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# A NEW APPROACH FOR GEO-OPPORTUNISTIC ROUTING PROTOCOLS BASED ON ANT COLONY OPTIMIZATION (ACO) TECHNIQUE IN URBAN VEHICULAR GRIDS

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## ABSTRACT

A new vehicle technology for communication called VANET requires the establishment of a secure and safe traffic system. VANET performance is adversely affected by a number of issues, including dynamic network topology, highly mobile nodes, infrastructure-less networks, etc. A vital component of any communication is routing. As a result, a large number of routing protocols have been created, aiding in VANET performance improvement. The opportunistic routing protocols are the most reliable of all for a variety of applications. Moreover, a lot of optimization techniques are used at present to improve routing protocol efficiency. This paper discusses the implementation of the MAC-independent Opportunistic Routing and Encoding (MORE) protocol and the Extremely Opportunistic Routing (ExOR) protocol. Ant Colony Optimization is a swarm intelligence-based optimization technique. Both of the MAC-independent Opportunistic Routing and Encoding (MORE) protocol and the Extremely Opportunistic Routing (ExOR) protocol have been simulated with and without optimization. The average packet delivery ratio, end-to-end delay, throughput, routing overhead, packet loss, and other metrics are used to assess and compare the performances of the MAC-independent Opportunistic Routing and Encoding (MORE) protocol and the Extremely Opportunistic Routing (ExOR) protocol, both with and without optimization. Network Simulator 2 has been used for all of the simulation. The results demonstrate how the ACO technique enhances the effectiveness of the VANET's Extremely Opportunistic Routing (ExOR) protocols. Additionally, the Extremely Opportunistic Routing (ExOR) protocol exhibits encouraging outcomes.

**Keywords:** Vehicular Ad Hoc Network, position, based routing protocol, Network simulator, ExOR, MORE Protocol.

## 1. INTRODUCTION

An ad hoc network is one that forms spontaneously from a group of autonomous, battery-constrained devices without the need for a pre-established infrastructure. One kind of ad hoc network that uses both stationary Roadside Units (RSUs) and moving vehicles as network nodes is called a Vehicular Ad hoc Network (VANET). Vehicular ad hoc networks have given rise to a number of fascinating research topics due to the difficulties in establishing effective (wireless) communication between these mobile vehicles and the stationary RSUs in a particular traffic environment. Furthermore, the need for vehicular safety measures, traffic efficiency, and the need to curb the rise in road accidents resulted in the development of Intelligent Transportation Systems (ITS), which rely primarily on communication between stationary RSUs and moving vehicles.The most crucial part of any communication process is routing, which involves using routers to transfer data packets from one node to another. Numerous algorithms for routing protocols have been created. Routing, which involves routers sending data from one node to another node, is the most crucial task for any communication. Routing protocols must be specific to each network. For VANET, a variety of routing protocols were developed, the most common being cluster-based, position-based, topology-based, and broadcast-based routing. The main focus of this paper was VANET Geo-Opportunistic Routing Protocols. The process of making something as perfect as possible is called optimization. Numerous optimization methods have been created to identify the best option given the conditions. Ant Colony Optimization (ACO), a method for determining the best Probable paths via graphs, is based on swarm intelligence. Routing of vehicles is among the most significant uses of ACO. It contributes to the position-based routing protocols in VANETs becoming more efficient. This paper is organized as various sections in II contain related work. We discuss Extremely Opportunistic Routing (ExOR) protocol, MAC-independent Opportunistic Routing and Encoding (MORE) protocol and Ant Colony Optimization technique in section III. We present our Simulation environment in section IV. Simulation Results and comparative analysis is described in section V. Section VI contains conclusion.

## 2. RELATED WORK

Opportunistic routing protocols capitalize on the wide-ranging capabilities of wireless communications by exploiting the fleeting nature of channel and node availability. The situation of mobile ad hoc networks, where nodes are highly mobile and wireless propagation is intrinsically unstable, causing frequent changes in network topology, appears to be addressed by this design principle. In those situations, standard MANET routing protocols might not function as well.

Numerous protocols for opportunistic routing have been created. Opportunistic behavior in the presence of weak wireless links is a concept that ExOR [5] pioneered. A list of potential nodes is specified by the sender in the packet header when using ExOR. These nodes have the ability to forward the packet. By negotiating with the neighbor nodes, the receivers relay the packet based on its priority in the list.

The first study to incorporate network coding into opportunistic routing is MORE [6]. Utilizing network coding and opportunistic routing, this MAC-independent protocol makes use of spatial reuse. Using network coding before forwarding, MORE randomly combines packets, in contrast to ExOR's extremely structured scheduler. By doing this, it is prevented that neighbors who hear the same transmission will send the same packet. Thus, MORE does not require a scheduler. In addition, numerous other protocols have been suggested in recent years. The first study to incorporate network coding into opportunistic routing is MORE [6]. Utilizing network coding and opportunistic routing, this MAC-independent protocol makes use of spatial reuse.

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The promiscuous nature of the air interface is used by OPRAH [7], a hop-count based protocol, to determine the optimal path for every packet. A coding-aware routing protocol called CORE [8] dynamically ranks the candidates in the forwarding set based on coding opportunities. To choose and rank candidates, OAPF [9] suggests a new metric called Expected Any-path Transmission (EAX) in place of Expected Transmission Count (ETX). Because ExOR and MORE are the original works that applied opportunistic routing and network coding to enhance network performance, we use them as the foundation for comparison in this paper.

Most of the proposed opportunistic routing algorithms are tested on actual testbeds or with particular simulators. When it comes to simulations specifically made for assessing opportunistic routing protocols and delay-tolerant networks (DTNs), ONE [9] is arguably the most successful one. ONE, however, does not model low layer mechanisms like signal attenuation and physical medium congestion in detail because its primary goal is to model the behavior of store-carry-forward networking. Instead, a communication range and a link with a specific bit-rate—which is supposed to remain constant throughout the simulation—are used to model the radio link. Because of all these drawbacks, ONE is not a good model for opportunistic routing protocols, which are based on the use of varying channel conditions.

We designed a framework in our earlier work to use the INETMANET [6] framework to simulate opportunistic routing protocols in OMNeT++. An open-source framework called INETMANET provides comprehensive radio propagation modeling, interference estimation, and network layer and MAC protocol implementation for wireless networks. It is a superior option for simulating opportunistic routing protocols because it can replicate the time-varying characteristics of the wireless medium. The four procedures that comprise the most representative opportunistic routing algorithms—forwarder candidate selection, forward selection, forwarder role change notification, and collision avoidance—are abstracted in the proposed framework. These four procedures serve as implementation stubs in the framework and are defined as virtual functions that can be overwritten to implement various protocols. Most opportunistic routing protocols require a few shared operations in addition to their core functions. These shared functions—neighbor management, packet buffer management, and ETX/EAX calculation and distribution—are also implemented by the framework. These implementations could be used by protocol developers to expedite their development cycles.

## 3. PROPOSED METHODOLOGY

### Extremely Opportunistic Routing (ExOR)

When the transmission of the current hop, each hop in a packet's route is chosen in the opportunistic routing approach to reflect which intermediate node actually received the packet, allowing for faster progress. This method provides a higher throughput than conventional routing because each transmission may have more independent chances of being received and forwarded. Loops can also be avoided in a tree structure of the participating nodes. Conventional routing protocols adhere to the idea of routing that is similar to wired networks by abstracting wireless links as wired links. They are able to determine the path that will save the most money, process the most data, and travel the shortest distance between the source and the destination. There is a bandwidth savings. This is because, when a packet is unicasted to a specific next-hop node, it is received by every neighboring node within the sender's communication range. Rather than retransmitting the packet, they take advantage of the neighboring nodes' successful reception. In opportunistic routing protocols, every neighboring node that is closer to the destination has the ability to overhead a data packet and can be used as transmitters to forward the packet to its intended location. The ExOR protocols can be used to increase the communication reliability in wireless networks. The selection, prioritization, and coordination of candidates are the three most crucial steps in OR protocols. Because of this, the majority of the research done in this field focuses on candidate selection and coordination strategies. ExOR shows how successful OR is when compared to conventional routing methods. A metric known as expected transmission count (ETX) is used by the nodes for selecting their candidate set. ETX calculates the number of times a packet must be sent by a sender node over a specific link before the corresponding receiver receives it. The candidate nodes in ExOR are chosen from the group of neighbors that, when the ETX metric is applied, reduce the shortest path between the origin and the destination. Extremely Opportunistic Routing (ExOR) is a combination of media access control and routing protocol. The rule that is adhered to is this: the node that is closest to the destination among the numerous nodes that can decode the transmission should forward it. ExOR dynamically selects paths based on each transmission to achieve the highest throughput in lossy wireless links.

**MAC-independent Opportunistic Routing and Encoding (MORE) Protocol**

When the source in MORE is set up for transmission, it continues to produce coded packets by combining the K native packets in the current batch in a random linear fashion. Such coded packets are continuously sent by the source until the destination acknowledges the entire batch. The source then moves on to the following batch. Data packets in MORE are always coded. Along with a code vector that documents the way the native packets were joined, they also carry a list of forwarders. When a node in the forwarder list receives a coded packet, it first determines whether the packet is innovative that is, whether it is linearly independent of the packets it has already received. A forwarder only keeps novel packets in storage. In addition, every forwarder maintains a TX Counter variable, which is determined by a distributed algorithm utilizing the ETX concept. A forwarder increases the counter by its TX Credit upon receiving an inventive packet from an upstream node. The node verifies that the counter is positive before transmitting when the MAC layer permits it to do so. In that case, the node generates a coded packet, sends it out, and subtracts one from the counter. The node doesn't transmit if the counter is zero or negative.The destination can decode the entire batch after receiving K inventive packets. In order to proceed to the next batch, it then replies with an ACK to the source. Unlike ExOR, which makes use of duplicate packets to determine whether a received packet contains new information, MORE makes use of the notion of innovative packets. To further cut down on transmissions, a TX Counter is used at each forwarder.

**Ant Colony Optimization (ACO)**

Marco Dorigo proposed the swarm intelligence-based method known as "ant colony optimization" in the early 1990s. The original idea behind the ACO algorithm came from the clever ways that real ants navigate their environment to find the best routes between their nest and a food source. Ants leave behind a chemical substance called pheromones when they travel along these paths. Shorter paths produce a high concentration of pheromones, which draw other ants to follow. Ants find the quickest routes from the food source to the nest in this manner. This diagram below can be used to explain why ants seek the shortest path. Three pathways, P1, P2, and P3, connect the source, an ant colony, to the destination, a food source, in Figure 1.

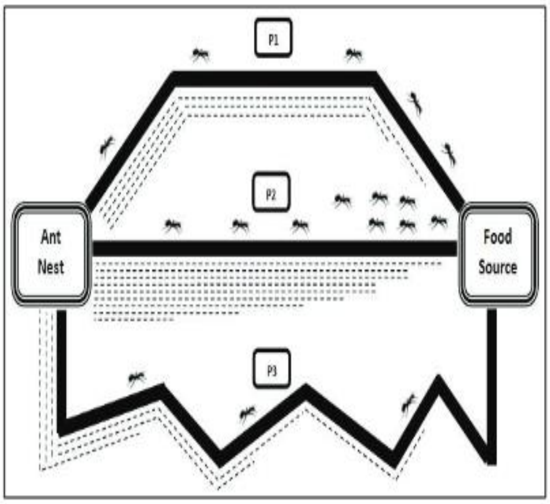


**Figure 1:** Ant Colony Optimization(ACO)

The first ant to go in search of food walks aimlessly and gets to its destination. As it returns to the source, this ant leaves pheromone trails along the routes it took to get the food. The ant that takes the shortest route gets to its nest the quickest. As a result, the person going out to eat takes the quicker route. A shorter path leads to a higher pheromone concentration. By using this information artificial ants can implement different behavioral action. ACO algorithm is based on three basic processes 1. Pheromone deposition 2.pheromone updating 3.pheromone evaporation. In first phase of process, artificial agents deposit pheromone on the paths they travelled. If the path is shorter then more ants will travel this path and thus this path will result in more pheromone concentration. In the second process, these pheromone values is updated after every iteration and in the last phase according to evaporation rate, pheromones on the longer paths gets evaporated. Since path P2 is the shortest of the three paths in the above figure, it has a higher concentration of pheromone. Ants thus determine the optimal path in this manner. Artificial ants, also referred to as artificial agents, take the place of real ants in the ACO algorithm. These agents use an indirect method of communication known as "stigmergy" to communicate with one another. Artificialants' long-term memory contains stored data such as the path they have taken and the cost of the links they have visited.

## 4. SIMULATION ENVIRONMENT

### A. Simulation setup

This paper's simulations are all run through the network simulator, or NS. Network simulator is the most appropriate tool for accurately obtaining results for scenario-based networks, such as vehicular ad hoc networks. The foundation of the network simulator is C++ and otcl. OTcl script is used to define network topology and achieve desired output, while C++ script aids in efficiency. There is a large library of protocols and network objects in the network simulator. Code for a specific protocol is contained in tool command language (.tcl) files. Following the compilation of this code, two output files, such as the Trace File (*.tr) and Network Animator File (*.Nam), are produced by NS 2. The scenario and operation to be carried out during the simulation are contained in the Nam file.

This paper describes the implementation of the Extremely Opportunistic Routing (ExOR) protocol and the MAC-independent Opportunistic Routing and Encoding (MORE) protocol in network simulator 2. After their implementation, these protocols are put through to the ant colony optimization technique, which maintains the same scenario. Finally, a comparative analysis has been conducted to examine these routing protocols' performance. 2.34 is the version of NS2 that is used for simulation. The simulation is done in a 500 x 500 m area. The number of vehicles used in the simulation has varied. The number of vehicles on the road varies from 10 to 20, to 50, and so on for each quality of service parameter.

### B. Simulation Parameter metrics

The performance of routing protocols like ExOR , MORE with ACO and without ACO has been investigated on the basis of following quality of service (QoS) parameters:-

1) Average end to end delay

This parameter shows the time required for data packet to reach from source node to destination node. Average End to End delay is calculated as,

Delay = Reception time – send time

2) Packet Delivery Ratio (PDR)

It is the ratio of number of packets received to the total number of packet sent successfully to the destination the packet delivery ratio is calculated as,

$$\text{PDR} = \frac{\text{Number of packets received}}{\text{Total number of packets sent}} * 100$$

3) Throughput

This parameter shows the rate at which packets are transmitted .Throughput is calculated as

$$\text{Throughput} = \frac{\text{Number of packets received}}{\text{Total simulation time}}$$

4) Packet Loss Ratio

This parameter shows how many packets are dropped during transmission. Packet loss ratio is calculated as

$$\text{Packet Loss} = \frac{\text{No. of pkt. sent} - \text{No. of pkt. received}}{\text{Total pkt. sent}}$$

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5) Routing overhead

This parameter shows additional traffic generated by Routing Protocol (R.P.). This additional traffic helps to successfully deliver data packets to the destination. Routing overhead is calculated as

$$\text{Routing Overhead} = \frac{\text{Additional traffic generated by R.P}}{\text{Data packets received successfully}}$$

## 5. COMPARATIVE ANALYSIS

In this section, comparative analysis of Extremely Opportunistic Routing (ExOR) protocol and the MAC-independent Opportunistic Routing and Encoding (MORE) protocol with ant colony optimization technique is presented. Fig. 2 shows Average end to end delay of Extremely Opportunistic Routing (ExOR) protocol and the MAC-independent Opportunistic Routing and Encoding (MORE) protocol before and after optimization. For the best performance of any protocol delay should be as minimum as possible. It is very clear from the figure that Average end to end delay of ExOR _ACO is very low as compared with other Protocols. Thus, ExOR _ACO is best in terms of delay.

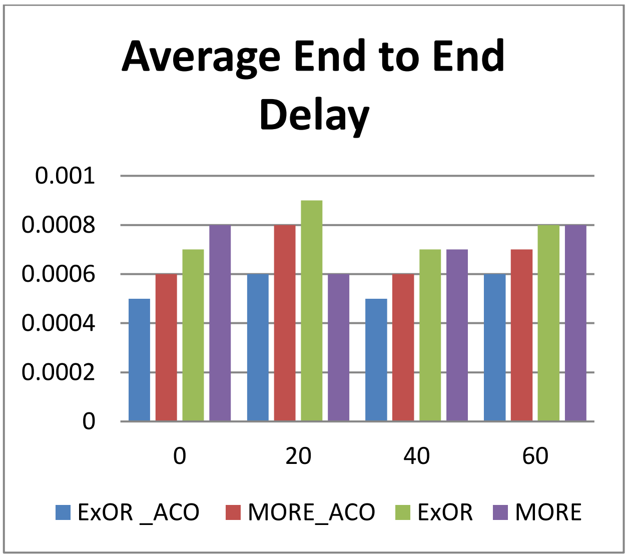


**Figure2:** Average End to End Delay

Fig. 3 shows packet loss ratio of Extremely Opportunistic Routing (ExOR) protocol and the MAC-independent Opportunistic Routing and Encoding (MORE) protocol with and without ACO. Packet loss ratio of ExOR_ACO is much low as compared with other protocols. Thus, the performance of ExOR_ACO is best in terms of packet loss ratio whereas on the other hand performance of MORE is very worst as its packet loss ratio is very high.

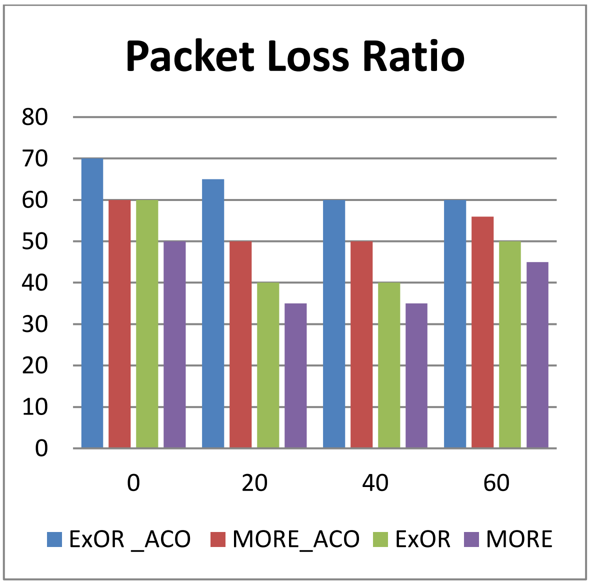


**Figure 3:** Packet Loss Ratio

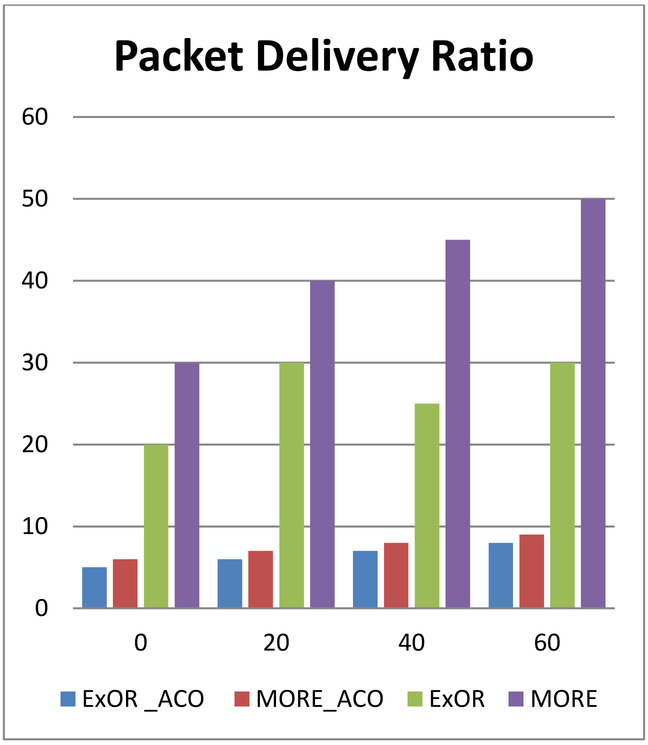


**Figure 4:** Packet Delivery Ratio

Fig. 4 shows packet delivery ratio of Extremely Opportunistic Routing (ExOR) protocol and the MAC-independent Opportunistic Routing and Encoding (MORE) protocol with and without ACO. For the best performance of any protocol packet delivery ratio should be as high as possible. Here, Packet delivery ratio of ExOR_ACO is highest among all the other protocols and it is increasing with number of nodes. On the other hand, PDR of MORE is worst and it is decreasing with the number of nodes.

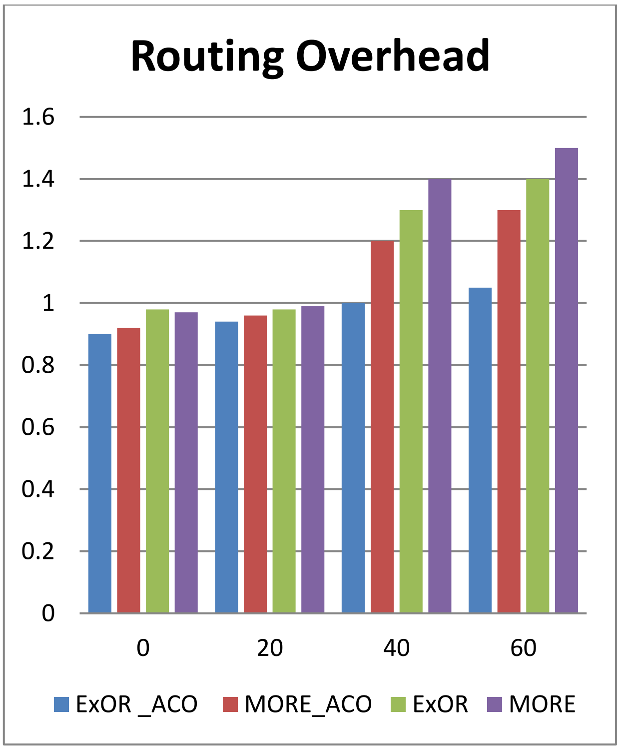


**Figure 5:** Routing Overhead

Fig. 5 shows Routing Overhead of Extremely Opportunistic Routing (ExOR) protocol and the MAC-independent Opportunistic Routing and Encoding (MORE) protocol with and without ACO. For the best performance of any protocol routing overhead should be as low as possible. Here, routing overhead of EoOR-ACO is low as compared with MORE.

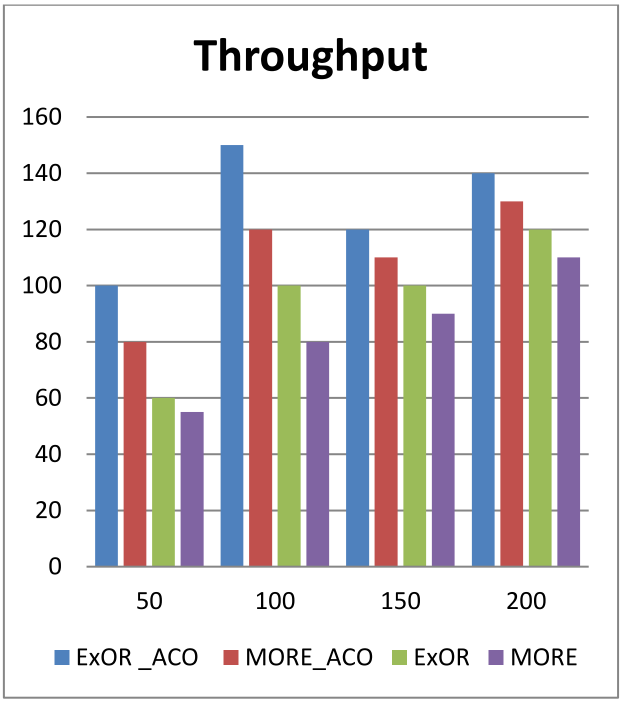


**Figure 6:** Throughput

Fig. 6 shows throughput of Extremely Opportunistic Routing (ExOR) protocol and the MAC-independent Opportunistic Routing and Encoding (MORE) protocol with and without ACO.Throughput of any routing protocol should be as high as possible. Here the graphical results shows that the throughput of ExOR_ACO is highest and thus, the performance of ExOR_ACO is best among all the other protocols.

## 6. CONCLUSION

The performance of opportunistic routing protocols, such as the MAC-independent Opportunistic Routing and Encoding (MORE) protocol and the Extremely Opportunistic Routing (ExOR) protocol, using the ant colony optimization technique, is presented in this paper. Because opportunistic routing protocols are best suited for extremely dynamic networks, such as VANET, they improved the network's performance. We have assessed the effectiveness of the MAC-independent Opportunistic Routing and Encoding (MORE) and the Extremely Opportunistic Routing (ExOR) protocol using the ant colony optimization technique for a range of vehicle counts. According to a simulation result, optimization has improved the performance of the MAC-independent Opportunistic Routing and Encoding (MORE) protocol, Extremely Opportunistic Routing (ExOR) protocol, and both. In terms of throughput, packet delivery ratio, and packet loss ratio, ExOR_ACO has performed better. ExOR_ACO and ExOR protocol are compared, and the results indicate that MORE performs better than MORE_ACO in terms of throughput, packet delivery ratio, and packet loss ratio. The simulation results make it abundantly evident that ExOR_ACO performs the best out of all the routing protocols. Additionally, as ExOR and MORE's performance improved following optimization, the ACO technique improved it as well. As a result, the ACO technique contributes to the enhancement of routing protocol efficiency while demonstrating encouraging results in VANETs. Future research can compare the effectiveness of ExOR and MORE with ACO to that of other ACO-based routing protocols currently in use.

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