DBR: Distance Based Routing Protocol for VANETs

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***Abstract*—Vehicular Ad-Hoc network mainly involves Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I) communication. This communication facilitates in reducing number of accidents, avoiding traffic congestion, enhancing the transport facility with the aid of infotainment and entertainment application. One of the major challenges of VANET application is in routing the packet in efficient and effective manner since the network topology is dynamic. In this paper we present Distance Based Routing (DBR) protocol designed especially for Vehicular Ad hoc Networks (VANET). The proposed algorithm adopts both position based and map based routing technique. In DBR, a connectivity graph based on the intervehicular distance, the duration of connectivity between neighbouring vehicles and the information from the digital map are collectively used to route the data. In proposed protocol the network traffic is reduced due to the relative position information of the neighbouring vehicle. The stability of the route path is high due to intervehicular distance based next hop selection technique as implemented in this protocol. The proposed routing protocol is simulated using NS2 simulator to analyze the efficiency and effectiveness of the protocol.**

***Index Terms*—Ad-hoc networks; routing protocol; VANETs.**

I. INTRODUCTION

The Vehicular Ad hoc Network technology is of interest to automobile industries to extend the comfort of commuters in terms of safety, entertainment and infotainment. In order achieve this automobile industries are keen on V2V communication than V2I due to the high cost incurred in maintaining the road side infrastructure. The VANET is a special case of Mobile Ad hoc Network (MANET) with frequent changes in the topology and a highly self organizing form of network [1]. The major challenges associated with VANET are lack of infrastructure and shorter communication session due to rapid change in the network topology. Therefore routing protocols play a significant role in achieving successful intervehicular communication. The routing protocol for VANET can be designed using position based approach and map based approach. The position based approach makes use of GPS technology to fetch position information. The Global Positioning System (GPS) [2] technology provides essential information like longitude (X), latitude (Y), altitude (Z) and time error (Δt). This positioning system is used in mobile phones, fixed base stations and vehicles to obtain the position information. The GPS requires at least four satellites to provide accurate position information. But in GPS, transmission delay of 1µs gives rise to positional error of 300m. Therefore the position based approach which utilizes such position information will locate the vehicle at wrong position in the digital map. This intern leads to inefficient routing. The map based approach involves dynamic computation of the route map while forwarding the data from source to destination. Since vehicles are highly mobile in nature, it is difficult to dynamically compute and maintain the route map. Furthermore, transmission delay is one of the key parameter used to analyze the routing protocols. The safety application of VANET requires very low transmission delay where as application related to entertainment and infotainment can compromise with transmission delay to a certain extent. Therefore different applications of VANET have different requirements.

In this paper, we introduce DBR: Distance Based Routing protocol, a new routing protocol to address the short coming of position based and map based approach. In this protocol real time traffic information is utilized to build a connectivity graph of the vehicles. The connectivity graph depicts distance between neighbouring vehicles. Based on intervehicular distance and the longest duration of connectivity, an appropriate path for routing the data is selected. The major advantages of DBR are reduced network traffic and comparatively less dependency on the GPS technology. The rest of the sections in the paper are organized as follows: Section II provides overview of the related works on routing in VANET. Section III describes the DBR protocol in detail. In section IV we explain the simulation setup and results thus obtained. Finally, section V provides a brief conclusion of the current work and future enhancements

II. RELATED WORK

Due to the inherent characteristics of vehicular networks and limitations of GPS navigation system it seems to be very difficult to design a routing approach that can be suitable for all situations and applications of VANET. Because of high mobility nature of the vehicles it is very difficult to use any traditional MANET routing protocols for VANET. The topological-based approaches such as AODV [3] and DSR [4], fails to maintain the communication links in a rapidly changing network topology. In order to reduce route repairs and failure notifications, the position-based routing protocols like GPSR [5] and PSR [6] have offered an alternative solution where no route is established and only the position of nodes is used to forward the data. The routing protocol may fail in case GPS provides false data about the position of vehicle. The vehicle direction based routing algorithms like ROMSGP [7], forms groups of vehicle, based the on velocity. The grouped vehicles are associated with the link expiration time (LET) which

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signifies the stability of the link between the vehicles that are in the communication range of each other. This technique fails when road has more curves and intersection points. The authors of [8] introduce the gossiping method to overcome the broadcast problem. The gossiping technique involves building the dependency graph using the concept of parent, sibling and child. In this technique the packets are forwarded in both direction and hence creating more network traffic. In the vehicle heading based routing protocol [9], the destination is determined based on location information obtained from the GPS and direction which is calculated based on the movement history. The information is updated by sending update message to all its neighbouring nodes. In this technique the message length is considerably long.

The analytical routing model [10] for VANET computes and uses intervehicular distance depending on the speed of the vehicle and the time taken to transmit the message. This distance signifies physical location of neighbouring vehicle and time delay in delivering the message. The intervehicular distance based grouping is more stable than the position based grouping. The latter approach takes care of the direction of vehicle, multi-lane road and heterogeneous vehicle networks. But the intervehicular distance is calculated with respect to a static observer, which needs roadside equipment. The RBVT [11] is a reactive and proactive routing protocol, which uses route discovery and route maintenance process for maintaining the topology of the network. The RBVT generates more route discovery (RD) packets whenever traffic on the road is high. In life time based protocol [12], route expire time (RET) represents the stability of the route and helps the forwarding node to propagate the message towards the destination. The vehicles moving with same velocity will have same RET. The probabilistic model introduced in [13] is an infrastructure based technique that address the problems of route maintenance by calculating the probable stability of route, based on which the route is selected for further communication.

The mobility prediction model RB-MP [14] divides the neighbours into several sets according to the direction of movement. Further it utilizes the position and velocity to predict the time required to maintain the information of all neighbours. Based on this, several rebroadcasting nodes are selected. The route discovery face is required to establish the routing table. A next hop selection technique [15] is a position based routing method where the node uses a table to store the information about the position of neighbouring nodes. The expected progress distance (EPD) is calculated from the table and it is used in selecting the next hop. The direction of the vehicle is not considered while forwarding the node. The location based routing algorithm [16] significantly reduces the probability of dropping packet and the network traffic when compared to flooding based routing protocols. This routing can be implemented only in city model. Furthermore short falls of position based routing and reactive routing protocol are addressed in SNESA [17]. This routing technique uses the relative position of the neighbouring vehicle calculated using speed and direction and thus reduces the frequent broadcast of position information. The SNESA uses destination of the vehicle due to which the efficiency of this protocol decreases when destination is unknown.

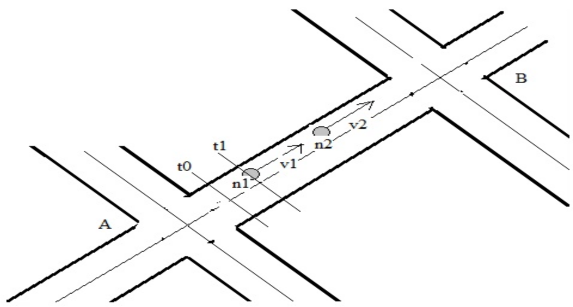

Fig 1. Calculation of intervehicular distance based on relative speed

III. Distance Based Routing Protocol

A. Intervehicular Distance

In DBR, every vehicle computes the intervehicular distance between itself and its neighbouring vehicles based on the propagation delay. The intervehicular distance is determined using Equation 1 where D represents the intervehicular distance, S is the velocity of vehicle and T is the propagation delay. It is evident from Equation 1 that the intervehicular distance (D) is directly proportional to velocity(S) of the vehicle and prorogation delay (T). Selection of intermediate vehicle for the purpose of routing directly depends on the relative speed of the vehicles and hence on the intervehicular distance. Therefore the intervehicular distance remains constant as long as there is no change in the velocity or direction of the vehicles.

$$D = S * T \tag{1}$$

Fig. 1 depicts the procedure involved in determining the intervehicular distance based on Equation 1. The n1 and n2 represent two vehicles moving on road with velocity v1 and v2 respectively. The vehicle n1 broadcasts position and speed information at time t0 and the vehicle n2 receives this information at time t1. Based on the information received, the vehicle n2 computes the intervehicular distance with respect to propagation delay, using the Equation 4. The d2 represents the distance between the current position of vehicle n2 and the position of the vehicle n1 at time t0. It is determined using the Equation 2. Similarly d1 as shown in Equation 3 represents the distance covered by the vehicle n1 in time (t1 - t0). Using later said approach vehicle calculates relative position of neighbouring vehicle. Hence it is clear that the proposed approach aids in reducing the network traffic due to significant reduction in the frequent exchange of location information.

TABLE I: Routing Table

Vehicle identification number
Source X-coordinates
Source Y-coordinates
Destination X-coordinates
Destination Y-coordinates
Speed of the neighbouring vehicle
Intervehicular distance

$$d2 = v2 * (t1 - t0 \quad (2)$$

$$d1 = v1 * (t1 - t0) \quad (3)$$

$$inter\_vehicular\_distance = d2 - d1 \quad (4)$$

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Algorithm 1 Send Hello message
1: while Vehicle running!=stop do
2: Read current speed from the vehicle
3: if change in speed OR change in direction then
4: Generate hello message
5: Read destination coordinates and encapsulate in hello
message packet
6: Broadcast()
7: end if
8: end while

Algorithm 2 Receive Hello Message
1: nodeid: Unique vehicular identification
2: dx: destination x-coordinates
3: dy: destination y-coordinates
4: Read the nodeid,dx,dy,speed from the hello packet
5: Temporarily store the neighbouring vehicle information
6: Calculate the intervehicular distance
7: if nodeid exists in neighbouring table then
8: Update the neighbouring table with new values
9: Save the updated entry in the table
10: else
11: Create new row in neighbouring table
12: The row is named with vehicle nodeid
13: Insert the new vehicle information in it
14: end if

Algorithm 3 Send Data Packet
1: Generate data to send
2: Decide the destination vehicle
3: if nodeid is exists in the table then
4: Set destination vehicle as nodeid
5: Send(packet)
6: else if nodeid exists in packet information table then
7: Search the next hop in the packet table
8: Set the next hop with nodeid
9: Send(packet)
10: else
11: Set destination with Broadcastid
12: Send(packet)
13: end if
14: The sent packet information is maintained in Data Forwarding

B. *Propagation of Geographical Information*

In the proposed routing protocol every vehicle makes use of digital map. We suppose that digital map provides entire detail of the road network such as coordinates of intersection. All the vehicles determine its initial position using GPS technology or from users and identifies its location in the digital map. Table I represents routing table maintained by all the vehicles. The vehicles keep track of velocity and direction information. Whenever there is a change in these parameters, the vehicle will broadcast a hello message. The neighbouring node which receives the hello message will updates its routing table accordingly. The fundamental parameters of hello message are position of the vehicle, speed of the vehicle and destination coordinates. The destination coordinates represent the coordinates of approaching intersection and it is used to determine the direction of travel of the vehicle.

The Algorithm 1 and 2 explains the procedure involved in broadcasting and processing of hello message respectively. Whenever vehicle receives hello message due to the change in velocity or direction of its neighbouring vehicle, it recomputes intervehicular distance analogous to change in velocity and also updates the vehicle ID, velocity, position information and coordinates of destination in the routing table. The size of the table depends on the traffic congestion of the road. When there is huge traffic congestion, maintaining all the vehicle information will increase the computational load. So the delay of updating and searching while forwarding the data is minimized with the help of varying table size.

Algorithm 4 Receive Data Packet
1: nodeid: Vehicle identification
2: Read destination nodeid
3: if nodeid is received vehicle id then
4: Read the data packet
5: else
6: Send data(packet)
7: end if
8: The sent packet information is maintained in packet table

TABLE II: DATA FORWARDING TABLE

Packet sequence number
Destination vehicle id
Next hop
Previous hop
Number hops

C. *Forwarding Data Packet*

The DBR forwards the data packet using both location information and vehicle ID present in the routing table. In ordered to forward the data packet, a vehicle selects the next hop based on the direction if the location of destination is known.

To avoid repeated link failure, the forwarding vehicle selects next hop based on intervehicular distance and current speed. The velocity of the vehicle is an influencing parameter in selecting the next hop because, communication link with the vehicle moving at a very high speed are less stable than the vehicle moving at the lower speed. Therefore vehicles moving with high speed are given less priority in forwarding the data packet. The algorithm 3 explains the procedure involved in forwarding the data packet. Table II represents data forwarding table maintained by every vehicle. Before forwarding any data packet the parameters of data forwarding table associated with the data packet are stored in the table. The vehicle searches for necessary information in data forwarding table to select the next hop whenever a data packet is received. The algorithm 4 represents the procedure involved in receiving and processing the data packet.

IV. Simulation

The proposed routing protocol is simulated using Network Simulator 2(NS2) [18] and road map is generated using SUMO & MOVE. The simulation environment is summarized in the Table III. As indicated in the table, the simulation was carried out for duration of 500 seconds over an area of 1000 sq. meters, with a varying traffic density of 100 vehicles to 600 vehicles. Fig. 2 shows a snapshot of the road network used for the simulation at t=0s. As indicated in Fig. 3 the number of hello messages generated directly depends on the number of vehicles and frequency of change in their velocity. Therefore, it is evident that the proposed approach facilitates in reducing the number of hello messages when compared to the traditional approach involving periodic broadcast. From the Fig. 4 it is noted that change in the velocity of the vehicle do not affect the hop count because the proposed approach selects the forwarding vehicle based on the stability of velocity of the vehicle. The intervehicular distance increases with increasing speed. Therefore the vehicles moving with high speed are not given much importance while selecting next hop. Similarly in Fig. 5, the hop count increases steadily with the increase in number of vehicles. In DBR, the next hop is selected from both routing table and forward data table depending on the vehicle speed and intervehicular distance, so that the connectivity with the next hop is maintained for a longest duration.

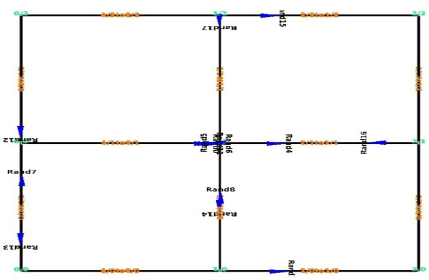

Fig 2. Position of the vehicle at t=0s

TABLE III: Simulation Parameter

Simulation area (m x m)	1000 X 1000
Simulation time (s)	500
Number of vehicles	100,200,300,400, 500, 600
MAC layer protocol	IEEE 802.11
Transmission range (m)	250
Maximum velocity (m/s)	100

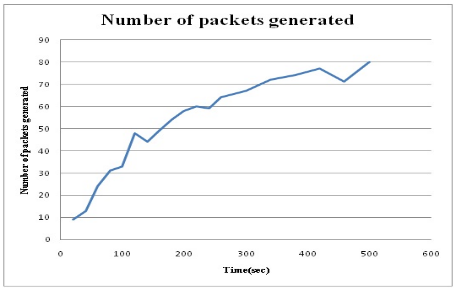

Fig. 3. Hello packet generation in unit time

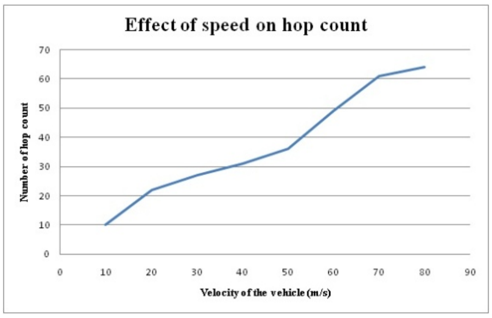

Fig. 4. Effect of vehicle speed on hop count

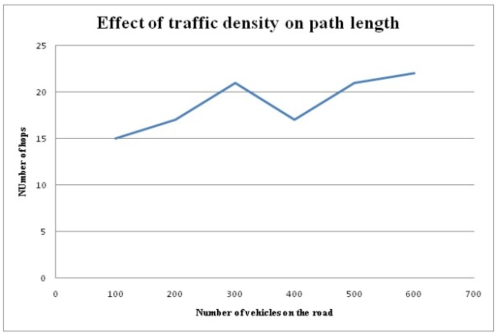

Fig. 5. Effect of vehicle density on path length

V. Conclusion

In this paper, we have proposed a routing protocol which uses both position based and map based technique. As said earlier, the DBR is capable of handling a highly form of mobile network. It is also evident that DBR is not affected by the GPS error, because of the use of relative speed and position of the vehicle. The proposed protocol locates the neighbouring in digital map using the velocity information even though an error occurs in position information obtained by GPS. It also avoids periodic broadcast of hello message unless there is change in velocity and direction of the vehicle, thus reducing the network overhead. Therefore DBR deals with challenges of both rural and urban road environment. As part of our future work, we test the DBR protocol for various scenarios of the VANET and tune the protocol by performing different optimization analysis.

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