Decreasing Traffic Congestion in VANETs Using an Improved Hybrid Ant Colony Optimization Algorithm

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Abstract—Vehicular Ad-hoc Network (VANET) is a definitive form of mobile ad-hoc network (MANET), which delivers data communication in a vehicular environment, using wireless transmission. Its fundamental goal is to increase the service quality of Intelligent Transportation Systems (ITS), such as road safety, logistics, and environmental kindliness, as well as information interchange. Smart cities are encountering problematic traffic congestion, particularly in developing countries. This paper presents an Improved Hybrid Ant Colony Optimization (IHACO) algorithm for decreasing congestion in smart cities. The objective of the proposed scheme is to choose a best routing path during rush hours by providing an optimal path. The scheme also introduces the IHACO algorithm to improve QoS for ITS. This algorithm (IHACO) differs from other algorithms, such as particle swarm optimization (PSO), in terms of pheromone update processes, which makes it more efficient. Also, the ant colony hybrid routing protocol (ACOHRP) protocol is introduced to improve the service quality of intelligent traffic systems (ITS). It delivers superlative efficiency through a better origination of packet delivery ratio, throughput, and end-to-end delay. Simulation-based testing is performed using Matlab simulation. It was found that traffic congestion time decreased gradually when using IHACO, unlike with other algorithms. The computed results demonstrated that the IHACO algorithm offers improved performance in terms of reliability, period, distance, and throughput, compared with different algorithms presented in this paper.

Index Terms—Ant colony optimization, vehicular ad-hoc networks, hybrid routing protocol, hybrid optimization algorithm

I. Introduction

Currently, VANET is gaining a great deal of attraction within the industry as well as among the academic research community. This well-thought-out system has been measured as the most distinguished for improving performance and efficiency for future transportation. Congestion is mainly caused by substantial volumes of traffic on the roads, together with other social activities taking up road space. This increases the number of accidents on the road because drivers all wish to reach their destination at the earliest time. This study shows that commuters can plan their trips by escaping congested routes should traffic congestion be identified in advance. Other optimization algorithms, such as PSO can be used to select the shortest route.

Ant Colony Optimization (ACO) is a swarm intelligence (SI) method motivated by the behavior of ants searching for food. ACO leaves behind a chemical element recognized as a pheromone on their path, which is sensed by other ants for the discovery of the best path to follow. Other ants follow the path comprising maximum pheromones in order to reach the source of the food. In the ACO scenario, ants interconnect employing pheromones; and the route of the journey is built via this method. PSO has, however, the shortcoming of the impulsive and slow speed of convergence.

This paper presents an improved hybrid ant colony optimization (IHACO) algorithm for decreasing congestion by lowering the overall travel time. This algorithm is less expensive and more highly effective than other algorithms available in VANET's framework. This paper also compares the ACOHRP routing protocol with existing dynamic source routing (DSR) protocol, based on throughput, data collision, and data dropped [1]. It also discusses the limitations, strengths, and strategies of each category. Based on a qualitative comparison of performance and environmental feasibility, it is shown that the ACOHRP routing protocol is more accurate than the DSR routing protocol [2].

The objective of this study is to build and develop a VANET algorithm system, namely (IHACO), which can detect traffic congestion in real-time, allowing vehicles to choose the most reliable routing path available.

The remainder of this research paper is organized as follows: Section II briefly describes the related work in the VANET area. In Section III, the proposed approach is presented in detail. In Section IV, the ACOHRP is presented in detail. Section V presents the results of the analysis of three different scenarios. Section VI concludes the paper.

II. Related Work

A. VANET Algorithms

An optimal solution to road traffic has become a difficult task for researchers to realize. Such an optimal solution would incorporate efficient vehicle movement on roads. Algorithms such as Dijkstra handle the shortest distance between source and destination. Also, the Dijkstra algorithm has been accessed by many VANET

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researchers in order to realize an optimal traffic-movement solution. However, there is no handy method in the VANET system for managing prodigious traffic and dynamic conditions. This results in traffic congestion. VANET solutions have concomitant complications. Other alternative methods must be applied [3]. Ant Colony System is one of the algorithms that can be used to solve the static routing issues in a vehicular environment. This theory is based on artificial ants that are able to engage a sub-optimal route for a real-time traffic problem [4]. The scenario is centred on traffic blockage between several connections, leading to an increase in overall travel time. This was achieved with the aim of nodes being removed or injected from the network, the time being directly proportional to the distance between the nodes.

VANET is an encouraging and growing technology for the next generation of vehicles. VANET offers a variety of applications; however, the main concern is to discover an efficient routing protocol that is feasible for the highly dynamic VANET [5]. For this challenge, eight routing protocol types have been discussed. For this paper, the focus is on 'Global Topology Routing Protocols.' In the past, swarm intelligence algorithms have been used in the literature to solve real-time VANET routing issues. An Ant system was proposed [6] that became a benchmark for its other variants, including Max-Min Ant System and Ant Colony System, for resolving static routing problems in the VANET environment. This system was based on the time that was directly proportional to the distance between the vehicles, with the option to inkjet or removed them from the network [7]. Other researchers provided the modified version of ACO in order to adjust the optimal path, which would take the least time and respond positively to many problems in their respective work [8]. PSO and MACO algorithms have previously been utilized by numerous researchers for continuous optimization issues. In the PSO algorithm scenario, each particle will attempt to move to an improved position in the solution space. Hence PSO was used for continuous optimization problems, whereas ACO was used for digital optimization problems [9].

B. VANET Routing Protocols [10]

1) Global Topology Routing Protocols: This kind of routing protocol requires the topology of all vehicles, so that information about links can be used to make routing decisions in the VANET [10].

2) Topology Free Routing Protocols: These protocols are based on position information for the moving nodes; they are also known as geographic routing protocols [10].

3) Cluster-based Routing Protocols: These are protocols based on the principle of clustering, in which group formation and cluster-head selection determine the process [11].

Geo-Cast Based Routing Protocols - These protocols utilize GPS to learn about the position of nodes, and it is a position based multicast routing [11].

4) Multicast-Based Routing Protocols: These protocols focus on transmitting packets within specific regions from a single source to numerous targets [12].

5) Broadcast-Based Routing Protocols: This is a protocol with numerous benefits in VANET, such as the distribution of traffic, emergency assistance, and weather information, the road situation amongst vehicles, and the supplying advertisements, messages, and unicasts for a well-organized route [12].

6) Delay-Tolerant Routing Protocols: In the process of avoiding congestion and complexity, this type of routing is introduced into VANET with several partitions, resulting in greater flexibility [13].

7) UAV-Assisted Routing Protocols: This is an improved type of routing protocol completing the connected sections while advancing routing, in order to have a world-wide vision for UAVs [14].

C. The Structure and Behaviour of VANET

VANET and MANET have almost the same structure, differing only in high mobility of nodes, making regular technological variations [11]. Thus, a vehicle can rapidly join or leave a group of vehicles in a short space of time, resulting in having little connectivity. Moreover, VANET supplies broadband connectivity and technical resolutions with great accuracy [12]. When any vehicle enters the cluster zone, its default status will be cluster member (CM); and the HELLO message will be exchanged with the cluster header (CH), as shown in Fig. 1.

1) Cluster creation

Vehicles change topology regularly, restricting the lifespan of connections between vehicles, because of high mobility and flexibility. [13]. This allows the vehicles to move, based on predefined methods by road infrastructure, as well as by traffic laws [14]. In order for better communication of the application of specific data, a cluster-header is nominated to construct and keep the structure of the clustering mechanisms [15]. The road segment has multi-lanes in which vehicles can travel in different directions. Fig. 1. shows a single clustered network in which node S acts as a cluster head, which maintains the surrounding neighbours, namely, A, B, C, D, E, F, H, I.

Vehicles that are in the same cluster connection are able to exchange information efficiently for a period of time at normal speed. [16]. The nodes cluster will be built based on two standards identified in Fig. 1. If the cluster is not yet recognized, and there are at least two vehicles of which their speed and path are checked from Fig. 2 [17]. The selection of cluster header (CH) will depend on the path of the route segment amongst vehicles. The path should be suitably long to form a connection, allowing for the exchange of information [18]. For the other cluster standards, if the cluster has already been created, the request will be thereafter be broadcast for integration with path and speed, as shown in Fig. 2.

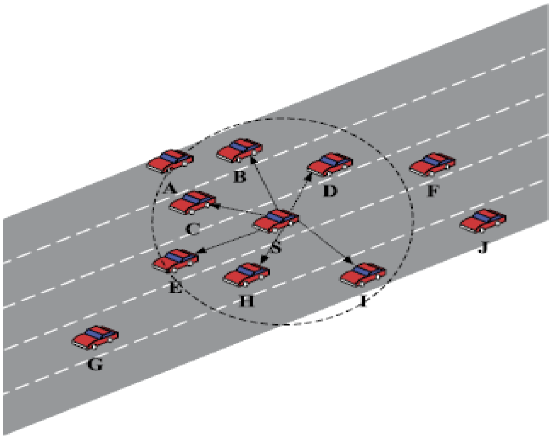

Fig. 1. Connection of vehicles in clusters [19]

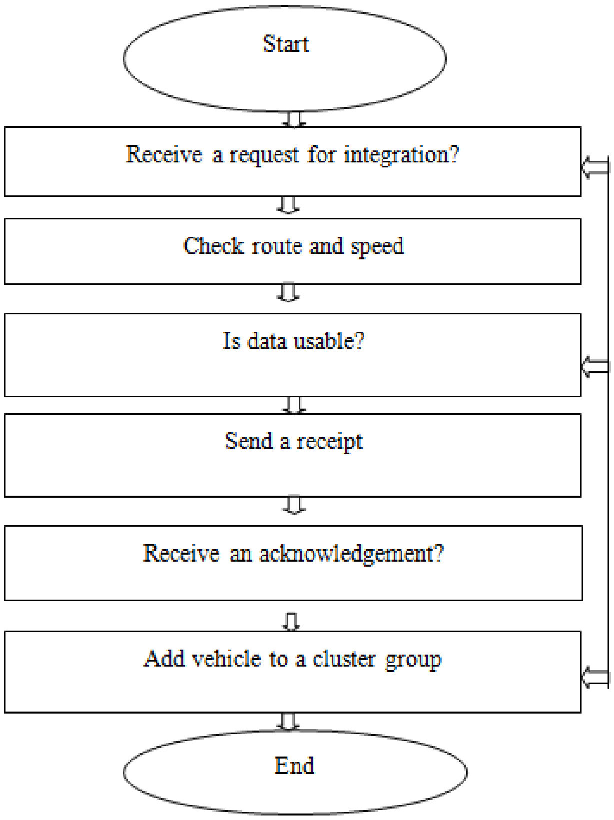

Fig. 2. Establish a connection for vehicle [3]

2) Cluster change for a simple node

The migration of a cluster from one vehicle to another is conducted by the route and speed changes. If the vehicle approaches the end of a mutual segment, it will need to search for a new cluster, using cluster-head [19]. If the vehicle changes suddenly in terms of path or speed, it will search for a new cluster by returning a warning message to the old cluster. [20]. The vehicle must choose its own successor before leaving the cluster if there is a needs to change speed or path. As a result, it must relate to the pathways of all vehicles. [21], [22].

3) Ant colony technique

Ant Colony (ACO) can be described as a metaheuristic protocol influenced by the scavenging conduct of ants. It uses the pheromone (hormone), which is deposited and identified by ants when they pass along paths. [28]. Pheromones captivate the ants, which causes more ants to be attracted to the same path. The ACO can point out a selection technique that raises an issue by iteratively trying to improve a candidate solution, with respect to a particular measure of quality. In VANETs, ants are denoted as special packets and rules that can be configured based on the algorithm for the packets [28], [29].

In order to build the infrastructure of a VANET system, some inter-roadside units are required to begin the route at a fixed distance. The red line indicates the communication between vehicle and vehicle; whereas the blue line indicates the vehicle-to-roadside communication. Finally, the green line shows inter-roadside communication. The RSUs are equipped with a Wi-Fi router, a storage device, and an electronic device that acts as a communicating platform, counting each vehicle that passes the RSU. A Central Maintenance Database (CMD) is a database that can store and analyse data received from both vehicles and RSU. Each RSU located in that particular area can communicate with the CMD. Every node/vehicle can also communicate with the CMD through the internet. Nowadays, the motor industry is manufacturing vehicles with VANET-compatible equipment, such as a visual warning signal, Wi-Fi, GPRS capability, inter alia, in order to easily cope with the VANET system. The VANET architecture uses the intelligent transport system (ITS) to transfer data between various on-board units (OBU). The entire scenario is shown in Fig. 3.

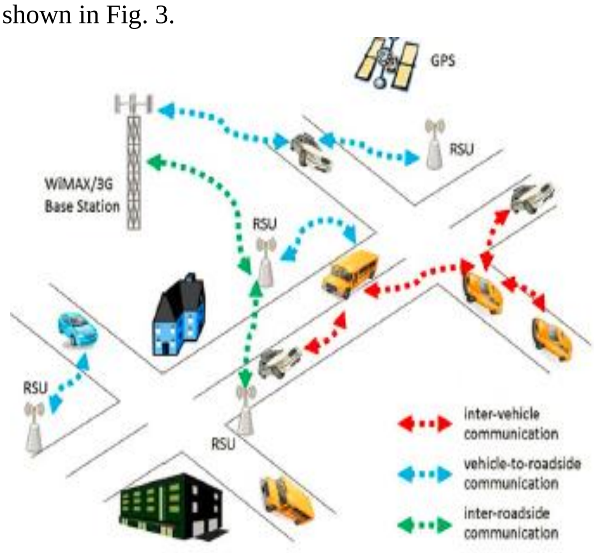

Fig. 3. VANET scenario [4]

III. Proposed Improved Hybrid Ant Colony Optimization (IHACO) Algorithm

The Improved Hybrid Ant Colony Optimization (IHACO) algorithm is based on Ant Colony (ACO), on the assumption that all nodes maintain a constant speed. In this case, vehicles may initially choose a different route, but after receiving information about traffic congestion, they can easily select an alternative route [23].

In order to provide a smooth and congestion-free route, the IHACO algorithm has incorporated both the PSO and ACO algorithms. The two algorithms, PSO and ACO, are then compared based on the best solutions found. The algorithm with the best solution is allocated as the global best solution of the VANET system [24]. The ANTS parameters are then reset to default, in order to generate the new solutions, using the global-best-solutions parameters of the VANET system. Hence, the pheromone is updated for the best solution of the system in IHACO, in order to avoid congestion under normal conditions.

The ACO and PSO algorithms are summed up in a discussion since they form the main components of IHACO. An ACO is defined by the probabilistic method, which was inspired by studying the conduct of ants. The behavior of real ants is supposed to lead to the discovery of a food source under normal circumstances [25]. As soon as ants find the food source, they make estimates, transporting some food back to the nest. When an ant returns, it leaves a trail of pheromones on that route that tips off other ants apropos of quantity and quality of the food. Each Ant will then be able to select a route according to the concentration of the pheromone deposit [26]. After some time, should ants abandon a route, the pheromones will evaporate. In the same way, vehicles are represented as ants in the ACO algorithm, which deposits pheromones on the traverse route. The congestion is indicated by pheromones collected on the roads. Ant will be led to avoid congestion if the amount of collected pheromones exceeds a threshold value. The pheromone value is associated with the movement of vehicles. If the vehicle enters a particular road intersection, the threshold value is incremented; and when the road is not busy for some time, the pheromone value for that road is decremented. The pheromone value is sometimes changed to a higher value in order to avoid road congestion. The pheromone threshold value is set back to a reasonable value when road conditions become normal.

A. *Particle Swarm Optimization (PSO)*

The PSO algorithm is a metaheuristic protocol, based on an optimization technique developed in 1995 by Drs Eberhart and Kennedy. The technique was inspired by the social behavior of fish schooling or birds flocking. The technique searches for the optimum solution by regularly updating generations in the subsequent iterations, initializing a random population. The particles in the PSO algorithm have both position and velocity, allowing for the selection of those particles with the highest suitable value in the whole search space.

B. *IHACO Algorithm*

This is an improved version of the existing ACO with pheromone strength as a measure of traffic-congestion reduction on the road. Each road is assigned an initial random pheromone value. The pheromone value is updated in order to reflect changes in the traffic as soon as vehicles shift on the road. Vehicles use a pheromone value to select the road with the least traffic; as a result, reducing the traveling time of their trip. The assumption here is that actual road conditions will serve the purpose of experimentation. In order to accomplish actual road conditions effectively, the PSO-modified algorithm has a pbest parameter representing the local best solution obtained. Alternatively, it has a gbest parameter denoting the global best solution [27].

The IHACO algorithm has a global search ability as well as a local search capacity, in making use of Ant concurrently. Each VANET algorithm has its best solution. However, the main difference between ACO, PSO, and IHACO is the pheromone update process. In the ACO algorithm, the pheromone is being updated by ants in order to achieve their best path. The PSO algorithm uses the pbest and gbest parameters for updating the pheromone value. For the IHACO algorithm, both scenarios, ants, as well as particles, are being considered in the pheromone update process.

1) *Pheromone initialization*

The formula below demonstrates the speed of the vehicle, together with the length.

$$Vx = V * \cos\theta \qquad Vy = V * \sin\theta \tag{1}$$

$$a_x = dv_x / dt \qquad a_y = dv_y / dt \tag{2}$$

where $Vx \text{ and } Vy$ denotes the velocity of the vehicles for both directions, simultaneously.

a_x and a_y refer to the attitude and latitude acceleration of vehicles.

The information drawn from the equations (1) and (2) is measured from vehicle sensors as an assumption.

Time denoted by t is used for the pheromone initialization formula, as given by equation (1) below:

$$\rho_{ij}(t) = \rho_{ij}(t-1) + C_1 * length(edge_{ij}) \tag{3}$$

In the above equation, ρ_{ij} denotes the value of the pheromone from vehicle i to vehicle j, which is directly proportional to the value of the edge. Time is denoted by t = 0, which is the measurement of the time taken by each vehicle to travel from source to destination. C_1 denotes the constant value of the vehicles in the [0, 1] range. The more the edge increases, the more does the length. This also illustrates a shorter and congestion-free route.

2) *Pheromone update process*

The IHACO, as explained, is an improved version of ACO. An ant updates the pheromone value on the edges after negotiating time taken by the vehicles to travel. This method is given by the formula below:

$$\rho_{ij}(t) = \rho_{ij}(t-1) + C_2 * (1 + \Delta p_{ij}) \tag{4}$$

where $\Delta p_{ij} = \frac{1}{N}$, or otherwise $= 0$. In this scenario, N represents a number of nodes, C_2 is a constant value which lies between [0, 1].

The travel time includes waiting time at the intersection, waiting at a green light, and is calculated as the sum of the actual travel time plus the waiting time at the lights.

$$\tau ij = (1-\rho)\,\tau ij + \Delta\tau ij \qquad (5)$$

In the above equation, τij denotes the amount of pheromone between path i and j. The variable ρ denotes the amount of pheromone evaporation rate, whereas the $\Delta\tau ij$ value denotes the deposited volume of pheromone [28]. $\Delta\tau ij$ is typically given by $\Delta\tau ij^k = 1/L_k$, only if ant K travels on paths i *and* j where, L_k is the cost of the K^{th} tour typical length. Otherwise $\Delta\tau ij^k = 0$.

$$\Delta\tau_{ij}\,(t+n) = p\tau_{ij}\,(\mathrm{t}) + \Delta\tau_{ij} \qquad (6)$$

where $\Delta\tau_{ij}$ denotes the sum of increased pheromones at the edges for the degree of pheromone dissipation. The number of pheromones per circle is shown by $(t+n)$.

3) System model for IHACO optimization

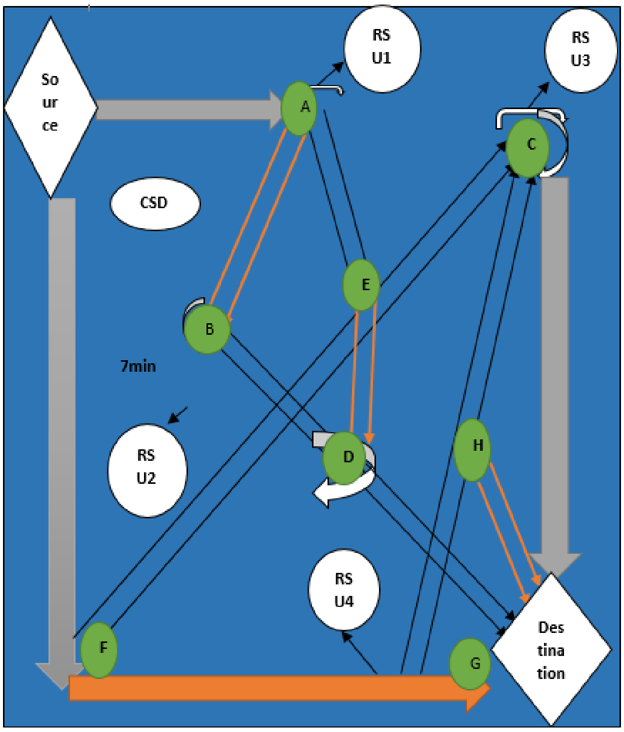

Fig. 4. Traffic flow estimation

The above graph shows the estimated optimal time for reaching the destination. Some components are included in the scenario in order for traffic flow to be efficient. The CSD is the central server database responsible for optimizing the entire route, in order for vehicles to reach their destination as quickly as possible via the IHACO algorithm. In this scenario, the vehicle will start from the source and look for a congestion-free route in order to reach the destination. It will connect to the CSD every time it reaches an intersection; the CSD will feed the correct information to the vehicle, providing the best route to take. This will help a vehicle to avoid routes that are congested, indicated by the red arrows. RSUs are located at the intersection to ease the communication amongst the vehicles. By employing the IHACO algorithm, the CSD will notify vehicles not to use the route from point A to B because it is congested; rather, take point A to E, then C, since this is less congested. The full scenario is shown in Fig. 4.

Algorithm1: for IHACO

1) Initialize pheromone update
2) While t < maximum value
   For all particles
      Generate routes using PSO algorithm
   Calculate pbest for generated paths (ref equation 3)
3) Continue for loop
   For all ants
      Generate paths using ACO algorithm
      Calculate ant-best paths
      Continue for loop
      Calculated gbest path among all pbest paths (ref equation)
4) If gbest <= ant-best then
   ant-best = gbest
   gbest = ant-best
   end while

Algorithm 2: Route best for IHACO

Input = Roadmap
Output = Routebest
Routebest = Routebest
Routebest = Routedistance
Pheromone = Initialise_Pheromone ()
While (nofinishcondition)
For i= (1 to n)
Ri = FindNewRoute (Pheromone, RoadMap)
Ridistance = distance (Ri)
If Ridistance <= Routebest (distance)
Routebest (distance) = Ri distance
Routebest = Ri
End
UpdatePheromone (Pheromone, Ri, Rbest)
End

Table I illustrates the route selection parameters based on PSO, ACO, and IHACO protocols. The IHACO algorithm has a YES on all the parameters, unlike the PSO and ACO, which makes it the more suitable solution for decreasing traffic congestion in real-time.

TABLE I: ROUTE SELECTION PARAMETERS

Schemes/ Protocols	Distance	Connectivity Level	Congestion	Designed For
PSO	Yes	No	Yes	MANET
ACO	Yes	Yes	No	MANET
IHACO	Yes	Yes	Yes	VANET

IV. ACO HYBRID ROUTING PROTOCOL (ACOHRP) FOR VANET

This routing technique enables the vehicle to communicate various information efficiently to other vehicles for a certain time, depending on the average speed and route of the vehicles that are in connection. Fig. 2 represents a group of vehicles that will be checked against the route and speed in the common-route segment. On the other hand, Fig. 4 elaborates the broadcast of vehicles against path and speed, respectively. Clusterhead creation is responsible for sending an acceptance signal, awaiting an acknowledgment [28].

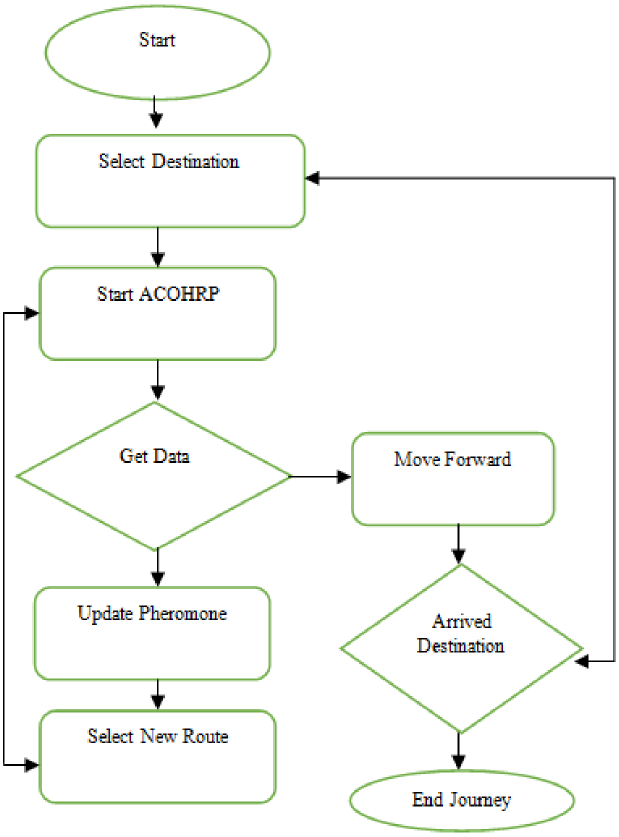

Fig. 5. ACOHRP route selection [29]

The number of vehicles passed through RSU is regularly updated in the central maintenance database (CMD) by RSU. The difference between the two RSUs is currently calculated by the CMD. The CMD will assume the number of non-moving vehicles as the pheromone level, by taking the algorithm of ACO into account. The concentration level of pheromones will be triggered to high if a large number of vehicles remain on a route [30]. A low number of vehicles staying on a route will trigger the pheromone to low. The CMD will check all possible routes with less possibility of having traffic congestion, by comparing the number of vehicles. As a result, they will make a decision on other vehicles selecting that route. Fig. 5 shows the application of ACOHRP.

A hybrid architecture is an architecture that combines both V2I and V2V communication. This architecture includes wireless networking devices which are fixed within communication units, such as access points, cellular towers, etc. Hybrid architecture also consists of vehicles that communicate by exchanging information received from infrastructure equipment or other vehicles, through ad hoc communication. The solid blue line indicates the communication between the vehicles, while the orange dotted line indicates the communication infrastructure and vehicles, respectively, as shown in Fig. 6.

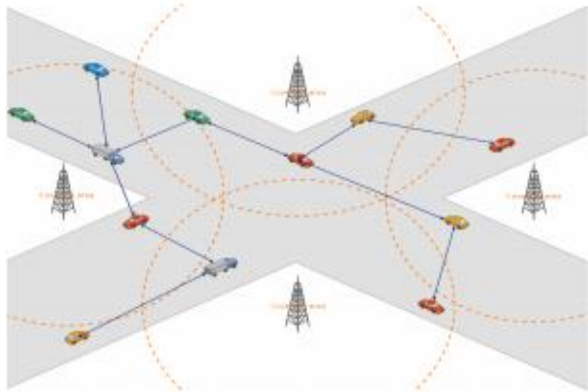

Fig. 6. Hybrid architecture [27]

Fig. 7. V2V Communication [29]

The system received information about the nearby vehicles and the other vehicle through V2V communication and employed it for traffic operation. The location global positioning system (GPS) measuring system provides the vehicle location as well as heading angle information [29] corresponding to the tolerance of commercial differential GPS. Fig. 7 shows the entire global system.

1) ACOHRP structure for VANET

As mentioned earlier, the method is based on traffic information in order to enable communication between vehicles. To achieve this, the Ant Colony is employed to signify knowledge and vehicular traffic information. This section describes the architecture of the proposed system, as shown in Fig. 5. ACOHRP consists of numerous processes, such as configuring nodes, network initialization, source and destination allocation, data transmission, and performance analysis [29], [30].

2) Dynamic Source Routing (DSR)

DSR is a sensitive path-finding scheme which does not need periodic HELLO packets and a warning signal. The DSR protocol technique is deluging the packets within the network by using route requests. The node responds regarding destination and conveys route traverse in its Cluster Header. DSR is composed of two techniques that collaborate to permit route maintenance and route discovery [30]. Route maintenance is achieved by the propagation of the route error message (RRER). Route discovery is accomplished whenever a source node needs to transfer any packet to an end-point node. The source node starts by consulting its source cache [31]. DSR is designed especially for usage in a multi-hop ad-hoc network of mobile nodes. This permits a network to behave entirely as self-organized and self-configuring without using any existing infrastructure. This protocol uses no periodic routing messages, therefore it avoids large routing updates and decreases network bandwidth overhead [31].

TABLE II: ROUTING PROTOCOLS COMPARISON

Parameters	Scenario	Routing Protocols	
		ACOHRP	DSR
Throughput	Metro	High	Low
Data Dropped	Metro	Low	High
Data Collide	Metro	Low	High

From Table II, it can be seen that ACOHRP and DSR routing protocols are being compared for the following parameters: throughput, data dropped, and data collide. The simulation parameters data dropped and dropped collide are high for DSR, and low for ACOHRP. The resulting analysis shows that ACOHRP routing protocols have a higher performance for road traffic safety measures than do the DSR routing protocols. Hence, it can be justified that ACOHRP routing protocols have high performance for the VANET system.

3) Improved ant dynamic source routing

ANT-DSR is a reactive technique that uses proactive route protocols over a constant validation of its stored routes. In this scenario, when packets are transmitted, proactive methods are used within the network; and reactive methods between networks [32]. The performance metric is improved when the ant-net algorithm is applied to the DSR protocol. This technique increases the lifespan of a listed route in the VANET network [32].

V. SIMULATION AND RESULTS

The simulations were executed on Matlab for experimental purposes. Vehicles were entering randomly. Each vehicle has been allocated a beginning and finishing position within the VANET system. The participating vehicle is taken out of the network after reaching its destination position. Vehicles are using a random speed ranging from 60 m/s to 90 m/s. The main objective of the IHACO algorithm is to decrease travel time by avoiding a congested route, regardless of the path selected. In this scenario, the number of ants is used as the number of vehicles, with particles being used as travel time. Hence, particles and ants hunt for the best solution, informing the corresponding pheromone. In order to achieve the best global results, the initial best solution for ants and particles is calculated and matched against one another. The solution will be repeated until all the corresponding parameters are acquired with respect to the global-best solution.

The IHACO algorithm has a more superior metric for optimization than the ACO and PSO algorithms. The results obtained from the IHACO algorithm are compared with those from the ACO and PSO under a similar environment. The results are generated and depicted graphically as the distance versus the number of vehicles, which is shown in Fig. 8.

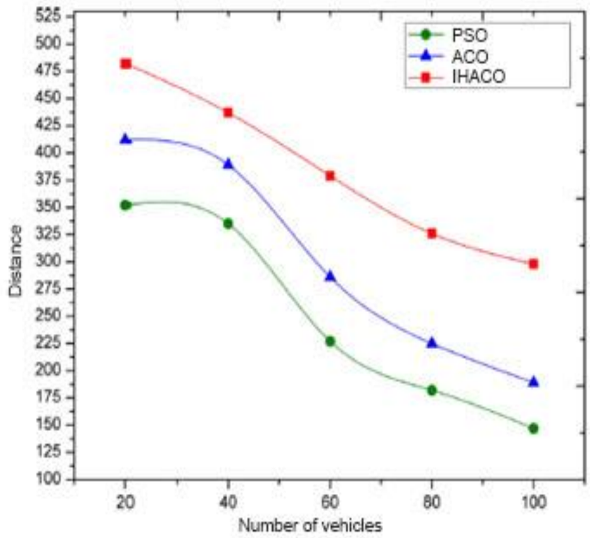

Fig. 8. Number of vehicles vs. distance covered

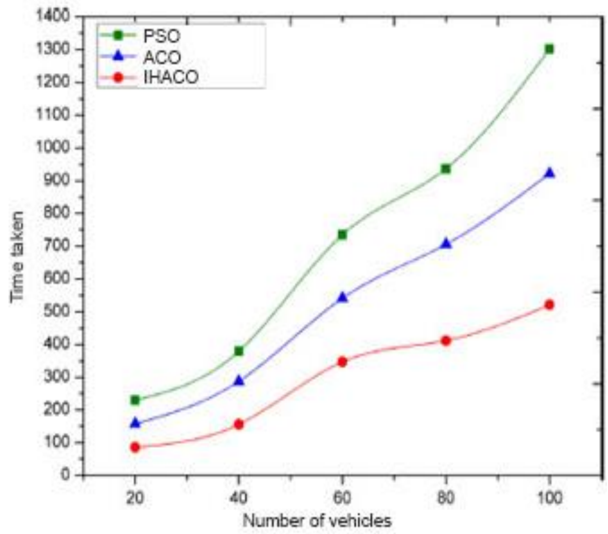

Fig. 9. Graphical representation of time taken vs. vehicles

It was also observed that the total distance covered by the vehicles is improved when using the IHACO algorithm, unlike the PSO and ACO approach. The single goal of the IHACO algorithm is to avoid congestion and to inform other vehicles of the road conditions. This can be seen in Fig. 9 as the graphical representation of IHACO algorithm compared with the PSO and ACO algorithms for the time taken by vehicles to reach their destination. When the number of vehicles decreases, the IHACO algorithm shows a substantial decrease in the total travel time for a journey taken by vehicles. The results obtained by using the IHACO algorithm shows that the total distance covered by vehicles increases by 85%, unlike with the PSO algorithm, which is at 55%. The distance using the IHACO algorithm decreases by 35%, unlike with the ACO algorithm, which decreases with 20%. Hence, the IHACO algorithm reduces the travel time by avoiding congestion in path length for the vehicles.

Reliability – there is a probability that a link between two vehicles will exist over a specific period of time. TheIHACO algorithm shows better reliability achievements compared with existing schemes − PSO and ACO. The IHACO algorithm outperforms the other owing to the adoption of congestion avoidance by informing other vehicles about the road conditions (see Fig. 10).

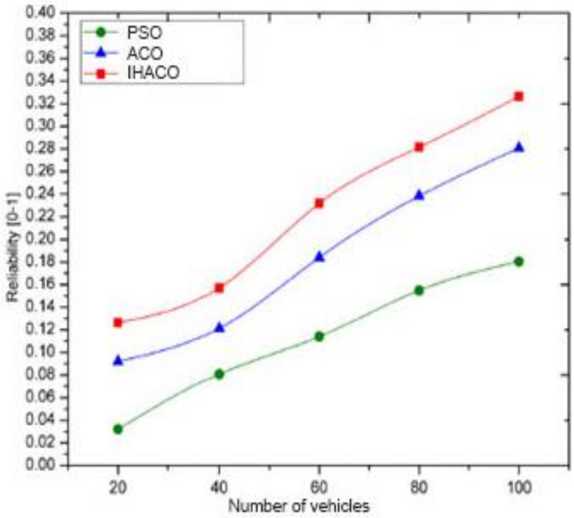

Fig. 10. Reliability of vehicles

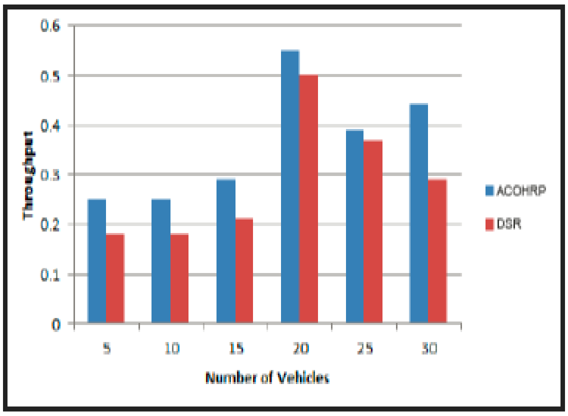

Fig. 11. Comparison of throughput VS Vehicles

In this subsection, the performance parameters, as well as the efficiency of network estimation, are discussed. These parameters are:

- **Throughput** – Fig. 11. Indicates the throughput values of ACOHRP and DSR. The outcome confirms the conclusion of the traffic-information results. Throughput increases gradually for both protocols with an increasing number of vehicles. It is seen that ACOHRP out-performs DSR, having the highest throughput.
- **End-to-End delay** – Fig. 12. This represents the average end-to-end delay of ACOHRP and DSR. From the above observation, it can be seen that the average end-to-end delay gradually improves for the ACOHRP routing protocol compared with the DSR routing protocol, owing to the time taken by the route discovery mechanism. Also, with the increase of the ACOHRP, the relaying of information packets has taken much time and will result in incremental delay-packets relay by hops. It is observed that ACOHRP has the highest delay.
- **Packet loss** – this refers to the packets dropped during the transmission. Fig. 13 indicates that the DSR routing protocol has dropped more packets than the ACOHRP routing protocol.

By making use of the Matlab program, using simulations, the results below were obtained. The next measurements have been executed per simulations for the routing protocols that have been concisely described − routing overhead, end-to-end delay, and throughput. The values in the figures are obtained by a simulation average set for each vehicle.

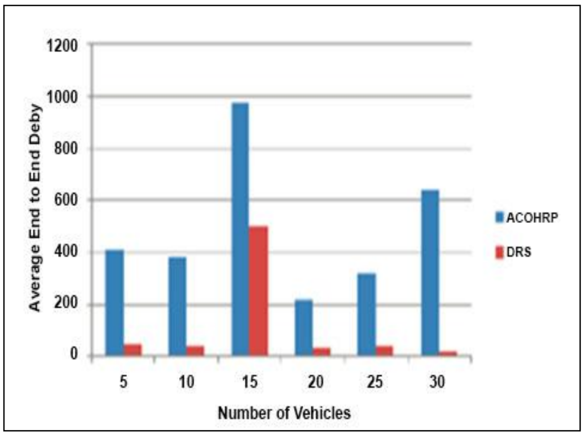

Fig. 12. Comparison of end to end delay vs. the number of vehicles

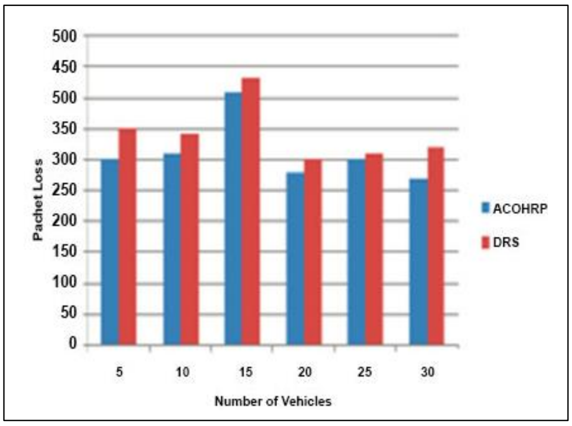

Fig. 13. Number of vehicles vs. packet loss

The simulations and experimentations were performed via a MATLAB version 2017b environment. Three (3) CBR connections were used as network traffic.

The simulation was conducted on 30 nodes. The velocity for each node is constant, which is represented by the C value. The two routing protocols are used for comparison, namely, ACOHRP and DSR. The data packet size is 512 bytes, respectively, using graphical representation analysis. It was observed that, when traffic volume increases, the total distance increases concomitantly, as with PSO; however, it decreases concomitantly, unlike with ACO.

TABLE III: SIMULATION PARAMETERS

Parameters	Value / Range
Mobility model	MATLAB
Network traffic connections	3 CBR connections
Simulation zone area	20m X 20m
Number of nodes	30
Fading	Nil
The velocity of each node	Constant
Speed	Up to 40 m/s
Transmission range	< 100 m
Routing protocols	DSR, ACOHRP
Data packet size	512 bytes

The above table summarises the simulation parameters as well as the range/value. The mobility model used is the Matlab program with three (3) CNR connections as network traffic. 30 Vehicles have been used for this experiment with the constant velocity of each vehicle. The traveling speed is up to 40 m/s with the transmission range of 100m. Two routing protocols has been used for this simulation, namely: DSR and ACOHRP.

VI. CONCLUSION

The IHACO approach is an improvement on the existing ACO algorithm, which hybridized PSO and ACO algorithms. This IHACO algorithm is introduced in order to solve the issue of increased congestion on the roads, assisting commuters by selecting the best path during peak hours. The IHACO algorithm results were compared with the results acquired from the PSO and the ACO, respectively, using graphical representation analysis. It was observed that, when traffic volume increases, the total distance increases concomitantly, as with PSO; however, it decreases concomitantly, unlike with ACO.

The paper also focuses on traffic information, as well as on ACOHRP, in order to allow suitable routing of packets from source to their final destinations. A low latency multipath routing structure has been introduced per an ACO method for vehicular network communication. The various routing protocols are required in order to facilitate the proper routing of packets to their final destination. The ant colony is used in vehicles to enable the analysis of information acquired from traffic. Furthermore, the ACOHRP has excellent flexibility for routing in various ad hoc networks. It also includes properties such as dynamic topology, efficient path selection, as well as evaluation of link-transmission quality. Three factors are measured to calculate discovered paths, namely, routing overhead, end-to-end delay, and throughput. This approach optimizes routing by improving road-service performance, significantly reducing delivery time. The results show that ACOHRP performs better than DSR routing approaches. The new proposed ACOHRP will be a better solution in dealing with all kinds of traffic scenarios. The new ACOHRP out-performs the VANET metrics in a dynamic environment. Future scope includes a hybrid protocol which can be developed to overcome all drawbacks of the existing protocols.

CONFLICT OF INTERESTS

The authors declare that no conflict of interest for this paper.

AUTHOR CONTRIBUTIONS

Author A wrote the full paper, including analysis of data and simulation. Author B contribute the idea, proofread the paper, correcting the contents and structure. Author C provided valuable comments, and all authors had approved the final version of the paper.

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