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ENERGY EFFICIENT MULTI-HOP CLUSTER BASED D2D COMMUNICATION FOR CATASTROPHIC AREA

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Abstract: **Earth has been experiencing different types of disasters since time immemorial, causing death and destruction (to all types of infrastructure). Different parts of the world have been devastated by cyclones, earthquakes, landslides, and tornadoes. Over the past few years, energy and resource management has been the goal of research. Device-to-device communication is one of the emerging technologies that have the potential to play a crucial role in natural disasters by utilizing direct D2D communication to help achieve specific goals. Communication between D2D devices was designed for short-range use but can be applied to long-range applications through multi-hop relays. In addition, it is applicable to a number of practical applications including disaster management, un-coverage areas in cells, and battlefields. In order to optimize energy balancing and resource utilization, a cluster-based channel allocation scheme was used. Our communication infrastructure can work independently in case of any natural disaster, where primary infrastructure is damaged or not available. The proposed scheme "relays the communication traffic to the nearest base station through multiple hops. We applied the Dijkstra algorithm for the shortest path calculation. In order to calculate linkages from the source to the destination and to send data over reliable channels, the Link Calculation Method (LCM) is employed before transmitting frames. Our RF energy harvesting mechanism HSEH ensures energy is harvested from the most efficient source for maximum efficiency. The high strength signal of the RF source continues to ensure that energy is being harvested. Finally, we compared our simulation results with existing schemes. Results indicate that the proposed scheme outperforms the existing schemes in terms of consuming less energy while transmitting the data through a more reliable channel.**

Keywords: **D2D communication, energy harvesting, multi-hops relay, reliable channels**

I. INTRODUCTION

1.1 Motivation and Background Knowledge

Through Device to Device (D2D) communication, the communication devices are able to communicate without the use of network infrastructure. When no network infrastructure is involved in communication. Then valuable network resources can be utilized more effectively and the cost of network resources can also be reduced. D2D communication does not only refer to cell phones, it can be a vehicle. Short-range communication is often tied to bind with WLAN (802.11p) standard, but the support of WLANp standard equipment for cars to communicate with each other [1]. After the 5G deployment, huge spectrum availability made it possible for devices to take advantage of the spectrum. Multi-Millions of devices to communicate under a single umbrella [2]. The challenging part, where the available spectrum with millions of devices is a massive increment in the network to absorb, D2D communication provides the best way to tackle the spectral issue in the next-generation network. D2D communication can play an essential role as part of the solution. Instead of an established current cellular system and the previous generation, the Next-generation adopts D2D communication as an accreditation technology [3]. Opportunity usually doesn't come alone also brought a number of challenges with it. The major challenge in D2D communication is currently interference and that is making this emerging technology extremely complicated [4]. The spectrum utilization in D2D communication can be divided into 2-sub categories. Unlicensed technologies like ZigBee, Bluetooth, etc., are used for out-of-band D2D communication. In the licensed spectrum (In-Band) first scenario, where the specific part of the spectrum reserved for d2d communication is identified as an overlay. The second scenario where the entire licensed spectrum is shared among D2D users in a specific manner is identified as underlay [5]. The study observed that underlay mode spectrum efficiency is increased by sharing the spectrum as compared to overlay mode. This point indicates the interference among devices [6]. The current challenge is to maintain technology status without degrading it and to implement D2D communication.

There is degradation due to the interference of co-existing technologies, such as the ISM band and cellular communications.

In out-band communication (in a D2D environment), it can also divide into two parts as mentioned in Fig. 1.1. The first one has controlled communication. In controlled D2D type communication, the central network (cellular network) is responsible for maintaining the interference and all the parameters that are required to make possible D2D communication. Controlled D2D communication also helps improve system performance, spectral efficiency, and reliability. In the case of autonomous D2D communication, the cellular network is not responsible for managing communication. Instead, on, it is controlled by users or devices that are part of the communications [8]. D2D communication usually takes place in three modes. The most common mode is a cellular network and the remaining two are dedicated and re-useable modes. Dedicated mode is dependent on cellular resources that are specified for D2D communication used by the user equipment (UE). In reuse mode, the D2D UE required the same resources that are used by the general cellular UEs. Reusable and dedicated modes, both are part of the direct D2D communication mode. D2D communication is always not possible because of the source and destination's weak channel coverage, and distance plays a vital part in it. In this case, the relay method is one of the solutions to increase the range of D2D communication [9]. In 3GPP 15 and 16 release, the modification in which instead of 2-hop fixed relaying to mobile relaying and make it possible to multi-hop communication among devices in a cell. This up gradation breaks the limitation of D2D communication for short distances due to interference and device battery limitations. In relaying mode, the source UE has a choice to relay transmissions through a central station or a number of other available UE's [10].

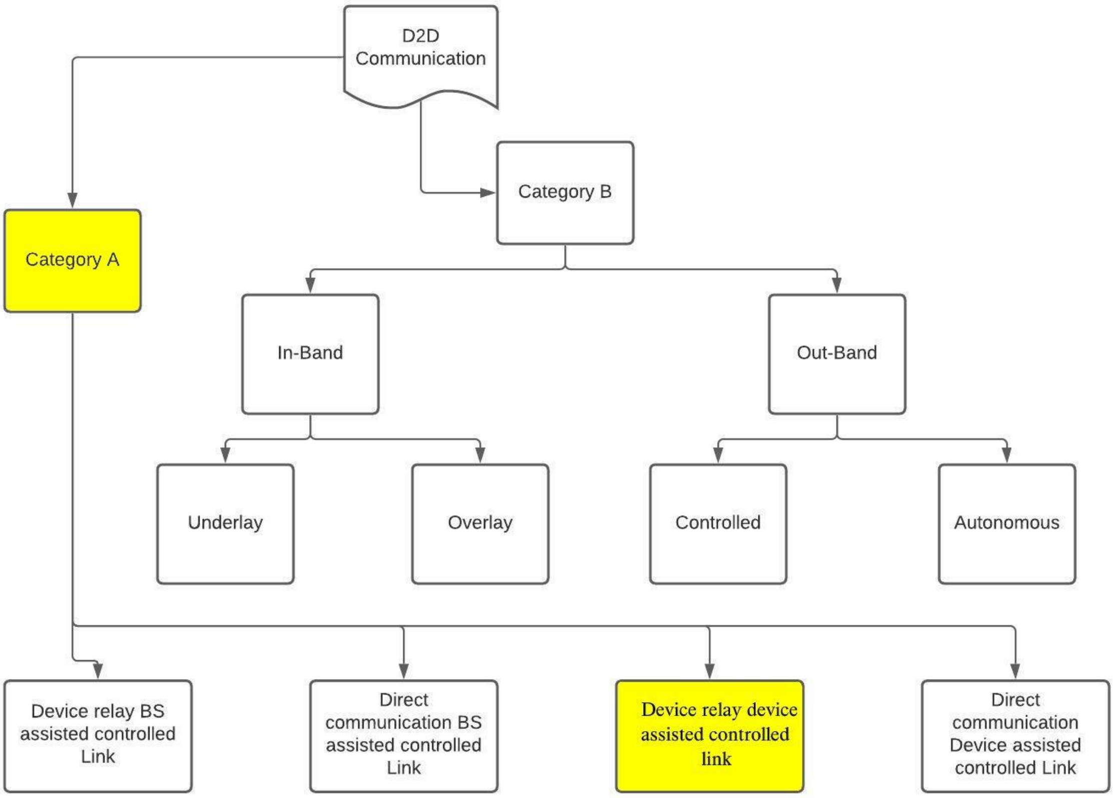

Figure1.1 D2D Classification

In mode choice, consider the predefined threshold for path loss in D2D user's communication. If the predefined value of the threshold crosses the D2D user communication distance. Carry-on multiplexing mode [11] is selected instead of cellular mode. According to [12], the determination of the mode of selection does not solely depend on the UEs involved in D2D communication. In addition, it is related to the distance between the base station and the D2D device. The user's equipment meets the requirements for a direct link (direct communication) in a cellphone generation network (4G LTE-A or above), and the base station will choose which base station to use to make the communication successful (cell selection problem [13]). Recent studies find that cluster-based D2D communication is the most effective way to increase spectrum efficiency and the most efficient way to save system (network) resources and improve performance [14].In this thesis work. We are considering relay-assisted transmission. In devices relay assisted transmission (RAT), A device discovery process allows the source to discover the destination and establish a link with it. Relay-based D2D communication has several use cases. Because of the widespread use of D2D communication, a standard incorporating multi-hop D2D communication is conceivable [15]. This is because multi-hop D2D communication is not bounded to specific geographical locations like traditional D2D communication. Additionally, relaying has several other benefits. Having this ability can bring to light the potential for cooperative communication to meet the increasing demand for faster data rates and expanded capacity in 5G cellular systems [16]. In networks using relays, spectral reuse is maximized due to multi-hop transmission. Additionally, 'promises' of improving the quality of service (QoS) and network load balancing are included with the potential of boosting data rates and network capacity. Additionally, relays can improve network performance in areas with poor coverage, such as places with damaged cellular infrastructures [17].

1.2 Problem Statement

In the event of a natural disaster, conventional cellular networks are susceptible to failure and damage as well electrical infrastructure. In areas of the cell where the cellular network has limited or no coverage, this communication facility cannot be provided to the UEs in specific cell or to any specific area within the cell. There will be no way for mobile devices to connect with the base station, not to mention no way to keep the network operational. Electrical infrastructure is the backbone of the cellular network. This device relay-assisted transmission enabled the mobile device to reach the neighboring cell base station (BS) using a device (mobile device) that is connected to the neighboring cell base station. In order to keep the network alive, we incorporated energy harvesting and efficiency. Data transmission is another critical factor. If the data does not transfer through efficient channels, it will consume more energy in retransmission. That’s why the Link Calculation method assures data transmission through an optimal available channel to avoid retransmission.

1.3 Motivation

This project was motivated to provide an alternative communication infrastructure whenever there is a natural disaster anywhere in the world. Natural disasters affect infrastructure like buildings, bridges, roads, and also communication networks, especially in urban areas. Communication is an essential part of life, especially in natural disasters. When we require medical, fire, and law-enforcement management teams in the disaster area, the first thing that we need is communication infrastructure and without that, it might be impossible to get help from outside the area. I was inspired to work on a strategy that would provide backup support as a communication infrastructure, or link the unreachable areas with the closest nearby communication networks. When it is equipped with an energy harvesting module to harvest energy from the grid, it must also be able to monitor the strength of the harvesting source signals and decide if the energy will be harvested from the current source or if it should be reassigned to a source that has a stronger signal to boost the power of the User Equipment. By using the Link Calculation method, the computer utilizes the basic two factors of latency and data rate and selects the most efficient path based on the algorithm Dijkstra. Instead of any acceptable channel.

1.4 Research Objectives

The purpose is to develop an emergency network that can maintain communication in a worst-case scenario (without a base station) using a multi-hop relay method over a D2D communication network. When we talk about D2D communication spectrum efficiency or D2D short and long-range communication alternative we talk about taking the burden away from the cellular network. There are a number of proposed system models, schemes, and techniques, but the majority of them fail to maintain the stability of energy and spectrum.

- In this thesis, the relay process uses relay-assisted controlled transmission from one cluster node to another in this scheme, consuming energy while relaying information. On the other hand, using HSEH is capable of harvesting energy from the design environment with the most optimal signal strength at any time.
- The LCM ensures reliable data transmissions by selecting the best-trained channel and ensuring the connection must be good before transmitting data from one cluster to another by using the Dijkstra algorithm for the shortest path selection.
- The main core of the LCM model is confirming the path and channel (allocating the best channel) before transmitting the data.

II. LITERATURE REVIEW

In the following section, we discuss some related work that has been published and helped with improved spectral efficiency or resource allocation for D2D communication. Particularly interested in those that assess the energy and spectrum efficiency of D2D networks. The articles [18], [19], [20], [21], [22], and [23] consider resolving the issues regarding spectrum efficiency, performance metrics, resource optimization problems, network efficiency, and data rate optimization. It provides a vast view of resource allocation.

In [18] the author introduced the architecture of a Cognitive Radio (CR) that set the Het-Net network environment to optimize the spectrum efficiency by reducing the spectrum interference of primary users in the network. In order to find the gaps in the spectrum through wideband frequency mutual spectrum sensing, various CR nodes can use different frequency bands. The 3-Dimension concept covers time, space, and frequency. A primary user may set and control the transmission power for CR users (D2D) with this estimated element. Short distances and transmission delays are an advantage of D2D communication, which can be estimated to determine an appropriate transmission power for D2D communication. Device to Device communication consumes the least amount of network bandwidth and places the least burden on the network, and allocates valuable network resources to primary users (PU). In this research [19]. Based on cooperative game theory, the author proposes a two-stage resource allocation scheme based on meta bargaining and weighted utilitarian solutions. The current scheme improves performance metrics such as system throughput, CU payouts, and fairness among users by about 5% - 10%. The downside of the research is that it is for a specific environment or scenario where nodes are not in mobility. Despite incredible network devices and innovative infrastructure, users were unable to access services according to their needs. The next-generation infrastructure could help wireless users get on track. The most productive ways to improve the throughput and spectrum efficiency of D2D communication. One of the biggest challenges that are caused by device-to-device (D2D) is interference management. In [20] this research, the author formulates the resource allocation optimization problem among D2D pairs. Aim for maximum throughput by restricting interference so the primary user of the networks is protected. The second part provides the solution for mixed underlay nonlinear resource allocation that is solved by matching theory. The final result of the proposed methods achieved 45 to 90 percent of throughput gains. The main problem in this research is that D2D communication is only possible within a 10 to 20 m maximum distance. [21] Units that are close enough to each other can communicate directly using device-to-device communication. The author proposed a technique to improve the network spectrum by using graph theory in the band overlay environment. Which author presents the spectrum and joint power allocation issue with an exponential time complexity increase if the number of nodes (D2D) and frequency increases. The author proposed an algorithm that provides the solution for the abovementioned problem in two stages. It is essential to minimize the frequency resources in the first round of entry control for D2D nodes that require a certain amount of power. This is done with a resource assignment block that includes frequency reusability. During the second round, the author's work consisted of minimizing the transmission power D2D nodes and scheduling the resource blocks organized in the previous phase. The simulation results indicate that the proposed scheme achieved 5% to 10% spectral efficiency against MinInterf and more than other methods, however, the author gave less attention to the transmitter-receiver separation distance and the channel path loss exponent when designing this scheme. In the next generation of technologies, the number of technologies can work together and achieve optimal frequency efficiency. The most significant challenges are resource allocation and interference management due to the high demand for frequency reuse. In [22] the author sets the environment for D2D communication through mm Waves underlay method integrations of MIMO and NOMA network systems. In his article, the author proposes a novel resource allocation for D2D wireless communication systems MIMO-NOMA mobile networks. Resource allocation, the first optimized problem was formulated to maximize the spectral efficiency. For solving the Np challenging problem. To begin, the part is broken into 3 parts: power allocation based on particle swarm optimization, interference awareness by using graph-based user clustering, and MIMO-NOMA beam forming designation. Results show that the proposed model delivers higher spectral efficiency than the conventional D2D communication underlay environment by utilizing MIMO with the inclusion of orthogonal multiple access (MIMO-OMA) in the mobile network model. [23] The author in this paper describes the method by incorporating a cognitive cellular network along with orthogonal frequency division multiplexing (OFDM) and D2D communication, which are modeled with the Lagrange formulation and solved with GWF. The author chose an adaptive subcarrier allocation method that depends on metrics that exist for three terms associated with transmission rate, interference, and power. The proposed power allocation method is based on GWF. The total downlink rate is optimized for a device-to-device (D2D) communication network under proposed constraints for power and the interference side of the minimum required data rate. The simulation results clearly indicate that the redesigned scheme achieved optimal resource allocation as compared to the existing schemes (classical schemes: uniform power loading, water-filling). The number of D2D users increases in the cell. Then the proposed scheme starts losing its credibility.

In 5G, D2D is designed for short-range communication, but the multi-hop strategy enables long-range communications. Short-range communications are for nearby devices and allow D2D communication to be done over a limited path. In [24], [25, [26], and [27], we provide prime information about D2D communication routing and path issues which are also directly related to energy efficiency and resource optimization. The author proposed a multi-hop protocol that is based on conventional Dynamic Source Routing (DSR) with the integration of 5G wireless network features. Multi-hop routing protocol enables wireless networks to reduce bandwidth and to be energy efficient, in the shortest time possible. In the proposed protocol, you would simply store the routing information on the base station of the existing D2D device to speed up the discovery process. In simple words protocol used the base station as a cache to store the information. Cached information can only be used if establishing a path with the destination devices is difficult. This protocol saves D2D devices' energy by preventing them from sending messages in a storm to discover the path. The simulation result indicates that the proposed protocol technique is far better than the conventional DSR protocol. It sets the low overhead with respect to control messages that are used to establish the routing path. Communication relayed hop-to-hop for D2D wide-area communications allows UEs to communicate with/without a base station, which is necessary to make the link possible, but it can sometimes be difficult to establish a communication link between DUEs so that they can communicate with each other. Also, finding the shortest distance to maintain the DUEs' battery life is tough. Their energy efficiency also plays a crucial role in communication, since spectrum efficiency is crucial in D2D. In [25] the author introduced a centralized multi-hop technique. The base station can view the network topology better than any other part of the network. The shortest path for D2D can be determined using this approach. The proposed centralized reactive scheme is well-performed against the proactive scheme in the sense of low overhead message control as compared to the centralized proactive method. Message floods can impair the performance of the network in terms of energy and can make it more difficult to establish a reliable connection between devices. The proposed method allows updating the network topology with the help of a UE help message and the amount of time DUE's have to wait. In this case, the envisioned routing scheme consumes fewer resources that depend on cell density. Natural disasters are a part of human life and, for a number of reasons, they are increasing with time. At the time of emergency, the cellular network plays a vital role in being connected with the rest of the world. In this case, D2D communication can be considered extremely relevant in catastrophic scenarios. Disaster is not only one of the conditions in the case of a base station technical fault or problem in the backhaul network. In [26] the author proposed multi-hop D2D communication by using mobile equipment (ME) as a relying node to maintain the communication in a disaster scenario (where Pico and Femto-cells are damaged, but the macro cell is operational). The proposed method works on two key parameters that measure the success of multi-hop. First is the proportion of ME that uses D2D communication, and second is the maximum hop length required for the connection to be established. After achieving the parameters, it will be necessary to evaluate the reliability of multi-hop D2D communication that is being considered for this purpose. This is because the success of multi-hop communication depends on active nodes in a specific geographic area (cell). For reliability, the author derived the formula to calculate the success of multi-hop probability and examine the reliability probability by utilizing the multi-agent simulation. A number of d2d UEs were successfully connected using the proposed method, however, when the upper limit of maximum hops is increased, the probability of success connectivity for d2d communication decreases. In this article [27] the author proposed the environment the device to device (D2D) communicates from function area (FA) to nonfunctional area (NFA) with the help of multi-hop relay method. In this scenario, the D2D is communicating from the functional area where the D2D user exists near base stations (BS) to the nonfunctional area (where the base station is not operating in a specific cell to support the cell users). The author proposed a method where D2D devices are distributed in cells at different geographical locations and certain distance is among them in the nonfunctional area (NFA) and the devices from the functional area (FA) are carried out to NFA by using the multi-hop method and also the power parameter is fixed (fixed power) through base station (BS) transmission in the D2D network. D2D UEs harvest the energy from the information transmitting D2D UE relay link and pass the packet to the next UE unless it was the destination UE. For the way, selection methods, immediate best path selection, and parallel best path are selectively chosen for the nonfunctional area. As NFA, there are a number of strategies taken for the FA in prospective of deployment, and UE to UE distance is also considered from reaching Functional area to nonfunctional area at specific destination UE. A structure introduces get some measure of capacity, throughput, and outage probability. The energy utilization system is already estimated in practical performance. The author sets the different scenarios to test the above-mentioned parameters with previous schemes and all tested and evaluated methods show the best performance as compared to previous work that has been published in case of traffic from functional area to nonfunctional area.

As can be seen in [28], [29], [30], and [31], the main goal of the author is to solve the power issues with respect to D2D energy. This is done by introducing various schemes or setting up network resources. The Battery-powered D2D UE or the Internet of things has one of the biggest problems with its battery power: until a power supply is available, the devices can't communicate with each other. For resolving that issue, a fast way to energy harvesting was proposed [28]. for data transmission, the author proposed a method for harvesting energy from the cellular origin for primary device-to-device communication in node the different parameters of devices, energy harvesting, meddling management, and transmission introduced two policies, the first of which required that d2d UE residual energy mustn't be less than the transmission power that is required to communicate with other devices. Policy 2 requires a set of restrictions on d2d UE residual power but also places a zoning restriction to protect d2d UE communication from different types of meddling and obstruction. Zonal protection is challenging because the researcher has to control the energy from various directions. The author proposed the stochastic geometric framework to tackle the situation where d2d UE is in a closed or semi-closed environment. A simulation shows that the implementation of a protected zone increased the UE transmission rate by 41 percent in a D2D environment and provides delightful guidelines for energy harvesting. Communication between two devices is one of the most promising research areas in which the majority of communication problems are resolved. In this paper [29] the author tried to propose something that could tackle the d2d communication coverage and energy harvesting problem with the help of unmanned aerial vehicles (UAVs). UAVs are effective because of their power and the area that can be covered by UAVs. By providing power to D2D UE with the UAV, they can harness the energy from the nearest source of energy to build their power rapidly and connect in case of emergency (in case of disaster). The author also incorporates the clustering method to improve the overall network performance and coverage during and after the catastrophic event. CH and Cluster members were affected by the proposed ECS method. UAV takes the advantage of cluster method to distribute the energy in a systematic manner to boost the network and take the burden from the D2D UE to build the links between them to make the system more effective and efficient. Due to the limited battery power, the author also considered the network outage in the sense of maintaining the network traffic. The optimization of the CH proposed and improved energy harvesting in order to keep the network alive. By improving the bonds and links between CH and CM, the uncertainty of the network is reduced. The simulation results indicate that the proposed technique provides better performance as compared to no optimal CH links and also reduces computational complexity. In D2D communication all resources have a valuable contribution to make the communication successful. But there are a number of resources that are highly limitation constrained like energy efficiency due to the limited battery of D2D UE. In this paper [30] the author tried to resolve the problem of resource allocation (fast joint time, energy allocation, and frequency) to achieve energy efficiency in d2d UE communication in situations of an overlay mobile network. Where various D2D UEs are communicating with each other and also receiving (harvesting the energy through their transmitter) energy through the Base Station (BS). D2D UE consumes a lot of energy through the transmission of the data over the appropriate channel. To assist, channel condition and it is availability make a huge impact on D2D UE power. The efficient resource allocation allows to lift the imperfection of the channel state information and reduce the burden from the D2D UE battery power that can be used in transmission more efficiently. The author proposed the method of formulating the problem is a non-convex robust enhancement to achieve the required level of energy efficiency of the system and also ensure that the quality of services maintains its statistics at the lowest level of data rate and small of harvested energy for mobile and D2D UE. The suggested iterative algorithm ensures that all D2D UE exhaust all the harvested energy by the transmitter and find a rapid solution to optimize the situation. The iterative algorithm also keeps the balance between the performance of the system and computational complexity. The simulation results indicate that the proposed method works well as compared to the number of baseline schemes that gain the energy efficiency of the D2D UEs in a situation where channel state information was imperfect. [31] deals with the problem of spectrum resource shortage and energy harvesting to make D2D communication more reliable. Here, the author discusses both the UE energy harvesting technique and the UE energy harvesting model in terms of a radio cognitive model. UE is communicating with each other using the multi-hop D2D method and all the devices are harvesting energy. The author’s main goal was to improve the D2D UE energy efficiency of the allover network by using joint time allocation and by applying the multi-hop method. For this, the author sets the limitation on cellular users’ data rate and places the restriction on the signal-to-noise ratio on D2D UEs. The main restriction of this model is that d2d UEs have arbitrary time during which they must harvest energy and communicate. Further, the author divides the problem into sub-problems and optimizes the problem by using the weighted sum problem for multi-hop (for finding the shortest path) and non-convex for the energy harvesting model. Iterative algorithms were proposed in order to solve the convex problem using fractional theory. the proposed method performs better than the RS scheme and that energy harvesting, and relay selection have been improved. The following table 2.1. is providing the targeted point of each research article to provide a brief view of the literature view.

Table 2.1Summary of relative work

Ref	**Year**	**Problem**	**Technique**	**Advantages**	**Disadvantages**
[18]	2017	Detection of un-used spectrum band	3D spectrum hole detection through SVM	Enhance the spectrum allocation among D2D communication	Still need to work on transmission control and interference between PU and D2D communication

					exist.
[19]	2020	Spectrum allocation problem	two-stage bargaining approach	The proposed model provides better efficiency for system throughput and excellent fairness among users that is improved 5 to 10 percent than the existing schemes.	Mobility-aware resource allocation issues are not addressed in this research.
[20]	2021	Resource allocation problem	RB allocation algorithms	The final result of the proposed methods achieved 45 to 90 percent of throughputs gains	The main problem in this research that the D2D communication only possible within 10 to 20 m maximum distance
[21]	2021	spectrum and power allocation optimization problem	Graph theory	The proposed method provided the highest efficiency that is provided in resource management section. The GPR can be best schemes where bandwidth is limited	In this scheme the author gave less attention to transmitter receiver separation distance and the channel path loss exponent
[22]	2021	Resource allocation	NP-hard resource allocation problem	Well proposed method where the number of clusters is high in cell can provide the efficient interference management and help to increase the spectrum efficiency.	It is only designed for specific scenario where a number of D2D cluster is high, but in reverse scenario, it is not able to get the desired results.

Ref	Year	Problem	Technique	Advantages	Disadvantages
[23]	2017	Resource allocation	Sub-carrier assignment strategy	The proposed scheme achieved better performance of resource allocation in which there are the three key resources (interference, power, data rate) are enhanced as compared to the existing schemes	As soon the number of D2D users increases in the cell. Then the proposed scheme starts losing its credibility
[24]	2021	Multi-hop routing None neighboring nodes	Enhanced DRS	Help to support better way to establish connection between d2d devices and optimize the d2d equipment energy.	The proposed routing protocol faced problem when there is complex path and no coverage of a base station.
[25]	2019	Decision routing in multi-hop	Centralized Multi-hop Routing	Consumed less network resources as compared to centralized proactive, multi-hop routing scheme.	Still utilize the network resource and stablished the link building increase the traffic load on the network., also delay can increase if the DUEs are dense in single cell.
[26]	2018	Maximum hops through multi-hop	Multi-hop communication with probability function	Provide the mechanism (probability) of successful multi-hop communication between	Complexity increases, when the upper limit of multi-hop exceeds the threshold that

				d2d UE in case of natural disaster.	automatically reduce the probability function success rate to establish the connection

Table 2.1 {Continued from previous page}

Ref	Year	Problem	Technique	Advantages	Disadvantages
[27]	2020	Multi-hop communication &Energy harvesting in NFA	Harvest the energy from the preceding node.	In comparison to incremental and fixed distances, a decremental distance proves to be more effective. The ergodic capacity is also evaluated from FA to NFA. According to the results, PBPS outperforms IBPS in terms of outage probability.	When the distance between two D2D nodes is reduced, the harvesting time is reduced, but the transmission time is increased
[28]	2020	Signal interference in EH environment	stochastic geometric framework	D2D transmission success can be substantially increased by 41.2% and outage performance can be improved by 23.19 % when using a guard zone	This outage probably works until the transmission power is high between BS and CU.
[29]	2021	Energy harvesting & outage probability	UAV deployment model	An EH with optimal CH links has a greater advantage than an EH with nonoptimal CH links.	Due to a higher path loss or lower received SINR when the distance is increased, the EH performance is stably degraded.
[30]	2021	Resource allocation (joint time, energy allocation and frequency)	Non-convex robust optimization problem	In comparison with two baseline schemes, the proposed joint resource allocation algorithms offer flexible bandwidth allocation and beamforming adjustment thereby dramatically improving the system EE	In situations where multiple D2D pairs are using the same radio resource and thus possibly interfering with each other

Ref	Year	Problem	Technique	Advantages	Disadvantages
[31]	2020	Energy efficiency resource allocation	weighted sum maximum & optimization iterative algorithm	When a relay is selected, an algorithm is used to determine the optimal EE solution. In addition, the EE of D2D which is proposed in this paper is much higher than the other scheme	The EE for D2D is reduced as the distance between BS and C is decreased. This occurs because of C's interference with relays

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III. PROPOSED WORK

1.5 System Model and Our Approach

Communication with D2D is gaining tremendous traction in the mobile communication world. As mobile communication evolves to reach new heights, the old dynamics are changing rapidly. In the previous generation, infrastructure was the base of communication, and user equipment was fully dependent on it to establish the connection for communication. However, new technologies allow devices to communicate wirelessly without requiring the use of expensive and complicated communication equipment. These technologies can provide a solution in emergency situations or during natural disasters. This solution is where the base station capabilities are managed by a UE relay system that can operate in a systematic manner to maintain cell communication [32].

3.1.1 Network Model

We consider the environment of device-to-device communication in a disaster area (cell without base station services). In UE, cluster C is formed to enable users to find their nearest base station. Also, the formation of clusters allows UE to save energy more efficiently. Each cluster is equipped with data channels Dch, control channels, and N user equipment. Each device will have two separate antennas for data transmission and energy harvesting, allowing the device to harvest energy from the environment during data transmission. There is a specific interface used in order to establish better connectivity and communication mechanisms for intra-cell communication. The reasoning behind the clustering technique was to reduce the energy requirement of devices that are present in disaster cells. These devices may not be connected to electrical power in order to transmit data. In such cases, energy-saving and harvesting will be the most efficient ways to ensure the flow of data among devices and keep them alive. The clustering of the discus in the Clustering Formation section of the device.

1.6 ASUMPTIONS

The assumptions are we considering that defines that the consideration of work, but not a part of the implementation process.

1.6.1 Assumption (UEGN Connected with UENC)

We are considering the D2D environment where transmission of data travel by number of clusters C1 to CN(In some condition C1 and CN can be same). CN is the final Cluster node (user equipment gateway node (UEGN)) who is communicating with next User Equipment neighboring cell (UENC) that is connected to a base station (BS) of neighboring cell to make the D2D communication network alive.

1.6.2 Assumption (Equipped with Dual Antenna)

Cluster head and members are harvesting nodes while they are transmitting the data or receiving the data to/from other members. Each device is equipped with dual antenna that provide the facility to transmit the data and energy harvesting simultaneously. So, there is no need to create a schedule for energy harvesting and data transmission. Both jobs can be done at the same time.

1.6.3 Assumption (Turn on Discovery mode)

We assume all the devices are enabled d2d communication and when the devices are not able to get the cellular network coverage, then they turned on the d2d discovery mode automatically and send the message “hello” to each other.

1.7 Phases of Proposed Method

The proposed method is existed of a number of phases. Each phase contains specific steps to make the system to accomplish a certain level to move into the next phase. The deign phases are mentioned below.

1.7.1 In First Round

In the first-round, devices recognized and form clusters that is nearby. As shown in below Fig.3.1.

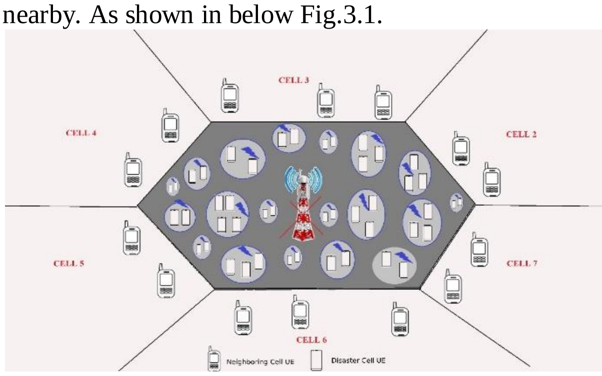

Figure3.1. Level 1 Clustering Formation

1.7.1.1 Level 1 Cluster Formation

Due to a natural disaster, our problem description describes the base state (BS) as completely damaged, and the user's equipment is unable to access any of the designed infrastructure's services. With respect to our proposed method. The user equipment (UE) is divided into a number of clusters according to their geographical locations. Clustering is an unconquered study that has the basic purpose of breaking the dataset into sub-categories (subsets) that are called clusters. By doing this, we can gather subsets with similar characteristics, whereas data in different subsets represent distinct characteristics.

In order to establish cell phone communication in the catastrophic cells, cluster heads (CHs) have to communicate with conterminous cells. The distance between them may not be possible for all CHs to communicate with their conterminous cell members due to the distance between them. As a result, the User's equipment's UEs organized themselves into clusters according to their geographical locations and according to their distance from one another. Clusters are based on cluster members and cluster heads. Clusters that are formed in the catastrophic cell can be considered intra-cell clusters. The geographical location indicates the position of the cluster inside the cell. In conterminous cells, clusters are formed at the boundary between the UEs of the conterminous cells. It is the boundary cluster head's responsibility to send and receive transmissions from conterminous cell equipment's user equipment's gateway nodes (UEGN). In each cluster, the cluster head CH receives all basic information from the cluster member's CMs. The received information consists of the preferred payoff method, temporary mobile subscriber identity, and international subscriber identity [33]. CMs can be grouped based on their location, and each CM has its own unique identifier (CM-id) within the cluster.

Clustering algorithms are categorized into two main categories. The first one is hierarchical clustering and the second is partitional clustering. If we talk about the hierarchical clustering method, in general, we tend to break down the entire dataset into a small number of NN objects. This is actually a shape of the tree structure that is called a Dendrogram. Each leaf of the tree contains part of the dataset information, and the root includes the entire dataset. In the case of hierarchical clusters, clusters can be created by decomposing the tree structure into different levels. Hierarchical algorithms are also subdivided into agglomerative and divisive types.

On the other hand, partitional clustering uses a variety of methods for creating clusters. In which it divides the data set into a CN number of clusters with an NN number of objects. The ratio between CN clusters and N objects CN<=NN. Ranking criteria decompose the dataset into partitions or clusters. The CN algorithm is one of the most famous cluster-partitioning algorithms used to form clusters. The implementation of the K-mean algorithm with Euclidean distance measurement in a Python environment. The Euclidean metric can be calculated through various methods. However, Euclid is the most effective method because it uses k parameters and NN objects that are given datasets as a basis. Clusters are based on NN objects' similarity to each other (if the intra-cluster similarity is high, then objects are placed in the same cluster; if the intra-cluster similarity is low, then they are placed in another cluster with a high similarity value).

The basic idea of placing the centroid in each and every cluster is to create a systematic way to secure the cluster's position because different locations impact various outputs. For a more valuable outcome, keeping them at a distance is the most effective way to keep them at bay. After setting the center of the data set, is that all the objects that are associated with or part of the given data set must have appeared stone away from its centroid. If all objects associated with the collection are no longer pending, the random centroids are recalculated in each cluster, and the updated centroid is determined by calculating the value. The center is the central part of the NN dataset and is responsible for forgiving clusters/partitions according to their nearest data point with the help of a loop

The official steps of the algorithm are:

1. To begin the calculation of centroids, CN is chosen as the value.
2. Rerun
3. Forming the cluster CN by assigning the nearest value to the dataset's centroid.
4. Re-calculate the centroid of all the formed clusters until the transformation does not occur anymore in the centroid. [34].

The diagrammatic representation of the K-mean algorithm:

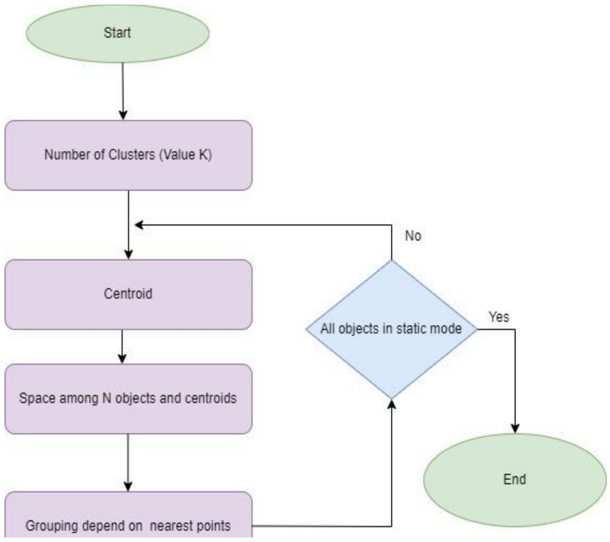

Figure 3.2Flow chart of K-mean algorithm [34]

1.7.1.2 Distance Measurements In K-Means Algorithms

In the K-means algorithm, the distance calculation is one of the import parts between the dataset point and the initialized centroid. Based on the location of the value found to its nearest centroid according to calculation, assigned to its nearest centroid. In the partitioning and clustering algorithm, the distance measure is crucial in order to associate the value with the correct centroid. There are a number of different methods available to calculate distance measurement. Linking datasets and analyzing their properties are the techniques chosen. The selection of distance measurement techniques is Cosine, City block, Correlation, and Euclidean distance [35]. From all the techniques listed above. Our focus is the Euclidean distance. The Euclidean distance calculation is based on the distance between point x and y including dimension k. Euclidean and Euclidean squared distance was calculated from the raw value of the dataset, not from systematized data. The primary benefit of this technique is that the space between two points is never affected by the new measurements that are coming for analysis. Which may be considered as. When we talk about distance affected by the Euclidean technique that is caused by variation in scale among dimensions from which side distance is calculated. We can visualize this point with an example, such as if there is one of the dimensions that represents a length in meters. We can also convert this length to centimeters. In this case, the final outcome of the Euclide depends on the different varieties of length that are converted from meter to centimeter. As a result of changes in the variational dimension, the manifestation form of clusters changes in a different way.

1.7.2 In Second Round (Selection of Cluster Head)

After the clusters have been created. All the cluster members are at the same level as shown in Fig. 3.3. The main target in round two is to select the cluster head CH from existing cluster members' CMs. There is a cluster head (CH) and a cluster member (CM) based on their resource (for example, if there are three members in one cluster and from which 2 cluster members' residential energy is less than the third one, then that one is the cluster head CH). There is a separate antenna for energy harvesting and data transmission. Due to separate antenna transmission nodes can harvest energy while they are transmitting data. Each cluster is controlled by the same CH. Its remaining resources are greater than CM. Even the Nodes are a part of the relaying process, but still in the energy harvesting mode. It gives the sustainability of the D2D communication network to maintain the communication with the help of power resources. Transmission of data and receiving of data also consume energy depending on how many data frames are received/transmitted. Due to the clustering mechanism, there are minimum D2D UE involved in the relaying process to keep the network alive, and setting the CH at a specific threshold level allows to replace the CH with the other D2D UE that has more power in the existing cluster. In this way, the previous CH gets enough time to boost its energy for the next selection. The cluster form hierarchy from C1 to CN until the final cluster CH is called User equipment gateway node (UEGN) that reaches the available UE (UENC) that is connected to the neighboring cell base station. CH communicates with CMs through broadcast messages. To get the updated status of cluster transmission and communication. Below is a detailed explanation being about the energy harvesting model.

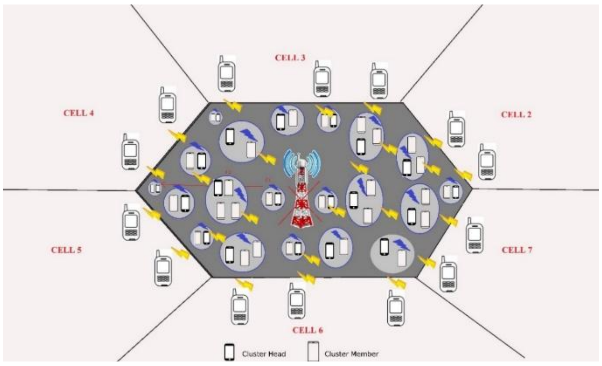

Figure 3.3 Level 2 UE Classification

In this case, we used K-mean clustering to form the cluster based on UEs geographical location [36]. The main benefit of the cluster is that all the UE don't take part in the transmission and only the UE that want to communicate, sends the transmission data to the cluster head (that holds the high power in the existing group)

$$\partial = \sum_{L=1 d=1}^{C} \quad \sum_{d=1}^{N} \quad {}^{\circ}FdL \ldots\ldots\ldots \ (1)$$

Where indicate the interspace between the D2D UE 'd' and the concerned CH of the cluster

L. shows the global view of the D2D UE network. Individuals tend to cluster and do not cluster with each other at the same time (overlapping). K is the available communication channel for all D2D user equipment in the cluster. But the assigned channel in the same clusters can't be assigned to other user equipment in the same cluster. It serves to protect the communication channel from a collision within the same cluster in which more than one device cannot communicate simultaneously. In CH selection, the residual power of the UEs is clearly taken into account. When CH power reaches the predefined threshold of power, it is handed over to another UE that has more power in the cluster. If there is the same power contained in more than one device, then the power can be transferred to any device randomly [37]. In a similar way, each cluster also analyzes the channel before transmission (channel is available or not). The analysis is not limited to the analysis of the empty channel. The idea is to distribute the analysis result with d2d UE in conjunction with an event already occurring in surrounding clusters so it can continue parallel with (side by side with) the energy harvesting [38]. According to the rules defined in Fig. 3.3, CH receives data from CMs (cluster members) and forwards it to the next corresponding cluster. As UEGN, it communicates with neighboring cell UEs to reach the base station.

1.7.2.1 Frame Structure

The frame structure related to period intervals is shown in Fig. 3.4. Each frame is based on the functional period and the control. As we already assumed in the previous section,

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each d2d UE is holding a separate energy harvesting and transmission antenna. In the D2D mode, the antenna partition allows the UE to harvest energy throughout the entire frame. This is instead of waiting for the transmission to end and harvesting to take place with a single antenna. The CH is selected for the specific period of time during which the remaining cluster member's CMs power is lesser as compared to the existing CH. For example, after ten frames, CH's energy becomes less as compared to other CMs. This allows members who share the average energy level with CH to determine the updated CH of the cluster. The frame index is represented with r and the time period in which CMs were selected as Cluster heads CH is denoted with CHT.

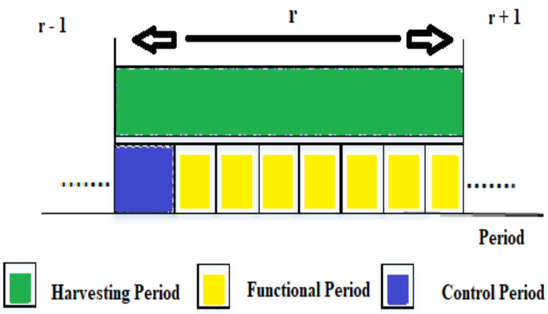

Figure 3.4 Period-interval frame structure

1.7.2.2 Energy Harvesting Model

We are considering that all CMs, including CH, can harvest energy from nearby RF resources. The amount of energy extracted from the RF environment is completely dependent on the source of the RF as well as the harvesting circuit. Transmit power and, subsequently, propagation properties. The energy harvesting EHDU can be performed by the UE in disaster conditions with the UE originating from the RF origin [39].

$$EH\ d,u = ULTPU \frac{GdGuLamALP\ ,u}{4\pi d^{ALP} d,u}\ Ht\ldots\ldots\ldots\ (2)$$

In the above equation, Gd and Gu are the antenna gains that are retrieved from the u-th energy origin and d-th UEs. TPu denotes the transmission of power by means of signals originating from u-th. The distance between RF origin U-th and UE d-th, which may be CMs and CHs, is known as ddu. The path loss component is represented by ALP, the efficiency of harvesting energy is UL, the wavelength of the harvesting signal is Lam. The harvesting period is represented by Ht.

For energy harvesting, all the CMs are receiving a number of signals from different sources. Each signal has its own strength according to various parameters (like signal power, distance, path, etc.). We are assuming that we have a cluster that consists of 20 UE (CM including CH). CH is already chosen based on UE's current residual energy. In each cluster, devices are either transmitting data or are not involved in any operation (idle state). With the help of the above equation, we can determine the values between -5 to 0 dBm. It has been discussed that each CM might be getting a different source of radio frequency (RF) signal and capturing energy from the most suitable source available. Due to the dual antenna, CM and CH are able to conserve energy while transmitting data. The harvested energy is converted into mW according to the current battery status. The core energy harvesting model is shown below in Fig. 3.5. Devices harvest energy from the most efficient RF source.

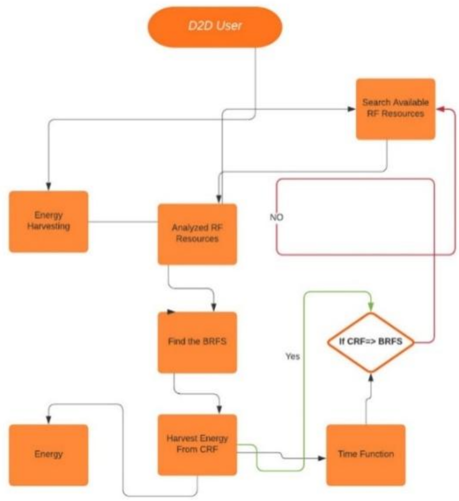

Figure 3.5 High Source Energy Harvesting Model

HSEH is designed to harvest from the best RF source. At the initial level HSEH searches all the available RF sources. After preparing the list it analyzed the source and categorized the source according to the signal strength. The best available source function finds the maximum value that is stored in BRFS. Current RF (CRF) takes the value from BRFS to harvest the energy from the high source to recover the D2D UE battery more efficiently. The time function triggers at a specific interval to compare the current RF values with BRFS values that source is providing the same amount of energy or the current RF (CRF) is less than the Best RF Source (BRFS) values. If the CRF is signal strength is less than the BRFS then the system analyzes the available RF (ARF) source. If CRF's value is greater than or equal to ARF then CRF continues harvesting the energy from the current source. Else maximum function categorized the best source value and link with CRF. In this case, HSEH algorithm continues to find the best source to link with the best available source. HSEH algorithm works more efficient manner as compared to once on selected single RF source in random CH selected in D2D clustering, communication, or energy harvesting with individual D2D UE relay method. Where D2D UE harvests energy much lesser as compared to the HSEH method and consume more energy on CH selection and relaying process.

<u>Algorithm 1: High Source Energy Harvesting Algorithm</u>
1: Initialization: Search RF sources
2: List [] = Rf sources # list all the sources
3: max= List [signal strength] # analysis process RF signal strength
4: CRF= BRFS # BRFS Select the source that hasthe highest value
5: Harvest the energy from CRF
6: while (Time Function is true)
{
Harvest the energy
}
7: if CRF <BRFS # Compare the current RF source value with previous time stamp values
{
Then goto step 2 # if the current source signal strength is reduced. BRFS select the again the highest value to continue harvesting
}
Else:
Goto step 4 # if CRF is still same or high in strength

1.7.3 InThird Round (Channel Allocation (LCM))

We applied the algorithm to find the shortest path to the neighboring cell node to establish the communication with disaster cell. It helps to reduce the participating nodes and their energy. For example, there is UE in cluster A want to communicate with another UE another city. For this we already performed round 1 and 2 (established, formed clusters and chose the cluster head based on their resources). In the third round, the Cluster A calculates the shortest path through the shortest path (Dijkstra algorithm) algorithm. After determining the shortest path, cluster A (cluster head of cluster A) forward the data through cluster B (cluster head of cluster B),C (cluster head of cluster C) and from cluster C (cluster head of cluster C) to neighboring Cell UE. When data reach to the neighboring UE. It is responsible to forward the data to its connected base station. In above given scenario disaster cell (Cell 1)UE makes connections through Cell 6. As it is shown in Fig. 3.6(shortest path transmission). The color scheme of the clusters is just indicating the distance from the central base station (yellow= nearest, green medium and red=far). Above strategy fulfils the criteria of communication in catastrophic conditions or it also can be used in different scenarios like in urban areas where cellular coverage is not sufficient to provide the quality of services. In this case, the shortest path is import to for make a connection and deliver the data transmission to the next level but for the channel condition is also one for the challenging task for reliable transmission. The detail information is mentioned below.

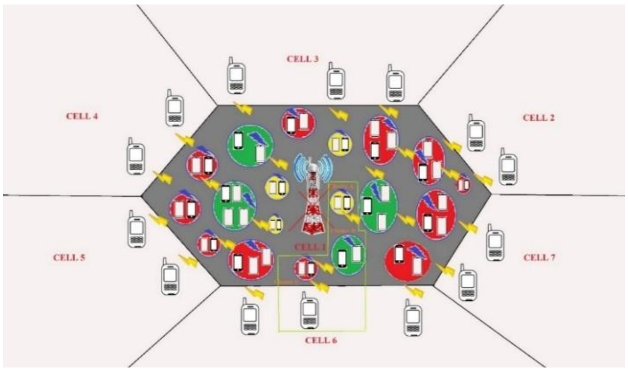

Figure 3.6 Level 3 Shortest Path Transmission

1.7.3.1 Channel Selection

By creating the three phases, we ensured that data communication in disaster cells would run smoothly. This is where infrastructure is not responding due to any catastrophic condition but all neighboring base stations are up and running. The UE enters into D2D mode. As a result of the above phases (like cluster formation, selection of cluster heads based on their residual battery power, and the critical state of the infrastructure, it is imperative to harvest RF energy from the nearest RF source to increase the battery to support the reply process), there are a few areas that need attention. Finally, we need to select the appropriate data channel to send data from any CH to the other clustering CH unit so that it can be connected to the UE of the neighboring cell (UENC) to establish the complete path for communication with the help of D2D UE in the form of clusters. For choosing a trustworthy channel. We are using the SVM model. In which, we trained the machine on data rate and latency to find the suitable channel for transmission.

1.7.3.1.1 Data Rate and Latency Implementation of SVM

If we talk about the classification approach, then the support vector machine is considered to be the best classification. The SVM is not only a good classifier but also work well with regression problem [40]. Diving the data into different classes according to their attributes. For this reason, SVM uses the hyperplane to draw the multi-dimension space to separate the data classes more accurately so this way it can manage various variables and outright variables. The margin of the hyperplane optimizes the error rate by using the marginal hyperplane.

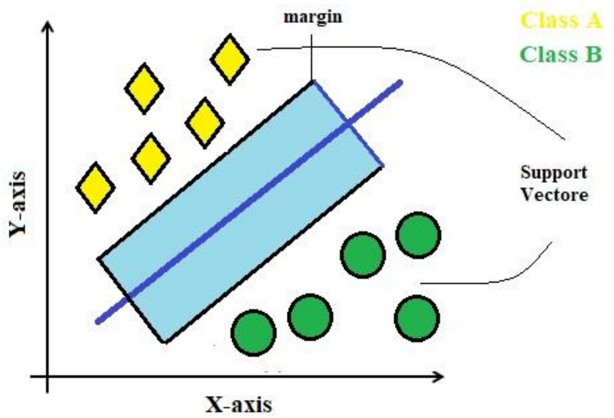

Figure 3.7Support Vector Machine [40]

Support vector indicates the data point that is closest to the margin. The following points can help clarify how to define the separation of data sets using margins. These points provide the base classifiers. Another key factor influencing the decision line between two different classes is the hyperplane [41]. Where margin refers to the space between the lines around the different categories of classes allows determining which data point belongs to a particular class. it is acceptable for a gap between classes to be larger than it is acceptable as a favorable margin and as the gap narrows it is considered a bad margin.

We trained our machine on two significant parameters. Transmission, whether real-time or non-real-time, is a function of latency and data rate. They play a vital role in making data transmission possible from one end to another end. Latency and data rate limitations are depending on the type of transmission that is transmitted through the channel. Then classify real-time services as streaming and conversational (voice calls, online games, remote services, and live chat services) non-real-time services are considered as (text message, recorded messages, etc.), but the channel requirements for both real time and non-real time data are different according to their need. In which latency and data rate requirement is imported to deliver the services through channel according to their standard. To deliver real-time services, low latency and a specific data rate are required. Latency acceptance in real-time services allows a limited time frame (several milliseconds). In non-real-time services like messages, audio, and video also has a limitation to deliver the services according to their standard. But delay in non-real-time service allowed various seconds for the machine to machine (M2M) communication (information or data that is coming from the different sensors) in which latency limitation could be several hours [42].

Table 3.1: Delay Limits in Real and Non-Real time of D2D Communication

Services	**BearableDelay**	**Mux interval**
Audio communication live	Less than $150*10^{-3}$ Seconds	Less than $30*10^{-3}$ Seconds
Online games	Less than $200*10^{-3}$ Seconds	Less than $40*10^{-3}$ Seconds
First person avatar games	Less than $80*10^{-3}$ Seconds	Less than $15*10^{-3}$ Seconds
Third person avatar	Less than $120*10^{-3}$ Seconds	Less than $25*10^{-3}$ Seconds
Remote desktop services	Less than $200*10^{-3}$ Seconds	Less than $40*10^{-3}$ Seconds
live messaging	Less than 5 Seconds	Less than 1 Second
M2M	Less than 1 Seconds	Less than 1 hour

The above table represents the acceptable delay limit and latency limit during the mux interval of time. The requirement of latency differs in different situations, indicating that communication in a particular mode can bear a specific amount of delay, as shown in Table 3.1 above. The delay period in non-real-time communication is high in comparison to real-time communication. In our work, we are assuming the maximum bearable latency instead of treating each service separately in near-time D2D communication.

To fulfill the requirement of any services (in D2D data communication) where latency is an issue, we cannot deny the importance of data rate. The most common data rates are divided according to their classes. Real-time and non-real-time, and they are further divided into more categories like real-time high turnout, real-time live messages, non-real-time high turnout, and non-real-time live message. The minimum data rate is mentioned below for acceptable data communication. The quality of service (QoS) that is required at a minimum level is listed in table 3.2, along with the information described in [43][44][45].

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Table 3.2. Minimum Data rate for different D2D services

Services	**Min. Data-Rate (Kbps)**
Real time message	10
Non real time messages	5
Real time high turnout	90
Non real time high turnout	50

We are merging the real-time and non-real-time data communication processes based on minimum latency and data rate that makes it possible to communicate D2D UE and be able to relay this communication to the next available cluster by CH. We trained the model on a minimum data rate requirement of 90 Kbps and maximum acceptable latency of 400 ms. In this case, the selected channel must have a minimum data rate of 90 Kbps and a latency of 400ms. On the other hand, if latency reaches above 400 milliseconds and the data rate is less than 90 kbps, the channel is considered an unacceptable channel.

For training the machine we used 70% of the dataset and the remaining 30% we used for testing. After training and testing the dataset. The machine achieved an accuracy of 99.67%.

1.7.3.2 Shortest Path

One of the most significant steps in d2d UE communication is the shortest path. To conserve overall D2D network energy and to establish communication more effectively and efficiently. For this purpose, we used the modified form of the Dijkstra algorithm to find the shortest path. The Dijkstra algorithm used the greedy approach to find the minimum cost to reach the destination. We know the source node (that is transmitting the data to the CH) but we are applying the shortest path algorithm. In this scenario, we are considering each cluster as a single node and at that level, the cost of the source cluster is zero.

Step 1: Find the neighbor clusters ([B, C]) of Cluster A (source).
Step 2: Find the cost of the Adj clusters.
Step 3: Find the minimum cost from the Adj clusters.
Step 4: whichever cluster we already visited. We considered as a visited cluster so, we are not going to visit again.
Step 5: We take the next neighboring clusters and find the cost and then compare with the neighboring clusters. We do not assign any value until neighboring clusters comparison is not done (until we can find the minimum cost neighbor).
Step 6: We take the next cluster that is not in visited array for next comparison until we reach to the destination UE (UENC).
Step 7: To find the minimum cost neighbor (to reduce the time complexity we are using the min-heap priority queue).
In step 7 we use the min-heap priority since if we used any other sorting algorithm, we would end up with an inconsistent result. It increases the time complexity of the algorithm. After applying the optimized version of the Dijkstra algorithm to the D2D communication network. We found the minimum path from source D2D UE to the destination UE (UENC) to establish the connection with the nearest BS. In this research, we are considering the maximum three-hop communication link between source and destination. Before transmitting the data, we have already trained our machine through SVM to pick the best available channel based on latency (minimum latency) and data rate (maximum data rate). The system selects the most efficient channel based on the parameters mentioned on each link until it reaches the destination. In Fig. 3.8, the system shows how it selects the most appropriate available channels and also incorporates the energy harvesting model (HSEH) that maintains the D2D UE's reliability to transmit data frames longer than existing models.

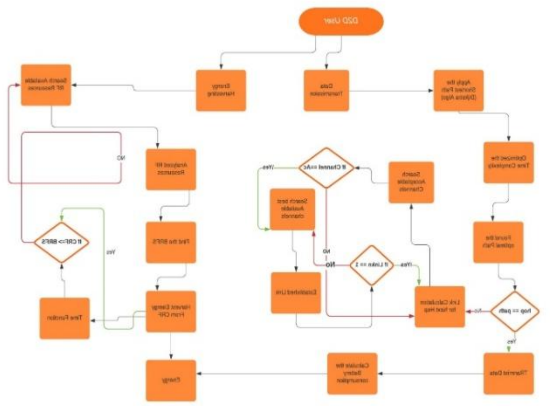

Figure 3.8Energy Harvesting& Link Calculation Model

When any D2D UE is ready to transmit the data to the cluster head (CH). The CH contains all the routing information of the existing cluster in the non-functional cell. The CH applied the optimized Dijkstra algorithm to the current situation to find the shortest path. The route consists of the number of hops but in our scenario, we are considering the maximum of three hops communication. We are assuming all the UENC (User Equipment of Neighboring Cell) maintain the same distance from the neighboring cell base station (NCBS). Hops are considering cluster to cluster communication until it reaches the UENC (that is considered to be an individual UE of the neighboring cell base station). When source CH sends the data frames, it predefines a path that is taken from the path algorithm and the system lists the available channels between two clusters.

The system finds the best available channels based on two parameters (latency and data rate) that have trained by the SVM model as acceptable (AC) and non-acceptable channels (NAC). The best available channel function finds the best channel for the transmission of data frames. There is a 100 percent transfer of data frames with the faster and more efficient way to reach the next cluster with minimum delay and maximum data rate. As compared to RAC and DRM select the channels based on any acceptable channel rather than considering the channels that has the low latency and high data rate that are available to base on latency and data rate. According to the policy each link must calculate first before transmission of data. The same rules apply to each link before transmitting the data to the next cluster until it reaches the UENC.

Algorithm 2: Link Calculation Model Algorithm

```
1: Data Transmission
2: Calculate the shortest path # Calculate the shortest pathby using Dijkstra algorithm
3: reduced the time complexity # \minimum heap function to minimize the time complexity of the algorithm
4: Optimal path
5: if path! =hops # calculate the link on each hop until is not equal to the optimal path
{
  Link calculation for next hop
}
6:   Search AC   # List the acceptable channels
:              If channel! = AC
   {

           Goto step 5
}
Else
7:Select the best channel
 Established the link
 If link !=1
{
          Goto step 6
}
Else
Lined established # specific channel assigned to hop
Goto step 4
8:Else
    Transmit data
Calculate the E # calculate the total energy that is required for transmission
deduct from the total battery
```

IV. SIMULATIONS& RESULTS

In this section, we describe the implementation process of the proposed method. We compared the proposed method with different existing schemes to evaluate the performance of the proposed method. In which different parameters are tested to achieve the required results. Table 4.1 contains all the simulation parameters with their properties that are evaluated in the python simulation environment. According to the results of the comparison of the energy harvesting model with the existing technique, the proposed method preserves the D2D network environment as well as BSEH and RSEH. This transmission scheme allows the D2D UE to send the data through an efficient channel (which selects the channel that has the highest data rate and lowest latency) and the comparison demonstrates that LCM sent that data through a more reliable and efficient method.

1.8 Simulation Parameters

Table 4.1 Simulation parameters and attributes

Parameters	Description
Number of clusters	5
D2D devices in each cluster	20
CH in each cluster	1
CH battery power threshold	60%
Initial d2d users' energy	70 to 100 %
D2D range	300m
Network area	600m
Latency	1ms to 1200ms
Data Rate	1 kbps to 1200 kbps
RF source power	-5 dbm to 0dbm
Maximum number of hops	3
Per data frame consumption	2 mW

1.9 Results & Analysis

The following section contains information about the results and strategies to achieve the goal of the proposed method to successfully transmit the data from NFA to FA. In this way, the NFA can keep data flowing in the event of a natural disaster.

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1.9.1 Discover of D2D Users In NFA

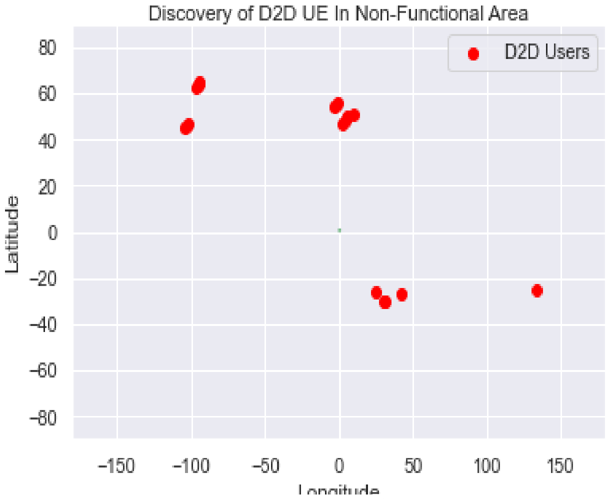

Figure 4.1Discovery of D2D User Equipment

The D2D UEs in the specific cell that is affected by the natural disaster are unable to access the network, while the neighboring cells are fully functional. In this case, first, all devices are in the discovery process, where they discover each other through their geographical values (longitude and latitude) that are taken from the UE existing database (visitor and home location).

1.9.2 Formation Of Clusters In NFA

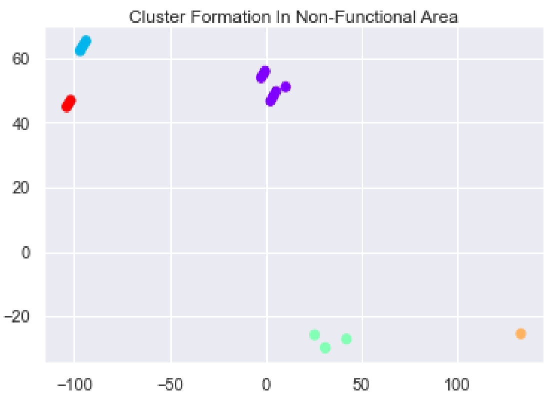

Figure4.2 Formation of Clusters in NFA

After the discovery of D2D UEs. All the nearest UEs formed clusters with the help of K-means clusters. We used the d2d UE geographical location to find the exact location to add in a specific group near its location (by using K-mean clustering). The different colors of the D2D UE indicate specific clusters based on their location.

1.9.3 Residual Energy Based Cluster Head

Figure 4.3Residual Energy-Based Cluster Head

After the formation of the clusters. The next phase is choosing the device that has better power as comparable to other cluster members (CMs). We chose the cluster head (CH) based on the device's residual energy. Choosing the cluster head based on power allows other cluster members to harvest the energy from the best available source to maintain the D2D communication. If the cluster head is not selected based on residual energy, then there is no guarantee of communication, due to insufficiency of power or if the transmission is happening without the form of clusters, in that case, more devices are involved in the relaying process that causes the D2D UE to drain the power faster as compared to the cluster method. In our proposed method when devices are increasing in the cluster, it allows more stability as compared to without clustering or randomly selected CH. Fig. 4.3 indicates that the proposed technique allows sustainable energy from CH as compared to a random selection of CH in the d2d communication network. Where the frequent change of CH increases the pressure on the system and increases the delay in communication due to a selection process. In this case, it decreases the efficiency of the D2D communication network.

1.9.4 Energy Harvesting Method Comparison

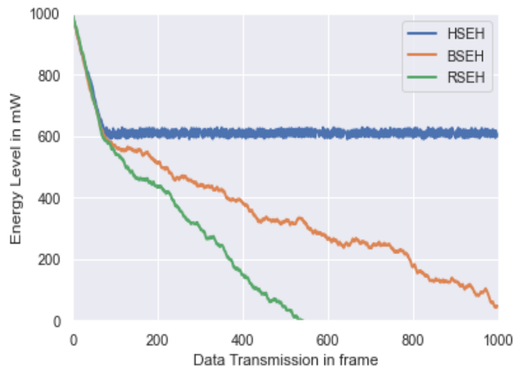

Figure 4.4Energy Harvesting Method Comparison

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We are assuming that each d2d UE is equipped with a dual antenna. While one cluster member (CM) is transmitting the data frames to the cluster head (CH) at meanwhile it is also harvesting the RF energy from the best available source of RF (the harvesting process works according to our proposed HSEH algorithm). The above Fig.4.4 indicates that energy harvesting is continuing to maintain the D2D UE battery power through energy harvesting. We are assuming that in the cluster, only one D2D UE can communicate with the CH head at the time. When a cluster member and CH are sitting idle, they are harvesting the energy, but when data frames are sent through any CM to CH or sent from CH to CH consume energy, and that is deducted from the all involved D2D UE existing power. The consumption of energy depends on the number of data frames and side by energy harvesting process maintaining the UE battery power. We set the threshold of 60 percent of CH battery power as soon as it reached the limited threshold. Then the re-selection process helps to choose the new cluster head to maintain cluster communication. Another hand random CH selection technique or without clustering relaying process consumes more energy as compared to our proposed technique. Soon the D2D communication network reaches the dead level, due to randomly selects of the cluster head creating more complexity in communication (due to the resolution process). In disaster conditions, the clustering mechanism is more efficient as compared to relaying the data frame device to device. Device-to-device relay makes the system unreliable due to a large number of devices, taking part in the relaying process. Figure 4.4 indicates the transmission of data in the D2D network where the number of D2D UEs are sending the data frames. The proposed mechanism (HSEH) maintains the energy level after sending a large number of Data frames as compared to BSEH (there is no re-checking is available to maintain the best source) and RSEH fails to maintain the energy after sending a specific number of data frames. Normally this is used in the D2D relay process where the path is more important to reach the data to the next hop with a complex d2d routing table.

1.9.5 Selection Of Acceptable Channels

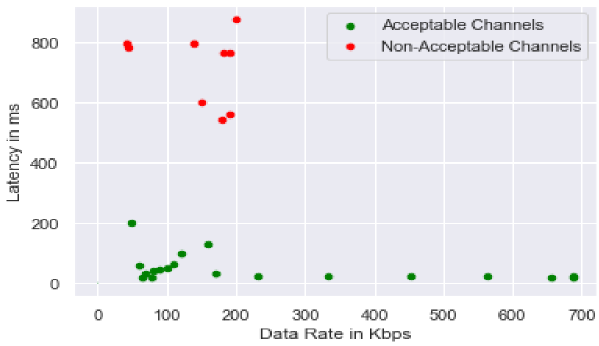

Figure 4.5 Selection of Acceptable Channels

When any cluster node transmits the data frames. The channel is selected based on its requirements. For different types of communication different channel characteristics are required. However, for simplicity from Table 3.1 and 3.2, we are looking at the minimum requirement of Data rate and latency acceptances. IF the data rate is greater than, equal to 90 Kbps and the latency is 400 ms then CM can send the data frames through that channel otherwise it is considered a rejected channel. Even though the data rate is high and latency is greater than the given threshold that is considered as rejected channels and if the latency is low or under given the threshold, but the data rate is lower than the mentioned limitation then those channels are also not be considered. As it is shown in Fig. 4.5.

1.9.6 Acceptable Channels Accuracy Report

```
              precision    recall  f1-score   support

           0       1.00      0.99      1.00       113
           1       0.99      1.00      1.00       187

    accuracy                           1.00       300
   macro avg       1.00      1.00      1.00       300
weighted avg       1.00      1.00      1.00       300

Accuracy: 0.9966666666666667
```

Figure 4.6Acceptable Channels Accuracy Report

We used SVM to train the machine by feeding the data rate and latency parameters. The 70 percent data was used for training purposes and the remaining 30 percent data was used for testing the machine. The above Fig. 4.6 indicates that we got 99.6% accuracy to predict the right channel for data transmission from source to destination (next hop). The precision and recall indicate how many percent of feeder data information is correctly labeled, such as data rate and latency. Based on the dataset trained by SVM, the relationship between latency and data rate is required at a certain level to accept the channel conditions. Based on the latency and data rate of the available channels, a category of channels is set up which is acceptable and a category that is non-acceptable. whenever the data rate and latency do not match a predefined threshold, the data rate is represented by zero (0) and acceptable channels by one (1).

1.9.7 Increment Of Users In Cluster

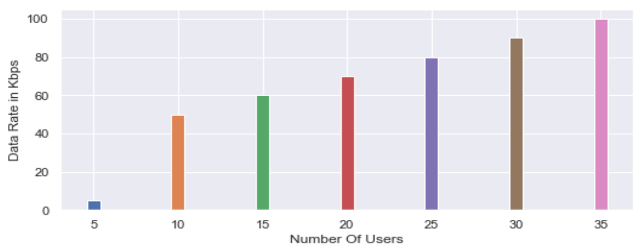

Figure 4.7Increment of Users in Clusters

In the D2D communication network, as the number of users increases, more data rate is required to enable UE communication when more users join the network. Fig 4.7 depicts the way in which the increment of d2d UE is directly proportional to the data rate. At a low data rate, the D2D UE communication is not able to meet QoS requirements. When more clusters become active in the D2D communication network. A higher data rate is needed to handle traffic otherwise it would become a bottleneck in the data relaying process.

1.9.8 Communication Through Best Channels

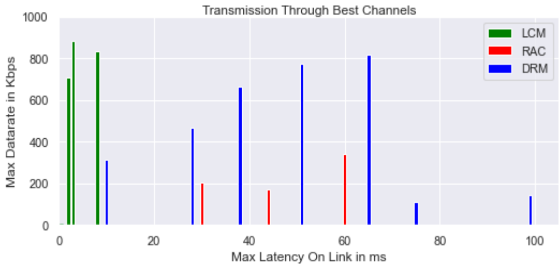

Figure 4.8Communication Through Best Channels

When any D2D UE wants to communicate, according to policy, D2D UE transmits the data to the cluster head and the cluster head relays the data frames to the next CH until it reaches UEGN, which is linked with neighboring cell UE (UENC). In the simulation, 'A' is not the d2d UE (starting d2d UE) source node that is transmitting the data to Cluster head (CH) 'C' because we are considering the cluster as a single node unless it is UENC then N-1 (E) is UEGN that is linked with neighboring cell UE (UENC) that is 'F'. For finding the shortest path we applied the Dijkstra algorithm to the current situation and optimized the time complexity of the algorithm. The results indicate the cost of links in the implemented scenario is 10 based on the shortest path. The data transmission system should choose the best available channel. For achieving that goal. We calculate the minimum latency of the available channel and maximum data rate before sending the data frames on each calculated link that is achieved by the Dijkstra algorithm. Once the system got the best channel based on giving parameter CH relay the data frames to the next hop. This process is run again and again until the data frames reach the UENC. Other hand RAC (Random available channel) work on the strategy to select the channel without link calculation (LC) and transmit the data before establishing the reliable path to send the data frames to next-hop. The main RAC strategy is to list the acceptable channels rather than refine them after they have been created based on latency and data rate factors. DRM (D2D relay method) works in a similar way to RAC, but without the clustering, where more hops are required, that becomes an obstacle to transmitting the data frames. The above simulation results indicate the proposed method shows the best performance as compared to existing methods.

V. CONCLUSION

D2D communication is the most emerging technology in upcoming communication systems. Where it is allowing the users to communicate with each other without the involvement of network infrastructure partially or fully. Within D2D, multi-hop communication could provide the best solution in most critical scenarios where the central structure of the network is damaged due to natural disasters or through any other cause. In this thesis, the same scenario where mobile BS is damaged due to the natural cause is considered with the assumption that all the neighboring cells are still in operational condition. To maintain the traffic from non-functional cell to establish a connection with functional cell to maintain the communication in the non-functional cell through multi-hop D2D communication. In a disaster cell, all the infrastructure might be in critical condition. In that case, we incorporated the energy harvesting model to keep the D2D UE live and help to establish the D2D network. The proposed technique is divided into parts. In the first part, all the devices are equipped with dual antennas and harvest energy from the best available source. For energy efficiency, we divided the D2D UE in the form of clusters and for the formation of the clusters, we used the K-mean cluster to divide the D2D user equipment according to the geographical location. Then the selection of CH based on residual energy and dual-band allows harvesting and transmission simultaneously. The second part is based on the transmission of data frames from the shortest path that is achieved by the Dijkstra algorithm and sent through the best available channel that has the highest data rate and low latency. This process is applied on each link path of the clusters until it reaches the final destination which is UENC. The simulation results indicate that the energy harvesting model (HSEH) showed better performance as compared to BSEH and RSEH in the cluster environment. The HSEH is an iterative model to continue to search for the best energy source to harvest the energy as compared to other models. Clustering and the shortest path maintain the energy of the device. The link calculation (LCM) ensured the transmission of reliable data between devices to reach the neighboring cell base station. Where it achieved more accuracy to send data through reliable channels as compared to RAC and DRM.

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