DELIVERING SERVICES TO BORDER USERS THROUGH D2D MULTICASTING

Thesis is submitted in the partial fulfillment

of the requirements for the degree of

BACHELOR OF TECHNOLOGY

in

COMPUTER SCIENCE AND ENGINEERING

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DECLARATION

We the undersigned declare that the thesis work entitled "**Delivering Services to Border Users through D2D Multicasting**", submitted towards partial fulfillment of requirements for the award of the degree in **Bachelor of Technology** in **Computer Science and Engineering** is our original work and this declaration does not form the basis for award of any degree or any similar title to the best of our knowledge.

Durgapur
May, 2024

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This is to certify that the thesis entitled "**Delivering Services to Border Users through D2D Multicasting** ", submitted by **P. Priya and M. Poojitha** of Department of Computer Science and Engineering, National Institute of Technology, Durgapur, in partial fulfillment of the requirements for the award of the degree in **Bachelor of Technology** in **Computer Science and Engineering** is a bonafide record of work carried out by them under my guidance during the academic year 2023 – 2024.

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ABSTRACT

5G is the advanced technology beyond the 4G, which has faster speed, more bandwidth, wider range, low latency, and better Quality of Services. Very soon, trillions of wireless gadgets will be linked to billions of people, resulting in an overloaded spectrum. Device-to-Device (D2D) communication is an innovation that can contribute to the fulfillment of the demand of 5G and it offers a new paradigm for addressing these impending issues by permitting the transmission of data between proximity devices. In D2D communication, mobile devices communicate directly with each other without routing through the base station, thereby reducing network congestion and latency. However, the performance of D2D communication networks can be affected by the distance between the nodes.

This report presents a novel approach to device-to-device (D2D) communication wherein the farthest nodes from the base station leverage intermediate internal nodes to establish and maintain connectivity. The proposed framework aims to enhance network reach, reduce latency, avoid interference, multicast and optimize resource utilization.

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION OF D2D COMMUNICATION

Device-to-Device (D2D) communication in cellular networks is defined as direct communication between two mobile users without Base Station as an intermediary. It is generally non-transparent to the cellular network and it can occur on the cellular frequencies (i.e., inband) or unlicensed spectrum (i.e., outband).

D2D communication is normally referred to as the technology to enable proximate users to directly communicate with each other without the use of an infrastructure. D2D communication can not only increase the spectral efficiency of the network but also improve network throughput, communication delay, energy efficiency, and fairness[4]. The concept of D2D seems tolerable, but it has a lot of confrontations, such as resource allocation, power allocation, interference management, etc. So, this paper concentrates on the resource allocation and interference management.

Researchers estimate that trillions of wireless gadgets will eventually connect billions of people, resulting in an overcrowded spectrum. As a result, meeting these expectations will be a significant problem for the impending 5G technology with network slicing and aggregation. D2D Communication is one of the most promising 5G technologies in cellular communication, which can improve spectral utilization in cellular networks. D2D is also important for proximity services and in the disaster prone areas.[2]

Global mobile traffic flow grown seven-fold between 2017 and 2022. The number of mobile-connected devices is expected to increase drastically in the upcoming years, which requires the more efficient design of the cellular architecture. Per capita mobile devices will be 1.5 times, the network connection speed will increase up to 28.5 Mbps, 5G connections will generate approximately 2.6 times more traffic compared to 4G, and average 11 GB traffic will generate by smartphones up to 2022. D2D communication is the most innovative technology which contributes to the reduction of the heavy traffic problem.

Next-generation cellular networks need high capacity, power efficiency, and guaranteed Quality of Service (QoS). To achieve these goals D2D communication is an important technology for fifth-generation applications. Bluetooth and Wi-Fi-Direct are the two most popular D2D techniques. With the emergence of machine-to-machine (M2M) applications, D2D communication has assumed a very pivotal role. It facilitates the discovery of devices that are closer to each other and enables direct communication between them. This results in improved communication quality and reduces energy consumption and communication delays. In a traditional cellular network, all communications must go through the BS even if communicating parties are in range for proximity-based D2D communication. Communication through BS suits conventional low data rates mobile services such as voice calls and text messaging in which users are seldom close enough for direct communication. However, mobile users in today's cellular networks use high data rate services (e.g., video sharing, gaming, proximity-aware social networking) which could potentially be in the range for direct communications (i.e., D2D). Hence, D2D communications in such scenarios can greatly increase the spectral efficiency of the network.

D2D can deal in an integrated way with various techniques to improve Network performance such as the Internet of Things (IoT), Vehicle-to-Vehicle (V2V) Technology, Artificial Intelligence (AI), millimeter Waves (mmW) Technology, the other hand, may encounter many difficulties that must be taken into account. When implementing D2D technology, there is interference between centralized users (CUs) and distributed users (DUs) because they share the same resources in the same area. Other problems facing D2D technology such as peer discovery, delivery, management of radio resource allocation, optimization, and security issue in addition to energy consumption. Thus, many researchers and mobile operators have paid attention to D2D to enhance network performance without breaching any of the requirements of the service.

Based on spectrum usage scenarios, D2D communication can be divided into two categories:

- Inband D2D communication
- Outband D2D communication.

Inband D2D communication can be further classified into

- Underlay D2D Communication
- Overlay D2D Communication

1.2 TYPES OF D2D COMMUNICATION

INBAND AND OUTBAND COMMUNICATION

InBand D2D Communication: In this type of communication where both D2D and the cellular links use the licensed cellular spectrum. The inband resource allocation is divided into two types, namely, underlay resource allocation and overlay resource allocation, the underlay inband D2D shares (i.e., reuses) the spectrum resources between D2D and the cellular links, the overlay inband D2D allocates dedicated cellular resources to D2D links[3]. The cellular resources are utilized for both cellular users and D2D users, where the D2D users are controlled by the cellular system.

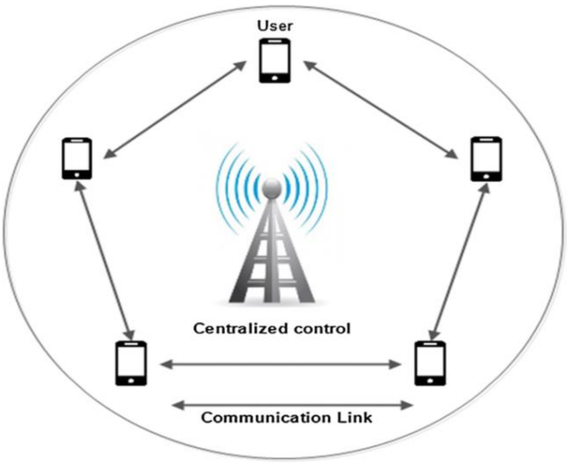

Figure 1.1 (InBand D2D Communication)

OutBand D2D Communication: Out band D2D communication utilizes the unlicensed spectrum other than the cellular band with the motivation of eliminating the co-channel interference problem between D2D and cellular links. The out-band resource allocation is divided into two types controlled and autonomous. In the controlled out-band resource allocation, the D2D users are controlled by the cellular network. On the contrary, in the autonomous out-band resource allocation; the cellular network does not have such control on the D2D communication.

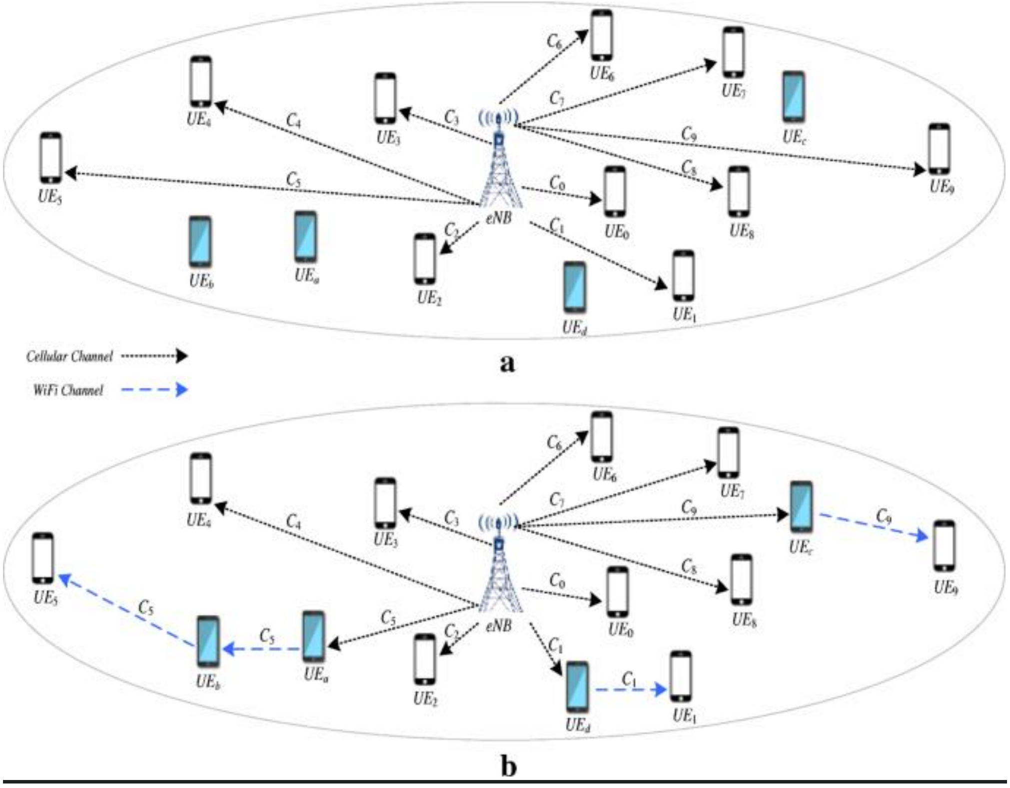

Figure 1.2 (OutBand D2D Communication)

UNDERLAY AND OVERLAY COMMUNICATION

InBand D2D communication is further categorized into two types viz. Underlay and Overlay as described below.

Underlay D2D Communication: Underlay D2D communication shares the same radio resources for cellular and D2D communication. In the underlay inband resource allocation, the cellular users and D2D users share the same band; and consequently this improves the spectrum efficiency. The major challenge of underlay D2D resource allocation is the mutual interference among the cellular and D2D users[1]. This interference problem should be solved by using improved resources allocation and power control algorithms.

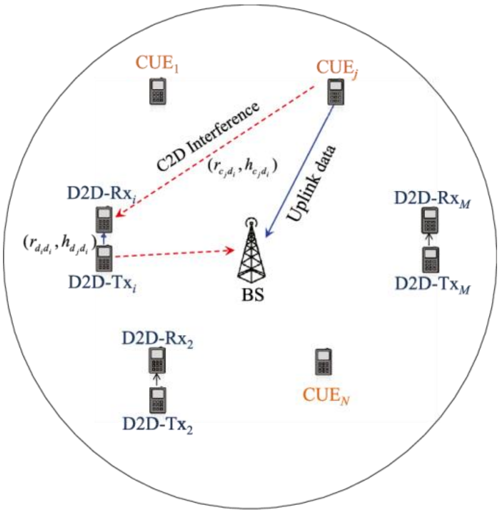

Figure 1.3 (Underlay D2D Communication)

Overlay D2D Communication: Overlay D2D communication uses a dedicated cellular spectrum for cellular and D2D communication. In the overlay in-band resource allocation, the resources are divided into two dedicated bands; the first band is used by the cellular users and the second band is used by the D2D users. The merit of the overlay resource allocation is that there is no interference between the cellular users and D2D users, but it may reduce the spectrum efficiency.

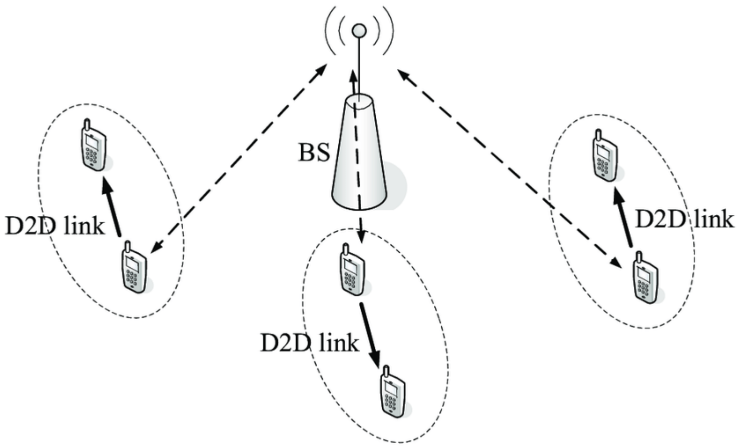

Figure 1.4 (Overlay D2D Communication)

1.3 IDEA OF D2D MULTICASTING

Multicasting in device-to-device (D2D) communication provides a range of benefits for both cellular networks and users. By enabling users to transmit the same file simultaneously to multiple receivers, multicasting saves time and network resources. This is particularly useful for cellular communication, where it allows for efficient data sharing across the cellular network.

In densely deployed D2D networks, short reuse distances and low transmitting powers can lead to significant interference, which requires base stations with large capacity. However, this can introduce delays in communication. One solution is to divide the network into clusters, each with its own base station for D2D communication. Multicasting within these clusters ensures efficient use of resources and supports local file transfer on commercial platforms.

The growing demand for high-quality mobile live video streaming services has placed pressure on cellular networks due to dramatically increased data usage. D2D-aided multicasting has emerged as a promising technique to address this challenge by enabling direct data transmissions among users in close proximity. The clustering strategy is essential for effective D2D-aided multicasting in cellular networks, helping to manage data traffic and optimize performance.

Some important applications of multicasting include:

- Dissemination of marketing/advertisement data in commercial networks
- Device discovery,clustering,coordination in self organising newtworks
- Dissemination of critical information such as police,fire,ambulance,etc. in the public safety netwroks

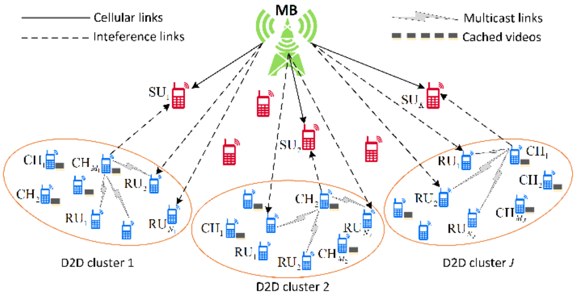

Figure 1.5 (D2D Multicasting)

CHAPTER 2

LITERATURE REVIEW

This literature review provides background information on the issues addressed in this thesis and highlights the importance of the present study. The focus is on the significance of device-to-device (D2D) communication in disaster-prone areas, where traditional network signals may not reach all users over larger distances, putting lives at risk due to a lack of communication.

Previous research in this field has demonstrated improvements in spectral efficiency for D2D communication using various techniques such as clustering, frequency reuse, spectrum sharing, resource block allocation, and the implementation of advanced waveforms such as orthogonal frequency division multiplexing (OFDM), filtered orthogonal frequency division multiplexing (F-OFDM), filter bank multicarrier (FBMC), and universal filtered multicarrier (UFMC).

Most proposed approaches divide users into clusters based on K-means or K-medoid algorithms. However, in this thesis, users are divided into clusters using the DBSCAN clustering algorithm, which ensures that signals are transmitted to users at greater distances from the base station. This approach addresses interference issues using resource blocks, multicasting signals, and 2-hop communication when necessary. As a result, this approach achieves better performance than previous methods.

D2D Communication:

A number of studies have focused on the use of D2D communication in wireless networks. Research has shown that D2D communication can improve network efficiency, reduce latency, increase bandwidth, and enhance security. Some of the challenges associated with the deployment of D2D communication include interference with existing networks, security concerns, integration with existing systems, regulatory barriers, and lack of standardization.[10][11][12][13]

Underlay D2D Communication:

In underlay D2D communication, devices share the spectrum with traditional cellular networks, operating on the same frequency bands. This approach enhances spectral efficiency by enabling simultaneous communication between devices and cellular users within the same frequency spectrum. Underlay D2D communication holds promise for improving network capacity, reducing latency, and enhancing overall communication reliability in scenarios such as crowded urban environments or areas with limited network coverage.

Overlay D2D Communication:

Overlay D2D communication involves establishing direct communication links between nearby devices without relying on the existing cellular infrastructure. In this approach, devices create a separate communication overlay on top of the cellular network, operating on dedicated frequency bands or through the use of alternative communication protocols. Overlay D2D communication can be advantageous in scenarios where the cellular network is congested or unavailable, providing a more flexible and resilient communication solution. It is particularly useful for applications such as content sharing, collaborative tasks, or emergency communications, where direct device-to-device connections can enhance efficiency and reduce dependence on centralized networks.

D2D Clustering:

Research has also been conducted on the use of D2D clustering in wireless networks. D2D clustering can improve network efficiency, reduce latency, increase bandwidth, and enhance security. The challenges associated with the deployment of D2D clustering are similar to those of D2D communication. Some studies have proposed solutions to these challenges, such as the use of cognitive radio technology, dynamic spectrum access, and distributed resource allocation.[5][6][7][8]

Future Directions:

Future research in D2D communication and clustering could focus on the dynamic environment of the network[9], resulting in a more realistic approach and emphasizing vehicle communication.

CHAPTER 3

PROJECT DESCRIPTION

3.1 SOFTWARE UTILIZED

Python:

Python, a dynamic and high-level programming language, has established itself as a cornerstone in the world of software development. Guido van Rossum created Python with a focus on readability and simplicity, making it accessible for both beginners and experienced programmers. Its clean syntax and extensive standard libraries facilitate rapid development across various domains.

Python's versatility is evident in its application across diverse fields. From web development with frameworks like Django and Flask to scientific computing and data analysis using NumPy and Pandas, Python has become a go-to language. The rise of machine learning and artificial intelligence further propelled Python's prominence, with libraries such as TensorFlow and PyTorch driving innovation.

Figure 3.1 (Python logo)

Ubuntu:

Ubuntu is a Linux distribution based on Debian and composed mostly of free and open-source software. Ubuntu is officially released in three editions: Desktop, Server, and Core for Internet of things devices and robots. All the editions can run on the computer alone, or on a virtual machine. Ubuntu is a popular operating system for cloud computing, with support for OpenStack. Ubuntu's default desktop changed back from the in-house Unity to GNOME after nearly 6.5 years in 2017 upon the release of version 17.10.

Ubuntu is released every six months, with long-term support (LTS) releases every two years. As of October 2022, the most recent release is 22.10 ("Kinetic Kudu"), and the current long-term support release is 22.04 ("Jammy Jellyfish").

Ubuntu is named after the Nguni philosophy of ubuntu, which Canonical indicates means "humanity to others" with a connotation of "I am what I am because of who we all are".

Figure 3.2 (Ubuntu logo)

3.2 NETWORK ENVIRONMENT

First, a random allocation of N nodes is made across a 500 x 500 area. These points are then divided into two groups: Group 1 comprises points within a 150-unit radius, representing users within the coverage area known as Cellular users, while Group 2 includes points outside this radius, indicating users beyond the coverage area known as Boundary users. Next, nodes outside the coverage area are clustered for D2D communication using the DBSCAN Algorithm. Nodes that remain outside coverage and cannot be assigned to any cluster are deemed isolated nodes.

DBSCAN, short for Density-Based Spatial Clustering of Applications with Noise, is a commonly employed clustering algorithm in data mining and machine learning. It aggregates data points based on their proximity, defining clusters by density rather than geometric shape. The algorithm functions by establishing a neighborhood around each data point and identifying core points that have a sufficient number of neighbors within a specified distance. Points that are not core points but lie within the neighborhood of a core point are considered part of the same cluster.

Additionally, points with fewer neighbors than the required threshold are labeled as noise. Key parameters in DBSCAN include the radius (eps) defining the neighborhood and the minimum number of points (min_samples) necessary to constitute a dense region and maximum number of points(max_samples) in a cluster so that the maximum distance between cluster head and any other cluster member is within the threshold distance. The algorithm excels in identifying clusters of various shapes and is less affected by outliers compared to some other clustering methods.

The central node operates as the base station, with each resource cluster distinguished by a unique color code. Consequently, nodes unable to receive signals from the base station are facilitated through a cluster head or cooperative node (if available), which in turn receives signals from cellular users situated within a designated threshold distance. This arrangement aims to minimize power consumption effectively.

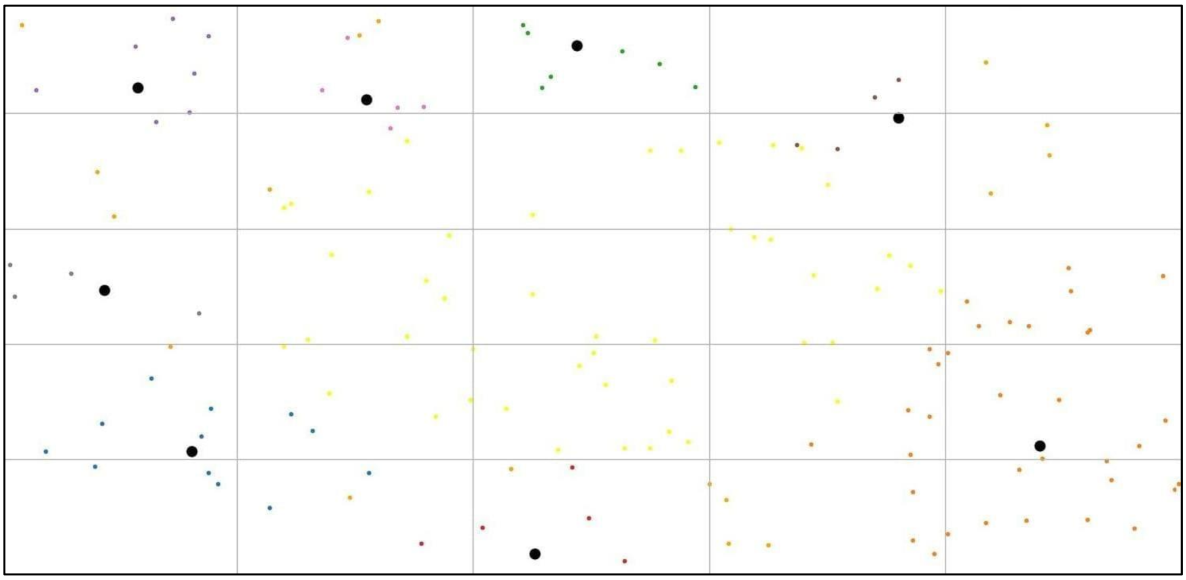

Figure 3.3 (Network Scenario)

This network environment comprises of cellular users, clusters formed through DBSCAN algorithm showing the cluster heads and isolated users.

CHAPTER 4
MOTIVATION

Device-to-device (D2D) communication is expected to play a significant role in upcoming cellular networks as it promises ultra-low latency for communication among users. In recent years, 5G communication has emerged as a promising technology, allowing devices to access the cellular spectrum rapidly. The ever-increasing demand of subscribers underscores their pressing need for high-speed and efficient wireless communication. Traditional technologies often fall short in meeting these demands. The surge in digital applications, including online video streaming, video conferencing, and cloud computing, has further intensified the requirement for high-speed, low-latency wireless communication technologies.

The exponential growth of wireless communication and data traffic, coupled with the high demands for broadband mobile wireless communications, has prompted the development of Long Term Evolution-Advanced (LTE-A) networks. One of the main challenges of LTE-Advanced is to enhance local-area services, improve spectrum efficiency, increase data rates, and reduce network energy consumption.

To address these challenges, technical capabilities are required. Device-to-device (D2D) communication is a new technology that offers wireless peer-to-peer services and improves spectrum utilization in LTE-Advanced networks. Initially proposed as a paradigm shift to enhance network performance in cellular networks, the motivation for D2D communication arises directly from user requirements. D2D communication is envisioned to cater to specific future needs by providing efficient wireless peer-to-peer services.

CHAPTER 5

PROPOSED APPROACH

1. **Approach for Initial Node Allocation:**

   Random numbers are generated for the X and Y coordinates of N nodes, ensuring that these coordinates fall within the range [0, 500] for both axes. Moreover, a minimum distance of 10 meters is maintained between any two nodes. These generated coordinates are then stored in text files to facilitate later access, enabling simulations to be conducted across various time slots. The initial time slot consists of 150 nodes, with an increment of 50 nodes for each subsequent time slot, culminating in the last time slot containing 400 nodes. This systematic approach allows for a thorough analysis of the results.

   An example allocation of 350 nodes (Time Slot 5) is illustrated below:

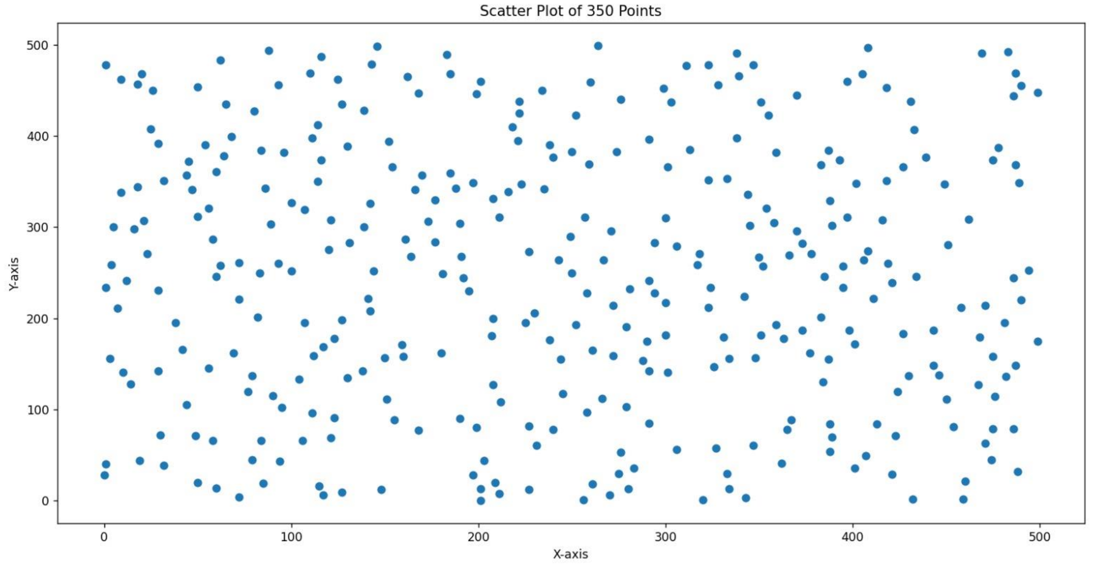

Figure 5.1 (Scatter plot of 350 nodes)

2. **Segregation:**

   Segmentation of points into two groups based on their calculated radius is conducted. Group one comprises points within radius 150, designated as cellular users, while group two encompasses points with a radius above 150, referred to as boundary users.

3. **Clustering:**

All the boundary users are segmented into clusters using the Density-Based Spatial Clustering of Applications with Noise Algorithm with parameters as eps being 50, min_samples as 2 and max_samples as 11.

4. **Selecting Cluster Heads:**

Within each cluster, the cluster head is determined by computing the average of the x-coordinates of all the points in the cluster. If the resulting average is not one of the cluster members, the nearest cluster member to that average is designated as the cluster head.

Clusters formed using the DBSCAN Algorithm, along with their respective cluster heads, are outlined below:

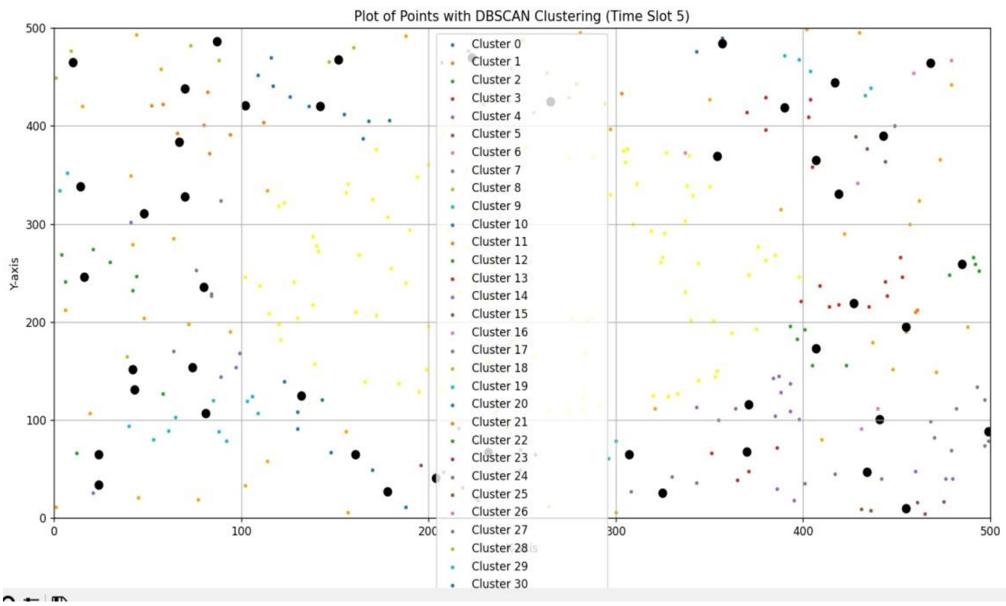

Figure 5.2 (Clusters formed using DBSCAN algorithm)

5. **Identification of Cellular Users Using D2D Radius:**

For each cluster, a source point is chosen from the cellular users, ensuring it is within the D2D radius as {50, 60, 70, 80, 90, 100} from the cluster head. In cases where no source point is within this radius, a cluster member is selected such that the distance between the source point and the cluster member falls within the D2D radius, thus designating it as a cooperative node.

6. **Power Allocation**:

   Allocation of 20 Decibel power to all the nodes that are transmitting signal which constitutes of source nodes, cluster heads and cooperative nodes.

7. **Resource Block Allocation**: In our project, signal transmission between transmitters and receivers relies on the use of resource blocks (RBs). To facilitate performance comparison, we have designated the number of RBs as {1, 2, 3}. Initially, an RB is allocated to the source node of the first cluster for first hop communication. Allocation then proceeds sequentially to subsequent clusters while ensuring Signal-to-Interference-plus-Noise Ratio (SINR) at the receiver, thereby minimizing interference from other transmitters sharing the same RB. This allocation process is repeated for transmitters within the first, second, and, if applicable, third hops. A threshold SINR of 6 decibels is enforced, indicating RB allocation only to transmitters whose respective receivers achieve SINR≥6 dB.

$$\text{SINR} = (P_t \cdot g \cdot d_{ij}\hat{}(-\alpha) \cdot |h_0|^2 \cdot \delta) / (\sigma^2 + I_e)$$

Formula 5.1 (Formula for SINR)

   where,

   P_t is the transmit power (20 dB),

   g is the channel gain (-33.58 dB),

   d_{ij} is the distance between nodes transmitter i and receiver j,

   α is the path loss exponent (4),

   h_0 is the modulus of the channel gain (1),

   δ is the signal power factor (4 dB),

   σ is the noise power (σ^2 having value of -107 dBm),

   I_e is the interference from other sources

8. **Relay based communication:**

   Signal is transmitted from the source point to the cluster head or cooperative node (if available), constituting the first hop communication. If a cooperative node is present, the signal is relayed from the cooperative node to the cluster head. If no cooperative node is present, the cluster head multicasts the signal to all cluster members, marking the second hop communication. In clusters with a cooperative node, a third hop communication occurs, wherein the cluster head multicasts the signal to all cluster members.

9. **Calculating Data rate:**

Data rate, also known as data throughput or transmission rate, is calculated for each node for which RB is allocated. This calculation determines the speed at which data is transmitted from one node to another across a communication channel. It is a critical factor in determining the performance and efficiency of a communication system. Higher data rates generally facilitate faster transmission of data, leading to quicker downloads, smoother streaming, and an enhanced overall user experience across various applications.

$$\boldsymbol{C=B\times\log2(1+\mathrm{SINR})}$$

Formula 5.2 (Formula for Data rate)

where,

C is the capacity (data rate) in bits per second (bps)

B is the bandwidth of the channel in Hertz (Hz)

SINR is the Signal-to-Interference-plus-Noise Ratio

10. **Resource Block Allocation for Isolated/Rejected Users**:

Our project also caters to users (nodes) that cannot be accommodated within any cluster in the DBSCAN algorithm or cannot be served due to a shortage of RBs. In such cases, we explore potential solutions to serve these isolated or rejected nodes. We examine if there are any cellular users within the D2D radius from the isolated or rejected node. If so, we attempt to allocate RBs to these particular transmitters, ensuring minimal interference at the receiver's end from previously allocated transmitters in the first hop communication. If the SINR at the receiver side is greater than or equal to 6 dB, we allocate RBs for that specific transmitter. This process is repeated for all isolated and rejected nodes to enhance overall system performance.

All steps of the proposed approach are depicted in the diagram below (Figure 5.3):

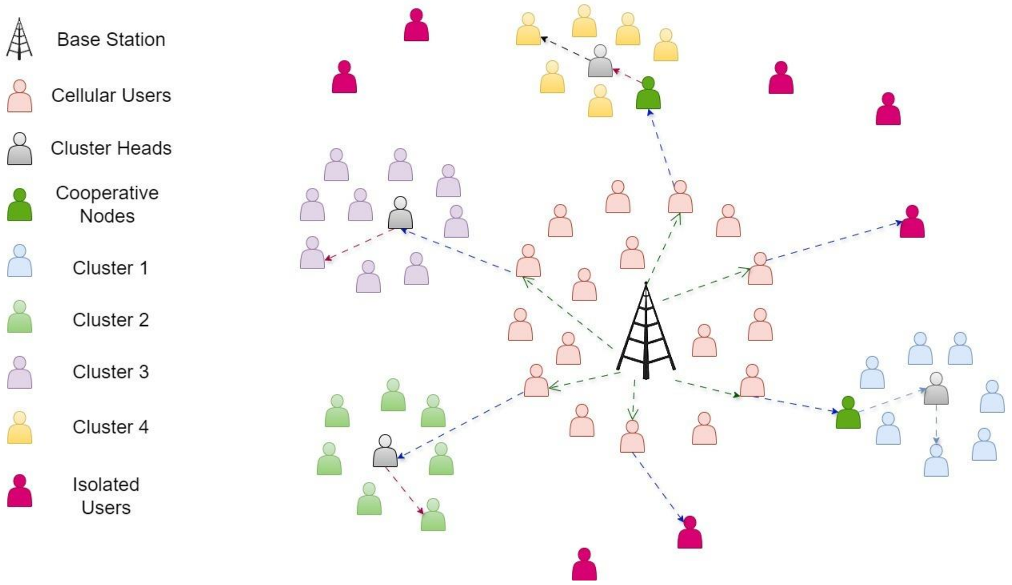

Figure 5.3 (Overall scenario of our algorithm)

CHAPTER 6

RESULTS AND DISCUSSIONS

In our experimentation, we deployed nodes in 500*500 area initiating with 150 nodes and incrementing 50 nodes for every 2 seconds ,i.e. for every time slot until 6 time slots resulting in 400 nodes.

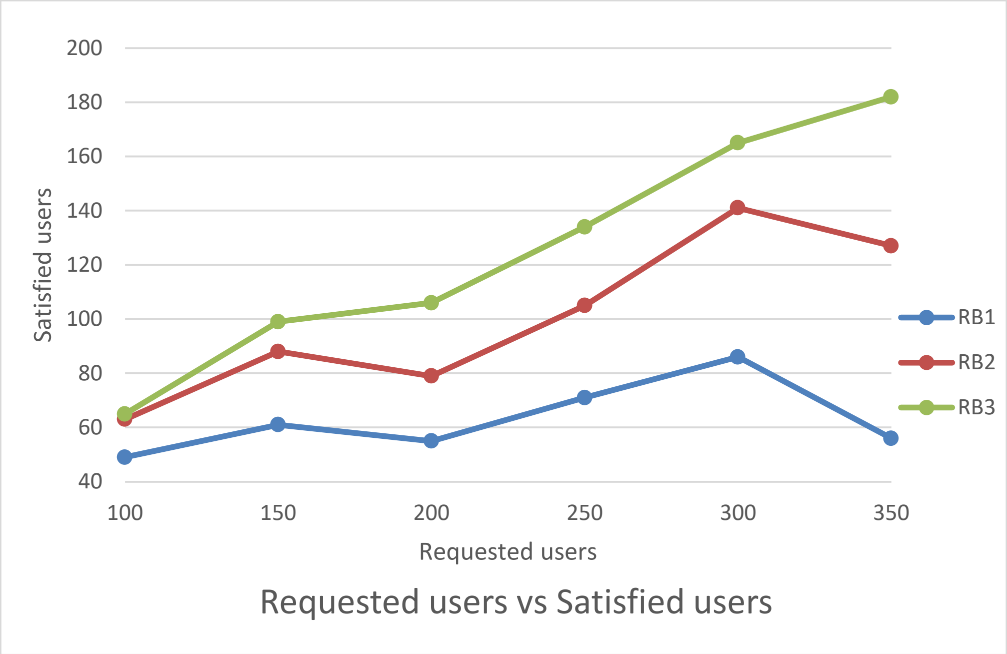

Figure 6.1 (Plot of requested users vs satisfied users)

The plot in Figure 6.1 illustrates the comparison between Requested users, representing boundary users located farther from the base station and seeking signal access, and Satisfied users, indicating those users able to receive signal after the application of our algorithm for varying number of resource blocks that are used to transmit signal. This plot is generated with a D2D radius constraint of 80. After observing the plot, it is evident that as the number of resource blocks allocated for signal transmission increases, the number of satisfied users also increases.

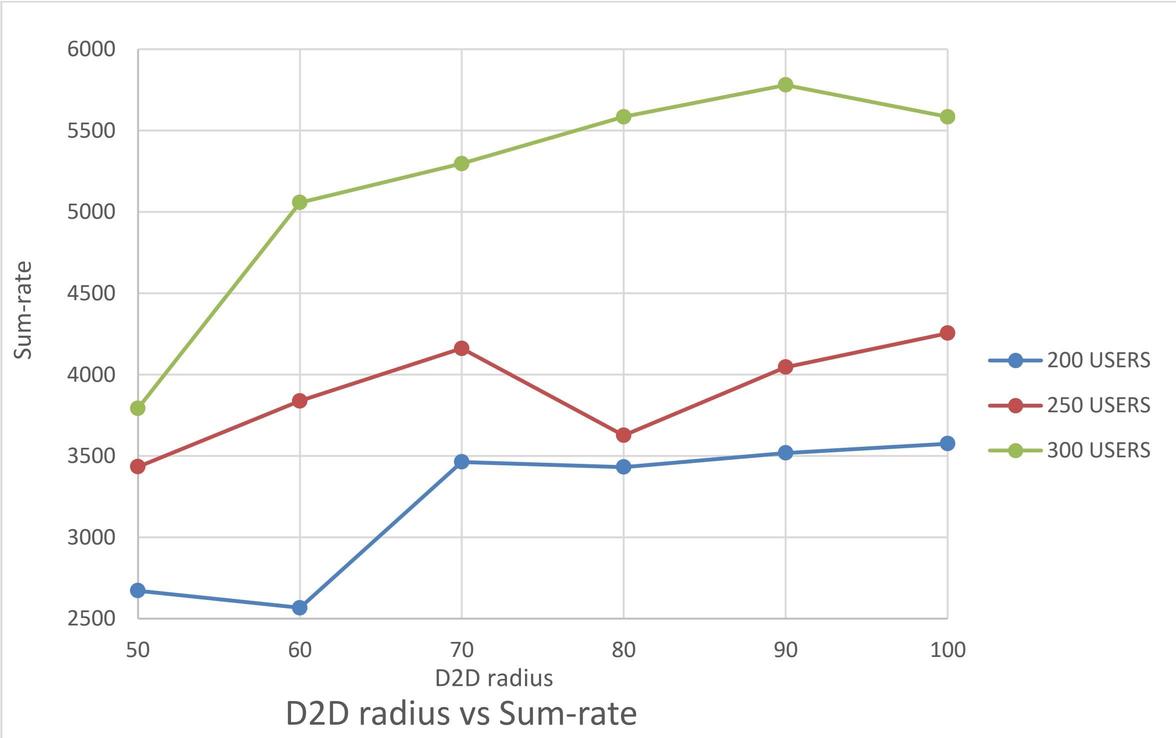

Figure 6.2 (Plot of D2D radius vs Sum-rate)

The plot in Figure 6.2 illustrates the relationship between D2D radius, which is the distance between the transmitter and receiver, and sum rate, which is the total sum of data rate across all clusters, each data rate being multiplied by the total number of users within each cluster. It presents data for scenarios with 200, 250, and 300 users. This plot is generated with a constraint on the number of resource blocks used, set at 3. The plot demonstrates that as the number of users increases from 200 to 300, the sum rate also increases.

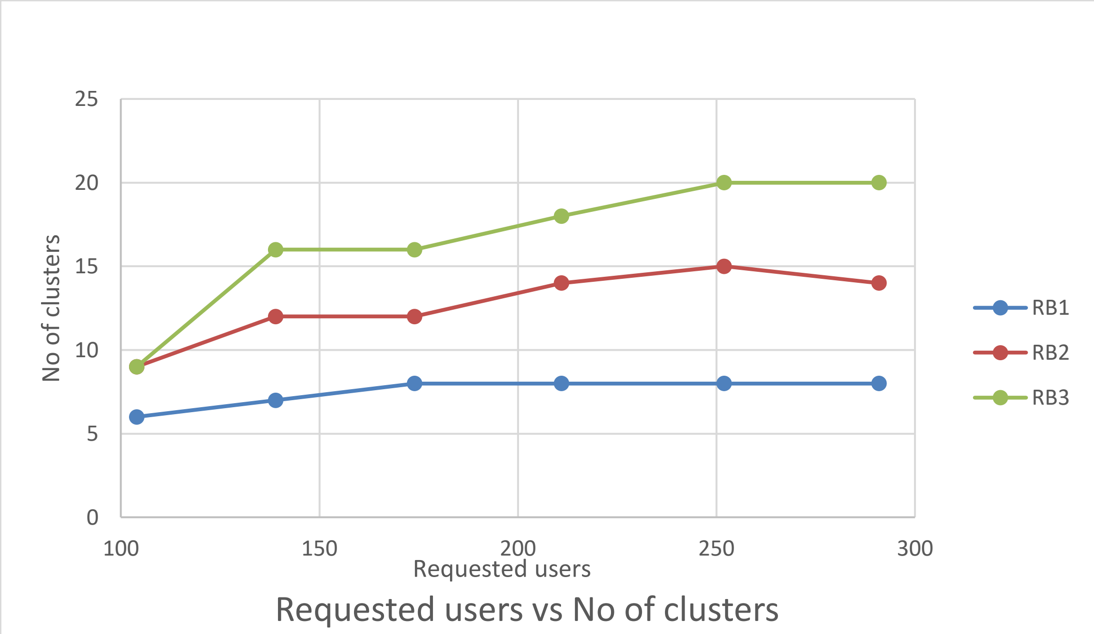

Figure 6.3 (Plot of requested users vs number of clusters)

The plot in Figure 6.3 presents the relationship between the number of requested users, representing boundary users located farther from the base station and seeking signal access and the number of clusters formed using the DBSCAN algorithm for varying number of resource blocks used for signal transmission. This plot is generated with a D2D radius constraint of 80. The plot reveals that as the number of resource blocks increases, the number of clusters formed using DBSCAN also increases.

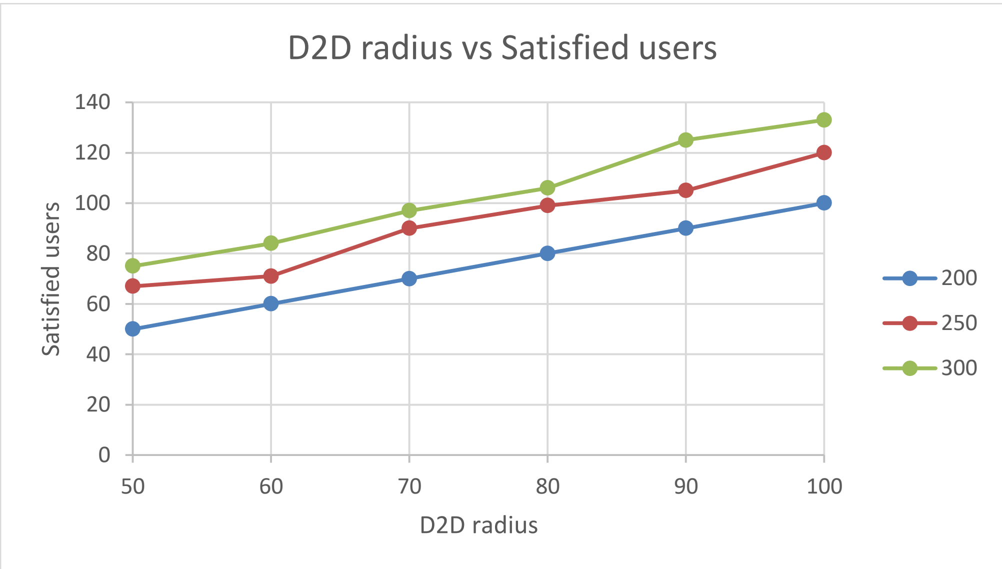

Figure 6.4 ((Plot of D2D radius vs satisfied users)

The plot in Figure 6.4 illustrates the relationship between the D2D radius (the distance between transmitter and receiver) and the number of satisfied users for populations of 200, 250, and 300 users. This plot is generated with a constraint on the number of resource blocks used, set at 3. The plot clearly demonstrates that as the number of users increases from 200 to 300, the number of satisfied users increases and also as D2D radius increases number of satisfied users increases.

CHAPTER 7

CONCLUDING REMARKS AND SCOPE FOR FUTURE WORK

7.1 CONCLUSIONS

To assess the performance of the proposed approach, we analyzed various plots one of which is examining the number of satisfied users in relation to varying number of requested users and D2D radius. As the number of requested users increases across different levels of resource block usage, the number of satisfied users and clusters also increases. This is an optimal outcome, as more resource blocks facilitate greater signal reach, thereby increasing the number of satisfied users across various clusters and improving the overall result of the algorithm.

Similarly, as the D2D radius expands for a fixed total user count, the number of satisfied users also rises. A larger D2D radius allows for increased transmission range, encompassing more users in a large 500x500 area. This wider range of transmission includes more users within its coverage, thereby increasing the number of served users.

Additionally, as the total number of users increases, so does the number of users served. This rise is due to increased user density, allowing for the formation of more clusters and the inclusion of a greater number of users in each cluster, resulting in an increase in total satisfied users.

With an expanding D2D radius and increasing total user counts, the total sumrate also rises. As users become denser and closer to one another, more users can be served with an extended D2D radius, leading to faster signal transmission and an increase in total sum rate.

The significance of this methodology lies in its ability to optimize power consumption by strategically assigning boundary users to relay signals from the cellular users that are unable to receive direct signals from the base station. This approach enhances connectivity and coverage, mitigating the difficulty for nodes beyond the initial coverage area. Ultimately, the project offers a robust solution for efficient resource block allocation, minimizing interference and enabling effective multicasting and communication clustering in wireless networks.

7.2 FUTURE SCOPE

Several works have been done in 5G D2D communication but when the nodes are mobile, then it is a challenging issue to successfully implement the D2D communication and to establish communication between devices as they will change their positions. This will be the further improvement of our work. We want to investigate the impact of mobility on D2D communication.

D2D communication will play a vital role in the upcoming future in certain technologies such as V2V communications, mmWave technology, social D2D networks, energy harvesting, and SWIPT. Other than we would like to find a solution that will increase the number of users that can use device-to-device communication simultaneously at affordable pricing. There are still many problems that we need to solve regarding this. We hope we would be able to deploy our hypothetical model for a dynamic environment too. We would be optimizing the model to move in this direction. We will continue with this experiment of network simulation in the near future too.

In future, we will further extend this project to investigate the impact of mobile users for next generation cellular networks like 6G.

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