



Opportunistic Directional Location Aided Routing Protocol for Vehicular Ad-Hoc Network

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Abstract

The Vehicular ad-hoc network (*VANET*) is an autonomous system mobile vehicle connected over a wireless link to transmit data packets in the network. It is noteworthy that vehicles are highly mobile with a limited communication range so that they change their network topology frequently. Therefore, efficient and robust data delivery in *VANET* is a challenging task due to dynamic network topology, unstable links, and high mobility. In this paper, an opportunistic routing protocol named Opportunistic Directional-Location Added Routing (*OD-LAR*) protocol proposed that uses full broadcast characteristics. The proposed protocol *OD-LAR* is a combination of geographical location, link quality, and angular deviation. Using all of these three metrics proposed protocol prioritizes the candidate next-hop forwarder (*CNHF*) nodes at the border area (*BA*) of the forward area (*FA*) towards destination node *D*. The proposed protocol *OD-LAR* assign the highest priority to *CNHF* node has the minimum distance from destination, good link quality, and minimum angular deviation and selects it as an optimal next hop forwarder (*ONHF*) node. The basic aim of the proposed *OD-LAR* protocol is to improve packet overhead, packet drop rates, delay, and throughput. To evaluate the performance of *OD-LAR*, it has simulated through network simulator-2 (*NS-2*) and compared with the directional-location aided routing (*D-LAR*) and location aided routing (*LAR*) protocols. Through simulated results, it has shown packet drop rate and delay is minimum in *OD-LAR* as compared to the *D-LAR* and *LAR* protocols.

Keywords *VANET* · *OD-LAR* · *D-LAR* · *LAR* · *ONHF* · *CNHF* · *BA* · *FA*

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1 Introduction

VANET is a self-configuring decentralized wireless network created by using mobile vehicles, where mobile vehicles communicate with each other based on mutual trust and work as nodes in the network. Vehicular Ad hoc Networks are widely applicable in so many fields such as emergency deployments and community networking. In *VANET*, power and adequate storage are not an issue because *VANET* use vehicles as a node instead of other devices and they have sufficient energy and power for data processing and storage. One of the most important characteristics of *VANET* is dynamic topology [1].

As shown in Fig. 1, vehicles *V2*, *V3*, and *V4* are within the communication of the vehicle *V1* and they can transmit data packets with each other. The vehicle *V5*, *V6*, and *V7* are within communication range of the vehicle *V4* they can communicate with each other. The vehicles in the vehicular ad-hoc network move at very high speed on the road, therefore, they change their network topology frequently. Due to the highly dynamic nature of the vehicles, both mobility model and location prediction of the vehicles play a very important role in designing of data dissemination in *VANET*. In *VANET*, all nodes are highly mobile so that efficient routing is a fundamental and challenging task to deliver data packets at the intended destination node [2]. The usage of physical location information of the nodes improves the efficiency of routing techniques of *VANET*. Location information of the nodes in *VANET* mainly leads to reduce routing overhead and increases packet delivery rate. In *VANET*, routing protocols are required to transmit the data packet from a source node to the destination node via the number of intermediate nodes. The main purpose of the routing protocol is to search a better route for packet delivery to the correct destination in the network. Mainly two type routing protocols; topology and position based are used in *VANET* [3].

Routing overhead is a measure shortcoming of topology-based routing protocols, the Greedy Perimeter Stateless Routing (*GPSR*) protocol is one of the best examples of the position-based routing protocol. *GPSR* protocol uses location information of the nodes and eliminates drawbacks of the topology-based routing protocol and increases packet delivery rate in the network [4]. Location information of node helps to find out better route in the network during route discovery time and gives some knowledge related to the destination node [5]. Other than this, in *GPSR* protocol-neighboring nodes appropriately help in forwarding decisions without any interfering with the information related to topology-based. The main advantage of greedy forwarding is that it keeps the current position of the forwarding node. This helps in decreasing the distance between the source and destination node and data packets can be delivered within a short time. There are some disadvantages

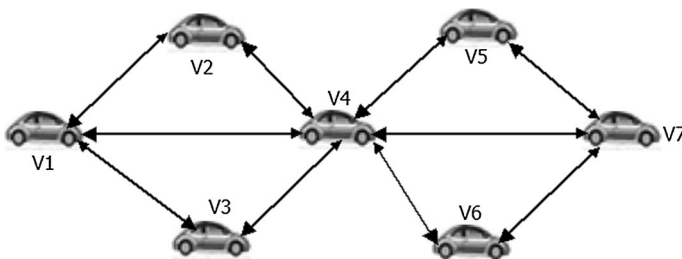


Fig. 1 V2V communication

of GPSR protocol it limits the movement of the data packet within a particular range. This method also does not work if there is no closer neighbor node present to destination [6, 7]. The GPSR is more suitable for high dynamic networks and does not require any routing table.

The major studies and research work being done on *VANET* mainly focused on traditional ad-hoc topology-based routing and position based ad hoc routing. Selection of routing protocol depends upon kind of network topology. Therefore, we need to study various routing protocols to select a suitable routing protocol for different kinds of the network in *VANET* [8]. There are some challenges and problems for the researcher in *VANET* routing as follows:

1. How reliability of a routing protocol can be improved and simultaneously delay of data packet delivery and retransmission of data packet can be reduced.
2. Scalability is another important issue because networks may grow or shrink for example in metropolitan cities it may be large and in an urban area may be small. Therefore, there may be a possibility of more than one routing request simultaneously. The conflicts in different routing requests between the vehicles should be considered.
3. The behavior of the driver should also be considered to design the delay-bounded routing protocols since the carry-and-forward method is the main approach used for delivering the packets.
4. While designing the routing protocol for a big city, the interference caused due to the tall buildings present on the roads should also be considered.
5. Security is also one of the major issues in *VANET*, we need to further investigate and analyze the cooperation between inter-vehicular networks. With the increasing number of vehicles on the road, the trust between these vehicles should also be sustained to have smooth communication.

In *VANET*, the recent improvements day by day in consumers interest are ever increasing and it is an important research topic [9]. Vehicle-to-vehicle (V2V) and vehicle-to-road-side (V2R) communications have become an important vehicle infrastructure of *VANET*. Most of the *VANET* research focused on urban and suburban roadways for dense network due to small inter-vehicle distance and terrain is not an important factor the fixed communication infrastructure is available [10].

Conditions and constraints are radically different for both rural and sparse areas. The inter-vehicle distance may be large in the sparse network due to low node density terrain may affect. In urban areas along major highways, wireless carriers provide coverage area, not in the rural area and minor highway [11]. Global positioning system (GPS) and other techniques have become more popular for current location awareness in vehicular ad-hoc networks. Public safety and other benefits make location awareness as a requirement for routing in the vehicular ad-hoc network. In wireless network due to lacks of infrastructures and terrain effects, there may be certain problems to locate nodes in rural areas [12]. Due to the lack of fixed communication infrastructure, *VANET* has important applications in sparse networks and rural areas. *VANET* in the sparse areas may be characterized as partially connected with low node density and high node mobility. Routing algorithms for these circumstances have less explored and the design of such a routing protocol is challenging [13].

To find the best next-hop towards the destination node both *D-LAR* and *LAR* protocols use current location information of the nodes obtained through *GPS*. The proposed model

OD-LAR has used the concept of the baseline drawn from the source to the destination node. This baseline is useful to decide the minimum angular deviation of the nodes moving towards the destination node. *OD-LAR* assigns priority to the *CNHF* node based on their link quality, movement direction and distance towards the destination node. The *CNHF* has the highest priority selects as an *ONHF* node to forward data packets towards the destination node. To evaluate the performance of the proposed protocol *OD-LAR*, the mathematical analysis has been done and simulation work is done through *NS2*. In the simulation section, it has been shown the proposed model *OD-LAR* performs better as compared to the *D-LAR* and *LAR* protocol.

Remaining parts of this paper structured as follows: Related research works are discussed in Sect. 2. Section 3 presented an overview of the proposed model *OD-LAR*. Mathematical analysis has been discussed in Sect. 4. In Sect. 5, the simulation work of proposed model *OD-LAR* and results have been discussed. Finally, the conclusion is given in Sect. 6.

2 Related Work

In *VANET*, the nodes are vehicles and they move with varying speed on the road. At first in 2007 Menouar et al. proposed a routing protocol named movement prediction based routing concept (*MOPRC*) based on a prediction of the movement of vehicles for position-based routing protocols. In this mobility model of nodes, depend upon nodes lifetime in a particular place determined for routing. This mobility model used current position, lifetime, direction and speed of the nodes for routing [14].

In *VANET*, all nodes are highly movable so that *VANET* requires efficient routing protocols to find out the best path from the source to the destination node for better performance of the network. Due to the dynamic nature of nodes, it is very difficult to deliver data items from the source to the destination so that an efficient routing protocol can perform well in all scenarios. For routing in *VANET* vehicle speed, position, and network density are challenging issues. On the highway, *VANET* depends upon speed and direction of the vehicles thus *VANET* requires customized routing protocols for better performance. Kaleem et al. [15] presented direction and relative speed based routing protocol for highways using a single hop packet forwarding approach. It selects the next-hop using *DARS* of the vehicle.

In location-based routing protocols, as the size of the request zone increases the route discovery overhead increases as well. Therefore, partitioning of the large size requested zone limits search process of the neighbor nodes in the request zone that results in reduced routing control overhead. Rana et al. [16] proposed a location-based improved directional *LAR* (*ID-LAR*) to minimize the average number of next hops and end to end delay. In this, the request zone is divided into several subrequest zones to reduce control flooding in the network.

Position based routing protocols are more suitable in *VANET* as compared to the topology-based routing protocols due to advancement and usability of GPS device. Due to the limitations of *GPS*, the system to collect the current position of the nodes depends upon the beacon interval [8]. Therefore, there a delay occurs during collecting the current position of nodes that forces routing protocol to use inaccurate position information of nodes that lead to low throughput and high overhead. Shelly and Babu [17] proposed a Link Reliability-Based Greedy Perimeter Stateless Routing for vehicular ad-hoc networks that predict the location of neighbor nodes of the sending node using speed and direction information provided in beacon packets during the beacon interval.

In *VANET*, nodes are highly mobile on the road that causes network topology frequently changes and it decreases throughput and efficiency of the routing protocol. To improve the throughput and efficiency of routing protocol position based next-hop forwarding method has recommended for the linear and nonlinear network [18]. The position-based routing protocol is useful in multi-hop vehicular ad-hoc networks, due to the high mobility of nodes. Selection of the next-hop node is an important factor to improve routing performance in the networks [19].

Raw and Lobiyal [20] have proposed a protocol that selects the next-hop forwarding node based on the distance and link quality between the source and next-hop node. The expected delay and throughput also estimated for the proposed method. To guarantee reliable data transmission and route calculation in the context of the proactive routing protocol in [21] proposed a link-state aware geographic opportunistic routing protocol for *VANET* for multipoint relays selection. They considerably optimized end-to-end delay from sender to receiver nodes based on an updated estimation model of link lifetime correlated with a connectivity ratio by this proposal. Indeed this new approach could be the subject of many applications, where the delay of packets delivery is critical, namely, in the aerospace domain.

In sparse *VANET*, the number of vehicles is to less so that route maintenance is still more complex. Sivakumar [22] proposed an efficient hybrid routing protocol for sparse *VANET*. This is an on-demand routing protocol with proactive route maintenance (*OPRM*) using roadside units (*RSUs*) repairs route using *RSUs* in place of the vehicles.

Takagi and Kleinrock [23] have designed a reliable routing protocol for *VANET* using GPSR protocol, exploiting information about link reliability during the selection of one-hop forwarding vehicles. In this routing scheme node closer to the destination node and satisfies link reliability criterion will be chosen as the next forwarder node. Also, they have given an idea for probabilistic analysis of communication link reliability for one-dimensional *VANET* and this model used for the evaluation of the modified routing scheme. The routing method discussed in this ensures that most reliable nodes chosen for forwarding data packets and building a route from source to destination.

VANETs are highly mobile wireless ad-hoc networks and play a decisive role in public safety communications and commercial applications. Position based routing protocols are becoming popular due to the advancement and availability of *GPS* devices. One of the critical issues of *VANET* is frequent path disruptions caused by the high-speed mobility of vehicle that leads to broken links, which result in low throughput and high overhead. Kumar and Kumar [24] presented the use of current location information of vehicles movements such as location, direction, and speed of vehicles to predict a possible link-breakage event before its occurrence.

3 Proposed Work

Here we have proposed an opportunistic routing protocol named Opportunistic Directional Location Added Routing (*OD-LAR*) benefits over *D-LAR* and *LAR* protocols using link quality, angular deviation and distance of border node from the destination node. The proposed protocol uses link quality, angular deviation and distance of the node from the destination node to assign priority to *CNHF* nodes. The *CNHF* node has higher link quality, minimum angular deviation and minimum distance from the destination node assigns the highest priority. The proposed *OD-LAR* protocol selects an *ONHF* node among the *CNHF*

nodes has the highest priority. The main objective of the proposed *OD-LAR* protocol is to provide high throughput with increased routing overhead, decreased the packet drop rate and delay in the network.

3.1 Motivation

D-LAR routing protocol has the property of both *LAR* and *DIR*, *LAR* reduces the route discovery overhead and *DIR* complements it with the directional concept. Therefore, *D-LAR* routing protocol performs efficiently in the city traffic environment. In partial flooding, *D-LAR* reduces bandwidth without taking care of the required optimal path for transmission thereby delay increases and throughput reduces. For better performance of the network, it becomes necessary data must reach at the destination within the time interval with a reduced average number of hop counts. *OD-LAR* aims to reduce the average number of hop count by selecting optimal forwarding node based on link quality, minimum angular deviation and maximum possible distance in the direction of the destination node. This helps to route data over the shortest path over the network with a reduced average number of hops thereby network performance increases. In the proposed model, city traffic scenario considered where the source node selects the node having maximum distance from the source and minimum angular deviation from baseline *SD*, line from source to destination.

3.2 Link Quality

Link quality is an important parameter to select an optimal next-hop forwarder node at the border area of the forward area. Link quality between source and neighbor nodes is the ability of the link to be stable as long as possible, have fewer bit errors and reach at destination with high signal strength with maximum transmissions. In the proposed protocol *OD-LAR*, we considered nodes at the border area of the forward area. To measure link quality of the *CNHF* nodes at the border area of the forward area, *OD-LAR* obtains expected number of the transmissions (*ETX*). The *ETX* is the expected number of successful transmission of data packets to a receiver over the given link. During successful data transmission, the receiving node sends an acknowledgment (*ACK*) to the sending node, therefore, the link between both sending and receiving nodes is considered as a bidirectional link. The proposed model *OD-LAR* evaluates link quality of *CNHF* nodes according to the number of transmissions with the sender node.

3.3 Angular Deviation

The angular deviation is an angle formed between baseline *SD* and another line from the sender and candidate next-hop at the border area of the forward area. Let, θ_{si} is a random variable represents the angular deviation formed between *i*th candidate next-hop and sender node. If there are *n* candidate next-hop nodes then the node has minimum angular deviation can be obtained as:

$$\min(\theta_{Si}) = \text{Min}(\theta_{Si1}, \theta_{Si2}, \theta_{Si3}, \dots, \theta_{Sin}) \quad (1)$$

3.4 Data Transmission Approach in *OD-LAR*

Data transmission approach in proposed model *OD-LAR* depends upon three parameters:

1. Link quality of the *CNHF* nodes at the border area of the forward area.
2. An angular deviation of node's movement.
3. The distance of *ONHF* node from the destination node

In proposed protocol *OD-LAR*, the sender node knows position information of the neighbors at the border area of the forward area. As shown in Fig. 2, the sender node *S* selects an *ONHF* among the *CNHF* nodes that has the best link quality, minimum angular deviation (θ), and nearest to the destination node for further transmission of data packets towards the destination node. The proposed protocol *OD-LAR* always forces the sender node to select *ONHF* at the border area of the forward area has minimum angular deviation. Therefore, the average number of hops between the source to the destination node in the data transmission reduces that causes the performance of the network increased. Analysis of the proposed routing protocol *OD-LAR* has given in the next section.

4 Analysis of proposed Model

Since in *VANET* each node has direct connection with all its neighbour nodes within its communication range R . Therefore, the nodes can receive or transmit data packets at any instant of the time with their neighbour nodes. In *VANET*, the nodes has limited communication range, therefore, if the node *D* is out of the communication range R of the node *S* then next hops are needs to deliver data packet at intended destination node. To analyse the performance of the proposed model *OD-LAR*, the routing metrics i.e. link quality, expected angular deviation, expected maximum progress distance, and prioritization of *CNHF* nodes have analysed.

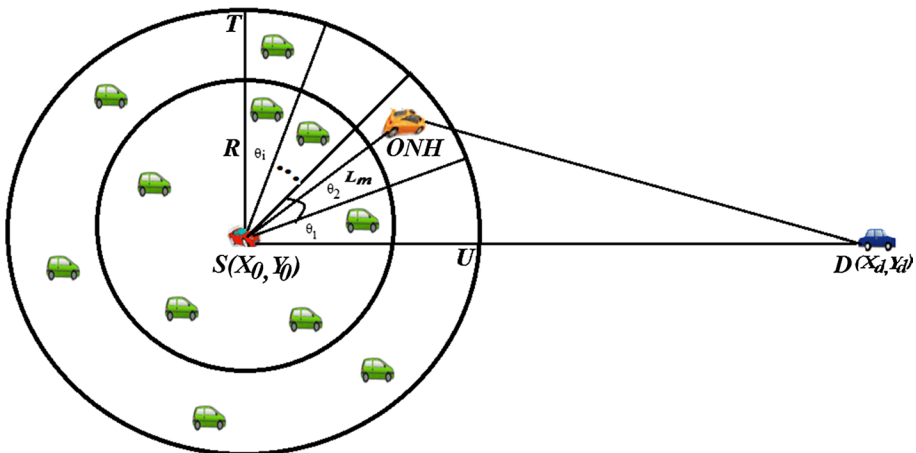


Fig. 2 Selection of *ONH* node

4.1 Link Quality

To measure link quality of the *CNHF* nodes at the border area of the forward area in proposed work obtains the expected number of transmissions *ETX* [22]. The *ETX* is the expected number of successful transmission of data packets to a receiver on the given link. During successful data transmission, receiving node sends an acknowledgment (*ACK*) to the sending node so the link between sending and receiving nodes needs to consider as the bidirectional link. Suppose *ETX* (*S*, *CNHF*) denote the *ETX* of a link between sending node *S* and candidate next-hop forwarding (*CNHF*) node. Then, *ETX*(*S*, *CNHF*) can be given as follows:

$$ETX(S, CNHF) = \sum_{i=1}^n i \cdot P_f(S, CNHF)^{i-1} P_r(S, CNHF) \tag{2}$$

$$ETX(S, CNHF) = \frac{1}{P_r(S, CNHF)} \tag{3}$$

$$ETX(S, CNHF) = \frac{1}{D_f(S, CNHF) \cdot D_r(S, CNHF)} \tag{4}$$

where $D_f(S, CNHF)$ is the probability of successful forward data transmission and $D_r(S, CNHF)$ is the probability of the reverse data delivery on the same link. In the proposed work, $D_f(S, CNHF)$ and $D_r(S, CNHF)$ are measured using the Hello message broadcasts at regular intervals by each node. The structure of the Hello message is as follows:

$$Hello = (NodeId, NodePos, NodeSpeed, NodeDir, HHT(k))$$

where *HHT*(*k*) is hello history table of the node *k* that indicates the number of Hello messages that node *k* has received from each of its neighbors within the specified time window. Here *NodePos*, *NodeSpeed*, and *NodeDir* represent the node’s position, speed, and the moving direction respectively.

4.2 Expected Angular Deviation

To find out the best *ONHF* at border area of the communication range, the sender node checks angular deviation of every *CNHF* node. The *CNHF* node having minimum angular deviation selects as the *ONHF* node among *CNHF* nodes. Let θ_{Si} is a random variable represents the angular deviation between *i*th *CNHF* node and source node. If there are *n* *CNHF* nodes, the minimum angular deviation can be obtained through $\min(\theta_{Si}) = \text{Min}(\theta_{Si1}, \theta_{Si2}, \theta_{Si3}, \dots, \theta_{Sin})$, where *i*th node is selected as an *ONHF* node.

Suppose, $F_{\theta_{min}(\theta)}$ and $f_{\theta_{min}(\theta)}$ are CDF and PDF of θ_{min} respectively.

$$F_{\theta_{min}(\theta)} = P(\theta_{min} < \theta) \tag{5}$$

$$F_{\theta_{min}(\theta)} = 1 - P(\theta_1 \geq \theta, \theta_2 \geq \theta, \theta_3 \geq \theta, \theta_4 \geq \theta, \dots, \theta_n \geq \theta) \tag{6}$$

$$F_{\theta_{min}(\theta)} = 1 - \left(1 - \frac{\theta}{\frac{\pi}{2}}\right)^n \tag{7}$$

$$F_{\theta_{min}(\theta)} = 1 - \left(1 - \frac{2\theta}{\pi}\right)^n \tag{8}$$

PDF of θ_{min} can be given as:

$$f_{\theta_{min}(\theta)} = \frac{d}{d\theta} (F_{\theta_{min}(\theta)}) \tag{9}$$

$$f_{\theta_{min}(\theta)} = \frac{d}{d\theta} \left[1 - \left(1 - \frac{2\theta}{\pi}\right)^n \right] \tag{10}$$

$$f_{\theta_{min}(\theta)} = \frac{2n}{\pi} \cdot \left(1 - \frac{2\theta}{\pi}\right)^{n-1} \tag{11}$$

The expected angular deviation can be given as:

$$E(\theta_{Min}) = \int_0^{\frac{\pi}{2}} \theta \cdot f_{\theta_{min}(\theta)} d\theta \tag{12}$$

$$E(\theta_{Min}) = \int_0^{\frac{\pi}{2}} \theta \cdot \frac{2n}{\pi} \cdot \left(1 - \frac{2\theta}{\pi}\right)^{n-1} d\theta \tag{13}$$

$$E(\theta_{Min}) = \frac{n\pi}{2(n+1)}. \tag{14}$$

4.3 Expected Maximum Progress Distance (EMPD)

During data transmission, the destination node D may be either within the communication range or outside of the communication range of the sending node S . If destination node D is out of the reach of the sending node thenulti hops are required to transmit data at the destination node. In this case, for better performance of the network intermediate nodes between the source to the destination node should be minimum. To minimize multi hops in the network we have considered expected maximum forwarding progress distance of a node during selection of ON_{HF} node. The predicted expected maximum progress distance can obtain as follows:

$$EMPD_{(S,CNHF)} = \left(\frac{d_{(s,D)} - d_{(ONHF,D)}}{R} \right) \tag{15}$$

where $d_{(s,D)}$ is distance between the sending and the destination node and $d_{(ONHF,D)}$ is distance between the optimal next hop forwarder and destination node.

4.4 Prioritization of CNHF Nodes

In sparse network availability of nodes be low and when a node wants to communicate on the network has to search throughout the forward area so network performance decreases. To increase the network performance we can assign priority to each CNHF node at the border area of the forward area. Prioritization of CNHF node is useful in selection of ONHF node at the border area of the forward area. The CNHF node has highest priority will be chosen as ONHF node for the further data transmission. To assign priority to each CNHF node at the border area of the forward area we can use following relation:

$$P_i = TXN \cdot \left(1 - \frac{EMPD_{(S,CNHF)}}{R} \right) \cdot \left(1 - \frac{90^\circ}{\theta_i} \right) \quad (16)$$

where θ_i is an angle between i^{th} CNHF node and baseline SD drawn from the source to the destination node that can vary from 0 to 90° . The TXN , $EMPD_{(S,CNHF)}$, α_i , and R represent total number of transmissions, expected maximum progress distance, angular deviation and communication range respectively. We can see in the above relation that priority of the nodes depends upon two parameters as $EMPD_{(S,CNHF)}$ and α_i between i^{th} CNHF node and SD .

4.5 Selection of ONH Node

Nodes are distributed randomly in the network within transmission range R and follows Poisson distribution rule, where N is a random variable represents number of nodes at the border area of the forward area of request zone and ω is node density per square meter. Suppose, source node S wants to send a message to a node in the network. If destination node is within communication range of the sending node, the sending node can directly send message to the destination node. As shown in Fig. 2, the destination node is out of the communication range of the sending node so that intermediate nodes are required to send message to the destination node. If sending node does not find CNHF nodes at the border area of the first sector of the forward area, then it will increase the angular forward area by a specific range (15°) up to 90° . The sending node will select an ONHF node among the CNHF node having highest priority and near to the destination node.

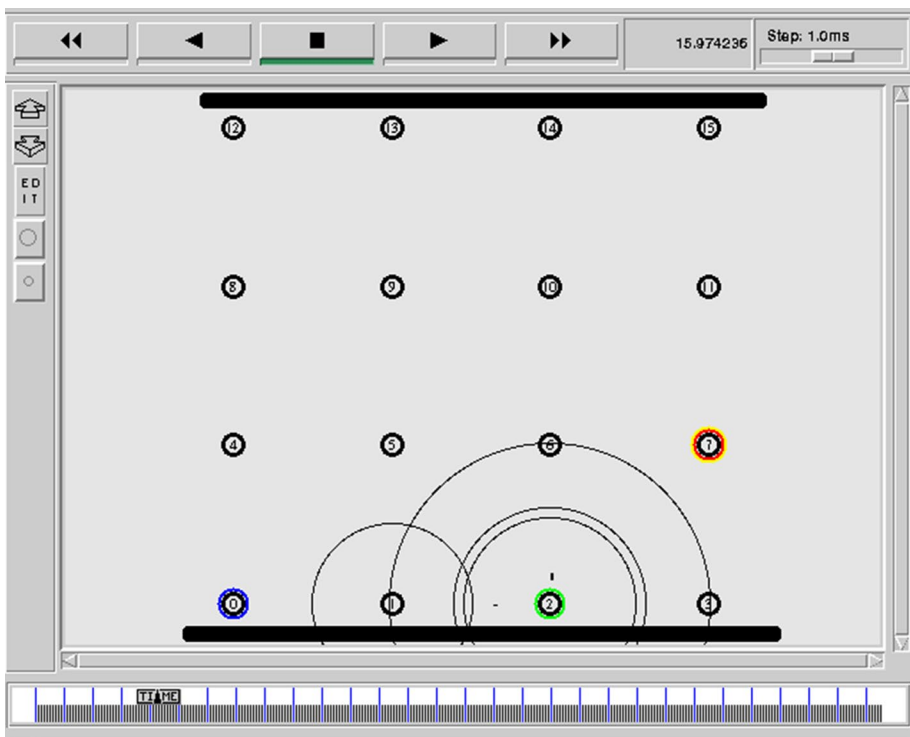
The node at the border area of the forward area has maximum expected progress distance not equal to communication range of node and minimum angular deviation will have highest priority and chosen as ONH node. The node at the end of the border area of the forward area will have minimum priority cannot be chosen as ONH node.

5 Simulation and Result Analysis

The proposed protocol *OD-LAR* has used the free space propagation model represents the communication range as a circle round the nodes in the simulations. *OD-LAR* uses mobile vehicle as nodes and they can move on the road with varying speed. Simulation model of the network with variable mobile nodes 100-300 placed randomly within a $1000 \times 1000 \text{ m}^2$ area. In the simulation section, we have discussed the performance of *OD-LAR* protocol in the term of packet overhead, packet drop rate, delay and throughput with the help of network simulator *NS2* compared with *D-LAR* and *LAR* protocol. Parameters that are used in

Table 1 Used simulation parameters

Parameters	Default values
Simulation area	1000 m × 1000 m
Communication range	250 m
Number of nodes	100–300
Node speed	10–26 m/s
Packet size	1000 bytes
Traffic type	CBR
CBR interval	0.5 s
Hello interval	1 s
Window size	15 s
Simulation time	180 s

**Fig. 3** Sample network topology using 16 nodes in grid form

simulation work summarized in Table 1. Sample of network topology of NS2 has shown in Fig. 3.

In this simulation, any four nodes are act as sender nodes with traffic rate of 0.5 s. As shown in the Fig. 3, node-0, node-1, node-2, and node-3 are sender nodes. The receiving nodes are node-12 and node-13. As shown in figure, color circled nodes indicate the transmission of packets with large circle in animation topology. The red-circled node-7 indicates congestion of traffic at a time of simulation.

5.1 Routing Overhead

Routing overhead is the number of routing packets required for communication between nodes in the network. To measure network performance the routing overhead is an important parameter. For better performance of the network, routing overhead should be low that causes node will consume less time to find out the route in the network.

Figure 4 shows routing overhead of the routing protocols *LAR*, *D-LAR*, and *OD-LAR* respectively with the varying number of the nodes in the network. We can see in Fig. 4, the routing overhead in each routing protocols increases as the number of the nodes in the network increases. The reason behind this is that as the number of the nodes increases the number of connections between sender and *CNHF* node increases as well. Therefore, transmission routing data packets between the sender and *CNHF* node increases. Packet overhead of routing protocol *OD-LAR* is about 36.395% while routing overhead of *D-LAR* and *LAR* is about 52.0137% and 69.395% that are high as compared to proposed model *OD-LAR*.

Figure 5 depicts the routing overheads of the *OD-LAR*, *D-LAR* and *LAR* protocols respectively with varying node speed from 10 to 26 m per second. It can be observed in Fig. 5, as the node speed increases the routing overhead of protocols increases as well. When nodes speed increase, the time requires carrying and forward data packets from the source to the destination take fewer time. Therefore, the transmission of data packets between sender and receiver nodes increases. Routing overhead of the proposed protocol *OD-LAR* is about 55.88% while in *D-LAR* and *LAR* it is about 66.885% and 73.219% that are higher as compared to proposed model *OD-LAR*.

5.2 Routing Protocol Packet Drop Rate

Packet drop occurs when data packets travel across the network fail to reach their destination. Usually, a packet drop occurs due to poor connectivity between nodes and network congestion. Packet drop rate is an important parameter to measure network quality for better network performance packet drop rate in the network should be lowed. The packet drop is measured as a percentage of packets lost with respect to packets sent across the network.

Fig. 4 Routing overhead versus number of nodes

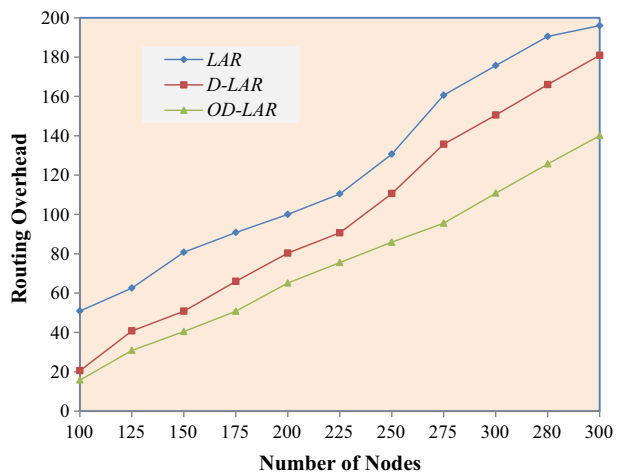


Fig. 5 Routing overhead versus node speed (m/s)

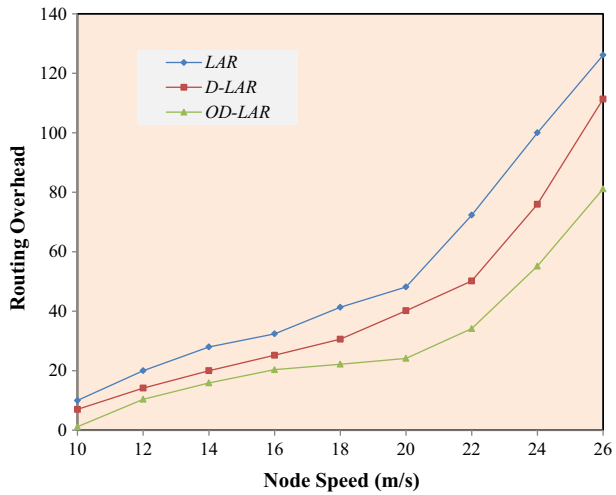


Figure 6 shows packet drop of the routing protocols *OD-LAR*, *D-LAR* and *LAR* respectively with varying nodes in the network from 100 to 300. As shown in the Fig. 6, as the number of the nodes increases in the network, the packet drop rate decreases as well. The reason behind this is that as the number of the nodes increases in the network the connection strength of the nodes increases. The packet drop rate of the routing protocol *OD-LAR* is about 48.345% while in *D-LAR* and *LAR* is about 64.99% and 74.513% that are high as compared to proposed model *OD-LAR*. Therefore, in the proposed model *OD-LAR* candidate next-hop nodes along with their link quality at the border area of the forward area used to improve the network performance.

Figure 7 depicts the packet drop rates of routing protocols *OD-LAR*, *D-LAR*, and *LAR* respectively with the varying node speed from 10 to 26 m per second. As shown in Fig. 7, the packet drop increases as the nodes speed increases in the network. The reason behind this is that as the node speed increases the network stability decreases as well. The packet

Fig. 6 Packet drop versus number of nodes

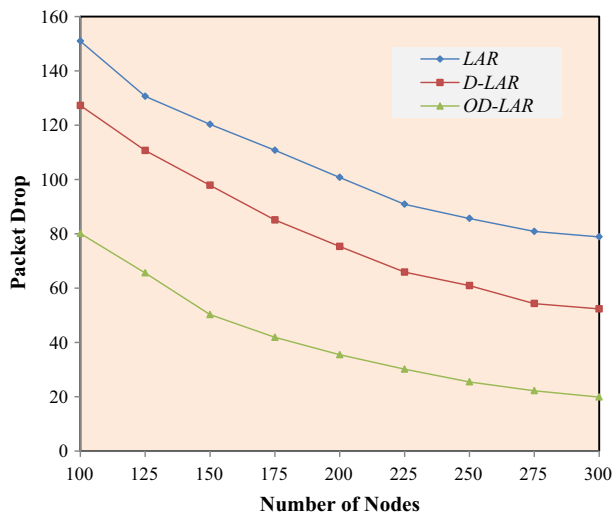
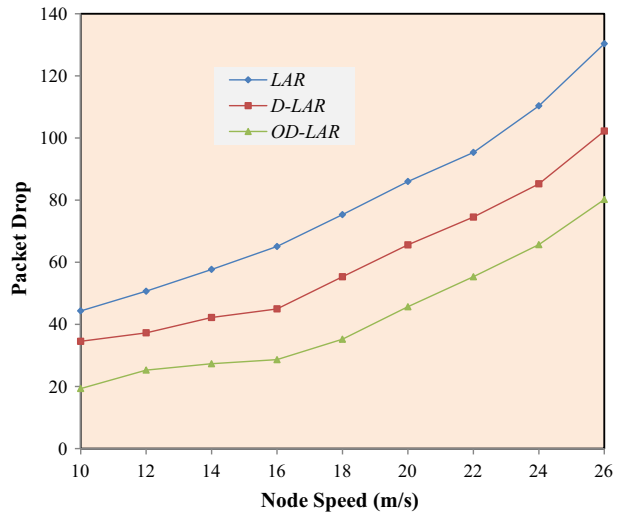


Fig. 7 Packet drop rate versus nodes speed (m/s)



drop of the routing protocol *OD-LAR* is about 52.63% while in *D-LAR* and *LAR* is about 67.47% and 77.59% that are high as compared to proposed model *OD-LAR*. Therefore, the proposed model *OD-LAR* performs better as compared to the *D-LAR* and *LAR* protocols.

5.3 Delay

Delay is an amount of time require to transmit data packets from node to their node in the network and it is an important parameter to measure performance of the network. For better performance of the network and to reduce the large number of accidents delay should be low so that data packet can reach earliest at the destination.

Figure 8 shows delay with varying number of the nodes for routing protocols *OD-LAR*, *D-LAR*, and *LAR* respectively. It can be observed in Fig. 8, as the number of the nodes is increases in the network the delay in each routing protocol decreases as well. The reason behind this is that as the number of the nodes increases in the network, the nodes establish a strong connection with each other's. Therefore, a strong connection among the nodes takes fewer times to deliver data packets at intended destination node. Delay in *OD-LAR* routing protocol is nearly 32.31% while in other hand delay in routing protocol *D-LAR* and *LAR* is about 43.235% and 58.386% respectively.

Figure 9 shows delay in the routing protocols *OD-LAR*, *D-LAR*, and *LAR* with the varying node speed from 10 to 26 m per second. It can be seen in Fig. 9, as the vehicle speed in the network increases delay decreases. The reason behind this is that as the vehicle speed increases the vehicles take minimum time to carrying and forwarding data packets at the intended destination node. The delay in *OD-LAR* routing protocol is nearly 62.88% while it is 76.51% and 83.82% in *D-LAR* and *LAR* routing protocols is respectively. For better performance of the network delay should be low, therefore, the proposed model *OD-LAR* performs better.

Fig. 8 Delay versus number of nodes

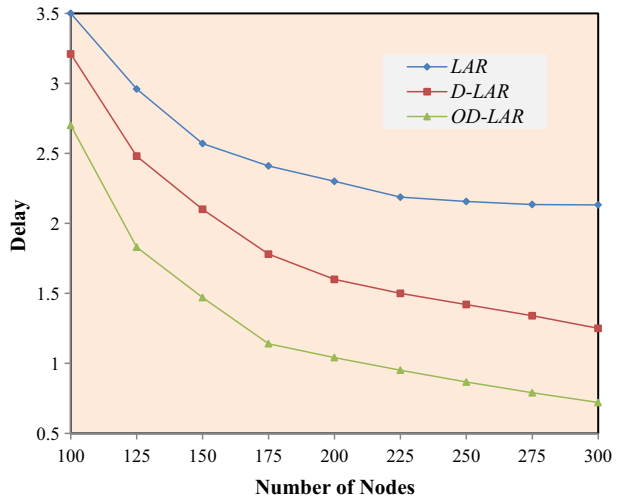
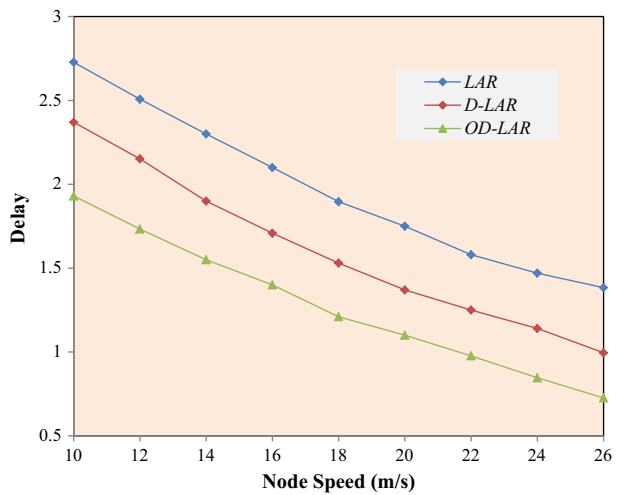


Fig. 9 Delay versus nodes speed (m/s)



5.4 Throughput

Throughput of any network reflects the effective network capacity; it is an amount of data packet transferred successfully per second in the network from source to destination node. For better performance of the network throughput of the network should be high.

Figure 10 shows the throughput of the network with the varying number of the nodes from 100 to 300 in the network. As shown in Fig. 10, the throughput in the routing protocols *OD-LAR*, *D-LAR*, and *LAR* increases as the number of the nodes increases in the network. The reason behind this is that as number of the nodes increases, the transmission of data packets increased in the network as well which turns into higher throughputs. We can see throughput in the proposed model *OD-LAR* is nearly 92.33% while it is nearly 81.25% and 78.57% and in *D-LAR* and *LAR* routing protocol respectively.

Fig. 10 Throughput versus number of nodes

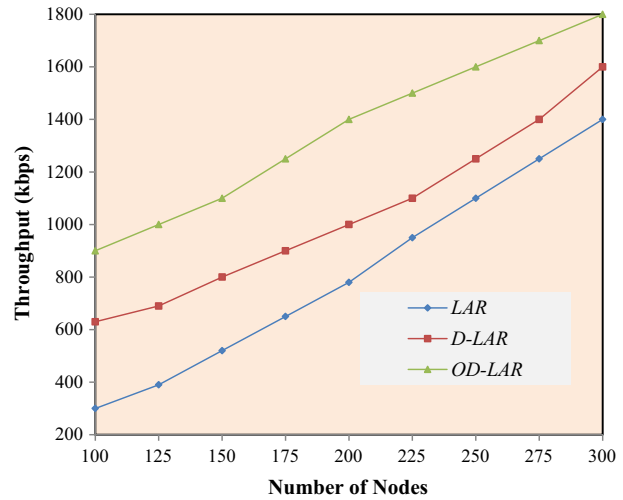


Fig. 11 Throughput versus nodes speed

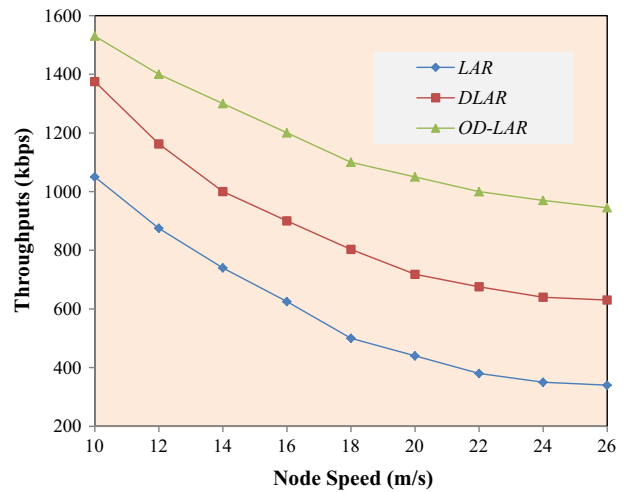


Figure 11 depicts the network throughput with the varying node speed 10–26 m per second for protocols *OD-LAR*, *D-LAR* and *LAR* respectively. As shown in Fig. 11, as the node speed increases the throughput in each protocols decrease. The reason behind this is that as the nodes speed increases the link duration between the nodes decreases, therefore, data transmission for a particular link decreases. Throughput in the proposed protocol *OD-LAR* is nearly 94.3% and in *D-LAR* and *LAR* routing protocol is nearly 82.33% and 77.43% respectively.

6 Conclusion

It is noteworthy due to certain reasons like movable nature and limited communication range in VANET based system frequent breaking of the link is prone to occur. In this research, we have successfully proposed and implemented a novel algorithm to improve the performance of a VANET based system in terms of almost all the parametric measures such as routing overhead, packet drops, end to end delay, and throughput. The proposed protocol *OD-LAR* reduced packet drop rates and end-to-end delay and besides throughput and data transmission has improved in the proposed model. In this model, we used location prediction and link stability of nodes that solved link breakage problem. To demonstrate the performance of *OD-LAR* protocol simulation work has done in *NS2* and compared with the existing *D-LAR* and *LAR* protocol. In future research work, more efficient routing algorithm that can handle the case of the intersection of communication range in which the prediction of node moving direction is not possible should be focused.

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