*Research Article*

# Efficient Spectrum Sharing by Cognitive User Section Through Clustering for D2D Communication

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**Abstract :** D2D communication is the direct communication between the wireless network node without the base station's involvement. This direct communication requires spectrum to communicate, which can be leveraged by using a cognitive radio approach through spectrum sharing. Spectrum sharing using sensed free channel among N number of cognitive users is one of the research issues and is an NP-hard problem. This spectrum sharing also called cognitive user selection. Channel sate-based user selection is usually carried. This user selection is carried out in such a way the sum rate in the network will be maximized. Here in this paper, a graph theory-based approach is followed. The entire node-set, which will share the spectrum, is represented as a weighted graph. The interference between the node that shares the spectrum is represented as the edge of the graph, and the participating cognitive user is represented as a node of the graph. Then clustering mechanism is applied to group the node as an interference-free set, and the cognitive user nodes are selected for the share the spectrum. The proposed mechanism simulation result proves that the mechanism can achieve a maximum sum rate.

**Keywords:** cognitive radion, D2D communication, graph theory,k means clustering, spectrum sharing.

## 1.Introduction

Device-to-device (D2D) communications have the potential capability of improving spectral and energy efficiency within the existing cellular network. It has a very simple approach to realize this efficiency and can be implemented easily in the existing cellular system.D2D system is designed in such a way it has to use the spectrum of cellular or unlicensed spectrum. A spectrum sharing strategy is required in both scenarios, which is one of the critical research in D2D communication. This research work intended to provide a mechanism of interference-free spectrum sharing between the D2D devices. There are various approaches reported in this direction, which are summarized below.

A new paradigm of cognitive radio in which the nodes are self-organized one and form an opportunistic ad hoc network to use the unused spectrum of the existing cellular network[1]. Each CR collaborate with each other to gather information about the assigned spectrum in use by the primary and secondary nodes. That information is used for selecting or sharing the spectrum among the secondary user without interference. The result of the work proved the reduction in call drop rate and improved QoS.

The traditional way of solving the channel assignment by using an optimization mechanism is reported [3] for uplink wireless communication.The mechanism is intended to maximize the sum rate of all users subject to integer channel assignment constraints. A convex optimization approach is utilized with the development of a new algorithm to solve channel assignment, then followed by machine learning approaches for efficient computational solutions. The formulated regression problem is solved by the integration of convolutional neural networks (CNNs), feed-forward neural networks (FNNs), random forest, and gated recurrent unit networks (GRUs).

The next-generation wireless networks are very complex systems because of the very diversified service requirements, heterogeneity in applications, devices, and networks. A data-driven approach will be a solution for solving next-generation wireless network channels where data analytics, machine learning (ML), is required[2,6]. In this direction, this work intended to apply the k means clustering approach for interference-free spectrum sharing among the cognitive D2D user.

Spectrum sharing scheme using deep learning also proposed [4] using dynamic Long Short-Term Memory(DLSTM) for CP-OFDMA based 5G waveform, but this approach specific to the CP-OFDMA which will not work for all scenario. Spectrum sharing on the unlicenced band for d2d devices using wifi technology is presented [5].

Reliable hardware-based spectrum sharing using SVM is proposed [7]. energy efficient direction using soft computing of genetic algorithm a spectrum sharing framework is presented[8]

The remaining portion of the article is organized as section 2 deals with the system model; section 3 gives the result and discussion and section 4 concludes the article with the future direction.

**2.System Model**

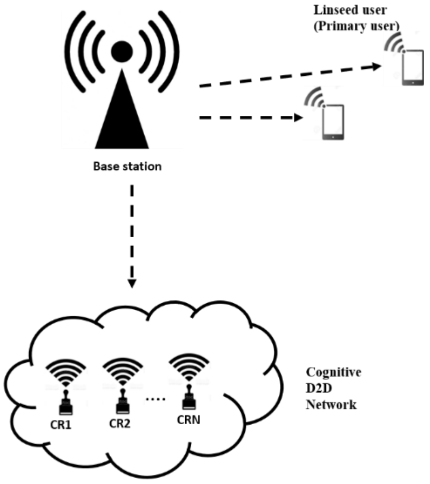


Figure 1 System model

Figure 1 shows the system model, which is utilized in this research study. The model consists of the traditional cellular network with primary users licensed to use the cellular frequency. The cognitive D2D network also co-exists with cognitive nodes that utilize the cellular spectrum's unused spectrum (White spaces). The proposed system model consists of an M number of primary nodes and an N number of cognitive D2D network nodes. As shown in figure 1.it is assumed that the spectrum hole (white spaces are already detected and available for every cognitive node in the D2D network. With this assumption, the research work focuses on sharing the detected spectrum hole among the cognitive D2D devices without interference. The research work is formulated to share the spectrum by maximizing the sun rate of the D2D network with the constraint of without inference or minimal interference among the nodes. The formulated research problem can we defend mathematical as below

$$maximize\ \sum_{i=1}^{N} R_i \qquad (1)$$

$$Subject\ to\ SINR_i \leq thresh\_sinr_i \qquad (2)$$

Where the rate of the ith user is defined as

$$R_i = Wlog(1 + \frac{h_{ii}p_i s_i}{\sum_{j\neq i} h_{ij}p_j s_j + \sigma^2}) \qquad (3)$$

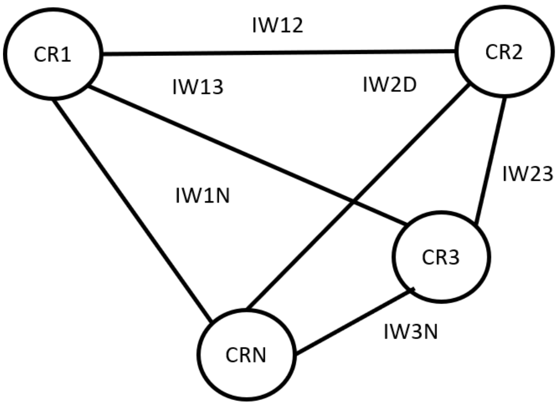


Figure 2. Network model

The above optimization problem can be solved traditional optimization mechanism. But this article intended to solve the problem by using graph theory approach and clustering mechanism. Under the approach, the cognitive D2D network is modeled as a bidirectional graph with cognitive nodes as the graph's node element. The interference component among the node by sharing spectrum is modeled as the graph's edge element, as shown in figure 2. In figure 2, IW12 Represents the interference weightage between nodes 1 and 2. Similarly, IWij represents the interference weight value between ith D2D node and j D2D Node.

In order to solve the problem by clustering mechanism, the interference weight value in the graph is calculated by Geographical location ( Spatial ) based. The normal solution for solving the problem requires full CSI information, which is not possible practically for wireless D2D networks. But each node in D2Dg has readily available geographic information (i.e., the locations of the transmitters and receivers), which can be used for the calculation of interference weightage value. Each edge or link in the network is represented by calculated Euclidian distance between a 2D representants of the node's interference point. This 2 D point representing the ith node is the midpoint between the transmitter and receiver, representing βi. The IWij is calculated as the euclidian distance between βi and βj. This euclidian distance meant the interference potential between the ith and jth node based on the location of it's received

This Euclidean space data IWij for i, j=1,2,….N is used as input for the modified k means clustering algorithm and clustered set output will be interference-free node-set to share the spectrum .the following modification is carried out in the k means algorithm 1)no of the node in each cluster is made as equal 2)clustering assignment is done based on a distance measurement which is calculated as the difference between a data point distance to the furthest centroid and the closest centroid. The detailed algorithm is given below.

**Modified K means clustering algorithm**

S1. Input: data-points, number of the cluster;
S2. while not all data points are assigned do
S3. For each unassigned data point i
compute $\boldsymbol{\delta_i}$ as the difference between it's distance to the furthest centroid and the closest centroid**;**
End for
S4. Rank $\boldsymbol{\delta_i}$ in the descending order and store in ol:
S5. While none of the clusters reach their desired sizes do
Take one data-point from the top of ol and Assign It to the cluster of its closest centroid;
End while
S6. One cluster with the desired size formed as $\boldsymbol{C_j}$
Remove the centroid and its data-points in $\boldsymbol{C_j}$
End while
S7. output: A set of equal-sized clusters $\{\boldsymbol{C_j}\}$.

**3.Result and Discussion**

The random D2D cognitive radio network with 40 nodes is generated with random location information to carry out the proposed research study. The generated random location of the network is plotted in figure 3. From figure 3, We can observe the nodes distributed randomly in the space. The K means clustering of the proposed mechanism is applied for the above 40 nodes, and four clusterings of the nodes are generated on which spectrums are shared. Figure 4 gives the clustered nodes under four groups. For sharing the spectrum, one node from each cluster is selected, and the same frequency is shared among them. This kind of communication strategy is repeated ten times, and the average sum rate of the network is calculated. It is observed that the proposed mechanism is capable of achieving a 6.0206Mbs sum rate for a 40 node network with unit transmit power with a noise variance of 0.5. Under this simulation, the interference node power is also assumed as unit power. All the channel gains are generated randomly to cover practical random scenarios.BPSK based modulation scheme is assumed for the simulation study.

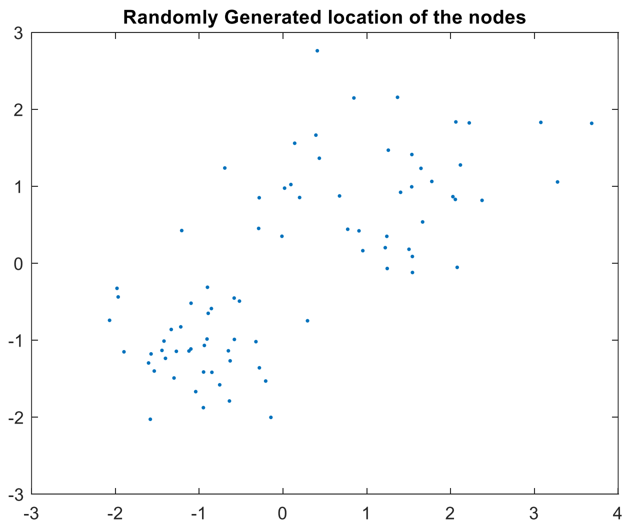


Figure 3. randomly distributed location-based node generation

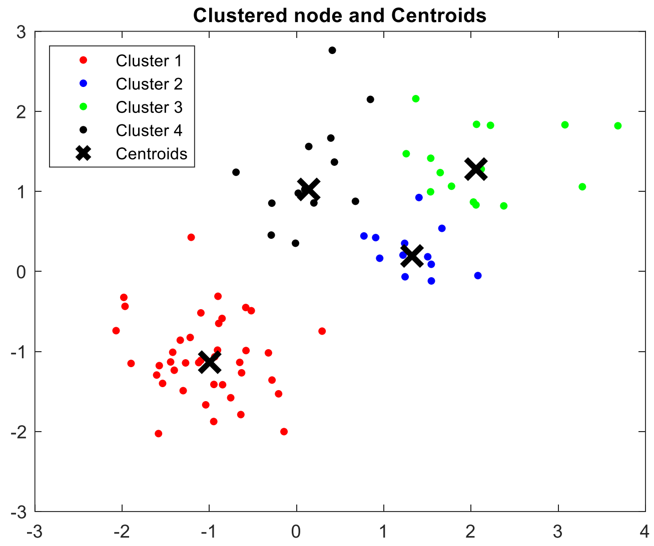


Figure 4.four clustering of nodes for spectrum sharing

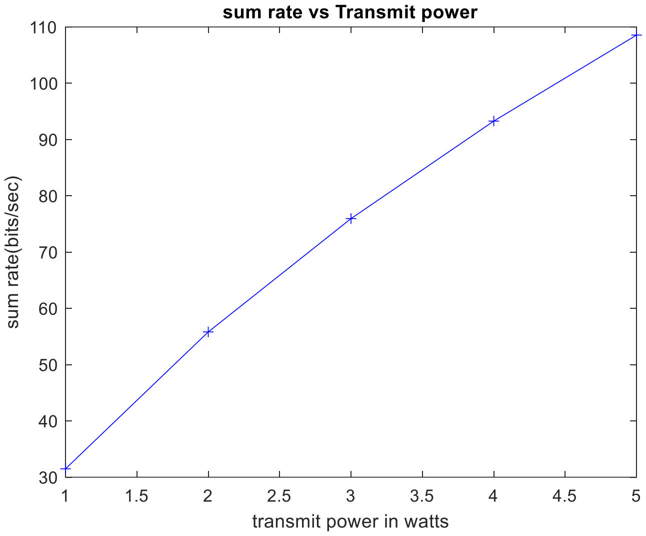


Figure 5.sum rate vs. transmit power

To illustrate the proposed algorithm's performance, the network's sum rate is calculated and plotted in figure 5. From figure 5, it is evident that the sum-rate increases with the increased transmit power.

## 4.Conclusion

Interference-free spectrum sharing is one of the requirements in the D2D communication network. Solving such an optimization problem is a challenging one, which is solved in this article by using graph representation and k means clustering. The proposed optimization mechanism achieves a sum rate of 6.0206Mbs.The simulated result shows the proposed mechanism provides a good sum-rate for the network without much interference. The future work will be solving the same problem using a deep learning model with much automation in solving the problem.

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