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A Novel Node Selection Function for Multilevel Hierarchical Clustering Scheme in Cooperative Cognitive Radio Networks

Jayakumar Loganathan[1], Oviya S.[3], Shobana R.[3] and S. Janakiraman[2]

Abstract: In Cognitive Radio Networks (CRN), one of the well known cooperative spectrum sensing scheme can overcome damaging effects of shadowing and fading. Even though cooperative way of channel sensing and sharing gives better performance, it takes increased amount of energy from all participating nodes in the network. In this paper, we designed an efficient cluster using multilevel-hierarchical and Euclidean-square distance for CRN. Reserved power of each node in the cluster also considered one the deciding factor for node selection, which greatly reduces the unnecessary allocation of resource to nodes which are not capable to sense for others. The proposed clustering model provides an optimal scheme to create cluster with reduced number of message exchange which improves the efficiency in sensing time, fault ratio and energy.

Index Terms: Cognitive Radio Networks (CRN), Channel Sensing, Multilevel – Hierarchical Clustering, Euclidean – Square Distance.

1. INTRODUCTION

In recent days, usage of spectrum has increased highly with the rapid development of radio communication technology. Nowadays in wireless communication radio Spectrum has become one among the inadequate sources. In a study conducted by the Federal Communications Commission (FCC) on the usage of spectrum indicates that the consumption of licensed spectrum varies from 15% to 85%, so there is a substantial possibility for increasing the spectrum usage. Cognitive radio (CR) is a form of wireless communication which consists of a transceiver that is capable of detecting which communication channels are in use and which are not in use, and move into unoccupied channels while avoiding occupied ones. Cognitive radio is the most hopeful way for increasing the efficiency of the spectrum by providing opportunistic access of frequency bands to a group of unlicensed users. The spectrum hole or white space is the frequency band allocated to a PU but that band is unoccupied by the PU at a particular time and specific geographic location. If the secondary unlicensed users dynamically access the spectrum holes that are not currently occupied by the primary user then the total consumption of the spectrum can be enhanced.

The major Operations of CR are the sensing of spectral environment over a larger frequency band. The licensed users of the spectrum are the primary users (PU) and the secondary users are CR user's. The CR users can utilize the spectrum while the PU's is idle. It is a difficult job for an individual CR user to obtain exact information about the radio environment so as to avoid interference to the PUs. Each SU consume much time and power to scan the whole bandwidth for collecting the information about the usage of spectrum. The detection quality of the SU is decided by the signal-to-noise (SNR) ratio of the received PU signal. If the user has a low SNR then it is a challenging task to distinguish between an occupied and unoccupied channel [1].

[1] Department of Computer Science and Engineering, Pondicherry University, Puducherry, India, *Email: jkaylogu@gmail.com*

[2] Department of Banking Technology, Pondicherry University, Puducherry, India, *Email: jana3376@yahoo.co.in*

[3] Department of Computer Science and Engineering, Christ College of Engineering and Technology, Puducherry, India, *Email: shobanashobi0407@gmail.com, ovirishi@gmail.com*

The functionalities of CR are: spectrum sensing, spectrum decision, spectrum sharing and spectrum mobility. Spectrum sensing means CR observes the radio environment and geographical surroundings and examines whether the spectrum is occupied or unoccupied and determine the space holes. Spectrum decision means the CR decides when to start its operation, operating frequency and its corresponding technical parameters [2]. Spectrum sharing means allocation of spectrum to the secondary users based on its cost of usage. Spectrum mobility is used to provide unified communication during transition. If PU requires the spectrum that is currently in use then the communication needs to be done in another portion so CR needs spectrum mobility. There are two types in cognitive radio they are full cognitive radio and the spectrum-sensing cognitive radio. In full cognitive radio each and every possible parameter is observable and in spectrum-sensing cognitive radio only radio frequency spectrum is considered [3].

Nowadays cooperative cognitive radio networking (CCRN) has got noticeable attentions, where cooperative networking is influenced to create a win-win situation for both Primary users and secondary users [4]. In temporal domain CCRNs will work. In CCRN primary user can choose certain secondary user in order to transmit the primary traffic cooperatively and in response gives a portion of the channel access time to the secondary users. By using Cooperative method the SUs transmission rate can be increased[5]. In temporal domain all CCRN based schemes [6],[7],[8],[9] will be working, considering that each secondary users or primary users are equipped with a single antenna. Particularly frame duration is time-splitted into three phases. In the first phase primary transmitter broadcasts the data to the relaying Secondary users. In the second phase, the SUs will form a distributed antenna array that will cooperatively transmit the primary data to the primary receiver, so that the throughput of the primary link will be increased. The third phase is let out to the SUs for their own traffic.

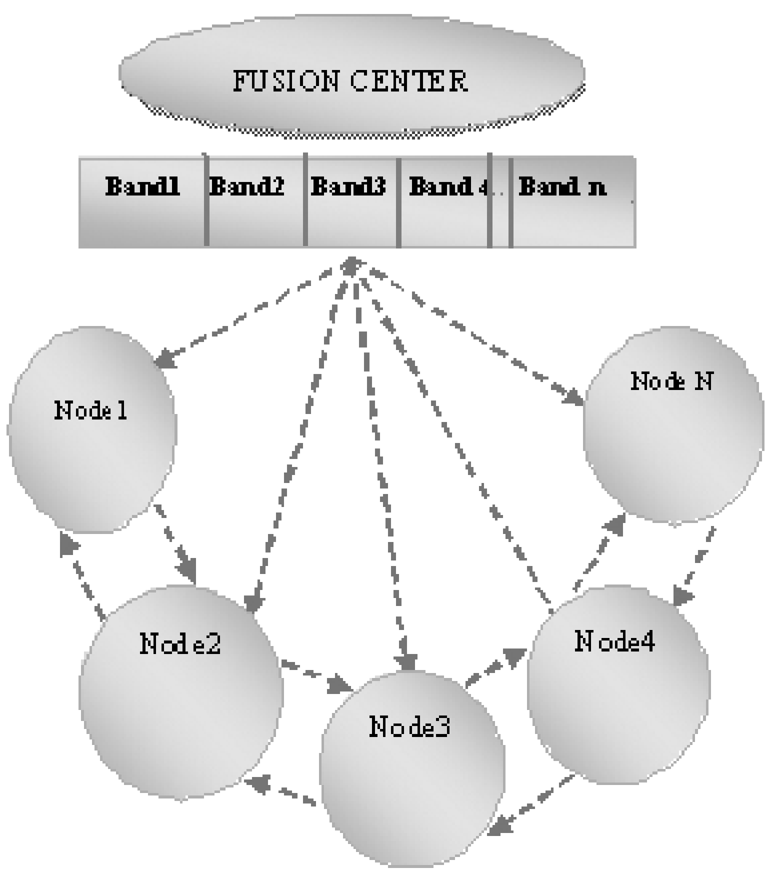

Figure 1: Cooperative Spectrum Sensing

The advantages of CCRN are it reduces excessive interference, the transmission rate can be increased, increases the efficiency of spectrum utilization, decreases the traffic, provide transmission opportunities to Secondary users, reception reliability can be improved and power consumption can be reduced, increase the secrecy rate of the primary transmission, secondary users cooperate with the primary users to improve the primary users utility [5]

2. RELATED WORKS

2.1. DistributedVs Centralized Spectrum Sensing

In CRN the distributed approach for cognitive radio cooperative spectrum sensing one node alone does not take control Instead communication takes place between different node and will share sense information between each and every nodes. This method needs for the individual radios to have a much higher level of autonomy and possibly positioning themselves up as an ad-hoc network. Distributed approach is used for the following purposes, Sensor nodes are disposed to failure; it provides high data collection to provide nodes with backup in case of failure of the central node. In distributed method there is also no central controller to allocate the resources and they have to be self-organized. By using distributed approach the reliability of the network can be increased to a better extent. In the distributed approach, each node on the route is participating in decision making on selecting the bandwidth. The request for connection passes through each node along the route and stores wavelengths on the basis of the local information at the node. When the connection request reaches the destinationnode, in order tocon figure the reserved wavelengths at each node an ACK message is sent back on the reverse path. When the ACK reaches the source node, then it will send the data using the reserved bandwidth on the route. If it finds any one of the intermediatenodes on the reserved route is not having the available band width for this connection. Then the connection request will beblocked. In order to release the previous reserved bandwidth an NACK is sent back to the source node. When a connectionis torn down, a release request will be sent to the destination to release the network resources that are used at each node. Node pathestablishment is not decided only by a central controller instead by coordination among different nodes. Due to its distributed nature of operation it is called a distributed approach [10]. In centralized approach if a single node fails then the entire network will get ruined but in case of distributed approach there is no such problem if a single node fails then another node can take control and avoid entire failure of the complete system. For larger networks Comparing to centralized approach the distributed approach is only appropriate. It removes the bottle neck problem from the central coordinator so that the reliability gets improved since all the nodes can communicate with each other it offers higher inter-operability and scalability so distributed approach is better than the centralized approach[16].

2.2. Cooperative Spectrum Sensing

The main idea of cooperative communication is to share resources among multiple nodes in the node because sharing of power and computation with neighboring nodes can save overall network resources. Since Cooperative way of sensing gives Better Performance in CRN, most of the Spectrum Sensing techniques are applied in cooperative methods. Cooperation is possible only when the number of communicating terminals exceeds two. Since it considers the requirements of all the nodes there is a frequent exchange of messages between all the nodes [11]. In co-operative communication several nodes are allowed to transmit signals co-operatively to the destination together. The cooperative communication gives increased improved transmission reliability, spatial diversity, multiplexing tradeoff. Co-operative communication is a system where users distribute and synchronize their resources so that the information quality is improved. It is assumed that each wireless user transmits data and act as well as a cooperative agent for another user in a cooperative communication system. In a relay system, the source node will transmit their data first to the relay nodes. Then each relay node processes the data, using some cooperation protocols relay nodes forwards its received data to the destination nodes with the received signal from the relay, the destinations decode the data from their corresponding sources. The advantages of co-operative communication are larger spatial diversity, higher throughput-lower delay, Lower power consumption and lower interference, adaptability to network conditions so cooperative approach is a better method for data transmission [12]

2.3. Non-Cooperative Spectrum Sensing

In Non-cooperative approach individual nodes are considered and interference in other nodes are not taken in consideration since it does not consider the necessities of all nodes so it does not exchange messages with all nodes frequently which results in low spectrum utilization. In this method, there is no cooperation between the nodes and each node transmits independently [13]. In this approach are nodes are selfish nodes and the intermediate nodes are given some inducements to make them forward the data to other nodes. In a multi-hop non-cooperative network only the destination knows whether the transmission of data between the nodes was successful or not, but not the individual actions of the intermediate node. Hence in the absence of absence of properly designed incentive schemes selfish intermediate nodes may decide to transmit data packets at a very low priority or just drop the packets, and they will put the blame on the unreliable channel [14]. The disadvantages of non-cooperative approach are low spectrum utilization, high energy consumption so this approach is not preferable for data transmission [12].

2.4. Centralized Spectrum Sensing

In centralized architecture a single node acts as the master and all other remaining nodes acts as a slave. The master node will collect data from all other nodes and controls the complete network. The significant advantage of this model is making the management task simpler by considering a single point of control. If a centralized architecture is used and the central node fails, then the entire network will collapse [15]. In centralized approach a central controller contains all the information of the resources, such as network topology, wavelength usage on each link, link states, and the states of each network element. If a source wants to transmit a data to the destination first it sends a connection request to the central controller and based on the routing and wavelength assignment Algorithm that are present at the controller, the wavelengths and the routes are calculated. Then, the controller stores and configures resources for the connection by notifying each node on the Route. Notification message is sent out in a hop-by hopmanner or a parallel manner depending on the detailed implementation. If the central controller finds that there is insufficient networkresources to support the connection then the connection will be blocked. After receiving acknowledgement from each node the controller will send a notification message to the source to send the data on reserved wavelengths along the route. This method uses first-come-first-served (FCFS) to allocate resources based on the global information Centralized approachis useful while many applications running in the system interfere with performance. The disadvantage of this network is high traffic, low scalability so this approach is not most advisable for communication. [16].

3. TECHNIQUES FOR COOPERATION

In cognitive radio networking, in order to relay the traffic the Primary users may select some Secondary users. The cooperation settings includes (1) single Primary user and single Secondaryusers;(2) Single Primary users and multiple Secondary users; and (3) multiple Primary users and multiple Secondary users. For a single user Cooperation, resource allocation is a main issue. For multiuser cooperation the problems are relay selection and coordination. The scheme used between one single PU and one single SU are based on amplify-and-forward (AF) and decode-and-forward (DF). The amplify-and-forward (AF) cooperative communication is used when the Secondary user acts a helper to transmit the signal of the Primary user. In decode-and-forward (DF) first the secondary user decodes the signal of the Primary user and then forward to increase the performance of the Primary user The amplify-and-forward (AF)cooperative communication is used when the SU acts as a helper to relay the PU's signal, the Secondary users first decodes the signal of the primary user and then forwards to improve the transmission function of the PU. Consider ascenario of multiuser; there exist a one primary pair and many secondary users which seek for transmission opportunities.

A distributed SU selection scheme is suggested which enhance the performance of the SUs without reducing the performance of the PUs. Specifically, the Secondary users which help the Primary users to achieve the aimed transfer rate are selected to transmit the message of the PU by using Stackelberg game the cooperation between a single PU and multiple SUs is studied where the Primary user cooperates with a set of secondary user to improve the transmission rate of Primary user. When multiple Secondary users compete to cooperate with the Primary user by acting as a relaying node to gain the transmission opportunities, the relaying Secondary User is selected among many secondary users using an auction mechanism. In CCRN multiple Primary users functioning over dissimilar channels cooperate with different Secondary to increase the network utility [17]

3.1. Clustering for cooperation

Clustering is a topology management method that organizes nodes into groups so that network-wide performance will be enhanced. The main aim of the clustering is to attain network scalability and stability. It also supports cooperative tasks that are important to CR operations, those tasks are and channel access and channel sensing[18]. There are two types of clustering schemes they are static clustering and dynamic clustering. In static clustering concurrently all nodes will begin and end transmission of data and will not enter or exit a cluster during the transmission of packets. In dynamic clustering concurrently all nodes can enter or exit a cluster during the transmission of packets. In clustering mechanism, based on the similarities

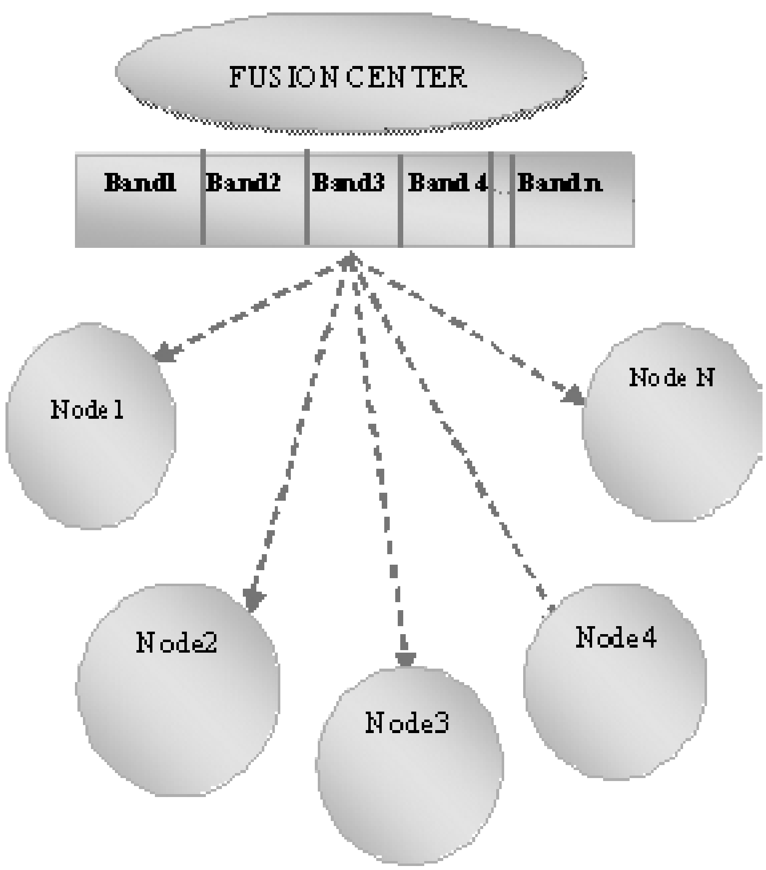

Figure 2: Non-Cooperative Spectrum Sensing

that are observed in the spectrum holes, the groups of Cognitive Users are formed The Clustering techniques can be broadly classified into two categories: Cluster first and Cluster Head first.[19]

4. VARIUOS CLUSTERING BASED ON COOPERATION

In cluster first approach first all the CR nodes sense the spectrum holes and will create a list of idle channels. It is considered that each and every node contains the information about its neighboring nodes. Once the idle channel list is created the nodes that observe similar spectrum opportunities are grouped together into a single cluster.. From a cluster the cluster head is selected such that it is one-hop away from every other node in the cluster. Then the cluster head selects a channel as Common Control Channel from the available list of probable Common Control Channel and notifies the remaining nodes about this decision through an idle channel; which is called as the master channel or control channel. In cluster head first approach, the node which initiates the cluster formation process will become the cluster head and then other nodes with similar spectrum holes will join the cluster one by one. [19].

Generally cluster heads collects the data, distributes the data and manages the network, clustering method with limit the route setup within the cluster, so the routing table's size gets reduced. Hence clustering provides more Scalability. Clustering routing scheme makes it more suitable for network topology control and responding to network changes such as node increasing, n mobility of nodes and unpredicted failures hence it offers more robustness. The resources can be separately allocated to separate clusters and reused by clusters so it avoids collision Formation of equal-sized clusters is implemented for the prolongation of the network lifetime because it avoids the premature energy exhaustion of CHs. Re-clustering is the most effective method to get rid of the cluster failure, though it usually disarranges the on-going operation. It provides guarantee of connectivity. It minimizes energy consumption

In CRN if we use flat routing scheme data transmission is performed hop by hop but if we use the clustering method it will divide the nodes into several clusters and only the cluster head will perform data transmission out of the cluster so it avoids collision between the nodes so the latency is decreased [20]. Clustering is used in CRN because its primary aim is to achieve reliability, stability and scalability and it performs the CR functions like channel sensing and channel access in an effective manner.

4.1. Single linkage

Single-linkage clustering is one of the methods of hierarchical clustering. Here the nodes are grouped in a bottom –up fashion manner, at each step combining two clusters that contain the closest pair of elements not yet belonging to the same cluster as each other. The disadvantage of this system is it produces produce long thin clusters where the nodes at opposite ends of a cluster may be very far away from each other than to nodes of other clusters. The single-link clustering's time complexity is O (n^2)The distance between two cluster is determined by finding the distance between two nodes (one in each cluster). The linkage function that is the distance $D(X, Y)$ between clusters X and Y are defined by the expression,

$$D(X,Y) = \min_{x\in X, y\in Y} d(x,y) \quad (1)$$

Where X and Y are any two sets of elements considered as clusters, and $d(x, y)$ denotes the distance between the two elements x and y. [21].

4.2. Complete-linkage

Complete-linkage clustering is one of the mechanisms of agglomerative hierarchical clustering. In the beginning of the process, each node is in a cluster of its own. Until all elements end up being in the same cluster, the clusters are then successively combined into larger clusters. At each step, the two clusters divided by the shortest distance are added together. The complete linkage function which is the distance $D(X, Y)$ in between two clusters X and Y is described by the following expression :

$$D(X,Y) = \max_{x \in X, y \in Y} d(x,y) \tag{2}$$

Where

- $d(x, y)$ is the distance between elements $x \in X$ and $y \in Y$;
- X and Y are two sets of elements (clusters)

4.3. Wards algorithm

Wards algorithm in one of the principle applied in agglomerative hierarchical clustering procedure. Here the principle used for selecting the pair of clusters to be merged at each stage is based on the optimal value of an objective function. "Any function that reflects the investigator's purpose could be the objective function. Within-cluster variance the total is decreased by Ward's minimum variance criterion. At each step the pair of clusters with minimum cluster distance are merged together To implement this method, at each step after merging find the pair of clusters that leads to minimum increase in total within-cluster. In the beginning, all clusters are singletons (clusters containing a single point). Under this objective function, to apply a recursive algorithm the initial distance between individual nodes must be proportional to squared Euclidean distance. In Ward's minimum variance method, the initial cluster distances are therefore expressed to be the squared Euclidean distance between points [22]

$$d_{ij} = d(\{X_i\}, \{X_j\}) = \|X_i - X_j\| \tag{3}$$

Where, X_i – i th Set of element

X_j – j th Set of element

4.4. Average linkage

In average link clustering the pair of clusters with high cohesion are merged together. In average linkage the cohesion, can be computed recursively asgamma ($C1 + C2$) = sum(v in $C1 + C2$), sum(w in $C1 + C2$) < v, w > = < sum(v in $C1 + C2$)v, sum(w in $C1 + C2$)w > = < p($C1 + C2$), p($C1 + C2$) >. The time complexity of average-link clustering is $O(n$^2 log $n)$.

4.5. Flexible l

In flexible linkage clustering the intensity of clustering can be varied continuously by means of a β. All hierarchical agglomerative algorithms operate similarly, but there will be a difference in the calculation of multi-member dissimilarity, so an a single algorithm with four parameters, alpha_1, alpha_2, beta, and gamma are developed. The formula is

$$U(J, K), L = [(tJ + \sigma tL)UJ, L + (tK + \sigma tL)UK, L - \sigma tLUJ, K]/(tJ + tK + tL) \tag{4}$$

4.6. Un-weighted pairs

It is a bottom up approach. Similarity between two clusters equals the mean similarity between all possible pair-group combinations:

$S(AB), C = (SAC + SBC)/2$

$S(AB), (CD) = (SAC + SAD + SBC + SBD)/4$

$SE, (C, (AB)) = (SAE + SBE + SCE)/3$

4.7. K-mean

K-means is a clustering method whose primary aim is to find the positions of the clusters that will reduce the square of the distance between the data points and the cluster. *K*-means clustering discovers the centroids, where the each centroid's coordinate is the means of the objects coordinates in the cluster and allocates every object to the nearest centroid. *k*-Mean works as follows First Select the objects randomly. These objects initial signify group centroids. *K* Then Assign each object to the group which has the closest centroid. Once when all objects have been assigned, once again calculate the positions of the centroids *k*. keep on Repeating the Steps 2 and 3 until the centroids no longer movesin the formula

$$Vi = \left(\frac{1}{ci}\right)\sum_{j=1}^{c_i} x_i \tag{5}$$

K-Means clustering is sensitive to the outliers and a set of objects closest to a centroid may be unoccupied in such case centroids cannot be updated. The disadvantages are it requires a prior description about the number of cluster centers. If there exists two highly overlapping data then k-means will not be able to resolve. This method is not invariant to non-linear transformations. Euclidean distance measures can unequally weight underlying factors. This method gives the local optima of the squared error function. Randomly choosing of the cluster center cannot lead us to the fruitful result. Applicable only when mean is defined. Cannot handle noisy data and outliers. This method is not applicable for non-linear data set

4.8. K-Medoids

K-Medoid is more powerful than *K*-Mean. Its aim is to minimize the distance between points labeled to be in a cluster and a point chosen as the center of that cluster. The most common realization of *k*-medoid clustering is the Partitioning aroundMedoids (PAM) algorithm and the working is as follow, First randomly select k of the n data points as the medoids Then Associate each data point to the closest medoid. • For each medium, for each non-medoid data point swap m and o and calculate the total cost of the configuration next select the configuration with the lowest cost. At last keep on repeating the steps 2 to 5 until there is no change in the medoid.[24]. The cost between any two points is found using formula

$$\text{cost}(x, c) = \sum_{i=1}^{d} |xi - ci| \tag{6}$$

4.9. Multilevel hierarchical clustering

Multilevel hierarchical clustering is one of the methods among clustering which is used to group the nodes and form a hierarchy of clusters. Generally the size of the routing table must be reduced to store more information about the nodes which are nearer to it and lesser information about the nodes which are far away to it in terms of hop distances. The formation of multilevel hierarchical clustering is as follows In Multilevel hierarchical clustering a hierarchy of cluster is formed each level of cluster has cluster head. Here the data is collected from the cluster head of all lower level of hierarchy and transfer the data to the cluster head of higher level of hierarchy. In the presence of heavy traffic a single cluster head cannot route all the data because it may lead to overburden on cluster head and it may lead to failure of the cluster head. In order to avoid the traffic multilevel hierarchical clustering is used because several layer of clusters are formed and each level has a cluster head which avoid overburden of a single cluster head. This higher level of hierarchy is created by incorporating a high level traffic area and a rather low traffic area which are in close vicinity and choose the cluster head, which is at low traffic area as the higher level cluster head. [25].

There are two types of clustering they are agglomerative and divisive clustering. In agglomerative clustering, each data item is regarded as a cluster, and clusters are recursively merged to yield a good clustering. Agglomerative is a bottom-up clustering method. Here clusters have sub-clusters which in turn have sub-clusters. Agglomerative hierarchical clustering starts with every single node in a single cluster. Then it fixes some criteriain each successive iteration, it merges the nearest pair of clusters that satisfies the fixed criteria, until all of the data is in one cluster. Clusters generated in early stages are nested in those generated in later stages. Clusters that have different sizes in the tree are valuable for discovery. Assign each object to a separate cluster. The hierarchical clustering takes place as follow first it evaluates all pair-wise distances between clusters. Then by using distance values construct a distance matrix. Then it searches for the pair of clusters that has the shortest distance. It removes the pair from the matrix and merges them. Then again recalculate all distances from this new cluster to all other clusters, and update values in the matrix. Repeat until the distance matrix is reduced to a single element. The advantages are It can produce an ordering of the objects, that may be informative for data display. Smaller clusters are generated, that are useful for discovery

In divisive clustering, the entire data set is considered as a cluster, and then clusters are recursively split to yield a good clustering. Divisive clustering starts from the top, treating the whole dataset as a cluster. It repeatedly divides a current cluster (a leaf node in a binary tree) until the number of clusters reaches a predefined value K, or till it meets the some other stopping criteria..

4.10. Advantages

The advantages of hierarchical clustering are, It reduces traffic. It avoids node failure. It is cost efficient. No prior information about the number of clusters required. Easy to implement and gives best result in some cases.

5. A NOVEL SELCTION FUNCTION FOR MULTILEVEL HIERARCHICAL CLUSTERING

To form a cluster we need to select he nodes based on some criteria here we select the nodes that has satisfies the selection function (SF) and the selection function must be greater than the fixed threshold value. The selection function is given below

$$SF(N) = E_{sd} + T_{rp} \tag{7}$$

Where, E_{sd} is the Euclidean Squared Distance

T_{rp} is the threshold reserved power

N is the number of nodes

5.1. Euclidean Squared Distance

The Euclidean Squared distance metric uses the same equation as the Euclidean distance metric, but does not take the square root. As a result, clustering with the Euclidean Squared distance metric is faster than clustering with the regular Euclidean distance. The output of Jarvis-Patrick and *K*-Means clustering is not affected if Euclidean distance is replaced with Euclidean squared[26]. However, the output of hierarchical clustering is likely to change. The general formula foe Euclidean distance is

$$\sum_{i=1}^{n}(x_i - p_i)^2 \tag{8}$$

In one dimension, the distance between two points on the real line is the absolute value of their numerical difference. Thus if x and y are two points on the real line, then the distance between them is given by

$$(x - y)^2 \tag{9}$$

In the Euclidean plane, if $p = (p_1, p_2)$ and $q = (q_1, q_2)$ then the distance is given by

$$(q_1 - p_1)^2 + (q_2 - p_2)^2 \tag{10}$$

if the polar coordinates of the point p are ($r1$, θ1) and those of q are ($r2$, θ2), then the distance between the points is

$$r_1^{\,2} + r_2^{\,2} - 2\, r_1\, r_2 \cos\,(u_1 - u_2) \tag{11}$$

In three-dimensional Euclidean space, the distance

$$(q_1 - p_1)^2 + (q_2 - p_2)^2 + (q_3 - p_3)^2 \tag{12}$$

In general, for an n-dimensional space, the distance is

$$(p_1 - q_1)^2 + (p_2 - q_2)^2 + \ldots + (p_{i-}q_i)^2 + \ldots + (p_{n-}q_n)^2 \tag{13}$$

6. ADDING POWER FACTOR FOR SELECTION FUNCTION

Each node has different power capabilities. Some have enough power to finish the task and some may not have enough power to finish the task so while choosing the nodes for the formation of cluster we need to choose the nodes that are capable enough to finish the task and it must have enough power. if we choose an incapable node then it may lead to failure and the entire task will get destroyed.

Since sensing is a complex and large task, It takes much amount of power. It has high energy consumption and it may lead to node failure. To avoid such situation we need to calculate the reserved power each participating node in the cognitive radio network. Then add the T_{rp} to existing Euclidean distance. SF (n) is directly proportional to the E_{sd} and T_{rp}.

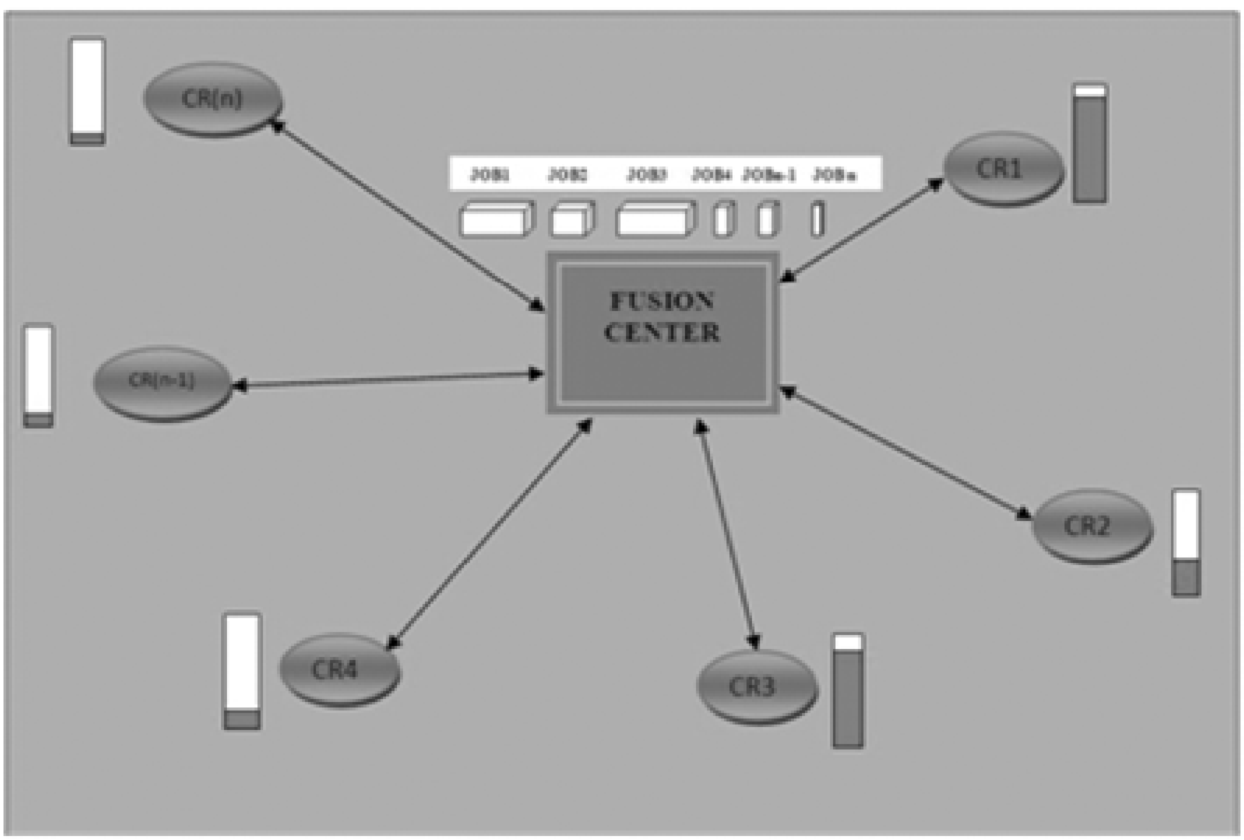

Figure 3: Node Selection Based on Threshold Reserved Power (T_{rp})

7. PERFORMANCE ANALYSIS

In this section, we provide a detailed analysis about the proposed novel node selection scheme. Even though it considers the additional parameter T_{rp} for taking consideration of available power in each node, it gives better results in the simulation. Majorly we interested to get results in two areas, first one is Average time for complete the clustering operation, second is ratio of faulty node in selection.

7.1. Cluster Formation Time Vs Number of Nodes

We have taken the existing clustering techniques such as K-mean and K-medoid for comparing with our proposed model. In Figure. 4, our proposed novel clustering scheme clearly shows that the average time for cluster formation reduced considerably compared to other clustering schemes such as K-mean and K-medoid.

7.2. Faulty Node Ratio Vs Number of Nodes

The ultimate aim of an effiecient clustering schemes not only lied on performance factors like time and effieicncy. That has to give importance for falut percentage in obtained result also. In this paper, We have analysed fault node percentage from the obtained result. In figure. 5, we have experiemennted and calculated the ratio of fault node selectio for the each level of increase in the number of nodes. For example, when the number of nodes in cluster formation is 500, K-mean based clustering detected 4.7% of faulty nodes after clustering, K-medoid based clustering detected 4.4% of faulty nodes after clustering, our novel multi-hierarchical, Euclidean-square based clustering detected only 3.9% of faulty nodes after clustering. Therefore, 17% performance improvement has been achieved in our Proposed Novel scheme compared with K-mean and 11.3% performance improvement has been achieved in our Proposed Novel scheme compared with K-medoid.

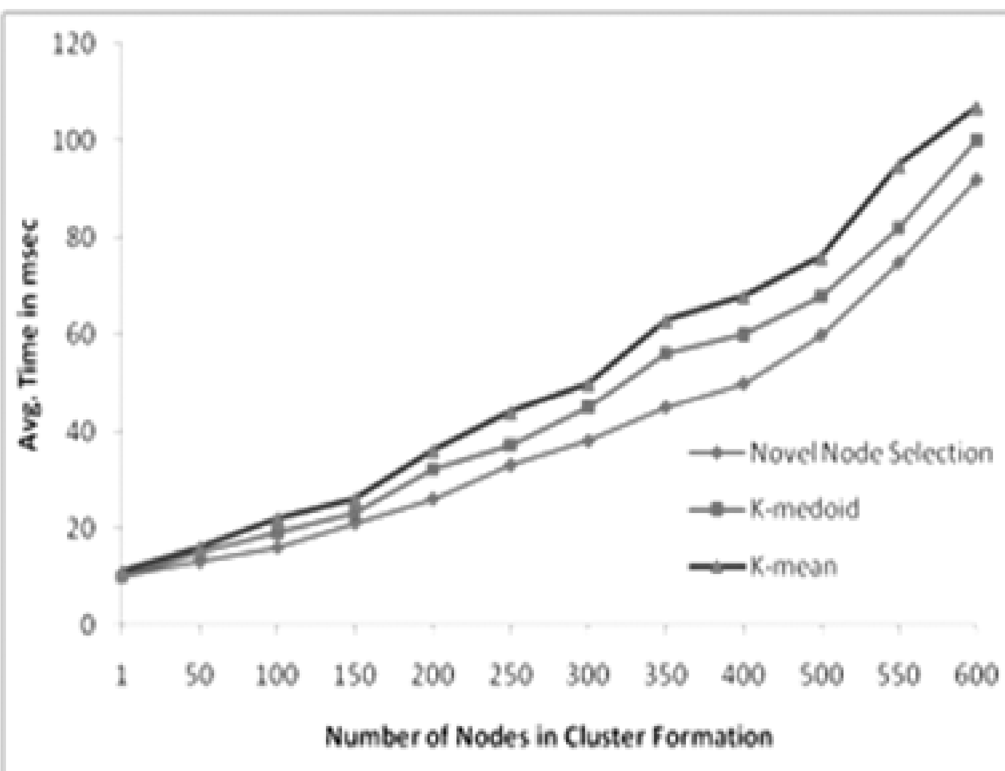

Figure 4: Average Clustering Time Vs Number of Nodes

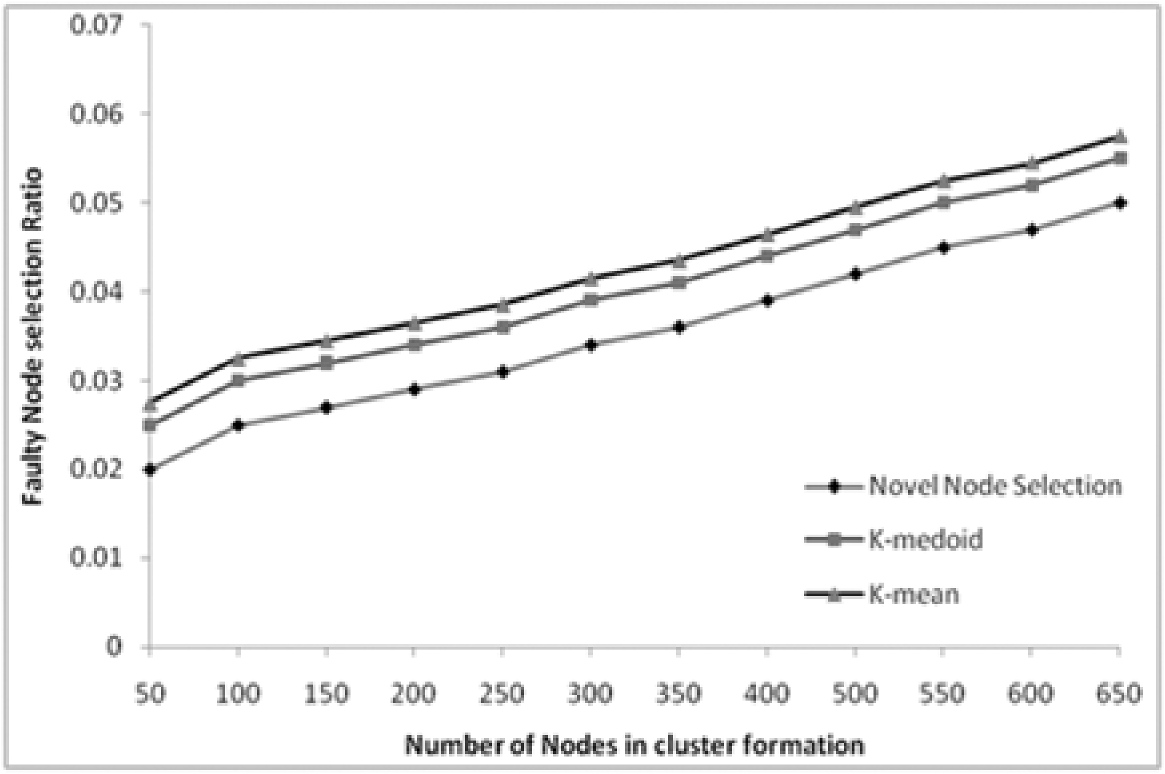

Figure 5: Faulty Node Ratio Vs Number of Nodes

7. CONCLUSION AND FUTURE WORK

In this paper, we designed an efficient clustering scheme using multilevel-hierarchical, Euclidean-square distance along with the consideration of reserved power of each participating node in the cluster formation. Multilevel hierarchical model suits well for cooperative CRN, since the channel sensing task carried out in distributed way. Task splitting and allocation needs level by level Fusion Center (FC) to avoid overload in a single FC. Since there is no root calculation in Euclidean-squared distance reduces considerable amount of complexity compared to Euclidean distance. Filtration at the end of first part of clustering performed by reserved power of each node. Thus we have balanced the complexity in all three integrated part of solution, the proposed method out performs well compared to all other existing schemes. In future, we planned to attach an efficient resource splitting and allocation scheme for created cluster.

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