Reliable Routing Scheme for VANETs in City Environment

Rab Nawaz Jadoon, Mehtab Afzal, and Jawad Shafi

***Abstract*—Vehicular ad hoc networks are more helpful in providing road safety and many other commercial applications. As routing plays very important role in VANET applications because it has to handle efficiently rapid topology changes. The most recent routing protocols are very useful in city environment but they cause end to end delay in some cases. In this paper, we have proposed a new reliable routing scheme (RRS) for VANETs by applying position based routing strategy with the consideration of nodes moving direction, and predicable mobility in city environment. It consists of two modules (1) Dynamically selecting the junctions through which the packets must pass to reach the destination and (2) applying efficient routing by keeping two hop neighbors information to forward packet between two junctions. Simulation results show that RRS performs better in terms of increased packet delivery ratio as well as decreased average end to end delay against GyTAR.**

***Index Terms*—City environment, VANETs, ITS, GyTAR, junctions, routing etc**.

I. Introduction

Wireless communication technologies have made tremendous effect in our lives and have enabled many of the conveniences to make our lives easier. Inter vehicle communications (IVC) is the area in which wireless technology have done great work and make a great impact [1]. The field of IVC is also known as Vehicle to Vehicle communications (V2V) and Vehicular Ad hoc Networks (VANETs).

An ad hoc network is a collection of nodes which are used in forming a temporary network without the aid of any additional infrastructure and having no centralized control. Laptop, PDA, or any other device capable of transmitting and receiving information is used as a node in vehicular ad hoc networks. Nodes act both as an end system (transmitting and receiving data) and as a router which results in multi-hop routing. Network is usually temporary in ad hoc networks as nodes are generally mobile and may go out of range of other nodes in the network [2]. VANETs (Vehicle Ad hoc Networks) are highly mobile wireless ad hoc networks which uses equipped vehicles as the network nodes and these nodes are moved relative to each other but within the constraints of the road infrastructure.

VANETs are more useful in providing road safety and many other commercial applications. For example, a vehicular network can be used to alert drivers about the traffic jams on the roads, providing increased convenience and efficiency. It can also be used to initiate emergency warning to drivers on the road behind a vehicle (or incident) to avoid multi-car collisions etc.

By keeping in mind this vision, FCC has allocated 75 MHz of spectrum for communications in short range (vehicle-vehicle or vehicle-roadside), and IEEE is working on standard specifications for vehicle to vehicle communication.

Many applications in VANETs need the support of multi-hop communication, such as web browsing, chat, file sharing, games etc. Multi-hop communication requires routing algorithms. VANETs have some characteristic i-e; high dynamics, which make the task of routing in VANET very complex because high dynamics (rapid topology changes) in large scale network causes uneven network density. While others characteristics likes mobility constraints and predicable mobility makes easier the task of routing in VANET.

In this paper, we presented an efficient routing algorithm for VANETs by keeping two hop neighbor information in city environment where routing is almost difficult task because of the node distribution, constrained but high mobility patterns, obstacles causing blocking of signal transmission etc. By keeping in mind the city environment we did the work in two phases (i) selection of junctions (ii) routing between two junctions. Main focus of this paper is to route the data packets from source to destinations in Vehicular network with reduced end to end delay and low packet loss.

The rest of the paper is organized as follows. In section II, we describe the Vehicle Ad hoc Networks, its properties and some of its characteristics. Section III describes the related work on the routing approaches in MANET and VANET. In section IV the Reliable Routing Scheme for Vehicle Ad hoc networks for city environment is described. And finally in section V, simulation results are discussed.

II. VANETs Properties and Characteristics

Intelligent transportation system (ITS) is the traditional system, which is installed on the road side for monitoring the traffic density, speed etc. ITS is connected to the some base station and it periodically send the monitored data about vehicles to the base station for further processing. Such

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traditional systems are very expensive and time consuming (long reaction time). So the alternative to this is to use the vehicle to vehicle communication i-e; inter vehicle communication (IVC) which is an important part of ITS architecture. IVC represents a setup of vehicles which can communicate to each other located out of the range of line of sight (or out of radio range if multi-hop communication is needed among several vehicles) [4].

IVC has attracted many organizations from different countries because of its applications. Different countries like Japan, US and EU have initiated projects in national vehicle safety like CarTALK2000 and Car2car communication consortium [6] in the EU and VSCC (Vehicle Safety Communication Consortium) in the US. IEEE 802 [7] has developed the new standard IEEE 802.11p for wireless communication in Vehicular network.

A. VANETs Characteristics

Some unique characteristics of VANETs compared with MANETs are defined here.

1) Geographical constraints

Nodes movement in MANET is distributed or random, while in VANET the nodes movement is limited within the structure of the road. Vehicles can communicate to each other within their radio range (which is typically 250 to 300 meters). While in city environment they can communicate if they have line of sight to each other [13].

2) High dynamics

In VANETs, as the radio range is usually small compared to the speed of vehicles, so vehicles will join and leave the network frequently as compared to MANETs, which causes frequent topology changes in VANETs.

3) Predicable mobility

Mobility can be predicted in VANET because of the regularity of the road layout. Vehicles speed, direction and road properties are used in predicting the vehicular mobility.

4) Partitioning and large scale

Partitioning means that if there is no vehicle to pass the data to the destination, then the network is partitioned into different parts. And network can be grown to large scale as it finds the road available.

III. Background and Related Work

This section describes some existing routing protocols used in VANETs and MANETs, and then describes the inconvenience of using them for VANET in city environment.

A. Routing in MANETs

In MANETs, routing protocols can be categorized by their characteristics. Proactive and Reactive routing are the two techniques which are used in MANET. In Proactive routing (e.g. OLSR and TBRPF [8]) table driven approach is followed, in which routing information is stored for each available path even those paths not used currently. This is the main drawback of using table driven approach because network topology changes frequently and bandwidth is wasted because of maintaining unused path information. Reactive routing (e.g.; DSR[9] and AODV[10]) is basically working as an on demand approach in which the only information about the current routes is maintained, which ultimately causes less burden on the network because only a small subset of routes are maintained here in this approach. As the most important property of VANET is its high dynamics, so reactive routing is best suited for routing in VANET.

Routing protocols can also be classified as topology based and position based. Topology based (e.g.; AODV [10]) protocols only considers those nodes which come under the topology connection. The main disadvantage of using this approach is its large latency. To remove this disadvantage another approach is used which is called position based (geographical) routing (e.g.; GPSR [1]) is proposed for this purpose. Position based routing protocols considers the physical position of the communicating nodes. In this type of routing, it is not required to establish or maintain the routes.

B. Routing in VANETs

In VANET, there are different routing protocols which are described as under.

1) GSR (Geographic source routing)

This routing protocol is proposed by Lochert et al., it is basically position-based routing with topological knowledge [11]. In this routing scheme a shortest path is selected before greedy routing is applied. As compared to AODV and DSR, GSR performance is very good because packet delivery ratio is high and latency is low with the use of realistic traffic in city environment. Problem with GSR is that along a preselected path it is difficult to find end to end connection when the traffic density is low.

2) A-STAR (Anchor-based Street and traffic aware routing)

A-STAR is position based routing scheme proposed by Seet et al. whose basic purpose is to support routing in the city environment [4, 13]. This routing scheme ensures end to end connection even in the case of low traffic density. It uses the information from city bus routes to find an anchor path for higher connectivity so that more and more packets can be delivered to the destination. This routing protocol is also very efficient in route recovery strategy and also proposed a new recovery strategy when the packets are routed to local optimum, which consists of the computation of new anchor path from local maximum.

3) GPCR (Greedy perimeter coordinator routing)

To deal with the city environment tasks Lochert et al [12], designed GPCR, which applies restricted greedy forwarding approach along a preselected path. In this routing when choosing next hop, a coordinator node (the node on the junction) is chosen even it is not the closest node to the destination. GPCR suffers the same problem as with GSR i.e. ignore the case whenever the traffic density is low.

4) GyTAR (Greedy traffic aware routing)

Improved Greedy Traffic Aware Routing protocol GyTAR [4], [18] is intersection-based routing protocol which dynamically selects junction to find robust routes within the city. It uses digital map to find the position of neighboring junctions and selects junction dynamically on the basis of traffic density and curve metric distance to the destination. A score is given to each neighboring junction and the junction with the highest score is selected as a next junction. The selected junction is the one which is closest to the destination and also have the highest traffic density. The improved greedy routing strategy is used to forward the packet between two involved

Junctions. GyTAR uses carry and forward [19] approach in order to recover from the local maximum. This mechanism of junction selection has maximum connectivity and thus increases the packet delivery ratio and at the same time decreases the end-to-end delay.

C. Discussion

In the previous section we discussed various VANETs characteristics like high dynamics, predicable mobility, partitioning and large scale. These properties of VANETs degrade the performance of conventional topology based protocols designed for MANETs.

The existing routing protocol which is designed specifically for city environment like GyTAR [4] is best in city scenario and selects the junctions dynamically but when the routing between junctions is done, it only takes into account one hop information, which causes end to end delay in some cases. This problem can be solved by taking into account two hop neighbour information PDGR [3], which reduces end to end delay.
The detailed work is described in the next section.

IV. Reliable Routing Scheme (RRS)

The proposed routing protocol, RRS ensures to relay data in VANETs for different applications which require more than one hop communication with minimum end to end delay. This routing protocol makes some assumptions according to which that each vehicle knows its position through GPS. Furthermore GLS (Grid Location Service) [5] is used for knowing the current geographical position of the destination. Similarly pre-loaded digital maps are used to determining the position of neighbor junctions. It is also being assumed in the protocol that each vehicle knows about the vehicular traffic.

Now on the basis of the above assumptions, the detailed description of the proposed routing protocol is as under,

A. Junction Selection

RRS adopts the anchored based routing approach with street awareness "Improved Vehicular Ad Hoc Routing Protocol for City Environments" GyTAR [4]. Thus using the street map, routing will be done between vehicles based on the idea of junction selection as used in GyTAR. This routing protocol dynamically selects the junction. A node or vehicle on the junction will select the next junction based on the number of vehicles between junctions and curve metric distance between them. It means a node will select that junction where traffic density is high and smaller curve metric distance is there between them. Weights are assigned to the junction with respect to number of vehicles and curve metric distance to the destination. The junction which gets highest score will be selected for routing because it will be the closest junction to the destination.

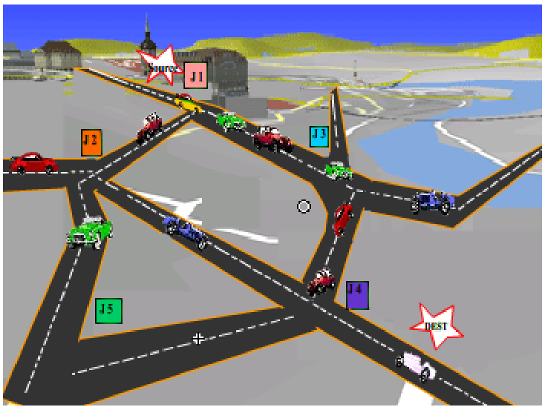

Fig. 1. Junction selection in city environment.

B. Routing Between Junctions

After junction selection, RRS is used between two junctions to pass data to the destination. As the idea given by GyTAR [4] for efficient greedy routing between two junctions is very effective but it can be further enhanced if it also keeps two hop neighbor information "Predictive Direction Greedy Routing in VANET" PDGR [3]. Let's check the scenario given in Fig. 2.

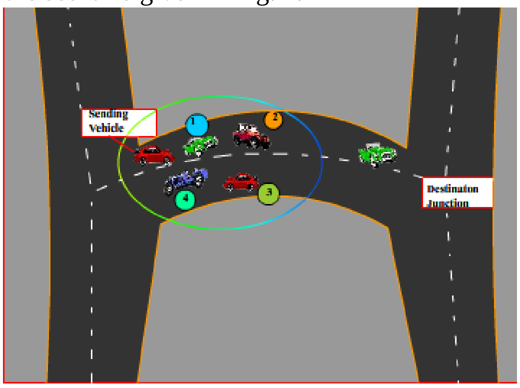

Fig. 2. Communications between 2 junctions using one hop information.

According to GyTAR a sending vehicle passes data to vehicle 1 because of its greater speed than vehicle 2. But when there are two hops information is used by packet carrier, which is achieved by using beacon messages. Now if the forwarding Vehicle or packet carrier keeps the information about two hop neighbors as described in Fig. 3 i.e. it knows that vehicle 2 is closer to the destination, it will forward packet to vehicle 2 instead of vehicle 1, because vehicle 1 is more closer to the vehicle 5 which invariably closer to the destination, and hence minimizes end to end delay. And hence the packet is get distend to destination in minimum number of hops.

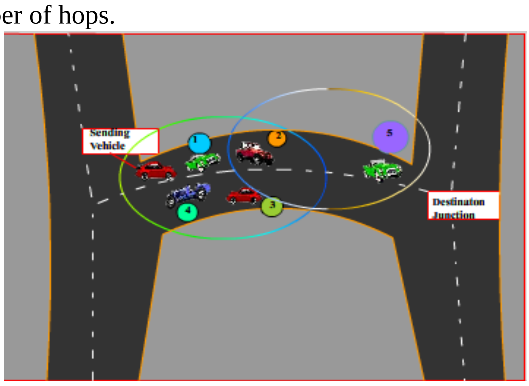

Fig. 3. Communication between 2 junctions using two hops information.

V. Simulation Setup

To evaluate the performance of RRS, simulations are carried out in the GLOMOSIM (Global Mobile system Simulator) simulator.

A. Mobility Model

The selection of the mobility model for VANETs simulation is very important because it should reflect as closely as possible the real vehicular activities. The mobility model also affects the performance of protocols as explained by D. Choffnes [14]. Usually vehicular mobility models are classified into two categories, the microscopic and macroscopic. Macroscopic mobility consider mobility constraint such as roads, streets, speed limits, number of lanes, traffic density, traffic flow and traffic lights. The microscopic mobility focuses on the vehicle behavior with each other and with infrastructure [15]. VanetMobiSim [16], which can support the micro and macro mobility, is an extension for the CANU mobility simulation environment [17].

B. Simulation Scenario

The vehicular mobility pattern is generated by using VanetMobiSim, which simulates a $1500\times2000\ m^2$ area. Node mobility is simulated against 16 numbers of intersections and 24 bi-directional roads with multi lanes as shown in Fig. 4. Vehicles are distributed randomly over the roads and start moving on both directions. Car following model or intelligent driver model is used for the movement of vehicles on the roads.

TABLE I: Simulation Setup

Simulation/scenario		Mac/routing	
Simulation Time	200s	Packet size	128 byte
Map Size	$1500\times2000\ m^2$	Channel Capacity	2Mbps
Mobility Model	VanetMobiSim	Transmission Range	266 meter
Number of roads	16	Weighting factors	(0.5; 0.5)
Number of vehicles	75-200		
Vehicle speed	25-60 km/h		

The speed of the vehicle depends on the vehicle type (bus, truck, car or other) and the type of the road. Same simulation parameters used in RRS as used in [20].

C. Simulation Parameters and Result Discussion

Following metrics are used to evaluate the simulation results,

1) Packet Delivery Ratio: The percentage of packets that are successfully delivered to their destination vehicles.
2) End-to-end delay: The average delay for the packet from its source to its destination.

Fig. 4 shows the packet delivery at a ratio of five packets per seconds. The number of packet delivery ratio increases as the network traffic increases which increases the probability of connectivity and also reduces the number of packet lost due to high network density. It is also observed that RRS performs better in terms of packet delivery ratio as number of nodes increases in the network against GyTAR.

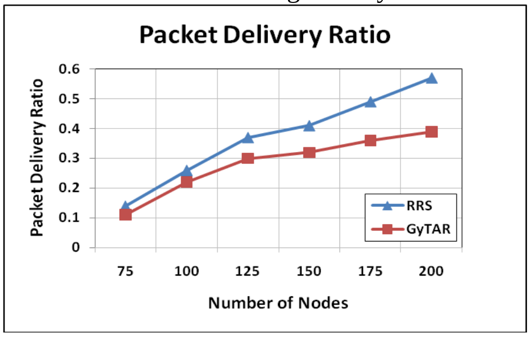

Fig. 4. Packet delivery ratio

Fig. 5. Shows decrease of end-to-end delay with the increase of network density. As the number of nodes in the network increases, the probability of packets being routed will be increased instead of being held in suspension buffer which will decrease the end-to-end delay for both these protocols.

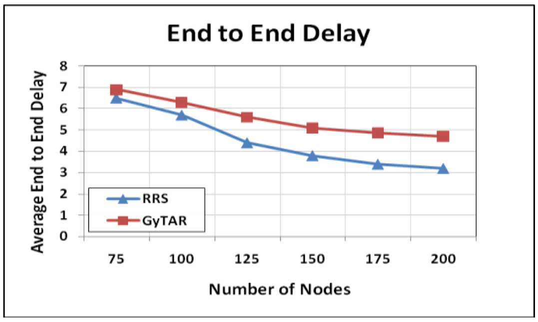

Fig. 5. Average end to end delay.

VI. Conclusion

In this paper we have presented the Reliable Routing Scheme (RRS) for VANETs in city environment. By keeping in mind the city scenario, this paper partitioned the work in two phases. First is to select the junctions based on the weighted score which is achieved through number of vehicles and curve metric distance between junctions. And then efficient routing is applied between two junctions by keeping the two hop neighbors information. The proposed protocol minimizes end to end delay and increases the packet delivery ratio as compared to GyTAR.

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