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MAXIMIZATION OF NETWORK LIFETIME USING ENERGY EFFICIENT SUPER CLUSTERING PROTOCOL BASED ON LDHA-TSRO IN MANET

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Abstract— A mobile ad hoc network (MANET) is a self-sufficient network made up of a collection of hosts that communicate with one another using wireless links. The inherent mobility of MANET nodes makes conventional network operations such as clustering and routing challenging. Erroneous CH selection, however, can result in imbalanced energy usage; therefore, it is essential to be careful while making a choice. The network's lifespan can degrade due to uneven energy usage between nodes. As a result, in this study, time-consuming delays were reduced by choosing cluster heads (CH) with the help of Trees Social Relations Optimization (TSRO). The suggested method aims to cluster nodes and select optimal routes for dependable and low-energy data transfer. Following the establishment of CH, the Leader Dolphins Herd Algorithm (LDHA) was used to pick the Super CH (SCH), which then collected data from all CHs and transmitted it to the home base (BS). The data transmission is via hop routing. The parameters used to evaluate the proposed LDHA methodology's performance are delay, delivery ratio, energy consumption (EC), network lifetime (NLT), and throughput. The performance of this work is compared to more established methods.

Keywords— Trees social relations optimization, Super-Cluster Head, Routing, Energy Consumption, Network Life Time, Leader Dolphins Herd Algorithm.

I. INTRODUCTION

The term "mobile ad hoc network" (MANET) refers to a network of independent mobile nodes communicating through wireless links. The substructure to which it is connected is not stable. It is fair to say that each node in the centre of the network is a router. MANET [1] possesses a wide variety of fascinating features. MANET's adaptability and versatility include its ability to keep devices linked even while a node moves from one area to another. Using may be sent from one node to the next. Because of the need to conserve energy [2] provided by wireless links between nodes in an ad hoc network, their reliability is often poor. It is also limiting because networks cannot change their topology on the fly. MANET is a distributed computer network in which nodes can freely join, leave, and relocate within the network. Since MANET [3] topology is inherently fluid, defining it is challenging.

Because batteries are the primary power source for mobile nodes, efficient routing methods have received much attention in MANET [4]. Many studies have introduced routing strategies for MANETs, which we may primarily categorize into reactive, proactive, and hybrid categories based on pathfinding [5]. Because routes are found only when they are required, reactive routing protocols can also be referred to as on-demand routing. In contrast, nodes using proactive routing protocols keep one or more routing tables continuously updated through broadcasting messages to all other nodes to detect changes in the network structure [6-7]. Table-driven protocols are another name for proactive routing methods. The State Routing Protocol [8-10] are two examples of hybrid routing systems that combine the best features of proactive and reactive routing methods.

Bio-inspired algorithms (BIAs) are algorithms that are inspired by biological systems and how organisms respond to challenges. BIAs are more efficient intelligence systems in unpredictable and dynamic settings like MANET. Numerous research, such as [11–13], have advocated looking into BIAs as routing protocols in MANET. However, some studies have argued that optimizing nodes' energy is the primary goal of employing BIAs in MANET because it is one of the primary elements affecting the Quality of Service (QoS) Metrics. Ant Colony [14], Particle Swarm Optimization [15], Bee Colony [16], Immune System [17], Fish Swarm [18], and Bat procedure [19] are just a few examples of energy-efficient routing protocols that depend on BIAs to discover the shortest path while consuming the least amount of energy.

Since all MANETs have the same problem of limited network resources, a well-known approach called clustering was developed to reduce the quantity of data transmitted from source to destination while using a minimum of EC and transmission bandwidth [20]. Nearly all clustering algorithms can select nodes and build a network spine to underpin command and management tasks. Any two nodes in a network can form an association, and this collection of nodes is known as aCH. Both direct and indirect connections between CH are made possible by gateways. When a gateway is combined with a CH, a linked backbone is produced that facilitates the simplification of procedures, including channel access, bandwidth allocation, energy savings during routing, and virtual-circuit support. The clustering of nodes is the second most challenging procedure in MANET [21], behind the routing process itself. Though several methods have been developed for determining the optimal cluster size, no one considers all the network characteristics needed to boost clustering performance [22]. Therefore, finding the optimal number of clusters is the primary focus of current MANET research. As individual nodes only store regional data, it is necessary to disperse the techniques used for clustering. In addition, it needs to be flexible enough to accommodate growth or contraction in the network without breaking down. One specific CH needs to keep a more significant number of nodes to keep the cluster functional [23].

The primary goal of the suggested approach was to enhance MANET's energy-effective routing. Time and effort savings were taken into account when voting for CH with the aid of TSR. When it came time to refine the scheme's presentation, SCH was chosen as the format of choice. An efficient route was established for this communication based on the total number of bounces from the sensor hubs. Delay, delivery ratio, energy, NLT, and throughput were used to evaluate the proposed TSR-LDHA technology and compare it to other established methods.

II. RELATED WORKS

The principal purpose of this research is to assess Suresh Kumar, R. [24]'s multicast routing for quality of service (QoS). One node sends data packets to several receiving nodes at once via multicasting. Transmission expenses can be lowered by using multicasting. One of the difficulties of MANET is picking a leader for each cluster. To prevent the cluster from collapsing, the proposed research paper, optimal route selection (ORS) generates a node's energy. It establishes the path with the maximum energy and the fewest possible hops between the nodes. ORS is superior to conventional approaches in providing an energy-efficient channel among the base station, the CH, and the member node. Compared to the current methods, the results reveal that the suggested ORS has better throughput, lower latency, lower jitter, and a more excellent packet delivery ratio.

T. Venkatesh for MANET [25] suggests a mechanism for optimal load distribution between the cluster's leader and its other nodes, cutting down on energy waste. The cluster is formed utilizing a method called HAMBO, which stands for ABC with Monarch Butterfly Optimization, and is used in conjunction with Cluster Head Load Distribution (HAMBO-CHLD). This suggested load distribution method takes advantage of associative clustering. When it comes to associative clustering, balancing energy and load factors in sensor nodes is critical. The transmission load of the cluster head is reduced when it has associative members. With multi-hop communication, the nodes in the cluster may spread the load of sending data to the CH among many nodes. The cluster's energy waste may be reduced by employing load dispersion. The multi-hop approach improves the efficiency of cluster-to-Access-Point (AP) routing.

For example, to find the shortest path, Goyal, A. [26] used an Ad hoc approach to determine the shortest path routing algorithm based on the hybrid AODV (HAODV) technique. The MFR technique was used to choose the neighbor node, and the HAODV technique was used to locate the quickest route. The performance of the projected work is determined by several network factors such as end-to-end latency, average routing overhead, throughput, and packet delivery ratio; the Firefly method is also incorporated into the Hybrid AODV to discover the equation. Compared to AODV and DSR, the suggested method (HAODV) performs better in terms of packet delivery ratio, end-to-end delay, and Routing overhead.

An Energy Efficient Centroid-based Ant colony Optimization (EECAO) hybrid protocol was developed in [27] to boost sensor network performance in a WSN-assisted IoT setting. This protocol employs ant colony optimization and centroid-based clustering concepts to collect and transmit data from individual clusters back to a central location. The cognitive sensors' remaining battery life determines the protocol's centroid location. The proposed protocol utilizes a novel distributed cluster formation architecture that takes into account a variety of clustering factors, such as the total cost of operation, the reliability of the communication channels, and the output of the cognitive sensors when deciding on the cluster leaders. The suggested technique uses the location of the energy centroid inside the specified coverage area to determine which node in the cluster should serve as the super cluster head. An ant routing model is used to optimize the path between the supercluster heads and the base station. Compared to the established ETSP and EECRP protocols, our simulation findings show that the suggested protocol performs better. Additionally, it works excellent for sensor networks that need a lengthy lifetime, regardless of whether the network's hub, edge, or periphery is located there.

Researchers in [28] looked addressed the problem of having two CHs in a single WSN cluster and how to choose between them using an algorithm inspired by nature called Ant Colony Optimization (ACO). Ants are used as inspiration for the Optimization. Simulation consequences demonstrate that the projected technique improves network lifespan and residual energy by using two cluster heads instead of one.

Using the throughput, Packets Delivered Ratio Factor (PDR), and NLT metrics, Al-Najjar, A.A.M. [29] compared the performance of several clustering algorithms, including HDCA and LIDCA. To extend the MANET's lifetime through energy conservation, we suggested a novel clustering technique that is more effective in NLT. The results of the experiments validated that the suggested clustering technique resulted in a more uniform distribution of energy across the nodes and a significantly superior NLT.

An approach for clustering with topology management in MANET called Chronological-Squirrel Earth Worm optimization (C-SEWO) was proposed in [30]. The clustering is carried out using the C-SEWO method and created objective functions. By fusing the techniques of C-EWO and S-EWO (Squirrel Search Optimization), the suggested C-SEWO algorithm was developed (SSA). On top of that, the goal functions are calculated in terms of the variables like power, mobility, connection, distance, and link lifespan. Once a cluster has been selected, all its nodes will work together to create a Gabriel graph for an analogous cluster, update their neighbors' files, maintain graph connectedness, and control transmission power based on that connectivity. C-improved SEWO's connection, latency, energy, and average routing distance are all results of its innovative design.

A. Problem Statement

Most of the current methods, like [31–35], are geared at enhancing the NLT by the selection of the CH alone on a WSN network, while other studies, like [24–30], enhance the NLT via the use of solely CH selection. However, the suggested approach enhances the NLT on MANET by using CH and SCH choices, allowing for more efficient data transfer

III. PROPOSED METHODOLOGY

A. Energy-Efficient Data Transmission in MANET

The suggested method's primary goal was to deliver energy-efficient multiple-stage information transformation in MANETs. The use of TSR was influential in this work's early stage of CH selection. The best CHs were chosen in this approach based on the average cluster standby and available drive. The chosen CHs were given specific details from the isolated non-cluster nodes, which let us save time and avoid congestion. Consequently, the SCH uses the smallest amount of time and power possible to do this. It was picked using the LDHA from among the CHs who had already been voted on. After then, SCHs amassed the data collected from CHs, which was sent to the BS.

1) Cluster Head Selection Using TSR

Think about the range and the number of sensors. The sensor gathers data at the location and sends it to the base station. Grouping heads are chosen using the TSR service to reduce energy use, save time, and prevent failure at the network's nodes.

a) TSR algorithm

A novel meta-heuristic algorithm, TSR [36], is built on the social relationships between trees. This approach is population-based and iterative, with the starting population is constructed from a random assortment of trees, each representing a unique solution. Each tree in the jungle is designated to one of the K sub-zones, all of which have the same total population but do not overlap. In (1), where n is the total sum of trees and k is the number of sub-jungles, we can see how many individuals make up each sub-jungle, denoted by the symbol Zj.

$$Z_j = \frac{n}{k} \quad (1)$$

(2) depicts the number of seedling trees, or G, in each mini-forest, when percent of the best solutions are evaluated.

$$SD_j = Z_j * p_s \quad (2)$$

The pace of development is another criterion in the TSR algorithm. To create new solutions, the TSR algorithm combines the existing ones. The growth rate is calculated by dividing each produced solution's fitness by its parents' average fitness. Generally speaking, the larger the ratio, the faster the pace of expansion. A strong solution, or "seedling," grows at a rapid pace, as shown by (3), where and represent the first and second parents, correspondingly.

$$GR = \frac{fitness_{new}}{fitness_{p_1} + fitness_{p_2}} \quad (3)$$

Higher GR solutions are more likely to be chosen throughout the recombination process. Better answers are reinforced in this way. Equation (4) illustrates how, at each juncture, the average fitness of each mini-forest is determined.

$$zf_j = \frac{k \times \sum_{u=1}^{n} fitness_u}{n} \quad (4)$$

After calculating the average fitness of each of the sub-jungles, they are ranked from highest to lowest. Sub-jungles with more prominence are located higher on the list, while those with less prominence are located lower. As a result of the sub-jungles working together, several robust solutions travel from the more robust to the less robust. This rate, which is the proportion of migrating solutions, is denoted by . Exploration behavior and avoiding local optima may be achieved with the help of (5).

$$PT = 1 - \frac{zf_j}{\sum_{w=1}^{k} zf_w} \quad (5)$$

The range of the produced random number is 0 to R-1. If this value exceeds PT, the optimal solutions go from the robust to the vulnerable sub-jungle. Should that not be the case, the migration process will be skipped. To ensure that each mini-jungle maintains the same population, the most acceptable parenting practices from each family are chosen to pass on to their offspring. Proliferation, Proliferation-Seedling, and Layering are the three operators that make up the TSR algorithm. In the process of proliferation, two trees are merged back together while their fitness values are taken into account. A random seedling tree and a non-seedling tree merge to produce new solutions in the Proliferation Seedling operator. The and PSP parameters establish how many solutions participate in the Proliferation and Proliferation-

Seedling processes, respectively. A new solution is created with the Layering operator by mutating across a single tree. The fraction of trees that take part in this operator is denoted by the variable . The TSR is an iterative process that will continue until it encounters a situation that causes it to terminate. The closest SN nodes are used to create a cluster based on the CH [37].

B. Super Cluster Head Selection

Once the CHs have been picked, a super grouping head is chosen so that the network's lifetime and energy efficiency may be improved to their full potential. All CHs and SCHs are for data collection and transmission to BS. To choose SCHs, this article uses LDHA. The ideal CH is determined to reduce power consumption and extend the useful life of an SN used for data transmission. In this procedure, LDHA [38] initially tests the MANET nodes to choose the best nodes in each area to run as a cluster leader. The MANET nodes independently determine their strengths, concentrations, and centers. The LDHA is fed with these numbers as parameters.

1) Initializing Dolphins

The phase's goal is to equally disperse the group's members over the target function's domain. The number of dolphins (N) and the number of dimensions (D) of the search space are used to describe these two variables. From this, we may determine where the artificial dolphin I am located as

$$X_i = (x_{i1}, \dots, x_{id}, \dots . x_{iD})$$

$$x_{id} = x_{min} + rand \times (x_{max} - x_{min}) \tag{6}$$

Here is a uniformly distributed random sum in the range [0, 1], and x max and x min are the maximum and minimum allowable values for the search space.

2) Optimizing the Division of Labor

Anyone can play the role of "guide" in the dolphins' predatory environment. As a first step, everyone in the group is dispersed arbitrarily over the area. A "guide" will use echolocation to relay the food location to the others if one of them happens across any.

Once the dolphins have gathered enough data, they will create virtual teams and work together virtually. Define dolphin $X_j (j = 1,2,\dots,n)$ and dolphin $X_i \ (i = 1,2,\dots,n)$ to get the most precise optimization result possible. The next step is to create an ascending order of the distances between any two dolphins. Then, assign each player to a virtual team consisting of the m dolphins closest to them. Follow these steps to determine how far apart the two dolphins are:

$$X_{ij} = \sqrt{\overrightarrow{X_\iota - X_j} . \overrightarrow{X_\iota - X_j} (i, j \in 1,2, \dots . , n)} \tag{7}$$

Dolphins often travel in groups, and each group has its leader. The team leader is chosen by comparing the members with the highest individual scores. The LDHA algorithm selects a leader for each virtual team based on the optimal local value of the fitness function. It then iteratively generates a single leader for the whole herd. The leader of the herd is selected when the value reaches the maximum during the feeding process.

3) Information Distribution

Once a leader has been chosen, they may consult with the rest of the group to figure out where they will be most effective and how they might improve their fitness. This interaction may be accomplished repeatedly, allowing dolphins with exceptional qualities to gain quick social acceptance. Therefore, dolphins may approach food, gradually create an encirclement, and then prey in an orderly fashion under the top-down leadership of a leader because of the knowledge they share.

4) Group Subsequent and Rounding Up Food

When the leader hears that food is nearby, it uses echolocation to call the rest of the group to its location. An accurate location update is the most crucial part of the hunting procedure for regular members.

The i-th integer produced in the interval [0, 1] is less than that of (a predefined threshold). Otherwise, it must revise its position relative to the leader and collect food supplies accordingly. Here, we update the iteration using the pulse loudness and emission rate . As a rule, the intensity of the pulse diminishes, and the emission rate rises as the animal approach a food source. After catching its meal, the i-th dolphin will cease producing noise for a while if . The equations (8-9) for the pulse volume and emission rate are updated.

$$A^{t+1}(i) = aA^{t} \quad (8)$$
$$R^{t+1}(i) = R^{0}(i) \times [1 - \exp(-\gamma t)] \quad (9)$$

In the overhead formulas, a and y are constants $(1 < \alpha < 1, \gamma > 0)$. It is not difficult to find that as , the updated location Xit+1 can be calculated as

$$X_i^{t+1} = \begin{cases} Xi_i^t r_m < \theta \\ X_i^t + \varepsilon A^t(i) r_m < \theta \end{cases} \quad (10)$$

where denotes a D- random vector belonging to the interval [0,1] and denotes the pulse loudness at time .

It is possible that regular members may not find any food. So, after a successful hunt for food, the dolphins' locations are revised according to the following formula:

$$x_{id}^{t+1} = \begin{cases} x_{max} x_{id}^{t+1} > x_{max} \\ x_{min}\ x_{id}^{t+1} < x_{min} \end{cases} \quad (11)$$

After establishing its place as leader, the dolphin herd communicates with its followers to share its whereabouts and fitness rating, allowing everyone to alter their positioning accordingly. This is the only way for the herd to construct the encirclement in an organized fashion, improve the condition, and maximize the benefits of preying.

5) Food Distribution and States Retrieval

Following the formation of the encirclement, the dolphins share their current locations, restrict their search area, and collectively hunt. They do not get their meals withtheir credits. Instead, the dolphin, having reached the global and local apex of the encirclement, waits to wait for the gathering of the other dolphins before sharing in the prey. Dolphins are excellent predators because they can quickly return to their initial, random states in the predatory space when each step of the process is complete. The process flow of the LDHA is shown in Figure 1.

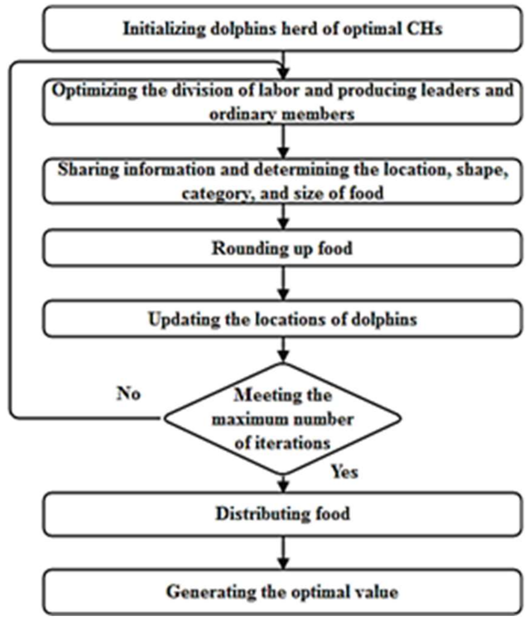

Fig. 1. Algorithm flowchart of LDHA

6) Calculation Stages of LDHA

Following the aforementioned dolphin-preying methodologies and algorithms, the LDHA computation processes are as follows:

Step 1: Let's get this pod of dolphins started. Set the maximum number of iterations to maxh and the total number of iterations to n. Supposedly (as shown by Eq. If we look at ((6)), we can set off a chain reaction by setting the starting points for dolphin locations.

Step 2: Find the best way to divide up the work. Use the distance calculation to create a virtual team for each dolphin, compare the fitness values of the various teams to determine where they should be placed, and finally, choose a leader for each team. Lastly, the ideal global value is calculated by averaging the fitness scores of all the groups from which the herd's commander is selected.

Step 3: Take the time to share your knowledge. Once in one place, the group's leader uses echolocation to gather data on nearby members' whereabouts and fitness levels. In the following phase, they can update their locations with the information they exchange.

Step 4: Retrieve all the food in the area. Eq. (11) is employed in international circumstances involving regular members, and (Eq. Group members' locations are iterated to create an encirclement and update their positions as necessary using (10).

Step 5: Move through the iteration cycle in a circle until you hit the limit. The loop should end after the condition has been met, and the data should be saved. In every other case, move on to the second step.

C. Routing

A good routing path to the BS is constructed among the SN once CHs and SCHs have been selected. Every CH periodically sends out a "Hello, message" to its immediate neighbors to fill out the neighbor table with information from other CHs. Within this greeting, you can find information on SCH HOP-Counts. Based on the minimal HOP-count value, the CH chooses the next HOP node. Equation (12) is used to determine the optimal number of hops between each of the target hubs

$$HOP_{min,i} = \{\min(HOP_j) j \in N_i\} + 1 \quad (12)$$

where $HOP_{min,i}$ = the neighbor CHs j with the fewest node.
Updated passages are gathered at the far end of the CHI's neighbor table in ascending requests following the hello bundle (NT). Next-door table information for CH1 is displayed in Table 1. The next CH will be the one that has the fewest hops. Figure 2 depicts CH4, CH6, CH13, and CH16 sending the data packet to CH18[39].

Table 1. CH1's Neighbor table.

Neighbor CHs of CH1	Hop Count
CH4	4
CH2	5
CH3	5

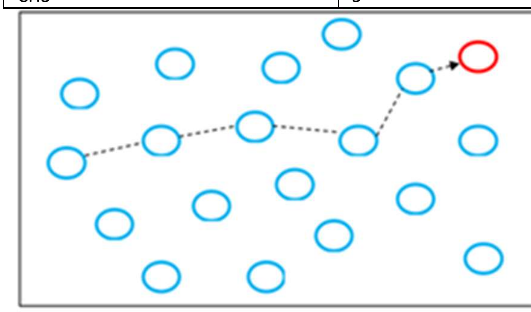

Figure 2. Hop-count-based efficient routing.

IV. RESULTS AND DISCUSSION

Here, we look at the findings of our research into a cluster-forming approach for use in MANETs to boost quality-of-service and energy metrics. The NS2 simulator was employed to do simulations of the proposed system. For the simulation, we took into account a 1000 m 1000 m area with 400 nodes and a transfer limit of 250 m—simulations of the suggested approach completed in less than half a minute. Here, we grouped the nodes and used the predetermined procedure to pick the cluster leader. Packet latency, delivery rate, energy consumption, efficiency, and NLT are just some of the metrics evaluated in this area, along with the overall success of the proposed method. The calculated results of our technique are displayed in Table 2. The IEEE 802.11 wireless standard was utilized in this virtual environment.

Table 2. Simulation strictures.

Parameter Name	Value
Communicate power	0.660 W
Receiving power	0.395 W
Initial energy	40 J
Simulation time	50 s
Packet size	512
Sum of nodes	400
Wireless protocol	802.11
Area	1000 × 1000

Transmission variety	250 m
Constant bit rate	500 kbps

A. Metrics for Evaluation

Delay, delivery rate, power, efficiency, and NLT were among the standard statistical characteristics used to evaluate the system's operation. The results were compared to pre-existing methods, including PSO, GA, and WOA, using several defined value indicators to gauge the system's efficacy.

Delay: This is the typical time it takes for a data packet to reach its destination. All delays due to support during disclosure delays are included, and the interface line is not broken. We may calculate this metric by deducting the time it took for the primary data bundle to arrive from when it was sent.

Delay Ratio: The number of data packets sent from the source node may be estimated using the packet delay rate. The packet loss rate is calculated using data collected by the destination node during transmission. It evaluates the efficiency of an estimate of their loss rate and level of accuracy. It is assumed that any network with a high packet delivery rate is reliable.

$$PacketDelayRatio = \sum Number\ of\ packet\ receive / \sum Number\ of\ packet\ send \quad (13)$$

Throughput: Performance can be seen as the number of constructed information packages by the destination during a data transfer or as the amount of data successfully sent over a specific date. In any network project, this statistic comprises the typical proportion of packets that arrive safely at their destination hub after passing through the source hub. Bit rates and byte rates are used to describe performance. Consistently excellent performance is the bedrock of every successful network.

B. Validation Analysis of proposed model

The existing techniques are considered and implemented with our simulation setting, then the results are averaged in the following figures 3 to 6.

The figure 3 represent the Analysis of PDR in comparison with different methods such as ACO, EECAO, C-SEWO, HAMBO, and TSR-LDHA with the proposed model, by these comparisons proposed model delivers better Analysis of PDR Comparison results than other methods.

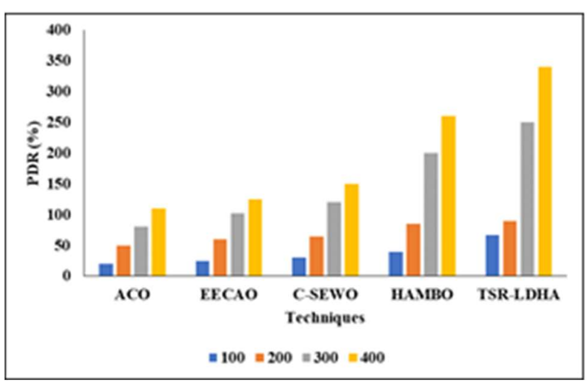

Figure 3: Assessment of various techniques in terms of PDR

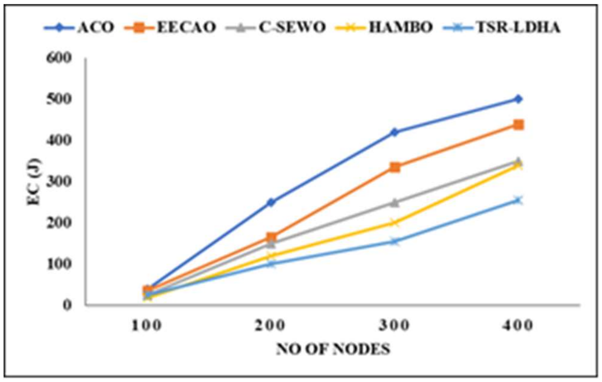

Figure 4: Graphical Representation of Energy Consumption

The figure 4 represent the Energy Consumption of different methods such as ACO, EECAO, C-SEWO, HAMBO, and TSR-LDHA with the proposed model; by these comparisons proposed model delivers better Energy Consumption results than other methods.

The figure 5 represent the Analysis of NLT Comparison of different methods such as ACO, EECAO, C-SEWO, HAMBO, and TSR-LDHA with the proposed model; by these comparisons proposed model delivers the better Analysis of NLT Comparison results than other methods.

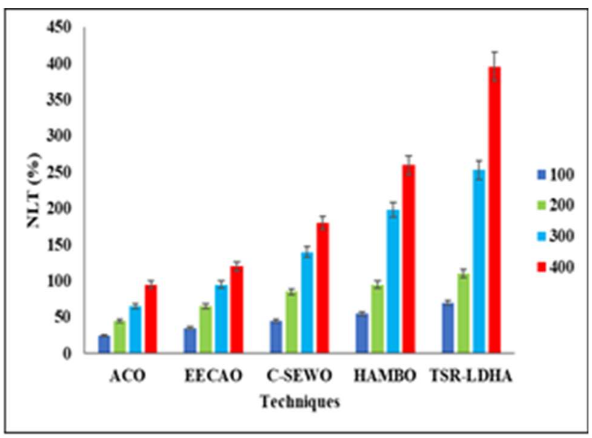

Figure 5: Description of NLT

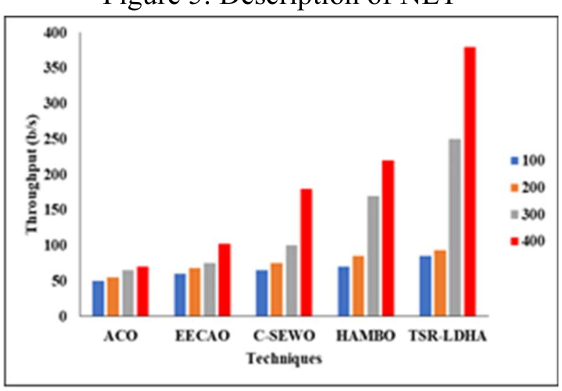

Figure 6: Throughput Comparison

In the above table 6 and Figure 6 represent the Throughput Comparison of different methods with the proposed model; by these comparisons proposed model delivers better Throughput Comparison results than other methods.

V. CONCLUSION

A MANET sends data between several nodes spread out along a path between the source and the destination. Recent years have seen significant growth in the study of how bio-inspired algorithms might be used to reduce the energy footprint of mobile ad hoc networks. The authors offer an optimization-based CH and SCH selection strategy for energy-efficient routing based on these findings. The approach presented here employs TSR and LDHA to address the issue of MANET's high energy usage. Using TSR and LDHA, the procedures for selecting CH and SCH candidates were developed and validated. To select CHs, a multi-objective function was also developed. Routing based on the number of hops between two nodes is a recent innovation. The suggested TSR-LDHA methodology's efficacy was measured across five dimensions: latency, energy consumption, network latency, network throughput, and network throughput ratio. A comparison was performed to show that the TSR-LDHA is superior to standard methods. The proposed strategy achieved a more effective result than previous approaches. MANETs are self-sufficient and are dispersed chaotically. Since there is no overarching authority and nodes are placed at random, the process is vulnerable to a wide range of security risks, such as a malicious attack in which a hacked node imitates healthy ones to fool them. An improved version of TSR-LDHA might be used to transport data in the future while keeping it secure.

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