

A Dynamic Time Scalable Hybrid Location based Ad hoc Routing Protocol

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Abstract: *Vehicular ad hoc networks (VANETs) are mobile wireless networks which are designed to support public safety by traffic tracking. In VANETs, vehicle mobility will cause the communication links between vehicles leads to broken. Such link failures are responsible for excessive increase in the routing overhead and degradation in network scalability. In this paper, we propose dynamic time scalable hybrid protocol which combines features of reactive routing with geographic routing to address this issue. A dynamic time scalable hybrid location- based ad hoc routing (HLAR) protocol is used for reducing routing overhead and degradation in network scalability by using available location information. As the location information degrades hybrid protocol is designed in such a manner that it can be exit to reactive routing.*

Keywords: VANET, HLAR, NS2, Scalability, Routing overhead

1. Introduction

As variety of services as variety of services provided by Vehicular Networks receiving a lot of attention. Vehicular Ad hoc Networks (VANET) is part of Mobile Ad Hoc Networks (MANET) i.e. In VANET, every node can move freely within the network and stay connected with each other. They can communicate with other nodes in single hop or multi hop. VANET is a distributed self-organized network formed between wireless communication devices equipped in vehicles (OBU i.e. on board unit) and any node can acts as a road side units (RSU). VANETs provide us such the infrastructure to enhance drivers and passenger's safety and comfort by developing new systems.

The focus of the ITS program is on the creation of an intelligent transportation system thereby on the intelligent vehicles, intelligent infrastructure through integration with and between these two components. The overall advancement of ITS is done through investments in its major initiatives to improve safety, mobility, and productivity. Such networks is developed as part of ITS (Intelligent transportation systems) to improve the system performance. One of the main goals of ITS is to improve safety of the roads and reduce traffic congestion, waiting times, and fuel consumptions.

2. Routing Protocols

Because of the high mobility of nodes and rapid changes of topology, designing an efficient routing protocol that can deliver a packet in a minimum period of time with few dropped packets is considered to be a critical challenge in VANET. Further, many researchers have concentrated on designing a routing protocol suitable for dense environments that have a high density of vehicles with close distances between them. Designing an efficient routing protocol has an impact on improving many factors; the first of these is enhancing the reliability of the system by raising the percentage of packets delivery, and second by reducing the

extent of interference caused by high buildings in the city environment; the third factor is scalability.

2.1 Multicast Routing Protocol

In multicasting there is at least one sender and several receivers (group of receivers called multicast group). In multicast routing, the router may forward the received packet through several of its interfaces. The multicast routing uses trees. Multicast trees (with source at the root and the group members being lives) are called spanning trees. The optimal tree is called shortest path spanning tree.

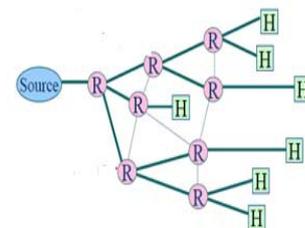


Figure 1: Multicast Routing

An application of Multicasting includes scheduled audio-video distribution (lectures, business TV). All routing protocol use Internet Group Management Protocol (IGMP) as the host router interface through which the hosts can sign in/off to/from m/c groups. There are two types of multicast trees are source-based trees and shared trees. DVMRP stands for distance vector multicast routing protocol which works within autonomous system. MOSPF stands for multicast OSPF is an inter domain routing protocol. Protocol Independence multicast works with any underlying unicast routing protocol DM-PIM stands for dense mode - protocol independent multicast. It is not formally standardized. It uses source-based trees. SM-PIM stand for sparse mode - protocol independent multicast. It uses shared trees. CBT stands for core based tree.

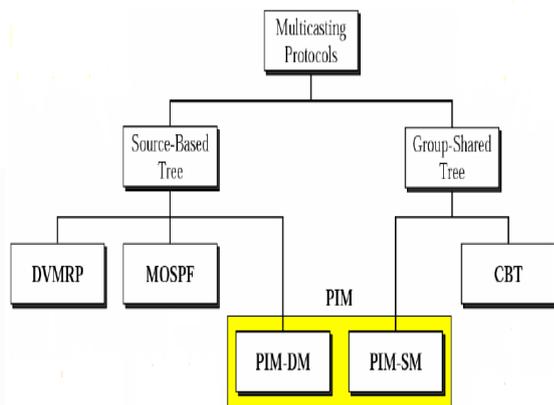


Figure 2: Multicast Routing Protocol

3. Geocast Routing Protocol

An application in VANET includes sending a message to certain or all vehicles within a region, called geocast. Geocast routing is to deliver a geocast packet to a specific geographic region. Vehicles located in this specific geographic region should receive and forward the geocast packet; otherwise, the packet is dropped. The goal of geocasting is to guarantee delivery thereby maintaining a low cost. Sometimes, in some applications geocast requires that the message be kept alive within that region for a period of time so it is called time-stable geocast. This time-stable geocast has an important role in some ITS applications which makes it necessary to change the duration of the stable message within the region i.e the dynamic nature of a geocast protocol helps to extend the time or it may be reduced or canceled. Moreover, with the informed time of zero, all the intended vehicles will be informed as soon as they enter the region. The protocol is independent of the networks' density, the vehicles' speed, and the vehicles' broadcasting range, makes it more robust than others who fail in sparse networks or in high-speed nodes. It is believed that geographic routing faces the scalability problem. The main reasons behind that geographic routing protocols do not exchange any link-state information and do not establish and maintain any routing tables.

Geographic routing assumes that sending vehicle knows the receiving vehicle's location. To fulfill above condition system should keep track of the locations of the vehicles within the network. However, geographic routing has several issues in that most important of is that of location error. Location errors can severely degrade the performance in location-based forwarding schemes, making accurate location information a necessity for geographic routing protocols. Geographic routing fails in the presence of void regions, where a closer neighbor vehicle toward the destination cannot be found.

Therefore, we will use a hybrid design approach, where we combine features of reactive routing (AODV) with geographic routing. As among all the various topology based routing protocols and according to their results it is shown that the ad hoc on-demand distance vector (AODV) has the best performance and lowest routing overhead. Due to this

combination, a limitation of geographic routing is overcome in some extent. Our protocol is designed to make use of all the location information available to minimize the routing overhead and to exit reactive routing as the location information degrades. We introduce new a dynamic time scalable hybrid location-based ad hoc routing (DTSHLAR) protocol, which was designed to achieve optimal scalability performance.

4. Hybrid protocol

HLAR combines a modified AODV protocol with a greedy-forwarding geographic routing protocol. In HLAR, we use AODV which is modified with the expected transmission count (ETX) metric to find the best quality route. In AODV-ETX, vehicles report the broken routes to their source vehicles. However, in this paper, we add to AODV-ETX the additional functionality where vehicles are allowed to repair broken routes. It has cost less power consumption which reestablishes a new source-to-destination route. To calculate the quality (ETX) of their shared links, vehicles need to broadcast small beacon packets periodically. These beacon packets include the vehicle's ID and the current location coordinates. This beacon packet allows vehicles to build their neighbor tables which include both the neighbor vehicle ID and its current location coordinates. HLAR initiates the route tracking in an on-demand fashion. If the source vehicle has no route to the destination vehicle, the source includes the location coordinates of both itself and the destination vehicle in a route request (RREQ) packet and then looks up its own neighbor table to find if it has any closer neighbor vehicle toward the destination vehicle. If a closer neighbor vehicle is available, the RREQ packet is forwarded to that vehicle. If closer neighbor vehicle is not available (i.e. void region or neighbor vehicles have no location information), the RREQ packet is flooded to all neighbor vehicles. In HLAR, the RREQ packets include a time-to-live (TTL) field, which will be set by the source vehicle depending on the estimated hop count between the source vehicle and the destination vehicle. The TTL field is decremented each time when a current vehicle cannot (or does not) use location information in the forwarding decision, and the RREQ packet will be dropped when its TTL field becomes zero. The unnecessary flooding of the whole network is avoided. Another feature of protocol is that vehicles that participate in exchanging data traffic are allowed to locally repair broken routes through a route repair (RRP) packet instead of just reporting a broken route to its source vehicle. To analyze the scalability of both HLAR and AODV-ETX protocols in VANET environment, we first need to analyze the parameter minimum traffic load (MTL).

4.1 Analytical Analysis of HLAR

MTL is the minimum amount of bandwidth required to forward packets over the shortest distance routes available, assuming that all the vehicles have instantaneous full topology information. We can define the network scalability factor in terms of the MTL with respect to parameter λ as

$$\Psi_{\lambda_i} \triangleq \lim_{\lambda_i \rightarrow \infty} \frac{\log MTL(\lambda_1, \lambda_2 \dots)}{\log \lambda_i} \quad (1)$$

$$N_{H_0} = \frac{\bar{L}}{\bar{h}} \quad (4)$$

This MTL will be dependent on parameters $\lambda_1, \lambda_2 \dots$ which represents the data generation rate, mobility, network size, network density or any other network parameter. We can define the protocol scalability factor in terms of the total overhead rate (ON) with respect to parameter λ_i as

$$\beta_{\lambda_i} \triangleq \lim_{\lambda_i \rightarrow \infty} \frac{\log ON(\lambda_1, \lambda_2 \dots)}{\log \lambda_i} \quad (2)$$

In a sense, this condition means that a protocol is scalable if the overhead of a protocol does not increase faster than the network's MTL.

The routing overhead rate ON can be divided into the following three subclasses:

- 1) The initiation overhead rate O_i , which is required to initiate the routes
- 2) The maintenance overhead rate O_m , which is required to maintain these routes
- 3) The beacon overhead rate O_b , which is required to estimate the quality of links and to build up the neighbor tables.

1) O_i Analysis

We need to calculate O_i for both the AODV-ETX and HLAR protocols. We assume that all vehicles have constant transmission range R and are localized in a network of dimensions $A \times B$.

a) O_i Analysis of AODV-ETX

In the AODV-ETX protocol, a source vehicle initiates a route to a certain destination vehicle by sending an (Route request) RREQ packet in the whole network. When a vehicle receives an RREQ packet, it checks the RREQ_ID and the originator address of that request to determine whether to flood or to ignore this RREQ packet so that duplicate packets can be eliminated.

The total number of RREQ packet transmissions, using AODV-ETX, for one communication pair is given by

$$N_{rreq}^{AODV-ETX} = N_p - 1 \quad (3)$$

Where N_p is the total number of vehicles in the network. A destination vehicle sends an (Route reply) RREP packet only if this is the first RREQ packet that was received from this source vehicle or if this RREQ packet indicates a lower cost (better quality) than the current route.

The average number of hops between a random source-destination pair N_{H_0} can be given as

Where \bar{L} is the average distance between random source-destination pairs \bar{h} is the mean length of a single hop. The total number of RREP packet transmissions, using AODV-ETX, for one communication pair can then be written as

$$N_{rrep}^{AODV-ETX} = N_{H_0} n. \quad (5)$$

Where n is the transmission range

The total number of routing overhead packet transmissions N_i need to initiate m communication pairs in the network can be written as

$$N_i = m (N_{rreq}^{AODV-ETX} + N_{rrep}^{AODV-ETX}) \quad (7)$$

O_i at a time interval t can be calculated as

$$O_i = \frac{N_i S_p}{t} \quad (8)$$

Where S_p is the control packet size

b) O_i Analysis for HLAR

If a closer neighbor vehicle is available, an RREQ packet is forwarded to that neighbor vehicle. The probability of finding a route using HLAR between any source-destination pair in the network, assuming that all found routes have a length of N_{H_0} , can be written as

$$P_T = \prod_{i=1}^{N_{H_0}} (1 - \exp(-\rho \chi_i)) \quad (9)$$

Where $\rho = \frac{N_p}{AB}$ is the density of vehicles in the network and χ_i is the forward progress area of vehicle i along the route toward the destination vehicle.

The total number of RREQ packet transmissions, using HLAR, for one communication pair can be written as

$$N_{rreq}^{HLAR} = (N_{H_0} \cdot P_T + (N_p - 1) (1 - P_T)) \quad (10)$$

A destination vehicle sends an RREP packet only if the received RREQ packet is the first to be received from this source vehicle or if the RREQ packet indicates a lower cost (better quality) than the current route.

The total number of RREP packet transmissions, using HLAR, for one communication pair can be written as

$$N_{rrep}^{HLAR} = (N_{H_0} \cdot P_T + (N_{H_0} \cdot n) (1 - P_T)) \quad (11)$$

Then O_i can be directly calculated by eqn

$$O_i = \frac{N_i S_p}{t} \quad (12)$$

emitting a rate R_b of beacon packets, and where the size of each beacon packet is S_b , O_b is given by

$$O_b = N_p R_b S_b. \quad (19)$$

2) Om Analysis

a) Oi Analysis of AODV-ETX

To calculate O_m for AODV-ETX, we need to find the total number of route maintenance overhead packet transmissions N_m .

We assume that vehicle mobility is the only reason for link failure. To calculate N_m , we need to find out the average link failure rate λ (number of times that a link fails per unit time) of a single link between any two active vehicles due to their mobility.

O_m of the routing protocol is directly proportional to the link failure rate. Now, the total number of active links N_L in the network

$$N_L = m \cdot N_H \quad (13)$$

Then, the total number of link failures N_f during time interval t is given by

$$N_f = \lambda N_L t \quad (14)$$

Each single link failure forces the source vehicle to flood a new RREQ packet and the destination vehicle to reply with a RREP packet. Therefore, N_m can be given as

$$N_m = N_f \left(\frac{N_{RREQ}}{N_{REQ}} + \frac{N_{RREP}}{N_{REP}} \right) \quad (15)$$

O_m can be calculated as

$$O_m = \frac{N_m S_p}{t} \quad (16)$$

bb

b) Om Analysis For HLAR

The total number of routing overhead packet transmissions to maintain m communication pairs in the network using HLAR can be calculated as

$$N_m = N_f \left(\frac{N_{HLAR}}{N_{REQ}} + \frac{N_{HLAR}}{N_{REP}} \right) \quad (17)$$

O_m can be calculated as

$$O_m = \frac{N_m S_p}{t} \quad (18)$$

3) Ob Analysis

O_b is the beacon overhead that allows vehicles to build up their neighbor tables and to estimate the quality of their links. O_b will be the same for both the AODV-ETX and HLAR protocols. To determine O_b , we assume that all vehicles in the network are locally broadcasting (with $TTL = 1$), are

5. Simulation Model and Parameters

We are going to simulate hybrid protocol of VANETs in this paper. In this result, we are going to simulate a multilane highway in which N_p vehicles (moving in either direction) are randomly and uniformly distributed along an eight-lane highway of length L_v . In this scenario, all vehicles are assumed to have the same transmission range $R = 150-250$ m, and their speeds are randomly distributed following a Gaussian, Rayleigh; with an average speed of 70 km/h. we allow vehicles to change lanes and to reverse direction. We summarize all the simulation parameters in Table I. In each simulation run, a group of source and destination pairs are randomly chosen. Each pair uses an 8-kb/s constant bit rate (1-kb packet size) traffic flow to exchange data traffic in each direction.

Each simulation run starts with an initialization phase, in which vehicles have zero speed (no mobility) and only exchange beacon packets (no data) to build their neighbor tables and also to initially estimate their link quality (ETX). After the initialization step, all vehicles get a movement around the network, and chosen source vehicles sequentially initiate the data flows to their intended destination vehicles.

Table 1: Simulation Parameters

No.	Parameters	Value
1	Number of vehicles	50 vehicles
2	Transmission range	150-250m
3	data rate	8 kbps
4	beacon sampling period	1 sec
5	MAC layer	802.11b
6	Bandwidth	2 Mbps
7	average velocity	40-100 km/hr
8	speed distribution	Gaussian, Rayleigh

Expected Result

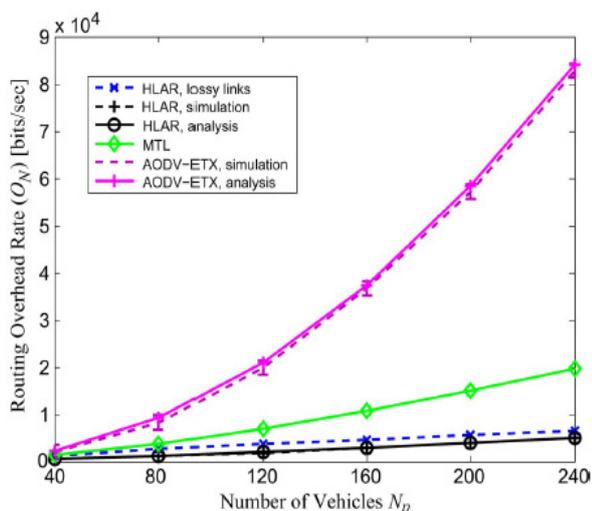


Figure 3: Routing overhead rate (ON) of the HLAR and AODV-ETX protocols with respect to total number of vehicles in the network (N_p)

6. Conclusion

In this paper, we have presented a new dynamic time scalable hybrid location-based ad hoc routing protocol which combines features of reactive routing with location-based geographic routing. It is responsible for significant reduction in the routing overhead and degradation in network scalability even in presence of high location errors. This can be achieved in HLAR compared to standard reactive and geographic routing protocols. This is helpful for routing protocols in emerging VANETS to improve ITS which is need of today.

6. References

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