

BACTERIA FORAGING OPTIMIZED SELF SECURE ROUTING IN VEHICULAR AD HOC NETWORK

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Abstract – Vehicular ad hoc network (VANET) is an ad hoc network system built on the idea of a mobile ad hoc network (MANET), where individual vehicles are linked to one another using wireless technology. However, the Network performance is affected by the routing problems, like high message latency, regular route interruptions, and inconsistent energy usage. To solve these issues a novel Bacteria foraging Optimized Self Secure based Rout(e)ing (BOSS-ROUTE) has been proposed for self-secure routing in VANET to find the secured optimal path. Optimization is the process of determining the optimal inputs to achieve the highest or lowest output at the lowest possible cost. Bacterial Foraging Optimization is able to find a much better spread of solutions and faster routing convergence. The suggested approach improves the energy efficiency of the VANET by finding optimal path to determine the best course of action. The proposed approach was implemented on NS2 simulator. The effectiveness of the proposed method is assessed using measures such as network delay, energy efficiency, throughput and packet delivery ratio. The observational findings shows that the BOSS-ROUTE achieves an end-to-end delay of 1.5 sec, whereas existing CORA, AODV-OLSR, ECLTR technique achieves 3.0s, 3.7s and 4.5 s, respectively.

Keywords – vehicular ad hoc network, Bacterial Foraging Optimization, Routing, Autonomous vehicle, Wireless communication.

1. INTRODUCTION

A VANET is a special kind of MANET where moving cars serve as access points or nodes for message exchange amongst other vehicles. It sets up its communication system independently. They attempt to do this without relying on infrastructure technologies to assist in managing the network topology. [1-3] A VANET is a system with high mobility. Vehicles gadgets like geolocation enabled gadgets, Road-side Information Stations, and Traffic control Centers (TCC) are the four main parts of VANET all these components use to communicate.[4]. Optimization is the process of determining the optimal inputs to achieve the highest or lowest output at the lowest possible cost [5]

An assortment of mobile hosts and vehicle nodes form a transient network without the assistance of any centralized management or pre-existing infrastructure. This type of network is referred to as autonomous and self-configuring. Because VANET nodes are very dynamic, the network must be established quickly [6,7]. Every node has the duty of acting as a router, and routing paths in these networks may involve several hops.[8]

Several benefits of VANET technology include a decrease in traffic accidents and a more pleasurable driving and travel experience due to the simplicity of several toll, parking, and fuel payment procedures. However, routing must carefully select the criterion used to transmit a data message because it may become stranded or drift away from its intended destination, decreasing the likelihood that it will be delivered successfully. [9-11] Multimedia data transmission quality is more challenging in VANETs than in other wireless networks. To overcome this issue a novel Bacteria foraging Optimized Self Secure based Rout(e)ing (BOSS-ROUTE) has been proposed to find a secure route in VANET [12,13]. The BOSS ROUTE's primary contributions are as follows:

- The main objective of this study is to develop effective approach for finding optimal and secure path in VANET.
- Initially the network packets are collected from geolocation enabled gadgets, Road-side Information Stations, and TCC etc. which is then updated to the routing table.
- The proposed method Bacteria Foraging Optimization Algorithm is used to discover secure and ideal route by enhancing packet delivery and reduces delay.
- The effectiveness of the BOSS-ROUTE is evaluated using measures such as end-to-end delay, energy efficiency, throughput and packet delivery ratio.

The remaining sections of the paper are organized as follows. The literature review is thoroughly discussed in part II. The routing in VANET is described in Section III. The experiment's results and observations are shown in Section IV. Conclusion and future work are included in Section V.

2. LITERATURE REVIEW

In 2024, Hussein, N.H. et al [14] suggested a thorough details on the most recent Software Defined Networking based VANET routing techniques. The outcome demonstrates how the Control Overhead Reduction Algorithm (CORA) lowers the clusters' control over head messages. However, scalability challenge remains static.

In 2023, Choudhary, D. and Pahuja, R [15] suggested Mobility through zone-based routing in VANET. A hybrid optimal method is used for routing approach. Results showed that a shorter delay and a greater delivery ratio were achieved nevertheless broadcasting of vehicle status may lead to privacy concerns.

In 2024, Nabil, M. et al [16] suggested a thorough analysis of network technologies to maximize Vehicle to Everything (V2X) messages in VANETs. The outcome demonstrates that performance loss is not directly correlated with power consumption reduction. The result shows an improvement of 6.72% in the average end-to-end delay of data delivery, 14.44% in the packet delivery ratio, 11.2% in the throughput as compared to another scheme.

In 2023 Xie, X., et al [17] suggested a novel cross-layer routing protocol, that uses virtual multi back bones and combines them with the quality of the link to choose the next forwarder vehicle. Here virtual multi back bones is used to forward data packets to the next forwarder. It exhibits an improvement of 6.72% in the average network delay of data

delivery. However, number of vehicles increases managing become difficult.

In 2024, Dutta, A. et al [18] recommended combining cluster-based routing technologies with VANET latency reduction techniques. According to the simulation results, package delivery has greatly improved using the suggested strategy, which has an 88.56% delivery rate. However, the suggested method's accuracy in anticipating the vehicles' travel pattern will be reduced.

In 2024, El-Dalahmeh, M et al [19] suggested VANET routing protocols ad hoc on-demand distance vector and Optimized Link State Routing to fill Challenges of energy efficiency, security, and reliability. The result shows a protocol with increased throughput, and less delay is a suitable protocol for a real time VANET environment.

In 2023, Naeem, A et al [20] suggested an enhanced cluster-based lifetime protocol an enhanced longevity based on clusters protocol that maximizes average network speed and routing reliability. The findings indicate that the network lifetime increased by 10%. However, vast networks are not a good fit for ECBLTR

3. PROPOSED METHOD

In this section a novel BOSS-ROUTE was proposed for secure routing. Here, network packets are collected using geolocation enabled gadgets, Road-side Information-Stations, and TCC etc. Then collected network packets are used for updating of routing table. Due to its dynamic topology Bacterial Foraging Optimization Algorithm is used for optimization. These BFOA helps finding the optimal path. The workflow of BOSS-ROUTE methodology was shown in Fig.1

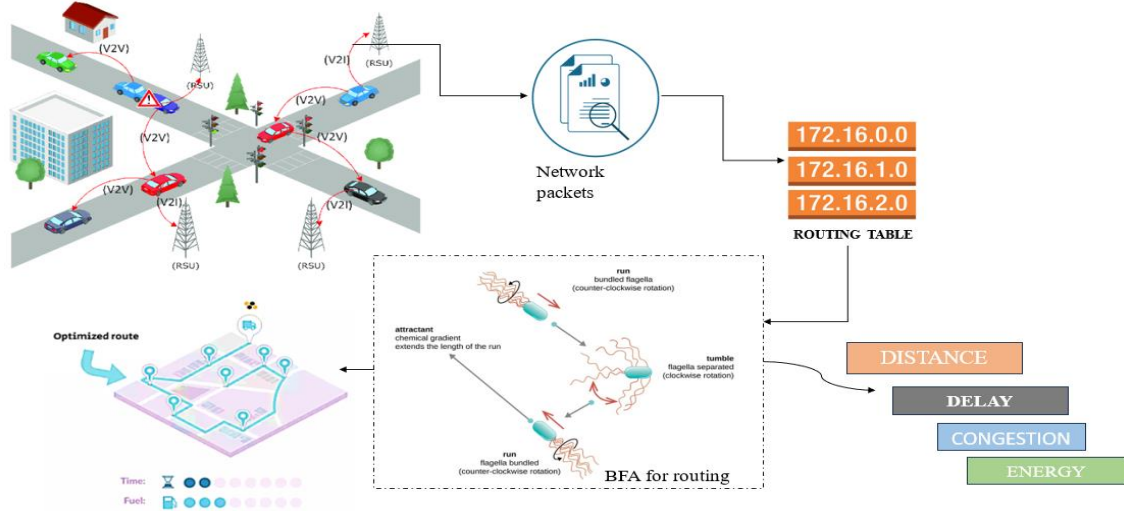


Figure 1. BOSS-ROUTE methodology

3.1 VANET data collection

A VANET (Vehicular Ad-Hoc Networks), are networks of moving automobiles that serve as either nodes or routers for message exchanges between other vehicles. Here sensors like Global Positioning System camera, RADAR are used to capture data from vehicles these data's have information about speed, location, vehicle ID etc.

3.2 Network Packets

Network packets are data collected from VANET for network transmission. Each network packets contains payload and header. Header contain data about sender and destination. Payload contains information from GPS, sensor etc.

3.3 Route table

The data from network packets are used to update route table. Route table is a data structure stores the path. There is a default route in the routing table, and each prefix in the table has only one next hop, including the null prefix at the tree's root.

3.4 Fitness function

The multi-objective function combines excess energy and Link reliability. When creating routing algorithms, position management and connection management are crucial factors to take into account. GPS manages location by providing the position and speed of the vehicle. It is necessary to compute connection management, which keeps the paths between the cars steady. In order to make wise Link reliability is determined by the data forwarding choices made for overall routing performance.

Assume that two cars, a and b, are traveling. GPS is used to determine the starting positions, which are represented by the numbers Mi0, Ni0, and Ml0, Nl0. Their speed is represented by the numbers Ri0 and Rj0. Neighbors will treat the vehicles if they are within the same communication range. The communication range is represented by R, while the distance between two vehicles is represented by D. The connection between the vehicles will break if $D > R$. When $D = R$ is t, the link's lifetime (t) is the time interval between current time (t1) and initial time (t0). The lifetime (t) is computed using the distance given the vehicles' starting positions and speed data. The following equation is used to compute the distance.

$$K^2 = ||N||^2 + ||M||^2 \quad (1)$$

Where;

$$N = (U_{i0} + Z_{i0}\Delta t) - (U_{j0} + Z_{j0}\Delta t) \quad (2)$$

$$M = (V_{i0} + Z_{i0}\Delta t) - (V_{j0} + Z_{j0}\Delta t) \quad (3)$$

The following formula can be used to determine the link stability (LS) of ij:

$$L^S = \frac{\Delta t_{ij}}{t_{max}} \quad (4)$$

Here, t_{max} corresponds to the term of validity of the routing table

and is a constant variable.

$$T_i^{Energy} = T_i^{initial} - T_i^{Consumed} \quad (5)$$

Where; $T_i^{initial}$ and $T_i^{Consumed}$ are defined as node i's initial and consumed energy. The following formula can be used to determine used energy:

$$T_i^{Consumed} = u_i \times T^T + v_i \times T^T \quad (6)$$

where the number of bits sent and received is represented by U_i and V_i .

Reception energy are calculated as

$$R^t = S_{radio}^R + S^A dis_{mn}^2 \quad (7)$$

$$R^R = S_{radio}^R \quad (8)$$

where, S_{radio}^T and S_{radio}^R radio are the energy.

3.4.1 Fitness Calculation

The fitness function makes use of the function with several objectives. Remaining energy and link reliability are used to design the fitness.

$$Fitness_i = \alpha * S_i^R + \beta * L_i^S + \gamma * C_i \quad (9)$$

where the weighting factors α , β , and γ are shown. The optimal course of action is the one having the highest fitness value.

3.5 Routing via Bacteria Foraging Optimization

The Bacteria Foraging optimization algorithm is used to find best path based on distance, delay, congestion and energy. By using BFOA the source node find its optimal path and helps vehicles avoid trafficking. The flowchart of bacterial foraging algorithm is demonstrated in the fig 2. Escherichia coli's social foraging behavior served as the model for BFOA. which moves towards nutrient rich area and avoids harmful substance. In same way BFOA moves and finds best path for optimal routing. They grow longer when they eat enough, and when the temperature is right, they break in the middle to form a perfect duplicate of themselves. A population of bacteria may relocate to different locations or be added to the swarm of concern as a result of abrupt environmental changes or attacks.

Neither data nor an analytical description of the gradient $\nabla l(\theta)$ are available to us and we wish to determine the min of $2(\theta)$ when $p \in \mathcal{R}$. BFOA solves this non-gradient optimization issue by simulating the four primary mechanisms, such as chemotaxis, swarming, reproduction, and elimination-dispersal.

Let $s(s(a, b, c,) = \{\theta^a(o, p, q) | a = 4, 5, \dots, r\}$ represent each member of r bacteria at l-th chemotactic, m-th reproduction, n-th elimination dispersal. Here l (a, l, m, n) denote cost of i -th bacterium

3.5.1 Chemotaxis

This procedure uses flagella to imitate the tumbling and swimming motion of an E. coli cell. The bacterium's movement in computational chemotaxis can then be depicted by

$$\theta^i(a + 2, m, m) = \theta^i(a, b, c) + d(i) \frac{\Delta(a)}{\sqrt{\Delta^T(a)\Delta(a)}} \quad (10)$$

Here Δ determines a vector with elements located in [-1, 1] in a random direction.

3.5.2 swarming

A collection of E. Coli cells travels up the nutritional gradient and forms a traveling ring. The following function could be used to illustrate between cells communication in an E. coli swarm.

$$l_{dd}(\theta, Q(o, p, q)) = \sum_{i=1}^s j_{dd}(\theta, \theta^i(o, p, q)) = \sum_{i=2}^s [-f_{attractant} \exp(-x_{attractant} \sum_{m=1}^p (\theta_m - \theta_m^a)^2)] + \sum_{i=1}^s [s_{repellant} \exp(-x_{repellant} \sum_{m=1}^p (\theta_m - \theta_m^i)^2)] \quad (11)$$

Where $l_{cc}(\theta, Q(l, m, n))$ represents the value of the target function that will be appended to the real target function.

Here $f_{attractant}, -x_{attractant}, s_{repellant}, x_{repellant}$ are distinct coefficient that must be appropriately selected.

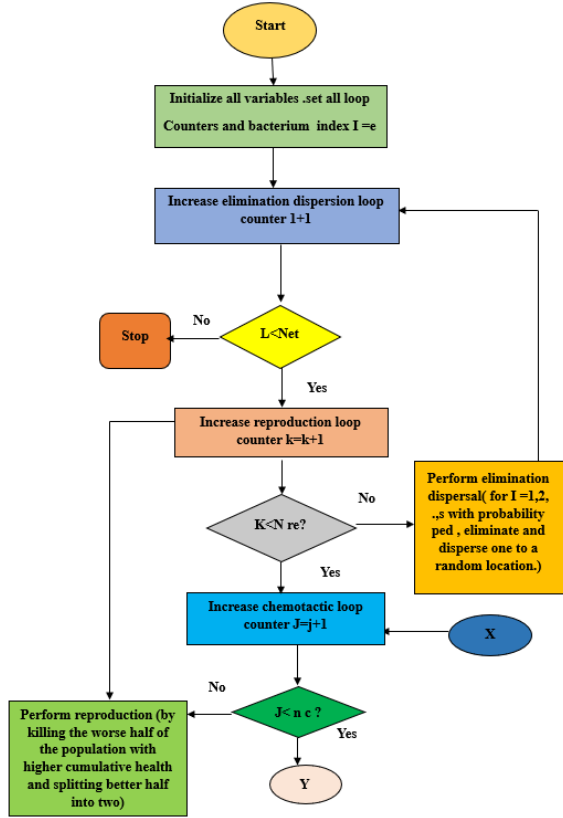


Figure 2. Flow chart of BFOA technique

3.5.3 Reproduction

The healthier bacteria split asexually into two and are then positioned at the same spot. whereas the least healthy bacteria ultimately perish. The swarm size remains constant as a result.

3.5.4 Elimination and Dispersal

There are several reasons why the local environment of a bacterial population may change suddenly or gradually. This process is replicated in BFOA by randomly initiating new replacements across the search space and randomly liquidating certain bacteria with a very low probability to find a secure path in VANET.

4. RESULTS AND DISCUSSIONS

This part examines the experimental outcomes of the recommended BFOA-based VANET routing. The simulation uses a random street layout in an urban traffic environment. For testing purposes, the number of cars in the 1500 × 1500 m2 area has been set at 25, 50, 75, and 100. In NS2, the suggested methodology is used. The effectiveness of the proposed methodology is assessed using network delay, Packet delivery ratio, throughput and energy efficiency.

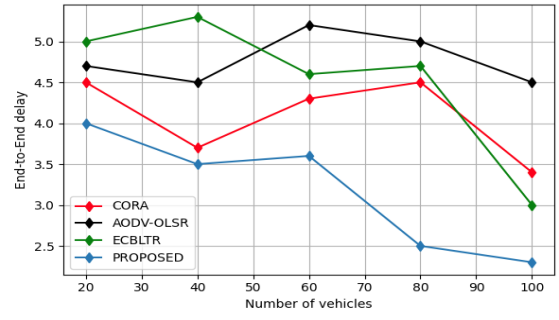


Figure 3. Comparative analysis using different numbers of vehicles network delay.

Fig. 3, indicate network delay of the proposed and existing methods. The BOSS-ROUTE achieves an network delay of 1.5 sec whereas existing CORA, AODV-OLSR, ECBLTR technique achieves 3.0s, 3.7s and 4.5 s, respectively. This algorithm facilitates quick end-to-end data transfer.

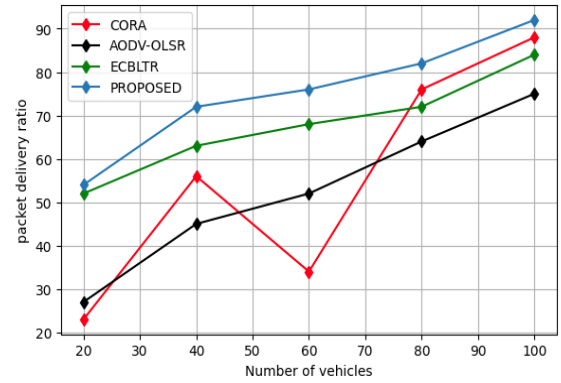


Figure 4. Comparative evaluation using the ratio of packet delivery

Figure 4 shows the suggested technique's packet delivery ratio in proposed and existing method. When there were fewer vehicles in the network, the existing techniques CORA, AODV-OLSR, and ECBLTR don't show a good proportion of deliveries. A network is deemed good if its delivery ratio is high. Since the suggested BFOA routing has a larger network than other methods.

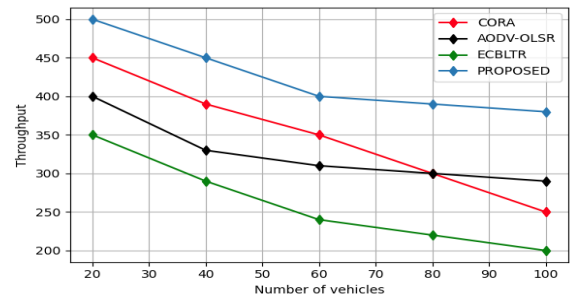


Figure 5. Comparative evaluation using throughput from different numbers of vehicles

Fig. 5, illustrate the throughput of the BFOA and existing methods CORA, AODV-OLSR, and ECBLTR. The BFOA technique produces better results compared to CORA, AODV-OLSR, and ECBLTR approaches. This is because of the BFOA based optimal route selection process.

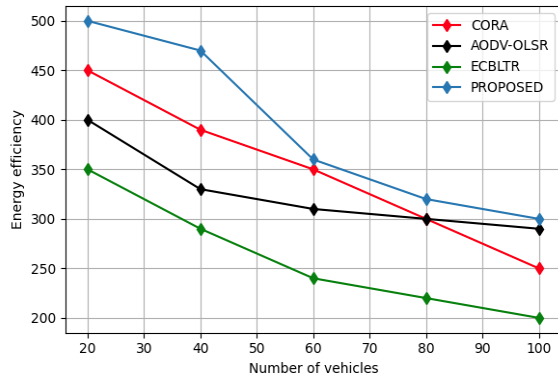


Figure 6. Comparative evaluation of different numbers of vehicles' energy efficiency

Fig. 6, compare the energy efficiency of the proposed method Bacterial foraging optimization algorithm with existing method CORA, AODV-OLSR, and ECBLTR. Here, proposed method Bacterial foraging optimization algorithm produces better results compared to other CORA, AODV-OLSR, and ECBLTR approaches. This is because of the BFOA based optimal route selection process

5. CONCLUSION

This study suggests a BOSS-ROUTE methodology to locate secure routing in VANET. By using BFOA technique the proposed method identifies secure and optimal path in VANET effectively. The optimal route are identified based on fitness parameter distance delay, congestion, and energy. The proposed method increases security and precisely locates self-routes. network delay, Energy efficiency, Throughput and packet delivery ratio are used to evaluate the effectiveness of the recommended technique. The proposed approach was implemented on NS2 simulator. The BOSS-ROUTE model outperforms the current CORA, AODV-OLSR, and ECBLTR methods regarding the total end-to-end latency of 3.0s, 3.7s and 4.5 s. In future work, machine learning and deep learning can be implemented generalize this protocol for a dense urban environment taking into account event-driven messages and the obstacles of the buildings

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

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