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Increasing the route lifetime stability of LAR protocol for VANETs in highway environment

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Abstract: **Vehicular Ad Hoc Network (VANET) is an instance of MANETs that establishes wireless connections between vehicles. Recently, it was shown for the case of highway traffic that position-based routing protocols can very well deal with the high mobility of network vehicles. In VANETs, these routing protocols must be adapted to vehicular-specific capabilities and requirements. As many previous works have shown, routing performance is greatly dependent on the availability and stability of wireless links. This work adapts the Location-Aided Routing protocol for inter-vehicle communications in a highway environment. We improved the stability of routes between sources and destinations, by forwarding the route request message to the neighbor which stays the longest time in communication range of the forwarder, and avoiding the nodes moving in opposite direction of source movement to participate in research of route if there are the nodes traveling in the same direction of the source motion. The performance metrics such as average delay of path stability between source and destination, packet delivery ratio (PDR), throughput, and normalized routing load (NRL) are measured using ns2. The Intelligent Driver Model with Lane Changing (IDM_LC) based on VanetMobiSim tool is used to generate realistic mobility traces in highway.**

Keywords: Route lifetime; Opposite direction; VANET; LAR; VanetMobiSim; IDM_LC; highway Scenario; NS2

I. Introduction

Vehicular Ad-hoc Network (VANET) is a rapidly emerging new class of Mobile Ad hoc Networks (MANET). VANET consists of a large number of vehicles providing connectivity to each other. Vehicles in this network can move in specified directions with high mobility. Vehicles which fall in each other transmission range can communicate directly over a wireless link. If source and destination vehicles are not in direct communication range of each other, then they communicate through intermediate node in multi-hop fashion [1]. The vehicles move in a broader and higher range of speed. Hence the network topology changes more rapidly, which then causes frequent network fragmentations and limited route lifetime. Therefore, routing protocols have to be designed to cope with the high mobility of the VANET environment and most importantly to ensure the reliability of safety related applications [2].

Besides that, in a VANET environment the vehicles' movements are also restricted by traffic rules such as traffic lights, road intersections, surrounding obstacles as well as the road patterns of specific areas. While this would render the current routing protocols designed for MANET ineffective [3,4], the proposed routing protocols for VANET can make use of this information in the route decision making process in order to forward packets more effectively. Position-based routing protocols present challenging and interesting properties of VANETs [5,6]. For any position-based routing protocol global topology information is not required. It uses only the local information of neighboring nodes that within the transmission range of any forwarding node. Due to this restriction, it gives low overhead of their creation and maintenance. The local information about the physical location of nodes can be provided by the global positioning system (GPS) if vehicular nodes are equipped with a GPS receiver [7,8].

Our study context is a vehicular ad hoc network on highway with high dynamicity of the network. This high dynamicity occurs because vehicles change lanes and overtake each other. Therefore, the absolute geographic position of the nodes varies continuously as well as their relative position, because the vehicles do not travel all at the same speed and at the same direction movement. Designing an efficient routing protocol that can deliver a packet in a minimum period of time and that can increases the route lifetime with great percentage of packets delivery is considered to be a critical challenge in VANET. For that, we seek to adapt the Location-Aided Routing Protocol for inter-vehicle communications in a highway environment. We have improved this protocol in a way to increase the route lifetime stability between sources and destinations. The Intelligent Driver Model with Lane Changing (IDM_LC) based on VanetMobiSim tool is used to generate realistic mobility traces.

The rest of the paper is organized as follows. Section 2 presents related work. Section 3 shows Location-Aided protocol and our improvement. Section 4 presents mobility model. Section 5 presents simulation methodology and results. Finally, we give a conclusion in Section 6.

II. Related Work

Several studies have been done to evaluate, compare and improve the performance of routing protocols in various traffic conditions in VANETs. In [9] the authors studied the routing protocols that were suitable for VANET, especially the protocols based on the position. They gave an overview of the evolution of routing protocols for VANET environment, and compared drivers in the security environment and the driving experience. In [10] the authors presented a DREAM protocol simulation study for inter-vehicle communication. The results show that the protocol is more sensitive to the traffic load that the speed of vehicles which is more suitable for VANETs networks. Husain et al presented in [11] a study on the use of Location-Aided Routing (LAR) protocols for vehicle ad hoc networks (VANET) in the highway scenario. They used Intelligent Driver Model (IDM) to generate realistic mobility traffic. The LAR was tested against nodes density for various metric with a high speed (100 km/h). The protocol has good performance in a communication environment for vehicle and it is sensitive to the density of nodes and the number of lanes. To improve LAR in MANET, Putthiphong et al. proposed the LorAReZ method [12]. The size of the expect-zone and the request zone are defined according to the level of the request zone. This level is calculated based on the distance between the source nodes and the destination nodes designated by Dd. Weijie Liu defined in [13] the destination faced area (DFA) which is the half-circle of the communication in the side closing to the destination for reducing the RREQ transmitting messages to the opposite direction. The DFA is the area for the proposed method to flood the received route request message. The nodes in the DFA will be considered to be the forwarders. Nodes in the DFA will be assigned different back-off time. The nodes which run out of time will forward the RREQ message to its neighbors. The nodes which receive the same RREQ message will ignore it and refuse to perform the forwarding operation. The authors proposed in [14] a new density-aware location-aided routing protocol (DALAR) to improve the performance of the route discovery phase. The nodes use their position information and exchanged messages to estimate the density of neighbor in destination faced area (DFA). A node whose number of its neighbor nodes in its DFA is lower than the threshold will refuse to forward the received RREQ messages. The path will be built over the area which has more nodes, and the nodes will reduce the protocol overhead on RREQ forwarding. The authors showed that the length of the constructed route in the proposed method is the same as the common used flooding methods, but the nodes which participate on forwarding the route request messages are reduced. In [15] the authors propose an optimized probabilistic broadcast mechanism other than the simple flooding mechanism. They propose a broadcast scheme through which the emergency warning packets (EWPs) in the ad hoc part in Client-Server Ad-Hoc (CSAH) communication platform [16] are transmitted from an abnormal vehicle to others in its zone. The idea behind this scheme is to reduce a set of forwarding or rebroadcasting vehicles based on an optimal choice for the rebroadcast probability at each vehicle such that the EWPs delivery ratio within distance of 400m from the abnormal vehicle is maintained to 90-100%. Hence, each vehicle node determines its own rebroadcast probability depending on its local information within two-hops. The local information is simply obtained from the periodical HELLO packets. The rebroadcast probability is dynamically determined depending on the estimation of local vehicles density around each vehicle node. The authors of [1] evaluated the D-LAR protocol [17] to VANET in the dense network scenario. The feasibility of VANET for D-LAR protocol was justified. They calculated throughput path for D-LAR scheme by using hop count and link lifetime. The simulation results show that the proposed scheme can be used to evaluate path throughput accurately in the network. T. Taleb, Kazuo H. suggested in [18] a scheme which group vehicles according to their positions of speed. This kind of grouping ensures that the vehicles belonging to the same group usually move together. Routes involving vehicles of the same group and have a high level of stability. Among the possible routes, communication is set up on the most stable route using the Receive On Most Stable Group-Path (ROMSGP) scheme. Decision of the most stable link is made based on the computation of the link expiration time (LET) of each path. Obviously, the longest LET of routes is considered the most stable link. In [19], the authors propose SCRP protocol. It builds stable backbones on road segments by considering vehicles' speed and spatial distribution. Backbones are built over road segments using connected dominating sets (CDS). The creation process starts at the beginning of each road segment and continues onward until an intersection is reached.

In this work, we seek to improve the LAR1 protocol in highway multi-lanes depending on vehicle density. In [12], when Dd is short, the size of the expect-zone and request zone becomes weak to reduce protocol overhead. In [13], if the number of nodes in DFA of a forwarding node is low, the probability that fails to build the route will increase. In [14], if all nodes have a number of nodes in DFA lower than the threshold, then the route will not be built. In [15], the vehicle node builds its decision based on the aggregated values of formulas described in this paper which constitute the proposed scheme. Authors have not yet determined in thier paper the different conditions under which these different formulas will apply, and consequently it will be used by a vehicle node to compute a rebroadcast probability. In [1], the authors have used MATLAB which is not a real network simulator and they did not use a realistic mobility model to evaluate their protocol. In [18], the authors have grouped vehicles according to their direction of movement. The stability of the communication is ensured by the choice of the most stable path using the ROMSGP scheme. This choice is made based on the calculation of LET of each path. The longest LET path is considered to be the most stable. The authors not take into consideration the case where vehicles travel in opposite direction if there is no vehicle travelling in the same direction of movement until the destination is reached. We seek to increase the stability of the chosen route, by sending route request message to the vehicle that remains the longest time in coverage area of the transmitting vehicle and travels in the same direction of the source movement or in opposite direction if there is no vehicle travelling in the same direction of source movement.

III. Location Aided Routing

A. Description

Location-Aided Routing (LAR) [20] is on demand routing protocol, it is similar to the DSR protocol [21] and AODV [22]. It uses the location information to reduce the routing overhead. Location information used in the LAR protocol can be provided by the Global Positioning System (GPS). The authors of LAR propose two methods used by intermediate nodes between source node (S) and destination node (D) to determine the forwarding zone of a route request message. In method 1, called LAR scheme 1 (LAR1), there are two concepts:

Expected Zone: It is defined as the area where node D is located, from the viewpoint of node S at current moment, (t1). The node S determines the Expected Zone based on knowledge of the location (XD, YD) of the node D at time t0. For example, if the node S knows at time t1 that the node D moves with an average velocity v at time t0, then S can assume that the expected zone is the circular region of radius v(t1-t0) and centered at location (XD, YD). If the node S does not know beforehand the location of node D, then the node S cannot determine the expected Zone. In this case, the entire region can be occupied by the network is assumed to be the expected area. In this case, the LAR algorithm is reduced to the basic flooding algorithm.

Request Zone: It is defined as the smallest rectangle surrounding the current position of the source S and the area Expected Zone, so that the sides of the rectangle are parallel to the axes X and Y. In Figure 1, the request zone is the rectangle whose corners are S, A, B and C, while in Figure 2, the rectangle has corners at point A, B, C and G where (XS, YS) are the coordinates of the current location of the node S.

On the route discovery initiation, the source node S adds its coordinates with the route request message transmitted. When a node receives a route request, it rejects the message if the node is not in request zone. For example, in Figure 1, if the node I receives the route request of another node, it forwards the route request to its neighbors because it is in the rectangular request zone. However, when the node J receives the route request, J ignores the route request because it is not in request zone.

When node D receives the route request message, it responds by sending a route reply message with its currents location, speed and time of speed in the response pathway message. When the node S receives the message route reply, it records the location, the speed and the time of D. The node S can use this information to determine the request zone for a future search of route discovery.

B. Proposal

We seek to improve the stability of the route between sources and destinations in a way to increase the route lifetime so as to ameliorate the protocol performance (PDR, NRL, Throughput). Hence, we propose to choose nodes that travel in the same direction of movement to participate to forwarding the route request message, because the route created by the nodes that go in opposite directions, quickly break compared to that created by the nodes moving in the same direction. Therefore, which direction of movement shall we choose? After, we select among vehicles traveling in same direction, the neighbor which stays the longest time in communication range of the transmitting vehicle. If there is no vehicle traveling in the same direction of the transmitting vehicle motion, then we select the neighbor that is both travel in opposite direction and stays the longest time in coverage area of the transmitting vehicle.

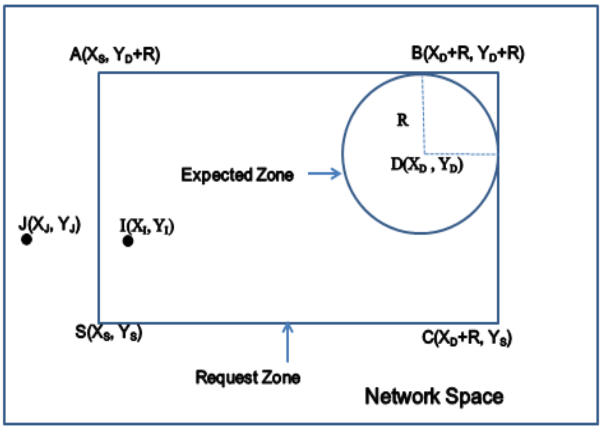

Figure 1. Source node outside the Expected Zone

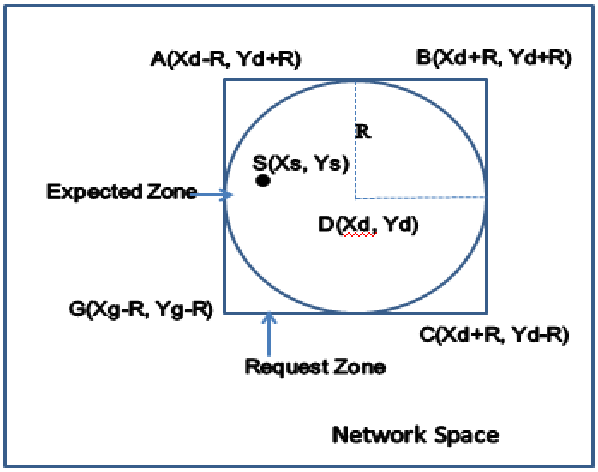

Figure 2. Source node within the Expected Zone

1) Direction of movement

When the node S wants to send a route request message to the node D at the time t1, S can estimate the area where's D located, but it does not know the direction of movement of the latter that means what direction does the destination take? Consequently, we can not know the nodes that go in the same direction of D. On the contrary, we know the direction of motion of S at time t1; Thus, the nodes which travel in the same direction of S motion. So, to improve the stability of the route between the source and destination on the highway environment, we propose to send a route request message to the nodes that are traveling in the same direction of the source movement, whether a node receives a route request message, it checks its direction of motion compared with S, if it goes in the same direction of S, it retransmits the route request message; otherwise, it deletes the latter. This proposal is added to the constraints of LAR Scheme 1 (LAR1).

An example scenario is presented in Figure. 3. The source S broadcasts the route request message to its neighbors, among them A, B, C and K in the forwarding zone. The vehicles A and B forward the route request message to their neighbors because they are within the forwarding zone and they are moving in the same direction of S. The vehicles C and K are within the forwarding zone but they are traveling in opposite direction of S, hence they delete the route request message.

If the number of vehicles traveling in the same direction of the source movement is insufficient to find the route to the destination, then a second route request message will broadcast in the entire network. To solve this problem, we can use the vehicles that travel in the opposite direction of source movement if there is a route through these vehicles. In this case, only the vehicles traveling in the same direction of the transmitter vehicle movement, participate to forwarding the route request message.

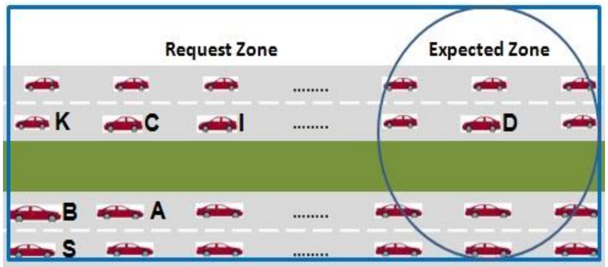

Figure 3. Bi-directional highway model

2) The neighbor stays longest time

To avoid sending the route request message to all vehicles traveling in the same direction of motion of the source S and increase the time of connections between sources and destinations, we propose to transmit the route request message to the vehicle which remains the longest time in coverage area of transmitting vehicle.

It is assumed that each vehicle periodically sends its information in beacon messages (location, speed, direction of movement, address and current time) to its neighbors. At time t0, the transmitter vehicle A is located at position (XA, YA) with speed VA, and the neighboring vehicle I is located at the position (XI, YI) with speed VI. At time t1, I leaves the coverage area of the vehicle A. Thus, the time of the vehicle I to stay in the coverage area of A is t = t1-t0. Assume that d and h are the distances between A and I respectively on the abscissa axis and the ordinate axis at time t0. a is the distance between A and I on the abscissa axis at time t1. x is the distance traveled by the vehicle I at time t1(See Figure. 5). It is assumed that the speed of each vehicle is constant during the time t.

When receiving beacon messages, each vehicle constructs its neighboring list. Each entry in this list includes information extracted from beacons. Whenever a new neighbor is discovered, a new entry is added and a timer is set. A vehicle waits two consecutive beacon intervals to hear from its neighbor. If no message was received, the neighbor's entry is deleted [19]. Once the neighboring list is established, the vehicle which has the route request message calculates the time of each neighboring vehicle to remain in half-circle of the coverage area of the sender vehicle in the side closing to the destination (D) (see Figure. 4: the vehicle J is not involved because it is not in half-circle of the communication range in the side closing to the destination). The vehicle that has the longest time will be chosen as the receiver and forwarder vehicle of the route request message. The procedure is repeated until the message reaches the destination under the LAR1 protocol's constraints. There are six cases to calculate the time of each neighbor.

First case: The speed of A is strictly greater than I at time t0 and the destination is located in the direction of S movement. The distances traveled by A and I at time t1 are respectively (see Figure. 5):

$$d + x + a = t * V_A$$

$$x = t * V_I$$

Therefore

$$x = \frac{V_I}{V_A - V_I} * (d + a)$$

$$d = |X_I - X_A|$$

$$a = \sqrt{R^2 - (Y_I - Y_A)^2}$$

Hence

$$t = \frac{|X_I - X_A|}{V_A - V_I} + \frac{\sqrt{R^2 - (Y_I - Y_A)^2}}{V_A - V_I} \tag{1}$$

Second case: The speed of A is strictly less than I at time t0 and the destination is located in the direction of S movement. The distances traveled by A and I at time t1 are respectively (see Figure. 6):

$$d + x - a = t * V_A$$

$$x = t * V_I$$

Therefore

$$x = \frac{V_I}{V_A - V_I} * (d - a)$$

$$d = |X_I - X_A|$$

$$a = \sqrt{R^2 - (Y_I - Y_A)^2}$$

Hence

$$t = \frac{|X_I - X_A|}{V_A - V_I} - \frac{\sqrt{R^2 - (Y_I - Y_A)^2}}{V_A - V_I} \tag{2}$$

Third case: The speed of A is strictly greater than I at time t0 and the destination is not located in the same direction of S movement. The distances traveled by A and I at time t1 are respectively (see Figure. 7):

$$-d + x + a = t * V_A$$

$$x = t * V_I$$

Therefore

$$x = \frac{V_I}{V_A - V_I} * (-d + a)$$

$$d = |X_I - X_A|$$

$$a = \sqrt{R^2 - (Y_I - Y_A)^2}$$

Hence

$$t = -\frac{|X_I - X_A|}{V_A - V_I} + \frac{\sqrt{R^2 - (Y_I - Y_A)^2}}{V_A - V_I} \qquad (3)$$

Fourth case: The speed of A is strictly less than I at time t0 and the destination is not located in the direction of S movement. The distances traveled by A and I at time t1 are respectively (see Figure. 8):

$$-d + x - a = t * V_A$$

$$x = t * V_I$$

Therefore

$$x = \frac{V_I}{V_A - V_I} * (-d - a)$$

$$d = |X_I - X_A|$$

$$a = \sqrt{R^2 - (Y_I - Y_A)^2}$$

Hence

$$t = -\frac{|X_I - X_A|}{V_A - V_I} - \frac{\sqrt{R^2 - (Y_I - Y_A)^2}}{V_A - V_I} \qquad (4)$$

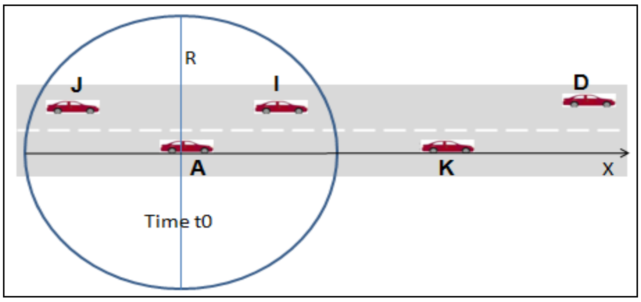

Figure 4. Half-circle of the communication range in the side closing to the destination

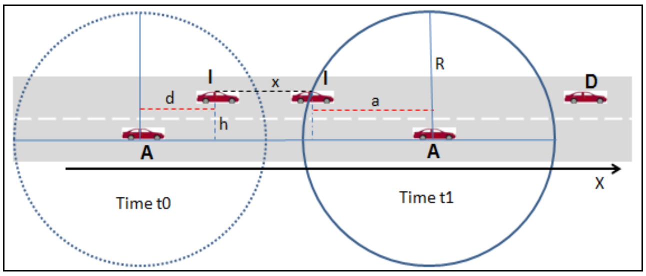

Figure 5. D is located in the direction of S movement and $V_A > V_I$

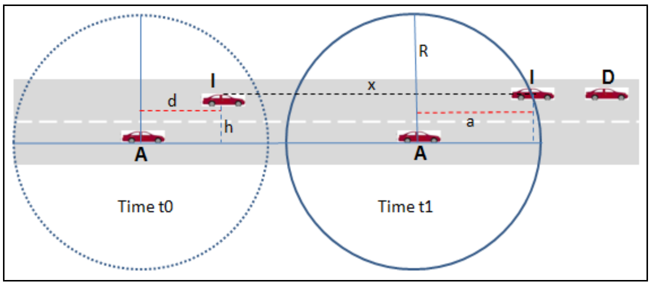

Figure 6. D is located in the direction of S movement and $V_A < V_I$

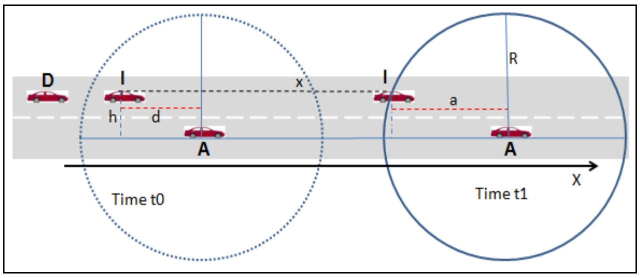

Figure 7. D is not located in the direction of S movement and $V_A > V_I$

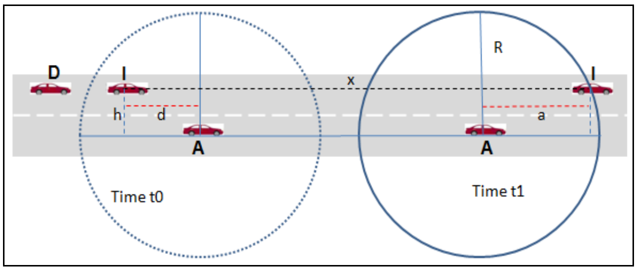

Figure 8. D is not located in the direction of S movement and $V_A < V_I$

Fifth case: The vehicles A and I have the same speed at time t0. In this case, the transmitting vehicle calculates the distance d between itself and each neighbor which has the same speed by this formula:

$$d(A, I) = \sqrt{(X_A - X_I)^2 + (Y_I - Y_A)^2} \qquad (5)$$

The vehicles moving with the same speed can be considered as moving in a platoon; therefore, they have high probability of staying connected for a considerable amount of time. On the other hand, vehicles moving with high relative speeds would endure rapid link disconnections. Hence, they would jeopardize our route's stability. Hence, we give priority to vehicles that have the same speed as that of the transmitter to receive and retransmit the route request message.

If several vehicles have the same the speed as that of the transmitting vehicle A, then in this case we penalize the neighboring vehicles that are located far from or near A. This is because the higher the distance between two vehicles, the lower is their link quality [23]. The distance between A and the very near neighbors will be considered negligible for receiving and relaying a route request message. This is why we give priority to vehicles that are neither far nor near the transmitting vehicle. Hence the vehicle which has the closest distance from the R/2 will receive and transmit the route request message.

For instance, there are three neighbors (I, J, K) which have the same speed as that of A. Their distances of A are d(A, I), d(A, J) and d(A, K) respectively. The vehicle A forwards the message to the vehicle that its distance is closest to R/2.

Sixth case: The forwarding vehicle does not have neighbors traveling in the same direction of source motion, and it has neighbors that travel in opposite direction of source motion at time t0. In this case, we give priority to the closest vehicle to the destination if the latter is located in the direction of the S movement. On the contrary, we give priority to the nearest vehicle to the forwarder if the destination is not located in the direction of S movement.

When the source wants to send a data packet to the destination, S checks its list of neighbors to the destination. If it is listed, then S sends the data. Otherwise, S executes the below algorithm if it has recent information about D. In this case, each vehicle (A) which receives a route request message verifies its list of neighbors to the destination. If it is listed, then the vehicle sends a route request message to D; otherwise, it executes the below algorithm.

Algorithm

```
S: Source vehicle
D: Destination vehicle
RZ: Request Zone
I: neighbor of A
t: time of I to stay in communication range of A
$T_m$: time of the vehicle that remains the longest time in the coverage area of A.
ID, IDD, IDO, IDDO: address of vehicle
d(A,I): Distance between I and A
t = 0
$T_m$ = 0
d = R
dop = 0
dops = R
ID, IDD = -1
IDO, IDDO = -1
While ( (I neighbor of A) and (I within RZ) ) then
  If (I travels towards the same direction of S movement) then
      If (D is located in the direction of S movement) then
          If $V_A > V_I$ at time t0 then
              $t = \frac{|X_I - X_A|}{V_A - V_I} + \frac{\sqrt{R^2 - (Y_I - Y_A)^2}}{V_A - V_I}$
          If Tm < t then
              Tm = t
              ID = ID(I)
          End if
          Else if $V_A < V_I$ at time t0 then
              $t = \frac{|X_I - X_A|}{V_A - V_I} - \frac{\sqrt{R^2 - (Y_I - Y_A)^2}}{V_A - V_I}$
          If $T_m$ < t then
              $T_m$ = t
              ID = ID(I)
          End if
          Else
          If |d(A, I)-R/2| < d then
              d = |d(A, I)-R/2|
              IDD = ID(I)
          End if
      Else
          If $V_A > V_I$ at time $t_0$ then
              $t = -\frac{|X_I - X_A|}{V_A - V_I} + \frac{\sqrt{R^2 - (Y_I - Y_A)^2}}{V_A - V_I}$
          If $T_m$ < t then
              $T_m$ = t
              ID = ID(I)
          End if
          Else if $V_A < V_I$ at time $t_0$ then
              $t = -\frac{|X_I - X_A|}{V_A - V_I} - \frac{\sqrt{R^2 - (Y_I - Y_A)^2}}{V_A - V_I}$
          If $T_m$ < t then
              $T_m$ = t
              ID = ID(I)
          End if
          Else
          If |d(A, I)-R/2| < d then
              d = |d(A, I)-R/2|
              IDD = ID(I)
          End if
  Else
      If (D is located in the direction of S movement) then
          If d(A, I) > dop then
              dop = d(A, I)
              IDO = ID(I)
          End if
      Else
          If d(A, I) < dops then
              dops = d(A, I)
              IDDO = ID(I)
          End if
End while
  If (d < R) then
    Send route request to IDD
  Else If ($T_m$ < > 0) then
    Send route request to ID
  Else if dop < > 0 then
    Send route request to IDO
  Else if dops < > R then
    Send route request to IDDO
  Else
    Write ("No route to destination at vehicle", ID(A))
```

This work is valid only in the case where the source is not in expected zone at time t1. Otherwise, it will be reduced to LAR scheme 1, because we do not know in this case where the destination is situated relative to the direction of source motion at time t1.

IV. Mobility Model

The results of performance studies strongly depend on the chosen mobility model. The literature shows that the results of most performance studies are based on mobility patterns where nodes change of speed and direction of a random way. These models cannot really describe the mobility of vehicles, because they ignore the specific aspects of the use of vehicles such as acceleration and deceleration in the presence of nearby vehicles, the queues at the intersection of routes and the impact of traffic lights. These models are generally inaccurate compared with VANETs and can lead to erroneous results [10].

The tool VanetMobiSim was used to have realistic mobility models of vehicles. It adds two microscopic mobility models to include the management of intersections controlled by signs or traffic lights and multi-lane roads [24], [25].

Intelligent Driver Model with Intersection Management (IDM-IM): adds intersection handling capabilities to the behavior of vehicles driven by the IDM. In particular, IDM-IM models two different intersection scenarios: a crossroad regulated by stop signs, or a road junction ruled by traffic lights. In both cases, IDM-IM only acts on the first vehicle on each road, as IDM automatically adapts the behavior of cars following the leading one.

Intelligent Driver Model with Lane Changes (IDM-LC): extends the IDM-IM model with the possibility for vehicles to change lane and overtake each others, taking advantage of the multi-lane capability of the macro-mobility. Two issues are raised by the introduction of multiple lanes: the first is the separation of traffic flows on different lanes of the same road, while the second is the overtaking model itself.

V. Experiments and Results

Performance studies of Vehicular Ad-hoc Network protocols depend mainly on the chosen mobility model to obtain accurate simulation results. In order to improve the performance of the protocol LAR, realistic vehicular mobility scenarios are necessary. A mobility model is the pattern that defines vehicles motions within the simulated area during a simulation time, which reflects, as close as possible, the real behavior of vehicular traffic. For this purpose, we have used the pattern IDM-LC generated per Vehicular Ad Hoc Networks Mobility Simulator (VanetMobiSim) [23] to create a movement pattern for a highway and we have used NS2 to perform simulation.

Vehicles are deployed in a 4000m x 80m area. This area is a highway with two lanes bidirectional. The vehicles move and accelerate to reach a desired velocity. When a vehicle moves near other vehicles, it tries to overtake them because the road is multi-lane. If it cannot overtake, it decelerates to avoid the shock. When a vehicle is approaching at end of road, it slightly reduces its speed and proceeds to the intersection.

Vehicles are able to communicate with each other using the IEEE 802.11 MAC layer. The number of vehicles is varied between 30 and 80 to portray the network state at different time periods. The vehicles’ speed fluctuates between between 22m/s and 27m/s, which is common for an ordinary hightway environment (see Figure. 3). We setup a quarter of the vehicles multihop CBR flows over the network that start at different time instances and continue throughout the remaining of the simulation time. The transmission range is kept at 250m. Simulation results are averaged over 32 simulation runs.

The original and improved protocols are evaluated for packet delivery ratio, throughput, normalized routing load, and the path lifetime at varying vehicles density (30 to 80 vehicles) in highway scenario using IDM-LC model.

Parameter	**Value**
Number of lanes in same direction	2
Number of lanes in opposite direction	2
Motion model	IDM_LC
Vehicle Length	5 m
The “comfortable” deceleration of movement	0.5 m/s2
The step for recalculating movement parameters	0.1 s

Table 1. Mobility model parameters.

Parameter	**Value**
Simulation Time	300 s
Simulation area	4000m x 80m
Beacon interval	1s
No. of Vehicles	30 - 80
Routing protocol	LAR scheme 1
Transmission range	250 m
Packet rate	4 packets/s
Packet Size	512 bytes
Traffic Type	CBR

Table 2. Simulation Parameters.

Route lifetime

Route lifetime (RLT) (time of a connection between the source and destination) is the difference between the time of arrival of the message RREQ to the destination and the breaking time of route created by the same message RREQ.

RLT = (breaking time of route - time to the arrival of RREQ to the destination).

Average route lifetime of connections between the source and the destination (ARLT) is the sum of the RLT of these connections divided by the number of times of breaking route (between the same source and the same destination) during the simulation.

ARLT = (sum of RLT / number of times of breaking route).

Average route lifetime of all connections between sources and destinations (ARLTs) is the sum of ARLT divided by the number of sources.

ARLTs = (sum of ARLT / number of sources).

Figure.9 shows that route lifetime of the modified protocol is better than that of the original in relation to the number of vehicles. Hence the route between the source and the destination becomes more stable.

Packet Delivery Ratio

The packet delivery ratio is the ratio of data packets received by the destinations to those generated by the sources.

The original and modified protocols show good packet delivery ratio for low-density vehicles as shown in Figure.10 and neither of them clearly outperforms the other. But with increasing density, the packet delivery ratio of modified version is slightly better than the original.

Average Throughput

It is the sum of data bits received successfully by all destinations. It is represented in kilo bits per second (kbps).

For low-density vehicles as shown in Figure.11 no protocol clearly outperforms the other. At higher densities, the throughput of modified protocol is improved.

Normalized Routing Load

It is the ratio of the number of control packets propagated by every node in the network and the number of data packets received by the destination nodes.

Figure.12 shows that Normalized Routing Load increases with increasing the number of nodes. Modified LAR1 has the lowest normalized routing load compared to LAR1. This may be explained by the fact that its route discovery process is decreased compared to the original.

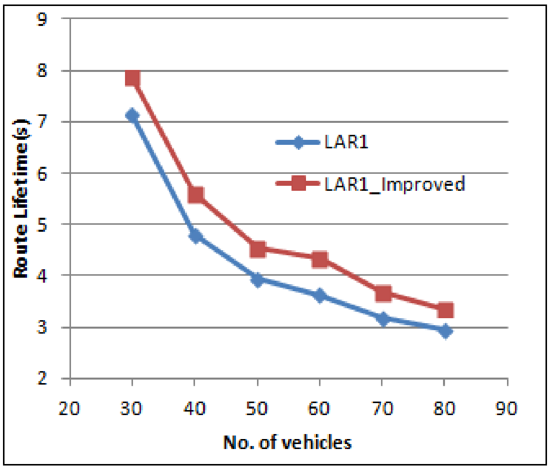

Figure 9. Average route lifetime vs vehicle density

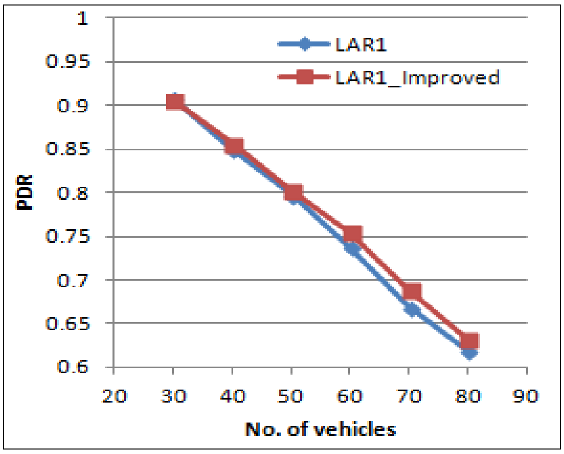

Figure 10. PDR as a function of vehicle density

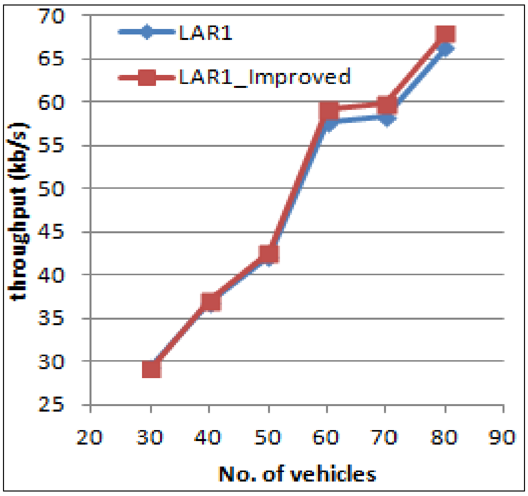

Figure 11. Average throughput vs vehicle density

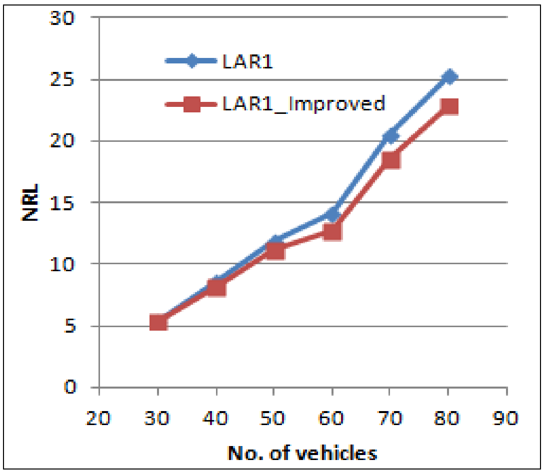

Figure 12. NRL vs vehicle density

VI. Conclusion and Future Works

In this paper, we increased the stability of route between sources and destinations by sending route request messages to both the vehicle remaining longest time in communication range of the transmitting vehicle and also travelling in the same direction of source movement or in opposite direction if there is no vehicle travelling in the same direction of source movement. Performance of LAR1 is improved for vehicular ad hoc networks in highway scenarios. We used the Intelligent Driver Model with Lane Changing (IDM_LC) to generate realistic mobility patterns. The original and modified protocols were tested against vehicle density for various metrics. It is found that modified LAR outperforms the original in highway environment. For most of the metrics the modified LAR has a better performance.

In this work, each vehicle which has a route request message will perform operations (algorithm above) to select the vehicle that will receive and retransmit the message. The accumulation time of these operations of all participating vehicles becomes significant. Therefore, they increase the route request period. That means, a new route request message can be triggered in entire network. Consequently, the protocol performance will be decreased. For future work, we shall deal with this problem and we will studied the case where the speed of each vehicle changes during the time t = t1-t0.

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