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Routing Optimization using Ant Colony Optimization in Vehicular Ad-hoc Network: A Survey

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Abstract—*VANET (Vehicular ad-hoc Networks) is a network with high mobility and it has a random network topologies. In VANET, vehicles communicate among themselves and with the devices (access points) on road and highways through internet or cellular data network. The important characteristic of VANET is the high moving vehicles on the road and this speed impacts the delivery of the data in the network formed. So, the main issue we are considering is routing of data in highly mobile network. In this work, we have explained a technique of metaheuristic known as Ant Colony Optimization (ACO). ACO is found to be suitable for routing and many researchers found it suitable for VANET. Its characteristic of pheromone trail makes it more efficient in terms of routing.*

Keywords: *Vehicular ad hoc network; routing; ACO;*

1. INTRODUCTION

In the present era, cars and other private vehicles are used on a higher amount and due to which a higher possibility of accidents on roads has raised. These arising problems of accidents and congestion on roads have been confronted by some of the modern society [25]. VANET is a wireless network which provides communication between two vehicles using a Dedicated Short Range Communication (DSRC), it is an IEEE 802.11a standard for low overhead operation to IEEE 802.11p [25].

In VANET, the communication allows vehicles to share different information like safety information, post-accident investigations, traffic congestion and other safety related information [25]. The other information like traveler information and position related information are considered in non-safety information.

VANET are network consisting of different vehicles communication among themselves on road or highway in urban areas [24]. Here, In VANET vehicles are considered as mobile nodes.VANET consists of access points and vehicles, in vehicles the main components are AU (Application unit), OBU (On Board Unit). OBU is a device which provides the services to the driver, the application may reside on OBU or RSU.

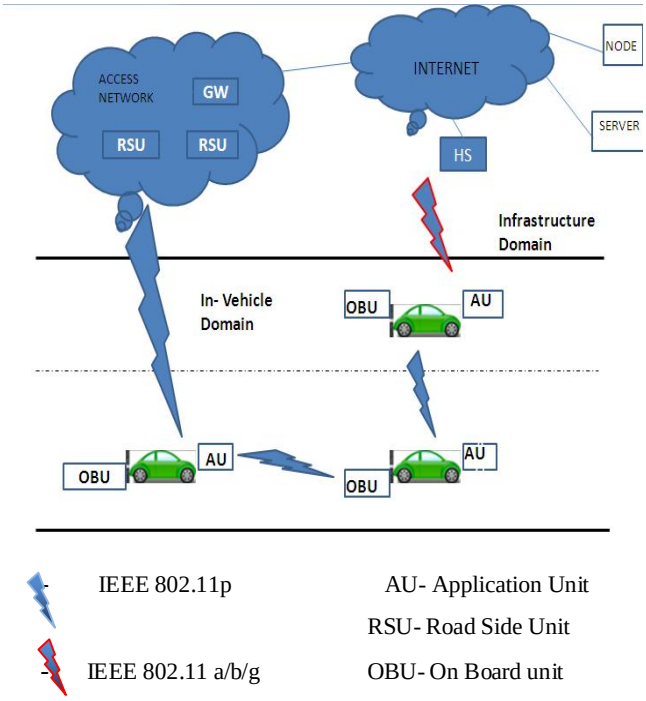

Fig. 1: VANET Communication architecture

The communication between vehicles or between a vehicle and an Access point (RSU) is achieved by a medium called WAVE, RSU is wave device fixed on road side. Vehicle can communicate with other vehicle (V2V) using IEEE 802.11p standard and with the RSU forming vehicle to infrastructure communication (V2I) [21].

2. VANET ROUTING PROTOCOLS

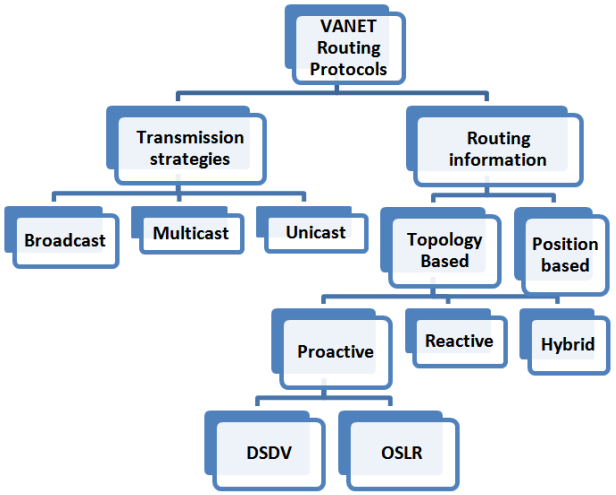

Fig. 2: VANET routing protocols

In VANET routing protocols, mainly they are classified in two types first is routing information and the other is transmission strategies.

Transmission Strategies: In this class of routing protocols delivery of information from a source to a destination node are classified in four types: unicast, broadcast, multicast and geocast. Where geocast is a special type of multicast transmission is used by the protocols to get the location of node and neighbor nodes [24].

Routing information: It is used in packet forwarding, it mainly focuses on topology-based and graphic based routing.

It is further classified as topology based and position based protocols.

In Position based routing protocol, source sends data packet to destination using its geographic process rather than its network address. GPS (Global Positioning System) assistance from source to destination [24].

In topology based routing protocol , it uses link information which is stored in routing table as a bases to forward packets They are further divided into proactive and reactive protocols. The main protocol used is AODV, DSV, DSR and other protocols

3. ANT COLONY OPTIMIZATION

ACO is a metaheuristic algorithm. Metaheuristic is a set of general algorithmic framework which is nature inspired and they are designed to solve complex optimization problems [13].

ACO is one of the most used and successful algorithm of metaheuristic field. The concept of ACO is related to biological ants and their foraging behavior, while searching for food they find routes from nest to food source [14]. Ants tend to find a random route which turns out to be good in terms of shortness, time travel etc. so their foraging behavior finds out an optimization problem out of a search space.

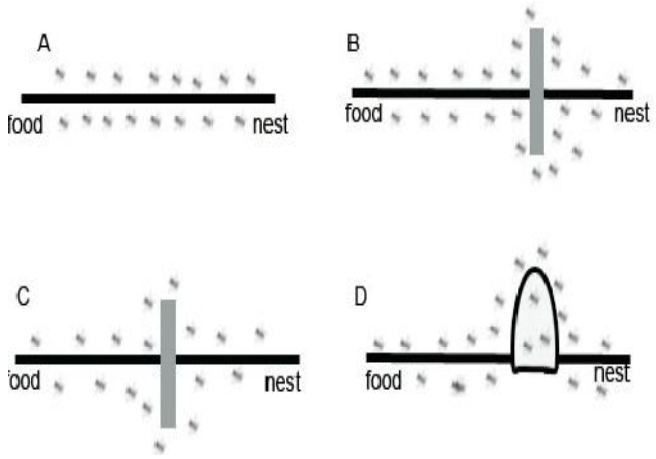

Fig. 3: Ant behavior [21]

The main success of optimization is explained by how ants communicate and by the decision of where to go. While searching for food, ants deposit some chemical called pheromone concentrations. While exploring the routes, it may be a longer or shorter route, Ant randomly walks on a path for food and in case they selects a shorter route , they deposit pheromone which will helpful for future ants to select the optimum path[11]. In return, they accumulate more pheromone on the route compared to longer route. Subsequent ants tend to follow the shorter route because it has more pheromone concentration on that path.

ACO are usually encoded by construction graph G= (V, A), where V are number of nodes of a fully connected graph and Arc A is connection between them. Finding a solution is equal to constructing a feasible walk on graph G [26].

The Main mechanisms on which ACO works are as follows:

- Construct ant solution
- Apply local search
- Update pheromone

4. RELATED WORK

Sergio Luis O. B. Correia et al [1], the author has proposed a new algorithm named MAR-DYMO which is derived from the traditional DYMO protocol, MAR- DYMO (Mobility Aware Ant colony optimization Routing –Dynamic MANET On-demand) routing protocol makes use of Ant colony optimization and the characteristics of ants are being deployed in VANET.The ACO is used to make use of speed and position of the vehicle as a heuristic function and to help the routing decisions based on it. The two main mechanisms of

ACO are pheromone deposit, which is used when exploring the routes and the the level of pheromone is deposited on each node/vehicle and the node updates their routing table with count of hop and pheromone level.

Ronan Doolan et al [2], In this paper author focuses on the traffic congestion throughout the week. In this paper Author proposes A Ant-based algorithm in which pheromone count for every road is used and an iteration based algorithm is used to lower the congestion on congested roads. The architecture of the proposed algorithm consists of vehicle model which gives information like speed and position of individual vehicle, Road model which gives the information about roads driving on, the current traffic model contains information about the instantaneous traffic information in the area and the time-dependent traffic model gives the information about the roads throughout the day. Using this architecture an algorithm is prepared and reiterating it the congested roads are made lighter.

Rodrigo Silva et al [3], the author gave AntRS algorithms which are used for two main objectives 1) for faster delivery of messages and 2) with a low probability of disconnections.

In this approach a given network with N vehicles randomly scattered in a square area of side L and the best path is to be established between different vehicles and a reference vehicle and it is desirable to find the best path between a message source and destination. The artificial ants are sent from the source randomly and they will select the best route based on the probabilistic equation and the pheromone trail found on the path .Three scenarios are considered in this paper 1) a static VANET without obstacles, 2) static VANET with obstacles and 3) dynamic VANET with obstacles. The simulation results are promising and find out best paths with the use of ant agents and considering the obstacles too.

Hao Dong et al [4], In this paper, an improved AODV protocol with ACO algorithm is used in VANET .The basic information like speed and position of the vehicle are used as heuristics information and using it a better route selection is done. By different modification of pheromone evaporation rate the nodes in the network can choose better route in two main discover steps with higher possibilities .The experimental results show that the new protocol has more effective performance than traditional AODV and it could find optimum route more quickly. The results also show that handoff frequency is reduced in given time. It also improves the routing path duration and the transmission efficiency of message.

Rashmi Ranjan Sahoo et al [5], the author proposed an algorithm based on clustering process and for routing purpose author used Ant colony routing .In every cluster a cluster head is selected to maintain the information regarding the whole clusters vehicles and status of network. CH is selected in a cluster only if it is the slowest moving vehicle and checking the trust value of the vehicle by broadcasting the packets to neighboring nodes. The member of clusters are selected only if they are moving in the same direction .The trust value of CH is calculated to ensure that the vehicle is not malicious and it decides the level of confidence of a vehicle on neighboring vehicle. The trust metrics which are helpful to calculate trust value of a vehicle are Traffic rule obey(TRO), Data packets forwarded(DPF), Data packet procession(DPP),Control packet forwarded(CPF),Control packet procession(CPP).Dynamic transmission range keeps a stable connectivity and for that dynamic transmission range is considered in it.

Alisson B. Souza et al [6], the author gave an algorithm based on multicasting trees and using the ant colony routing gave a new protocol for multicasting MAV-AODV (Multicast with Ant colony optimization for VANET based on MAODV), which is similar to a multicast protocol named MAODV (Multicast- AODV). The beacon messages are used to verify its position related to other nodes. The estimated link lifetime is an important issue to be considered and is calculated according the spatial distance between nodes and also range of the communication, so that the multicast group transmission becomes efficient.

Sumeet Sekhon et al [7], In this paper the author used the metaheuristic technique named Max-Min Ant system of Ant colony optimization. The accident information on the road should be flooded to the roads and cities, this task is done using sensors of WIMAX. The optimal path is selected using the bio-inspired algorithm which is followed by all the vehicles in the row. It tends to follow the path on which the the amount of pheromone trail is found more and a decision is taken as the upcoming vehicles come to know about the collision or accident information on the road.

S. Cloudin et al [8], author gave a new protocol named SI-DYMO (swarm intelligence-DYMO) derived from the metaheuristic technique Ant colony optimization is used. In this work, autonomous clusters are used in which there are cluster heads, gateways and cluster members. There are two kind of clusters considered in this work, they are intra clusters and inter clusters. The path selection procedure between the clusters is carried out by ACO and the data forwarding is done by SI-DYMO. Basically, ACO procedures are carried out in DYMO protocol.

Jamal Toutouh et al[9], in this paper author gave a parallel particle swarm intelligence based protocol(*p*PSO) to solve the problem of AODV routing optimization problems in VANETs. It uses the master-slave paradigm to evaluate all the swarm particles. Monte –carlo method is used for analyzing the results, the results of PSO and *p*PSO are compared. It was found from the work that PSO (Particle Swarm Intelligence) obtained better results than sequentially optimized by Garcia nieto.

Lenguajes y Ciencias et al [10], In this paper the problem optimal file transfer protocol configuration is saved using three metaheuristic techniques. It was found that the entire

algorithm efficiently worked for optimum FTC. From the simulation results it shows that PSO performs better than other algorithms in urban and highway scenario. So, the class of PSO techniques is efficient for VANET environment.

Manjot Singh Pandher et al[20], In this paper author showed that ant colony optimization is suitable for VANET environment and using Wi-Max and ant colony optimization technique the information of collision and accident can be flooded as soon as possible between roadside using Wi-max.

Er. GurpreetSingh et al [23], in this paper, author gave an approach for optimizing vehicle routing problem which is based on ant colony optimization, it also decides the open and closed routes for school buses. It not only decides the best route to follow but it also reduces the total distance travelled. The simulation shows that open routes are best for the school buses then closed routes.

Abubakar Aminu et al [19], in this work author gave Qos inspired routing strategy using artificial agents called ants. The technique proposed gave efficiency to traffic and sustainability to modern cities. The bio-inspired technique called Ant colony optimization is the biggest motivation for this work. The foraging behavior of ants and the pheromone trails are used as heuristic measures and the routing decisions are done.

Kwang Mong Sim et al [17], the comparison between ACO and different algorithms are compared and other measures like routing information, routing overhead and adaptivity are compared. The issue of stagnation occurring in ACO is also mitigated. The three main research groups are given for applying ACO for load balancing and routing information. This survey gives out the results on how the load balancing of particular network environment is balanced and lightened.

Bibhash Roy et al [17], in this approach a two phase reactive and proactive phase is used for end-to-end communication with Qos requirement of the user. In reactive phase an option a multipath to select a link from source to destination is given during a data session. In a proactive phase a stable, failure free link is being maintained to transfer the multimedia information through the network. This proposal works on ant agents which establish a multipath from source to destination nodes.

Anuj K. Gupta et al[15],In this proposed work DYMO protocol is enhanced by using Ant colony optimization in MANET, the ant behavior is used in it for enhancing the routing process in the MANET network. The two main phases of the ACO which are considered are routing discovery in which ants instead of TCP agents will be transmitted from source along with the ID of it and other network related details, and they will discover the path while depositing pheromone on the route and to select the best path they will return from the same path from which the ant started the discovery. The other phase is route maintenance in which the ants will keep information in the routing table about the hops generated for best path and other information in the intermediate nodes.

5. CONCLUSION AND FUTURE SCOPE

We studied the VANET and the communication architecture of the VANET, how two vehicles using DSRC communicates which each other. In this survey we studies how ACO is being implemented in many ways and how it optimizes the solutions.

Many met heuristic techniques are their which can be used for optimizing the solutions. In this survey we came to know that out of all metaheuristic technique like Evolutionary Algorithm (EA), Differential Evolution (DE), PSO (Particle Swarm Optimization) [10], and different other techniques are there and on comparing all of them in terms of Optimization PSO were most suitable for VANET dynamic and autonomous environment.

Mainly for VANET, ACO is suitable for routing optimization and the decisions related to routing. The ACO approach not only works well in VANET but also in MANET, we surveyed some papers in which ACO works at its best for route discovery and route maintenance phase for both the Ad-hoc networks.ACO is multipath iterative distributed algorithm, which gives multipath from a source to destination node. The techniques derived from ACO like MAR-DYMO, Ant-DYMO, E-DYMO, PIACO-AODV, SI-DYMO, TACR and other hybrid techniques which are derived from ACO was found to be useful for VANET and MANET for selection of the best path and maintaining that path for future nodes to visit it for optimal path.

For Future work, the different other hybrid ACO approaches can be made and they can be applied to the VANET environment.

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Appendix 1: Comparative study of different Ant based routing techniques

Title name	Description	Algorithm/ mechanism	Methods	Performance metrics	Advantages	Future scope
Mobility-Aware Ant Colony Optimization Routing For VANET[1]	The Mobility Of Nodes In VANET Is Considered And A Mobility Aware ACO Is Prepared For Less Routing Overhead	MAR-DYMO(Mobility Aware –Dynamic MANET On Demand)	Ants Are Used As Artificial Agents And The Pheromone Deposit And Pheromone Evaporation Rate Are Considered For The Route Selection Process Of ACO.	Delivery Ratio, End-To-End Delivery, Routing Overhead	It Performs Better In Urban Scenarios Than The Traditional DYMO.	Employ A Proactive Phase Of MAR-DYMO
Time-Ants: An Innovative Temporal And Spatial Ant-Based Vehicular Routing Mechanism[2].	Traffic Congestion Is Considered In Week And Weekend Days And The Congested Roads Are Made Lighter Using Proposed System	Time-Ants	Time Dependent Traffic Model Is Generated Which Gives The Throughout Information Of Current Situation Of Roads And The Vehicle Itself, The Proposed Time-Ants Is Used Iteratively To Make The Congested Roads Lighter.	Vehicle Which Reached Destination	It Outperforms Then The Existing Protocols Like Dna, Dijkstra And Sommer	Emission As Parameter Can Be Considered Instead Of Travel Time

A Heuristic Algorithm Based on Ant Colony Optimization for Multi-objective Routing in Vehicle Ad Hoc Networks[3]	The multiobjective routing with fast delivery of message with low probability of disconnections	Ant-RS	In this approach a given network with N vehicles randomly scattered in a square area of side L and the best path is to be established between different *vehicles and a reference vehicle and it is desirable to find the best path between a message source and destination.	Route selection	It tends to select the best path and with a low probability of disconnection	Comparison of proposed algorithm with the exiting routing algorithms.
Multi-Hop Routing Optimization Method Based on Improved Ant Algorithm for Vehicle to Roadside Network.[4]	The AODV with ACO is used for a better routing experience is used and the speed and position of vehicle is used as heuristic information	PIACO-AODV	An algorithm based on position information ACO and AODV is used for optimum route with iteration process	Packet delivery fraction, End-to-end average delay, packet loss rate and routing overhead	Performs better than AODV, gives position information along with optimum path selection	The proposed algorithm can be compared with different other existing protocols.
A Trust Based Clustering With Ant Colony Routing In VANET.	Using trust based clusters and ACO , the efficient cluster for routing optimization is done	TACR	Based on trust value a cluster head is selected and for every cluster the CH maintains the overall information of clusters and ACO is used for the routing process	Cluster creation time, probability of message transmission	Cluster improves resource usage	Application of trust mechanism to find out routes between two nodes in VANET
Stable Multicast Trees based on Ant Colony Optimization for Vehicular Ad Hoc Networks[5]	Using tree multicasting algorithm	MAV-AODV	Multicast with Ant colony optimization for VANET based on MAODV (MAV-AODV), Ant_RREQ_J and Ant_RREP is used instead of RREQ and RREP of MAODV	Maximum delay of multicast tree, overhead, packet delivery ratio	It uses paths with greater lifetime, obtains low disconnectivity	Create multicast trees which help for resource utilization.
Optimizing the Ad-hoc Applications in Vehicular Network using Max-Min Ant system.[6]	It uses the min-max ant system for routing optimization	Min-Max Ant system	Use of wi-max and bio inspired ant is done and the information of collision on the roads is flooded	Delay comparison	Useful for the information related to collisions on road and take routing decision as soon as possible.	Using min-max information regarding collision on road can be flooded on highways and roads
Reliable Routing Strategy for Data Communication in Vehicular Ad-hoc Networks[7]	With the use of clusters and ACO approach the routing optimization is done	SI-DYMO	The inter and intra clusters are used for the routing and the path selection is done using ACO.	Throughput, Overhead and delay	Packet can be transmitted through several clusters.	The clusters with ACO gives better routing