Chapter 4

Proposed Approach

4.1 Overview

In order to address the issues of shadow effect and hiding stations, a non-cooperative spectrum sensing is impacted by the issue of the Secondary user being unable to scan the unoccupied spectrum. In non-cooperative spectrum sensing, hiding terminals and shadow effect can be a concern; however, using co-operative spectrum sensing can eliminate these issues. According to what was covered in the previous chapter, the co-operative spectrum sensing can be categorized into two separate groups: centralized and de-centralized. There is a risk that the efficiency of the flat network may decrease as its size increases. This is thus because significant increases occur when both the network's volume and the communication overhead across the network are increased. To reduce the size of a big homogeneous network system and improve its efficiency, making a cluster is one method that has gained a significant amount of interest. The network infrastructure is partitioned into appropriate groups while clustering, the make-up of which is defined by the network's characteristics and the needs of the functionality. In this section, we explore the investigation on the clustering method for de-centralized cooperative spectrum sensing.

4.2 Proposed cluster based DCSS Model

An illustration of the proposed conceptual system model for Cluster based Decentralized-CSS may be found in Figure 4.1(a) and (b). The secondary users have been divided up into their own individual groups or clusters. Every secondary user in a cluster possesses its very own localized spectrum sensing, and then makes use of a fusion rule in order to exchange that knowledge with the other secondary users (CH) that are present in the cluster. The primary users' presence on a network is defined by the information provided by every cluster, which are then communicated amongst the heads of the clusters. As the construction of the cluster is being built, all of the secondary users who have participated in the networks have been divided up into different categories. There is one secondary user in each cluster who, out of all the secondary users, serves as the head of the respective cluster and makes decisions regarding the presence or absence of primary users in the surrounding environment. Since a network is composed of several clusters, then it works as mentioned in the following diagrammatic representation.

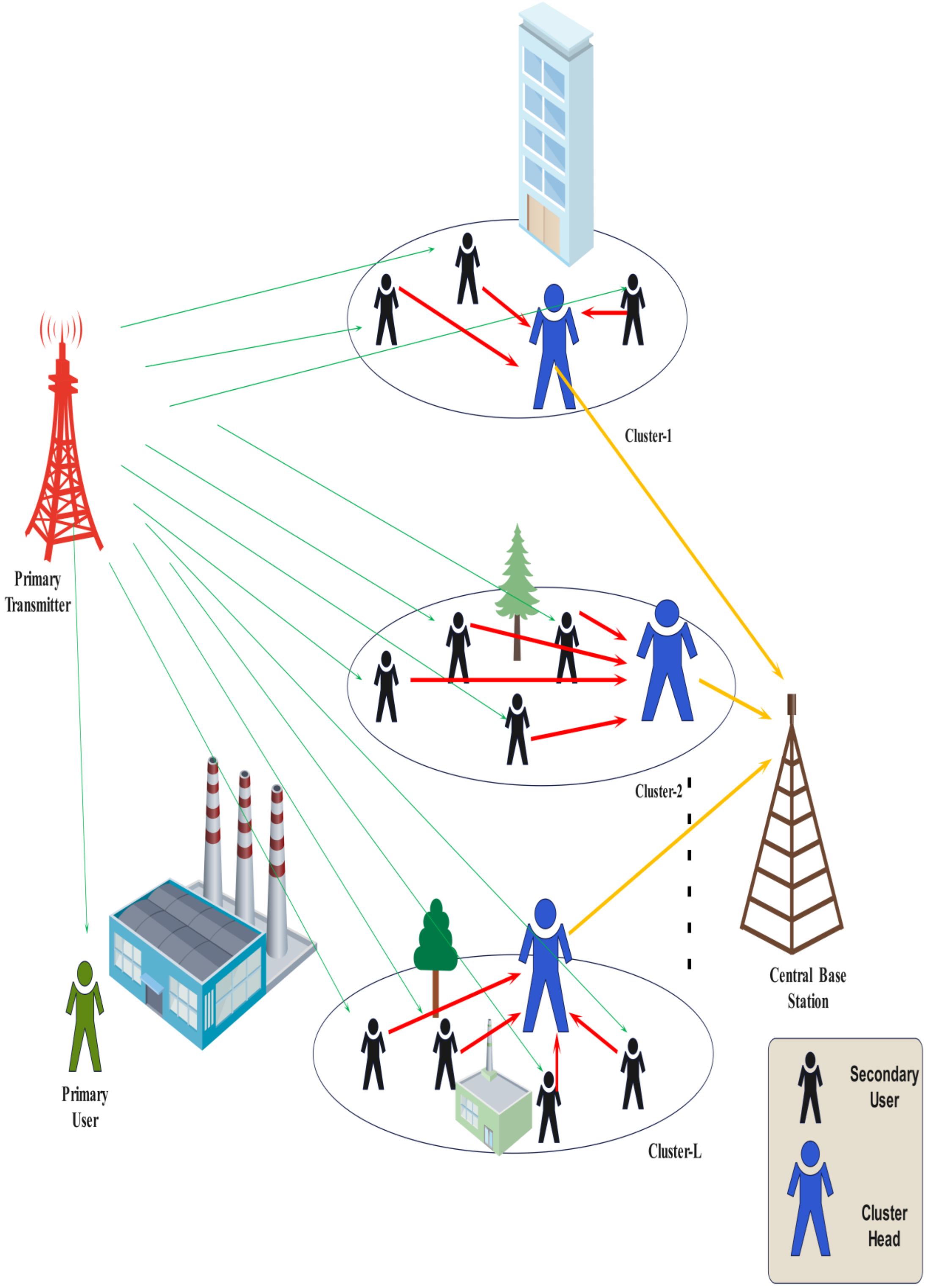


Figure 4.1(a): Proposed Cluster based D_CSS 3D-Model

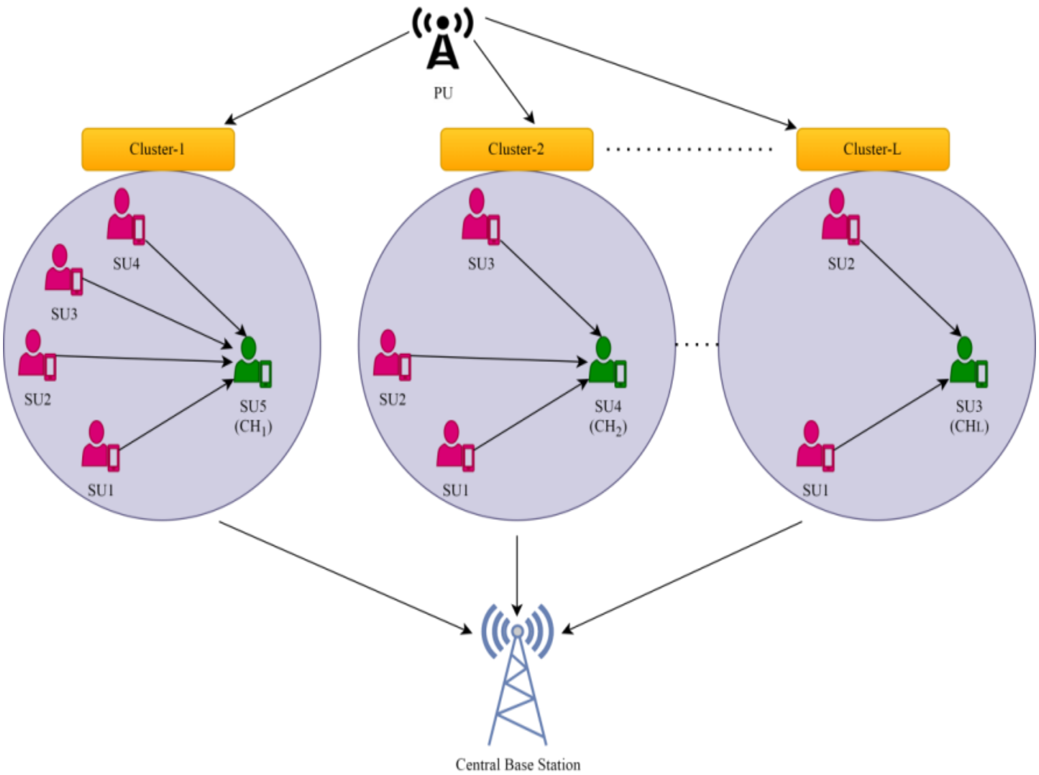


Figure 4.1(b): Proposed Cluster based D_CSS 2D-Model

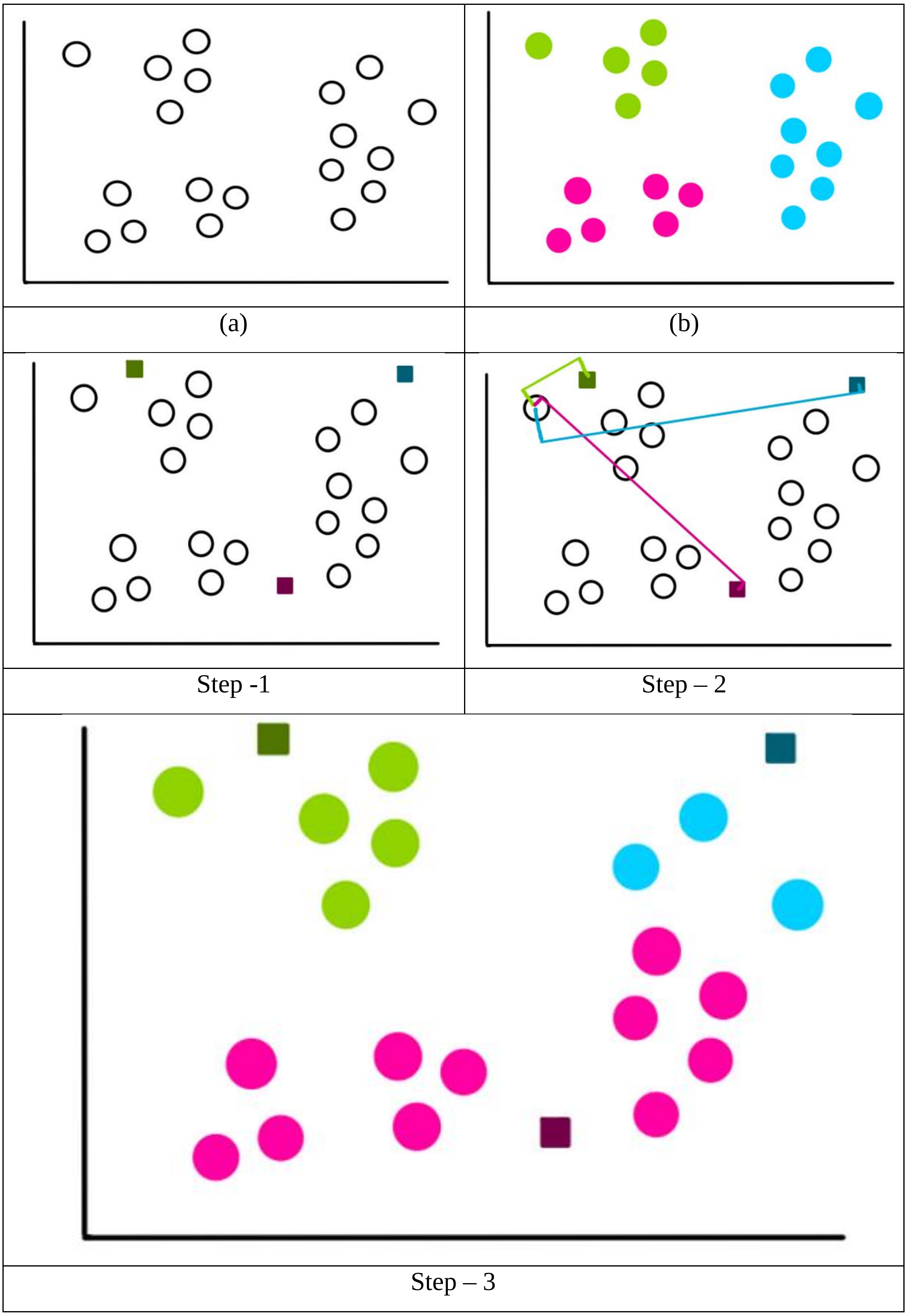
4.3 Clustering algorithm

Data clustering is the process of automatically identifying meaningful subgroups within a larger dataset. Typically, the visual system human can quickly generate separate clusters when presented with information that can be visualized (2- or even three- dimensional statistics). On the other hand, it's a bit complicated for machineries can do.

Clustering methods are useful for this purpose. And that is expanded to higher dimensions to cluster data that even the human eye can't. To reduce the size of a big homogeneous network system and improve its efficiency, making a cluster is one method that has gained a significant amount of interest. This is a strategy for partitioned clustering which is based on prototypes.

In this research work we have used k-means algorithm to partition the secondary users into the groups or cluster. It searches for a user-specified number of logical groups or cluster (L), being groups of similar items characterized by the centroid's of each cluster.

Let's assuming that, we have the following 19 sets of data (a). This information falls neatly into 3 groups (b). Our objective is to perform this grouping by employing the k-means Clustering algorithm. Assume the number of Cluster; i.e. L = 3.



(a) (b)

Step -1 Step – 2

Step – 3

Figure 4.2: Formation of cluster using K means algorithm

Step (1): Randomly selection of L points: this step locating clusters is to choose three points at random (not required from our data positions). These points itself will behave as centroid's or center.

Step (2): Formation of L Cluster: We begin by calculating the average distance of each dataset with each of the three centroids. And then we give preference for that to the nearest group. If we check at the distance between the data points and the green centroid, we can easily tell that it is shortest to the green centroid. So, the green cluster gets the point. The formula for measuring distance (D) in two dimensions $(X_2 - X_1)$ and $(Y_2 - Y_1)$ is given as under;

$$D = (X_2 - X_1)^2 - (Y_2 - Y_1)^2 \tag{4.1}$$

Step (3): Now, the above formula applied to the remaining spots then the clusters will resemble as shown in Figure 4.2.

4.4 Flow Chart for showing sequences of clustering algorithm

This clustering method relies heavily on Euclidean distances, and the choice of cluster heads is determined by the maximum energies of the nodes that are contained inside that cluster. In order to organize the nodes into 'L' clusters, we should begin by selecting an arbitrary number of centroids across the graph. Compute the Distance metric from every node to each of the centroids during the subsequent step, and then allocate that value to the centroid that is geographically closest to that node. Hence, 'L' Expected clusters are produced. Each cluster chooses its cluster head whose secondary user has maximum values of energy. After every centroid has finished the operation of clustering and chosen a cluster head, it will communicate back to each secondary user individually the knowledge related the cluster to which it resides as well as the cluster head.

As a result, all secondary users are aware of the cluster to which they correspond and the person in charge of that cluster means the cluster head (CH); this brings the clustering procedure for the suggested de-centralized co-operative spectrum sensing to a logical conclusion.

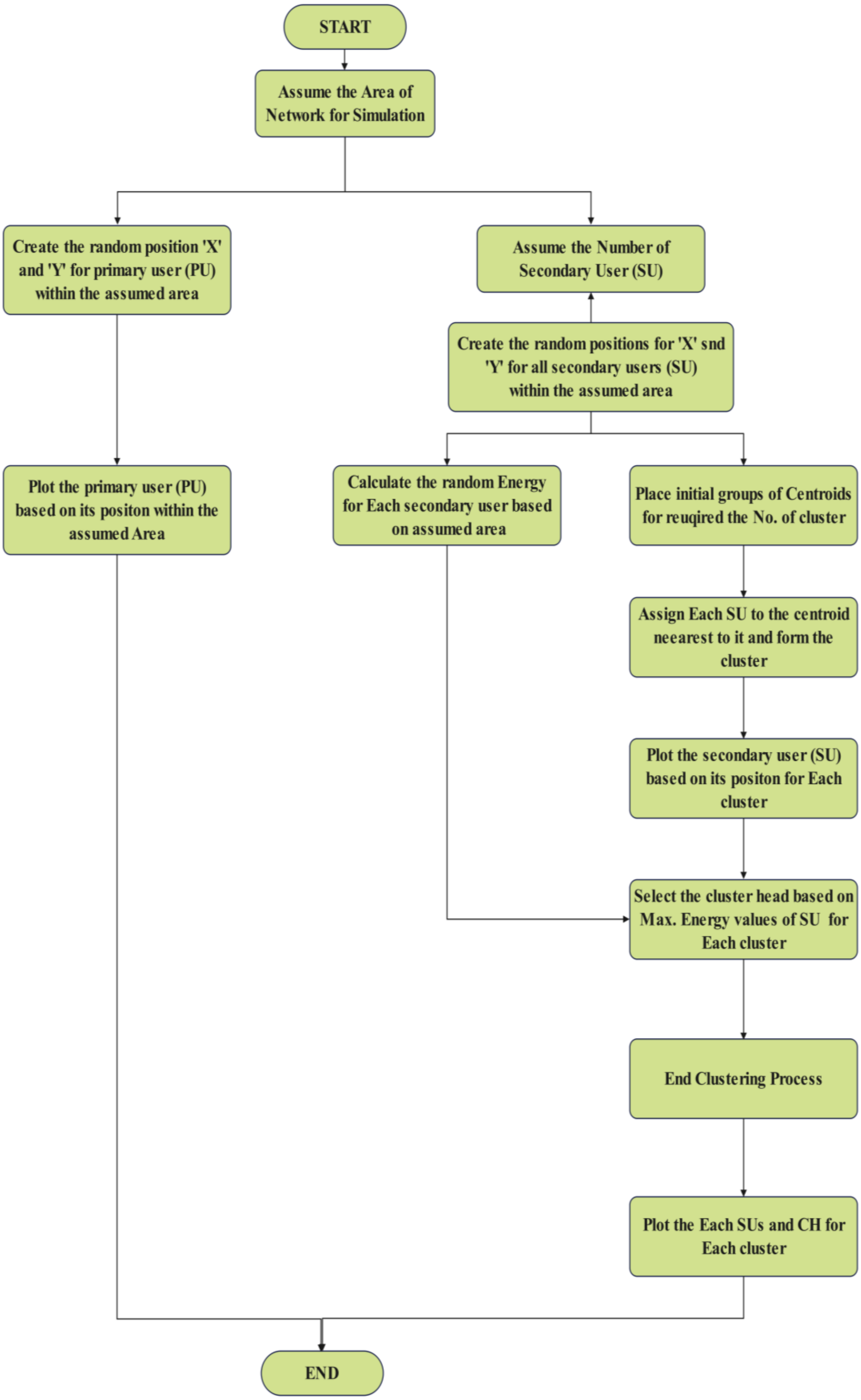


Figure 4.3: Flow chart for showing sequences of clustering algorithm

4.5 Flow Chart for cluster based DCSS model

Figure - 4.4 illustrates the flow chart for the De-centralized co-operative spectrum sensing using clustering approach.

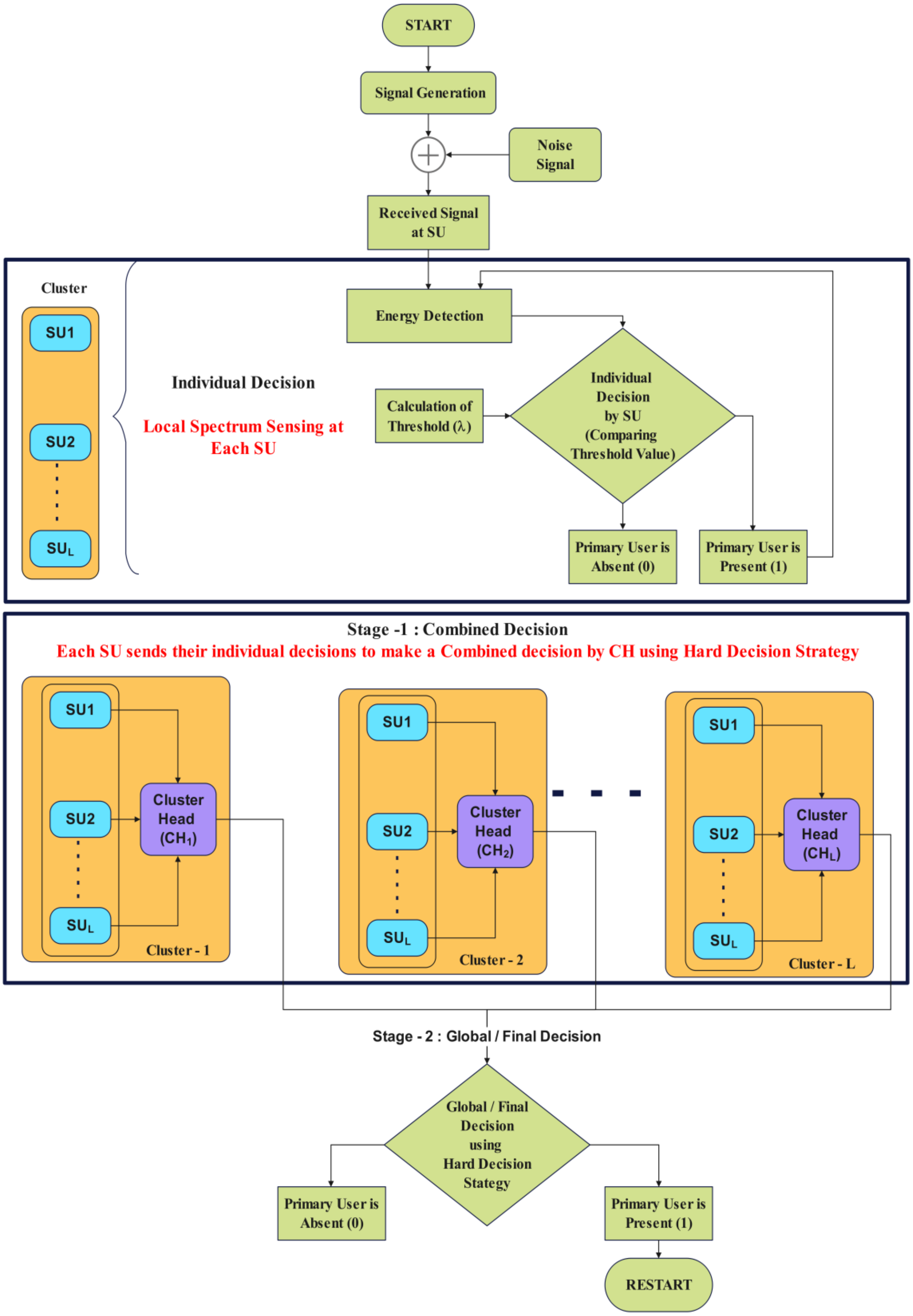


Figure 4.4: Flow chart of Cluster based D_CSS approach

Initially, for this proposed approach we take a scenario of a single primary user which is surrounded by the secondary users. Further, we separated the all the secondary users into the logical groups using k-means algorithm. Now, each cluster has the different number of secondary users.

Inside the cluster, each secondary user’s have some energy value which is received from the primary transmitter or user. In every cluster, among the group of secondary user, one secondary user declares as a head of cluster. The declaration of the cluster-head (CH) is based on the maximum energy value deserves the secondary user. Each secondary user will initiates the local energy detection within the cluster. It will decide the existence or non-existence of the primary user by comparing its received energy with the pre-determined threshold value and forward its individual judgments to the respective cluster head (CH) within their cluster. Each cluster head (CH) will collect and process the received individual judgment by using the hard-fusion strategy.

In second stage, each CH will combined their decisions at common base station by using hard-fusion strategy again and making a global decision to finally declare the status for the PU existence. Here two-stage hard fusion is used for making the global decision and is illustrated in the next section 4.6.

4.6 Two-Stage Hard fusion decision Scheme

For this proposed de-centralized cooperative spectrum sensing, the position of the cluster head remains same for a particular simulation. The cluster head (CH), primary user (PU), and secondary user (SU) locations will be randomly selected at the beginning of each simulation run. Also, all users' Energy values will fluctuate as a result of random energy creation during that simulation scenario.

CH oversees the network, coordinates the flow of information, and stores data. The remaining secondary users inside the cluster are in charge of doing localized sensing. Now, CHs from various clusters share data with one another by employing the same or by other fusion strategy to determine whether or not PU is present. Four distinct decision logics are described below with regard to the newly suggested De-centralized Co-operative spectrum sensing (D_CSS) using clustering method. We take L as total number SU’s in clsuter and l indicates number of group or cluster.

4.6.1 AND_AND Decision Strategy

To initiate the process of making global decision using "AND_AND" strategy, at the initial, every single secondary user of CR will be responsible for making its own individual decisions employing localized sensing based on the traditional approach of energy detection within the cluster. Now, all the secondary users have its own decisions concerning presence of PU. Additionally, all of the secondary users will communicate its knowledge with cluster head (CH) within the cluster by employing AND strategy during this first stage process, and then at the second stage each cluster head's (CHs) from every cluster will again apply AND strategy to communicate their decisions to make a final decision. Probability for false-alarm and detection of de-centralized Co-operative spectrum sensing for "AND_AND" strategy is calculated using the following formula, which has been obtained using mathematical expressions of centralized CSS.

$$PFA_{AND\_AND} = \prod_{i=1}^{l} \left(PFA^{AND^{(L)}} \right) \tag{4.2}$$

$$PD_{AND\_AND} = \prod_{i=1}^{l} \left(PD^{AND^{(L)}} \right) \tag{4.3}$$

Figure 4.5 offers a visual representation of the whole procedure for establishing final decisions for de-centralized co-operative spectrum sensing using the clustering technique with "AND_AND" decision strategy. This will make it easier to comprehend how these decisions are made.

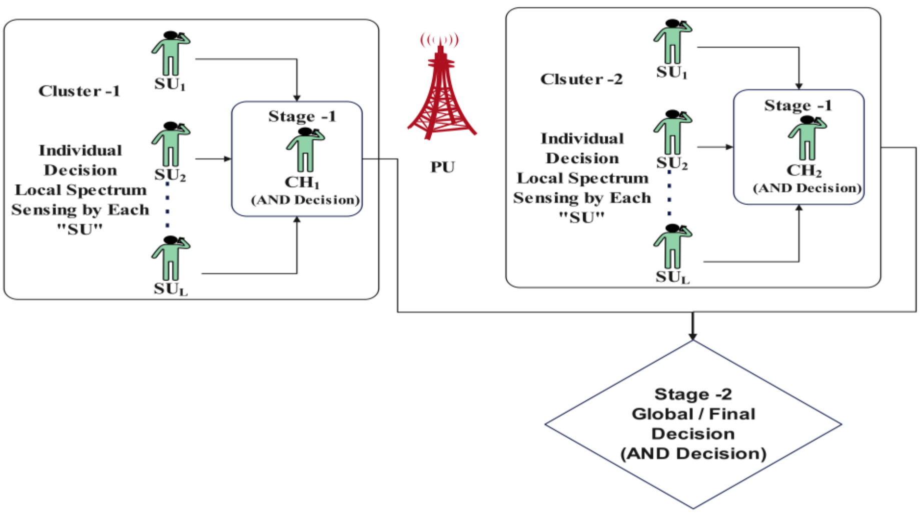


Figure 4.5: Illustration of AND_AND Decision Strategy

4.6.2 AND_OR Decision Strategy

To initiate the process of making global decision using "AND_OR" strategy, at the initial, every single secondary user of CR will be responsible for making its own individual decisions employing localized sensing based on the traditional approach of energy detection within the cluster. Now, all the secondary users have its own decisions concerning presence of PU. Additionally, all of the secondary users will communicate its knowledge with cluster head (CH) within the cluster by employing AND strategy during this first stage process, and then at the second stage each cluster head's (CHs) from every cluster will again apply OR strategy to communicate their decisions to make a final decision. The probability for missed-detection and detection of de-centralized Co-operative spectrum sensing for "AND_OR" strategy is calculated using the following formula, which has been obtained using mathematical expressions of centralized CSS.

$$PFA_{AND\_OR} = 1 - \prod_{i=1}^{l}\left(1 - PFA^{AND^{(L)}}\right) \tag{4.4}$$

$$PMD_{AND\_OR} = \prod_{i=1}^{l}\left(PMD^{AND^{(L)}}\right) \tag{4.5}$$

Figure 4.6 offers a visual representation of the whole procedure for establishing final decisions for de-centralized CSS using the clustering technique with "AND_OR" decision strategy. This will make it easier to comprehend how these decisions are made.

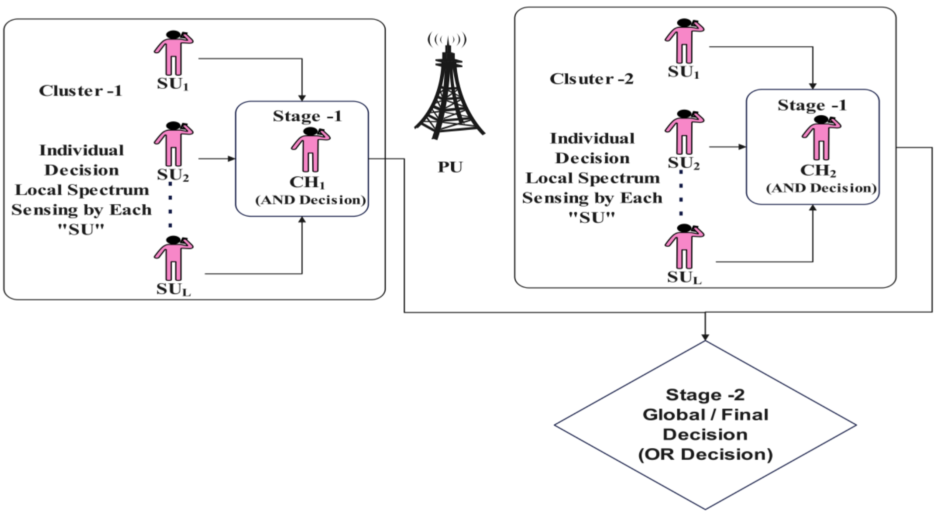


Figure 4.6: Illustration of AND_OR Decision Strategy

4.6.3 OR_AND Decision Strategy

To initiate the process of making global decision using "OR_AND" strategy, at the initial, every single secondary user of CR will be responsible for making its own individual decisions employing localized sensing based on the traditional approach of energy detection within the cluster. Now, all the secondary users have its own decisions concerning presence of PU. Additionally, all of the secondary users will communicate its knowledge with cluster head (CH) within the cluster by employing OR strategy during this first stage process, and then at the second stage each cluster head's (CHs) from every cluster will again apply AND strategy to communicate their decisions to make a final decision. The probability of false-alarm and detection of de-centralized CSS for "OR_AND" strategy is calculated using the following formula, which has been obtained using mathematical expressions of centralized CSS.

$$PFA_{OR\_AND} = \prod_{i=1}^{l} \left(PFA^{OR^{(L)}} \right) \tag{4.6}$$

$$PD_{OR\_AND} = \prod_{i=1}^{l} \left(PD^{OR^{(L)}} \right) \tag{4.7}$$

Figure 4.7 offers a visual representation of the whole procedure for establishing final decisions for de-centralized CSS using the clustering technique with "OR_AND" decision strategy. This will make it easier to comprehend how these decisions are made.

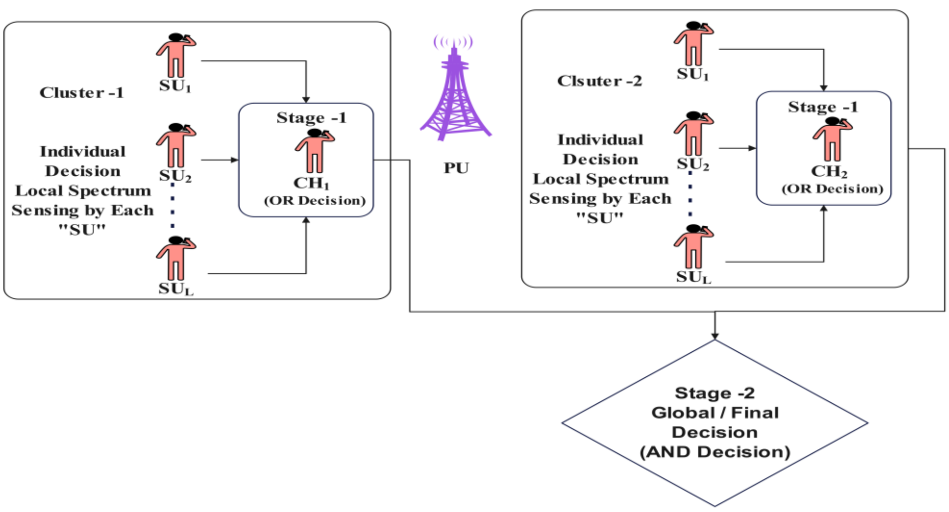


Figure 4.7: Illustration of OR_AND Decision Strategy

4.6.4 OR_OR Decision Strategy

To initiate the process of making global decision using "OR_OR" strategy, at the initial, every single secondary user of CR will be responsible for making its own individual decisions employing localized sensing based on the traditional approach of energy detection within the cluster. Now, all the secondary users have its own decisions concerning presence of PU. Additionally, all of the secondary users will communicate its knowledge with cluster head (CH) within the cluster by employing OR strategy during this first stage process, and then at the second stage each cluster head's (CHs) from every cluster will again apply OR strategy to communicate their decisions to make a final decision. The probability for false-alarm and missed-detection of de-centralized CSS for "OR_OR" strategy is calculated using the following formula, which has been obtained using mathematical expressions of centralized CSS.

$$PFA_{OR\_OR} = 1 - \prod_{i=1}^{l}\left(1 - PFA^{OR^{(L)}}\right) \tag{4.8}$$

$$PMD_{OR\_OR} = \prod_{i=1}^{l}\left(PD^{OR^{(L)}}\right) \tag{4.9}$$

Figure 4.8 offers a visual representation of the whole procedure for establishing final decisions for de-centralized Co-operative spectrum sensing using the clustering technique with "OR_OR" decision strategy. This will make it easier to comprehend how these decisions are made.

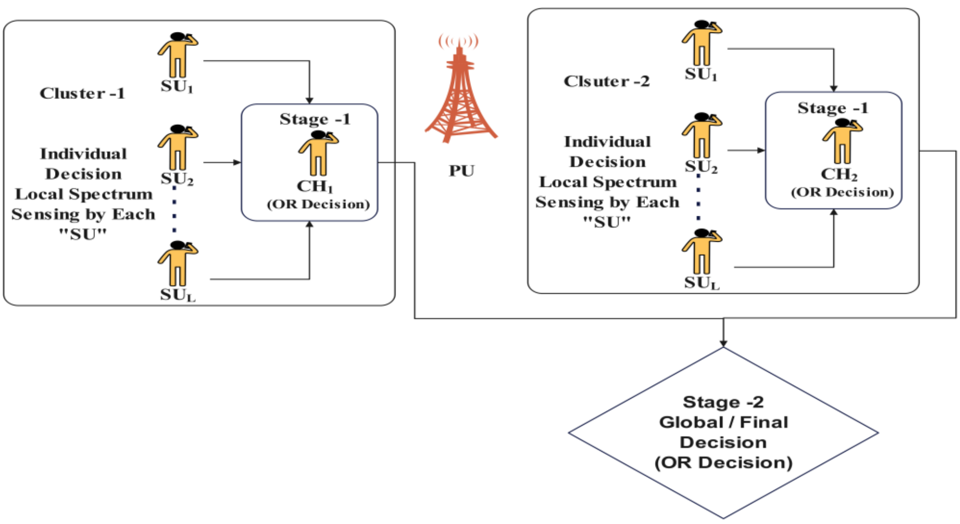


Figure 4.8: Illustration of OR_OR Decision Strategy