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An Ant Colony Optimization based Routing Techniques for VANET

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Abstract— With number of moving vehicles, vehicular Ad Hoc Network (VANET) is formed. These are provided with the wireless connections. Among various challenges in the VANET such as security and privacy of the messages, data forwarding is also considered as a major challenge. The effective communication is mainly depends on the how safely and fast the data is being forwarded among the vehicles. Data forwarding using Greedy mechanism suitable for routing in the VANETs, it depends only on the position of nodes and also data forwarding is done with minimum number of hops. In this paper, Position based GPCR and topology based DYMO routing protocol are adapted to make the use of Ant Colony Optimization (ACO) procedures. The resulting bio-inspired protocols, ACO_GPCR and ACO_DYMO had its performance evaluated and compared against existing GPCR and DYMO routing protocols. The obtained results suggest that making the use of ACO algorithm make these protocols more efficient in terms of Delay, Jitter, Packet Delivery Ratio and energy consumption.

Index Terms—Vehicular Ad Hoc Network (VANET), routing, Greedy forwarding, Ant Colony Optimization, bio-inspired

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I. INTRODUCTION

VANET, it is one of the major application of the ad-hoc network formed by the mobile nodes i,e (MANET). In VANET each vehicle has an electronic device fixed on each vehicle Safety and comfort of the passengers can be accomplished by using VANET. The comfort application such as playing the games by using internet, finding the nearest petrol pump and safety application such as information about the traffic, accidents.

The nature of communication i,e. whether it is efficient or not is dependent on the type of the data forwarding protocol used.

The data forwarding protocol for VANET broadly classified into:1) The routing protocol based on positional information 2) The routing protocol based on the topological information

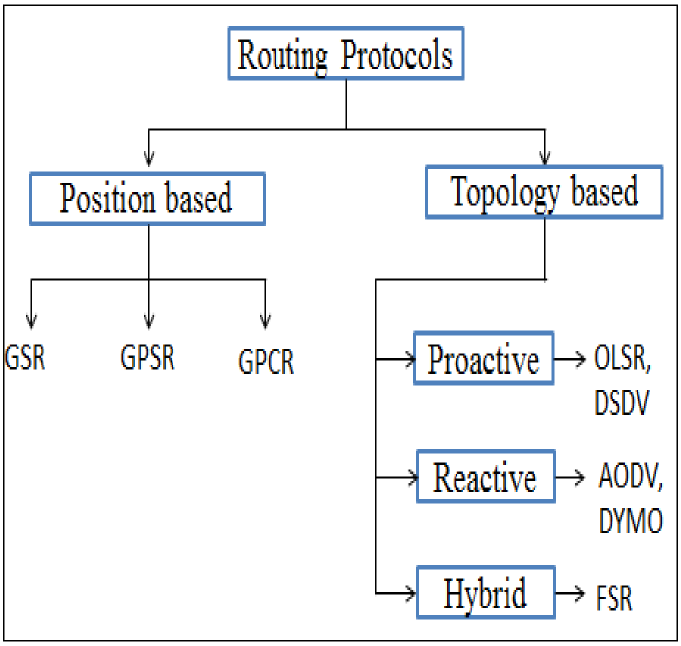

Figure 1. Routing protocol classification

Position based routing protocol: This category of data forwarding protocol uses only the locations of the packet generating node, its adjacent nodes and the target node. Using this robustness of the found routes and dropping of the data packets in case of very high traffic is reduced.

Topology based routing protocol:
In this the path based on the topological information of the network is selected to forward the data packet. Accuracy in finding the destination node, reduced number of hops for communication, no routing loops is achieved using this type of data forwarding protocol.

II. GREEDY PERIMETER COORDINATOR ROUTING PROTOCOL (GPCR):

GPCR is a position based data forwarding protocol. In any position based routing protocol, the forwarding of the data packets are basically dependent on the positions of the source node, destination node and on the adjacent nodes. The GPCR protocol is based on the traditional GPSR routing protocol by adding the concept of junction nodes in that. I the GPCR the data forwarding is necessarily done through the junction nodes that are present on the intersection of the two or more road segments.

GPCR uses greedy forwarding with the restriction of the road segments i,e selects only the node that are present on the same road segments. And at the junction node it decides on which direction the data should forward base on the distance of the nodes to the destination node. The node having smallest distance to the destination is chosen to forward the data packet.

[7] By forwarding the data packet with the above greedy forwarding technique, sometimes there may be a condition happens in which no node closer to the destination is found. In such cases data is forwarded using recovery concept. In this the data packet is first retrace to the node on junction in the greedy fashion and at that junction node, right hand rule is applied in order to find the next road for forwarding the data packet.[6]

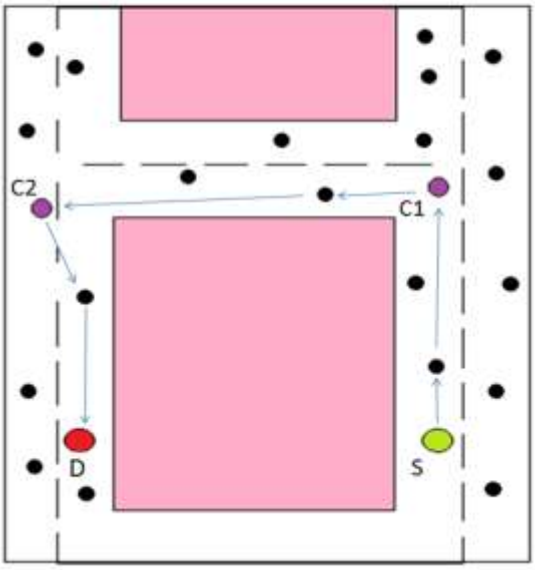

Figure 2. GPCR Recovery mode.

From the above figure 2, the data packet at node S suffered from a problem that it doesn't have any node in their range which is closer to the destination node D. So, now by using the GPCR's recovery concept, first the data packet will be forwarded to the node which is present on the intersection i,e node C1. At node C1, right hand rule is applied and the road segment counter clockwise to the previous road segment is selected. At the junction node C2, the distances of node C2 and destination D is compared with the distance of source S and destination D, and found that the distance between C2 and D is less so the packet is change to the greedy mode of data packet forwarding.

III. DYNAMIC MANET ON DEMAND ROUTING PROTOCOL (DYMO):

Dynamic MANET on demand routing protocol is proposed by Perkins & Chakeres and it is based on the AODV routing protocol. The DYMO data forwarding protocol search for the path only when the source node has the information to pass onwards to the destination i.e. it first discovered the route And also maintain that path until the communication is stop.

Route Discovery: In this process whenever the source node has data packet to forward, it first sent the requesting message to all their adjacent nodes which is called as RREQ message. If the nodes that receive the RREQ message are aware about of the path to the destination, acknowledgment is sent through RREP message. If not it is forwarded further. Each node taking the part in the process of discovery of route put their address in the RREQ message. The destination node sent the route reply i.e., RREP message to the source once the RREQ message reaches to the target node.

In DYMO protocol, each node is having a unique sequence number. The use of sequence number eliminate the chances of the loops in data forwarding and in this the low energy node has a facility to do not participate in the routing process.[14]

Route maintenance: Whenever the data forwarding from source to destination fails due to sudden breaking of the path, the RERR i.e. route error message is broadcasted by the node facing the link breakage and it is pass to the source node. The other nodes receiving the RERR message will update their routing table and the information related to the broken path is removed. Once the RERR message is received by the source node, the source nodes again start the procedure for finding another route to the destination node by sending the request message i.e., RREQ.

IV. OVERVIEW OF ANT COLONY OPTIMIZATION

Ant Colony Optimization, it is a Swarm based Optimization algorithm and was proposed by Marco Dorigo in 1992. It is basically dependent on how the ants search the food source even though they are blind and carry the food to their nest. The deposition of the chemical substance called as pheromone by the ants on the path they travel and the evaporation of this pheromone over certain duration of time, these are the two most essential terms in Ant colony optimization. With the help of pheromone, ants decide which path to follow; this process is the stigmergic communication [13]. As shown in figure 2, initially all ants move in an unplanned manner to discover the food. When they find food, they carry the food and come to the colony in reverse path by depositing the pheromone along the traveled path.

Now the nest ants which are coming out from the nest will first check for the amount of pheromone on all the available paths and it will choose the path on which the pheromone concentration is highest. As the time passes more ants will travel on the particular path, which is the shortest path having highest amount of pheromone deposited.

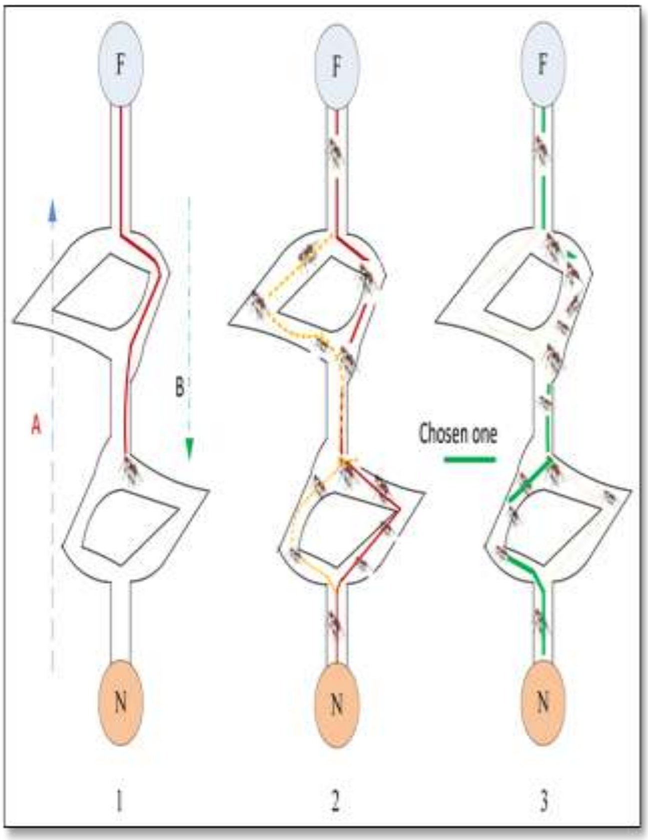

Figure 3.ACO technique

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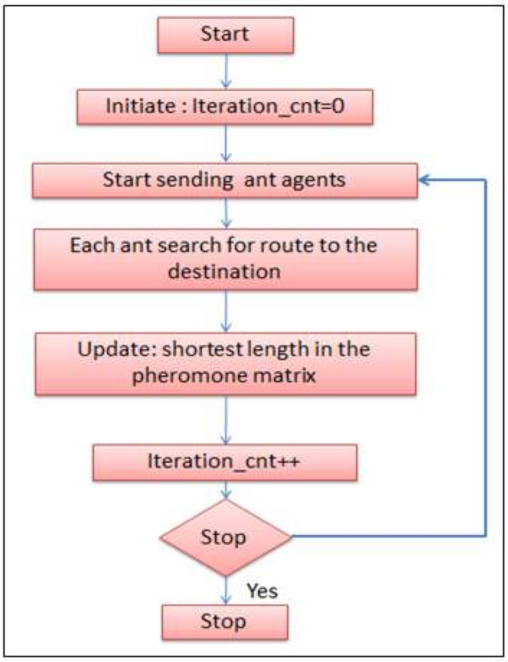

Figure 4. Flow chart for ACO

While implementing the ACO for VANET, first ants will randomly search for the destination node in possible direction. The later ants will first check for the probability which is given by following equation.

$$P_{i,j} = \frac{T_{i,j}}{\sum_{k=1}^{n} T_k} \qquad .....(1)$$

In this formula, $P_{i,j}$ is the probability that the ant will choose node j from node I, $T_{i,j}$ is the pheromone level concentration on the path between node i and j and T_k is the sum of pheromone of the whole path from node i.

The probability of the path that the ant will chose is basically depends on the amount of the pheromone on that path which is analogous to the number of times that path is chosen earlier.

Sometimes there may be possibility that the selected path is invalid or wrong so to correct that the evaporation or decaying of the pheromone is necessary. The decaying o the pheromone deposited by ants given by the equation below:

$$T_{i,j} = (1 - \rho)\, T_{i,j} \qquad .....(2)$$

In the above equation, $T_{i,j}$ is the amount pheromone present on the path in between node i and node j and ρ is a evaporation decay factor.

V. SIMULATION SETUP

We have used Network simulator 2, having version NS-2.34 to evaluate the different data forwarding protocols. In 1995 network simulator in its Version 1 and in 1996 version 2 network simulators was introduced. To run the simulation in NS-2, Tcl script is required to feed. During the simulation, all the information related to the data packets is stored in the trace files. After the completion of the simulation, the AWK program is used in order analyse the text based trace file and NAM program is to use to analyse the information in terms of animation.

Simulation setup:

In our simulation, the number of nodes is varied from 10 to 40. The simulation area of 300m * 300m is used. The packet size of 1000 bytes is used. Four routing protocols such as GPCR, DYMO, ACO_GPCR and ACO_DYMO are examined. Table 1 shows the input parameters that we have used in our simulation using NS-2.

Table 1: Simulation parameter settings

Parameter	Value
Simulator	NS-2
Area	300m *300m
Routing protocol	GPCR, DYMO, ACO_GPCR, ACO_DYMO
No. of nodes	10- 40
Packet size	1000 bytes
Packet interval	0.07 seconds
MAC protocol	IEEE 802.11
Transmission range	50m
Performance metrics	Delay, Jitter, Energy consumption, Packet delivery ratio, Throughput.

Simulation results:

In this part, the performance of existing GPCR, DYMO with swarm based ACO_GPCR and ACO_DYMO data forwarding protocol is evaluated. The time taken by the data packet to reach to the destination node is referred as delay.

Figure 5 shows the delay of optimized, ACO_GPCR and ACO_DYMO produces better results than the existing GPCR and DYMO routing protocol. The reason for this is that, initially using ACO technique multiple paths are computed. The main aim of the ACO technique is to find out the shortest path over all the other available paths. So, using the shortest path obtained through ACO technique, the delay in the delivery of the data packet is low.

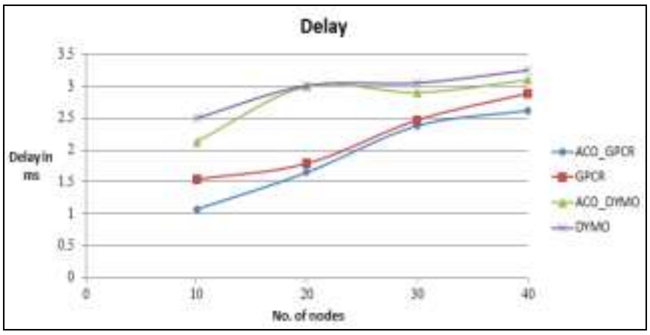

Figure 5.Delay Comparison

Figure 6 shows that jitter of GPCR, DYMO, ACO_GPCR, and ACO_DYMO. ACO_GPCR and ACO_DYMO produce better results than other data forwarding protocol such as GPCR and DYMO. Jitter is the difference in the packet arrival time to the destination node which is basically caused due to excess traffic; suddenly change of the routes and timing drift. ACO based ACO_GPCR and ACO_DYMO has less jitter rate than GPCR and DYMO. The jitter rate is calculated in milliseconds (ms).

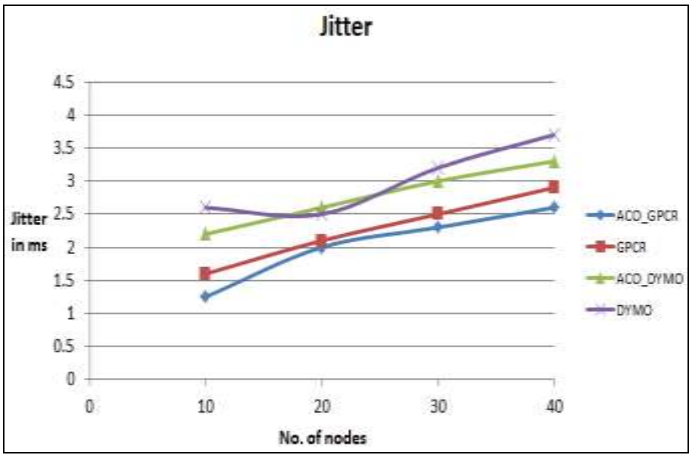

Figure 6.Jitter Comparison

Figure 7 shows Energy consumption graph of ACO_GPCR, ACO_DYMO, GPCR and DYMO. In this energy consumption for ACO_GPCR and ACO_DYMO is more than GPCR and DYMO routing protocol. The reason is that, ACO technique finds multiple paths and consumes more energy than existing GPCR and DYMO routing protocol.

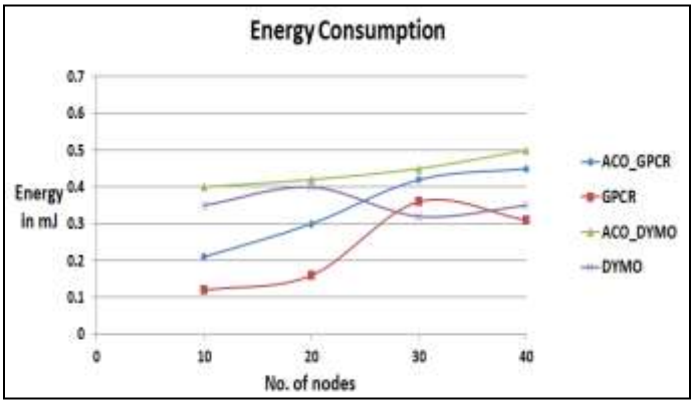

Figure 7.Energy Consumption

Figure 8 shows packet delivery ratio comparison of ACO_GPCR, ACO_DYMO, GPCR and DYMO. Packet delivery ratio is the ratio of received packets and sent packets. The result shows that Ant colony optimization based ACO_GPCR and ACO_DYMO has greater packet delivery ratio than existing GPCR and DYMO.

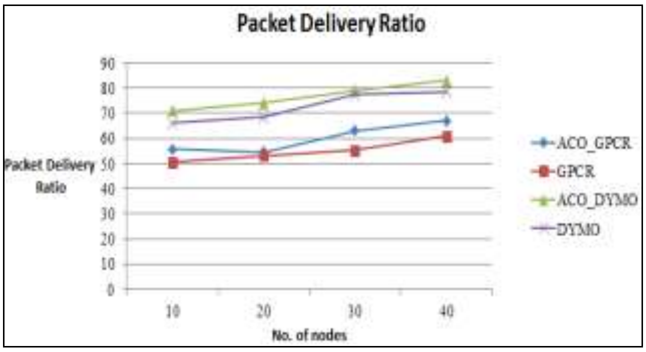

Figure 8.Packet Delivery Ratio Comparison

VI. CONCLUSION

To forward the data packets in VANET efficiently, the existing data forwarding protocols which are based on topological and positional information are not sufficient. Whereas the methods that are based on the behaviour of biological insects are more efficient for forwarding the data packets because the similarity between the two things such as procedure of finding the VANET paths from source to destination and the behaviour of the insects to find the path from nest to food source to fulfil their needs.

In this paper we have proposed, two ACO based routing protocols ACO_GPCR and ACO_DYMO. The result of the Ant colony optimize process shows that ACO_GPCR and ACO_DYMO performs well for Vehicular Ad hoc Networks. When compared to the existing routing protocol like GPCR and DYMO, the swarm based ACO_GPCR and ACO_DYMO shows good results in terms of quality of service parameters such as Delay, Jitter, Energy Consumption and Packet Delivery Ratio.

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