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Energy Efficient Cluster based Multipath Routing Protocol in MANET using Genetic Particle Swarm Optimization Algorithm

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Abstract: A group of independent mobile nodes that function as an ad hoc network without the need for an infrastructure is known as a mobile ad hoc network (MANET). The MANET's dynamic topology trait has the potential to reduce system performance. Multipath selection, therefore, is a very difficult operation to increase network lifetime. Multipath routing has been used into MANETs recently to enable reliable and scalable data transfer. Multipath routing has been established by MANET to support trustworthy and scalable data transfer. In order to overcome the limitations of slow convergence and premature resolution of Quality of Service multicast routing problems in the existing genetic algorithms, this paper combines the particle swarm optimization algorithm (PSO) and genetic algorithm (GA) and proposes a genetic particle swarm optimization algorithm (GPSO) based on the improved particle swarm optimization algorithm as the mainline (GA). In this study, sensor nodes are clustered using the Genetic Particle Swarm Optimization Algorithm to create a multipath routing protocol that is QoS aware. Despite the existence of numerous multipath routing systems, only a small number of them have focused on Quality of Service (QoS) based routing. By reducing and balancing energy usage, clustering is a tried-and-true approach of extending the life of a network. The protocol that has been proposed is uses the Cluster Heads to find numerous reliable multi-hop communication pathways to deliver data. The MATLAB simulator is used to test the performance of the suggested protocol in various scenarios. The parameters End-to-End Delay, Bit Error Rate, Packet Delivery Ratio, Network Lifetime, Packet Loss Ratio, Throughput, and Energy Consumption are utilised to assess the performance of the suggested technique.

Keywords: *Genetic Particle Swarm Optimization Algorithm, Multipath routing, MANET, Quality of Service*.

1.Introduction

A MANET is made up of wirelessly connected mobile nodes that are not tied to a centralised infrastructure. All nodes inside of an Ad Hoc network should work together to develop a partial design that allows them to interact effectively. Ad Hoc networks should utilise an effective routing algorithm to build this architecture and route the data. The nodes of an Ad Hoc network could be intimately tied. Between a source and a destination, more than one path may usually be established. Multipath routing is the term used when this Ad Hoc network functionality is used in the routing process. An autonomous group of distributed nodes known as an ad hoc network is capable of exchanging information and interacting with one another without the aid of a centralised management system or a rigid architecture. Each node on a network can operate as a host or router, participate in routing, and carry the data by transmitting the data to other nodes in addition to sending and receiving its packets. Wireless sensor networks and MANETs are two types of ad hoc networks. Because their nodes are mobile and autonomous, they are known as MANETs. A routing table is present on every node and it contains details about the network and its routes. The routing table, which is stored in the limited memory of the nodes, will grow in size as the number of nodes in the network increases.

By discovering other routes via a unique route discovery technique, the multipath strategy strives to improve flexibility to frequent topology change, link break, and network overhead. This strategy also aims to improve service quality by eliminating data transmission delays from beginning to finish. In recent years, genetic algorithms have been increasingly popular, although most of them employ regular genetic algorithms, and hybrid genetic algorithms are rarely used to solve QoS multicast routing problems. Because improving QoS performance is an objective of routing path optimization, some publications explore using genetic particle swam optimization (GPSO) to increase routing protocol performance. The multipath routing protocol evaluates the answer using a fitness function.

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In this study, an efficient routing algorithm integrating the characteristics of PSO and GA and proposing a fusion based on PSO and GA is used to optimise the routing path among source and destination nodes to improve the QoS performance of location-based multipath routing protocols in MANETs. To speed up route creation and maintenance, this method takes full advantage of PSO's rapidity and global convergence.

2.RELATED WORK

For essential data transfer, the MANET supports several pathways with QOS constraints. It outperforms DCEM because DCEM ignores CH congested and instead chooses CH depending on the amount of energy remaining and the shortest delay. Depending on the application requirements, the algorithm discovers the shortest path and generates multipath. Because of the time constraint, the transfer of time-critical data takes precedence. Distant sensor systems have shown that vitality efficient clumping conventions for heterogeneity remote sensor arrangements outperform vitality bunching conventions for homogeneous remote sensor arrangements in terms of prolonging system lifespan. Heterogeneous remote sensing systems are now more suitable for genuine application than their homogenous counterparts [2]. Maintaining the MANET network optimally for complete node mobility is a tough undertaking. The approach utilised in this study performs better in dynamically evolving MANET networks than the weighted clustering algorithm. The analysis and findings show that it can be utilised as a foundation for MANET dynamic changeable topology design in the future. It can adjust in real time to MANET to increase energy economy and speed [3].

The QoS-aware Multipath Routing (QMR) method has created many ideal paths among source and sink nodes in a wireless sensor network (WSN). To cluster sensor nodes and identify cluster heads for reliable data delivery, the protocol employs a hybrid Cuckoo Search-Particle Swarm Optimization technique. The proposed protocol delivers data packets across several channels and offers superior network traffic control[4]. ECRP-UCA is a cluster-based routing protocol for WSNs that uses unequal clustering and improved ACO algorithms to be energy-efficient and reliable. The sensor field is organised into clusters of varied sizes in this network paradigm. The cluster radius is calculated using significant data from the previous round, such as the CH's energy, distances from sinks, amount of neighbour node, and number of downstream relay node. [5].

This work offers a GCP that analyses a variety of circumstances and instantly reduces the latency between controllers and switches, as well as the delay between controllers and load unbalance inside controller, in order to improve the efficacy, scalability, and availability of SDN systems. Because the GCP's aims are incompatible, greedy algorithm that simplified the GCP's switching assignment are difficult to implement. As a result, many heuristic methods fail to converge a Pareto frontier in an acceptable length of time, resulting in a large solution search space [6]. These objectives are extremely nonlinear and incompatible. The suggested multi-objective hybrid MOCGWOPSO method 568 minimises wellbore risk and expense by minimising total measured depth (TMD), total torque, and well strain energy. The 17 tuning 570 variables optimization took into account limitations such as true vertical depth (TVD) and casing. The algorithm's results were compared to those of other state-of-the-art systems using IGD, spacing metric, and 571 maximal spread parameter. The suggested GWO, in combination with CA hybridization, helps the basic algorithm diversify its non-dominated solution. The approach saved money in contrast to others, but it is riskier because the strain energy is larger [7].

The SIGPA algorithm was put to the test in real-world scenarios as part of the ENORASI research, which is committed to navigating as well as assisting people with vision impairments in outdoor open diverse context. Real-time processing for navigation tasks may be possible since the recommended method's computing time meets the response-time requirement (100s 100ms) for real world application of control system operations and automating [8]. For stable and exact global localization, use the PSO approach only with median filter. A modified PSO technique using search engine is used to estimate the first robot pose, and the DBSCAN approach is used to find various pose hypothesis. As the robot evolves, many solution are preserved until the particle set converges on the genuine robotic position [9].

The ICSO is being utilised to test a new enhanced CSO technique as well as trajectories optimization for the ascension phase of a hypersonic vehicle. Three improvement measures are used to avoid early convergence. The average position of roosters alters the updating laws of roosters since the basic CSO seeks to converge near the source in the case where the source is a minimizer. In order to expedite the search, the difference in the best agreements between two iterations is also used. Similarly, to jump out from the neighbourhood surrounding the minima, the regular crossover operator is used. The enhancement methods address the flaws in the original CSO, resulting in better algorithm performance[10].

A MANET is a system in which information is sent to multiple node along the path between the source and destination. To prevent hostile nodes from obtaining this information, security is in place. Multipath routing is widely used instead of single path routing in wireless networks to improve error detection. It used 0.10 joules of energy, had a throughput of 0.85 bits per second, a 91 % detection rate, and an 89 % packet delivery ratio, and took a short period of time [11]. Ad hoc on demand distance multipath routing with lifespan maximisation (AOMR-LM), reduce emissions multipath routing protocol with expulsion technique (AOMDV-ER), and ad hoc on demand multipath distance vector with fitness value all improve the AODV protocol (FF-AOMDV). In terms of communication overhead, network lifetime, packet delivery ratio, and energy usage, the recommended AOMDV-ER improves on already-existing algorithms like AOMR-LM, AOMDV, and SRMP, according to this paper [12]. The EE-LB-AOMDV MANET routing protocol improve on the LBEC-AOMDV protocol. EE-LB-AOMDV doesn't even use queue length as a statistics due to its highly dynamic nature. The metrics eccentricity ECT, that must be reduced, has indeed been suggested. A route with such a low ECT value must be given more priority for data transfer[13].

This study proposes ESMRua an unique multipath routing protocol. In ad hoc mobile networks, it improves network robustness while reducing energy usage. A weighted function determines the path to take. This weight is calculated using node energy and link stability, as well as signal quality. Based on how mobile these nodes are, employ three computation variations to assess connection stability[14]. Because MANET lacks a clear infrastructure, routing becomes difficult. The effective usage of batteries is critical for extending the network's life. The purpose of this study was to evaluate ZBLE, an Energy-Efficient Zone-Based Leader Election Multipath Routing Protocol for MANETs. Various matrix throughputs, end-to-end delays, energy consumption, and network longevity were taken into consideration when developing these scenarios. [15].

Performance of an OLSR protocol is superior to that of an AODV protocol in terms of packet delivery rate and throughput latency. When comparing end-to-end Delay overhead and network throughput, the new GPSO algorithm outperforms the WOA.

2.1 Section Association

The remainder of the paper is divided into the following sections. The recommended Genetic Particle Swarm Optimization is introduced in Section 3. Section 4 contains the experimental results and discussions. Section 5 concludes with an overview of the findings as well as future study suggestions.

3. PROPOSED METHOD

To ensure stable and scalable data transfer, MANET has developed multipath routing. This study uses the Genetic Particle Swarm Optimization Algorithm to cluster sensor nodes, yielding a QoS aware multipath routing protocol. Although there are various multipath routing systems available, only a handful have focused on QoS-based routing. Clustering is a tried-and-true way of extending network life by reducing and balancing energy usage. The Soft-k means algorithm can be used to support the clustering process. The Cluster Heads are then used by the proposed protocol to find several trustworthy multi-hop communication paths for data delivery. The Cluster Head (CH), based on the cluster created, has been determined using the Genetic Particle Swarm Optimization Algorithm. Multiple routes between the source and destination nodes are made possible by OLSR (Optimized Link State Routing). In the event that a certain path fails, it increases successful packet delivery.

Figure 1 shows the process for CH selection using PSO. The initialization of the node's position and velocity precedes the calculation of each node's fitness function. The adjacent nodes and the currently chosen node C_{sn} are initialised. altering the nodes' position and speed with respect to iteration number n in more detail. Calculating the nodes' fitness value is another option. Any node that meets the criteria is chosen as the CH.

After choosing CH, use the GA Algorithm to pinpoint its location. Basically, the three stages of the GA algorithm—Selection, Crossover, and Mutation—are used to generate high-quality solutions. The creation of chromosomes is the first phase. The provided problem serves as the basis for the estimation of fitness value. The Crossover stage is the second stage.

3.1 Cluster head selection using generic particle swarm optimization

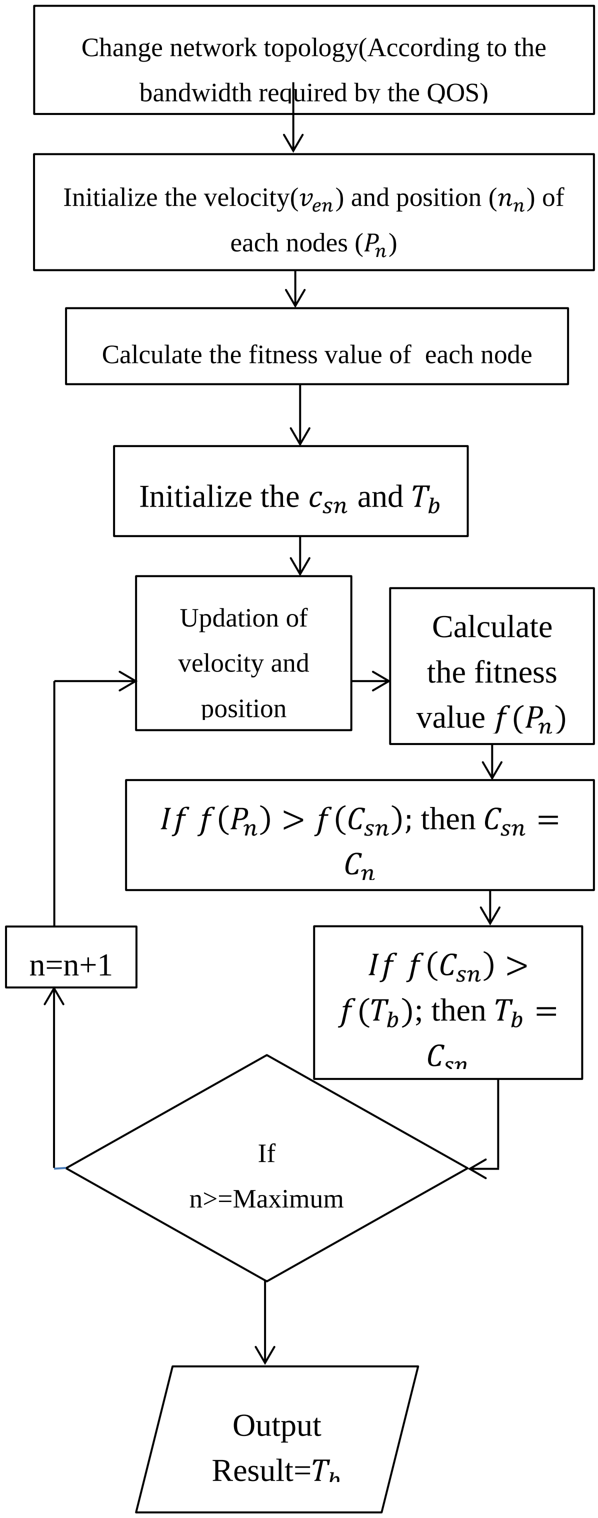


Fig. 1. Flowchart of GPSO algorithm

Two parents exchange genetic features at this time. The last step, mutation, increases the gene value and diversity of the progeny[16]. The chromosomes of GA, which are specified as $X_N = \{r_\varepsilon, r_\alpha, r_{m_o}\}$ where X_N denotes the positioning of nodes inside the clusters, are used to represent the nodes of MANET. The mobility symbols are r_ε, r_α, and r_{m_o} stand for the regular factors of energy, degree, and mobility, respectively. Calculation of the starting positions of CHs is the first of the three processes in calculating the CH location. Calculating the energy value of the chosen CH, and placing the CH based on lower energy usage, is the last stage.

During the first stage, the starting position of each desired CH is determined using a fitness value from PSO. Equation describes how to use node membership degree to calculate the energy value of a chosen CH. The selected CH is put in the centre of the relevant MANET Cluster if, after calculating CH's energy value, it exhibits less energy than its nearby neighbours.

Pseudocode for GPSO algorithm
Step 1: Set the network area and node count to their initial values.
Step 2: Create the nodes' location and velocity.
Step 3: The criterion for maximum iterations is met
Step 4: Calculate each node's fitness.
Step 5: Equation (1) Calculate the velocity based on your maximal level of fitness
Step 6: Equationally (2) determine the node's position
Step 7: Update the node with the highest velocity.
Step 8: Adjust the node's position according to the GA algorithm.
Step 9: Generate fitness by maximising node energy, decreasing node mobility, and increasing node degree.
Step 10: Every node's fitness is determined iteratively.
Step 11: Update the node's best fitness developing position.
Step 12: Put the CH in that location.
Step 13: Stop

3.2 Fitness evaluation

The produced Clusters are identified by the symbol A_x, which moves inside the Y dimension search region. Mobile nodes are members of the group $N = \{n_1, n_2, \ldots., n_m\}$. The fitness function is assessed using each of the nodes N_n. The sum of the node features is the fitness function (energy, degree, and mobility). $N_{n,y}$ denotes the position of each node in the search space, while $VE_{n,y}$ denotes the velocity of each node. The neighbouring node is indicated by T b, whereas the currently selected node is designated by C_{sn}. The values of each MANET node's velocity, mobility, energy, and degree are updated. Equations (1) and equation describe this procedure (2).

$$VE_{n,y}(\rho+1) = \varepsilon \times VE_{n,y}(\rho) + \alpha \times r_{an1} \times \left(NC_{sn,n,y} - N_{n,y}(\rho)\right) + m_0 \times r_{an2} \times \left(NT_{b,n,y} - N_{n,y}(\rho)\right) \quad (1)$$

$$N_{n,y}(\rho+1) = N_{n,y}(\rho) + VE_{n,y}(\rho) \quad (2)$$

Whereas a node's energy is symbolised by, ε a node's mobility is shown by m_0. represents the range of random numbers between zero and one. both r_{an1} and r_{an2}.

3.3 Quality of service multi-cast routing

MANET is made up of low-energy mobile nodes connected by a wireless network. The packets are forwarded from source to destination by each mobile node. Let directed graph G=(N,W) reflect the quality of multipath routing, where N represents the set of network nodes, W represents the set of two-way links, and $W \subseteq N$ denotes the number of two-way links. For all two-way links $\in W$ in G, specify three quality of service functions.

Cost of an edge: $C(e): W \rightarrow \mathbb{R}^+$
Delay of an edge: $D(e): W \rightarrow \mathbb{R}^+$
Loss of an edge: $L(e): W \rightarrow \mathbb{R}^+$

The cost C(e) of an edge e, measures the resources used by that edge. The sum of switching, propagation, and transmission delays is the delay for edge D(e). L(e) is the packet loss rate on link e at the receiving end. A multi-priced tree T(s, M) is a tree and a subgraph of G that spans a source node $s \in V$ and a collection of destination nodes $M \subset V - \{s\}$. The number of multicast destination nodes is given by |M|. M stands for the destination group, and $\{\{s\} \cup M\}$ stands for the multicast group. It's worth noting that the multicast tree T(s, M) could have vertices (Steiner vertices) that aren't part of the multicast group. To apply the concept of cost function to the tree, define the tree's cost as:

$$C\big(T(s,M)\big) = \sum_{e \in T(s,M)} C(e) \quad (3)$$

$P_{\mathrm{r}}(s,d)$ denotes a one-of-a-kind path in T from node s to destination node $d \in M$. Similarly, for the path $P_{\mathrm{r}}(s,d)$, the delay and loss ratios are defined as

$$L\big(P_{\mathrm{r}}(s,d)\big) = 1 - \prod_{e \in P_{\mathrm{r}}(s,d)} 1 - L(e) \quad (4)$$

3.4 K-Mean Based Soft Clustering

In the k-mean soft clustering method, clusters are formed at the centre by a fuzzy based clustering procedure. Due to overlapping concerns across groups, the conventional k-mean clustering method is ineffective. As a result, the Soft k-mean approach is presented. Each node in this approach has a different membership level. In comparison to nodes close to the cluster centre, the edge nodes exhibit a lower probability. Soft k-mean nodes can only be a part of one cluster. Speed, position, and distance are determined to create the clustering. The degree of membership is crucial to the reduction process.

3.5 Cluster Creation in MANET

In MANET, Members of the Cluster included by N=$\{n_1, n_2, \ldots.. n_m\}$, and they are categorised into M sets $M = \{m_1, m_2, \ldots. m_i\}$. Equation ( ) explains how clustering develops in MANET

$$F(N,B,H) = \sum_{h=1}^{i}\sum_{q=1}^{m} b_{hq}\left\|n_q - \gamma_h\right\|^2 \quad (5)$$

Where the distance between nodes is represented by $B\big(b_{hq}; h = 1 \ldots i; q = 1, \ldots. m\big)$ and the speed between nodes (Cluster Member) is marked by $H(\gamma_h; h = 1, \ldots i)$. Equation (5)

q^{th}, h^{th} describes the q^{th} membership degree to the H^{th} cluster.

$$\gamma_s = \frac{\sum_{q=1}^{k} b_{hq} n_q}{\sum_{q=1}^{k} b_{hq}} \quad (6)$$

where each node's α degree value is represented by the symbol. By minimising the value of b_{hq}, efficient clustering is produced, and this minimization process must abide by the three conditions given below[1].

1. A membership degree between zero and one is assigned to the cluster member within the MANET.

$$b_{hq} \epsilon [0,1], \qquad h = 1 \dots i, \qquad q = 1, \dots k. \quad (7)$$

2. For one Cluster Member, the sum of all membership degrees must equal one.

$$\sum_{h=1}^{i} b_{hq} = 1, \; q = 1, \dots k. \quad (8)$$

3. A cluster member with a membership degree greater than zero must exist.

$$\sum_{h=1}^{i} b_{hq} > 0, h = 1,,, i. \quad (9)$$

After meeting these requirements, equation estimates the cluster centres (10).

$$b_{hq} = \frac{e^{-\alpha \|n_q - \gamma_s\|^2}}{\sum_{b=1}^{i} e^{-\alpha \|n_q - \gamma_s\|^2}} \quad (10)$$

The proposed Soft k-mean algorithm's whole procedure can be summed up as follows: Equations (6) and (10) estimate the membership degree value and the position of the cluster's centre (10). Cluster formation stops if the cluster member's direction and speed are under the threshold value. [17].

3.6 OLSR (Optimized Link State Routing)

One of the routing methods used by the MANET is "Optimized Link State Routing (OLSR)". Compared to the existing link-state technique, the Protocol is an enhancement. The MPRs nodes and the chosen selection of one-hop neighbours aid in the optimization's reduction of the network's management and traffic message overflow. The hop-by-hop routing system has a list of probable destinations in each routing table. By consistently sending and receiving hello messages, each node will get to know its one-hop and two-hop neighbours. No more greetings or messages are permitted. A number of one-hop neighbours could make up the MPR set, with at least one MPR connecting each two-hop neighbour. The greeting messages provide information about the MPR nodes. The MPR selection set is made using the data gathered. It keeps track of the nodes that have identified a certain node as MPR. MPRs transmit the topology control (TC) messages. No TC messages are broadcast or retransmitted by an empty MPR selection set node. Because its selection table contains the final hop needed to reach all nodes, the sender of a TC message promotes themself. The TC Redundancy (TCR) parameter value determines the content of Traffic Control messages. The selection of MPRs is the main objective of OLSR. Each node within the network has the freedom to decide which MPRs it wants to send TC messages to.

4. PERFORMANCE MEASURE

The parameters End-to-End Delay, Bit Error Rate, Packet Delivery Ratio, Network Lifetime, Packet Loss Ratio, Throughput, and Energy Consumption are utilised to assess the performance of the suggested technique.

1.End-to-End Delay

End-to-end delay is the typical amount of time that data packets take to properly transmit messages across a network from source to destination. These include MAC retransmission delays, propagation and transfer times, queueing at the interface queuing, buffering during route discovery latency, and MAC retransmission delays, among other types of delays. The following equation can be used to calculate the E2E delay:

$$E2E\ delay = \frac{\sum_{i=1}^{n} (R_i - S_i)}{n} \quad (11)$$

2.Bit Error Rate

The bit error is calculated as the bit error divided by the total number of messages sent during the time period. The following equation is used to express the bit error rate for routing protocols as a percentage.

$$BER = \frac{Error\ rate\ of\ transferred\ bit\ of\ message}{T} \quad (12)$$

3.Packet Delivery Ratio

Signifies the proportion of data packets that were generated by the source to those that were delivered to the destination node. This measure demonstrates how well a routing protocol delivers data packets from source to destination. The performance of the routing protocol improves as the ratio rises. PDR is determined as follows:

$$PDR = \frac{number\ of\ packets\ received}{number\ of\ packets\ sent} * 100 \quad (13)$$

4. Network Lifetime

The time needed to drain the battery of n mobile nodes is referred to as the network lifespan and is determined using the formula below:

$$Network\ lifetime = \sum_{i=1}^{n} (ene(i) = 0) \quad (14)$$

5. Packet Loss Ratio

The amount of packets that were successfully transmitted from one node in a network but abandoned during data transit and never made it to their destination is known as packet loss. The amount of packets lost as a percentage of all packets transported from the source terminal to the destination terminal is known as PLR.

$$PLR = \frac{Total\ number\ of\ packet\ lost}{Total\ number\ of\ packets\ sent} * 100 \quad (15)$$

6. Throughput

The quantity of bits successfully received at the destination is referred to as throughput. Kbps is the kilobit per second unit of measurement. Throughput is a metric used to assess how well a routing mechanism receives data packets according to destination. The throughput is computed as follows:

$$TP = (number\ of\ bytes\ received * 8/simulation\ time) * 1000kbps \quad (16)$$

7. Energy Consumption

The amount of energy used by the network nodes during the simulation time is referred to as energy consumption. This is calculated by computing the final energy level of each node while accounting for their initial energies. The value for energy consumption will be generated using the formula below:

$$Energy\ Consumptio = \sum_{i=1}^{n} (ini(i) - ene(i)) \quad (17)$$

5. EXPERIMENTAL RESULT

The suggested method was used to simulate a network (NS2). An area of interest of 1000 m by 1000 m had nodes placed at random. 20 metres was the transmission range. Nodes adopted the random way point paradigm, which in a MANET determines the existence of connecting pathways. We looked at the simulation results by changing the network size from 50 to 200. The parameters End-to-End Delay, Bit Error Rate, Packet Delivery Rate, Network Lifetime, Packet Loss Rate, Throughput, and Energy Consumption are utilised to assess the performance of the suggested technique.

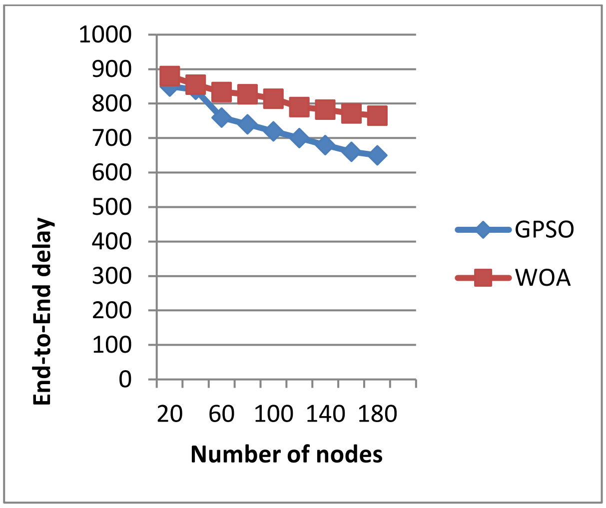


Fig 2: Performance of End to end delay

Figure 2 compares the performance of end-to-end delays to other methods using the Whale optimization algorithm. When compared to other strategies currently in use, the proposed method, which uses the GPSO protocol, produces better results.

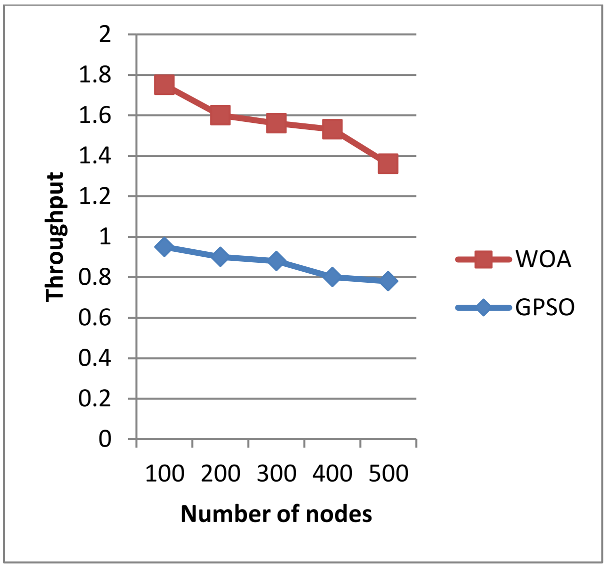


Fig.3 Performance of throughput

Figure 3 compares the throughput performance to several methods, including the Whale optimization Algorithm, When compared to other strategies currently in use, the proposed methods using GPSO yield better results.

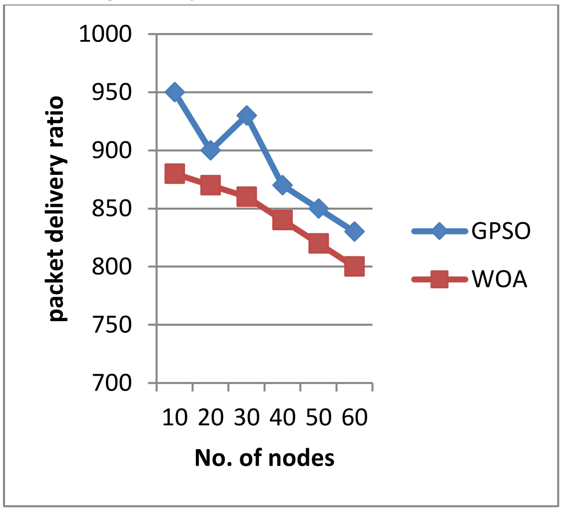
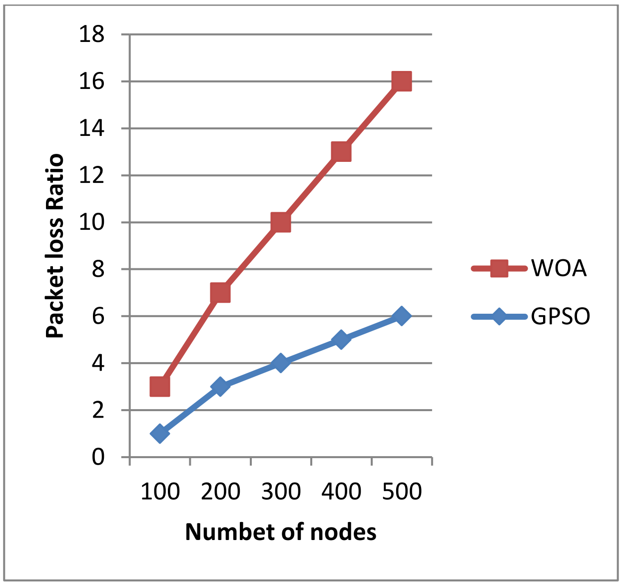


Fig.4 Performance of Packet delivery ratio

The performance of the packet delivery ratio as compared to other optimization techniques is shown in Figure 4. When compared to other existing techniques, the proposed methods leveraging the GPSO protocol deliver better results.



Fig, 5 Performance of Packet loss ratio

Figure 5 displays the PLR comparison between the suggested approach and other ways. In the case of 100 nodes, our recommended solution offers a PLR value that is 1% less than that of other methods. The PLR value of alternate methods is 2.5 percent in the case of 100 nodes (WOA). When there are 300 nodes, the PLR gradually increases according to all techniques. When the number of nodes rises, PLR's value is increased.

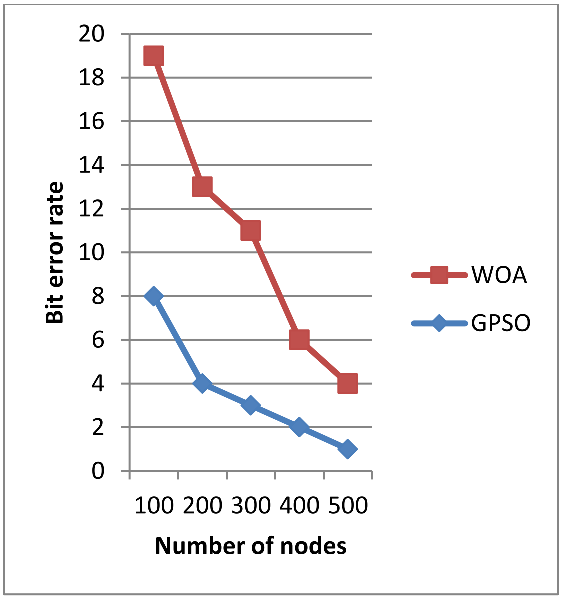


Fig .6 Performance of bit error rate

The suggested work's BER analysis is shown in Figure 6. In comparison to existing approaches, the suggested GPSO method has the lowest BER. The value of BER decreased for all techniques as the node increased. Our suggested work displays a BER of 8% at the outset. For 100 nodes, the other approaches display 19 percent (WOA). starting the analysis process. All approaches yield the lowest BER when there are 500 nodes.

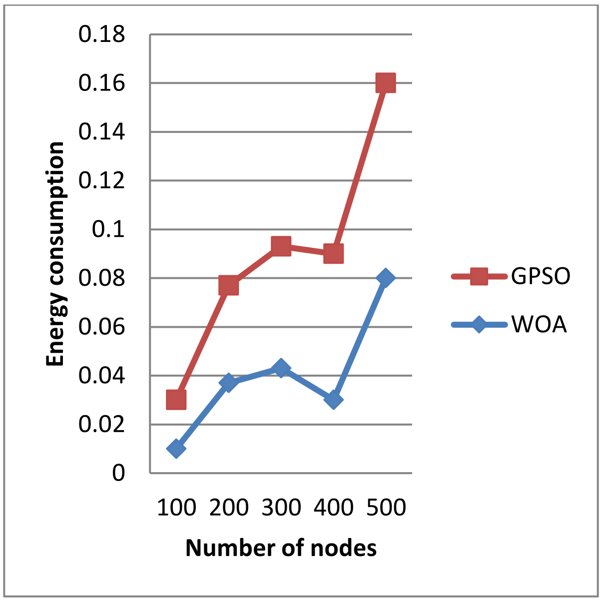


Fig 7: Energy consumption

Energy use increases linearly. The rise in traffic was brought on by the network's expanding node count. In terms of overall network energy usage, the suggested GPSO still performed better than the WOA.

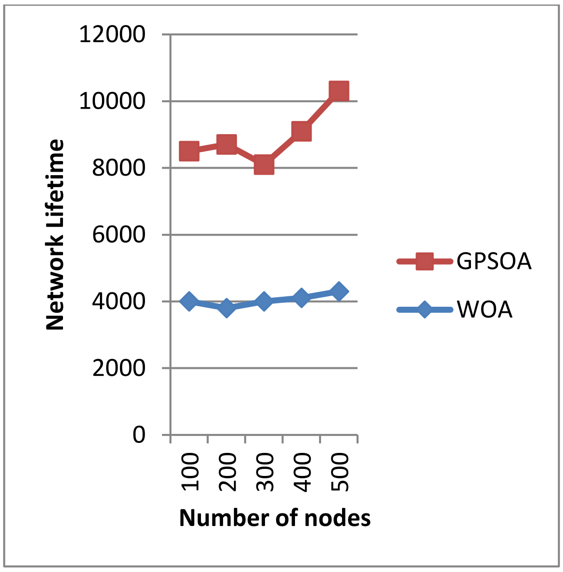


Fig 8: Network Lifetime

When compared to WOA, GPSOA demonstrated a significantly better maximum network lifespan. This assures that the density of nodes in the network has no effect on our suggested approach. When compared to existing methods, GPSOA resulted in less energy dissipation and improved load balancing across the network.

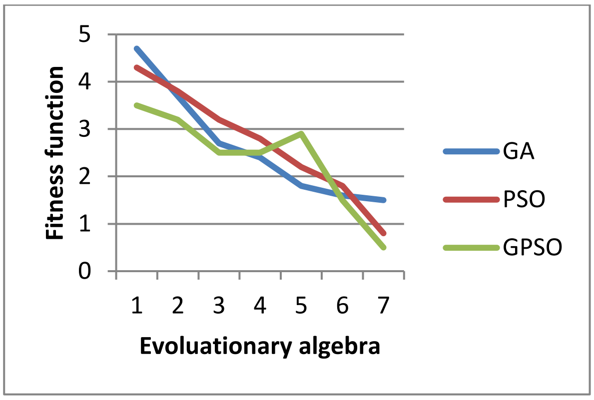


Fig. 9. Comparison of GA, PSO algorithm, and GPSO algorithm

The particle swarm optimization approach is evidently initially welcomed. Even if the speed is quicker, the convergence precision is subpar. This is due to the particle swarm optimization algorithm's limited use of the initial population's information about the optimal solutions and inability to conduct a thorough search of the solution space, which is prone to local optimality. The GA uses crossover and mutation operations, but there is no clear guidance, which makes it difficult to determine the best solution and causes a slow initial speed rate convergence. whereas the accuracy and speed of the GPSO algorithm have improved.

6. CONCLUSION

In Ad-Hoc networks with different quality of service restrictions, the multi-cast routing optimization problem is solved using the suggested GPSO method. It improves the running speed of the algorithm by improving the mutation operator among genetic operators and introducing the idea of particle swarms. End-to-end delay, bit error rate, packet delivery ratio, network lifetime, packet loss ratio, throughput, and energy consumption are the performance metrics employed for the proposed method. The optimization performance of GPSO is superior to that of GA and PSO algorithms. The proposed work's next directions include the creation of a cluster-based routing protocol, the application of the proposed model in a heterogeneous network environment utilising a mobile sink node, and a rewrite for delay-constrained applications. Future network performance and longevity evaluations will combine the CH selection method with energy-efficient routing.

Conflicts of interest

The authors declare no conflicts of interest.

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