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Peli-Remo Optimization Algorithm for Reliable routing in MANET: K-means node clustering process and CNN based Energy Prediction

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Abstract: MANET, an ad hoc wireless network is made up of several nodes connected, governed by certain rules for packet movement from one node point to another. The structure of communication may be designed using a variety of protocols. For an ad hoc network, routing protocols are used to manage the connections. It must manage several issues, including supporting mobile devices and reducing overhead when nodes only have access to a portion of the resources. In order to improve the communication, this article suggests an effective MANET cluster-based routing paradigm for multimedia communication. The clustering process is started using the K-means clustering method. The Deep Convolutional Neural Network (DCNN) model will first predict the node energy. The cluster head will be chosen using the Hybrid Remora with Pelicon Optimization technique (HRPOA), that integrates the Remora optimization technique and the Pelican optimization algorithm. Further, reliable retransmission will increase the communication's reliability.

Keywords—*Mobile Adhoc Wireless Network; K-Means Clustering; DCNN; HRPOA Model; Reliable Retransmission.*

Introduction

Ad hoc networks have significantly expanded around the world in recent years to offer wide area data access [7]. In order to attain accessibility and high data rates in the 5G network, automotive ad hoc networks were integrated. Due to challenges with their integration, including the lack of infrastructure, variety, and frequent link-state changes, only a small number of research have focused on integrating MANETs with the 5G network [8]. With relation to 5G communication, MANETs have received a lot of interest since they attained a higher data throughput & lower latency. The clustering of nodes facilitates communication between mobile nodes and speeds up data transfer. Cluster formation depends on CH selection. To achieve this, a dynamic topology-based CH selection method is proposed. Establishing a stable cluster in a mobile environment, including the MANET, is difficult because of connection losses among mobile terminals [9]. Using a modified stable clustering algorithm, the problem of frequent connection losses between mobile nodes is addressed. This approach considers the distance between mobile terminals. A stable clustering strategy is also used, which has been tweaked, with the backup node acting as a CH node.

Reactive and proactive routing protocols are two broad categories that encompass several effective ways for routing performance that have been presented [10]. Routes are found by the nodes in protocols based on reactive routing as necessary. The reactive routing method is used in the operation of the AODV protocol. As there is no centralized management in MANETs [11], routing techniques must rely on existing nodes cooperating with one another, supposing only dependable and trustworthy nodes. When a malicious node is present in a hostile environment, routing operations, including DoS assaults, are interrupted by initiating routing attacks [12] and blocking services to stop genuine nodes. Methods for resisting such malicious assaults have recently been developed, thanks to recent advancements in MANET research. The major focus of earlier efforts has been on leveraging a variety of techniques to guarantee secured routing performance for MANETs.

Integration of MANET with the Internet is a crucial step toward establishing global connection. Due to its lack of infrastructure, MANET has severe latency and poor data rates. By choosing the right gateway, MANET-Internet integration can get around these issues [13]. Gateway selection using bio-inspired techniques was offered to locate gateway nodes with a proactive approach [14]. Through optimization-based gateway selection, a PSO approach is employed to connect the MANET and Internet. connection quality and mobility are significant issues in MANET routing because of the frequent connection failures [15]. The intermediate nodes for packet routing to the destination are selected using the Q-learning approach based on the mobility measurements. By reducing the nonuniformity of the route, a route-availability metric-based node selection improves communication quality in routing. In MANET, packets are routed using a hierarchical routing system that takes link-oriented metrics into account [16]. However, MANET routing is the complex issue to be solved, hence this article aimed for the major contribution of:

- Introducing the concept of node energy prediction using the DCNN approach, which helps with the subsequent process of optimal routing.

- Suggesting the K-means clustering method for optimal clustering in MANET and the Hybrid Remora with Pelicon Optimization Algorithm (HRPOA) for choosing the cluster head.

The topics discussed in every section are listed below. A review on recent cluster-based routing in MANET papers are organized into Section 2. The framework of the novel cluster-based routing architecture of MANET is explained in Section 3. Section 4 presents the results and discussion. The article conclusion is provided in Section 5.

II.Literature Review

A. Related works

In 2019, Mani Kandan *et al.* [1] has presented significant possibilities for ad hoc network routing utilizing fuzzy hierarchical ACO routing since it was challenging to support the CH inside of a cluster in an ad hoc network. The three processes that make up the proposed FHACO protocol are Cluster's Gateway, ACO, and Fuzzy Rules for CH Selection Process. According to the results of the experimental research, fuzzy hierarchical ACO model yielded superior results for preserving the adaptability of the CH.

In 2019, Jamaesha *et al.* [2] has suggested "a secure location aware routing protocol" using the trustworthy ECC. The aforementioned study findings demonstrated that this procedure performed better outcomes than the existing method. The link to life duration was estimated sooner since the future location may be forecasted. The trust value was determined to determine whether a network has been compromised by a hostile node. ECC was used to encrypt the packets for data security. As a result, this technique's overall performance becomes more efficient.

In 2019, Satheeshkumar *et al.* [3] has introduced ACO-CBRP to provide an improved method for secured transmission. This method uses a suggested ACO-based strategy to cluster nodes, and the performance of the routing is depending on node's trust value. Further, the nodes with the necessary trust values allow the MANET's trust tables to be calculated in order to identify jellyfish assaults. The observed result demonstrates that the suggested ACO-CBRP strategy would perform better in reducing jellyfish assaults.

In 2021, Alghamdi *et al.* [4] has suggested a reliable 5G clustered MANET infrastructure based on zones. The goal of integrating the MANET was to increase data rate whereas lowering cost and delay with 5G communication. The GD gateway selection, stable zone-based clustering, interest-region-based routing, and adaptive buffer management were the four main procedures included in this paper. The outcomes show that the suggested strategy increases the metrics for throughput and PDR. It improved upon previous techniques like

AERP, MCQR, and M-AODV by 35% with respect to jitter, end-to-end delay, and PLR. Quite similarly Ara et.al [5] has demonstrated how cluster is setup and cluster head is selected for each cluster. Periodically the heartbeat of each cluster head is tested for the sufficient resources. If it does not respond it indicates that the energy level is low and before it leads to any failure the new cluster head is selected.

In 2023, Nirmaladevi *et al.* [6] has suggested a routing protocol to manage the existence of selfish nodes. The suggested SN-TOCRP created node groups via hierarchical clustering. The nature-inspired Fuzzy based CSA was employed to choose the CH. The authentication mechanism that will authenticate the CHs was implemented in order to detect selfish nodes. The suggested work improves throughput, PDR, energy consumption, end-to-end latency, and loss ratio, according to a thorough experimental analysis performed on the NS2 simulator.

III.FRAMEWORK OF NOVEL CLUSTER BASED ROUTING MODEL IN MANET

The two main components that make up the structure of this suggested HRPOA based MANET routing model are (i) Optimal cluster-based Routing and (ii) Reliable retransmission, and their graphical representation is illustrated in Fig. 1.

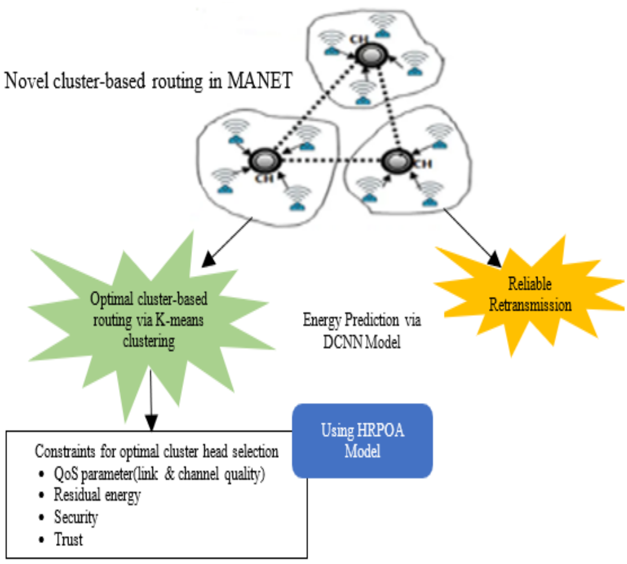

Fig 1:Proposed cluster based routing protocol in MANET

B. System Model

Assume that there are three different sorts of nodes that make up MANET:

- Advanced nodes ($Ad_1, Ad_2, Ad_3, ..., Ad_n$)
- Intermediate nodes ($I_1, I_2, I_3, ..., I_n$)
- Normal nodes ($N_1, N_2, N_3, ..., N_n$)

A DL technique is used to first anticipate these nodes' energy levels. In order to estimate the energy level for these nodes, a deep CNN model has been used. The deep CNN model is trained here with a few features or parameters, including the location, distance and type of nodes, for the aim of predicting the energy level in nodes.

- Location refers to a node's specific place in the network.
- Distance—The separation between a node and the base station.
- Three types of nodes are described as normal, intermediate, and advanced.

These restrictions are viewed as features with the following targets: 0, 1, and 2. Fig. 2 depicts the requirements for the network's energy level prediction.

```
if type of node = 'N'
        target = 0: energy = 0.5
if type of node = 'I'
        target = 1: energy = 0.8
if type of node = 'Ad'
        target = 2: energy = 1
```

Fig 2: Energy level prediction: Requirements

C. DCNN for Energy Prediction

In the suggested research, a DCNN [17] model is used for predicting the node's energy. Deep CNN is used in conjunction with convolution operation rather than matrix multiplication. Convolution, activation, pooling, and fully linked layers are the layers in deep CNN.

- **Convolution layer-** To identify the features of the input multimedia data, a convolution filter is used.
- **ReLU Activation layer-** In the convolution maps, the ReLU Activation layer substitutes 0s for the filtered multimedia data's negative values.
- **Pooling layer-** By maintaining just the most crucial data, the pooling layers steadily minimize the quantity of the data. For each group of four data, for example, either the highest value is retained (max pooling) or just the average is retained (average pooling). Pooling layers assist in the control of overfitting by reducing the number of calculations and parameters in the network.

After several convolution and pooling layer rounds (this may occur thousands of times in certain DCNN topology), the network concludes with a traditional multi-layer perceptron or "fully connected"NN.

- **Fully connected layer-** CNN systems often have several completely connected layers sandwiched between the activation and pooling layers. After being corrected, filtered, and minimized through pooling and convolution layers, the multimedia data that has been flattened is introduced into this layer. The outputs are then subjected to the softmax algorithm.

D. Optimal cluster based routing using K-means clustering

K-means clustering technology is employed to carry out the clustering procedure. K-means clustering [18] is a useful clustering technique, particularly in MANET owing to its simple implementation and quick convergence. However, there are several restrictions, including fixed cluster heads and members and an uneven distribution of nodes within clusters.

The most significant flat clustering algorithm is K-means. The average squared Euclidean distance from their cluster centers is what it seeks to reduce. K-means' first step is to choose K as the initial cluster centers. The method uses a straightforward process to sort out a certain data group via predetermined clusters quantity. The key idea is to identify k centroids, each of which corresponds to the single cluster.

The location of these centroids should minimize the algorithm's objective function. A squared error function has been designated as an objective function. The following is an explanation of a square error function:

$$J = \sum_{j=1}^{k}\sum_{i=1}^{n}\left|x_i^{(j)} - c_j\right|^2 \qquad (1)$$

Where, $\left|x_i^{(j)} - c_j\right|$ denote distance measure between a node location $x_i^{(j)}$ and c_j centre of cluster . It really determines the overall distance between each node's location and the center of its associated cluster.

The K-means algorithm will be used as follows:

1. Choose K nodes to be placed in the area where the clustered items are demonstrating. The original group centroids were these nodes.

2. Assign each item to the set containing the centroid that is closest to it.

3. Determine where the K centroids are once all the items have been assigned.

4. Repeat Steps 2 and 3 as necessary until the centroids stop moving. The items are divided up into clusters throughout this procedure, from which the criteria for minimization can be repeated.

E. Constraints for Optimal CH Selection

The optimal cluster head is then chosen for the ideally formed clusters created utilizing the K-means clustering approach. Utilizing certain nodal factors including QoS parameters, residual energy, security, and trust, the cluster heads are chosen in the best possible way.

1. QoS Parameters

When regulating PLR, delay, and flapping in multimedia transmission, QoS is employed to provide different priorities to different traffic. Link quality and channel quality are the main two QoS metrics mentioned in the paper.

(i)Link Quality

This parameter is checked via PLR, a performance measure. If the value of PLR is low then the link quality of the multimedia communication is good. Or else the quality of the link is worse. It is determined as per Eq. (2).

$$PDR = \frac{D_{pac}}{S_{pac}} \qquad (2)$$

where, $D_{pac} \rightarrow$ the qunatity of multimedia data packets received at the destination without any data loss, and the count of multimedia data packets transmitted by sender is denoted as S_{pac}.

(ii) Channel Quality

It defines channel availability during multimedia data transmission. In a channel, interference measuring utilizes resources for ensuring reliable multimedia communication. By the allocation of on-the-fly resources in the network, latency is reduced with the help of channel quality.

$$CQ = T_b \times R_b \left(\frac{\lambda}{4\pi d} \right)^2 \qquad (3)$$

where, T_b and R_b are the gains obtained transmitter and receiver ends. The distance among the source node & destination node is indicated by d and λ denotes the signal wavelength.

2. Residual Energy

In MANET, the energy depletion of a node is taken place in each state and the sum of depleted energy is to be residual energy of the node. It is expressed in Eq. (4) in which E_{IN} is initial energy and E_C is consumed energy.

$$RE = E_{IN} - E_C \qquad (4)$$

3. Security

Initially, the security of each node in MANET is allocated randomly with ranges from 0.7 to 0.8 which is mathematically expressed in Eq. (5) here, $y = \{1,2,3,...m\}$ and sum of multimedia nodes is m.

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$$s(y) = (CH)_s - (m_y)_s \quad (5)$$

The risk of each node in MANET is evaluated as per security allocation. The conditions utilized for this allocation is expressed as follows.

$$\begin{aligned}
&if \quad s(y) \le 0 \\
&\quad Risk = 1 \\
&else\ if \ \ 0 < s(y) \le 1 \\
&\quad Risk = 1 - e^{[-3/2 * s(y)]} \\
&else\ if \ \ 0 < s(y) \le 2 \\
&\quad Risk = 1 - e^{[-1/2 * s(y)]} \\
&else \\
&\quad Risk = 0
\end{aligned} \quad (6)$$

Therefore, security of node is allocated by 1-Risk i.e. $s(y) = 1 - Risk$.

4. Trust

It is the degree of reliability about other node to perform specific action by tracking all past node interactions through indirect or direct observations.

$$Tr = W \times DI.Tr_{(A-B)} + (1 - W) \times ID.Tr_{(A-B)} \quad (7)$$

Where, $DI.Tr_{(A-B)} = \frac{E}{d(A,B)}$ and $ID.Tr_{(A-B)} = \sum DI.Tr_{(A-G)} \times DI.Tr_{(G-B)}$. The energy and distance of the nodes are E and d and the A, B and G are the nodes.

F. Objective function

The objective of the suggested HRPOA algorithm for optimal CH selection is to minimize the fitness defined. The mathematical expression of HRPOA approach's objective function is expressed in Eq. (8).

$$\begin{aligned}
HRPOA_{Fitness} &= w_1 * (1 - RE) + w_2 * (1 - Tr) \\
&+ w_3 * (1 - s) + w_4 * PLR + w_5 * (1 - CQ)
\end{aligned} \quad (8)$$

Where, the weights are represented as w_1, w_2, w_3, w_4 and w_5; it is evaluated by an expression $w_z = \frac{constra\text{int}\ s(z)}{sum\ of\ \ constra\text{int}\ s}$ where, $\sum w_z = 1$.

G. Solution Encoding

The optimal solution, or optimal CH is chosen by setting a node's lower limit as "0" and its upper bound as the "number of nodes n under each K-means-based optimal clusters" in the proposed HRPOA method. Problem size, pop size, and iteration are all set to 10, 10, and 25 as their respective numbers.

For example,

i. Initialize problem size as 5.

ii. If the solutions or cluster heads are [10, 5, 2, 6, 11].

iii. Then the clusters 1, 2, 3, 4 and 5 formed by K-means technique has optimal cluster heads as 10th, 5th, 2nd, 6th and 11th respectively.

iv. Which means, if the optimal cluster 1 formed by a K-means technique then its optimally selected cluster head is 10th node and its node ID is 20.

H. Optimal task scheduling process via HRPOA model

Although it provides the optimal results, the conventional POA [19] approach is unreliable. In order to address the problems in standard POA, the HRPOA technique is used in this article. The POA and ROA [20] models are merged to create the HRPOA model. A portion of the inhabitants of the POA are pelicans. Every individual in the population suggests a potential answer for population-based algorithms. Each participant inputs a value on the available search space for each variable in the optimization issue. The population's members are typically initialized as random first. The population's initialization is determined using Eq. (9), according to the HRPOA model. Here, the initial random initialization procedure of population is replaced with the logistic sine chaotic map LS .

$$h_{u,v} = K_v + LS(P_v - Q_v),\ u = 1,2,...H, v = 1,2...M$$

(9)

In Eq. (9), $LS \rightarrow$ logistic sine chaotic map, H denotes population member count, $h_{u,v}$ is v^{th} variable attained through candidate of u^{th} solution, M is the count of problem variable, P_v and $Q_v \rightarrow$ v^{th} upper & lower bounds of issue variables.

$$LS_{l+1} = r.LS_l(1 - LSl) + \frac{\sin(\pi LS_l)}{2}.\mathrm{mod}(1) \quad (10)$$

Here, LS_l is randomly generated number sequence $\in (0,1)$, and $r = 2$. Logistic sine chaotic map provide higher performance and attained better random distribution. The population matrix is determined in Eq. (10).

$$U = \begin{bmatrix} U_1 \\ \cdot \\ \cdot \\ U_u \\ \cdot \\ \cdot \\ U_H \end{bmatrix}_{H\times M} = \begin{bmatrix} g_{1,1} & \cdots & g_{1,v} & \cdots & g_{1,M} \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ g_{u,1} & \cdots & g_{u,v} & \cdots & g_{u,M} \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ g_{H,1} & \cdots & g_{H,v} & \cdots & g_{H,M} \end{bmatrix} \quad (10)$$

Here, $U \rightarrow$ pelicans population matrix and $U_u \rightarrow u^{th}$ pelican. Eq. (11) determine the objective function values.

$$f = \begin{bmatrix} f_1 \\ \cdot \\ \cdot \\ f_u \\ \cdot \\ \cdot \\ f_H \end{bmatrix}_{H\times 1} = \begin{bmatrix} f(U_1) \\ \cdot \\ \cdot \\ f(U_u) \\ \cdot \\ \cdot \\ f(U_H) \end{bmatrix}_{H\times 1} \quad (11)$$

where $f_u \rightarrow$ objective function value of u^{th} candidate solution and $f \rightarrow$ objective function vector.

This hunting method involves two steps:

(i) Exploration phase

(ii) Exploitation phase

Exploration Phase:

Prior to flying in that way, pelicans first search for their prey. By imitating the pelican's tactical strategies, the recommended POA's exploration power and search space scanning are useful. Eq. (12) incorporates both the pelican's method and the topics previously covered.

$$g_{u,v}^{a_1} = \begin{cases} g_{u,v} + ran(a_v - V.g_{u,v}), & Z_a < Z_u; \\ g_{u,v} + ran(g_{u,v} - a_v), & else \end{cases} \quad (12)$$

In Eq. (16), V $\rightarrow$ arbitrary number that was equivalent to 1 or 2, a_v $\rightarrow$ prey location at v^{th} dimension, $g_{u,v}^{a_1}$ $\rightarrow$ new position of u^{th} pelican in the v^{th} dimension, and Z_a $\rightarrow$ value of objective function.

A pelican could change its location if its goal is achieved. Eq.(13) serves as the process' POA paradigm.

$$g_u = \begin{cases} g_u^{a_1}, & Z_u^{a_1} < Z_u; \\ g_u, & else \end{cases} \quad (13)$$

In Eq. (13), $Z_u^{a_1}$ $\rightarrow$ objective value in this phase & $g_u^{a_1}$ $\rightarrow$ novel position of u^{th} pelican.

Adopted Exploitation phase:

Traditionally, Eq. (14) employs mathematics to simulate pelicans' hunting activity.

$$g_{u,v}^{a2} = g_{u,v} + F\left(1 - \frac{t}{\hat{T}}\right).(2.ran - 1)g_{u,v} \quad (14)$$

In accordance with the PDPOA paradigm, the pelican position is updated by integrating Eq. (14) and remora Eq. (15).

$$g_{u,v}^{a2} = V * e^{\alpha} * \cos(2\pi\sigma) + g_{u,v} \quad (15)$$

By reformatting Eq. (15)

$$g_{u,v} = g_{u,v}^{a2} - V * e^{\alpha} * \cos(2\pi\sigma) \quad (16)$$

Substitute Eq. (16) in Eq. (14)

$$g_{u,v}^{a2} = \left[g_{u,v}^{a2} - V * e^{\alpha} * \cos(2\pi\sigma)\right] + F\left(1 - \frac{t}{\hat{T}}\right). \quad (17)$$
$$(2.ran - 1).\left(g_{u,v}^{a2} - V * e^{\alpha} * \cos(2\pi\sigma)\right)$$

$$g_{u,v}^{a2} = g_{u,v}^{a2} - V * e^{\alpha} * \cos(2\pi\sigma) + F\left(1 - \frac{t}{\hat{T}}\right). \quad (18)$$
$$(2.ran - 1)g_{u,v}^{a2} - \left(F\left(1 - \frac{t}{\hat{T}}\right).(2.ran - 1).V * e^{\alpha} * \cos(2\pi\sigma)\right)$$

$$g_{u,v}^{a2} - g_{u,v}^{a2} - F\left(1 - \frac{t}{\hat{T}}\right).(2.ran - 1)g_{u,v}^{a2} =$$
$$-V * e^{\alpha} * \cos(2\pi\sigma) - F\left(1 - \frac{t}{\hat{T}}\right)(2.ran - 1).V * e^{\alpha} * \cos(2\pi\sigma) \quad (19)$$

$$-F\left(1-\frac{t}{\hat{T}}\right).(2.ran-1)g_{u,v}^{a2}=$$
$$-\left[V*e^{\alpha}*\cos(2\pi o)+F\left(1-\frac{t}{\hat{T}}\right).(2.ran-1).V*e^{\alpha}*\cos(2\pi o)\right] \quad (20)$$

$$F\left(1-\frac{t}{\hat{T}}\right)(2.ran-1)g_{u,v}^{a2}=$$
$$\left[V*e^{\alpha}*\cos(2\pi o)\left[1+F\left(1-\frac{t}{\hat{T}}\right).(2.ran-1)\right]\right] \quad (21)$$

$$g_{u,v}^{a2}=\frac{\left[V*e^{\alpha}*\cos(2\pi o)\left[1+F\left(1-\frac{t}{\hat{T}}\right).(2.ran-1)\right]\right]}{F\left(1-\frac{t}{\hat{T}}\right).(2.ran-1)} \quad (22)$$

Where, $V=\left|g_{best}-g_{u,v}\right|$ (23)

$$o=-\left[1+\frac{t}{\hat{T}}\right] \quad (24)$$

$$\alpha=rand*(o-1)+1 \quad (25)$$

Here, t $\rightarrow$current iteration, $g_{u,v}^{a2}$ $\rightarrow$new position in v^{th} dimension of u^{th} pelican in this phase, F $\rightarrow$constant value as 0.2, $\hat{T}$ $\rightarrow$maximum iterations count, & $F\left(1-\frac{t}{\hat{T}}\right)$ $\rightarrow$neighbor radius of $g_{u,v}$.

The new pelican location is supplied in Eq. (26), which is followed by either rejection or acceptance by updating the new pelican location g_u^{a2} and objective value $Z_u^{a_2}$.

$$g_u=\begin{cases} g_u^{a2}, & Z_u^{a_2}<Z_u; \\ g_u, & else \end{cases} \quad (26)$$

The pseudo-code of HRPOA model is determined in algorithm 1.

ALGORITHM 1: HRPOA approach
Input the optimization problem.
Determine the population size (PS)&iterations count (it)
Initialization of Population
For $t=1:\hat{T}$
As per HRPOA model, the population initizationalization is determined using *logistic sine chaotic map* LS as per Eq. (9), .

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	For $V=1:H$		
	Phase 1: Exploration phase		
		For $v=1:M$	
			The update of v^{th} dimension is given in Eq. (12).
		End.	
		The update of u^{th} population member is given in Eq. (13).	
	Phase 2: Exploitation phase		
		For $v=1:M$	
			In PDPOA model, the u^{th} dimension of pelican is determined using Eq. (22).
		End	
		The update of u^{th} population member is determined in Eq. (26).	
	End.		
	Best candidate solution		
End.			
Return			

3.3 Reliable Retransmission

The next phase of this proposed work is providing multimedia data retransmission with enhanced transmission reliability. Usually in wireless networks, the technique of data retransmission is used to improve reliability in data communication. Consider data reliability for each node is *re*, each node's configuration metric is X and the arbitrary nodes in MANET is *n*. The data packets transmitted from the node q to the node p might be follow three conditions and are

i. Packet loss due to correctly not received packet in the node p.

ii. The node q send ACK packet loss to node p but the packet transmitted to the node p is correctly received from the node q.

iii. The data packet send by the node q is received correctly to node p and the node q also received the node p's ACK packet.

The data retransmission between nodes is stopped immediately, if the node x received the ACK packet. While in other two cases, the node q continues the process of retransmission to achieve maximum retransmission times. The maximum retransmission times is denoted by $n_{(X,q)}$.

$$n_{(X,q)} = \frac{\log(e_q)}{\log(1-re_q)}$$

(27)

IV.RESULTS & DISCUSSIONS

I. Simulation setup

The adopted HRPOA model with cluster based routing protocol in MANET was simulated in PYTHON version 3.7, and the outcomes were verified. Moreover, the processor is “11th Gen Intel(IR) Core(TM) i5-1135G7 @ 2.40GHz 2.42 GHz” and the installed RAM size is "16.0 GB (15.7 GB usable).

J. Comparitive Analysis

The HRPOA approach was compared to BWO, GWO, BA, POA, and ROA in order to confirm that it is an effective MANET routing protocol. Additionally, the research took other factors like trust, PDR, and channel quality into consideration. Additionally, the statistical analysis, and error analysis were carried out.

BWO is an optimization problem-solving swarm-based metaheuristic algorithm inspired by beluga whale behavior. Three phases of exploration, exploitation, and whale fall are established by BWO based on the behaviors of pair swim, prey, and whale fall, respectively. Grey wolves served as the inspiration for the new meta-heuristic GWO. Using the GWO algorithm, the leadership structure and hunting tactics of grey wolves in the wild are modeled. The HRPOA approach was compared to BWO, GWO, BA, POA, and ROA in order to confirm that it is an effective MANET routing protocol. Additionally, the research took other factors like trust, PDR, and channel quality into consideration. Additionally, the statistical analysis, and error analysis were carried out.

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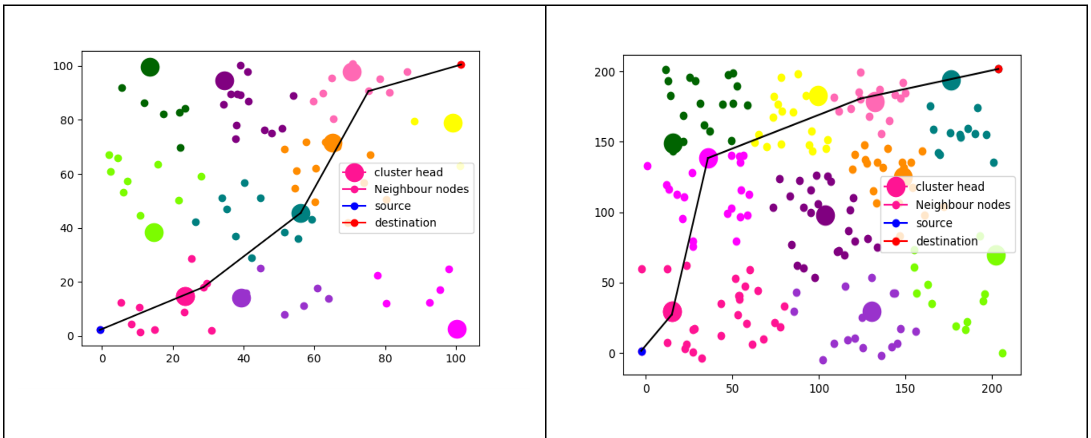
ROA is a novel bionics-based meta-heuristic algorithm that draws inspiration from nature. The main idea for ROA came from the parasitic behaviour of remora. Various hosts update various places: By consuming the host's ectoparasites or wrecks in certain enormous hosts, such as enormous whales, remora avoids its inherent enemies. The simulation configuration for (a) 100 nodes and (b) 200 nodes is shown in Fig. 3.

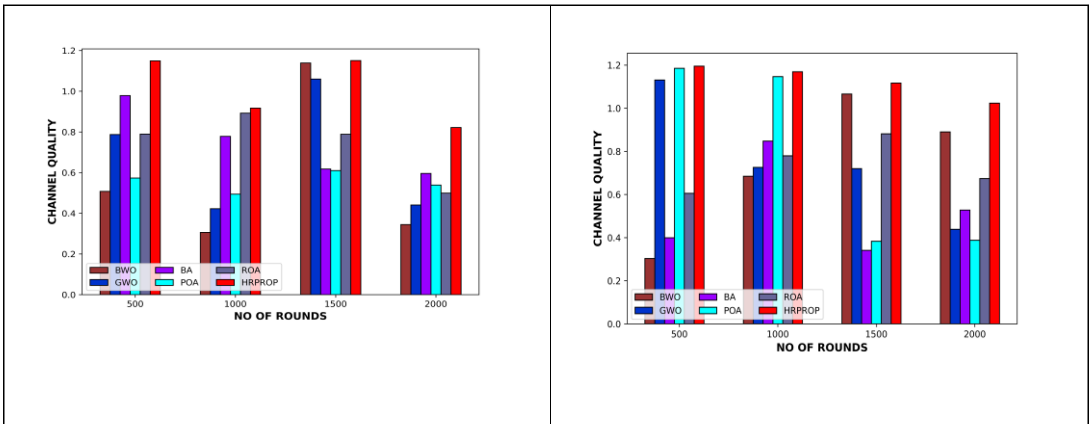


(a) (b)

Fig. 1. Simulation setup for (a) 100 node, & (b) 200 node

K. Channel Quality evaluation on HRPOA and extant schemes for cluster based Routing protocol

The analysis on channel quality of HRPOA scheme is compared over extant models including BWO, GWO, BA, POA, and ROA for cluster based Routing protocol in MANET is exposed in fig 4. Moreover, it is assessed under two varied types of nodes (100 and 200) while altering the number of rounds (500, 1000, 1500 and 2000). For optimal MANET routing, the HRPOA model should attain greater channel quality ratings. In particular, the channel quality of the HRPOA model for number of round 500 is ~1.56, whereas the traditional strategies acquired least channel capacity like BWO =~0.5, GWO =~0.78, BA =~0.98, POA =~0.57, and ROA=~0.78, correspondingly. Similarly, for node 200, the HRPOA model accomplished the highest channel quality rating than the previous strategies for number of round 2000. Thus, the HRPOA model uses K-means clustering-based optimal cluster routing to ensure trustworthy in MANET while also providing excellent channel quality during data transfer.

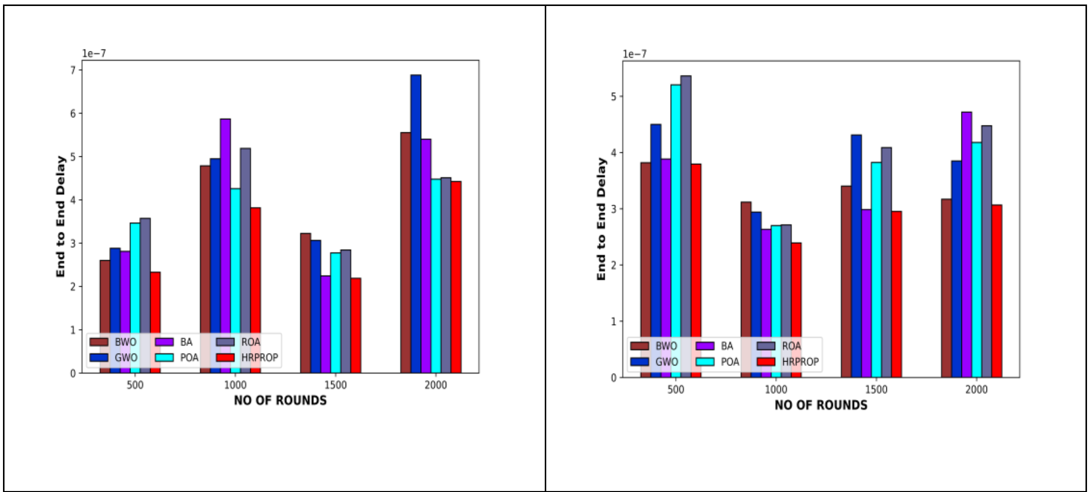


(a) (b)

Fig 4: Analysis on channel quality of HRPOA scheme and previous methods for a) 100 Nodes and b) 200 Nodes

L. End to End Delay analysis on HRPOA scheme and conventional schemes for cluster based Routing protocol in MANET

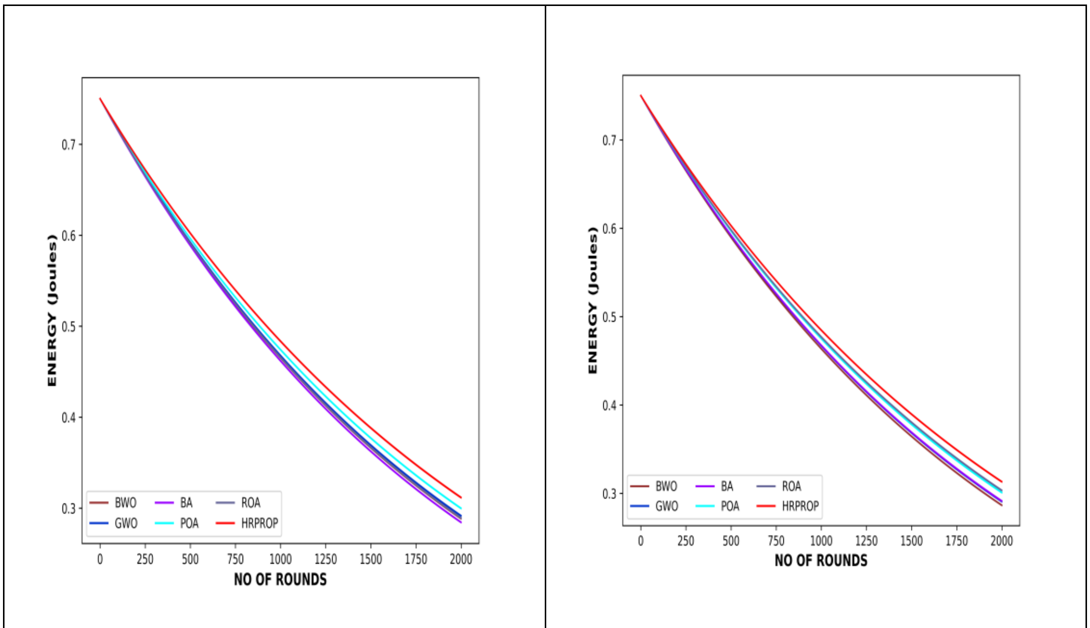
Fig 5 explains the end-to-end delay analysis on HRPOA scheme over previous models like BWO, GWO, BA, POA, and ROA for cluster based routing protocol in MANET. Here, it is analyzed for distinct types of nodes while modifying the number of rounds with lower end to end delay for the optimal MANET routing protocol. Moreover, the HRPOA scheme yielded the lowest end to end delay of 3.8×1e-7 at the round 1000 (Node=100), whilst the previous models like BWO, GWO, BA, POA, and ROA scored the highest end to end delay ratings. Likewise, the HRPOA scheme holds minimum 2.5×1e-7 over previous models like BWO, GWO, BA, POA, and ROA for cluster based routing protocol in MANET. Using the K-means clustering and DCNN for optimal cluster based routing during packet transmission, the HRPOA reduced end-to-end delay among the source & destination.



(a) (b)

Fig 5: Analysis on End to End delay of HRPOA scheme and traditional methods for a) 100 Nodes and b) 200 Nodes

M. Energy assessment on HRPOA scheme and conventional schemes The energy examination on HRPOA scheme is contrasted with the extant schemes like BWO, GWO, BA, POA, and ROA for cluster based routing protocol in MANET is shown in fig 6. Further, the energy rate should be higher for the effective MANET routing. Similarly, the HRPOA scheme as well as the extant algorithms acquired the greatest energy value at the initial (0th) round, still the rounds get increased as the energy values get dropped. Whatever, the HRPOA scheme achieved the highest energy value even at the final (2000) round. When examining the fig 6(a), the BA scheme recorded the minimized energy rate from the 0th to 2000th round. Further, the HRPOA scheme the maximal energy of 0.35J at the round 2000, whilst the BWO, GWO, BA, POA, and ROA, correspondingly holds minimal energy. Thereby, the HRPOA scheme has asserted its supremacy for cluster based routing protocol in MANET with higher energy level in all rounds

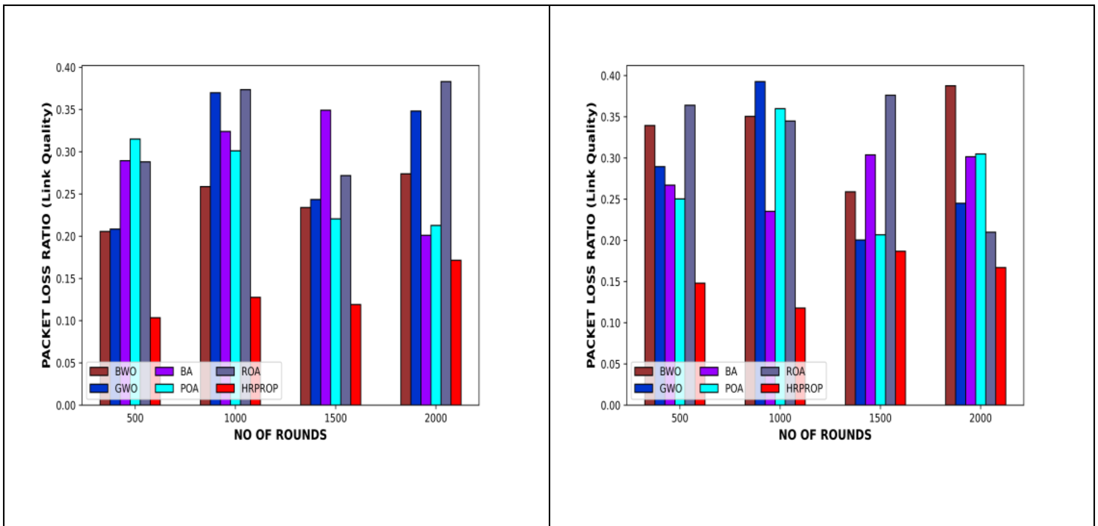


(a) (b)

Fig 6: Validation on energy of HRPOA scheme and traditional methods for a) 100 Nodes and b) 200 Nodes

N. Link quality analysis on HRPOA scheme and conventional schemes for cluster based Routing protocol in MANET

The estimation on HRPOA scheme as well as the established methodologies regarding link quality metric (packet loss ratio) for cluster-based Routing protocol in MANET is exhibited in fig 7. Moreover, the link quality metric is evaluated via Packet Loss Ratio. Here, the packet loss is lowered thereby, the link quality is enhanced. Here, the HRPOA scheme gained the packet loss ratio of 0.10 at the round 500, even though the BWO, GWO, BA, POA, and ROA correspondingly hold higher packet loss ratio values. The HRPOA scheme uses K-means clustering with DCNN for optimal cluster-based routing and thus substantially minimum the packet loss ratio.

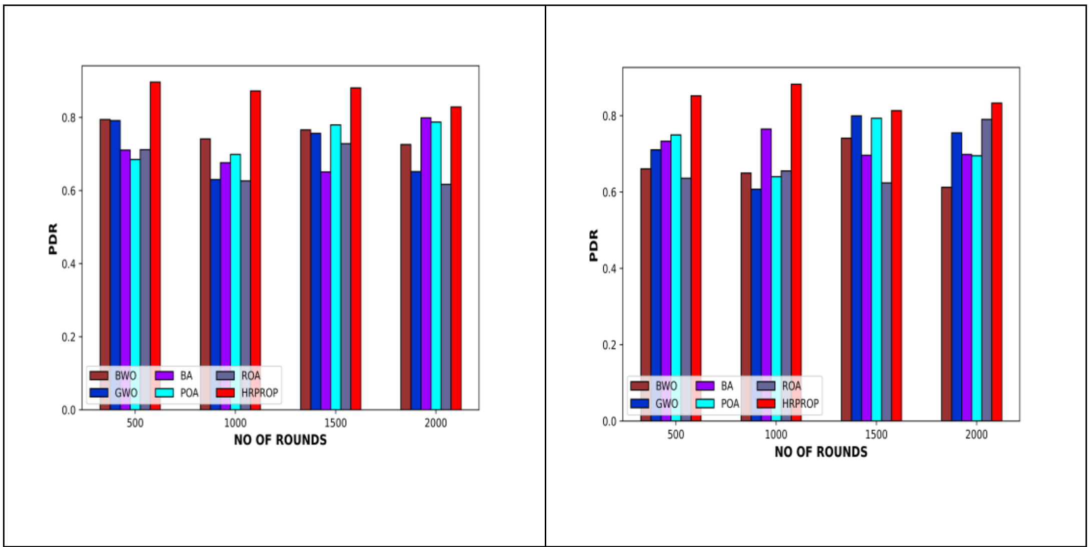


(a) (b)

Fig 7 Analysis on Link Quality of HRPOA scheme and traditional methods for a) 100 Nodes and b) 200 Nodes

O. PDR evaluation on HRPOA scheme and conventional schemes

Fig 8 show the PDR evaluation of HRPOA scheme over the conventional approaches for efficient cluster based routing protocol in MANET. Here, more number of packets has been delivery by the HRPOA scheme than the conventional methodologies. Particularly, at the round 1500, the PDR using the HRPOA scheme is 0.90, whilst the BWO, GWO, BA, POA, and ROA acquired minimized packet delivery ratio. Thus, the worst PDR is attained using the BWO, GWO, BA, POA, and ROA algorithm at the node 200 for number of rounds 1000. However, the HRPOA scheme scored the greatest packet delivery ratio in the entire round. The best cluster-based routing is necessary for transferring data to the appropriate MANET node, and the HRPOA scheme assure a higher PDR than conventional approaches.

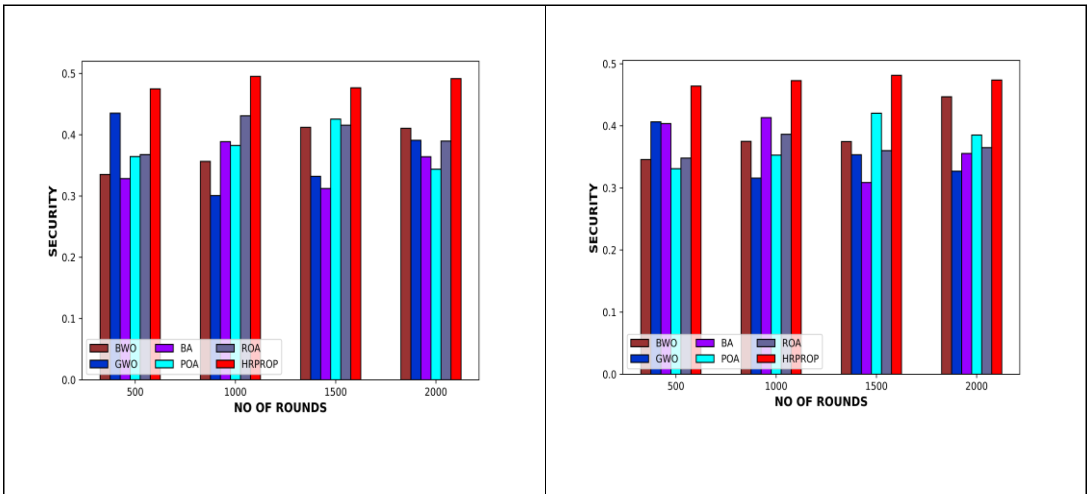


(a) (b)

Fig 8: Validation on PDR of HRPOA scheme and traditional methods for a) 100 Nodes and b) 200 Nodes

P. Evaluation on Security of HRPOA scheme and conventional schemes

The security evaluation on HRPOA scheme is illustrated in fig 9. Further, the analysis on security is done for distinctive number of nodes while modifying the rounds (500-2000). Retransmission has become more reliable once the security rates have increased. Moreover, the HRPOA scheme offered higher security ratings over the conventional methodologies. In addition, round=1500, the HRPOA scheme generated the higher security rate of 0.48, even though the BWO, GWO, BA, POA, and ROA scored lesser security value for node 200. Similarly, for node (100), the HRPOA scheme yielded the best security rate at the 1000th round than the BWO, GWO, BA, POA, and ROA correspondingly. The HRPOA scheme enhances the higher security while the data transmision in MANET by reducing the risk rates.

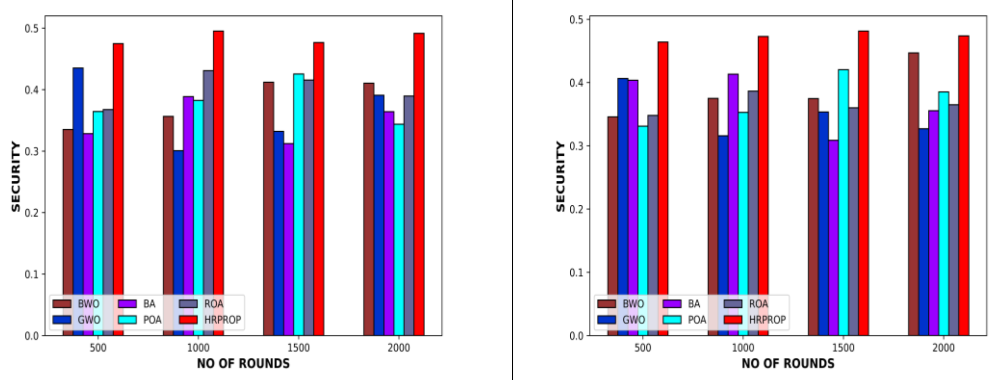


(a) (b)

Fig 9:Validation on security of HRPOA scheme and traditional methods for a) 100 Nodes and b) 200 Nodes

Q. Trust evaluation on HRPOA scheme and conventional schemes

The assessment on HRPOA scheme over established strategies regarding trust for cluster based routing protocol in MANET is depicted in fig 10. The cluster based routing protocol in MANET is assessed over the BWO, GWO, BA, POA, and ROA. Moreover, the trust rate ought to be higher for the effective MANET routing performance. Mainly, at the round 2000, the HRPOA scheme yielded the greatest trust rate i.e. greater than 0.32 (node=100), this is superior to BWO, GWO, BA, POA, and ROA. Furthermore, the HRPOA scheme obtained maximal trust rates over the established algorithms at the round 500 in node 200. The HRPOA scheme indicates that the trust value has increased over the existing approaches, resulting in a decrease of dead nodes.



(a)	(b)

Fig 10: Validation on Trust of HRPOA scheme and traditional methods for a) 100 Nodes and b) 200 Nodes

R. Statistical Analysis of HRPOA scheme and conventional schemes

Tables I and II presents the statistical analysis of the proposed HRPOA scheme computed using the existing methods based on fitness. Because of their stochastic nature, meta-heuristic algorithms may be used to continually test if the defined aim has been reached. In the worst-case scenario, the chosen HRPOA strategy outperformed other traditional approaches, such as the BWO, GWO, BA, POA, and ROA model for node 100, by 0.352 better values in the best (max) case scenario. In the mean case scenario for node 200, the proposed HRPOA model achieves (0.350) with more accurate results when compared to other standard methods like BWO, GWO, BA, POA, and ROA model. Thus, the HRPOA model has demonstrated better cluster based routing in MANET with k-means clustering and DCNN concept

TABLE I. STATISTICAL ANALYSIS FOR 100 NODE BASED ON FITNESS: ADOPTED VS. PREVIOUS MODELS

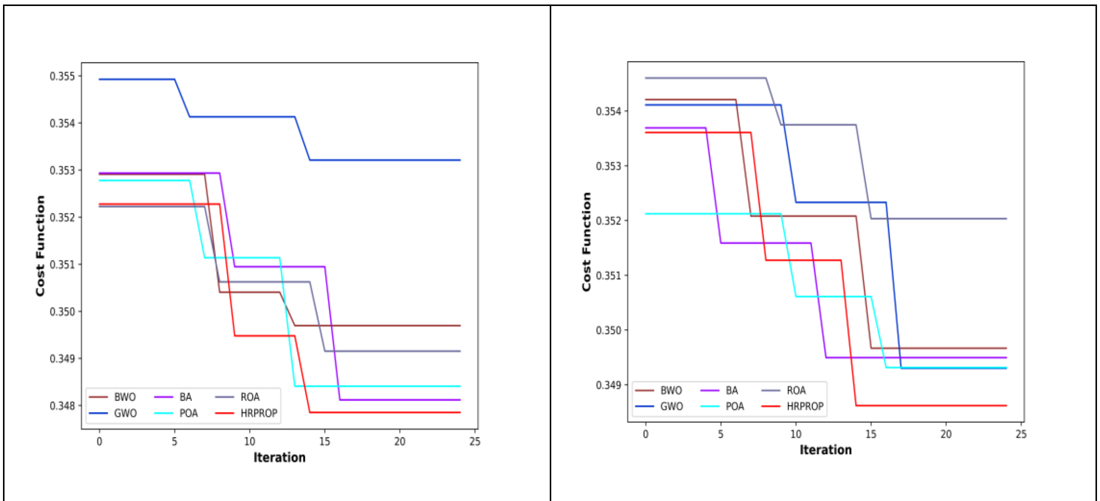
Metrics	BWO	GWO	BA	POA	ROA	HRPOA
Min	0.349696	0.35321	0.348118	0.348409	0.349153	0.347851
Max	0.352909	0.354926	0.352933	0.352778	0.352223	0.352276
Mean	0.350866	0.353917	0.350643	0.350287	0.350547	0.34977
Median	0.350404	0.35413	0.350947	0.351136	0.350624	0.349478
SD	0.001427	0.000692	0.002052	0.001898	0.001295	0.001974

Table II Statistical analysis for 200 node based on fitness: adopted vs. previous models

Metrics	BWO	GWO	BA	POA	ROA	HRPOA
Min	0.349668	0.349302	0.349496	0.349315	0.352034	0.348619
Max	0.35421	0.354111	0.353692	0.352124	0.354602	0.353606
Mean	0.351712	0.352074	0.350921	0.35075	0.35337	0.350852
Median	0.35208	0.352333	0.349496	0.350611	0.353748	0.351274
SD	0.001861	0.002034	0.001648	0.001225	0.001138	0.00216

S. Convergence Analysis

Fig 11 presented the convergence evaluation of HRPOA scheme over other previous models like BWO, GWO, BA, POA, and ROA model while adjusting the iterations (0-25). Here, the cost rate ought to be lowered with better convergence. The HRPOA scheme and the existing schemes both achieved the lowest cost rate from the first iteration; however, as the number of iterations increased, the cost rate increased. The HRPOA strategy provided the lowest cost value. The HRPOA scheme also provided a minimal cost value that was significantly lower than that of the BWO, GWO, BA, POA, and ROA at 0.3478 (node=200) and 0.348 (node=100). Altogether, the cost evaluation indicates that the HRPOA scheme converges more quickly, which reduces the cost rate than the standard methods.



(a) (b)

Fig 11: Convergence analysis of HRPOA scheme and traditional methods a) 100 Nodes and b) 200 Nodes

V.Conclusion

In order to improve communication, this article suggested an effective MANET cluster based routing paradigm for multimedia communication. Clustering was carried out using the K-means clustering method. Earlier, node energy prediction would be carried out by the DCNN model. In order to choose the cluster head, the HRPOA model combines the POA and the ROA. Reliable retransmission would increase the communication's dependability. The efficiency of the suggested HRPOA model-based MANET routing was also shown by a number of investigations. In addition, the HRPOA scheme produced a greater security rate of 0.48 at round=1500, despite the fact that the BWO, GWO, BA, POA, and ROA scored a lower security value for node 200. The proposed HRPOA model achieved (0.350) with more accurate results in the mean case scenario for node 200 when compared to other traditional strategies like BWO, GWO, BA, POA, and ROA model.

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