An Ant Colony Hybrid Routing Protocol for VANET

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***Abstract*— Vehicular Ad-hoc Network (VANET) is a definite form of Mobile ad-hoc Network (MANET), which delivers data communication in Vehicular environment using wireless transmission. Its key goal is to increase the service quality of intelligent transportation systems (ITS), such as road safety, logistics, and environmental kindliness as well as information exchange. Nowadays transportation systems are facing serious issues in terms of performance and efficiency of VANET applications, nevertheless these depend typically on the method in which messages are conveyed between the nodes. Finding a better routing protocol for dynamic VANET systems is one of the main challenges. This paper presents an Ant Colony Hybrid Routing Protocol (ACOHRP) to improve the service quality of ITS, by increasing the efficiency and reliability of vehicle traffic information message transmission. ACOHRP delivers high efficiency through better beginning of packet delivery ratio to end-to-end delay. A comparative study on the proposed ACOHRP and existing Dynamic Source Routing (DSR) protocol is conducted in a realistic scenario with VANET architecture, to demonstrate the performance of the proposed method. Simulation based testing is performed using Matlab with ACOHRP performing better than DSR in a dynamic environment of VANETs.**

Keywords—Ant Colony Optimization, Vehicular Ad-hoc Networks, Hybrid Routing Protocol.

I. INTRODUCTION

Currently VANET is gaining a lot of popularity among the industry as well as among the academic research community. This thought has been measured as the most valuable for improving performance and efficiency for future transportation. The operation of wireless communication technologies in vehicles as VANET has been growing quickly to improve road safety in intelligent transport systems (ITS). This kind of network permits the vehicles-infrastructure and vehicle-vehicle interactions in order for communication to take place. VANET is a type of MANET, whereby vehicles are denoted by nodes that are characterized through set of particular properties that changes speedily and continuously leading to an extremely dynamic topology. The routing protocol must support the high mobility, however, most MANET routing protocols are incompatible with VANET system. When deploying a routing protocol, certain properties need to be taken into consideration such as speed, security, geographic position, scope and the quantity of information supplied in order to enhance the movement of a signal. The inter vehicle network incorporates diverse wireless technologies such as 3G and 4G cellular, long term evolution (LTE) and LTE Advance.

This paper classifies existing routing protocols based on the architecture of VANETs [1], discusses the limitations, strength and strategies of each category. Based on qualitative comparison of performance and environmental feasibility, it is shown that geo-cast based routing and position-based routing are more accurate as compared to other routing protocols [2]. A new VANET routing protocol is then presented using Ant colony to structure the fast and reliable road traffic data transmission.

The remainder of this document is structured as follows, Section II briefly describes the related work of various VANET routing protocols with different strategies. In Section III, the proposed approach is presented in detail. Section IV presents the results analysis for three different scenarios. Section V concludes the paper.

II. RELATED WORK

A. VANET routing Protocols

VANET is an encouraging growing technology for subsequent generation of vehicles. VANET is offering a variety of applications, however the main concern is to discover an efficient routing protocol that is feasible to the highly dynamic VANET. For this challenge, several routing protocols were proposed which can be categorized into eight types.

1) Global Topology Routing Protocols

This kind of routing protocol needs the topology of all vehicles so that the information about links can be used to make routing decisions in the VANET. These protocols have advantages of discovering and maintaining the routes before the data transmission begins [2]. These protocols are categorized as follows: proactive, reactive, and hybrid protocols.

Proactive protocols are protocols that stores routing information of all the nodes within the entire network and it is table driven. The information is updated constantly because the nodes keep on changing its position every time [3]. The main

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advantage of proactive protocol is the availability of information about the nodes in the routing table because there is no route discovery [4].

Reactive protocols are known as on-demand routing since there is no updated information about the topology, and routing information is retained only when required. This protocol is based on the principle of flooding the network with the route request and route reply messages [4]. It requires a route discovery mechanism unlike proactive because there is no information about the route maintained. It has an advantage of suitability of higher mobility scenario and for large scale networks [5, 6].

Hybrid protocol is the combination of both proactive and reactive routing protocols based on their features. Its main function is to reduce the delay in proactive protocols, and decrease the control overhead in reactive routing protocols [7].

2) Topology Free Routing Protocols

These protocols are based on position information for the moving nodes and they are also known as a geographic routing protocol. It uses GPS (Global Positioning System) to locate the nodes that are participating within the network. One of the advantages of these protocols is that the route discovery and route maintained are not required, unlike topology based routing [8].

3) Cluster Based Routing Protocols

These is the type of protocols are based on the principle of clustering in which group formation and cluster head selection are determining the process. One of the important advantages of this protocol is lowering costs and the delays in data packet delivery [9]. Clustering is also suitable in big scale distribution networks for easier management. However, each and every group is assigned a cluster lead, which is accountable for nodes, management of similar groups as well as amongst the other groups [10, 11]

4) Geo-Cast Based Routing Protocols

These protocols utilize GPS to learn about the position of nodes and it is a position based multicast routing. One of its benefits is to ensure that the packets are delivered within an identified geographical region from source node to all other nodes in the network. It is also considered as a multicast service within the identified geographic area. The operation of this type of routing uses multicast group within a specified geographic area to broadcast a packet by directing flooding technique. [12].

5) Multicast Based Routing Protocols

These protocols focus on transmitting packets within specific regions from single source to numerous targets [13]. Multicast routing adapt to networks properties by considering high mobility, high speed movement and frequent topology variations. Multicast protocols are beneficial to VANETs since their wireless nature permits a packet to be broadcasted all over the network within the same range [14].

6) Broadcast Based Routing Protocols

This is a protocol with numerous benefits in VANET such as distribution traffic, emergency, and weather, road situation amongst vehicles, and supplying advertisements, messages and unicast for a well-organized route [14]. The standard of operation is by flooding and independent node re-broadcast to others which guarantee the message delivery. The advantage of this type of protocol is to guarantee message delivery, easy to set up but with some limited nodes.

7) Delay Tolerant Routing Protocols

In the process of avoiding congestion and complexity, this type of routing is introduced in VANET with several partitions resulted in the high flexibility. The carry and forward method is utilized by vehicles in order to store data packets to the network. [15]. One of the characteristics of Delay Tolerant routing is Intersection-based Geographical Routing Protocol (IGRP) which has been recognized by most investigators for routing packets in city surroundings [16].

8) UAV Assisted Routing Protocols

This is an improved type of routing protocol completing the connected sections as well as advancing routing in order to have a world-wide vision for UAVs. [17]. One of the important benefits of this protocol is to overcome the presence of obstacle along the path with two categories namely: UVAR-G and UVAR-S. It also guarantees the packet delivery by sending data packets on the ground over connected vehicle. [18, 19].

B. The Structure and Behaviour of VANET

VANET and MANET have almost the same structures, but differ in high mobility of nodes, that makes regular technological variations. Thus, a vehicle can rapidly join or leave a group of vehicles in a little space of time, resulting in having little connectivity. Moreover, VANET supply broadband connectivity and technical resolutions with great accuracy [19]. When any vehicles enter the cluster zone, its default status will be a Cluster Member (CM) and the HELLO message will be exchanged with cluster header (CH) as shown in Fig. 1.

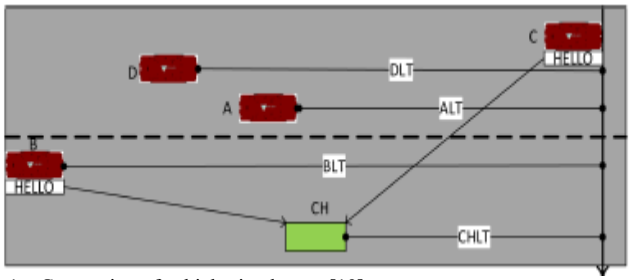

Fig. 1. Connection of vehicles in clusters [19]

1) Cluster creation

Vehicles change topology regularly and restricted lifetime of connections between vehicles because of high mobility. This will allow the vehicles to move based on predefined methods by road infrastructure as well as traffic laws [20]. In order for better communication of application of specific data, a cluster leader is nominated to construct and keep the structure of the clustering mechanisms. Cluster creation permits the division of networks into smaller segments for easy management [21].

Vehicles that are in the same cluster connection can be able to exchange information efficiently for a period of time on normal speed. [21]. The nodes cluster will be built based on two standards identified in Fig. 1 and Fig. 2. 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 (a) [22]. The selection of clustered (CH) will depend on the path of the route segment amongst vehicles that should be suitably long enough to form a connection and exchange information [22]. On the other standards if the cluster is already created, the request will be broadcasted for integration with path and speed consequently as shown in Fig. 2 (b).

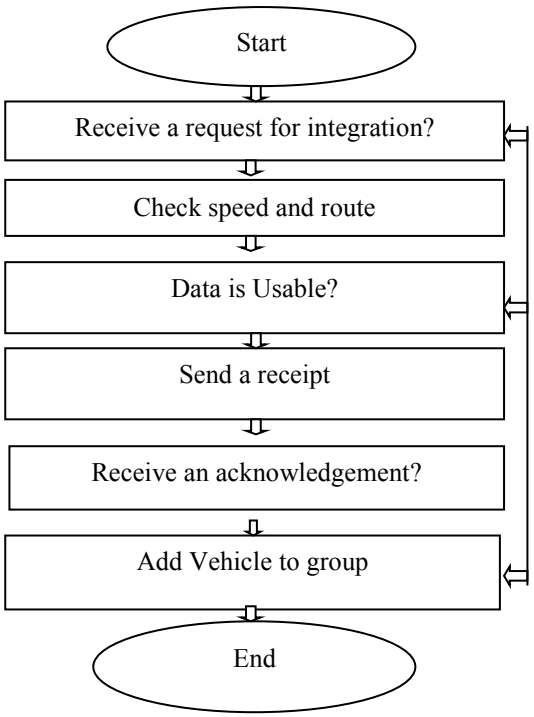

Fig. 2. (a) Establish a connection for Vehicle [3]

2) Cluster change for a simple node

The migration of a cluster for one vehicle to another is carried out by the route and speed changes. The vehicle changes will suit any new vehicle added to the cluster. If the vehicles approaches to the end of mutual segment, then it needs to search for a new cluster using cluster-head [22]. If the vehicle changes suddenly in terms of path or speed, then it will search for a new cluster by returning a warning message to the old cluster. [23]. The vehicle must choose its own successor before leaving the cluster if needs to change speed or path and as a result it must relate the pathways of all vehicles. [23, 24].

III. ACO Hybrid Routing Protocol (ACOHRP) for VANET

This routing technique enable the vehicle to communicate different information with other vehicles efficiently for a certain time depending on the average speed and route of the vehicles that are in connection. Fig. 2(a), represents a group of vehicles that will be checked against route and speed in the common route segment. On the other hand, Fig. 2(b), elaborates the broadcast of vehicles against path and speed respectively. Clusterhead creation is responsible for sending an acceptance signal and awaits an acknowledgement [24].

1) Ant Colony Technique

Ant Colony (ACO) can be described as metaheuristic protocol that is influenced by scavenging conduct of ants. It use the Pheromone (hormone) which is deposited and identified by ants when they passing along the paths. [24]. Pheromone captivated ants, which cause more ants to get attracted to the same path. The ACO can point out a selection technique which raises an issue by iteratively trying to improve a candidate solution with respect to a particular measure of quality. In VANETs, ants can be denoted as special packets and rules that can be configured based on the algorithm for the packets [25, 26].

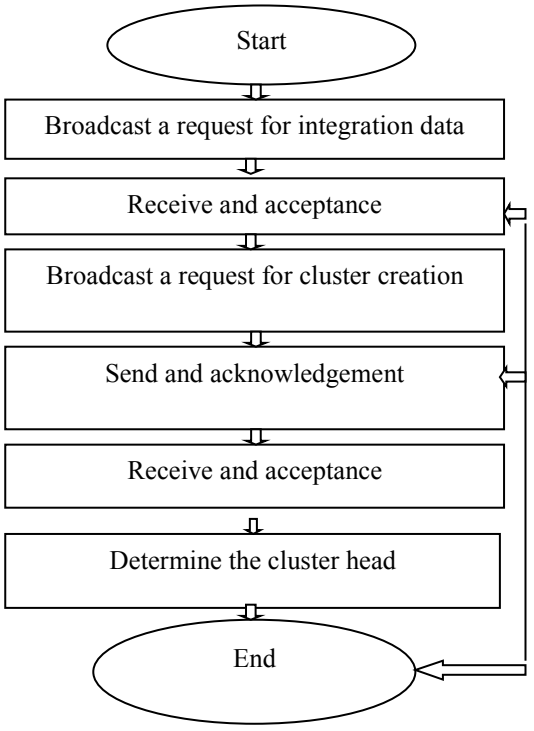

Fig. 2. (b) Steps to add new vehicle in a cluster-head [3]

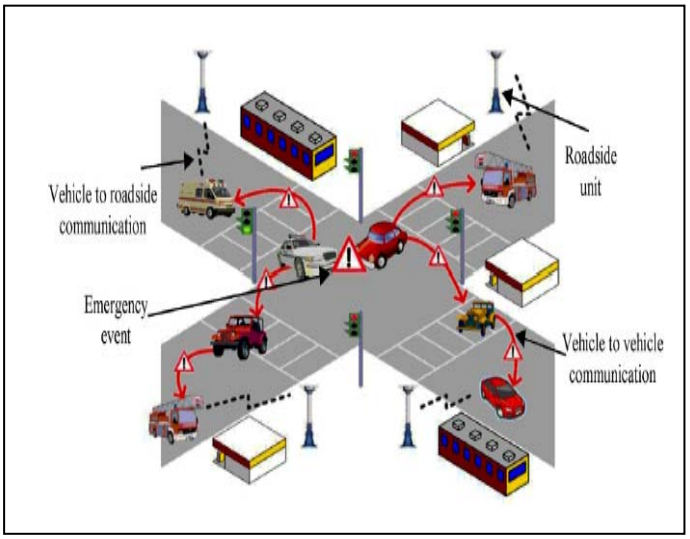

Fig. 3. VANET Scenario [4]

2) ACO structure for VANET

As earlier mentioned, the method is based on traffic information in order to enable the communication between the vehicles, and to achieve this, the Ant Colony is employed to signify knowledge and vehicles traffic information. This section describes the architecture of the proposed system as shown in Fig. 3. ACO consists of numerous processes such as configure nodes, network initialization, source and destination allocation, data transmission and performance analysis [25, 26].

Configure nodes – the nodes are organized as mobile vehicular nodes as specified from VANET.

Network initialization – in this scenario, the nodes are well-defined and it is done with specified area.

The data transmission uses DSR path finding protocol that is located in Zone based ACO whereas Source and destination nodes are assigned by the users.

The method focuses on traffic information to simplify communication amongst vehicles, for this reason ant colony is proposed to represent vehicles information and knowledge.

3) Dynamic Source Routing (DSR)

DSR is a sensitive path-finding scheme which does not need periodic HELLO packets and warning signal. The DSR protocol technique is deluging the packets within the network by using route request. The node responses over destination and conveys route traverse in its Cluster Header. DSR is composed of two techniques which collaborates and works to permit route maintenance and route discovery [27]. Route maintenance is done by the propagation of the Route Error message (RRER). Route discovery is done whenever a source node needs to transfer any packet to an end point node, which starts by consulting its source cache [28]. DSR is designed especially for the usage in a multi hop ad-hoc network of mobile nodes. This permits a network to behave entirely 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 [27, 28].

4) Improved Ant Dynamic Source Routing

ANT-DSR is a reactive technique that uses proactive route protocol 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 [29]. The performance metric is improved when ant-net algorithm is applied to DSR protocol. This technique increases life span of a listed route in the VANET network [29].

IV. Results and Discussion

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

a. *Routing Overhead* – for carrying routing information, the same bandwidth used by data packets is added to the user transferring data with the nodes exchanging routing information. The overhead parameter estimates additional traffic in which routing protocol produces. In order to accomplish routing tables. It is usual to have higher traffic loads than other algorithms, since all nodes in the network re-broadcast messages without processing through a calculation.

b. *Throughput* - Fig 4. Indicates the throughput values of ACOHRP and DSR. The outcome confirm the conclusion of the traffic information results. Throughput increase gradually for both protocols with an increasing number of vehicles. It is seen that ACOHRP outperforms DSR with the highest throughput.

c. *End to End delay* – Fig 5. Represents the average end to end delay of ACOHRP and DSR. From the observation, it can be seen that the average end to end delay gradually improves for both protocols as zone radius increases, due to period consumed by route discovery mechanism. Also with the increase of the zone radius, the relay of information packets consumed a lot of time and will result in the increment of delay packets relay by hops. It is observed that ACOHRP has the highest delay.

By making use of Matlab program, the results below were obtained using simulations. The next measurements have been executed over 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 simulation average set for each vehicles.

Table I: SIMULATION PARAMETERS

Parameters	**Value / Range**
Mobility Model	MATLAB
Network Traffic Connections	3 CBR Connections
Simulation Zone Area	20m X 20m
Number of Nodes	100, 200
Fading	Nil
Velocity of each Node	Constant
Speed	Up to 20 m/s
Transmission Range	< 100 m
Routing Protocols	DSR
Data Packet Size	512 bytes

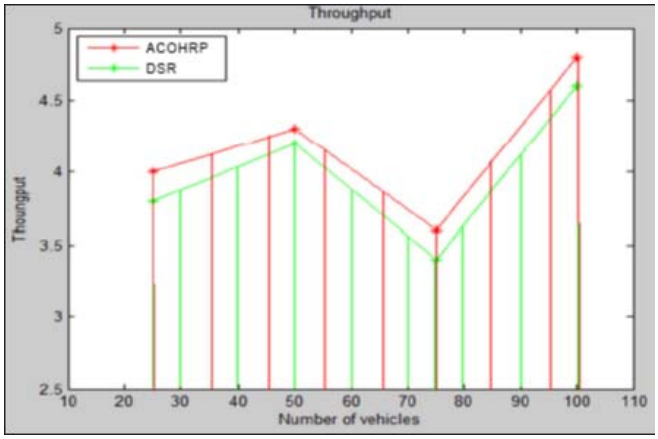

Fig.4. Comparison of throughput VS Vehicles

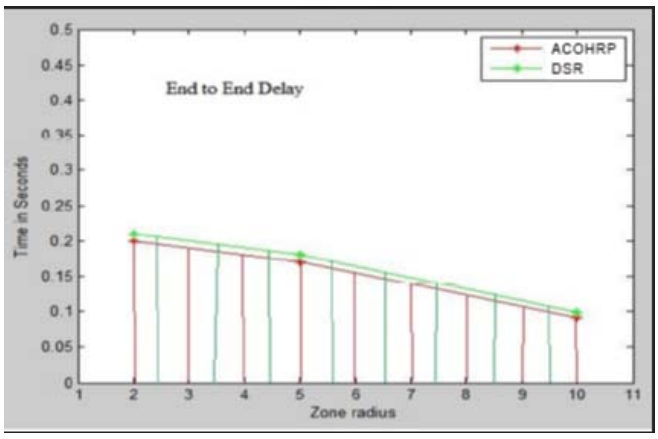

Fig.5. Comparison of End to End delay VS Zone radius

V. CONCLUSIONS

The networks of VANET are featured by high mobility vehicle, in which vehicle can connect and disconnect from the cluster network in a very limited period, and frequent topology changes occurred. Low latency multipath routing structure has been introduced by using an ACO method for vehicular network communication. The different routing protocols are required in order to permit the proper routing of packets to their final destination.

The paper, is focusing on traffic information as well as ACOHRP in order to allow suitable routing of packets from source to their final destinations. 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 different 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 optimize routing by improving road service performance and can reduce significantly the delivery time. The results show that ACOHRP performs better as compared to DSR routing approaches. The new proposed ACOHRP will be a better solution to deal with all kinds of traffic scenarios and can outperform well when evaluated using VANET metrics in dynamic environment. For future scope, hybrid protocol can be developed in order to overcome all drawbacks of existing protocols.

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