

AFRICAN VULTURE OPTIMIZED SELF SECURE ROUTING IN MOBILE AD HOC NETWORK

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Abstract – Mobile ad hoc network (MANET) is an ad hoc network system. MANET is a self-configuring network of mobile routers connected by wireless links with no access point. However, routing problems like high message latency, frequent route interruptions, and irregular energy consumption continue to affect network performance. In order to find a secure optimal path for MANET routing, a novel seCure African vultuRe-based netwoRk rOuTing (CARROT) technique has been proposed. The process of choosing the optimal inputs to produce the highest or lowest output at the lowest feasible cost is known as optimization. The African Vulture Optimization Algorithm can achieve faster routing convergence and a far better distribution of solutions. The NS2 simulator has been used to test the suggested methodology. The proposed method's effectiveness is measured through performance indicators like packet delivery ratio, network delay, energy efficiency and throughput. The observational findings shows that the CARROT achieves an end-to-end delay of 1.5 sec, whereas existing OFC-TR, SN-TOCRP and RRCSTON technique achieves 2.0s, 3.5s and 4.2s, respectively.

Keywords – Mobile ad hoc network, African Vulture Optimization, Routing.

1. INTRODUCTION

MANET is a wireless mobile node that creates a connection on its own Within a certain distance spectrum, MANET nodes are able to connect with one another [1]. utilizing an intermediary, a node that is outside of the communication range can still speak with another node. The dynamic approach interaction for forums, home automation, tracking patients, the military and battlefield, and other delicate tasks are the main uses for MANET [2,3]. Unlike regular wireless networks, this network hyperlinks nodes in an inconsistent or similar ways using wireless connections [4].

MANETs are generally infrastructure-free, multi-hop networks where each node has a direct or indirect connection to other nodes through an intermediary node [5]. According to the nodes that comprise the community's infrastructure, However, this issue provides clients autonomy in activity, interaction, and authority over their peers. Ad hoc systems are wireless systems that are momentarily configured for a

particular purpose.[6]. MANET has become a very promising tool for emergency communication and disaster management. Because MANET routing protocols manage network nodes with limited resources, they are important performance factors [7, 8]. Movement, transmission interference, and outside noise frequently prevent routes in a MANET from operating correctly [9].

Energy efficiency and security have emerged as key concerns in MANET due to the absence of fixed infrastructure [10,11]. The short battery life of mobile nodes, frequent topology changes, and restricted bandwidth brought on by node migration continue to be problems for MANET. For energy management and longer network lifespans, a number of energy-efficient clustering schemes use clustering techniques like k-means, fuzzy k-means, and c-means clustering. however, security and energy efficiency issues in MANETs still need to be addressed [12–14]. In order to address these problems, this study suggests a brand-new seCure African vultuRe-based netwoRk ROuTing (CARROT)-based technique for determining the best path in MANET. The main contributions of the suggested methodology are as follows.

- The Secure African Vulture-Based Network Routing's (CARROT) primary goal is to create a practical method for locating the safest and best route in MANET.
- Initially the network packets are collected by sensor nodes which form cluster using DBSCAN then using Crocodile optimization cluster heads were selected.
- The proposed method African Vulture Optimization Algorithm is used to discover secure and ideal route by enhancing packet delivery and reduces delay.
- The effectiveness of the CARROT is assessed using metrics like productivity, latency, packet transmission ratio, and energy consumption.

The following is the construction of the paper's residual. In Section II, the literature review is thoroughly examined. Section III of the MANET is where the routing happens. Section IV presents the experiment's findings and

observations. Section V contains the contribution and upcoming work.

2. LITERATURE REVIEW

In 2024 Singh et al [14] proposed an Ideal Fuzzy Clustering and Trust-based Routing (OFC-TR) may decrease time and usage of energy while boosting network safety and durability. Among the evaluation indicators used to assess the effectiveness of the suggested OFC-TR technique are network endurance, packet transportation, and energy utilization. The recommended method performs better than 3LWT-GWO [35], S2ALBR [33], and E-TDGO [32] in terms of network lifetime, achieving 52.88 percent, 44.34%, and 9.42%, respectively.

In 2023 Nirmaladevi and Prabha [15] proposed a method for forming node clusters called SN-TOCRP stands for Selfish Node aware Trustable and Optimized Clustering-based Routing. With a 96% packet delivery ratio, 0.045% loss ratio, 0.325 ms average delay, 76 Kbps throughput, 0.425 ms end-to-end delay and use of energy about 88 mJ, the NS2 simulator demonstrates that the suggested work produces better results. However, in highly dynamic or large-scale network environments, it might not always be possible to accurately detect selfish nodes.

In 2023 Abdulhae et al [16] suggested cluster-head arbitration to be altered by a central agent at a ground station that is far away. The findings demonstrate the superior energy consumption of our developed RL-based clustering, stability and the majority of indicators for systems. On the other hand, constant communication with the ground station might lead to decreased latency and robustness.

In 2023 Naeem et al [17] suggested the improved cluster-based lifetime protocol (ECBLTR), which maximizes routing stability and the system's median throughput. Our findings demonstrate a 10% longer network lifespan and an

effective CH selection technique utilizing the fuzzy system. However, the proposed ECBLTR protocol may be less accurate in dynamic environments due to its precise input parameters for fuzzy-based cluster head selection.

In 2023 Saha et al [18] suggested a clustering approach protocol that allows non-urgent data to be temporarily stored in order to speed up the transmission of emergency messages. The outcome demonstrates that the suggested CBP-PMC outperforms VMaSC-LTE regarding the ratio and delay in the delivery of packets. The potential complexity of the suggested CBP-PMC protocol in managing temporary storage and prioritization could result in an increase in processing overhead.

In 2021 Muruganandam, S. and Renjit, J.A[19] proposed a Realtime Reliable Clustering and Secure Transmission technique that offers a 97% Quality of clustering for 200 nodes. The suggested strategy improves the safety of data and quality of service. However, the proposed RRCST approach may increase computational overhead due to the complex computations involved in cluster head selection and route optimization.

In 2025 Yilmaz et al [20] proposed a technique (HACADM) that, in comparison to current clustering approaches, has the potential to improve MANET performance by guaranteeing a more balanced load distribution. The results of the performance evaluation also demonstrate that HACADM prolongs the network lifetime, maintains high performance under dynamic network conditions, and makes a substantial contribution to the efficient management of MANETs. However, in highly dynamic or large-scale MANETs, the HACADM approach might encounter scalability issues and increased control overhead.

3. PROPOSED METHOD

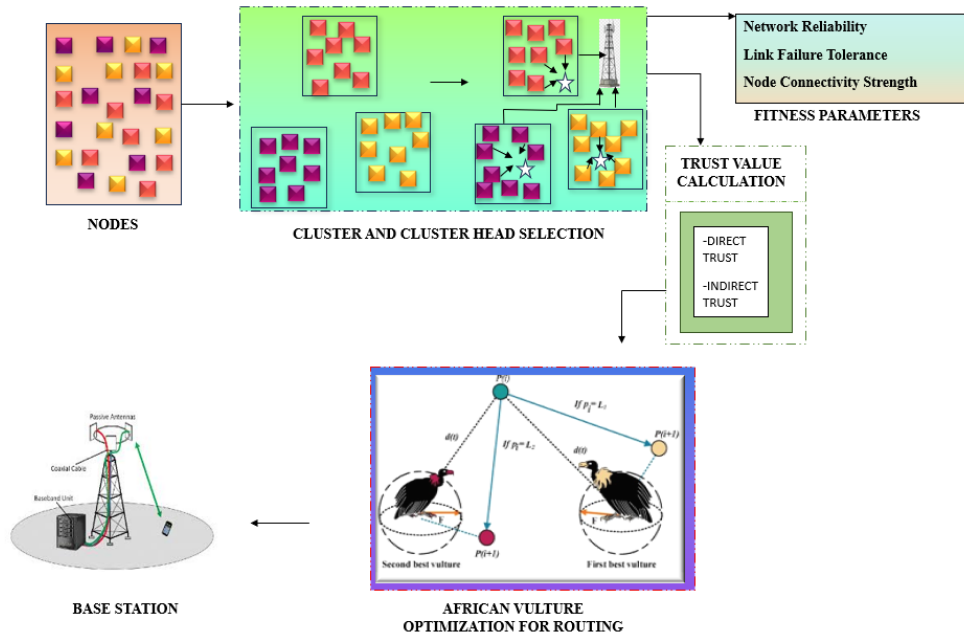


Figure 1. Secure Data Transmission

A new approach to secure routing was put forth in this section. In this case, sensor nodes are responsible for

collecting environmental data. The African Vulture Optimization Algorithm is used to solve the issue because of

its energy constraints and dynamic network configuration. These AVOA make it easier to find the best path. Figure 1 shows how the system that was designed operates

3.1 Data Collection

Sensor nodes gather environmental information and send it to the central location. By reducing direct contact with the base station, they are in charge of local data collection and short-range communication within the cluster. They are essential for ensuring efficient data collection and prolonging network life.

3.2 DBSCAN based Clustering

According to DBSCAN, the cardinality of the neighborhood must be greater than a certain threshold for every object in a cluster if there are a minimum quantity of objects (MinPts) in the area around a specified radius (Eps). The radius of any number of "p's" is described as

$$N_{EPS}=\{M \in D / \text{dist}(N, M) < Eps\} \quad (1)$$

D is the object database in this case. A point is referred to as a crucial point, if only a few of points are present in its neighborhoods. The definition of the core point is:

$$N_{EPS}(p) > \text{Minpts} \quad (2)$$

The user-specified parameters in this case are Eps and MinPts, which stand for the neighborhood's radius and the bare minimum of points in neighborhood, respectively. This is regarded as a non-crucial point if this requirement is not met. The DBSCAN pseudo code looks for clusters by examining each object's neighborhood within the dataset. An object p becomes the core of a new cluster if its neighborhood contains more than MinPts. From these core objects, iteratively gathers directly density-reachable objects, possibly involving the merger of a new cluster that can reach a particular density. The procedure stops when no more items can be stated to any group.

3.3 Cluster Head Selection using Crocodile Optimization Algorithm

COA simulates the way crocodiles interact with one another and hunt in the wild. It involves exploration (searching for prey) and exploitation (attacking prey) stages.

3.3.1 Exploration Phase

In this phase, crocodiles move randomly or follow others to explore the solution space.

$$X_i^{t+1}=X_i^t+\alpha.r_1.(x_j^t-x_k^t) \quad (3)$$

Where:

X_j and X_k are two random individuals (crocodiles)

This mimics random roaming and following behavior

3.3.2 Exploitation Phase

Once prey is spotted, crocodiles intensify the attack by refining their position:

$$X_i^{t+1}=X_i^t+\beta.r_1.(X_{best}-x_k^t) \quad (4)$$

This moves each crocodile closer to the best solution found so far.

3.3.4 Updating the Best Solution

$$X_{best}=\arg \min_i f(X_i) \quad (5)$$

Where $f(X_i)$ is the fitness function.

3.4 Routing Via African Vulture Optimization

The African Vultures Optimization Algorithm (AVOA) is a novel heuristic algorithm. influenced by African vultures' organic foraging habits. The simplicity, adaptability, and efficiency of this algorithm have drawn interest in resolving a range of optimization problems.

3.4.1 Initialization

When the initialization phase begins, N vultures are dispersed at random within a given

$$\text{rangelb}_j, \text{ub}_j$$

$$pi_j = \text{lb}_j + \text{rand}_j [0,1] \times \text{ub}_j - \text{lb}_j, i \in [1, I], j \in [1, g] \quad (6)$$

3.4.2 population grouping

The fitness of each solution is assessed following the creation of the initial population.

$$R(i) = \begin{cases} \text{BestVulture1} & \text{if } pi = L1 \\ \text{BestVulture2} & \text{if } pi = L2 \end{cases} \quad (7)$$

Eq. (7) shows that parameters L1 and L2, which sum to 1 and range from 0 to 1, regulate the likelihood of choosing the designated vultures. According to Eq. (8), the roulette wheel selection method is used to calculate the selection probability for any of the best solutions.

$$pi_i = \frac{F_i}{\sum_{i=1}^n F_i} \quad (8)$$

In AVOA, greater intensification is expected as the L2 and L1 parameters get closer.

3.4.3 the rate of starvation of vultures

This conduct points to a change from exploration to exploitation. An indicator of this transition is the extent of vultures' starvation, represented by F_i for the i th vulture and modelled as follows:

$$F_i = (2 \times \text{rand}_i + 1) \times z \times (1 - \frac{\text{iteration}_i}{\text{maxiterations}}) + t \quad (9)$$

Furthermore, t can be calculated as follows:

$$t = h \times (\sin^w(\frac{\pi}{2} \times \frac{\text{iteration}_i}{\text{maxiterations}}) + \cos(\frac{\pi}{2} \times \frac{\text{iteration}_i}{\text{maxiterations}}) - 1) \quad (10)$$

3.4.4 exploration stage

The vultures in the AVOA algorithm employ two distinct strategies to inspect randomly selected locations.

$$F_{new}^i = F_i \times (1 - \frac{t}{T}) + \gamma \times rand4 \quad (11)$$

3.4.5 exploitation phase (first stage)

In this phase, the operational efficiency of AVOA is examined. AVOA initiates the first operation phase if $|Fi|$ falls within the interval $[0.5, 1]$.

$$P(i+1) = P(i) + \beta \cdot (R(i) - P(i)) \cdot e^{-\lambda \cdot t} \quad (12)$$

3.4.6 exploitation (second stage)

The majority of vultures in the population are satiated if $|Fi| < 0.5$ during this algorithm phase. On the other hand, after extended effort, the two most skilled vultures have grown weaker and more ravenous.

$$P(i+1) = w_1 \cdot A_1 + w_2 \cdot A_2 + w_3 \cdot (R(i) - |d(t)| \cdot F_i \cdot Levy(d)) \quad (13)$$

4. RESULT AND DISCUSSION

The experimental results of the recommended routing of the AVOA ROUTE-based MANET are examined in this section. A random street layout in an urban setting was taken into consideration when the simulation was run. The number of nodes in the 1500×1500 m² area was recorded as 25, 50, 75, and 100 for testing purposes; this does not imply that the number was fixed. In NS2, the recommended strategy was put into practice. Energy imbalance factor versus network run time, packet delivery ratio, throughput, and energy efficiency were the metrics used to evaluate the suggested method.

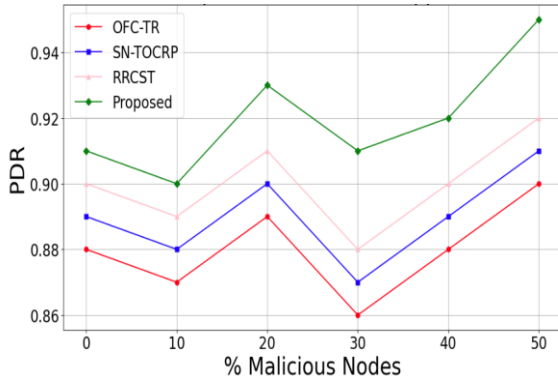


Figure 2. PDR Comparison for Different Approaches

Figure 2 compares the Packet Delivery Ratio (PDR) of four cluster-based routing techniques across different percentages of malicious nodes. In all situations the Proposed method performs better than OFC-TR, SN-TOCRP, and RRCST method. Higher PDR values show the strength and dependability of the proposed method in a hostile network environment.

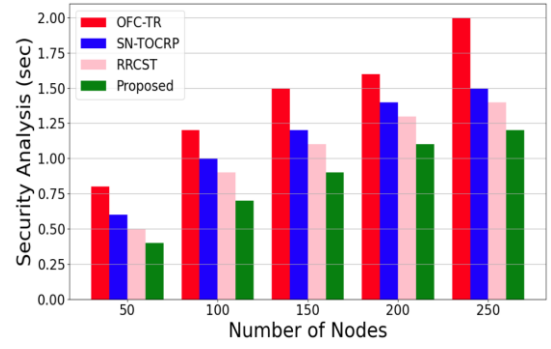


Figure 3. Security analysis comparison

In Figure 3, the Security Analysis time across four approaches (with different number of nodes) has been showed. The Proposed method (green) consistently takes the least amount of time to analyze, suggesting that it is a better method. As the number of nodes has increased, the proposed method was still outperforming OFC-TR, SN-TOCRP, and RRCST.

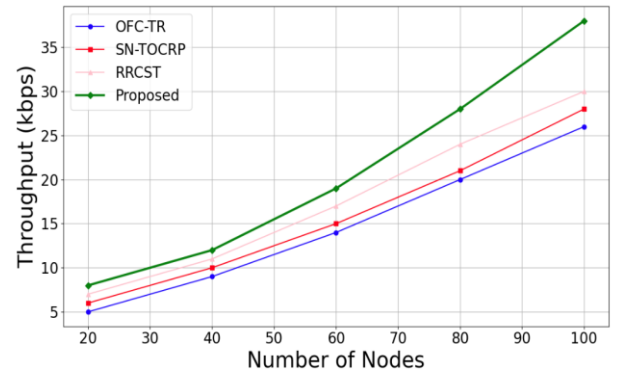


Figure 4. Comparative analysis using different numbers of nodes Throughput

Figure 4 compares Throughput across four methods with an increasing number of nodes. The suggested method continually has the highest throughput indicating greater efficiency for data transmission. The suggested method has always had better through put than OFC-TR, SN-TOCRP, and RRCST regardless of number of nodes.

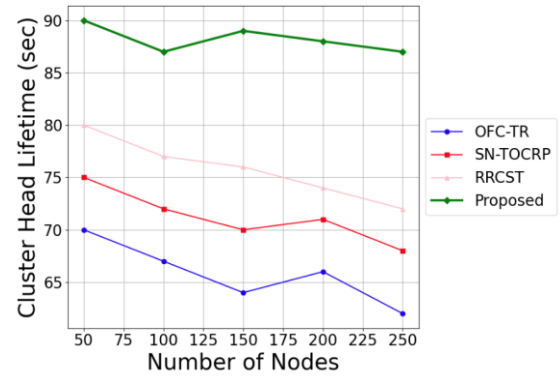


Figure 5. Cluster Head Lifetime vs. Number of Nodes

Figure 5 shows the cluster head's lifetime between the four routing protocols in a MANET environment. The proposed method has consistently achieved the longest cluster head

lifetime, suggesting it consumes the least amount of energy and is the most stable compared to OFC-TR, SN-TOCRP, and RRCST. As the quantity of nodes rises, the suggested method still shows longer lifetime because it creates fewer re-clustering events.

5. CONCLUSION

This study suggests a seCure African vultuRe-based netwoRk ROuTing (CARROT) to locate secure routing in MANET. By using AVOA, the proposed method identifies a secure and optimized path in MANET efficiently. The optimal paths are determined by the fitness parameters like distance, delay, congestion and energy. The suggested approach works better in terms of energy is concerned and accurately found optimal-routes on the sensor network. The effectiveness of the suggested method is evaluated using key performance indicators such as energy efficiency, throughput, and packet delivery ratio. The proposed method was implemented on NS2 simulator. The CARROT performs better than current proposed OFC-TR, SN-TOCRP and RRCSTON routing as far as the total end-to-end latency of 2.0s, 3.5s, and 4.2 s respectively. In future work, the proposed cluster-based routing protocol can be enhanced by integrating machine learning techniques for dynamic cluster head selection based on real-time mobility, energy, and traffic patterns.

CONFLICTS OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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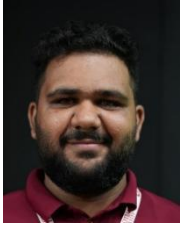
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