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An ACO based Routing Protocol for VANET

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Abstract

The vehicular ad-hoc network (VANET) is an instance of MANET that establishes wireless connection between cars in the road network. The main characteristic of VANET system can be summarized as high dynamics, predicable mobility, large scale, no power limitation etc. It is very difficult to maintain communication between the vehicles in VANET system due to their high mobility and which is mainly depends on the routing protocols. In this work, we propose a routing protocol for VANET system namely, Cluster Based Ant Colony Optimization (CBACO) which combine the characteristic of clustering and bio-inspired technique, based on real time interaction of ants known as the Ant Colony Optimization (ACO). Clustering the network reduces network overhead, redundant message exchange and the randomized behaviors of the artificial ants displayed a high efficiency in packet delivery to the nodes available in network with less latency. To realize the efficiency of CBACO in VANET System, the MATLAB-R2014a simulator is used. Hence, in this paper we tried to contribute in the improvement of Intelligent Transport System (ITS) in VANET technology.

Keyword: *VANET, MANET, CBACO, ACO, ITS.*

1. Introduction

The Vehicular Ad Hoc Networks (VANET) is mainly introduced for the development of the Intelligent Transport Systems (ITS), which have ability to coordinating with millions of vehicle on the road moving in different directions. The main components of the VANET system are On Board Unit (OBU), Application Unit (AU) and the Road Side Unit(RSU). Reliable message transfer, network congestion control, data security are the main functionality of the OBU. The AU is attached to the OBU through wire or wirelessly and provides information to the user. The RSUs are mainly fixed along the roadside or some specific location such as railway station, hospital, parking place to get information or communicate with those area [1]. There are mainly four types of communication in the VANET system. The communication inside the vehicle is called In Vehicle communication, this type of communication is very important for the VANET system which detect vehicles performance and specially driver tiredness and drowsiness. The communication between the vehicles to interact with each other is called vehicle-vehicle communication. The communication between the vehicles with the roadside unit to get information of the nearby place is called vehicle to roadside communication and the communication between the vehicles with the broadband mechanism such as 3G/4G is called vehicles to broadband cloud communication. The broadband cloud may include more traffic information's; and assist the driver to get more information and help in vehicle tracking [2].

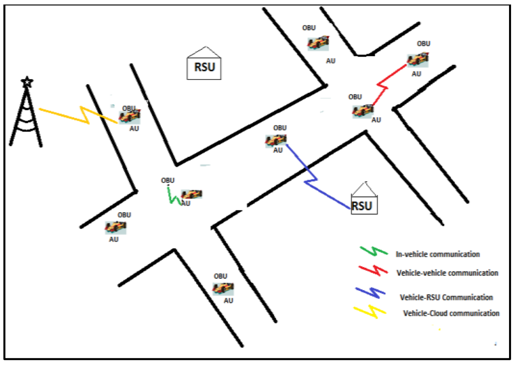

Figure 1: VANET architecture

Finding an optimal path from source to destination is a challenging task in the VANET system due to their high mobility [13]. The routing protocols play important role in selecting optimal path hence, various works going on to developed a new routing protocols for VANET system or modify the existing one [17][18]. Typical VANET scenario is shown in figure 1. There are mainly five type of routing protocols in the VANET system, these are topology based routing protocols, cluster based routing protocols, geo-cast routing protocols, location based routing and broadcast routing protocols [3]. In this paper, we propose a cluster based routing protocols for the VANET system using an ant colony optimization. The performance measure is calculated in term of packets successfully received to the destination by the shortest path and minimum time taken form source to destination.

2. Related work

The cluster based routing protocol (CBRP) [4] is a classical cluster based routing protocol for vehicular ad-hoc network where, the geographic area is divided into square grids called cluster and cluster head routes the data packet across different grids one by one. For electing the cluster header, each node has a specific node id and the node who has the lowest id among all other connected is considered as a cluster head. A Cluster-Based Directional Routing Protocol (CBDRP) for the highway scenario is describe in [5], where the mobile nodes moving in same direction and are near to each other are considered into one cluster and the centre of the cluster is fixed. The node with position nearest to the center is consider as cluster head. Only cluster head is responsible to find destination path therefore routing overhead is proportional to number of clusters, not number of nodes which reduce the network traffic. Cluster-Based Life-Time Routing protocol (CBLTR) [6] divides the road into multiple clusters and the cluster head is selected based on the lifetime of the nodes. The life time of every node primarily depends on the present speed of the vehicle and the distance from directional edge of the cluster. In their simulation, they compare the performance of proposed routing protocol with CBDRP using MATLAB-2013 simulator and from their experimental results they found that the proposed method increase efficiency of the system. In [7] authors proposed an Ant Colony Optimization (ACO) algorithm in VANET to overcome some issue such as connectivity loss, high latency and from their experimental result they found that, the proposed system is more precise and accurate. A hybrid technique with the combination of AODV and ACO is introduced in [8]. They considered both the route creation and route recovery mechanism with the help of routing and the pheromone tables. In their proposed work, the node closest to the destination node consider as the next intermediate node if the neighbor node is out of range. Thus, it improves the performance by avoiding the frequent path loss. In [9] proposed a dynamic mobility aware ACO routing protocol for the urban scenario, which consider the speed and position of the vehicle for designing such dynamic networks. From their experimental result they found that using of ACO algorithm make the routing protocol more suitable for the VANET system.

2.1 Clustering

In the cluster based routing, the nodes are divided into virtual groups according to some specific rule. Each of the group is called cluster and the technique is called clustering. In each cluster, there are mainly three types of nodes; cluster head, cluster member and gateway nodes. The cluster head is elected to maintain the cluster information, therefore electing a cluster head is a challenging task in the cluster based routing protocol. Various methods have already been developed and to find an efficient cluster head is one of the research area [12][14][15][16]. The gateway node of a cluster maintains information of the neighbor cluster and all the member nodes of the cluster. The clustering approach minimizes the on-demand route discovery traffic and network collision, which increases the packet delivery ratio but, the packet overhead and the transmission time increases with the increase in cluster size [10].

2.2 Ant Colony Optimization (ACO)

Ant colony optimization is a bio inspired technique use to find the optimal path from source to destination. Due to the dynamic behavior of ants these techniques is mainly used in the NP-hard problems, which is difficult to efficiently solved by traditional algorithms and in the dynamic shortest path problems, where some characteristic of the problems changes over time. The basic idea behind ACO is that, the ants moves randomly until they finds the food source and after finding the food source they return to the nest, laying a pheromone trail on the route. The pheromone is a chemical substance released by ants when they go for food search. The ants choose the shortest path from food source to nest. Therefore, the pheromone density of the shortest path is high as compared to others path and rest of the ants follow this path only. The pheromone value of the paths evaporates in a specific amount with respect to time. The pheromone trail of the longer paths almost evaporates after a specific amount of time because almost all the ants follow the shortest path only.

3. Proposed work

In our proposed work we divide the task in three stages. First we set the environment for the movement of nodes and then the clusters are made and accordingly cluster head is chosen. Lastly optimal selection of routing path is done using ACO.

3.1 Movement of the node

The nodes are moves very high speed in the VANET system. The movement of the node is considering randomly in any direction with a specific velocity within the range of minimum velocity to maximum velocity. To update the nodes position following formula is used.

x_coordinate=x-coordinate+velocity sin(direction).*

y_coordinate=y-coordinate+velocity cosine(direction).*

If the coordinate of the node is less than zero, then the absolute value of the coordinate is considered as the coordinate of the node. In the same way, if the coordinate of the node in any axis is greater than the maximum coordinate value of the network in that specific axis then the coordinate value is subtracted from the double of the maximum coordinate of that axis. The random movement of the nodes is shown in figure 2.

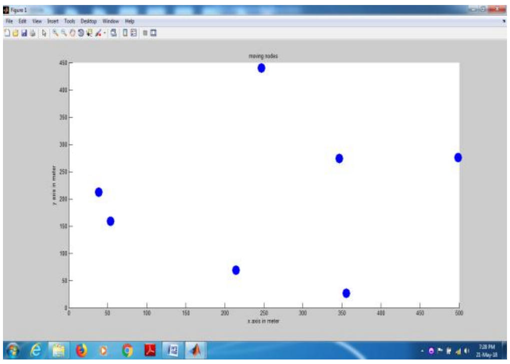

Figure 2: Random movement of the nodes

3.2 Network Clustering

In the traditional routing algorithm, the entire node bear equal responsibility for forwarding packet to every other node. Therefore, a large amount of message flooding take place which decrease the efficiency of the routing. The clustering method possible solves this problem and increase the efficiency of the routing. In clustering, the cluster head maintain all the information of the cluster therefore, electing a cluster head is a challenging task. In this method, the lowest id node is considered as the cluster head. The id of the node is based on entering of node in the network. The other nodes calculate their distance with the existing cluster head and compare it with the communication radius. If the communication radius of a node is greater than the distance between the node and the existing cluster head, then the node consider as the member of the cluster otherwise the node consider itself as a new cluster head. The process continues until all the nodes include in the cluster and ensuring that at a given time a node entered can be the part of one cluster only. The clustering of the nodes are shown in the figure 3, where the red nodes are cluster head and blue nodes are member nodes.

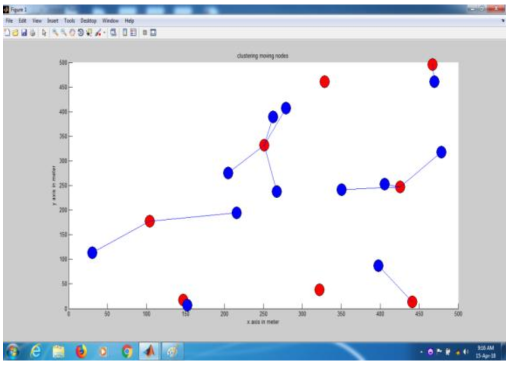

Figure 3: Clustering the nodes.

3.3 Routing using ACO

The ACO algorithm applied in the network routing problem to find the optimal path due to its dynamic nature. The main component of the ACO algorithm is the pheromone, which represent the quality of the path. In this method, we consider that the cluster head first select any one of its member node and the member node then select the next cluster head and the process is continue until the destination node is found. Each time when the current node finds the next node it checked that either the node already entered in the path. If the selected node is already entered in the path than the node is discarded and find another node. To find the next node following formula[11]

$$P_{i,j} = \frac{\alpha_{i,j} * \beta_{i,j}}{\sum_{i}^{n} \alpha_{i,j} * \beta_{i,j}}$$

Where,

i is the label of the current vertex.
j is the label of next candidate vertex.
Pi,j is the selection probability of the edge i-j.
n is the set of all the cluster member

α *ij is the pheromone concentration at edge i-j.*

β *i,j is the user defined heuristic value.*

The pheromone value of all the edge is considered as one at the initial condition and the distance between the edges consider as the heuristic value. To calculate the heuristic value we used the following formula.

$$\beta_{i,j} = \frac{1}{Distance_{i,j}}$$

Each time when an ant finds a path from source to the destination, calculate the distance of the path and compare it with the earlier best path value. If the current path value is smaller than the earlier value then the current value is consider as the new best path. After an ant travel a specific path the pheromone value of the path is updated using the following formula

$$\alpha_{ij} = (1-\rho) * \alpha_{i,j} + \sum_{k=1}^{m} \Delta\alpha_{ij}^{k}$$

Where,

ρ is pheromone evaporation

m is the total no of ants

ξ *i,jis increased pheromone on edge i,j.*

The pheromone evaporation rate is a user defined value range from 0 to 1. In our work, we consider it 0.45. The increased pheromone is calculated by the following formula.

$$\Delta\xi_{ij} = \frac{Q}{L}$$

Where,

Q is the constant

L is the distance of the route travel by the ant.

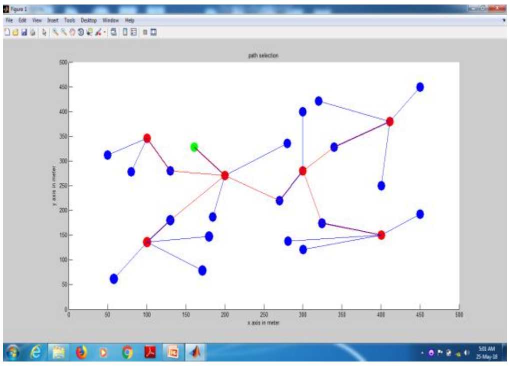

Figure 4: Optimal path selection using ACO

4. Simulation Result

The simulation of this proposed work is carried out by using MATLAB-R2014a simulator. The simulation parameters that are used to build the simulation environment are shown in the table 1.

Table1: Summery of simulation parameter

Simulation parameter	
Simulation area	500*500sqm
Communication range of nodes	100m
Minimum velocity	60km/hr
Maximum velocity	80 km/hr
Number of vehicle	10-60
Number of ants	50

Figure 4 shows the optimal path selection using ACO. The performance of the proposed protocol is evaluated in terms of Packet Delivery Ratio (PDR) and End-End Delay.

1) Packet Delivery Ratio: It is the ratio between packets received by the destination node to the total packet send by the source node. It specifies the packet loss rate and the delivery ratio performance. The high packet delivery ratio represents better performance of a protocol.

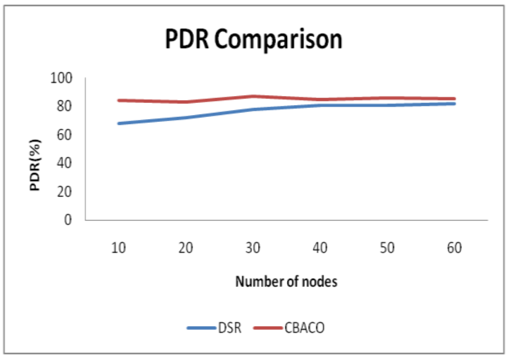

Figure 5: Packet delivery ratio

The figure 5 shows the packet delivery ratio of the proposed protocol and existing protocol with respect to number of nodes. From the comparison, we find that the proposed protocol is comparatively efficient than the existing protocol.

2) End-to-End delay: The total time for transmitting a packet from source to the destination node is known as end-to-end delay. The delay of a packet is mainly dependent on the distance covered by the packets.

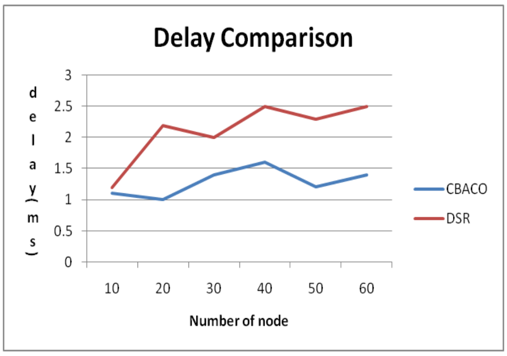

Figure 6: End-End delay

The figure 6 shows the end-to-end delay comparison of the proposed protocol and existing protocol with respect to number of nodes. From the comparison, we find that the proposed protocol is highly efficient than the existing protocol.

5. Conclusions

In this paper, the advantages of clustering and bio-inspired Ant Colony Optimization techniques are utilized to make vehicular communication more effective. The simulation result shows that, the performance of the proposed routing protocol is better than the existing DSR routing protocol. For the future work on this project, we can try to improve performance of the proposed work by using some other cluster head selection method which minimize the frequent change of the cluster head.

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