Destination and Moving Direction Based Routing for VANET

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ABSTRACT

One of the major critical issues in vehicular ad hoc networks (VANETs) is Routing. In this paper we are considering the issue of routing in vehicle to infrastructure (V2I) AND vehicle to vehicle (V2V) communications in VANETs. And also proposes a DEstination and MOving DIrection Based Routing (DEMODI) algorithm for supporting V2I and V2V communications. DEMODI takes the benefit of both the destination location and moving directions of vehicles to select the next hop (neighbor vehicle) for forwarding data. Without using other control messages it only uses a single INIT message to acquire or revise routing information, which mainly reduces the control message counts in routing. The packet delivery ratio of the network can be considerably improving by the DEMODI algorithm.

Keywords— Vehicle Direction, VANET routing

I INTRODUCTION

VANETs are an emerging technology for support intelligent transportation systems (ITS) [1]. In a VANET, communication occurs either from vehicle to infrastructure (V2I) or from vehicle to vehicle (V2V). A vehicle needs to transmit data to roadside units (RSU) or other vehicles to provide a better traffic control, inter-vehicle communication and environment monitoring. Before data transmission a path is established from source to either roadside unit (RSU) or destination. Therefore routing is one of a major critical issue in the design of a VANET.

A VANET has some characteristics similar to mobile ad hoc networks (MANETs) such as self-organization, self-management and short-range radio transmission. In addition VANET has some unique characteristics such as highly dynamic topology, adequate energy capacity, and predictable mobility model. Particularly the moving speed of a vehicle can reach 50km/h in a street, average of 100km/h in a highway scenario. If two cars at a distance of 250m are moving in the opposite directions at a speed of 90km/h, the link for communication can last for only 10 seconds. This results a highly dynamic topology of the network, which is a big challenge in the design of a routing protocol. For dissimilar network scenarios various routing protocols have been suggested such as Ad-hoc On-demand Distance Vector (AODV) [2] and Dynamic Source Routing (DSR) [3] to address the unique characteristics of VANETs. These two protocols were originally proposed for MANETs but can also used for VANETs with lower throughput [4]. Furthermore, well-known routing protocol proposed particularly for VANETs is Greedy Perimeter Stateless Routing (GPSR) [5], which can achieve a better performance in a suburban scenario than that of AODV and DSR. Another routing protocol proposed particularly for VANETs is Greedy Perimeter Coordinator Routing (GPCR) [6], developed based on GPSR and no maps can be used. Even though these protocols have been proposed specifically for VANETs, all of them have some limitations in addressing different network scenarios (city, highway and urban) and achieving network performance. Therefore better routing protocols can be expected to achieve better performance in different scenarios.

In this paper, we consider the routing issue in both V2I and V2V communications in a VANET, and propose a DEstination and MOving DIrection based routing (DEMODI) algorithm for supporting V2I and V2V communications. For forwarding data DEMODI make use of both the destination location and the moving directions of neighbor vehicles to select the next hop or to make a routing decision. In case there is no neighbor vehicles found to store and carry its data packets, then a node employs a store-then-forward mechanism until it meets an appropriate neighbor node for forwarding the packets. On the other hand, because of the high moving speed of a vehicle the routing information maintained at each node may quickly become ineffective within a few seconds or minutes in a VANET. Therefore more control messages to be exchanged between different nodes for update the routing information maintained or timely obtain at each node. This is not desirable because this would reduce the resource utilization. To address this problem, DEMODI only uses only one message (INIT) to update or obtain routing information without using any other control messages like REQUEST and REPLY messages. The packet delivery ratio of the network can be considerably improving by the DEMODI algorithm as compared with the AODV (Ad hoc On-demand Distance Vector Routing) algorithm.

The remainder of this paper is as follows. In Section II related work on routing protocols for VANETs, Section III presents the proposed DEMODI algorithm. Section IV evaluates the performance of DEMODI. Section V concludes this paper.

II RELATED WORK

Variety of routing algorithms for VANETs has been proposed in the literature can be classified into the categories: ad-hoc routing, position-based routing, cluster-based routing, broadcasting, and geocast routing [7]. Position-based routing and geocast routing are considered as a promising routing paradigm for VANETs.

AODV [2] used for VANETs is a well-known routing algorithm originally proposed for MANETs. Because of the high mobility of vehicles unfortunately this algorithm cannot achieve good throughput performance. Another algorithm [8], which is proposed based on AODV is PRAODV, and uses the concept of the link and route time estimations. Before the end of lifetime it constructs a new alternate route, predicted based on the location information and speed of vehicle.

Networks which have a large number of vehicles used the Cluster-based routing which clusters the vehicles into a virtual network to provide scalability. Clustering for Open IVC Networks (COIN) [9] is another clustering algorithm, which selects a cluster head based on drivers intentions and vehicular dynamics whereas other clustering algorithms select a cluster head based on vehicle ID or mobility. Conversely, clustering leads to overhead and delay routing. This is not suitable for a network with a highly dynamic topology. The simplest and widely used routing method in VANETs is Broadcasting which causes contentions and collisions leads to affect network performance. A special type of multicasting is Geocast routing [10] in which after a waiting time the received packets were rebroadcasts to avoid contentions and collisions.

Topology assist Geo opportunistic Routing [11] is the position-based routing protocols which makes use of 2-hop beaconing and the topology knowledge to select the best forwarder and also uses opportunistic packet reception to increase delivery ratio of the packets. GPSR[5] which combines greedy routing and facing routing, where facing routing is used to get out of a local minimum when greedy routing is not possible. In a highway scenario GPSR is appropriate for V2V communications. Since direct communication between vehicles may not be possible it is not suitable for an urban scenario. During the routing process Packets needs to travel along a long path may be dropped.

GPCR [6] is based on the assumption that the streets and junctions form a natural planar graph and doesn't use any global information for routing. It consists of two components a greedy routing algorithm and a repair strategy. Compared with GPSR, the greedy routing is restricted to a certain area in the network and data packets are always routed along the streets. In GPSR it assumes that there is always a node at all junction and a routing decision is made by the same node present at a junction. Packet always forwarded to the junction node rather than forwarded directly to a node across a junction. In the repair strategy, a well-known right-hand rule [5] is applied to recover from the local minimum. However In the real world the assumption that there is always a junction node is not a sensible, which limits the use of GPCR. To address this problem, we present DEMODI which does not need a junction node and allows a node to directly make a routing decision or forward data packets in a pre-intersection area.

III MOVING DIRECTION BASED ROUTING PROTOCOL

In this section, we present a new position-based routing protocol named DEMODI for VANETs.

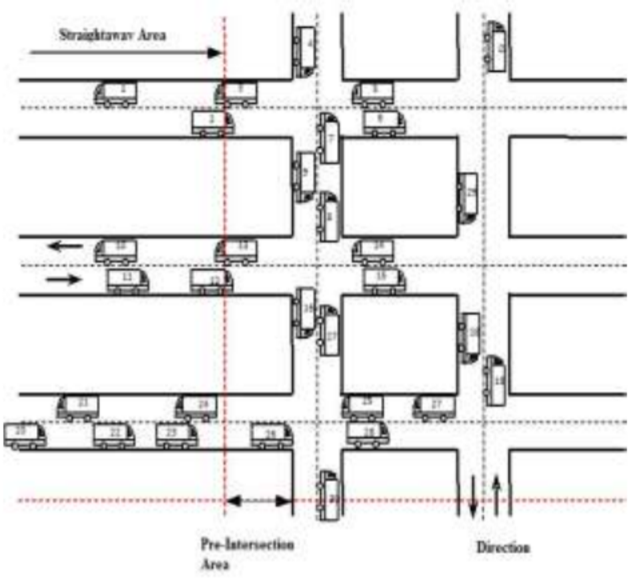

Fig 1 Network Model

(a) Network Model

We consider an urban network scenario, in which the streets are distributed horizontally and vertically, as shown in the above Figure 1. In this, all the two lanes streets are segmented by traffic lights, whose cycle time is set to a constant. Two vehicles can communicate with each other when they are located within the communication range or radio transmission distance of each other.

In the above network model, we assume that a vehicle is equipped with a digital map and a GPS (Global Positioning System) device, which provides the position of the vehicle itself and the location of the destination. There is no limitation on energy and buffer size for all the vehicles. Because of the distance and obstacles between two parallel streets are usually much larger than a vehicle's transmission range, two vehicles from any two parallel streets cannot communicate with each other. The destination of a data packet can be a road-side unit (RSU) which is stationary, or a moving vehicle whose real-time position can be known or obtained by other vehicles through the equipped digital devices.

(b) Routing Strategy

The key idea of DEMODI for forwarding data is to take advantage of the destination location and vehicles moving directions to decide on the next hop. Each vehicle in the network periodically broadcasts a INIT message, which contains the vehicle's ID, exact position, driving direction, and vehicles speed, to discover one-hop neighbors. After a vehicle receives this INIT message, it stores all the information contained in the message and adds the sender's information to its neighbor table. Each and every vehicle maintains two tables: the neighbor table, a data list locally. Vehicle checks the packet's ID in the data list available in vehicle whenever a data packet is received by them. If it is not already exists, the packet will be added into the list in a first-in-first-out (FIFO) manner, Otherwise the vehicle drops the packet.

(c) DEMODI Protocol Description

DEMODI consists of two procedures: a straightway procedure and a pre-intersection procedure. When a source node generates or an intermediate node receives a data packet, it will first store the packet and then trigger a routing procedure. If the node is located at a position with a distance prior to an intersection, which is based on the transmission range of a vehicle and the width of a street, the pre-intersection procedure is triggered. Otherwise, the straightway procedure is triggered. The above process is repeated until the packet arrives at the destination or the Time Limit (TL) in the packet reaches zero. The procedures of the DEMODI algorithm are described in Figure 2.

(d) Straightway Procedure

The straightway procedure is similar to a conventional greedy routing algorithm. In this practice, if a vehicle does not have any neighbor, it will store and then carry the packet in its data list until it meets another vehicle. Compared with the conventional greedy routing, the difference is that the straightway procedure first compares a packet's destination location with the driving direction and chooses the vehicles whose driving directions are same as the candidate next hops. Then, if the destination is in the neighbor table of the current vehicle, the data packet is forwarded to the destination directly. Otherwise, the vehicle with the shortest distance to the destination will be selected as the next hop. If the current vehicle itself has the shortest distance to the destination, it will continue to carry the packet until it meets a neighbor vehicle closer to the destination.

Figure 1 illustrates an example of the straightway procedure, in which vehicle 20 is driving on a straight way. If the vehicle receives or generates a packet for vehicle D, it triggers the straightway procedure. In this case, its neighbors include vehicles 21, 22, 23 and 24, among which vehicle 24 is the closest to the destination D. However, the moving direction of vehicle 24 is in the opposite direction of the destination. As a result, vehicle 23 is selected as the next hop.

DEMODI Algorithm

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Let  VID $\leftarrow$ vehicle's ID;
     DEST $\leftarrow$ packet's destination;
     POS $\leftarrow$ vehicle's position;
     0$\leftarrow$ pre-intersection;
Initialization: VID receives or generates a packet
     If TTL $\neq 0$ & VID $\neq$ DEST then {
         update pos;
         If POS = 0 then{
                Trigger pre-intersection procedure;
                Return;}
         else{
                trigger the straightway procedure;
                return;}

     else{
                store the packet;
                return;}
```

Fig 2 Routing Procedure of DEMODI

(e) Pre-Intersection Procedure

In [6], GPCR assumes that there is always a junction node and routing decision is made only by the same. But in the real world, this assumption is not reasonable because it is not possible to always have a forwarding node at a junction. To address this problem, DEMODI allows a node in a pre-intersection area to make a routing direction without using a junction node. The definition of a pre-intersection area is based on the distance between a vehicle and an intersection, the transmission range of the vehicle and the width of a street. If a vehicle is far away from the destination, the width of a street can be ignored.

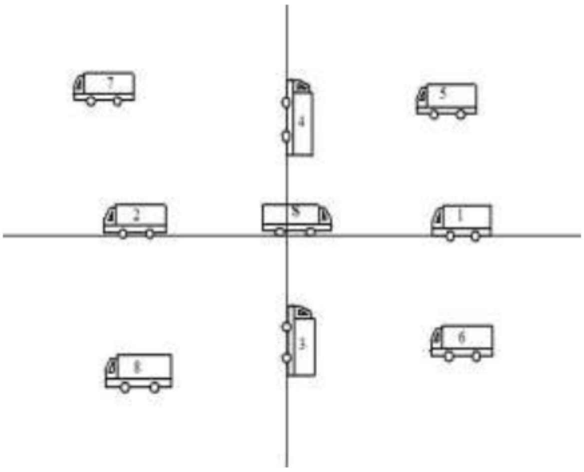

Fig 3 Eight Cases of the Relative Position

Similar to the straightway procedure, the pre-intersection procedure first determines the neighbors of a vehicle and then selects the more appropriate one as the next hop. According to the position of a vehicle and the destination location, the relative position of the destination respect to the vehicle may have eight cases: east, west, south, north, northeast, southeast, northwest and southwest, as shown in Figure 3. If the relative position belongs to the former four cases, the selected neighbor vehicles can only move in one direction, denoted by dir_. Otherwise, the vehicles can move in two directions, denoted by dir1_ and dir2_. For example, if the relative position is southwest, dir1_ is south and dir2_ is west. If the relative position is south, dir_ is south. The procedure at pre-intersection can be described below:

- Step1: A vehicle with a packet checks its neighbor list periodically and if it does not have neighbors then it carries the packet until it meets a neighbor vehicle. Otherwise, resort to step 2;

- Step 2: Based on the vehicle's destination's location and position, the vehicle calculates the relative position of the destination respect to the vehicle itself. If the relative position is in the vertical or horizontal direction, resort to step 3. Otherwise, resort to step 4;

- Step 3: Choose the neighbor vehicles whose driving directions are the same as dir. select the vehicle with the shortest distance to the destination as the next hop from these neighbor vehicles, and forward the packet to it. Otherwise, resort to step 1;

- Step 4: If some neighbors' driving directions match dir1_ or dir2_, resort to step 5; Otherwise, if there are some neighbors driving in dir1_ and some driving in dir2_, resort to step 6; otherwise, resort to step 1;

- Step 5: Select the neighbor as next hop with the shortest distance to the destination and then forward the packet to it.

- Step 6: The neighbors are usually moving with different speed on different streets. According to the car-following theory, if a vehicle drives at a much lower speed than the road speed limit, it is probable that there are some vehicles in front of it. Therefore, compare the speed limits of the road with the neighbor vehicles' speeds, select the vehicle with the maximum speed difference as the next hop, and then forward the packet to it.

Figure 1 also gives some examples to illustrate the pre-intersection procedure. For example, if vehicle 2 is a source node and the destination of a packet is vehicle D. The candidate neighbors are vehicles 3, 4, 5, 6, 7 and 9, and the next hop can be selected according to step 2. Vehicle D is in the northeast of vehicle 30, whose neighbors are vehicles 25, 26 and 28, moving in the east or west direction, and dir1_ and dir2_ are set to north and east, respectively. By step 5, the next hop can be selected. Vehicle 12 is the most complicated case, and just like vehicle 30, dir1_ and dir2_ are north and east. The candidate neighbors include vehicles 8, 13, 14, 15, 16 and 17, which are distributed on different streets with different speed limits. In this case, step 6 is used to select the next hop.

IV PERFORMANCE EVALUATION

In this section, we evaluate the performance of the DEMODI algorithm through simulation results. For evaluation, we compare DEMODI with AODV in terms of packet delivery ratio and latency. The experiments were conducted with a transmission range of 250m and a transmission rate of 2Mbps was used as the underlying MAC protocol. We used VanetMobiSim [13] to generate a 4 x 4 urban grid topology of a 1500m by 1500m area. All streets have two lanes and are bi-directional. All street segments have speed limits and all intersections are controlled by traffic lights.

Table 1
Simulation Parameters

Constraint Parameter	Value
Network simulator	NS2
Mobility simulator	VanetMobiSim
Area of Simulation	1500m x 1500m
CBR rate	512bytes/second
802.11 rate	2Mbps
Transmission range	250m
Simulation runs	10
Average vehicle speed	50km/hr
Simulation time	500 to 1000 sec
Number of vehicles	30 to 50

In VanetMobiSim, the micro-mobility is controlled by the IDM-IM, an extension to the Intelligent Driver Model (IDM) considering intersections. In each simulation run, we randomly selected five sender-receiver pairs, using 512-byte constant bit rate (CBR), an UDP-based packet generation application. In the simulations, the number of vehicles considered is 20 to 40. The running time of each run is 500 to 1000 seconds. All results are an average over 10 runs. Table 1 summarizes the parameters used in the simulations.

Figure 4 shows a snapshot of the network topology with 30 vehicles, where vehicle 2 has a packet whose destination is vehicle 12.

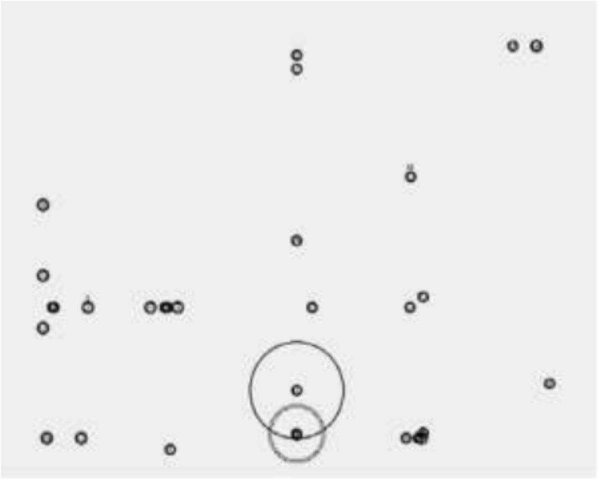

Fig 4 A snapshot of the network topology

It is seen that the packet delivery ratio with DEMODI is larger than that of AODV, which is expected. On the other hand, the average packet delay with DEMODI is also increased as compared with AODV. This is because DEMODI is proposed for delay-tolerant applications. It employs the store-then-forward strategy in routing when a vehicle does not have an appropriate neighbor vehicle to forward its packets. And also the packet delivery ratio increases with the node density. The DEMODI algorithm can significantly improve the packet delivery ratio as compared with the AODV algorithm.

V CONCLUSION

In this paper, we projected a DEstination and MOving DIrection based routing (DEMODI) algorithm for data transmission in VANETs for the urban scenario. DEMODI makes use of both destination and the moving directions of vehicles to select the next vehicle hop for forwarding data. DEMODI also permits a node itself to make a routing decision and forward data packets in a pre- intersection area. Furthermore, it uses an INIT message alone to acquire or revise routing information, which mainly reduces the control message counts in routing. The results have made known that DEMODI can notably improve the packet delivery ratio with an increased average to some extent. In future work we will consider a more practical scenario for the expansion of DEMODI algorithm.

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