An Optimal Navigation Model for Realistic Traffic Network Scenarios in VANET

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Research Article

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Posted Date: November 9th, 2023

DOI: https://doi.org/10.21203/rs.3.rs-3500181/v1

Additional Declarations: No competing interests reported.

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Abstract

Vehicle Ad-hoc Networks (VANETs) are a kind of Internet of Things system where groups of vehicles connect and vehicle tracking infrastructure to enhance driver and public security as well as lifestyles. In a VANET, vehicles oversee the communicating status to the controller and other drivers for processing, as well as the statuses of the road, traffic, and atmosphere around them. In these actual VANET network traffic scenarios, this research presents the mixing of enhanced genetic algorithms (EGA) based on ant colony optimization (ACO) techniques (EGAACO) to create an optimized routing algorithm. This research evaluates the conventional algorithm with metaheuristic possibilities and includes the experimental VANET simulation scenario. To verify the outcomes, the proposed approach is tested using open-source network and traffic simulation tools. On Simulation of Urban Mobility (SUMO), all three different traffic scenarios were simulated and examined using NS3.2. The results of these analyses were satisfactory, and it emerged EGAACO algorithm, performed better than the others in each of the three traffic scenarios. The four real-time traffic network scenarios include average throughput, packet delivery ratio, end-to-end delay, and packet loss in a network, which is collected from the city of Bangalore, and the performance metric measures utilized in traffic network conditions. The experimental result proved that the proposed EGAACO algorithm outperforms the Ad-hoc on- Demand Distance Vector Routing (AODV), Particle Swarm Intelligence (PSO), and ACO routing protocols in all settings.

Keywords: Genetic algorithm, ant colony optimization, routing, VANET

1. Introduction

One of the key components of Intelligent Transportation Systems (ITS) is VANET. The standard protocols such as Dynamic Source Routing (DSR) and AODV formed the foundation for the evolution of VANET routing protocols. For multi-hop wireless ad hoc networks and Internet of Things (IoT) devices, DSR and AODV were shown to be reliable and most suited [1]. Vehicle–to–Vehicle (V2V) communication scenarios consider the algorithm while developing any routing protocol. Thelatest technology experiences are significant and frequent improvements. Thus, it will soon be evident that the 5G GSM network is being deployed in a Vehicle-to-Infrastructure (V2I) scenario. Due to this, V2V and V2I in UITS (Urban Intelligent Transportation Systems) are created. Through autonomous vehicle communication, the VANET is created. It is possible to consider these vehicles to be in the nodes with the ability to establish wireless contact with other nodes, thereby establishing an innovative self-organizing transnational link system.

It offers an enormous number of opportunities for the development of various VANET applications. The act of driving can be made simple, safe, enjoyable, and efficient with the assistance of these applications. Additionally, it will reduce the amount of time spent traveling because of the increased capacity of the roads, their ability to be used in emergencies, and to avoid crowded places [2]. There are currently several wireless standards and VANET routing protocols available, but none of themcan offer an exhaustive routing scheme for actual VANET circumstances [3].

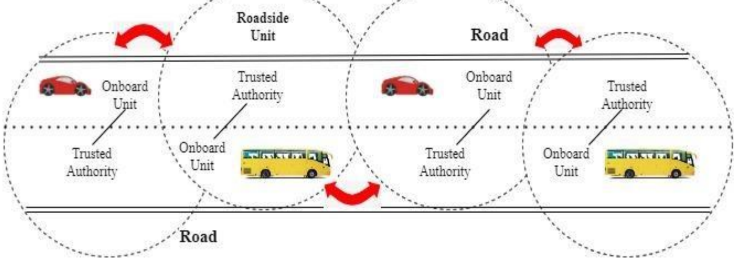

Figure 1: Components of Vehicular Ad hoc network

Figure 1 represents the components of VANET. There are three main physical components in theVANET as named Onboard Unit (OBU), Roadside Unit (RSU), and Trusted authority (TA). The VANET structure is shown in Figure 2 and demonstrates how the vehicle establishes a VANET environment by sending information to other vehicle nodes. Vehicles in this dynamic arrangement communicate with one another to disseminate information.

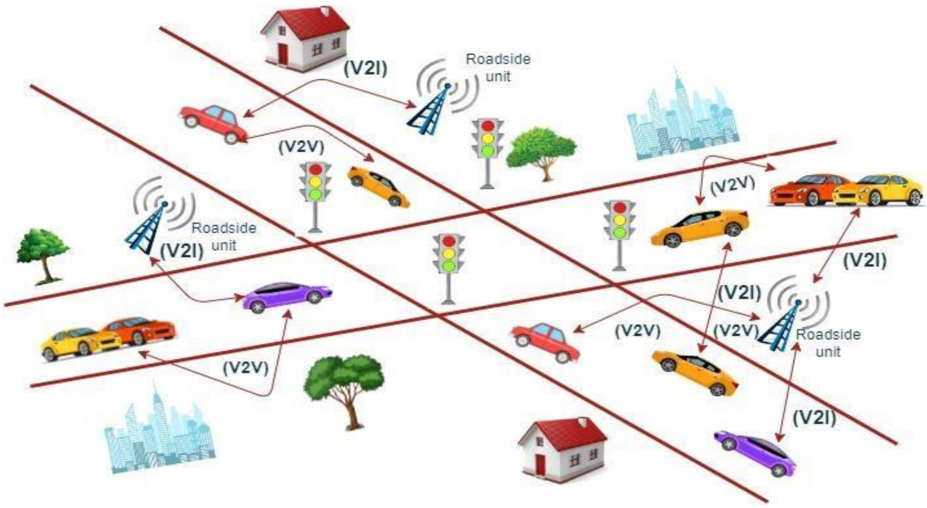

Figure 2: Structure of VANET

Numerous routing issues affect automotive networks, including dynamic topology, networkvelocity, availability and dependability, realistic traffic scenarios, unintentional driver conduct, and a lack of algorithms for all kinds of vehicular traffic scenarios. Routing plays a crucial role in this structure. This research addresses the issues and offers a useful routing technique for VANET routing that emphasizes performance indicators including End-to-end delay, packet delivery rate, and median capacity.

The predominant findings of the investigation are outlined below.

i) The routing approach is proposed to be enhanced for three realistic traffic scenarios utilizing an enhanced genetic algorithm-based ant colony optimization approach (EGAACO).

ii) The proposed network's typical efficiency, transmission of packets ratio, delay across thenetwork, and the loss of packets have proven better VANET routing efficiency.

iii) Used NS 2.35 simulator with typical and accurate congestion circumstances, the efficiency of the developed novel EGAACO approach is reviewed and checked with the traditional protocols.

The other part of this research work is structured as shown: In Section 2, the numerous VANET research concepts about the importance of routing in VANET are examined. Section 3 describes the method employed and the intended framework. In Section 4, the methodology of the experiment and its findings are discussed. The results of this research work are given in Section 5.

2. Related work

The specifications for connecting the optimal path between the nodes in their network must be minimized. For VANET routing applications, there are some common routing protocols. These protocols are grouped according to several factors, including Quality of Service (QoS), routing algorithm, and information properties of the protocol and network layout [1]. Five significant VANET routing protocols have been addressed in the literature review in this work and are shown in Figure 3. Additionally, it is proven that the literature on vehicle-to-vehicle networks does not focus on transmission strategy-based protocols since it does not address the problems and challenges associated with information dissemination in VANET [2].

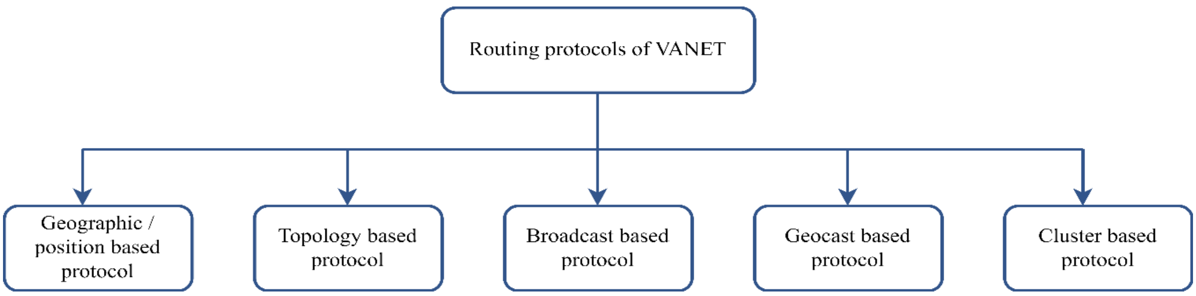

Figure 3: Different routing protocols of VANET

Therefore, this extensive literature review can infer the conclusion that, in any traffic scenario, the present conventional standards are not appropriate for the VANET network. Topology-based and geographic/position-based [3]. The VANET network standards can be divided into two types Topology- based and geographic/position-based [4]. While forwarding a packet using position-based routing, Every single node is aware of where the other nodes are in the network, whereas using topology-based routing, every node is alert of the network. Because Gaussian probability circulations approximately correspond to their node degree distributions and the topology. While a connection is too low, even considering incorporating the small-world characteristic, low-density VANETs act similarly to small- world networks [5].

According to the author [6], drivers can employ a distributed, real-time navigation system to reach their destination by gathering online information about the roadways through VANET. The outcome of the simulation test demonstrates that the new methodology improves the rate of local awareness of the vehicle via simulated barriers. The records of the neighboring car are updated because of the messages exchanged, and attention is drawn to other nodes that jointly forwarded problems and solutions. The WiMAX mesh framework [7] is designed using a comprehensive simulation, which is acknowledged in the OPNET architecture. The authors' platooning system, which is based on swarm- based intelligence, is presented in [8]. To shorten the journey time, this method uses two separate elements. It emphasized green traffic signal timing, creating a clear path for moving vehicles. The cars are then designed to platoon using the proposed pre-emptive traffic signal strategy in conjunction with an already-in-use modified ACO technique. These features led to the conclusion that the platooning algorithm is an effective technique to reduce passengers' waiting times. The authors of [9] presented an examination of several simulation tools available for VANET. The taxonomy of VANET simulators makes it easier for upcoming VANET analysts to select the best simulator for the goals of the VANET scheme. P-AODV and enhanced AODV are two AODV protocols that have been investigated and are reliant on certain factors [10].

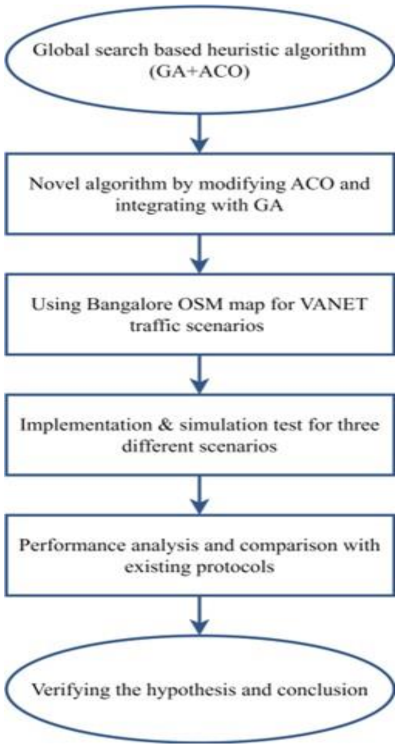

Figure 4: The adopted methodology

Figure 4 represents the adopted topology of this research and in high-traffic circumstances, the current routing protocols cannot support VANET with efficient routing [11]. It is not preferred to use the Optimized Link State Routing Protocol (OLSR) because it uses high bandwidth to do the transformation and to find the best network path [12] and uses artificial intelligence and GA to handle multicast routing. The ACO-based swarm intelligence approaches are also used to construct the multi- constrained QoS-conscious routing algorithm. As a result, it is possible to implement a network with database QoS. So, a trustworthy QoS algorithm also contributes to VANET security. In a few VANET applications, the ACO and DSR algorithms are additionally developed as transmitting choices that employ stable connections.

A sustainable ACO-based routing method that makes use of common road connections is used to track real-time performance. The problem in VANET routing is fixed using an original information and cost update mechanism [13]. Prediction-based Greedy Perimeter Stateless Routing (PGPSR), is a modified variant of Greedy Parameter Stateless Routing (GPSR), proposed by the authors in [14]. PGPSR is more effective than normal GPSR because VANET routing has been found to boost maximum throughput and packet delivery ratio (PDR). However, due to the lengthy computation time and its intricate calculations, it doesn't operate in dense or sparse network conditions. The authors of [15] suggested the Genetic Algorithm created &controlled the information exchanged and lowered the method for VANET to identify the most suitable population of automobiles that wireless network's bandwidth utilization. Based on relevant effect coefficients, the original population size is lowered using random values.PSO and ACO are viewed in the mobility infrastructure to improve VANET performance.ACO [16] is used to build several routes with a consistent vehicle density from the source to the destination.

The proposed algorithm performed better in terms of throughput, durability, stability upgrade, and time required for delay reduction and introduces the enhanced genetic algorithm-based ant colony optimization technique (EGAACO). VANETs are unable to fulfill all users' requirements and applications.For instance, in real-time conditions, emergency signals must be delivered with the shortest possible delay and highest priority, whereas messages like emergency and entertainment can be queued and delayed. Therefore, the minimal calculated desired time (MCDT) technique is recommended in sparse and dense networks, and data distribution is carried out concerning a context-aware congestion resolution protocol.

Through a peak-stable link, MCDT defines the node's connectivity. Cost, complexity, and convergence comparisons between the general algorithm (GA) and the modified lion algorithm (LA) have been conducted. The simulation testing of the modified LA compared to the regular GA and LA proved the modified LA's superiority. As a result, a research strategy for efficient routing in VANET is established. The freeware technology includes network simulators (NS) and SUMO, which are used for the experimental test, which is carried out in a realistic simulation environment.

3. Proposed Methodology

Traditional and recently created VANET routing techniques are tested using simulations. An enormous number. of algorithms is appropriate to ensure the intended traffic situation. However, neither of these methods could deliver the three different traffic circumstances with satisfactory results. Along with two other conventional VANET routing protocols, the ACO technique with the EGA approach is chosen and placed in use for performance testing in the chosen scenarios. The simulation environment is then created using simple traffic situations and sophisticated traffic scenarios.

Figure 5: Open Street Map of Bangalore Road scenario (Karnataka)

Then, using the mutation features of EGAACO, a new algorithm is developed to have better efficiency. The ACO population is rearranged and integrated with the GA algorithm to create a new EGAACO algorithm. In the VANET routing algorithm of EGAACO, population selection, crossover, and mutation are used. Utilizing three fundamental actions on the population's members, In each iteration, the current population can generate a new population of the same size. The VANET's ACO approach for the situations including traffic on the roads is most suited to EGA since it can modify routing as necessary. By evaluating the simulation results of all three different traffic conditions, the suggested approach is shown to be effective.

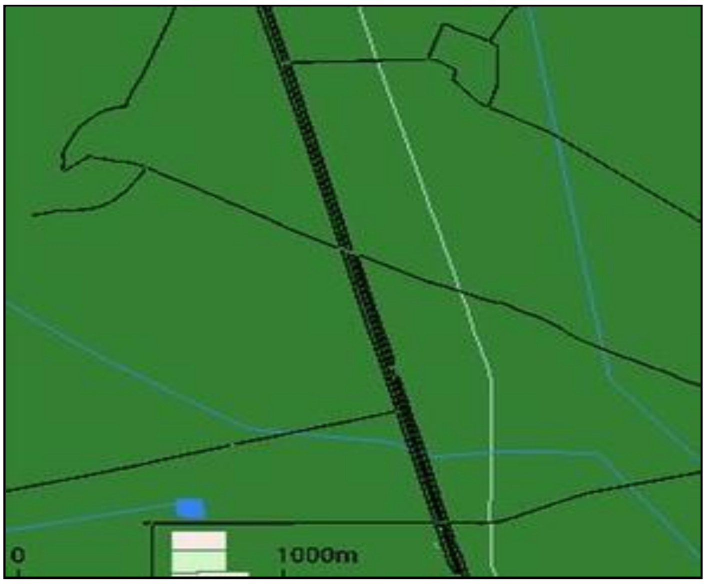

Figure 6: Bangalore Road scenario using SUMO tool

The VANET's ACO approach for the situations including traffic on the roads is most suited to EGA since it can modify routing as necessary. By evaluating the simulation results of all three different traffic conditions, the suggested approach is shown to be effective.

Input: SCI = {SC1, SC2, SC3,…..SC_I}// occurrences in VANET
CPn_K= {CP1, CP2, CP3,….CP_k} $\forall CP_k \in^1_{I=1} (SC_I)$
itrn:=0 & Gn:=0 // itrn& Gn are repetition and development response
Max_{itrn} = Maximum no. of iterations
£ = Measure of threshold
Ω = Density of the particular node
$T_{configure}$ = total traffic congestion
Output: $\lambda_{R_{TR}}$ = Optimized traffic route
Step 1. Repeat while in ≠ Max_{itrn}

$$\lambda_{R_{TR}}\left\{C=\begin{cases}\text{Call 2nd algorithm } (S_I,CP_k,£)\\ \text{all 3rd algorithm } (S_I,CP_k,£)\\ \text{Call 4th algorithm } (S_I,CP_k,£)\end{cases}\right\}$$

$\forall CP_k\ I^i_{I=1}=(SC_I),\ \lambda_{R_A}=\{\lambda_{R_1},\lambda_{R_2},\lambda_{R_3}........\lambda_{R_a}\}$ and $R_{AF}=\{R_1,R_2,R_3.....R_z\}$
Step 2: If ($T_{configure}$ ≤ Ω)do
If($\lambda_{R_{TR}}$ better than $\lambda_{R_{TR}}+1$) where $^a_{A=1}\ \lambda_{R_{TR}}$ and R_{AF}
Save R_α
Step 3: Find λ_{R_A} and call the corresponding algorithm
End if
End if
End while

Algorithm 1: Enhanced GA and ACO algorithm for VANET

Algorithm 1 shows the algorithm developed for this research. Additionally, all the algorithms, from algorithm 2 to algorithm 5, are implemented to deploy and test the developed algorithm, which is done using simulation trials. The simulation test approach is developed by Algorithm 1. The three various scenarios were created in a simulated setting. To gather data on routing performance, the simple traffic network, complex traffic network, and realistic city traffic network scenarios of Bangalore isdeveloped and tested.

```
Calculate basic performance, computational
parameters (CPk), and velocity (£),
position = location of the node
Step 1: POS ← 0 // for iteration
    While POS ≠ END
        Do the process // for every component
Step 2: Calculate £ as well as CPnk
        If (CPnk I^i_{I=1} =(S_I))
            Evaluate CPnk
            Compute new velocity
Step 3: Update POS
        POS ≡ POS + 1
        End if
    End do
    End
```

Algorithm 2: PSO (SI, CPK, £)

```
Setting up of Xn → 1 to x
Createthe starting position of every node
Step 1: POS → 0 //for iteration
        While POS ≠ END
Step 2: Determine the place using the density of nodes
 Do the process // for every component
     Compute £ and CPnk
Step 3: If (CPnk I^i_{I=1} =(S_I))
        Evaluate CPnk
            Compute new velocity £
Step 4: POS = position + 1
        End if
    End do
End while
```

Algorithm 3: ACO (SI, CPK, £)

PSO deployment is shown in Algorithm 2 for three different traffic conditions. The simulation is conducted using this algorithm to collect data for the specified performance indicators. Three differenttraffic situations are suggested, and all the data are tabulated for further comparison with the ACO and developed EGAACO algorithms. The ACO technique used in this Algorithm 3 similarly best fits the three suggested traffic situations. ACO is also used to simulate these three traffic situations, record data for thechosen performance indicators, and analyze the results.

```
Input: cluster count (overall count)
A_Lo origin of node ∀ {Loc ∈ 1,2,3,..........l}
    Itrn to indicate iterations {20 – 45}
The improved approach
Step 1: Set Itrn = 0, Gern = 0;
Start GA, ACO
    Call 5th Algorithm (GA for cluster)
        Maximum (Gern)
            Generation++
        Continue;
      End for
Step 2: Start the process
    For Itrn → 1 to T
ANTi++;
Update the process;
End for
Step 3: Return to Step 1
```

Algorithm 4: Proposed GAACO for optimizing parameter

```
Step 1: TE ← 0 // repeating no. of times
Step 2: Compute SI(T) // starting of the process
Step 3: Assess SI(T) with variables
        While TE ≠ END
            Do
Mixture of SI(T) to produce CN(T)
 Compute CN(T)
Choose SI(TE+1) from SI(T) and CN(T)
            TE = TE + 1
          End
       End
```

Algorithm 5: Genetic algorithm of cluster position.

The developed methodology is shown in Algorithm 1 as a combination of ACO and GA characteristics. ACO algorithm is used to improve the GA strategy of EGAACO. The fourth algorithm utilizes the fundamental components of ACO optimization approaches, treating vehicle nodes like ants in a swarm. To rebuild the car routes for the simulation, algorithm 4 calls algorithm 5. This makes it possible to create the latest vehicle cluster size in the suggested traffic situations, which is particularly beneficial in a setting that includes a genuine city traffic network.

Algorithm 5 is applied to start the simulation test and assess the outcomes of the suggested traffic scenarios. As a result, the enhanced outcome is noted for additional investigation and process. When PSO, ACO, and EGAACO are implemented, the four chosen performance measures are applied to each of the three situations. The comparison is made to conduct the simulation experiments and discussions of the findings with the final analysis are presented in the following section of the research.

4. Experiments & Results

Four important performance indicators, including Loss of packets, total delay, transmission amount, and average speed are used to describe the results of this research. Three VANET scenarios were used in the simulation. For a realistic approach, the calculations were compared out by importing the Bangalore real city scenario map from Open Street Map. Later, it was modified for the SUMO network. The Bangalore area is chosen since it is the most congested route due to the heavy traffic during the peak season from various places. The data provided in Table 1 shows the properties of the simulation parameters. According to four important performance metrics such as average throughput, packet delivery ratio, end-to-end delay, and packet three VANET scenarios have been deployed in the simulation.

Table 1: Components with specification

Requirements	**Information**
Network Simulator	NS 2.35
Traffic Simulator	SUMO- 0.25
OSM of Bangalore city vehicle traces	https://shrturl.app/SWTfba
Model	Car flowing model
Transmission network range	250m
Size of data packets	516 bytes
Interval	0.025 seconds
Data rate	3 Mbps
Protocol	MAC layer 802.11p
Velocity	0 to 30 m/hr

Table 2 shows the functionality of the proposed EGAACO and it is compared with existing ACO and PSO routing protocols in all metrics. Figures 7 – 12 exhibit the graphical representations of the efficiency evaluation.

Table 2: Comparison of different traffic network

Routing algorithm	Simple traffic network	Complex traffic network	Bangalore realistic traffic scenario
PDR of EGAACO with PSO	1.9%	1.45%	1.54%
PDR of EGAACO with ACO	1.76%	1.56%	1.13%
Average throughput of EGAACO with PSO	1.43%	1.69%	1.34%
Average throughput of EGAACO with ACO	1.23%	1.42%	1.24%

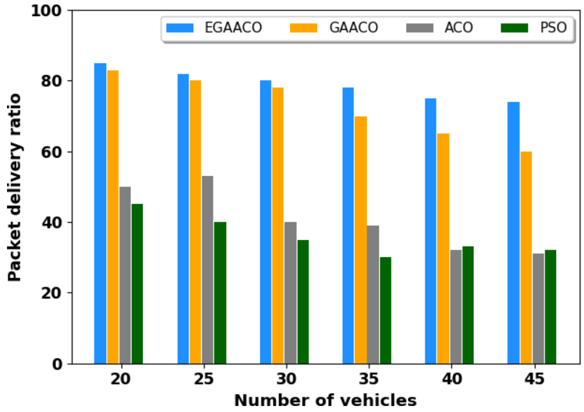

Figure 7: Efficiency evaluation of PDR in a simple traffic network

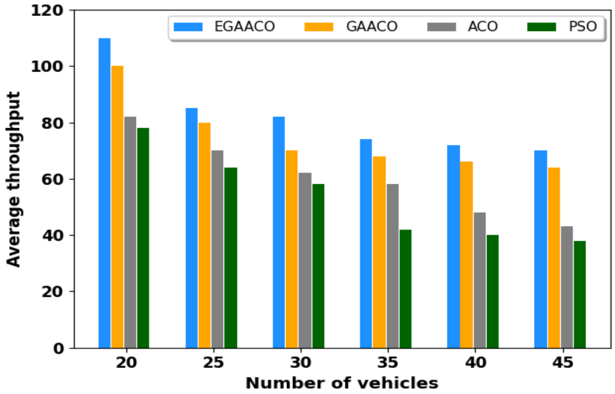

Figure 8: Efficiency evaluation of average throughput in a simple traffic network

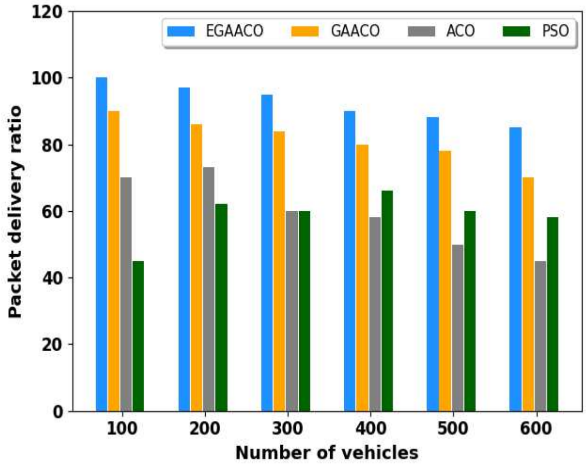

Figure 9: Efficiency evaluation of PDR for a complex traffic network

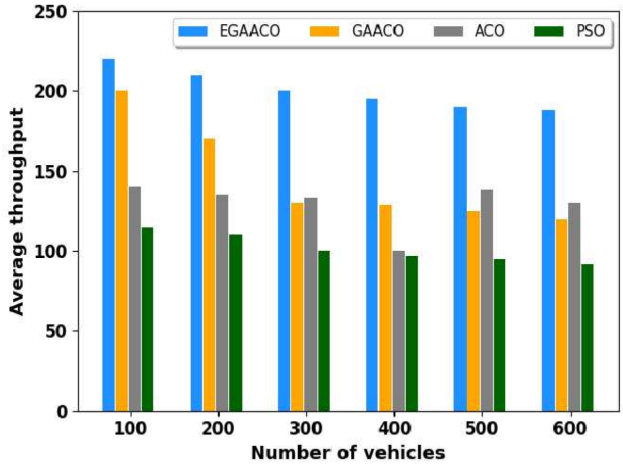

Figure 10: Efficiency evaluation of PDR for average throughput a complex traffic network

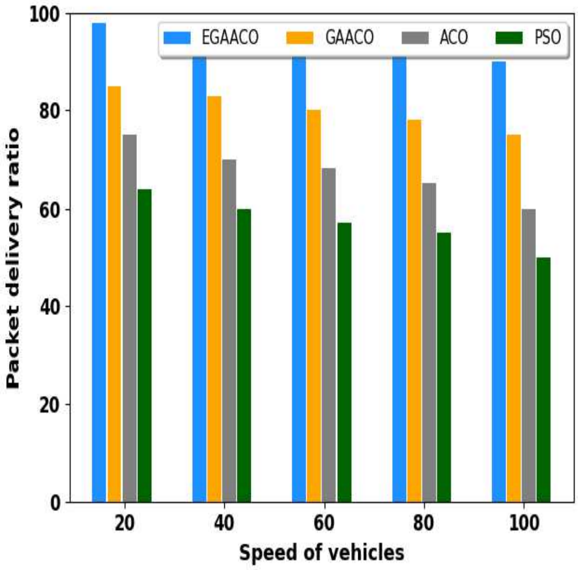

Figure 11: Efficiency evaluation of PDR calculated for for realistic traffic network

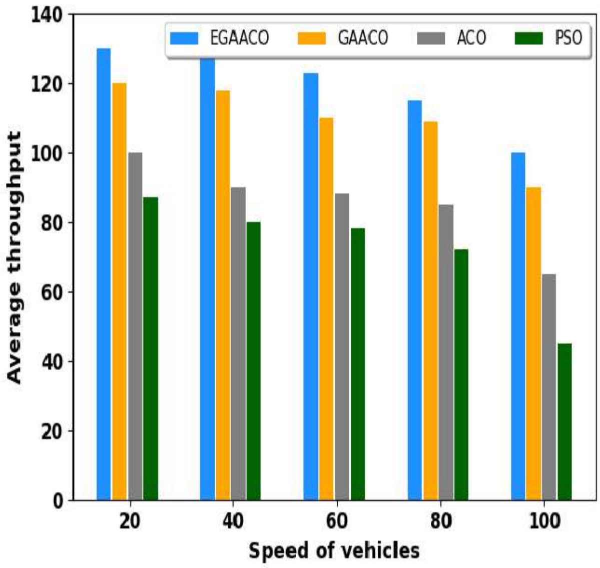

Figure 12: Efficiency evaluation of average throughput calculated realistic traffic network

5. Conclusion

An effective approach is proposed in this research by combining the GA and ACO approaches. To increase throughput and efficiency, the proposed methodology made use of GA and ACO capabilities. The GA, ACO, and PCO routing algorithms were examined and evaluated with the proposed approach. The data obtained from the simulation's results show that the ratio was substantially reduced when it was used for the simple, complex and Bangalore Road scenarios, and it has performed even better than the existing algorithms. The proposed algorithm has shown better efficiency in transmission time. The resultant comparison of three VANET traffic approaches like GA, ACO & PSO shows significant improvement in terms of PDR for PSO as 1.54%, ACO as 1.13% and average throughput for PSO as 1.34% and ACO as 1.24% for EGAACO routing protocol. Hence, this concluded that the proposed algorithm is proven better and can be further deployed for realistic routing protocol for congestion networks.

Ethics Approval

The paper is not currently being considered for publication elsewhere. The results are appropriately placed in the context of prior and existing research.

Conflict of Interest

All co-authors have seen and agree with the contents of the manuscript.

Data Availability

Not applicable

Author Contribution

Research work, data collection and analysis were done by the author and coauthors.

Funding

Not applicable

Consent to publish

We give our consent for the publication to publish the work.

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