International Journal of Engineering & Technology, 7 (3.16) (2018) 52-56

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

A Combined Modified OpportunisticNeighbor Selection and Vehicle Localization Routing Approach for Improved Connectivity in Indian Road Scenario

Jothy.N[1]*, Jayanthi. K[2] and Gunasundari. R[3]

[1]*Research scholar, Department of ECE, Pondicherry Engineering College*
[2] *Faculty, Department of ECE, Pondicherry Engineering College*
[3] *Faculty, Department of ECE, Pondicherry Engineering College*
**Corresponding author E-mail: njothy2005@gmail.com*

Abstract

In the recent years, VANET is becoming a spectacular research area in wireless networks. The high mobility vehicular node in VANET dynamically changes the network topology resulting in highly unstable vehicle connectivity. This induces network partitioning and hence ensuring link availability remains to be a challenging task. To surpass these issues, design of efficient VANET routing algorithms is necessary. The routing design for VANET scenario is highly complex and challenging making the existing AODV, greedy, cluster based routing algorithms to suffer from degraded link quality resulting in high end-to-end delay and significant packet loss. Although Opportunistic Neighbor Selection (ONS) scheme proves to be a better routing logic, it does not seem to always ensure link availability at road intersections, particularly in Indian road scenario, where multi road lane discipline is very hard to implement. To overcome these limitations, a combination of Modified Opportunistic Neighbor Selection (MONS) and Vehicle Localization (VL) routing logic for adoption in Indian road sector has been proposed in this paper. This paper addresses the connectivity challenges and provides better solution to achieve improved performance. In this work, two specific scenarios namely: varied mobility/node density rates is considered by treating the other fixed inorder to evaluate the suitability of the proposed logic in terms of packet delivery ratio, end-to-end delay.

Keywords: *Modified Opportunistic Neighbor Selection (MONS); Vehicle Localization (VL); Routing in VANETs*

1. Introduction

In the present Indian roadway scenario, congestion is a major problem associated with vehicular traffic and VANET comes to the rescue in such scenarios. The key technical challenges faced by vehicular networks are connectivity issues, signal fading, routing protocol design, security and privacy [1]. The vehicular nodes in VANET change the velocity of vehicles very frequently and hence VANET changes its topology based on the density of the neighboring vehicles leading to unpredictable connectivity issues and performance metrics. Consequently, routing remains to be a prime challenge. To overcome these shortcomings, to establish routes in VANETs, Ad hoc On Demand Distance Vector routing protocol (AODV) [2] is introduced. It has the ability to perform both unicasting and multicasting routing options along with assignment of destination sequence number which makes it distinct from other on-demand routing protocols. However, more time is required to establish a route in this approach which is considered as the major drawback of this method. The old entries in the intermediate nodes can lead to inconsistency in the route resulting in the multiple route reply packets. Subsequently, Greedy based routing protocols are introduced to compete with existing routing protocols like AODV, OLSR and DSR. Traditional Greedy Routing protocols use beacon messages using which each vehicle announces its address and geographic position to all its neighbors via a radio broadcast. Whenever a vehicle receives such a beacon message from its neighbor, it updates the address and position of that vehicle in its neighbor's table. When a vehicle has to forward a packet, it uses the updated table to determine the neighbor from whom the packet should be forwarded in order to make progress towards the final destination. Routing algorithms based on Greedy forwarding have been used to resolve the characteristics of VANETs. When the nodes in the network moves, the established paths break, thus forcing the routing protocols to search for other feasible routes dynamically. Greedy forwarding algorithm provides the best routing in VANETs since it has the capability to maintain the local neighbor's information by acquiring the actual position of the participating nodes through periodic transmissions of the beacon messages. Unlike AODV, the routing decision at each node is based on the position of destination and the forwarding node's neighbors contained in the packet header and hence the trouble to establish or maintain the routes is not required in greedy logic. Greedy Routing protocols use the geographic position of vehicles to estimate the direction for forwarding a data packet. Maintaining link quality is difficult with a frequently changing topology and hence such networks require a routing algorithm that finds valid routes quickly.

Greedy Perimeter Stateless Routing (GPSR) is a typical Greedy-Forwarding protocol [3] of a VANET. It uses a greedy forwarding method to forward the packets to nodes that are always progressively closer to the destination. However, GPSR may increase the possibility of getting a local maximal problem and link discontinuities.

In all the greedy based existing routing protocols, the drawbacks are intersection routing and poor link quality. Although it is easier to deploy the greedy forwarding method, the link between two vehicles may become unstable at any point of time and the routing decision may fail. This scenario particularly arises at the intersection. To overcome these shortcomings, cluster based routing protocol CRP [4] is introduced. Before sending the data messages the distributed routing protocol computes the end-to-end delay, for the entire routing path. CRP considers backbone nodes for data transfer. These nodes assign weights to road segments based on the collected information of delay and connectivity. Routes with the lowest aggregated weights are selected to forward data packets. The drawback in CRP is poor efficiency and huge end-to-end delay. To overcome these drawbacks, opportunistic routing protocols [5-8] are introduced for obtaining a reliable communication link over the VANET at reduced end-to-end delay and increased packet delivery ratio. Although opportunistic routing protocols brings several rewards, it fails to provide connectivity at road intersections.

ANTSC [9] an Intelligent Naïve Bayesian Probabilistic Estimation Practice for Traffic flow to form Stable Clustering in VANET scheme aims to improve routing by employing awareness of the current traffic flow as well as considering the blend of several factors such as speed difference, direction, connectivity level, and node distance from its neighbors by using an intelligent technique. The proposed technique has proven to be more strong, stable, robust, and scalable than existing ones. The ANTSC also fails if the number of lanes is less and also cluster creation phase consists of number of steps like initialization, join, cluster head selection and leave procedure which pull up the end-to-end delay. Considering the above limitations, ANTSC is found unsuitable for Indian roads as there exist very few lanes in roadways. This necessitates an appropriate routing logic suitable for Indian roadways. The proposed scheme discussed in next section exploits information related to vehicle density, mobility, direction and lane information for selecting a neighboring vehicle with high connectivity measure and is found suitable for a minimum of two lanes, which exist in indian roadways.

The rest of this paper is organized as follows: section II describes the logical sequence of proposed routing algorithms. Section III shows the simulation environments along result analysis. Finally, section IV concludes this paper.

2. Proposed System

Opportunistic routing protocols require link state to select proper candidates while it is hard to collect such information for VANET because of rapid movement of the nodes. The working logic of ONS is detailed with algorithm support.
The source vehicle determines the vehicle density of in-range vehicles and computes the mobility and direction of the same. Source vehicle identifies its neighbor vehicle based on the speed and direction towards the destination vehicle and also consider the least distance between source and current vehicle by comparing it with the distance from current neighboring vehicle. This process end up with a link creation between the source and identified current vehicle. Once the link is established with the current vehicle, its link state is updated and acknowledgement is received. The ONS routing logic is described in algorithm 1.

Algorithm 1: Opportunistic Neighbor Selection (ONS)

Notations:
SV; Source Vehicle
(i); Current vehicle
(j); Current neighboring vehicle

1. For all vehicles compute set of edges and links
2. Compute number of in-range vehicles of the source vehicle
3. Compute the available vehicle of in-range >1
4. Compute change in mobility and direction of each vehicle towards destination
5. If mobility of (i)<mobility (j) & if distance(SV, i) < distance (SV, j), then
6. Slowest moving vehicle (i) is chosen and fixed as neighboring vehicle
7. If (i) moving towards the direction of destination vehicle then
8. Get link Id of (i)
9. Request for transmission from the source vehicle
10. Data transmitted to (i)
11. Acknowledgement received from (i)
12. Else
13. (j) is selected as the neighboring vehicle and follow steps 7 to 11 as carried out for (i)
14. End if

The suggested logic fails if the source vehicle does not have any neighbor vehicle in its range, link could not be established in Opportunistic Neighbor Selection method. To surmount the issue, three variants have been suggested to improvise the performance parameters.

2.1. Opportunistic Neighbour Selection with Vehicle Localization (ONS-VL)

In this method, RSU is used to update the position of multiple in-range vehicles to the source vehicle, if the immediate neighbor is not available in its range. The in-range vehicle distances are estimated and a vehicle with high link availability is selected .Then the current position of the neighbor vehicle is updated to the source vehicle. The stepwise working of the ONS-VL routing logic is briefed using algorithm 2.

Algorithm 2: Opportunistic Neighbor Selection with Vehicle Localization (ONS-VL)

Notations:
SV; Source Vehicle
(i); Current vehicle
(j); Current neighboring vehicle
d; distance
RSU; Road Side Unit

1. For all vehicles compute set of edges and links
2. Compute number of in-range vehicles with respect to the source vehicle
3. Check if the available vehicle of in-range >1
4. Compute change in mobility and direction of each vehicle towards destination
5. If mobility of (i)<mobility (j) & if distance(SV, i) < distance (SV, j), then
6. Slowest moving vehicle (i) selected as the neighboring vehicle
7. If (i) moving towards the direction of destination vehicle then
8. Get link Id of (i)
9. Request for transmission from the source vehicle
10. Data transmitted to (i)
11. Acknowledgement received from (i)
12. Else
13. (j) is selected as the neighboring vehicle and follow steps 7 to 11 as Carried out for (i)
14. End if
15. Available vehicle of in-range <1
16. Compute d(SV,RSU)
17. Check if the distance between SV and RSU is lesser, through RSU the neighboring vehicle is selected
18. Go to step 7 and the process continues

2.1. Modified Opportunistic Neighbour Selection (MONS)

In MONS method, source vehicle identifies its nearest neighbour based on the distance (i.e. in-range vehicle), mobility, direction and also considers the vehicle lane location additionally. If the neighbour is on the same lane of the source vehicle, preference is given to it , the link state is updated and acknowledgement is received by the source vehicle from the same lane vehicles. If the neighbour vehicle is not in the same lane, then check in-range neighbour vehicle. The MONS routing algorithm 3 is given below.

Algorithm 3: Modified Opportunistic Neighbor Selection (MONS)

Notations:
SV; Source Vehicle
(i); Current vehicle
(j); Current neighboring vehicle

1. For all vehicles compute set of edges and links
2. Compute number of in-range vehicles of source vehicle
3. Identify in-lane vehicles out of in-range vehicles based on their distance
4. Check if the available vehicle is the in-lane >1
5. Compute change in mobility and direction of each vehicle towards destination
6. If mobility of (i)<mobility (j) & if distance(SV, i) < distance (SV, j), then
7. Slowest moving vehicle (i) selected as the neighboring vehicle
8. If (i) moving towards the direction of destination vehicle then
9. Get link Id of (i)
10. Request for transmission from the source vehicle
11. Data transmitted to (i)
12. Acknowledgement received from (i)
13. Else (j) is selected as the neighboring vehicle and follow steps 8 to 12
14. End if
15. Available vehicle of in-lane <1, then identify the neighboring vehicle in the neighboring lane in-range of the source vehicle
16. Go to step 5

It is very obvious that MONS may fail if the immediate neighbour is not available in its lane of the source vehicle, then the connectivity loss may occur.

2.2. Modified Opportunistic Neighbour Selection with Vehicle Localization (MONS-VL)

In MONS-VL routing protocols compute the nearest neighbouring vehicle, both in-lane and in-range of the source vehicle. If the immediate neighbour is not available, RSU helps to identify the nearest neighbour and check whether the neighbour is in the same lane of the source vehicle. If the neighbour is on the same lane, then the link state is updated and acknowledgement is received by the source vehicle. The logical sequence of MONS-VL routing protocol can be expressed below.

Algorithm 4: Modified Opportunistic Neighbor Selection with Vehicle Localization (MONS-VL)

Notations:
SV; Source Vehicle
(i); Current vehicle
(j); Current neighboring vehicle
d; distance
RSU; Road Side Unit

1. For all vehicles compute set of edges and links
2. Compute number of in-range vehicles of source vehicle
3. Identify in-lane vehicles out of in-range vehicles based on their distance
4. Compute the available vehicle of in-lane >1
5. Compute change in mobility and direction of each vehicle towards destination
6. If mobility of (i)<mobility (j) & if distance(SV, i) < distance (SV, j), then
7. Slowest moving vehicle (i) selected as the neighboring vehicle
8. If (i) moving towards the direction of destination vehicle then
9. Get link Id of (i)
10. Request for transmission from the source vehicle
11. Data transmitted to (i)
12. Acknowledgement received from (i)
13. Else (j) is selected as the neighboring vehicle and repeat steps 8 to 12
14. End if
15. Available vehicle of in-lane <1, then identify the neighboring vehicle, in-range of the source vehicle and repeat steps from 5 to 12
16. Go to step 5
17. If the available vehicle is in-range <1
18. Compute d(SV,RSU)
19. Check if the distance between SV and RSU is lesser, through RSU the neighboring vehicle is selected
20. Go to step 7 and the process continues

3. Simulation Results and Discussion

The aim of the proposed work is to compare the existing cluster based backbone routing protocol (CBBRP) and opportunistic neighbour selection (ONS) with proposed ONS-VL, MONS and MONS-VL routing algorithms. The performance parameters such as Packet delivery ratio (PDR) and Average end-to-end delay (E2ED) have been analysed under varying network conditions that includes varying vehicle speed and vehicular density.

The performance is tested by considering a realistic intersection scenario with 4 road segments (having two lanes each) intersection. The scenario is depicted in the fig.1. The proposed variant of MONS has been tested for a junction/intersection scenario at Puducherry city of India, where vehicular traffic congestion is severe and as the authors reside there. Packet delivery ratio is defined as the ratio of the number of packets successfully delivered to the destination to the number of the total packets generated in the simulation. The simulation parameters considered for analysis is listed in the table 1

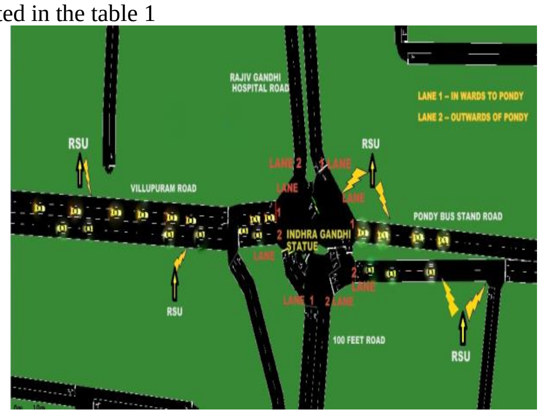

Fig.1: A Typical Road section at Puducherry UT, India

Table 1: Simulation Parameters

Simulation Parameters	Value
Simulator	NS 2.35
Number of nodes	100 Minimum :20 Maximum: 100
Transmission Range	250 m
MAC type	IEEE 802.11
Radio Propagation Model	Two Ray Ground propagation
No. of lanes on each road	2
No. of RSU's considered	4
Queue length	50 Packets
Packet Size	512 bytes
Traffic type	CBR
Beacon interval	1 s
Min. Speed	32 Km/h
Max. speed	86 Km/h

The performance is tested for two real scenarios of which in scenario 1, the vehicle node speed is fixed to 72Km/hr and the density of the vehicle is varied from 20 to 100. In scenario 2, vehicle density is fixed to be 100 and the speed of the vehicle is varied to 32Km/hr, 43Km/hr, 54 Km/hr, 64Km/hr, 75Km/hr and 86Km/hr. The number of lanes on each road segment is fixed as 2, which is a common practice followed in Indian roads near junction segments.

Fig.2 depicts that when the vehicle density is lower, the probability of network partition is high and thus PDR is minimum at the initial stage. But when the vehicle density increases, the network gets gradually better connectivity leading to improved PDR. At low node density, the deviation is clearly visible between the MONS-VL and MONS due to bare minmum in-range or immediate neighbor nodes. Under such circumstances, as MONS-VL is supported by RSU, it manages to offer high PDR unlike the MONS.

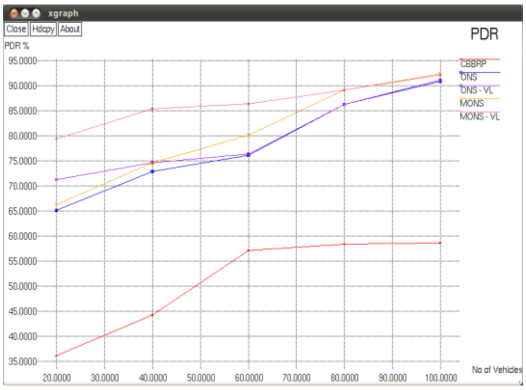

Fig.2: Impact of vehicle density on packet delivery ratio (Scenario 1)

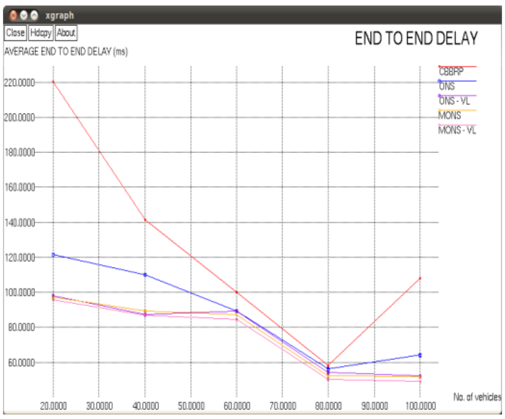

Fig.3 End –to-End delay Evaluation for varying node density (Scenario 1)

Fig. 3 illustrates the variation of the average end-to-end delay with the variation in number of vehicles. When the number of vehicle in the network increases, more transmission links are available offering more flexibility in choosing a link immediately. Therefore, with the increased node density, the end-to-end delay reduces. However, when the node density in the network of the proposed routing algorithm MONS-VL reaches 80, the average end-to-end delay attains 50ms and remains almost constant and less insensitive to further increase in node density. This is mainly because the proposed routing algorithm minimizes the number of options in selecting the neighboring vehicle by considering in-lane vehicles. This feature is responsible for ensuring stability in MONS and MONS-VL against CBBRP and ONS.

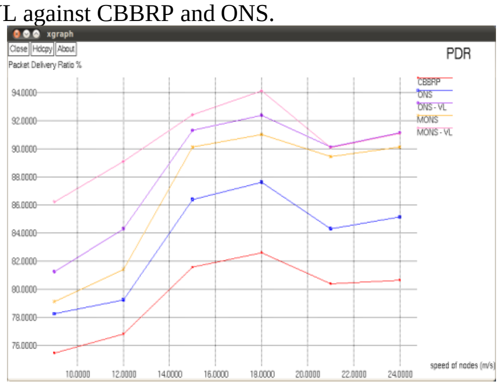

Fig.4: Packet Delivery Ratio analysis for varying mobility rates (Scenario 2)

Fig. 4 illustrates the variation of the packet delivery ratio with the variation in node speed/ mobility rates. Average Packet delivery ratio of MONS-VL is about 90.1%, whereas ONS and CBBRP is about 83.38% and 79.53% respectively. It is observed that PDR shoots upward at first and then drops when the speed of the vehicle increases. If the speed of the vehicle further increases, the connectivity between the vehicles deteriorates and hence the bad link quality results in a reduced delivery ratio.

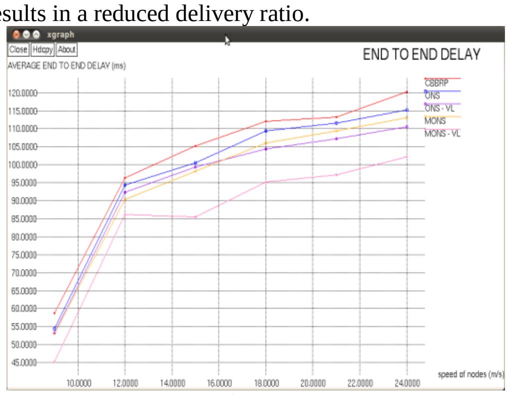

Fig.5: End–to-End delay Evaluation for varying mobility rates (Scenario 2)

Fig.5 shows the performance of the speed of the nodes vs. end-to-end delay. When the speed of the node increases end-to-end delay also increases since the network partition is more, due to pronounced Doppler effects at higher velociites. It is observed that the average end-to-end delay decreases around 15ms in MONS-VL against ONS and CBBRP. Since MONS-VL checks for in-lane vehicles and also if the immediate neighbor is not available within its range directly it will communicate to RSU unit, an improvement in link connectivity is achieved. Thus MONS-VL gives reduced end-to-end delay compared to existing routing protocols.

4. Conclusion

This paper addresses the issue of ensuring link availability particularly targeting Indian road scenario with limited lanes. The classical VANET routing algorithms were designed for a perfect multi-lane road discipline and so cannot be adopted for Indian roads as multilane road segments are rarely seen. In addition to this, the popular Opportunistic routing logic needs to check the link availability of the vehicles while it is hard to collect such information for a VANET scenario because of rapid and random movement of the nodes. This serves as a motivation for this work. An attempt is made to combine Modified Opportunistic Neighbor Selection and Vehicle Localization (MONS-VL) logic to make it suitable for Indian roads. In order to select the most stable paths between source and destination, it makes use of multiple criteria like vehicle speed, direction of the vehicle, position of the vehicle, lane information and expected transmission range information. The improvement of average packet delivery ratio in MONS-VL is 6.72% compared with ONS, and 10.57% compared with CBBRP and the improvement of average end-to-end delay, in MONS-VL is 10ms compared with ONS, and 15.8 ms compared with CBBRP. Simulation results have demonstrated that MONS-VL outperforms existing opportunistic routing and cluster based backbone routing logic.

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