Hindawi
Scientific Programming
Volume 2022, Article ID 5424356, 11 pages
https://doi.org/10.1155/2022/5424356

Research Article

OCHSA: Designing Energy-Efficient Lifetime-Aware Leisure Degree Adaptive Routing Protocol with Optimal Cluster Head Selection for 5G Communication Network Disaster Management

S. Raja,[1] **J. Logeshwaran**,[2] **S. Venkatasubramanian**,[3] **M. Jayalakshmi**,[4] **N. Rajeswari**,[5] **N. G. Olaiya**,[6] **and Wubishet Degife Mammo**[7]

[1]*School of Mechanical Engineering, Vellore Institute of Technology, Vellore Campus, Vellore 632006, Tamil Nadu, India*
[2]*Department of Electronics and Communication Engineering, Sri Eshwar College of Engineering, Coimbatore, Tamil Nadu, India*
[3]*Department of Computer Science Engineering, Saranathan College of Engineering, Trichy 620012, Tamil Nadu, India*
[4]*Department of Mathematics, Vellore Institute of Technology, Vellore Campus, Vellore 632006, Tamil Nadu, India*
[5]*Department of Mechanical Engineering, Surya Engineering College, Erode 633107, Tamil Nadu, India*
[6]*Department of Industrial and Production Engineering, Federal University of Technology Akure, PMB 704, Akure, Nigeria*
[7]*Department of Mechanical Engineering, Wollo University, Dessie, Ethiopia*

Correspondence should be addressed to Wubishet Degife Mammo; wubishetdegife7@gmail.com

Received 13 July 2022; Revised 25 July 2022; Accepted 3 August 2022; Published 25 August 2022

Academic Editor: Punit Gupta

As an underlayment to cellular 5G communication network, device-to-device (D2D) communications will not only boost capacity utilization and power efficiency but also provide public health and public safety services. One of the most important requirements for these businesses is to have alternate access to cellular networks in the event that they are partially or completely disrupted as a result of a natural disaster. Despite limited communication coverage and bandwidth scarcity, the 3rd Generation Partnership Project (3GPP) must have developed a new device-to-device (D2D) communication method fundamental enhanced mobile that can strengthen spectral efficiencies besides allowing direct communication of gadgets in close propinquity devoid of transitory by elevated-node B (eNB). Unfortunately, enabling data transmission on a cellular connection offers a challenge in terms of two-way radio source administration, because D2D associates recycle cellular users' uplink radio resources, which might create interference to D2D user equipment's (DUE) receiving channels. In this study, we concentrate on optimal cluster head selection using the binary flower pollination optimization algorithm by designing an energy-efficient lifetime-aware leisure degree adaptive routing protocol named OptCH_L-LDAR. This topology is constructed with a multi-hop obliging communication system, instructed on the way to wrap an extensive remoteness connecting source and destination. The proposed OptCH_L-LDAR is compared with three state-of-art methods such as binary flower pollination (BFP) algorithm, time division multiple access (TDMA), and data-driven technique (DDT). As a result, the proposed OptCH_L-LDAR achieves 96% of energy efficiency, 89% of lifetime, 97% of outage probability, and 98% of spectral efficiency.

1. Introduction

Extreme climate proceedings are flattering more common and more severe as a result of global climate change, in terms of both human casualties and economic losses. Governments must be prepared to deal with these global realities [1]. The loss of life and property may be reduced if a reliable disaster detection and alerting system were in place. Another critical concern in the event of a disaster is a good search and recovery system that is precise, timely, and comfortable including both survivors and rescuers [2]. Wireless sensor networks (WSNs) have gradually matured to the point that they may now be used as one of the development tools for catastrophe earlier than usual systems, rather than just fine-grained continuous monitoring platforms. Event detection capabilities are typically required for all nodes, including end nodes, in a sensor network. Due to this, it is possible to detect and count the jobs in progress at various nodes in the network. This event detection capability helps to calculate important things such as the completion time of the jobs on that node and the next jobs of the nodes. WSNs' event detection capabilities can be extremely useful and important for (near) real-time identification of meteorological natural disasters and wild and domestic fires [3]. A cluster in the network design has four ad hoc transmitters and a wireless sensor [4]. Every cluster's sensor networks are bordered by ARS, and the leader node in the centre is in charge of communication with all of the nodes in the sensor field. Every cluster in a network is connected directly to a sink node, which is in charge of keeping the communication link between each cluster's head nodes in the network [5]. The base station employs a UMTS or WiMAX-based communication technology to relay disaster-affected data from clustered network architecture to an emergency service centre. When the node in the terminal is in an idle state, various problems arise. That is, the nodes in the cluster are used to connect the nodes in the other clusters. If it is in an idle state, there are more chances of cluster-to-cluster communication being lost. Also, problems and time delays in data communication during the time to correct it can create inconvenience to the user.

Several technological hurdles must be addressed before WSN may be used among various architectures, whenever the network of thing industry persists. The independent interaction within nodes is a representative open issue. The main server controlling all devices in a WSN is inefficient. As a result, device-to-device (D2D) communication makes being touted as a promising solution in WSNs [6]. Available nodes can communicate with one other in a self-contained manner in D2D communications. [7]. The network coverage expansion and interworking with heterogeneous networks are another ongoing topic of WSN to improve IoT. Cellular networks could be a great contender for solving this issue. Cellular networks typically span the majority of countries and communicate with one another. As a result, there is a rising trend to combine WSNs and cellular networks [8].

Hence, the research addresses D2D communiqué solutions among WNS in light of these considerations. To adapt wireless sensor networks to IoT, researchers are looking at device-to-device transmission that underpins long-term systems [9]. Hence, these long-term system devices employ deformation, which is described as a expertise that enables clear relation between adjacent sensor network and user equipment (UE). IoT devices need not transit across cellular infrastructure nodes such as enchanted node or a mobility management entity (MME) to establish quality connection with users. Mobility management includes important elements such as monitoring, controlling the behavior of various sensor nodes present in clusters, and configuring routes for communication tasks. The licensed spectrum of cellular networks should be shared with D2D communications to avoid bandwidth loss in those communications underneath long-term systems. Interference between cellular user equipment and D2D user equipment is unfortunately unavoidable [10].

In this study, to help disaster management, we use WSN technology and D2D communications together. In disaster scenarios, a cluster-based network is proposed to bridge the possibly lengthy distance between source and destination devices. Even in the absence of a communication infrastructure, we use relay selection and D2D communication architecture to keep devices connected [11]. If the communication infrastructure issues occur during the disaster, a better way to find alternative nodes for shortest path identification and route management are predicted. If the infrastructure was absent, then there is another initiation of path finding and resource allocations are performed by the leader node. To interact with each other, the cluster leaders (PUs) set up their cluster members (SUs) as relay nodes. We assume that each node has a single antenna and that there is no LOS between PUs in our calculations. Furthermore, in this research, we analyze a slow fading channel, in which the communication timescale is short in comparison with the synchronization time span for all participants [12]. Typically when two devices connected to a network communicate directly with each other, various resources are saved. For example, when two devices make contact, the speed of communication between them is high. So, the communication time for those devices will be less. Chances of any delay are minimal. Their bandwidth usage is at the desired level when in direct contact.

The contribution of our work is as follows:

(i) Using D2D communication and WSNs, we present a quick deployment paradigm in which information can be transmitted together without the need for infrastructures. We explore an overlay network in which SUs operate together to transport data among PUs.

(ii) An analysis of the challenges of relay design and allocation scheme in SUs situated in multiple clusters and hierarchical levels is presented using a system model. The effectiveness and durability of this approach are demonstrated by quantitative findings.

The rest of this article is laid as follows. The following section gives a review among the most significant publications within research, whereas Section 3 discusses the design methodology. Section 4 discusses the network model's evaluation process. The study comes to a close with Section 5, which highlights direction for future.

2. Related Works

Masaracchia et al. [13] provide a device-to-device (D2D)-based architecture that might enable interactions from a disaster zone to a functional department depending on certain basic information such as the locations and charge levels of victims' gadgets. Such architecture, which is used by a ground station in a functional department, divides individuals in a disaster zone across clusters and selects a gateway for every cluster.

Ali et al. [14] utilize renewable energy at the relaying alongside those communication and electricity transmission to increase the benefits of an electricity network. Researchers concentrate on either a device relaying, which gathers power from such a radio wave transmission and utilizes it for single-hop communication through an access point. With mobile networks, it combines clustering and full-duplex connections such that messages could continue even though the mobile infrastructure is largely down. As per simulation results, the proposed clustering method performs well enough in respect of reliability and emission reduction, while clustered construction may enlarge the provided significance.

According to Khan et al. [15], the device-to-device (D2D) network is considered to enable self-sustaining communication in crisis situations. By mutual sharing of energy on the RF link, such direct cable connections can maintain communication with equipment having exhausted backup whenever stranded in collapsed infrastructure. To tackle the suggested mixed-integer issue, we offer an energy-efficient peer selection and time switching ratio allocation (EPS-TRA) algorithm. When compared to the uniform allocation scheme of time slots, numerical findings confirm our proposed strategy for obtaining superior result.

Wang et al. [16] look at urgent transport in disaster scenarios in addition to formulating the difficulty since the integer linear encoding unites the accumulated means of expression direction finding problem and the multi-depot vehicle route planning. The cum-MDVRP is an NP-hard problem. A novel hybrid ant colony optimization-based algorithm is planned to solve it, which combines all preserving methods plus a straightforward two-step select process.

A multi-objective allocation of resources approach is formulated in the article of Wang et al. [17] to realize the effective distribution of rescue resources and the appropriate choice of transport networks taking into account the features of unpredictability and persistence during the rescuing process. Furthermore, by integrating the supplementary population and neighbourhood organization in the automata, the multi-objective cellular genetic algorithm (MOCGA) is constructed to obtain the solution. The multi-objective has been used for decision-making in complex situations, and it is applied to a lot of emerging problems [18, 19].

Path planning in a 3D topography catastrophe situation is presented as a multi-objective optimization difficulty with restrictions inside [20]. The detachment plus danger of the corridor is vague using the Bézier theory as an objective function. The junction viewpoint and flight height are two of the restrictions. A discrepancy advancement algorithm based merely on the lap tip is projected to resolve this problem effectively and efficiently, with the knee solution guiding the algorithm's search path.

Niu et al. [21] offer a multi-objective optimization strategy for solving the issue of large-area target satellite planning. To begin, they create a method that breaks down a geographical assignment into a series of inspection panels. The challenge of satellite communications multiple tasks is therefore expressed as an inter-integer programming framework, including value observed, imagery finish time, mean positional accuracy, plus averaged movable direction as improvement criteria.

To predict the automated situation in industry, Venkatasubramanian et al. [22] found the fault analysis model by IIOT. The best number and locations of temporal rescue centres are then determined using global particle swarm optimization and mixed-integer linear programming.

Several clustering approaches in wireless networks to address energy harvesting concerns, catering to power supply limitations, may be seen from the methods stated above. The energy collecting technology described in this research has the potential to extend battery life and keep the network operational in the event of a disaster. When the cellular infrastructure fails partially or completely, the clustering approach and D2D communication in networks can keep communication services running.

Kiruthuiga and Shanmugasundaram [23] discussed mobile networks, and it combines clustering and full-duplex connections such that messages could continue even though the mobile infrastructure is largely down. As per simulation results, the proposed clustering method performs well enough in respect of reliability and emission reduction, while clustered construction may enlarge the provided significant.

Yousefpoor et al. [24] expressed that some clusters draw near wireless network to address power harvest concerns, catering to power supply limitations, which may be seen from the methods stated above. The energy collecting technology described in this research has the potential to extend battery life and keep the network operational in the event of a disaster.

Logeshwaran et al. [25] provided that when the cellular infrastructure fails partially or completely, the clustering approach and D2D communication in networks can keep communication services running.

3. Research Methodology

Initially, the network is constructed by defiling the system model with its assumptions, followed by node placement in network, and it is shown in Figure 1. Now, the cluster head is selected using the improved binary flower pollination algorithm (IBFPA) and a lot time switching-based protocol for each cluster head. This improved binary flower pollination algorithm provides the following advantages:

(i) It imitated the backup route for every communication between the nodes.

(ii) It supports cluster-to-cluster communication with minimal resource utilization.

(iii) It locks the nodes while communication process. Until the end-to-end communication process, this does not allow the node to leave the path.

Now, the role of device-to-device comes into existence, which helps in power transfer mechanism, outage probability, and optimal power consumption in cluster head. The power transfer mechanism was obtained with the help of the following equation:

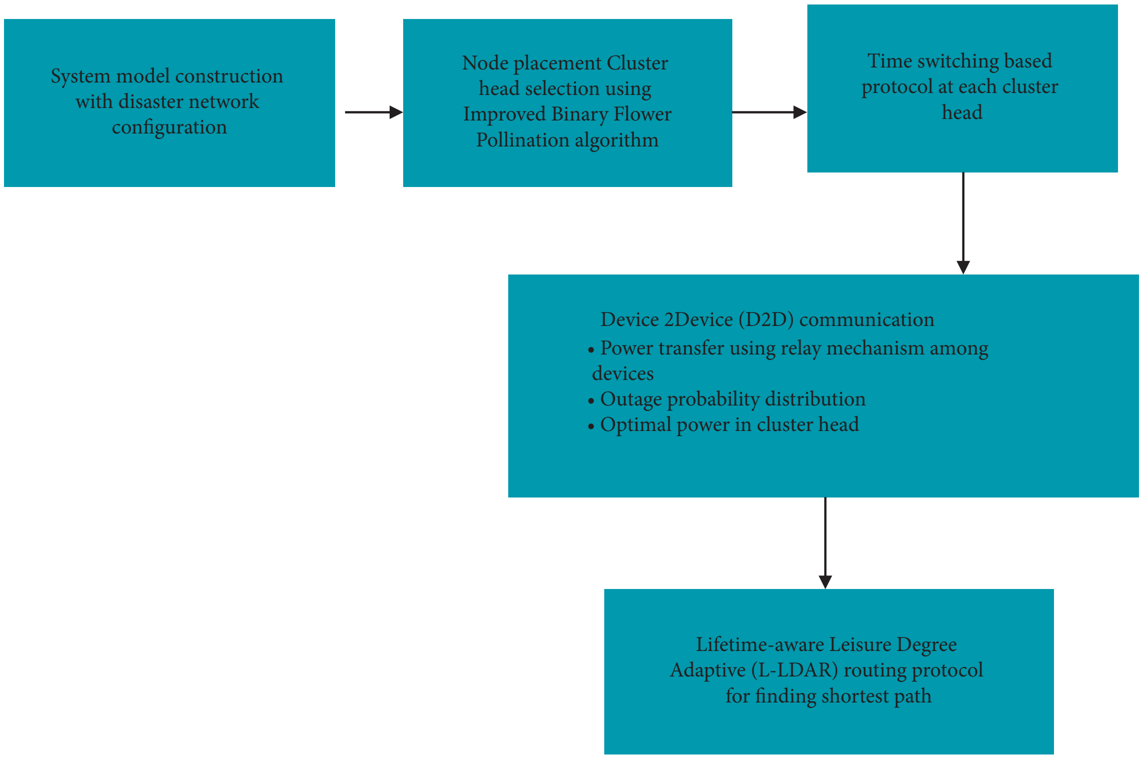

Figure 1: Block diagram for energy-efficient disaster management.

$$P_{\mathrm{LR}} = P_{\mathrm{SR}}, \tag{1}$$

where P_{LR} = load resistance of the power factor and P_{SR} = source resistance of the power factor.

Finally, the lifetime-aware leisure degree adaptive (L-LDAR) routing protocol is used for finding the shortest path. There is an issue raised while the bordered nodes are in the ideal state, because the communication link between the clusters is enabled with the help of the bordered communication nodes. If the bordered nodes are in the ideal state, then the communication interferences occur between the clusters, and also, these ideal nodes consume the network resources more.

The optimal power consumption of a sensor node was computed by the following equation:

$$P_o = \frac{U_{\mathrm{SN}}}{P_T}, \tag{2}$$

where P_o = optimized power, U_{SN} = utilized power of the sensor node, and P_T = total transmission power.

The energy consumption was increased, while the nodes are in the busy state in the communication route. The edge node and other nodes are in the waiting state, while the path node is in the busy state. So, the energy utilization of the nodes is increased.

4. System Model

It analyzed an emergency service situation in which a supplier (i.e., BS) with either limited energy resources wishes to send data towards a recipient that is outside of the service region. This same origin could indeed straightforwardly convey its own messages to the destination due to a shield seen between sender and receiver or connection-oriented length; thereby, it requests a relay to aid its data transfer such as through full-duplex proximity amenities because the location is in a disaster zone in which clear interaction is not really conceivable. In the disaster zone, the full-duplex proximity is getting more attention because the sensor node configuration and retransmission initiations are getting higher attention. Hence, the needs for full-duplex proximity are important in the disaster zone. Nevertheless, due to its selfish nature or even a reduction in power availability, the relaying must first acquire power before it can assist. The underlying set of factors will be examined all throughout the manuscript.

Hypothesis 1. Assume a mobile D2D network infrastructure in which data have been sent from source S to destination network D either through an approximate receiver station R. From another step inside the disaster zone, the target base station may serve as just a user equipment relay (UER) nodes. The user equipment relay (UER) node is very important in cluster-to-cluster communication because this node is the medium to receive the acknowledgement from the end node. If this was not available in the communication network, then reliable communication was not possible. Inside the grouping initial formation, UER also serves as a cluster head (UERCH).

Hypothesis 2. The nodes in the middle R are indeed a network with a limited amount of energy. It collects energy out from S and thereafter utilizes that energy of transmission ability to throw the original packets to the server. The transmission ability of the nodes was computed based on the consumption of resources. If the node has the ability to transmit the information with low resource utilization, then it is called the efficient node.

Hypothesis 3. Even just a relaying node with adequate power or perhaps the ability to recover energy is chosen with forward communications and power to the target. The decoding forward (DF) approach is chosen among the various receiving methods there at intermediate nodes. The ratio between the energy consumption and sensor nodes is directly proportional to each other. If the number of sensor nodes is increased, then the consumption of energy also increased, because the sensor nodes consumed the energy for transmitting the information.

The decoding forward is one of the secured transmission approaches, while the sensor nodes communicate with each other while the cluster-to-cluster communication. This mechanism encodes the path details and communication details and sends the decoding information to the sink node. So, the intermediate nodes are unable to know the details. If the route nodes do not recognize the information, then they may lose the message packets while transmitting the information. This is the major drawback of decoding forward.

4.1. Cluster Head Selection Using Improved Binary Flower Pollination Algorithm (IBFPA). The cluster is formed such that each sensor by them is selected to be assigned as a gateway having some specified possibilities. A CH has a single gateway to a sink. CH selects the gateway from the nodes, which are one hop nearer to the sink next to the selection of CH. The gateway may or may not be a member of the cluster. CH forwards gateway selection message (GSM) to the selected gateway, and thereby, there is a possibility to know to which selected node the gateway is linked. Disseminating queries from sink and gathering data to sink is accomplished using CH and gateway. This gateway sensor node distributes the transmitted sensor readings to every CH by deciding which portion of the readings has to be transmitted to CH say h based on the workload of h. If the workload is more, fewer amounts of sensor readings are sent to h by the gateway. Thus, the task of data aggregation, which is performed by CH, is balanced in a better way. Moreover, energy consumption among CH is also well balanced; thereby, CH resignation is reduced, which in turn reduces the reformation of cluster.

$$\mathrm{Ecl} = \mathrm{lEelec}\,(k-1) + \mathrm{lamp}\,E\sum_{k=0}^{n} d^2 \,\mathrm{to\ CH}, \tag{3}$$

where equations 3 represents the length of messages and “Eelec” represents the transmit electronics. Lamp denotes transmit amplifier, and the distance between a cluster member (CM) and its CH is represented by d to CH.

$E(\sum_{k=0}^{n} \mathrm{distance}^2 \mathrm{to\ CH})$ is the expected sum of the square distance of cluster member from their corresponding cluster head.

For any two CHs, the distance exceeds d. Every cluster is portioned into two areas and is handled separately in this proposed model. The first circular area has a radius of distance/2 from cluster. The next area covers the sensors with the distance exceeding distance/2 from the current CH. The following expression is used to identify the CH:

$$E = \sum_{k=0}^{n} \mathrm{d}^2 \mathrm{to\ CH} = 2\pi\theta \mathrm{CH}\int_{0}^{\mathrm{distance}/2} r^3 \mathrm{d}r. \tag{4}$$

Now, all the sensors with distance not more than distance/2 from other CHs are secure nodes in other CHs but not the nodes of current CH. At first, the nodes are deployed in the network using IFPAO. The area coverage is the important parameter to construct a cluster. This coverage of an area includes the number of sensor nodes and communication links. Based on this area coverage, the communication was classified into intercluster and intra-cluster communication. The coverage ratio is the term to define the number of sensor nodes to communicate and establish the connection link between each other in a geographical location.

When a new node is deployed, area coverage (AC) and coverage ratio (CR) of the node are tested by estimating $\mathrm{Reg}(i) = \mathrm{Width}(i) \times \mathrm{Height}(i)$. Deployments of nodes are optimized with CR and AC by which energy efficiency is improved. This algorithm is partially inspired by nature, which is commonly involved to provide solutions for optimization problems that are challenging. The pollination process transfers pollen via pollinators such as bats, insects, birds, and animals. Two pollinations taken into account are self-pollination and cross-pollination. Generally, pollen of the same flower creates pollination, which is then converted into various plants. In IBFPA, the protocols used are as follows.

Here, IBFPA is involved in three different operations. The objective function of IBFPA is given as follows:

$$\text{Objective Function (OF)} = \max(\mathrm{CR}, \mathrm{AC}). \tag{5}$$

Objective function constraints are hence used for the below-mentioned process.

(i) Deployment of sensor nodes
(ii) Discovering the route and selecting the best node
(iii) Optimum transmission

In this sensor node-to-node communication, the signal-to-noise interference ratio (SINR) provides the relationship between the exact communication signal and the interference created by the noises from some other interference sensor nodes. There are the following types of optimization problems available.

(i) Sensor node optimization problems
(ii) Communication optimization problems
(iii) Resource optimization problems

While deployment, the IBFPA optimization process verifies the sensors, sensing region, target, and covered directions. The entire AC is computed as follows:

$$\text{Total AC} = \sum_{n=1}^{a} \sum_{m=1}^{a} x(n, m, c), \tag{6}$$

and then, CR is calculated using the following equation:

$$\text{Total CR} = \frac{\text{Total cover area}}{\text{Total network area}}. \tag{7}$$

Initially, based on the CR, AC, and coverage of target object, SNs are deployed in optimal locations with accurate sensing angle. After deployment, the information of SNs is included in rank D lists, and it is shown in Figure 2. Each flower is denoted as a vector by integrating the information about area, CR, AC, I (cover), I (node), energy, and time (ts). In FPA, it is verified whether the best fitness solution is provided by pollination. AC, CR, and energy are optimized by motivating BFPA and by maintaining covered directions and targets and optimal sensors. Thus, SNs are placed at optimal locations to improve CR and AC to increase the lifespan of the network. The classification of SNs is based on the locations in network plane (X, Y) and total sensors N in a specified region, radius R, and number of directions K, and at the initial stage, even targets are included. After then, the process of pollination is executed. Every time for the objective functions, the constraints are determined. Once every operation is completed, global and local pollinations are verified. The similarities between the flowers are obtained using the Euclidean distance. The fittest solution is obtained until AC, CR, maximum energy, and target coverage are satisfied by the neighbour flower. The process is continuously performed until the stopping criteria are met. The routes are discovered based on the availability of the sensor nodes. If a sensor node utilized less resources and achieved the high rate of data transmission, then the node is selected as the best node.

4.2. Time Switching Method (TSM). The intermediary network device collects power from across all nearby transmissions and thus helps the AP and target mobile station to communicate. Throughout this part, we will utilize the standard prototype system shown in Figure 1, wherein the energy generated from AP is kept inside the relay's batteries during the first hop and is used for relaying node mobility broadcast within the next hop. Let us examine the suggested TSM protocol's possible bandwidth to acquire more information about its effectiveness. Users generate 2 phases in the TSM protocol, such as the energy phase and the informational phase. In the suggested TSM, the overall intensity of the input signals could be separated into two halves for power generation and data processing to really get wireless energies in ES. The message y_{RE} (equation (8)) received at the interface of an energy recovery recipient is written by depending just on power generation equipped receivers. Communication and noise interruptions occurred while transmitting the data from the source node.

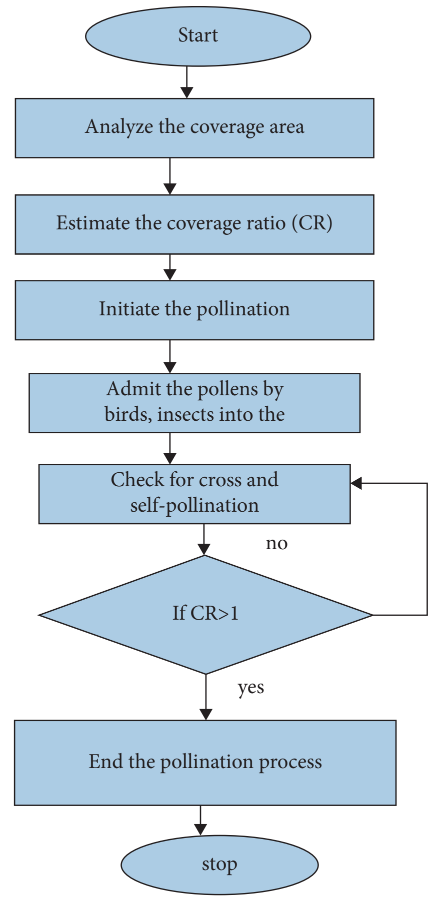

Figure 2: Flow diagram of improved binary flower pollination algorithm.

$$y_{\mathrm{RE}} = \frac{1}{\sqrt{\mathrm{d}_1^m}} \sqrt{\beta P_s} h_s x_s + \sqrt{\beta n_R}, \tag{8}$$

wherein h_s is capable of transmitting power from source node, which signifies connection correlation among source and relay mobile node, whereas x signifies communication information from generator, and n_R signifies the overall additive white Gaussian noise (AWGN) presented just at transmission mobile node by the receiving antenna and signal band conversion. T denotes the buffer time during which data are communicated from AP to the departure point member nodes, and $0 < \infty < 1$ signifies the small percentage of the time duration switching wherein the first part of time $\propto T$ can be used for harvesting energy and information transfer between the AP and the relay mobile node in the TSM protocol. The value P indicates the percentage of the energy splitting ratio in an energy recovery system; the recovery system plays a very important role in every sensor network. Due to this, active and inactive nodes are calibrated. Based on these measurements, the sensor nodes that are not functioning can be restored to the old state through the recovery system, wherein TSM separates this same strength of the receiver end into 2 components, notably, βP and $(1 - \beta)P$, only with aforementioned to be used for power generation but the latter used for source to redirect data communication, and αT signifies a time swapping ratio of the receiver end at the router mobile base station *f*. There are two different nodes available. They are the following:

(i) Leader Node: a node that performs monitoring and management tasks of all sensor nodes present in a cluster module

(ii) Edge Node: a node used to send information from one cluster module to another cluster module

4.3. Device-to-Device Communication. The adequate capacity of the battery inside is to retransmit input and output energy obtained and quasigathered (TX/RX) networks SINR inside the "i"th D2D duplex, typically recycles the available bandwidth of the "j" th mobile terminal. The secondary users are dependent on the on and off duration of the channel left by primary users, which is given as T (off) and T (on); i.e., the spectrum of primary users is in off state, but it is not used by secondary users at the time $T(i)$, and hence, the latency rate of average channel switching rate is given as follows:

$$\mathrm{Avg}\,(\mathrm{sec}-\mathrm{users}) = \frac{1}{N}\sum_{i}^{n}[T\,(\mathrm{off})\,(i) - T\,(\mathrm{idle}\,(i) + T\,(i)]. \tag{9}$$

To optimize the idle channel fading time and to minimize the number of channel switching rates and its delay, considering the idle time $p_{\mathrm{idle}}\ (t)$, which indicates the probability that the channel I should be idle at a time period between "t" and $T\mathrm{off}(i)$, the idle duration of the channel, the channel sequencing method is opted here, where the channels that are arranged in the ascending order of both $p_{\mathrm{idle}}\ (t)$ and $T\mathrm{off}(i)$ are sensed. If no idle channel is found in a complete search of $(N-1)$ channels, it is significant to go for another search ith limited time to get no idle channels. Let us represent the input of the optimal classifier as follows:

$$\mathrm{OC} = [\alpha, \beta], \tag{10}$$

where equation 10 denotes the expected output, which gives the categories that can be both populated and vacant. Through spectrum access, the user is assigned to vacant areas in order to maintain contact while leaving the inhabited channels available. This ensures that overall transmission quality also is not harmed. The interference's impacts are reduced not producing any issues for the PUs or licensed users. This probabilistic system relies on the likelihood function, which would be calculated using the certainty, a category antecedent possibility, and the category prior possibility. As a result, the likelihood measurement would be as follows:

$$\mathrm{Post} = \mathrm{arxmax}\,P\,(cr)\prod_{v=1}^{y} p\left(\frac{fv}{cr}\right). \tag{11}$$

Thus, the likelihood of the rth category equals $P(cr)$ and the likelihood of the vth transmission features in reference to the rth category is $P\ (fv/cr)$. Throughout this work, s has been set to 2 since the wavelength is divided into two classifications: occupied versus unoccupied. Having respect to the input, the likelihood of the vth confidence level has been determined as follows:

$$P\left(\frac{fv}{cr}\right) = \frac{1}{\sqrt{2\pi\mu^2}}^{e\left(\frac{fv}{2\alpha 2}\right)}, \tag{12}$$

wherein $\sigma^2 r$ denotes the average variability of the signal's y properties and μr denotes the overall median of both the transmitter y characteristics. The proposed model optimally allots the resource consumption information analysis. This includes the energy and power consumption allotments. Hence, the sensor nodes in the route have the minimum and maximum energy values. So, the proposed model saves the energy and utilizes the limited energy to transmit the information. Hence, the proposed model achieved high energy efficiency.

4.4. Shortest Path Achievement. Inside a multichannel context, the main controller transmits alert messages and information arbitrator messages, whereas this utility stream interacts with actual information. Whenever an incident happens, only those nodes react towards the communication link, and returns are generated and sent through the control channel depending on the data type relevance. The router assesses the overall relevance even during the data period of negotiating process and thereafter connects it all to the procedure channel allocation attributes. This information renegotiation signal reflects the type of the distribution hub specified either by sender or even the predicted duration of information transfer. After that, the transmitter shifts towards the consumer and service channel and waits therefore for recipient to deliver the accessible (AV) signal. It changes towards the communication system and then transmits the readied (RD) signalling if indeed the route is accessible upon that receiver station. Once receiving the prepared indication, the broadcaster begins communication, and then, after analyzing all the data, the recipient transmits the acceptance across the host controller, causing all stations to alter their respective internal databases. Every system keeps internal tables including information about its surroundings and a connection list. This channel database offers data on broadcast channels and streams, which have been marked as being occupied for such an extended period, and formerly utilized connections. The least load-free frequency path is allocated as that of the delivery channel for settlement. These receivers reply with such a rejection response and also the spectrum availability information after a slot if the desired station is not really reachable to the recipient. The broadcaster changes towards the next effective communication system and starts sending whenever it hears this. All those other nodes' spare route lists have been refreshed.

Assume a route, namely, $T_k = a_0, a_1, a_2, \ldots, a_d,$ where a_0 indicates the source node and a_d indicates the destination node. The notation "h" can be included to evaluate the hop count between transmitter and receiver nodes. The notation

"$r(a_i)$" indicates the remaining energy (REM_ENER) with averaging mode (AVG_MODE). To calculate the route "R," the following equations can be used:

$$\text{REM\_ENER} = \frac{(\min r\,(ai))}{h}, \tag{13}$$

$$\text{AVG\_MODE} = \frac{(\min r\,(ai))}{h}. \tag{14}$$

The following equations help to find the optimal route $O_{r.}$ Considering the path with minimal remaining energy and maximal threshold value, there is a possibility of calibrating AVG_MODE and the threshold (TH).

$$Kr = \max\left(\text{AVG\_MODE}\, r\,(ai) - \text{TH}\right). \tag{15}$$

If not the above condition applies, the REM_ENER will be progressed as shown in the following equations:

$$\text{Kr} = \max\left(\text{REM\_ENER}\, r\,(ai) - \text{TH}\right), \tag{16}$$

where "A" is all routes (sets) and "TH" is a preset energy threshold.

4.4.1. Algorithm for Intermediate Nodes

(i) Initially find the RREQ's realness with referring source and broadcast id

(ii) Check whether it coincides with the appropriate sequence number followed by updating REM, TRE, and RREQ field

  (a) REM = min(inter_res_ener, REM_rx)
  (b) TRE = (inter_res_ener + REM_rx)

(iii) Else remove RREQ

4.4.2. Algorithm for Destination Nodes

(i) Initially find the RREQ's realness with referring source and broadcast id

(ii) 2.If the solution is yes, then put in table

(iii) If not, wait for some time (wait_time)

(iv) If "wait_time" has not expired, it locates the proper value and compares it to the prestored rate; if the new value is larger or equal to the predefined value with a reduced hop count, it replaces the old value or throws away the fresh RREQ

(v) The above steps will progress, till it reaches wait time

(vi) Once the holding period has expired, the RREP packet will be sent directly to the origin through the route with the highest value

A lesser value option may result in a strategy that includes minimum energy node in the route, causing rapid energy exhaustion, which results in frequent link failure. Having a higher value threshold could result in less-than-optimal route selection of network performance. As a result, choosing the right threshold value is crucial for performance improvement. To determine the best threshold value, we ran simulations on our proposed approach, adjusting "TH" from 0% to 100% to evaluate the lifespan of network and load distribution.

5. Results and Discussion

The experimental result is carried out by analyzing the parameters such as energy efficiency, lifetime, outage probability vs. transmission block time, spectral efficiency vs. number of CHs, and energy harvested vs. transmission block time. These parameters are compared with three state-of-art methods such as binary flower pollination (BFP) algorithm, time division multiple access (TDMA), and data-driven technique (DDT) with the proposed optimal cluster lifetime-aware leisure degree adaptive routing protocol (OptCH_L-LDAR).

Figure 3 shows the comparison of energy efficiency between existing BPF, TDMA, and DDT methods and proposed OptCH_L-LDAR methods, where X-axis indicates the altitude with relay node as 50 and Y-axis indicates the energy efficiency in percentage for analysis. When compared, existing BPF, TDMA, and DDT methods achieve 74%, 85%, and 87%, while the proposed OptCH_L-LDAR method achieves 96%, which is 26% better than BPF, 10% better than TDMA, and 9% better than DDT.

The network lifetime is evaluated by the signals successfully completed duration of communication from the source to the destination. It depends on the source and sink sensor nodes.

Figure 4 shows the comparison of lifetime between existing BPF, TDMA, and DDT methods and proposed OptCH_L-LDAR method, where X-axis indicates the number of nodes and Y-axis indicates the lifetime in percentage for analysis. When compared, existing BPF, TDMA, and DDT methods achieve 67%, 74%, and 75%, while the proposed OptCH_L-LDAR method achieves 89%, which is 22% better than BPF, 14% better than TDMA, and 14% better than DDT.

The outage probability calculation is important while computing the transmission rate. In the sink node, the evaluation is started before sending the acknowledgement. The sink node computes the outage probability, while the received rate of information under the threshold level of information is transmitted by the source node.

$$P_o = P\,(\text{RR} < \text{TR}), \tag{17}$$

where P_o = outage probability, RR = information received rate, and TR = information transmission rate.

Figure 5 shows the comparison of outage probability between existing BPF, TDMA, and DDT methods and proposed OptCH_L-LDAR method, where X-axis indicates seconds and Y-axis indicates the lifetime in percentage for analysis. When compared, existing BPF, TDMA, and DDT methods achieve 89%, 86%, and 79%, while the proposed OptCH_L-LDAR method achieves 97%, which is 9% better than BPF, 11% better than TDMA, and 18% better than DDT.

The spectral efficiency of the sensor nodes is defined as the transmission and receiving capacity between the need-

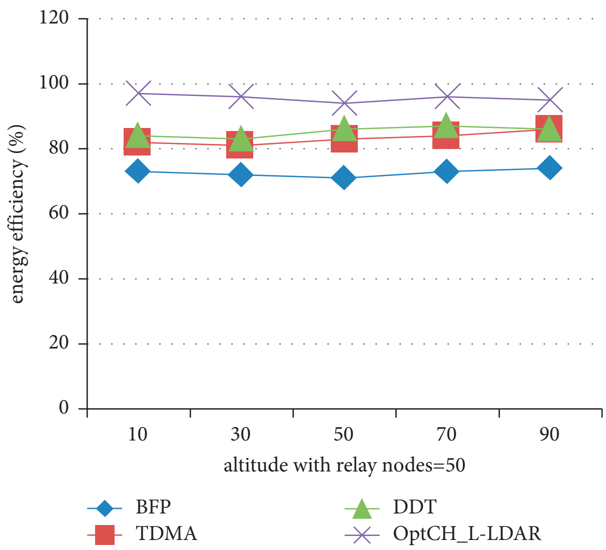

Figure 3: Comparison of energy efficiency.

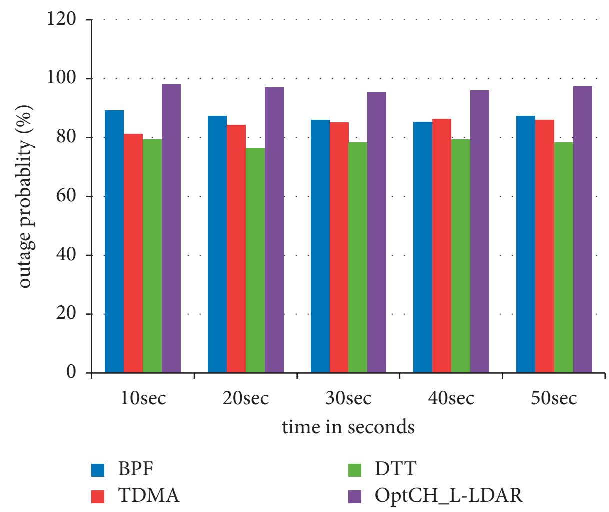

Figure 5: Comparison of outage probability.

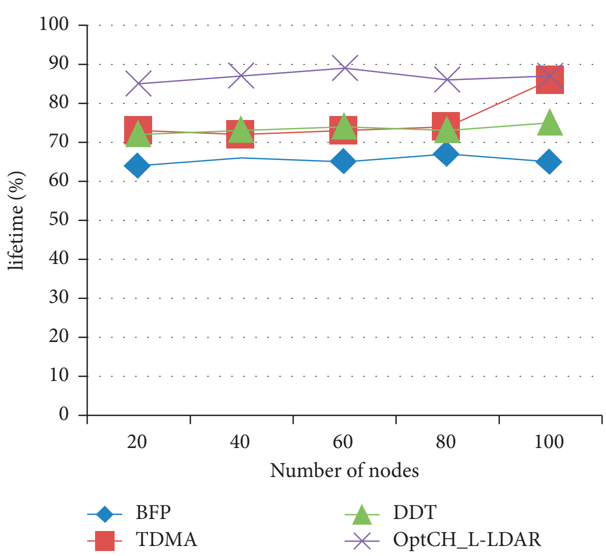

Figure 4: Comparison of lifetime.

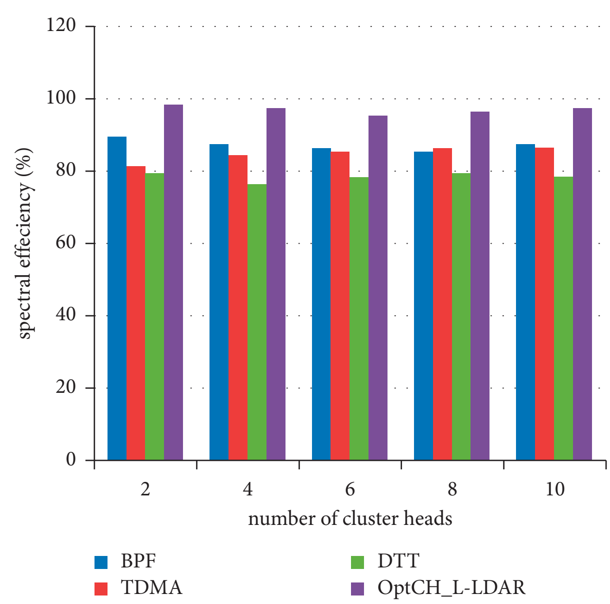

Figure 6: Comparison of spectral efficiency.

to-end sensor nodes and the route nodes. This is very useful to estimate the network capacity.

Figure 6 shows the comparison of spectral efficiency between existing BPF, TDMA, and DDT methods and proposed OptCH_L-LDAR method, where X-axis indicates the number of cluster heads and Y-axis indicates the lifetime in percentage for analysis. When compared, existing BPF, TDMA, and DDT methods achieve 89%, 86%, and 79%, while the proposed OptCH_L-LDAR method achieves 98%, which is 9% better than BPF, 11% better than TDMA, and 18% better than DDT.

In a cutoff range, the proposed model achieved 96% of energy efficiency, 89% of network lifetime, 97% of outage probability, and 98% of spectral efficiency, while compared with other existing models the proposed model achieved better results.

6. Conclusion

The public safety network and D2D communications were explored in this study. We have covered the basics of RF-based EH, including its applications and possible benefits in this field. In catastrophe and emergency scenarios, we have presented a novel architecture for a durable network. The goal was to provide the best communication route for disaster-stricken networks, minimizing end-to-end disconnection and allowing connections from functional to nonfunctional locations. The proposed method was found to save significant energy for both UE nodes and clustering heads, allowing them to survive in crucial conditions such as disasters. Furthermore, our suggested solution adds a new step to the provisioning phase for network survivability in the event of a network breakdown and can be implemented in stages. It can also be used in conjunction with other protection and restoration measures to improve network resiliency and link connectivity after a disaster. Extension of results for the uplink, where nodes are not necessarily interested in the same content, and deeper joint power optimization for the multicarrier relay network are two future research objectives. In future, the proposed model was enhanced in the aspects of bandwidth optimization, increasing the communication speed, reducing the number of nodes, end-to-end delay between the sources and sink nodes, and throughput optimization.

Data Availability

The data used to support the findings of this study are included in the article. Should further data or information be required, these are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

References

[1] A. Adeel, M. Gogate, S. Farooq et al., "A survey on the role of wireless sensor networks and IoT in disaster management," in *Geological Disaster Monitoring Based on Sensor Networks*, pp. 57–66, Springer, Singapore, 2019.

[2] M. Biabani, H. Fotouhi, and N. Yazdani, "An energy-efficient evolutionary clustering technique for disaster management in IoT networks," *Sensors*, vol. 20, no. 9, p. 2647, 2020.

[3] U. Palani, G. Amuthavalli, and V. Alamelumangai, "Secure and load-balanced routing protocol in wireless sensor network or disaster management," *IET Information Security*, vol. 14, no. 5, pp. 513–520, 2020.

[4] J. Logeshwaran and R. N. Shanmugasundaram, "Enhancements of resource management for device to device (D2D) communication: a review," in *Proceedings of the 2019 Third International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC)*, pp. 51–55, Palladam, India, December 2019.

[5] M. Yu, C. Yang, and Y. Li, "Big data in natural disaster management: a review," *Geosciences*, vol. 8, no. 5, p. 165, 2018.

[6] J. Swetina, G. Lu, P. Jacobs, F. Ennesser, and J. Song, "Toward a standardized common M2M service layer platform: introduction to oneM2M," *IEEE Wireless Communications*, vol. 21, no. 3, pp. 20–26, 2014.

[7] M. Lin, J. Ouyang, and W. P. Zhu, "Joint beamforming and power control for device-to-device communications underlaying cellular networks," *IEEE Journal on Selected Areas in Communications*, vol. 34, no. 1, pp. 138–150, 2016.

[8] S. T. Shah, J. Gu, S. F. Hasan, and M. Y. Chung, "SC-FDMA-based resource allocation and power control scheme for D2D communication using LTE-A uplink resource," *EURASIP Journal on Wireless Communications and Networking*, vol. 1, pp. 1–15, 2015.

[9] X. Lin, R. Ratasuk, A. Ghosh, and J. G. Andrews, "Modeling, analysis, and optimization of multicast device-to-device transmissions," *IEEE Transactions on Wireless Communications*, vol. 13, no. 8, pp. 4346–4359, 2014.

[10] J. Logeshwaran, M. J. Rex, T. Kiruthiga, and V. A. Rajan, "FPSMM: fuzzy probabilistic based semi morkov model among the sensor nodes for realtime applications," in *Proceedings of the 2017 International Conference on Intelligent Sustainable Systems (ICISS)*, pp. 442–446, Palladam, India, December 2017.

[11] A. S. Nandan, S. Singh, A. Malik, and R. Kumar, "A green data collection & transmission method for IoT-based WSN in disaster management," *IEEE Sensors Journal*, vol. 21, no. 22, Article ID 25912, 2021.

[12] R. Raheem, A. Lasebase, and J. Loo, "Performance evaluation of LTE networking via using fixed/mobile femtocells," in *Proceedings of the 28th International Conference on Advanced Information Networking and Applications Workshops*, Victoria, Canada, May 2014.

[13] A. Masaracchia, L. D. Nguyen, T. Q. Duong, and M. N. Nguyen, "An energy-efficient clustering and routing framework for disaster relief network," *IEEE Access*, vol. 7, Article ID 56520, 2019.

[14] K. Ali, H. X. Nguyen, Q. T. Vien, P. Shah, and Z. Chu, "Disaster management using D2D communication with power transfer and clustering techniques," *IEEE Access*, vol. 6, Article ID 14643, 2018.

[15] M. S. Khan, S. Jangsher, M. Aloqaily, Y. Jararweh, and T. Baker, "Eps-tra: energy efficient peer selection and time switching ratio allocation for swipt-enabled d2d communication," *IEEE Transactions on Sustainable Computing*, vol. 5, no. 3, pp. 428–437, 2020.

[16] X. Wang, T. M. Choi, H. Liu, and X. Yue, "A novel hybrid ant colony optimization algorithm for emergency transportation problems during post-disaster scenarios," *IEEE Transactions on Systems, Man, and Cybernetics: Systems*, vol. 48, no. 4, pp. 545–556, 2018.

[17] F. Wang, Z. Pei, L. Dong, and J. Ma, "Emergency resource allocation for multi-period post-disaster using multi-objective cellular genetic algorithm," *IEEE Access*, vol. 8, Article ID 82255, 2020.

[18] S. Raja, A. J. Rajan, V. P. Kumar et al., "Selection of Additive Manufacturing Machine Using Analytical Hierarchy Process," *Scientific Programming*, vol. 2022, Article ID 1596590, 20 pages, 2022.

[19] S. Raja and A. J. Rajan, "A Decision-Making Model for Selection of the Suitable FDM Machine Using Fuzzy TOPSIS," *Mathematical Problems in Engineering*, vol. 2022, Article ID 7653292, 15 pages, 2022.

[20] X. Yu, C. Li, and G. G. Yen, "A knee-guided differential evolution algorithm for unmanned aerial vehicle path planning in disaster management," *Applied Soft Computing*, vol. 98, Article ID 106857, 2021.

[21] X. Niu, H. Tang, and L. Wu, "Satellite scheduling of large areal tasks for rapid response to natural disaster using a multi-objective genetic algorithm," *International Journal of Disaster Risk Reduction*, vol. 28, pp. 813–825, 2018.

[22] S. Venkatasubramanian, S. Raja, V. Sumanth et al., "Fault Diagnosis Using Data Fusion with Ensemble Deep Learning

Technique in IIoT," *Mathematical Problems in Engineering*, vol. 2022, Article ID 1682874, 8 pages, 2022.

[23] T. Kiruthuiga and R. N. Shanmugasundaram, "Network data aggregation for wireless sensor networks: a survey. Computer networks, big data and IoT," *Lecture Notes on Data Engineering and communications Technologies*, vol. 66, no. 68, pp. 887–905, 2021.

[24] E. Yousefpoor, H. Barati, and A. Barati, "A hierarchical secure data aggregation method using the dragonfly algorithm in wireless sensor networks," *Peer-to-Peer Networking and Applications*, vol. 14, no. 4, pp. 1917–1942, 2021.

[25] J. Logeshwaran, M. Ramkumar, T. Kiruthiga, and R. Sharan Pravin, "Svpa - the segmentation based visual processing algorithm (SVPA) for illustration enhancements in digital video processing (DVP)," *ICTACT Journal on Image and Video Processing*, vol. 12, no. 3, pp. 2669–2673, 2022.