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HYBRID PARTICLE SWARM OPTIMIZATION WITH GENETIC ALGORITHM FOR CLUSTER HEAD SELECTION ALGORITHM IN MANET

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Abstract –

Mobile Ad-hoc Network have various techniques for improving the energy efficiency of routing between the mobile nodes. These modules are interconnected via wireless links. The mobility and limiting battery life of MANETs are the crucial aspects. Advanced strategies for increasing MANET energy efficiency and network lifespan are necessary. Clustering is a tried-and-true technique for prolonging the life of a network by reducing and balancing energy consumption. The network's energy performance is improved even more by selecting an appropriate cluster head from the cluster. Cluster heads (CHs) require more energy than non-cluster heads due to the additional responsibilities, Cluster heads (CHs) need more energy than non cluster heads. To increase the MANET network's energy efficiency and lifetime, a new technique for CH selection using a Hybrid Particle Swarm Optimization-Genetic Algorithm (PSO-GA) is proposed. Its an another approach of Hybrid Particle Swarm Optimization-Differential Evolution (PSO-DE). The proposed method is implemented using the NS-3 platform for the analysis. The Hybrid PSO-GA strategy is more efficient than the other methods, according to the evaluation.

Index Terms – Mobile Ad-hoc Network, Clustering, Soft k-Means, Cluster Head Selection, PSO-GA Optimization Algorithm.

1. INTRODUCTION

An ad hoc mobile network generally presents several challenges, such as a highly dynamic topology, packet loss, and frequent route detection, resulting in poor performance and a reduced packet delivery rate. To reduce the number of route discovery processes, multipath routing protocols use alternate routes to continue the transmission of packets. Ad Hoc Ondemand, Multipath Distance Vector Routing Protocol, or AOMDV, is one of the more popular multipath protocols that forwards hop count metrics to route packets. However, keeping active routes separate can shorten the lifespan of the nodes and generate more control messages, such as errors and packet sniffing. MANETs are network-based architectures made up of communication devices such as cell phones and laptop computers. MANET communication is decentralized, with connected devices communicating through a point-to-point strategy.

Ad hoc networks are critical during various emergency or relief operations when the existing network infrastructure fails and relief workers need a rapid deployment mechanism that requires less effort and time. MANETs are also used in situations where terrestrial networks are inconvenient, such as B. Military surveillance, medical attention, tracking of endangered species, environmental surveillance, disaster relief, etc. [1]. Each node in a MANET functions as a router and host. The nodes must work together on routing, packet forwarding, and the reliable MANET data transfer process. The MANET routing process is a complicated task due to the mobility of the nodes, which often leads to topology changes [2]. Therefore, MANETs require reliable routing for the best performance. In general, reactive, proactive, and hybrid [3] are the Routing protocols of MANETs fall into three categories. better coverage, lower operating costs, and greater flexibility offered by MANET architecture.

One of the most serious threats MANETs still face is security. MANET's main security challenges are integrity, confidentiality, authentication, and non-repudiation. Several studies have been conducted on security problems and solutions in MANET.

The biggest challenge for MANET is dealing with routing problems caused by node mobility [4]. A mobile ad hoc network, or MANET, is a wireless communication network made up of mobile nodes that cooperate to deliver packets. It presents several challenges, such as a highly dynamic topology, frequent changes in node movements, low throughput capacity, and limited performance and bandwidth. In such network scenarios, it is very important to manage packet routing effectively with a minimum of time and effort. Therefore, the routing protocol must adapt as quickly as possible to frequent topological changes. On-demand routing protocols provide the ability to discover and manage a route when required. Several reactive protocols have been proposed and implemented, including dynamic source routing (DSR) and ad hoc distance-on-demand vector (AODV) [4]. The most common reactive routing protocol for MANET is the AODV. Although AODV offers good performance and latency in small networks, as the size of the network increases, it causes high overhead, which can lead to deterioration in protocol performance[5].

Node movement changes the network topology, resulting in broken, unstable and unreliable communication links, increasing the possibility of packet loss and forcing a CH (cluster head) to retransmit data, affecting energy efficiency from the network[6]. We need an optimized routing algorithm that addresses the mobility, topology, and relay issues of MANET nodes. Cluster-based routing is a proven technique for more efficient and effective routing in MANET. Cluster-based approaches are used to balance network power and extend its life while reducing communication overhead. There are several algorithms available for the development of clusters and cluster heads [7].

A clustering algorithm groups nodes into a cluster. Each node in the cluster group belongs exclusively to the single identified cluster. Each MANET node acts as a router and sends a "Hello" message with its ID [8]. There are two types of clustering: safe grouping and insecure grouping. The secure pool is divided into three subcategories: hybrid schemes, trust-based schemes, and crypto-based schemes. The six types of unsafe clustering approaches are flood-based, weight-based, channel-based, connectivity-based, low-maintenance, and mobility-based. The cluster approach contributes to the longevity and energy efficiency of the network [8].

Clustering involves the selection of group heads (CH) for each group. The CH (Cluster Head) is selected based on a number of variables and factors, including the mobility and density of the nodes. The role of CH is to provide communication between clusters and coordination between nodes. CH will also be responsible for the maintenance of the cluster members, the collection and aggregation of data from the mobile nodes, the maintenance of the details of the topology, the allocation of resources, the routing and the transmission of packets [9]. In addition, the cluster administrator also acts as a local coordinator and manages the IDS to monitor various functions and attacks [10]. The CH selection algorithms have five types are introduced and categorized. They are based on mobility, identifiers, connectivity, performance and costs. In the efficient energy pooling approach, CH is selected because of its lower mobility and higher energy. After selecting CH, an energy efficient path for data transmission is also selected [11].

The main issues MANETs face are energy efficiency and mobility awareness. Due to lack of mobility, MANET nodes have the potential to move in the wrong direction. This process reduces the battery capacity of the node and affects the overall network topology. The CH node consumes most of its power due to node mobility and MANET topological change problems. Therefore, the selection of energy efficient CHs is required to address the grid problem.

The contribution of this post is to create an efficient power grouping scheme for MANET and combine this with a hybrid approach to choose the best node as CH. The proposed methodology consists of several mobile nodes responsible for routing. The soft kmeans method is used to generate clusters and the PSOGA hybrid approach to CH selection is developed by MANET.

The main contribution of the work is:

- Development of an energy efficient CH selection algorithm to improve the overall performance and service life of MANET.
- Efficient clustering through soft K stands for fuzzy clustering algorithm, which aims to improve the effectiveness of CH selection algorithms in energy efficient CH selection process.
- A hybrid PSOGA approach is used to select the best node as CH for MANET.

The rest of this process is as follows. Section 2 describes the associated work and the problem.. Section 3 describes the Overview of AOMDV Routing Protocol. The proposed methodology for the selection of CH is described in section 4. Section 5 contains the results and discussion of the proposed work after it has been validated in NS3. Finally, the conclusion in Section 6.

2. RELATED WORKS

In this part, we will review some of the research that has been done to date on energy efficient cluster-based routing.

2.1 Ad Hoc Ondemand, Multipath Distance Vector Routing Protocol:

Several studies have been conducted to reduce link failures of the AOMDV protocol.

Gupta and Prasad [13] presented a mechanism for congestion management in the AOMDV protocol. They suggested dynamic queues to reduce overhead and congestion on the network. First, the sender receives all the information from the intermediate nodes(queue size, data rate, etc.) on routes from source to destination. A commit packet is used to indicate the capacity of the intermediate nodes. If the load is not balanced, the source node changes the speed of each path and estimates the load. Simulation results show reduced delay and less administrative burden.

2.2 Network life time and Energy based reduction.

Aqeel et al. [14], proposed an energy efficient optimized AOMDV Routing protocol which could consider energy conservation using using Particle Swarm Optimization (PSO). A fitness function is used to find the optimal path from source node to destination node to decrease the energy consumption in multipath routing. The distance of this route will be considered, the optimum route refers to the route that has the highest energy level and the less distance. Whenever an intermediate node receives a path response packet, it calculates its remaining energy and adds it to the energy field in the path response packet. If the sender receives multiple replies, he chooses the path with the highest average power value per hop. Simulation results show a better performance in terms of delivery rate, end delay, and throughput.

Sriparna Saha et al.,[15] proposed to find membership values of each point with respect to different cluster centers, minimum symmetrical distance of that point with respect to all clusters has to be calculated. For this purpose, the Kd-tree based nearest neighbor search is used. The process of fitness computation, Pbest and Gbest calculations, update of velocity and position of the particles is executed for constant number of iterations. Differential evolution (DE) is a meta-heuristic technique to optimize real-life functions. The idea behind the DE-based clustering technique is as follows: Initial cluster centers are some randomly selected data points from the dataset and those are encoded as cluster centers in the vector.

Kaur and Singh et al. [16] present a comparative analysis of the EAOMDV protocol with the MCAOMDV protocol using Multi criteria Multipath Routing [15]. Remaining node power and distance is taken into account while creating multiple paths from source to destination to save power consumption on ad hoc mobile networks.

Choukri.A et al. [17], Energy consumption in wireless sensor networks (WSN) and various works were presented to improve the useful life of the networks. WSN consists of a very small device that is used to collect information. In most cases, these networks are in hard-to-reach areas where it is difficult to charge and replace the battery of the nodes, so conserving power from the WSN node is critical. Various routing approaches have been proposed to extend the life of the network. The authors demonstrated that the ARTLEACH protocol could improve power consumption and extend the life of the network by 40% compared to the LEACH and IBLEACH protocol. Therefore, a new approach was proposed in which the authors transfer and select the CH (Cluster Head). The simulation results showed that the proposed approach reduces power consumption and extends the life of the network.

2.3 Clustering based energy minimization :

To replace expensive direct connections for routing between CHs along with unsecured coverage, Syed Zohaib Hussain Zahidi et al. [17] developed an improved ILP formulation. Here, multi-hop links replaced expensive direct links and coverage restrictions to restrict nodes were within each other's radius. The choice of the most appropriate node as CH was a critical point in this scheme. Improving the life of the network was the main objective considered in this scheme. The improved formulation of ILP solved the clustering problems in MANET with the topological design. For a small network, the generation of complex network solutions was made possible by these improved formulations. The time it takes for this algorithm to produce a given result does not meet the strict requirements of the practical environment. Also, this model's serious attempt to provide an inexpensive and pervasive data link has come at the expense of the model's shortened lifespan, making it an unsuitable choice.

To reduce data replication in MANET during transmission in CH, Daichi Amagata et al. [18] proposed the CTR model, which uses Topk's efficient cluster query routing. According to the implemented framework, Cluster Heads (CHs) were selected from nodes that have high-level data items, and Topk requests were forwarded between CHs through gateway nodes that belong to multiple clusters. . The authors then improved the CTR framework by incorporating a data de-replication methodology using the CTR2 framework. CTR2 performance has been improved when restoring Topk logs from neighboring nodes. Extensive testing has shown that the proposed systems perform admirably in terms of accuracy of query results, traffic, and delay. The model helped reduce network data replication problems. However, due to the high power demand due to the transmission of additional requests from the cluster headers, the service life of the network was affected.

Naghma Khatoon and Amritanjali presented a SMWCA (Stability-Based Multimetric Weighted Clustering Algorithm) for MANET [19]. When choosing a CH, the focus was on individual parameters and total weight. In this proposed scheme, a non-periodic regrouping procedure was used when the current dominance set of the CH did not cover the nodes of the network. The selection criteria process prevented the lower nodes from participating in the Swiss electoral process. The proposed plan provided longer network life and reduced redundant computing and communications. The work had focused on the homogeneous network; therefore, the mobility of the node is zero.
Additionally, the regrouping process of this model causes a delay in data transfer and could result in further data loss.

Amutha S. et al. [20] introduced a cluster manager-based CH selection scheme (CMBCH) to eliminate CH workload leverage and power issues. CM and CH were the two limitations used in the proposed method. The activities of the nodes were observed and controlled by the CM. In the network, the transmission of packets between the nodes was carried out by the CH. If the current CH energy level was depleted, the CM would select the equivalent node with the maximum energy level and past CH activities and then save the data at the same time. Thanks to stable routing, the CMBCH offers low bandwidth, low power, and reliable performance. The use of additional loads (mechanisms) places a significant load on the network and the bandwidth of this model is also low, which creates a problem with PDR.

3. AOMDV Routing Protocol Overview

AOMDV "Ad Hoc Ondemand, Multipath Distance Vector Routing Protocol" is a special routing protocol that was developed for the MANET environment. The key concept of the AOMDV protocol is to calculate multiple paths without loops to switch to an alternate path if the main path of the destination node fails. AOMDV can use two approaches to find disjoint node or disjoint link paths [10]. A new route search process is not started until all disjoint routes have failed. On the disjoint node path, not all intermediate nodes immediately reject the RREQ path request that comes from the source node and arrives through another neighbor; the route is stored in the routing table of the intermediate node to mark a disjoint route of the node. However, these routing requirements are not propagated due to the fact that the transmission of more than one RREQ can result in more than one route traversing the same intermediate node.

When a routing reply RREP is received, the source node replies via the reverse disjoint path in its routing table. Note that node disjoint routes are stricter than link disjoint routes.

The link unbinding approach allows the computation of multiple routes passing through the same node, therefore common nodes can be established on routes from the source to the destination when an intermediate node receives an RREP from the destination and enters the source through the disjoint routes. of the link. your routing table responds. AOMDV uses the advertised hop count to ensure no routing loops are received. There are basically three basic procedures in the AOMDV routing protocol:

3.1 Send Route request

When a source has to deliver packets to a destination, it first checks to see if it has a valid route already existing in its routing table. If so, deliver the content directly. Otherwise, it buffers the current packets (packets are buffered "first in, first out" in a FIFO queue) and transfers them to the destination if a path is set [19]. After that, the source triggers a new route discovery process to find a route to the destination and follows the following main action rules:

• After sending a route request, a timer is set if the timer expires without a response of destiny. A new route discovery has process started.

• The source can retransmit RREQ packets a maximum number of times, after which the source will stop sending route requests to prevent the network overhead from increasing with endless transmission. Figure 1 shows the flood of RREQ packets on the network during route detection.

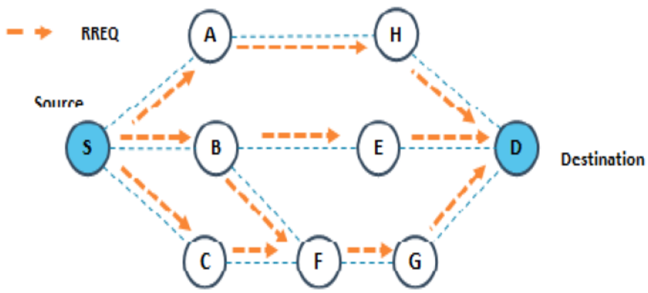


Figure 1. Route discovery packets flood in network.

The time to live (TTL) value is used to specify the maximum number of hops for packets to be forwarded. This value is set to a predefined value on the first transmission and increased to a higher value on second retransmissions (to avoid additional overhead). Retransmissions only occur if no responses are received.

3.2 Receive, Forward and Reply a Route Request

When a node receives an RREQ from an intermediate node, it checks if it is the first time it has received an RREQ from the source. If this is the case, forward this RREQ packet; otherwise, it stops propagation and discards the received RREQ packet. Second, the current node checks if it is the first node in the destination address, if so, it will set the RREQ first hop field by its address.

A new route entry is created if the source route entry does not exist. If the source sequence number of the received packet is greater than the source sequence number in the existing routing table, then the node updates the source sequence number in the routing table, removes all old routes that already exist , create a reverse route to the new one. fresh path and set hop - Count as the fixed maximum number of hops [20].

If the source sequence number of the received packet is the same as the sequence number in the existing routing table, then: The node checks if this new route already exists, if so, it updates the expiration time. If this route does not exist and it is a new disjoint route (there is no route with first hop as last hop for this route entry), the node only adds the new route to the routing table if there are not too many routes that already exist for this destination, and the new route is not much different in length from the existing routes. The packet is discarded if there is a route with the same first hop node and fewer hops than the received packet.

If the current node is the destination or has a valid route to it, it sends an RREP route reply; otherwise, the node forwards the RREQ packet. When the intermediate node receives the RREP, it adds the destination to its routing table and creates a reverse route to it. Figure 2 shows the flood of route response packets when building networks and routes.

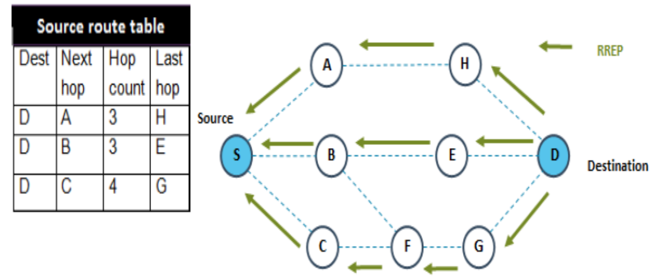


Figure 2. Route Reply flood in network and path establishment

3.3 Route Maintenance

To maintain a new state of disjoint routes, hello messages are periodically transmitted between neighbors. When these messages are received, the expiration time of the connection with the neighbors is extended. If no messages were received, these neighbors can no longer be reached and a connection error has probably occurred on the route between the source and the destination.

Various reasons can cause a link failure (network congestion, node mobility, or power failure, etc. A path maintenance procedure is initiated to recover from a link failure. Route maintenance consists of sending an RERR route error message back to the source node. The source node chooses a different child route for packet transmission. The best available route is selected from the alternative routes. If all alternate routes fail, the origin starts the route discovery process again. Figure 3 shows the REER flood in the network.

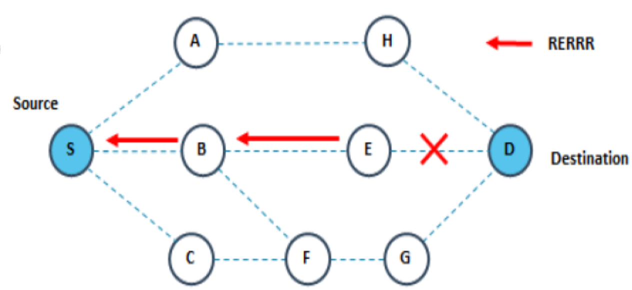


Figure 3. Route Reply flood in the network and path establishment

4 . Problem Statements and Motivation

The most serious problem ad hoc networks face is power consumption. Power usage and network life are closely related in ad hoc networks. Previous research has focused on improving network life, power consumption, general issues, etc. Neither method had provided a comprehensive solution to all the problems. Also, most low-power techniques use a large amount of CH, resulting in unreliable data delivery. Some works have reduced the number of channels, but the received signal strength is weak. So while each technique has an advantage, it also has a disadvantage.

However, the technologies introduced do not significantly improve the overall performance of MANET. We have focused on optimization techniques that provide a better solution to these problems in order to solve this problem. Optimized CH selection will solve the identified problem. A well-defined CH can be selected using various CH parameters such as nodal density, nodal mobility, nodal degree, energy level, position, etc. To ensure accessibility and reliability for the CH to aggregate data, the network is first divided into several groups that allow the optimized CH to identify relevant areas with high signal intensity.

5. PROPOSED METHODOLOGY

The schematic Diagram of Energy Efficient CH selection in MANET is shown in Figure 1.

A practical PSO-GA approach with Soft k-means clustering is employed in MANET to strengthen its energy efficiency. With the Support of the Soft-k means algorithm, the clustering process can be achieved Various parameters such as speed, position, and direction are taken into account to generate the cluster, and the minimization process helps estimate the center of the cluster. The Particle swarm optimization and genetic algorithm combination (GA) have been utilized to determine the Cluster Head (CH) depending upon the cluster formed. For the selection of CH, factors like energy, degree and mobility are estimated. Also estimate the position of the selected CH using the GA algorithm. After the selection process, the selected CH location is calculated using the cluster center based GA method. The placement process depends on the energy value of CH.

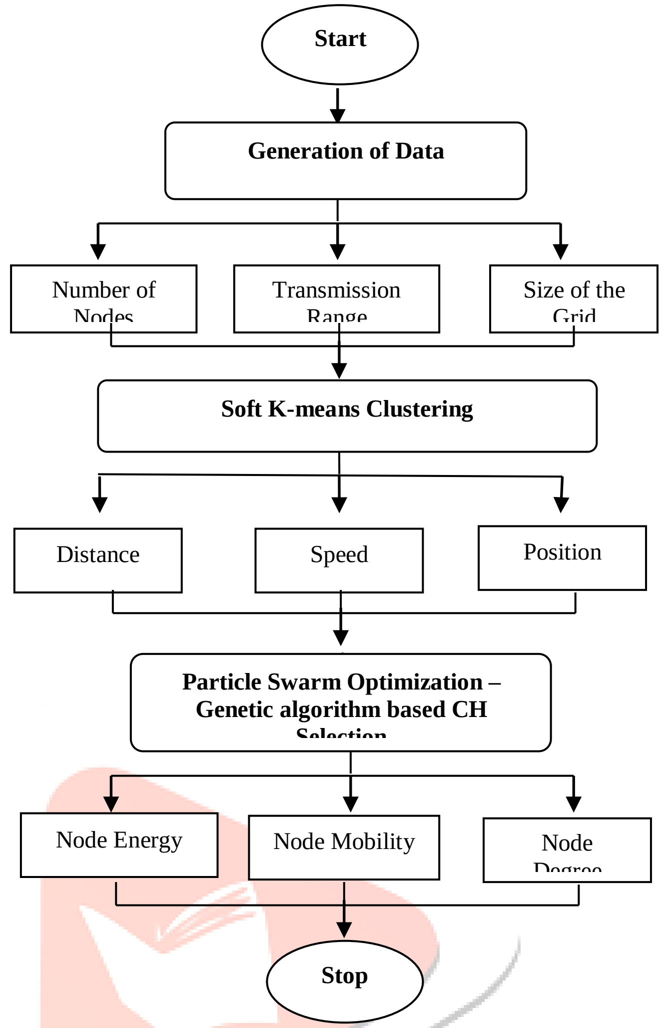


Figure 4 Schematic Diagram for Energy Efficient CH Selection in MANET

The proposed architecture model has three stages: data generation, soft k-mean Clustering, and a hybrid PSO-GA method for CH selection. The initial step is data generation, composed of determining the number of nodes, the range of transmission, and the grid's size. The second stage of Clustering is Soft k-mean based. For the Clustering process, factors like speed, distance, and position are considered. The Final Stage is Hybrid PSO-GA based CH Selection which used Node Energy, Node Mobility and Node Degree for selecting the CH.

5.1. Clustering Model of MANET

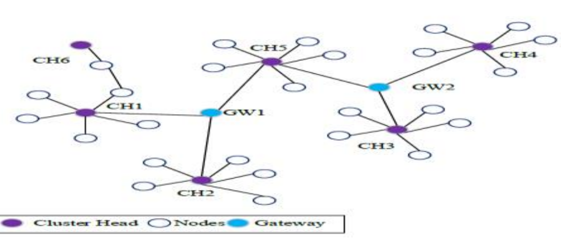


Figure 5 Clustering Model of MANET

The issue of mobility and limited battery lifetime is MANET's fundamental concern, and nodes of Ad-hoc networks have complete control over-processing. MANET Clustering Model represents in Figure5. Clustering consists of CH, Nodes, and Gateway. The communication process is done with the help of Gateway, and CHs. Each node is connected with their CH and each CH is connected with Gateway. The node which ensures parameters (Node Energy, Node Degree and Node Mobility) in an effective manner is considered as CH. After the selection of CH from clusters, a routing process occurred for data transmission.

5.2. Proposed Soft K-Mean Based Clustering

The Soft k-mean method is a fuzzy based clustering process, and clusters are created at the center. The traditional k-mean clustering process is inefficient because it causes overlapping issues between clusters. Hence, the Soft k-mean method is introduced. In this method, each node has various membership degree. The edge nodes of the cluster show a lower probability than nodes that are near the cluster center. Each node of Soft k-mean fit in to only one cluster. For the generation of Clustering, speed, position and distance are calculated. The membership degree has an essential role in the minimization process.

5.2.1. Generation of Cluster in MANET

The position of Cluster Members are represented by $N = \{n_1, n_2, \ldots, n_m\}$ in MANET, and these Cluster Members are grouped into *l* sets
$L = \{l1, l2 \ldots\ldots, li\}$.

The generation of Clustering in MANET is explained in equation (1)

$$G(N,D,S)=\sum_{s=1}^{i}\sum_{q=1}^{m} d_{sq}\left\|n_q-\gamma_s\right\|^2 \quad (1)$$

Where the speed between nodes (Cluster Member) are denoted by S (γ_s ; s =1,…., i) and the distance between nodes are represented by D(d_{sq} ; s=1, ….., i ; q = 1 ,…., m) .
The q^{th} membership degree to the *th s* cluster is described in equation (2)

$$\gamma_s=\frac{\sum_{q=1}^{h} d_{sq} n_q}{\sum_{q=1}^{h} d_{sq}} \quad (2)$$

Where α represents the degree value of each node. Effective Clustering is formed by minimizing the value of d_{sq} , and the process of minimization must satisfy the following three conditions.

a) The Cluster Member inside the MANET is assigned with a membership degree between zero and one.

$$d_{sq}\in[0,1],\quad s=1\ldots i,\quad q=1,\ldots,h. \quad (3)$$

b) The total value of all the membership degree for one Cluster Member must be one.

$$\sum_{s=1}^{i} d_{sq}=1,\quad q=1,\ldots,h. \quad (4)$$

c) There must be at least one Cluster Member who has a membership degree of non-zero value.

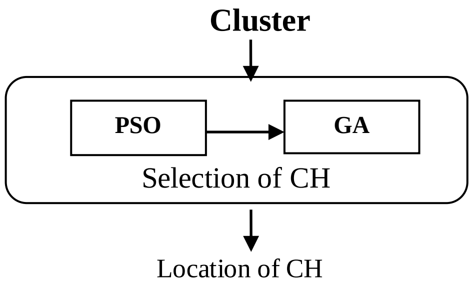
$$\sum_{q=1}^{h} d_{sq}>0,\quad s=1,\ldots,i. \quad (5)$$

After satisfying these conditions, the centres of clusters are estimated by equation (6).

$$d_{sq}=\frac{e^{-\alpha\left\|n_q-\gamma_s\right\|^2}}{\sum_{b=1}^{i} e^{-\alpha\left\|n_q-\gamma_s\right\|^2}} \quad (6)$$

The overall process of the proposed Soft k-mean algorithm is summarized as follows: The value of membership degree and the location of the center of the cluster is estimated by equation (2) and equation(6). The generation of Clustering stops if the direction and speed of Cluster Member are below the threshold value.

5.3. Selection of CH Using Effective PSO-GA Approach



One of the most popular meta-heuristic algorithms is PSO which resembles the flocking nature of birds. It is composed of a large number of particles. These particles are otherwise known as Agents. The population process of PSO is known as Swarm. The proposed method's primary goal is to develop energy-efficient CH selection for increasing the lifespan of MANET. Hence introducing a Hybrid PSO-GA approach for selecting the CH. The CH selection is made with the help of PSO, and the location of the selected CH is determined by GA algorithm.

Several factors are taken into account in the selection of CH, such as node mobility, energy value, and node degree. These parameters perform a significant impact on choosing the best node as CH. The workflow of Hybrid PSO-GA is shown in Figure 4.

The input of the PSO is clusters, which is formed with the help of the Soft k-mean method. After the formation clusters, the CH is selected with the help of the PSO algorithm, which depends on various factors like node mobility, node energy and node degree. Further, the location estimation to select CH using GA algorithm. The proposed Hybrid approach of PSO-GA gives energy-efficient CH, which increases the lifespan of MANET.

5.3.1. Selection Process of CH Using PSO

The generated Clusters are denoted by A_x, which is moving inside the Y dimension search area, and mobile nodes belong to N={ n1, n2,..., nm}. Each node N_n is employed to evaluate the fitness function. The fitness function is the sum of node features (energy, degree, and mobility). The position of each node in the search space is denoted by N_{ny} , and the velocity of each node is represented by VE_{ny} . The currently selected node is denoted by C_{sn}, and the neighboring node is represented by T_b.. Each node of MANET updates its velocity, mobility, energy, and degree values. This process is described in equation (7) and equation (8). Where the energy of node is represented by ε , mobility of node is denoted by *mo* .

The random numbers between zero and one are represented by ran1 and ran2. The flowchart of CH selection using PSO is given in Figure6. At the starting stage, the node's velocity and position are initialized, and then each node's fitness function is calculated. The currently selected node Csn and neighboring nodes are initialized. Further, updating the velocity and position of the nodes with respect to each iteration n. Then again, calculating the fitness value of the nodes. Whichever nodes satisfy the conditions, is selected as CH.

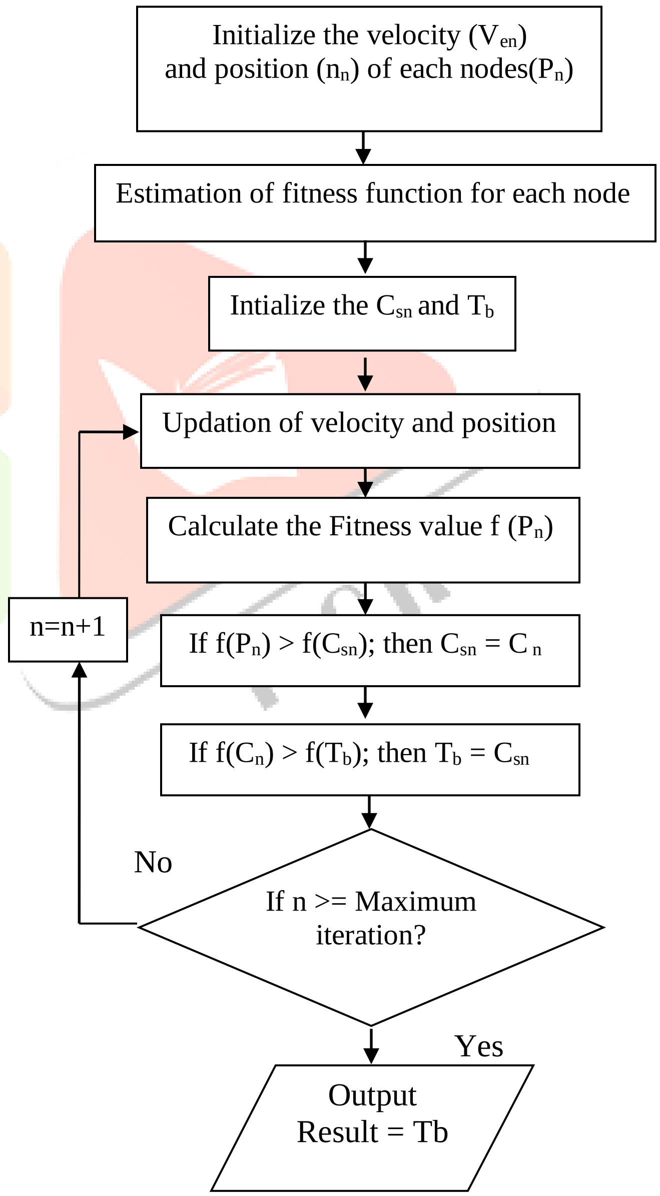


Figure 6 Flowchart of CH Selection Using PSO

5.3.2. Placement of CH Using GA

After the selection of CH, determining the location of CH using the GA Algorithm. Basically, the GA algorithm is utilized for producing high-quality solutions, and it is composed of three Stages-Selection, Crossover, and Mutation. The chromosomes is the initial stage of the generation. The fitness value estimation is based on the given problem. The Crossover stage is the second stage. During this stage, two parents exchange their genetic traits. The final step is Mutation which is used for increasing the gene value and diversity of offspring. The MANET nodes are represented using the GA chromosomes that are described as $X = \{ r_\varepsilon , r_\alpha , r_{mo} \}$ where X_N represents the placement of nodes inside the clusters. The energy, degree, and mobility are Regularity factors that's represented by r_ε , r_α *and* r_{mo} , respectively.

The three stages to estimate the position of the CH are the calculation of the initial position of the CHs. Estimating the energy value of selected CH and final stage is the Placement of CH based on lower energy consumption. During the first phase, the initial position of each desired CH is estimated using a fitness value of PSO. The energy value of the selected CH is calculated using the degree of nodal membership described in equation (2). After estimating CH's energy value, if the selected CH shows lower energy than the other neighboring nodes are placed in the middle of the corresponding MANET cluster.

Pseudocode 1 PSO-GA Algorithm

Step 1: Initialize the number of nodes in the network and the network area.
Step 2: Generate the velocity and position of nodes.
Step 3: For Maximum iteration condition is satisfied
//PSO for CH selection
Step 4: Calculate the fitness for each node
Step 5: Based on maximum fitness, calculate the velocity by equation (7)
Step 6: Evaluate the position of the node by equation (8)
Step 7: Update the node having the best velocity
//GA for relocate the CH
Step 8: Update the position of the node to the GA algorithm
Step 9: Generate fitness as maximum node energy, node degree, and minimized node mobility.
Step 10: Iteratively, every node the fitness is calculated.
Step 11: The best fitness evolving position of the node is Update.
Step 12: Relocate the CH to that position.
Step 13: Stop

Pseudocode 1 shows the Pseudocode for PSO-GA algorithm.

6. EXPERIMENTAL RESULTS AND DISCUSSION

NS-3 is used as a simulation tool in the research. In this work, Table 1 shows a summary of the parameters.

Parameters	Value
Area	1000m x 1000m
Number of nodes	500
Size of packets	512 bytes
The initial energy of nodes	0.65mJ
Simulation Time	500 sec
Value of iteration	100
Maximum Speed	20 m / s

Table 1 Simulation Parameters

6.1. Performance Metrics and Measures

For evaluating the proposed method's performance, the parameters

- Energy Consumption,
- End-to-End Delay,
- Throughput,
- Packet Delivery Ratio,
- Packet Loss Ratio,
- Network Lifetime are used.

6.1.1. Energy Consumption

It represents the total quantity of energy consumed by the nodes and the CH during successful communication.

$$E_C = \sum_{c=1}^{l} \left[CH_E(C) + \sum_{r=1}^{zc} H_E(zc) \right] \quad (9)$$

Where the overall energy consumption is denoted by EC , and the energy consumption of CH is indicated by CH_E *(C)*. The node energy consumption is indicated by S_E .

6.1.2. End- to -End Delay

The total amount of time required to transmit packets across the network.

$$End-to-End\ Delay = \sum_{e_g=1}^{e_{g\,max}} \frac{E(W_u, W_v)}{A} \quad (10)$$

Where the hop count of u^{th} *and* w^{th} nodes are represented by e_g . The speed of signal speed is denoted by *A*, The distance between u^{th} *and* v^{th} nodes are indicated by $E(W_u,W_v)$.

6.1.3. Throughput

It refers to the cumulative amount of information transmitted in a given period from source to destination.

$$Throughput = \frac{total\ number\ of\ delivered\ packets}{value\ of\ time\ taken} \quad (11)$$

6.1.4. Packet Delivery Ratio

The ratio of total packets arrived at the destination to the packets generated by the sensor node.

$$PDR = \frac{overall\ packets\ reached\ at\ destination}{total\ packets\ created\ at\ the\ sensor\ node} \times 100 \quad (12)$$

6.1.5. Packet Loss Ratio (PLR)

Total number of lost packets to the total packets transmitted from source to destination.

$$Packet\ Loss\ Ratio = \frac{total\ number\ of\ lose\ packets}{total\ number\ of\ packets\ transmitted} \times 100 \quad (13)$$

6.1.6. Network Lifetime

It is the value of time that is taken by the initial sensor in the network for running out of energy.

$$N_t = \min(N_{ts}) \quad (14)$$

Where the lifespan of the network is denoted by Nt, and lifespan of sensor is represented by Nts.

6.2. Simulation Result

The introduced model uses the area of 1000m x 1000m. The number of nodes used is 500. The packet size is 512 bytes. Initial node energy is 0.65mJ, and the number of CH is 17. The BW value is 11 Mbps. The value of iteration is 100. The rate of the packet is 35 packets / s, and the maximum speed is 20 m / s.

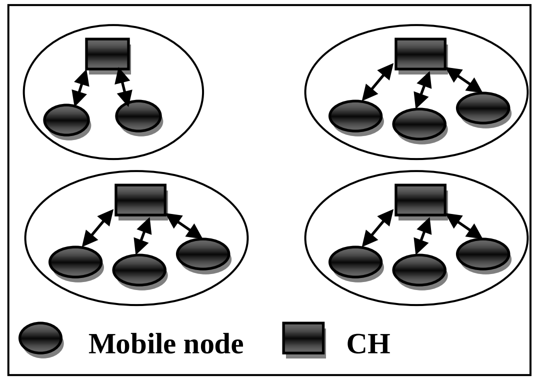


Figure 7 Representation of Proposed Model

In Figure7, the small circles represent the mobile node, and the square symbol represents the CH. With the help of Hybrid PSO-GA approach, the CH is selected from the clusters. After the selection of CH from each cluster, data packets are transmitted from source to destination.

6.2.1. Performance Comparison

In terms of Energy Consumption, End-to-End Delay, PDR, PLR, Throughput, , and Network Lifetime, our proposed Hybrid PSO-GA method is analyzed and compared to the Hybrid PSO-DE.

Figure 8 represents the Energy Consumption analysis of the proposed method with various techniques. The numbers of nodes are in the range of 100 to 500. Our proposed method gives better energy consumption performance than other existing routing methods. The proposed HPSO-GA consumes lower energy (0.63mJ) in 100 nodes. In the case of 100 nodes, other techniques HPSO-DE obtained an Energy Consumption value of (1.1mJ). The value of Energy Consumption is increasing as the number of nodes grows.

Figure 9 indicates the End-to-End Delay analysis of HPSO-GA with other methods. After the analysis, we can see that our proposed work gives a lower End-to-End Delay than other methods. Initially, the End-to-End Delay of the suggested method is 2s for 100 nodes. The alternative methods HPSO-DE provide initial End-to-End Delay value of 2.3s.

Figure 10 illustrates the throughput analysis of proposed with other techniques. The proposed HPSO-GA method gives a higher throughput performance than others. The throughput value for other methods decreases as the total node increases. Initially, the proposed HPSO-GA method acquires a Throughput value of 0. 95Mbps. The HPSO-DE methods gives Throughput value as 0.62 Mbps. After the analysis, we can see that the proposed HPSO-GA takes less time for data transmission.

Figure 11 represents the PDR analysis of the proposed HPSO-GA with other techniques. Our proposed method gives higher PDR performance (99.38%) at the initial stage. The value of PDR rises as the node number grows. While the number of nodes is 500, all the methods give a lower PDR value. HPSO-DE gives the lowest PDR performance.

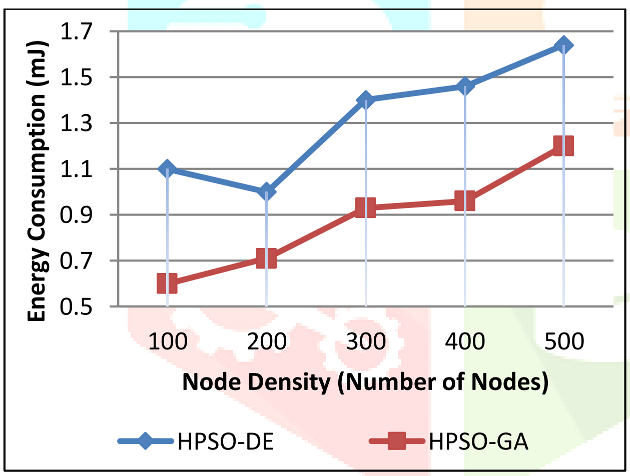


Figure 8 Performance Analysis of Energy Consumption

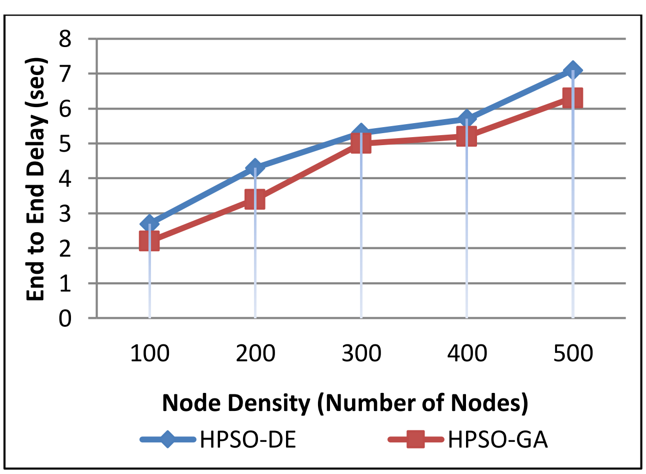


Figure 9 Performance Analysis of End-to-End Delay

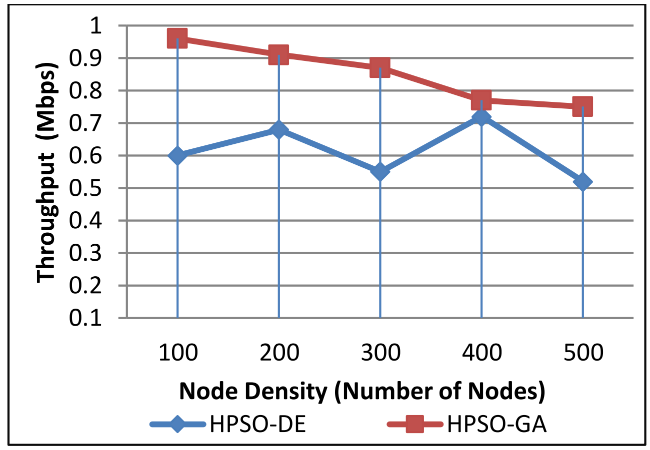


Figure 10 Performance Analysis of Throughput

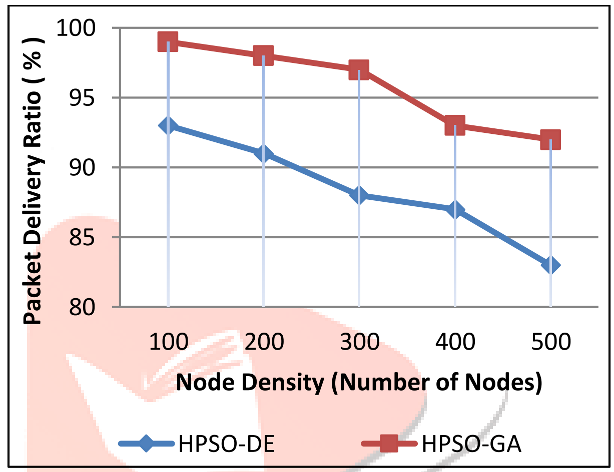


Figure 11 Performance Analysis of PDR

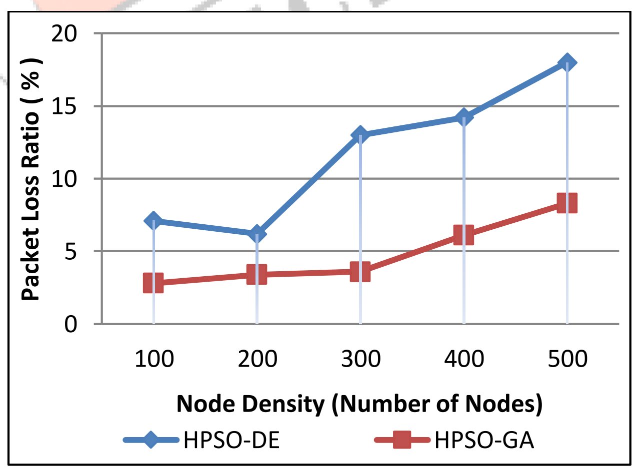


Figure 12 Performance Analysis of PLR

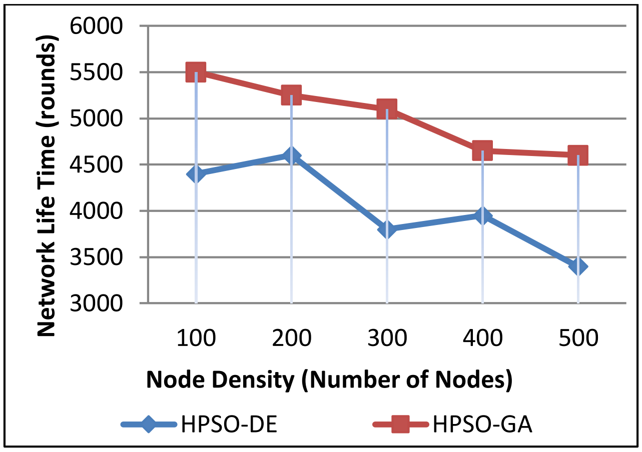


Figure 13 Performance Analysis of Lifetime of Network

Figure 12 represents the PLR analysis of the proposed method with other methods. Our proposed HPSO-GA method gives a lower PLR value (2%) than other methods in the case of 100 nodes. The PLR value of other HPSO-DE methods in the case of 100 nodes is (8%). All the methods show a gradual increase of PLR when the number of nodes is 300. The value of PLR is incremented when the node number increases. HPSO-DE offers the highest PLR Performance.

Figure 13 represents the performance analysis of the Network of HPSO-GA with other methods. The proposed method achieved the highest Network Lifetime value (5500 rounds) than other approaches in 100 nodes. The HPSO-DE method shows Network Performance of 4450 rounds respectively in 100 nodes. The Lifetime of the Network is reduced as the node number increases. After the analysis, PSO-DE shows poor lifetime Performance.

7. CONCLUSION

The different forms of Complex optimization problems like Genetic algorithm (GA), Differential Evolution (DE) and Particle Swarm Optimization (PSO) are implemented. Each method contains its own advantages and also the performance varies supported different case studies. An Energy-Efficient CH Selection method is introduced with the help of the Hybrid Particle Swarm Optimization – Genetic Algorithm (HPSO-GA) approach. The proposed work helps to overcome the energy consumption problem in MANET. The Soft k-means method is used for Clustering, which takes node distance, position, and speed into account for the best cluster formation. The Soft k-means method is utilized for clustering based on the factors such as node distance, position, and speed. After the cluster formation, the HPSO-GA method is used for selecting the CH from the nodes. The mobility of node, degree of node, and energy of nodes are used for CH selection.

The performances are monitored by PDR, Energy Consumption, PLR, Network Lifetime, Throughput, and End-to-End Delay. The simulation tool is the NS-3 platform. These performance metrics are compared with existing methods Hybrid Particle Swarm Optimization –Differential Evolution Algorithm (HPSO-DE) approach.. Simulation result verifies the performance of our proposed model with Higher PDR (99.38%), Lower Energy Consumption (0.6mJ), throughput (0.95Mbps, Minimum PLR (2%), Lower End-to- End Delay (2.01Sec), Network Lifetime (5500 rounds),) analyzed with HPSO-DE methods. Based on the result, GA was proven to perform better compared to DE and PSO in obtaining highest number of best minimum fitness and faster than both methods. In future, the CH selection algorithm will be used with energy-efficient routing to evaluate the overall network performance and lifetime.

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