum sensing should also monitor the activation of primary users in order for the secondary users to vacate the occupied spectrum segments. However, it is difficult for a cognitive radio to capture such information instantaneously due to the absence of cooperation between the primary and secondary users. Thus, recent research efforts on spectrum sensing have focused on the detection of ongoing primary transmissions by cognitive radio devices. Generally, spectrum sensing techniques fall into three categories: energy detection [5], coherent detection [6], and cyclostationary feature detection [7]. If the secondary user has limited information on the primary signals (e.g., only the local noise power is known), then the energy detector is optimal [8]. When certain primary signal features are known to the CRs (such as pilots, preambles, or synchronization messages), the optimal detector usually applies the matched filter structure to maximize the probability of detection. On the other hand, cyclostationary feature detectors differentiate the primary signal energy from the local noise energy by exploiting certain periodicity exhibited by the mean and autocorrelation of a particular modulated signal. In this paper, we assume that the primary signalling is unknown and we adopt energy detection as the building block for the proposed cooperative spectrum sensing scheme. The detection performance of spectrum sensing schemes is usually compromised by destructive channel conditions between the target-under-detection and the cognitive radios, since it is hard to distinguish between a white spectrum and a weak signal attenuated by deep fading. In order to improve the reliability of spectrum sensing, radio cooperation exploiting spatial diversity among secondary users has been proposed in [4] and [9]. In such scenarios, a network of cooperative cognitive radios, which experience different channel conditions from the target, would have a better chance of detecting the primary radio if they combine the sensing information jointly. In other words, cooperative spectrum sensing can alleviate the problem of corrupted detection by exploiting spatial diversity, and thus reduce the probability of interfering with primary users. Since cooperative sensing is generally coordinated over a separate control channel, efficient cooperation schemes should be designed to reduce bandwidth and power requirements while maximizing the sensing reliability

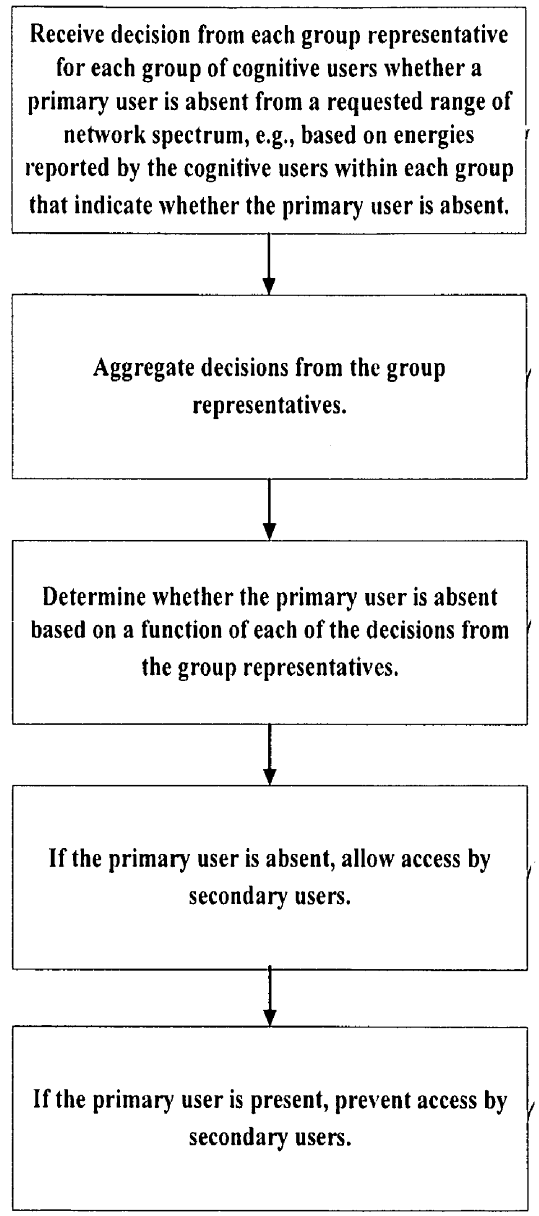

Figure 1: Flow Chart Of Cooperative Spectrum Sensing

As shown in Figure 1. the proposed work get progressed.Firstly cognitive users considered in the system are classified as ordinary nodes and cluster heads and then according to clustering strategy clusters are formed with elected cluster heads and ordinary nodes. Then in next step optimization problem of number of clusters is solved and probability of detection Q_d is derived. And finally the weighted-cluster algorithm is implemented on the constructed hierarchical clustered architecture in previous stages. each block can be elaborated as below In this section, we provide an efficiency clustering strategy for the proposed cluster-based cognitive radio network. We assume that the cognitive network topology is relatively stable status. The objective of clustering strategy in this paper is to gather cognitive users with similar locations into the same cluster, it operates in two phases: cluster-head election and cluster formation. In cluster-head election phase, the cluster heads are elected by BS in a centralized way. In cluster formation phrase, cognitive users join into their clusters in a distributed way. It should be noticed that we exploit distributed scheme in cluster formation to avoid crowding of dedicated control channel and reduce complexity of the algorithm.

2.1.Cluster Head Election*:*

In order to select appropriate cluster-heads, cognitive Base Station collects information from each node such as the distance from Base Station and the node's received signal power from primary user. Based on the information, cognitive Base Station assigns cluster-head for each cluster according to a given election algorithm and broadcasts the election to all nodes.

election algorithm is described as following:

A) Initialization:

Calculate all nodes' distance from BS and sort nodes in ascending order of the distance in a queue. Choose 2K nodes with the shortest distance in the queue as a set of candidate cluster-heads Can. Randomly assign K nodes as cluster-heads set from

Can,

c = {i1, · · · ,iK} and initialize ¯m = { ¯m1, · · · , ¯mK}, where

¯mk= _mik

B) Iteration:

1) Allocate each node into the cluster, where

k = arg min

1≤k≤K

(|_mi − ¯mk|) , i = 1, · · · ,N

2) For each cluster, update ¯mkby averaging _m of all nodes in cluster k.

3) For each cluster, update the node ID of cluster-head

ik= arg min

i∈Ccan

(|_mi − ¯mk|)

and then GOTO Step a). If all node IDs in set are not change, GOTO Step C.

C) Restore all node ID of cluster-heads ik, k = 1· · ·K

Where ik denotes the node ID of cluster-head k and _mi denotes the observation vector of node i. K is the number of cluster

2.2 Cluster Formation:

The cluster formation phrase is performed in a distributed way, which is divided into 4 steps. First, each cluster-head broadcasts beacon to ordinary nodes, which instructs the ordinary nodes to select their cluster heads. After receiving the beacons from all the cluster-heads, each node decodes the received signal power (RSP) of each beacon and selects one, which has the largest RSP, as its selected cluster-head (SCH). Other cluster-heads are sorted in descending order of RSP to form a candidate cluster-heads pool (CCP). Then, each node requests to join the cluster of its SCH. The request message contains its own node ID and RSP of its SCH. When each cluster-head receives the requesting messages from ordinary nodes, it counts the number of nodes and sorts nodes in a queue in descending order of the values of their corresponding RSPs. If ordinary node receives ACK from its SCH, it signs the SCH as its cluster-head and joins into this cluster. If ordinary node receives NACK from its SCH, it pops up the node ID with the maximum RSP from its CCP as new SCH. After that, the node starts a new process to join into cluster with the new SCH until it receives ACK from cluster-head. The scenario of the simulation is as follows. 100 cognitive nodes are randomly placed in a $300m \times 300m$ square with the cognitive BS located in the middle. Given Qf= 0.01, the number of cluster K = 5 according to (16). Two primary users are dispersed randomly in the square. The simulation results are obtained by 1000 iterations. In order to verify the performance of our proposed clustering scheme, we also simulate the K-means clustering algorithm[5] in the same network for comparison. Table I shows the simulation results of different performance with these two clustering schemes. Maximum and Minimum represent the value of average maximum and minimum number of nodes in one cluster respectively. Ave Denotes the average distance between node and the centre of its cluster. It is noticed from this table that in our proposed scheme, the nodes in each cluster are distributed more equally and the nodes in the same cluster are more close. It implies that the proposed clustering strategy can produce balanced clusters and evenly distribute nodes among the cluster-heads based on the nodes' locations.

2.3.Optimization Of Number Of Cluster:

It is intuitive that the sensing overhead and delay are generally reduced with the decrease of the number of clusters. However, the spectrum performance is degraded if the cluster number is decreased. Thus, there exists a trade-off between the number of cluster and the spectrum performance. Our aim is to determine the minimum number of cluster with the guarantee of spectrum sensing performance.

The trade-off can be expressed as:

minK

$$Qd\_c \geq Qd\_R \mid Qf\_c=Qf\_R \ \ \& \ \ 1 \leq K \leq N$$

Where,

whereQd_c, Qd_Rand Qf_c, Qf_Rare the Global Detection And False-Alarm Probabilities Of cluster-based scheme and conventional scheme respectively. K and Ndenote the number of clusters and cognitive users respectively. by solving the equation and following the optimization limits in above equation the value of optimum number of cluster K . As explained in step 2 of proposed work in our project value of false alarm probability Q_f =0.01 and optimal number of cluster K=5 are considered and then with the help of optimization equation probability of detection is calculated and compared with detection probability of previously available algorithms.

3.RESULTS

cognitive users with similar locations into the same cluster, it operates in two phases: cluster-head election and cluster formation. In cluster-head election phase, the cluster heads are elected by BS in a centralized way. In cluster formation phrase, cognitive users join into their clusters in a distributed way. It should be noticed that we exploit distributed scheme in cluster formation to avoid crowding of dedicated control channel and reduce complexity of the algorithm. The results obtained from the work done on the project are as shown below which shows the working state of the project figure 2 shows he first step of proposed work i.e. clustering of scattered nodes in the network. In figure 3 cluster head of the selected clusters is elected which are shown by pink coloured squares .figure 4 represents the graph of probability of false alarm and probability of missed alarm which is known as ROC graph. this is the important result of proposed system. figure 5 shows the result of average wake up time of a elected cluster head .as time passes cluster head loses its energy .figure 6 is the result showing optimum energy dissipation in clustering and spectrum sensing. And final result in figure 7 representing the increased number of alive nodes in particular time interval due to weighted cluster algorithm. Hence from all six results one can observe that the performance of clustering and spectrum sensing is improved than simple clustering algorithm.

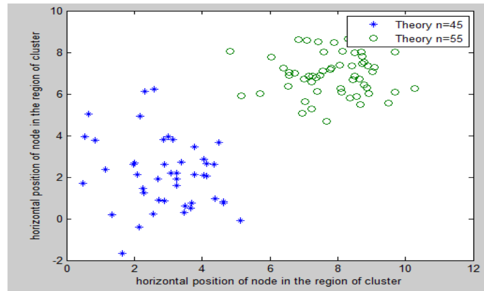

Figure 2:.Cluster Formation Of Secondary Nodes

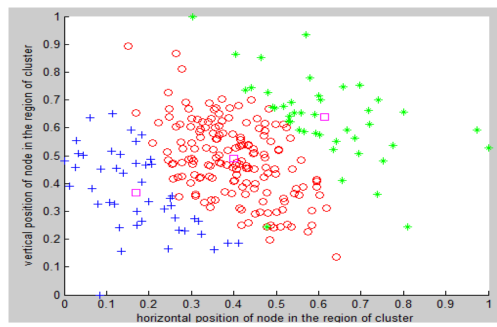

Figure 3: Cluster Head Selection

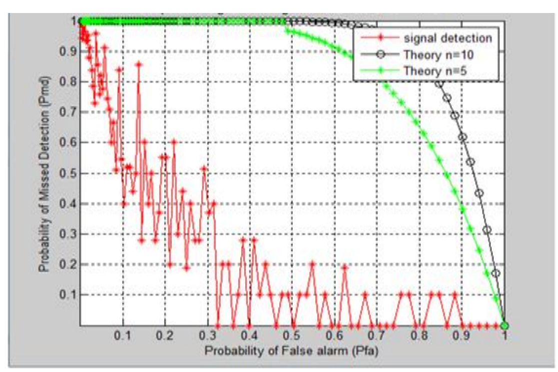

Figure 4:Performance ROC Graph

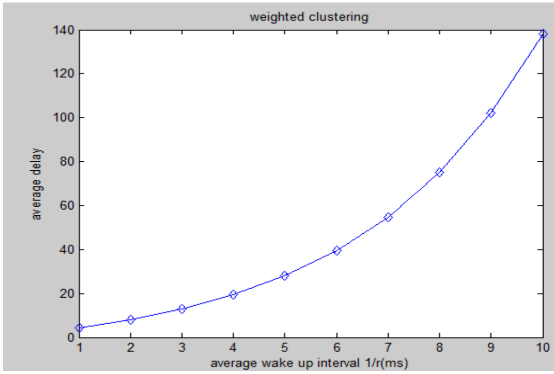

Figure 5: Average Wake Up Interval Of Node

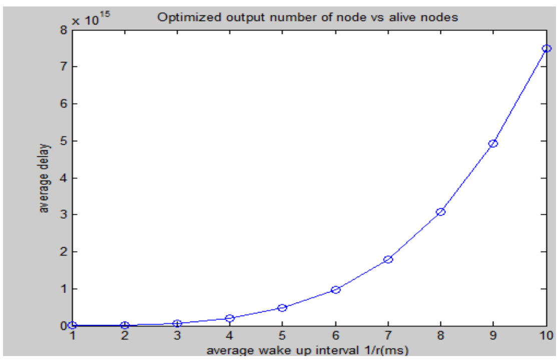

Figure 6: Optimum Energy Dissipation

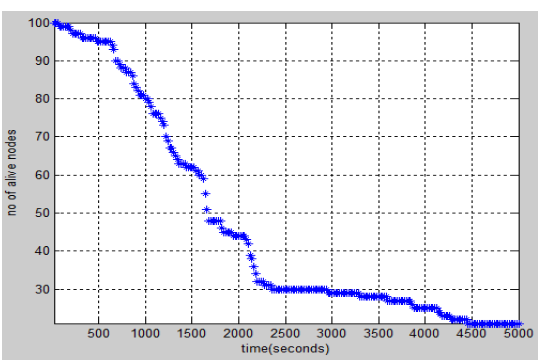

Figure 7: .Alive Nodes In Time Interval

4.CONCLUSION

From results obtained it seems that the proposed system gives better results and after further completion and comparison with other algorithms final conclusion will be obtained. coopertive spectrum sensing enhances the spectrum utilization. Optimization of number of clusters and number of nodes in the cluster are effectively reduces the power consumption and also increases the probability of signal detection..due to weighted cluster algorithm increases the efficiency of the algorithm

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