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Research paper

Geographical Zone based Cluster Head for Routing in Sparse Vehicular Networks

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Abstract

Vehicular ad hoc network is a wireless communication technology that is used to provide safety and comfort transport on the roads. Routing algorithm design is one of the main challenging issues in VANET. This paper presents a Geographical Zone Based Cluster Head algorithm for Vehicular Ad hoc Networks (VANETs) to reduce the communication overhead generated by the Control Packets (CP). Depending on the area, the network can be sparsely or fully connected. The Geographical Zone Based Cluster Head Routing in Sparse network (GZCHRS) algorithm can endure network partition due to low node density in the sparse network and high node density in the urban network. This paper inspects the issues of VANETs in sparse networks. In this algorithm, the routing decision is based on vehicular density, velocity and link lifetime. The simulation results display that under rural network conditions, the Geographical Zone Based Cluster Head Routing algorithm performs well when compared to Light Weight Intersection based Traffic Aware Routing (LITAR) and Intersection-based Connectivity Aware Routing (ICAR).

Keywords: *Control Packet; Link Lifetime; Master Node; Sparse Network; Zone Based.*

1. Introduction

Vehicular ad hoc networks have a great interest in both academic and industry. VANET is used to improve road safety, traffic management, and infotainment and grant internet access to the moving vehicle. Vehicular communication can be divided into Vehicle-to-Vehicle (V2V) and Vehicle to Infrastructure (V2I) communication [1]. VANET indulge Intelligent Transportation System (ITS) services to the end users for transferring data exchange and safety. It provides a wireless communication between moving vehicles using different standards like Dedicated Short Range Communication (DSRC) and Wireless Access in Vehicular Environments (WAVE) [2]. Basically, three units are used in vehicle communication, Road Side Units (RSUs), On Board Units (OBUs) and Application Units (AUs) [3]. The communication between OBUs and AUs with RSUs can be provided by employing wireless standards such as IEEE 802.11p.

The tremendous growth of vehicles on the road causes congestion and accidents. Road situation and traffic information, such as traffic signals, location, and speed of the neighbouring vehicles, enable the driver to take correct decisions to avoid traffic jams and accidents [4]. For this purpose, vehicles share their circumferential information with other vehicles using ad-hoc or infrastructure based communications. In ad-hoc communication, the information is shared with other vehicles using multi-hop communication [5]. During communication, it considers the factor, such as frequent changing network topology, high mobility, and network disconnectivity. To solve these issues, VANETs use specialized routing protocols considering the application environment (urban, rural).

The characteristics like irregular distribution of vehicles on the road, large size network, high mobility due to high speed the vehicles, frequent changing topology and disruption of communication due to obstacles hindrance make routing of data in vehicular ad hoc network more challenging [6]. Majority of the existing routing techniques are incapable of deciding optimal routes because of inefficiently incorporating aforementioned characteristics of VANETs. One of the problems with these routing algorithms is that when the streets do not contain enough vehicular density the relay of the packet towards the destination is interrupted. The results meet the local optimum situation. Local optimum is a situation when a forwarding node is unable to find the next neighbour because of the lack of traffic density on the road [7]. The node keeps the packet in its buffer for a long time, so time to live period expires and it's eventually discarded. This reduces the network performance in terms of end-to-end delay and packet delivery ratio. Designing a routing algorithm capable of solving such issues is critical and our proposed algorithm intends to overcome this issue by selecting the next forwarder node based on vehicular density, velocity and link lifetime.

The remainder of the paper is structured as follows. Section 2 reviews the related work. Section [3] presents the Geographical Zone based Cluster Head Routing for Sparse networks (GZCHRS). The performance evaluation of the proposed algorithm is given in Section4. Finally, Section 5 gives the conclusion of the paper.

2. Related work

In [8], a Light Weight Intersection based Traffic Aware Routing (LITAR) protocol was proposed, which introduces two algorithms Real Time Traffic Aware with Network Measurement process and Enhanced Validity Period Calculation Algorithm. The first algorithm measures the current traffic and network status. Based on the measurement of the first algorithm, the second algorithm takes the routing decision. LITAR makes routing decisions depending on road network connectivity, vehicular density and distance close to the destination. It cuts down the network overhead generated by the Control Packets.

Enhanced Greedy Traffic Aware Routing (E-GyTAR) [9] protocol is Intersection based routing protocol. Before selecting the next intersection, E-GyTAR considers the direction and speed of the vehicle. After selecting the intersection, it sends the packets between the selected intersection to the next intersection using improved greedy approach and carry and forward method. This algorithm does not predict the future neighbour.

Traffic Flow Oriented Routing (TFOR) [10] protocol selects the intersection, depending on the dynamic directional and non-directional flow of traffic density. To avoid the network disconnectivity problem this algorithm considers the non-directional flow of traffic. The sending vehicle calculates the distance from each neighbour intersection to the destination vehicle. The junction which has the maximum score is selected as the next forwarded junction. TFOR uses two-hop neighbour information for sending data packets from one intersection to another junction. Before sending the data packets it checks the neighbour table information. The simulation result displays that TFOR outperforms E-GyTAR and GyTAR in terms of end-to-end delay and packet delivery ratio.

Intersection based Connectivity Aware Routing (ICAR) for a vehicular network has been suggested in [11]. ICAR forward packets from one intersection to another intersection depends on the next junction selection method and forward packets from one hop to another depending on the next hop selection strategy. When a packet reaches the junction, the next junction is selected based on the scores of the neighbour junction, the geographical position and distance to the final destination. In this protocol, CP collects the real time traffic information. A large number of CP generations causes network overhead and degrades the network performance.

Anchor-Based Connectivity-Aware Routing (ACAR) protocol was proposed by Pete et al [12]. It is a hybrid protocol. ACAR investigates neighbour vehicles in sparse and highly dynamic vehicular environment. ACAR is using greedy forwarding approach for fully connected city environment and store-carry-and-forward approach for the sparse network.

Chen chen et al proposed a Connectivity-aware intersection-based routing (CAIR) protocol [13]. It is not reliable for routing decision in the urban area depending only on vehicle position. CAIR comprises of three phases such as intersection selection mechanism, next hop selection mechanism and route recovery. Intersection selection mechanism is based on rectangular restricted area searching. Next hop selection mechanism uses greedy forwarding algorithm and route recovery method uses the store-carry-forward method.

Kashif Naseer Qureshi et al introduced a Cluster Based Routing for Sparse and Dense Networks (CBRSDN) [14]. In cluster based protocol the vehicle nodes are grouped together to form a cluster. Each cluster has one cluster head, the remaining nodes are cluster members. This protocol consists of three phases namely cluster formation, cluster head selection and cluster management. Most of the cluster based routing protocols create network overhead due to the cluster head selection process. In order to reduce the network overhead CBRSDN protocol involves only limited number of nodes for the cluster head selection process.

When a packet is forwarded by intersection based traffic aware routing protocols make routing decisions at each intersection. Routing decision depends on road’s traffic and network status along with distance towards the destination. The real time road evaluation processes are based on generating and forwarding CPs from one road end to another. When CP is forwarded through road, it gathers traffic and network information. The high number of CP creation tends to network overhead as it reduces the TAR routing protocols performance. Unlike previous papers in the literature, this paper analyzes inter vehicles connectivity models with important factors like link lifetime, vehicles relative velocity and calculate one hop node density. Instead of generating CP in all the nodes in the zone, the master node sends CP, when the node in the zone leaves to the intersection. This algorithm combined with both geographical and cluster based routing, so it limits the CP generation and reduces the network overhead.

3. Geographical zone based cluster head for routing in sparse networks

GZCHRS is a zone based geographical routing algorithm. Assuming every vehicle equipped with GPS and navigation system so that each of them can obtain speed and location. In GZCHRS, the entire network is divided into zones and each zone has one master node .The master node is responsible for intra-cluster and inter-cluster communication. The selection of master node is based on the distance, signal strength and direction. Central vehicle node is selected as master node within each cluster. CP routing of the vehicles is controlled by the master node within the zone. The CP is used to gather data about traffic and network status from the road it passes through. In LITAR, the CP forwarding uses more number of nodes between the intersections. More number of CP generation leads to network overhead. Instead of sending CP to all nodes, GZCHRS sends CP to master node. So it suppresses the CP generation and reduces the network overhead to improve the network performance. GZCHRS maintains the neighbour table in which speed, direction and position of the neighboring vehicles are recorded. Tables are built and maintained depending on the information received from exchanging beacon messages between vehicles. Fig. 1 shows the working flow of geographical zone based cluster head routing for sparse network algorithm.

3.1 Measuring the density of one-hop node

Traffic density is the significant routing metrics to conclude the stable routing path in sparse networks. In a sparse network, the vehicles face the local maxima problem frequently. The vehicles calculate the one-hop node density depending on the number of neighbours in the neighbour table divided by the radio range of the vehicle. This shortens the packet risk by meeting local maximum. GZCHRS creates a reliable routing path by taking the one hop node density.

3.2 Motion Based Prediction for Routing (MPR)

MPR guarantees the vehicle velocity can be used for a definite measure of link stability. To calculate the feasibility of link failure while in a communication session, MPR takes movement direction, position, and speed of the vehicle. Considering this, the optimal node is elected as a next hop node for sending data within the radio range. Before choosing the next hop for transferring data between vehicles, the link stability is inspected.

The link lifetime between the vehicles is characterized by the small duration along with which two vehicles will get by in correspondence range to send the information packets. If the link between the vehicles is valid for the little amount of time then it would prompt to continual route restoration. If the link lifetime is calculated before it discontinues then that data can be utilized as the routing parameter for next node selection. The lengthy lifetime provides a stable routing path with less packet loss.

The routing metrics along with distance, speed and moving direction among the vehicles have a large effect on the forwarding selection. This work suspects that each node recognizes its own position and also the position of the destination. Forwarded vehicle selection depends on the average distance and average speed of the vehicle. Link validity of a node is estimated using the formula 1.

$$LT(t) = R - \frac{\sqrt{(a_i - c_s)^2 + (b_i - d_s)^2}}{(SP_s - SP_i)} \qquad (1)$$

R is the radio range of the vehicle. Let (c_s,d_s), (a_i, b_i)be the coordinates of source node s and neighbor i and SPs and SPi be the speed of the source and neighbor node.

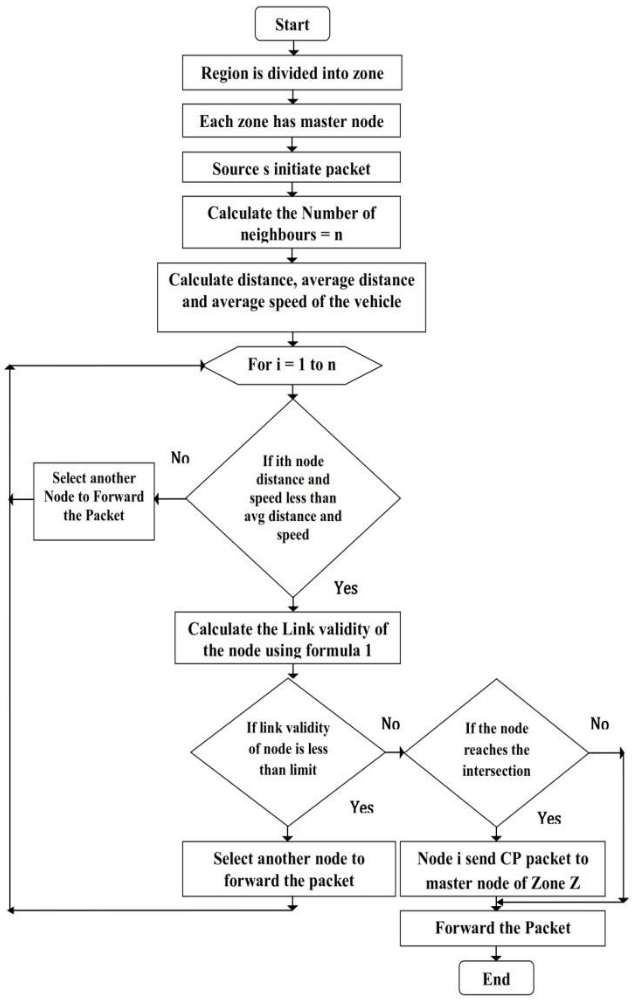

Fig. 1: Flow Chart of Geographical Zone Based Routing for Sparse Networks.

Instead of forwarding CP in all nodes in the zone, the master node sends CP when the node in zone leaves from current road to the intersection. The validity of a node in the road is determined by link lifetime of the node. If link validity of node is fewer than limit or reaches the intersection, Node i send CP to the master node of the zone.

4. Performance evaluation

In this section, description of simulations is executed to evaluate the performance of GZCHRS is provided. We also compare GZCHRS with the two existing protocols, ICAR and LITAR. The experiments were conducted with the well-known simulator NS 2.34. Sparse type of road network is used for simulation environment. Table 1 shows the simulation parameters.

Table 1: Simulation Parameters

Simulation Parameters	Value
Propagation	Two Ray Ground
Channel	Wireless Channel
Physical Layer	Wireless Physical
Queue	DropTail/PriQueue
Mac	802_.11
X dimension of the topography	3000
Y dimension of the topography	3000
Ad hoc Routing	GPSR
Antenna	Omni Antenna
Max packet	100
Number of nodes simulated	80
Cp	./cbr
Simulation time	100 s
Energy	Energy Mode
Initial Energy	100
MinNeighbor	6

The performance of this work is measured using Collision rate, Packet delivery ratio, Normalized routing load and Average delay which shows that an efficient result of the proposed algorithm when compared with the existing algorithms. A Constant Bit Rate (CBR) connection is established when a source node starts sending a data packet to a destination node through multi-hop communication. The impact of increasing CBR connections are discussed briefly below.

4.1. Collision rate

Fig.2, illustrates the collision rate of the three protocols, where a various number of CBR connections in low vehicular density scenario are considered. It can be observed that GZCHRS has the lowest collision rate compared to ICAR and LITAR.

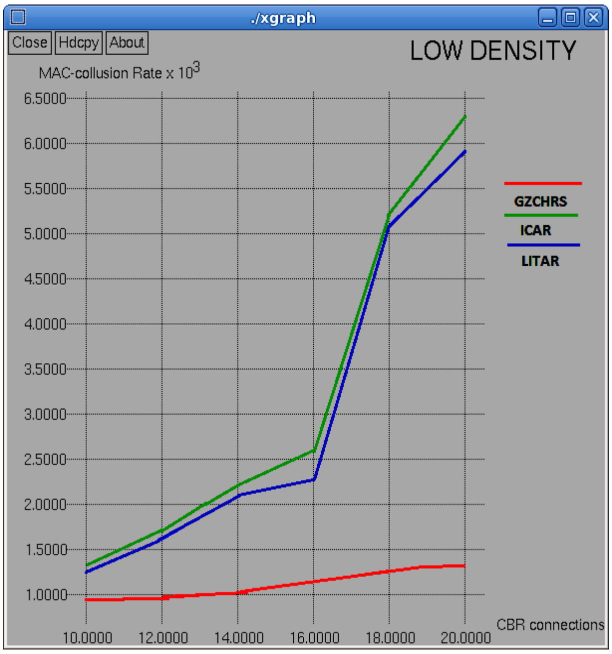

Fig. 2: Collision Rate.

4.2. Packet delivery ratio

Fig. 3 shows the effect of Constant Bit Rate (CBR) connections on packet delivery ratio. The packet delivery ratio decreases in all algorithms by increasing the number of CBR connections. GZCHRS achieves the highest packet delivery ratio compared to ICAR and LITAR.

$$\text{Packet Delivery Ratio} = \frac{\text{Received Packets}}{\text{Send Packets}} * 100$$

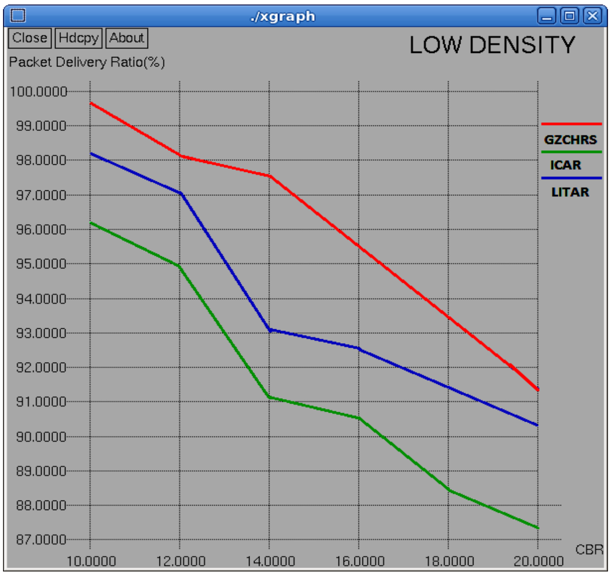

Fig. 3: Packet Delivery Ratio.

4.3. Normalized routing load

Fig. 4 shows the normalized routing load of all three algorithms with respect to the number of CBR connections. ICAR and LITAR show higher routing load than GZCHRS. Due to the fact in LITAR and ICAR generates more number of control packets for real time traffic and network calculation.

$$\text{Normalized Routing Load} = \frac{\text{Control Packet Generated}}{\text{Data Packets Received}}$$

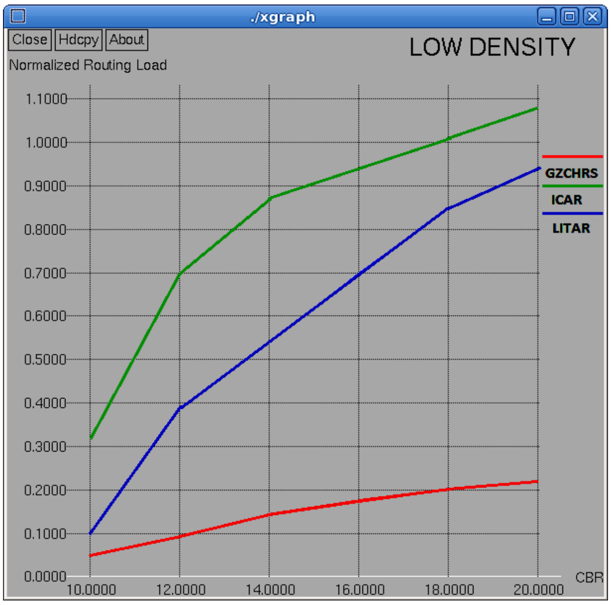

Fig. 4: Normalized Routing Load

4.4. Average end to end Delay

Fig. 5 compares the performance of three algorithms in terms of average delay. GZCHRS has low packet delay when compared to the existing algorithms. This is because GZCHRS has the more chance to reach the destination than ICAR and LITAR.

$$\text{AverageDelay} = \frac{\text{Sum of all packets delay}}{\text{Total Number of Received Packets}}$$

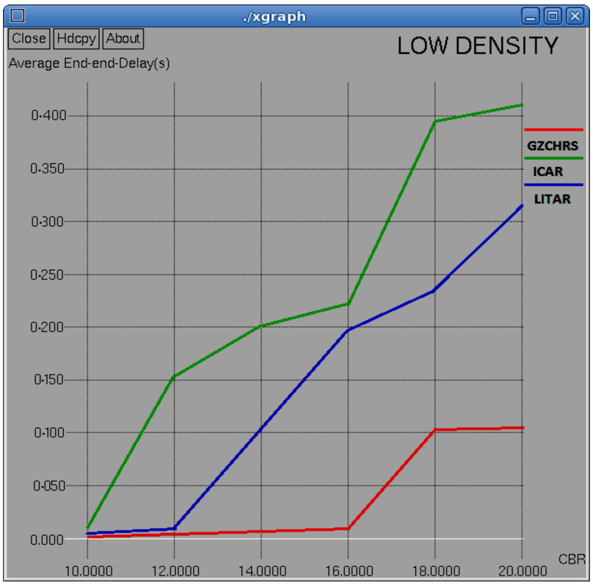

Fig. 5: Average End To End Delay.

5. Conclusion

The GZCHRS algorithm, designed to route the data packets optimally in a rural environment. Geographically zone based routing for sparse network considers recognizing routing metrics for next forwarder node election including vehicle speed, direction, density and link lifetime. The simulation results indicate that GZCHRS has better results in packet delivery ratio, routing load, collision rate and average delay compared with existing algorithms. In the future, it would be interesting to investigate the behaviour of GZCHRS, LITAR and ICAR in an urban vehicular network.

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