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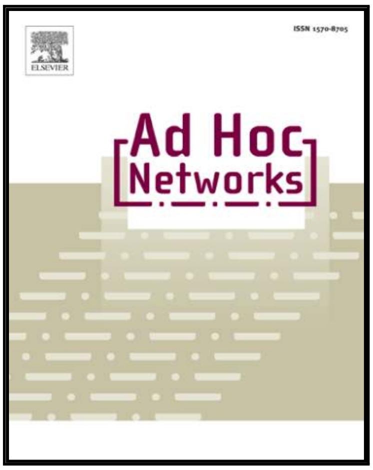

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Adaptive Beacon Broadcast in Opportunistic Routing for VANETs

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Abstract

Broadcast of beacon messages including geographic coordinates, node speeds, and directions are among the most commonly used methods in routing protocols of VANETs to obtain neighboring positions. Broadcast of periodic beacon messages in fixed time intervals will reduce network performance due to increased channel load and contention. In this paper, an adaptive update strategy for sending beacon messages according to the VANETs' characteristics (position, speed, and direction) and the nature of broadcast wireless channel in an opportunistic routing strategy is studied. It is based on two rules: 1) an estimation of the lifetime of the links between vehicles' beacon messages are sent after the expiration of the estimated time to inform their local topology and 2) if the forwarding set of consecutively received data packets is changed, a beacon message is sent to maintain the accuracy of the topology. The simulation results show that the proposed strategy significantly reduces the cost of routing and improves network performance in terms of packet-delivery ratios, average end-to-end delay, and routing overhead.

Keywords: Vehicular ad hoc networks, Opportunistic routing, Beacon message, Link life time, Forwarding set

Introduction

The VANETs are a special type of mobile ad hoc networks which have grown rapidly in recent decades due to the diversity and importance of their applications. These type of networks feature frequent changes in the network topology, high velocity of vehicles, restricted road traffic and other traffic conditions [1]. Given such features, it is necessary to design a reliable routing protocol to maintain a connection among the vehicles and to efficiently deliver data during the transmission from source to destination. In this regard, many routing protocols have been proposed in the VANETs. One method that has recently attracted much attention is the opportunistic routing strategy, which allows dynamic decision-making to select the relay node during routing [2, 3]. In fact, opportunistic routing has a set of candidate nodes instead of a predefined relay. In this process, the sending node broadcasts the data packets at time *t* to its *n* neighboring nodes. This set of neighboring nodes is defined as the forwarding set. The packet sender node selects a relay node among the candidates that have successfully received the data packet. In general, the sender

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prioritizes the forwarding set based on a criterion [2]. To compute the forwarding set according to the routing criteria (global or local), including geographical distance [4–7], expected transmission count (ETX) [8–10], expected transmission time (ETT) [11], signal strength [6, 7], stability, and link lifetime [12, 13], it is necessary to broadcast the beacon packets periodically or non-periodically to discover the neighboring nodes. Sending these probing packets can be classified into three categories: active, reactive, and collaborative [2]. In the active group, a node sends the control packets to explore neighbors. In this method, the routing decision is performed using the topology information obtained from the exchange of beacon messages among the neighbors. Beacons are very small messages which are periodically transmitted by each vehicle; they include parameters such as position, velocity, and direction of mobility of the vehicles [14]. Exchange of this information allows the nodes to maintain an accurate neighboring list and create a local topology of the nodes in their neighborhood. Given that the VANETs have high mobility and speed, the constructed topology changes continuously. Hence, each node needs to periodically broadcast its updated geographical information to its neighbors [14], but these updates are costly in many aspects. Every update increases wireless bandwidth usage, delay in packet sending, and collision risk in the medium access control (MAC) layer. Packet collisions lead to packet loss, affecting the routing performance. Chaqfeh, and Lakas [15] have shown, when vehicles send 200-byte beacon messages every 100 milliseconds within their communication range (300 meters) (10 packets per second), they create 80% traffic load. Upon factorizing them into five packets with the same settings, the channel load reduces to 40%. Considering the cost of periodic broadcast of beacons to obtain the neighboring information, it is necessary to provide an adaptive method for sending beacons, based on the mobility of nodes, their relative velocity, and the traffic conditions, rather than the beacons' static update policy.

Main Contributions

In this paper we focus on sending beacon messages according to the VANETs' characteristics (position, speed, and direction) and the nature of broadcast wireless channel in an opportunistic routing strategy. In order to adapt the beacon rates with the VANETs' features, a new approach is proposed. The main features of the work are as follows:

- A new strategy is proposed by considering two rules for opportunistic routing strategy with the low amount of consumed network bandwidth. The first rule is related to sending a beacon using a method for estimating the link establishment time between two nodes. In the second rule, if the consecutively received data packet-forwarding set is changed, they will send a beacon message to update their local topology. These rules aim to reduce the overhead caused by sending the beacon messages while maintaining the accuracy of the local topology.
- The proposed method is tested to verify its quality in terms of the beacon overhead. In the first set of simulations, the effects of change of vehicle density on the performance of the proposed method are tested. In the second part of the simulation, the performance of the method is evaluated in relation to the diversity of traffic flows. Extensive simulations show that the proposed method is superior to the methods reported in the literature, in terms of the number of beacon packets sent in the network and the routing overhead. It also improves the delivery ratio and end-to-end latency. The main reason for

improvements in our work is that in the proposed method, the beacon messages are sent based on the mobility models, vehicle velocity, and changes in the forwarding set of the data packet.

The rest of paper is organized as follows. In the second section, an overview of the related works is given. The details of the proposed method are discussed in Section 3, and the simulation environment and the analysis of the simulation results are provided in Section 4. Concluding remarks are drawn in Section 5.

Related works

Numerous methods for adapting the frequency of beacon updates in safety and non-safety applications have been reported in the literature. This section reviews some of the approaches presented in the field of non-safety applications. The authors in [16], use the vehicle positional estimation model to adapt and analyze the beacon message frequency. A beacon message is sent if the difference between the predicted value of the position and the actual position is greater than a threshold δ. However, determining an appropriate value of δ is one of the challenges in this method. For a small value of δ, the routing overhead is increased and a large amount of δ can cause inaccuracy in the formation of the local topology. In [17], the beacon messages are adapted, based on two parameters of the message utility and channel quality in the past, present, and future to reduce channel load. The beacon sending method in [18], controls the frequency of the beacon to efficiently exploit the bandwidth. In addition, during the transmission, a fair selection mechanism is used for received messages that have higher priority. For efficient use of the channel, the frequency of the beacon message is controlled by taking parameters such as data age, distance to destination, history of message reception, and the importance of data to the vehicle. However, methods such as ATB [17] and FairAD [18] do not consider the positioning of the vehicles in the absence of receiving beacon messages at a fixed time interval. Also, the transmission interval of the beacons in these methods is between a minimum and a maximum value and the interval affects the local topology. In [19], based on the greedy forwarding routing algorithm, a contention-based adaptive positioning update (CAPU) algorithm has been presented for the VANETs, which focuses on the selection accuracy of the next hop during data transmission. In this method, if the difference between an estimated position and actual position of the next hop is greater than a predetermined threshold, the vehicle characteristics, including position, velocity, and direction, are updated by sending a beacon message. Otherwise, a "Hello" message containing only the vehicle ID is sent. By defining two type of packets "Hello" and "beacon" in the network, this method will increase the communication overhead and the chances of collision in the network. On the other hand, in the MANETs, it has been shown that the beacon's adaptive schemes will effectively improve the awareness of the topology, as well as the accuracy of routing. For example, in [14], an adaptive positioning update (APU) has been presented based on two rules in the GPSR routing protocol. However, considering the different needs of the VANETs and the unique characteristics of these type of networks, the beacon's adaptive transmission is among the major challenges in the VANETs for non-safety applications [20]. In [21] a multi-hop broadcast routing protocol in VANETs (DV-CAST) is proposed. This method has three traffic situations for broadcasting data messages which are: 1) dense traffic situation, 2) sparse traffic situation, and 3) regular traffic situation. In DV-CAST when a new message is broadcasting, the receiving vehicle checks whether sender vehicle is behind it. If so, the broadcast suppression schemes are implemented to forward the broadcast message; otherwise, one of the neighboring nodes broadcasts message in the opposite direction of the traffic flow. In [22], by considering the presence of the intersections, a bandwidth-efficient technique for information dissemination in urban scenarios in VANETs is proposed. For identifying intersection it has used two different techniques: digital map and the calculation of the message reception angle. The aim of this method is trying to reach the neighbors that may be hidden around the corners of sender nodes. However, the protocols presented in [21] and [22] have not used the adaptive strategy to broadcast beacon messages. In our paper, considering the VANETs characteristics such as vehicle speed, distance, and direction, an "adaptive beacon broadcast in opportunistic routing" strategy for the non-safety applications is presented. In the employed strategy, the beacon messages are sent according to two rules. The beacon message sending rate changes based on a number of observations in VANETs communications. For example, if the network faces a partitioning problem, the lifetime of the link between the nodes is shortened and necessarily the beacon messages sending rate is increased. On the other hand, if the network is dense, the communication links between the nodes have more stability and a longer lifetime. This also reduces the sending rate of beacon messages; as a result, the contention, congestion, and broadcast storm problem are reduced. On the other hand, upon using the nature of the broadcast wireless channels and the forwarding set in the opportunistic routing strategy, a beacon message is sent if there are any changes in the forwarding set of consecutively received data packets. This strategy (named ABOR) ensures that the nodes in the data forwarding path maintain their exact local topology by sending the beacon messages. Table 1 presents the comparison of the related works and the proposed method considering the characteristics, such as: the positional estimation mechanism, adaptive strategy for sending the beacon message, simulation scenarios, and indicates advantages and weaknesses of each method. Considering the estimation model in Table 1, the proposed method similar to [16], APU [14] and CAPU [19], uses the vehicle positional estimation model. However, by considering adaptive strategy for [14], [16], and [19], beacon messages are sent if the difference between the predicted value of the position and the actual position is greater than a threshold δ, while in the proposed method (ABOR), beacon messages are sent according to the link life time estimation and the wireless channel conditions in VANET. Moreover, the proposed adaptive protocol in contrast to ATB [17] and FairAD [18], sends the position of the vehicles of the forwarding set in the beacon messages. This ensures that the exact positional information of the nodes in the data forwarding path is maintained. The proposed method similar to [21] and [22] is classified as a multi-hop broadcasting routing protocol. However, in these two methods ([21] and [22]) the adaptive beaconing mechanism or positional estimation model, are not considered. Finally, the last column indicates comparison between the related works and the proposed method in aspect of simulated scenarios. As given in the last column, in the evaluation of the proposed method the impacts of different number of vehicles, various vehicle speeds and different traffic flows are taken into account but the other methods have considered only one or two of these parameters in the conducted simulations. It is obvious that considering various node densities with different speeds of vehicles in different data traffic flows can indicate the performance of the protocol in a variety of situations, such as dispersed or dense environments, and high or low data traffics. In the next section, details of the proposed method are explained.

Table 1. Comparison of related research works

Protocol	Estimation model	Addaptive strategy	Advantages	Drawbacks	Simulation scenarios
A. Boukerche et. al. [16]	Yes	Mobility prediction using distance threshold value	Reduced overhead	Inaccuracy local topology	Different speed and period time for sending becon
ATB [17]	No	Message utility and channel quality	Efficiently exploiting the bandwidth	Inaccuracy in positioning of the vehicles	Different number of vehicles
FairAD [18]	No	Data age, distance, history of message reception, and the importance of data to the vehicle	Reduced overhead	Inaccuracy in positioning of the vehicles	Different application and connectivity time
CAPU [19]	Yes	Mobility prediction using distance threshold value	Accuracy of the next hop during data transmission	Increased overhead	Different traffic load and vehicles speed
APU [14]	Yes	Mobility Prediction and overhead of the transmission of data packet	Reduced overhead and accuracy of the next hop	Different VANETs characteristics	Different traffic load and vehicles speed
DV − CAST [21]	No	________	Broadcast suppression and applicable to delay tolerant applications	Increased overhead due to the control packets	Different traffic loads and different distances
E. G − Lozano et al. [22]	No	________	Efficiently using bandwidth and decreased hidden terminal problem	Increased overhead due to the control packets	Different number of vehicles
ABOR	Yes	Vehicles position, movement characteristics and forwarding set in OR	Reduced overhead, accuracy of the next hop and increased QoS	________	Different traffic load and number of vehicles with different speed

The proposed method

In this paper instead of using fixed periodic beacons, the beacon transmission rate is varied based on the variations in three factors: vehicles motion, changes in the topology of the vehicles around the sending node, and the number of vehicles participating in the forwarding set. In this work the following assumptions are made:

- ✓ Vehicles have omni-directional antennas.
- ✓ Beacon's information includes the position, direction, and velocity of the vehicles.
- ✓ Each vehicle has the same transmission range, equal to R, and its coverage area is a circle with radius R.

- ✓ Each vehicle is equipped with a positioning system that makes it aware of its speed as well.
- ✓ The data packet arrival rate at the source node and the intermediate forwarding nodes is constant and is represented by λ.
- ✓ The position of the destination vehicle can be obtained using the destination inquiry location services (such as RLSMP [23]) even during data transmission.

After initialization, each vehicle sends a beacon to inform the neighbors of its velocity and position. Also, only the vehicles in the neighboring list are considered as the forwarding set for sending data packets. The proposed method is based on two rules and in the following each rule is explained in detail.

First rule: Sending beacon based on the estimated time of link availability

Considering the high velocity of vehicles, instability of wireless channel, and the frequent changes in the topology of the VANETs, beacon messages in this rule are sent based on estimation of link lifetime (LLT). Using a prediction scheme for the availability of the link between two nodes, the time of sending the next beacon is set according to the minimum lifetime of the link between a node and its neighbors. This is based on the observation that vehicles moving at the same speed can be considered as moving in a platoon and it is very probable that they stay connected for a considerable duration of time. On the other hand, vehicles moving at relatively high speeds have links with frequent failures, requiring a faster transmission of the beacon messages. The LLT between two neighboring vehicles i and j moving at the same direction is obtained according to AODV-R [24], as follows:

$$\text{LLT} = \begin{cases} \dfrac{2R - d_{ij}}{|v_i - v_j|}, & \text{if } V_j > V_i;\ \text{i.e.: j approaches i from behind} \\ \dfrac{R - d_{ij}}{|v_i - v_j|}, & \text{if } V_i > V_j;\ \text{i.e.: i moves forward in front of j} \end{cases} \tag{1}$$

where, R is the transmission range, v_i and v_j are the velocities of vehicles i and j, and d_{ij} is the Euclidean distance between them. By computing the LLT of node i and all of its neighboring nodes js, node i will send a new beacon before the expiration of the LLT for the set of neighboring vehicles. Using this rule, broadcast of the beacon message is adapted based on the mobility characteristics of the vehicle (position of vehicles, speed and direction of their motions) and its neighbors. As a result, the nodes that have rapid changes in their neighboring vehicles will have faster beacon sending rates because they are likely to leave the communication range of sending node in a shorter time interval. Therefore, there is a need to update the local topology in a shorter time. On the other hand, for the neighboring nodes with relatively low speed, the beacon sending rate is reduced, because their positional information and communication links will remain constant for longer time interval. Since in the opportunistic routing strategy, the sender node extracts the positional information of its neighbors from beacons information for rank ordering of the neighboring nodes in the forwarding set, it is necessary that when the new beacon transmission interval is increased, the positional information of the neighbors is updated by some way without receiving a new beacon for relatively long time. Therefore, in the proposed method, one can use a linear estimation equation, according to APU [14], to maintain accuracy in routing operations. Table 2 shows the abbreviations used in the positional estimation mechanism.

Table 2. Abbreviations used in the positional estimation mechanism

Variable	Definition
(x_l^i, y_l^i)	The coordinates of node i at time T_l (included in the previous beacon)
(v_l^i, v_y^i)	The velocity of node i along the direction of the x and y axes at time T_l (included in the previous beacon)
T_c	The current time
T_l	The time of the last broadcasted beacon
(x_p^i, y_p^i)	The predicted position of node i at the predicted time

Based on APU [14], with the position of node i and the velocity along the x and y axes at time T_l, the node can estimate its neighboring node position in the current time as:

$$x_p = x_l + (T_c - T_l) * v_x \quad (2\text{-a})$$
$$y_p = y_l + (T_c - T_l) * v_y \quad (2\text{-b})$$

Algorithm 1 shows the details of the first rule. According to this rule, in the first step, each node sends a beacon message to create a local topology. By receiving the beacon message, each node also creates its list of neighbors (Lines 1 to 2 of the code). According to the specifications obtained in the neighboring list of each node, the LLT criterion is calculated for the neighboring nodes and is sorted in the descending order. Then, the smallest time is determined among the set of neighbors as the beacon-sending interval. Moreover, after a specified time interval based on the LLT, each node sends a beacon message to update its local topology (Lines 5 to 12 of the code). Otherwise, the nodes use equations (2-a) and (2-b) to estimate their positions (Line 14 of the code).

```
Algotithm 1:   Sending beacon based on the estimated time of the link availability
Input:         Characterestic of nodes such as position, velocity and direction
Output:        Beacon Period Value
Notations:
BPV:           Beacon Period Value
i:             Sender vehicle
N:             Neighbor list
j:             Neighbor node of i
LLT:           Link lifetime
Initialization:
1:             each node broadcasts beacon to inform its neighbors
2:             based on beacon received, each node creates the neighbor list
Rule1:
4:             While (1) do
5:                For (each node(j) in N) do
6:                   estimate the LLT between node i and j according to (1)
7:                   sort LLT values in descending order
8:                   BPV = minimum value of LLT
9:                   set a timer based on BPV
10:                  If (BPV == 0)THEN
```

```
            node i sends a beacon for its neighbors
            based on beacon received from node i each node updates its local topology
        else
            each node uses a prediction scheme accoring to (2 − a) & (2 − b)
        endif
    endfor
end
```

Second rule: Sending a beacon message based on the participation of the nodes in the forwarding set

Rule two is based on the idea that if a node persistently has a higher rank in the forwarding set, it is very probable that it stays in the future forwarding set. Thus, the sender node can use its old beacon information or use the positional estimation mechanism based on Equations (2-a) and (2-b) to estimate its positions for longer period of time and can avoid sending beacon for longer time interval. To realize this idea, if a node such as B in Fig.1 receives two consecutive data packets and its rank is higher than 3 in the forwarding set of the packets, then node B does not send a new beacon.

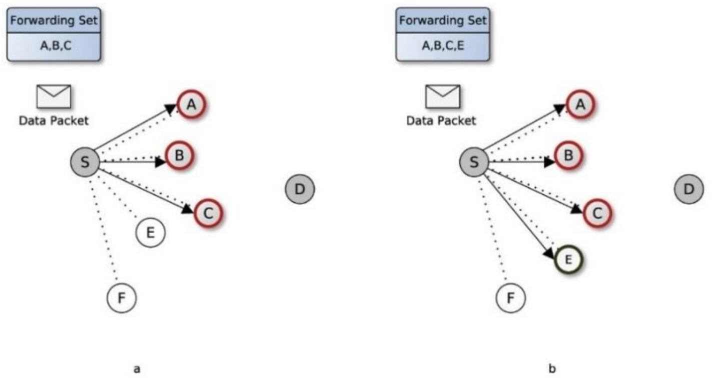

Figure 1: An example of the second rule

Algorithm 2 shows the details of the second rule. According to this rule, by sending data from the source node with the sending time interval of λ (λ is the time interval for sending data packets which is inversely proportional to packet generation rate) or broadcasting data packets by one of the nodes in the forwarding set, any node that receives the data packets at times t and t + λ will compare the forwarding set of the received packets. If the node is among the higher rank node in both of the lists, no action is taken (Lines 2 to 5 of the code). Otherwise, a beacon message is sent to update the local topology (Line 7 of the code). It is worth noting that, one of the assumptions is that the packet arrival rate at the source nodes and the intermediate forwarding nodes are constant, and is represented by λ. Thus, the time interval between two consecutive data forwarding operations at a node is 1/λ.

Algotithm 2: **Sending a beacon message based on the participation of the nodes in the forwarding set**

Input: Forwarding set of consecutively received data packets
Output: Beacon packet transmission
Notations:
P_k: Received data packet at time t
P_l: Received data packet at time t + λ
n_k: The nodes in forwarding set of data packet P_k
n_l: The nodes in forwarding set of data packet P_l
c: The candidate nodes which received both data packets P_k and P_l

```
Rule2:
    for ( each node in c) do
        If (node rank is higher than 3 in both forwarding sets) then
            node dose not send a beacon
            node uses a prediction scheme accoring to (2 − a) & (2 − b)
        else
            node sends a beacon to update the local topology
        endif
    endfor
end
```

Performance Evaluation

In this section, performance of the proposed method through the NS-2 simulator [25] is evaluated. The method in the first group of simulations is compared with APU and CAPU adaptive beacon routing protocols and AODV-R routing protocol which uses LLT metric in routing from source to destination. The APU and CAPU methods use adaptive beacon messages in greedy forwarding. Given that the APU method is designed for mobile ad hoc networks, for fair comparison this method is adapted to the vehicular ad hoc network features. Moreover, to illustrate the effect of the positional estimation mechanism on the routing function, the method is implemented on the LSA protocol presented in [12], which has used the parameters of stability and advancement which depend on the position of the vehicles. In addition, the proposed method in the second group of simulations is compared with multi-hop broadcasting routing protocols of DV-CAST [21] and method in [22]. The DV-CAST protocol is used the broadcast suppression schemes and employs store and carry forward mechanism in different modes. The method in [22] has used the distance criterion. In [22] the impact of the presence the nodes in the intersections during the broadcasting of data packets is considered as well. However, none of the two methods have used adaptive beaconing strategy, and so the beacon frequency in these methods is considered to be one packet per second. In the following subsection, the simulation environment employed in this paper is described.

Simulation environment

The SUMO-based C4R (City Mob for Roadmaps) [26-27] movement pattern generator is used to produce a realistic urban environment. SUMO is an open source, microscopic road traffic simulation package designed to handle large road networks. C4R uses layouts of real cities from OpenStreetMap. Therefore, in this paper, C4R is used for generating a real scenario in the urban environment of Detroit’s Downtown area in USA, as shown in Figure 2, which features a block-like grid commonly found in city centers. The size of the simulation area is set to 2000 m × 2000 m. This scenario has 30 horizontal and vertical streets. We considered different number of vehicles: 100, 150, 250 and 300 vehicles. The initial positions of the nodes in this scenario have been taken randomly. Each vehicle is moving at a minimum speed of 40 km/h and a maximum speed of 80 km/h, and they have various accelerations at different time stamps. To generate the movements for the simulated vehicles, we used the Krauss mobility model [28] (with some modifications to allow multilane behavior [29]) which is available in SUMO. The Krauss model is based on collision avoidance among vehicles by adjusting the speed of vehicles. This setup is done in order to evaluate the performance of the proposed method in a real urban scenario.

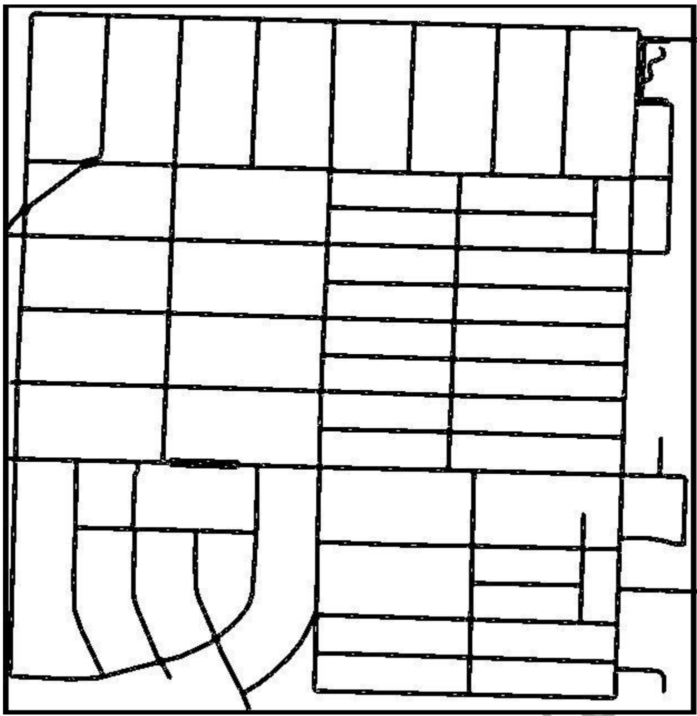

Figure 2: Detroit's Downtown Scenario Imported to C4R

Vehicles are randomly selected and their data flow to the final destination is at a constant bit rate. To provide fairness in the comparison of the proposed method with the other methods, IEEE 802.11 DCF and IEEE 802.11p standards of the MAC layer have been used in the simulations, according to the MAC layer standard which is employed in the compared method. In the first group of simulations, the methods AODV-R [24], APU [14], and CAPU [19] have used the IEEE 802.11 DCF to evaluate their performance, as a result we have also used IEEE 802.11 DCF in the MAC layer. In this case, omni-directional antenna within a communication range of 250 meters and channel data rate of 2 mbps have been considered. In the second group of simulations, the proposed method is compared with DV-CAST [21] and the method in [22] which employ IEEE 802.11p MAC layer protocol with omni-directional antenna within a communication range of 300 meters and channel data rate of 6 mbps. Hence, the proposed method in the second group of tests is simulated using the corresponding MAC layer protocol and settings. Other details of the MAC layer simulation parameters are listed in Table 3. It is noted that the results of first group of simulations which include comparison with AODV-R [24], APU [14] and CAPU [19] by using IEEE 802.11 DCF are presented as graphs. Whereas, simulation results indicating comparison of the proposed method with DV-CAST [21] and the method in [22] which employ IEEE 802.11p MAC layer protocol are presented in tables. Although there are numerous propagation models [30], in the simulations the Nakagami propagation model is used to simulate the fading effect of the channel. The parameters employed in the Nakagami model are tabulated in Table 4 [31]. The reason for using this model is to consider the obstacles (buildings) and provide a real model in a wireless channel of inter-vehicle network. Each test was repeated 20 times and the details of the simulation parameters are listed in Table 5. In the followings, the performance metrics considered in the simulations are defined.

Packet delivery ratio: ratio of the successfully received data packets at destination to the number of data packets generated by the application layer of the source vehicles.

Average end-to-end latency: the average delay for a data packet from source to destination.

The number of sent beacon (control) packets: the number of broadcast beacon packets over the simulation time to update vehicle conditions and perform routing operations. It is worth noting that, the AODV-R packets (RREQ, RREP, RERR, and Hello) are considered as control packets.

Normalized routing overload: the ratio of number of control packets to the number of data packets received successfully by the destination vehicle. In the evaluation of the normalized overload, the size of the packets rather than the number of control packets is used. This is because more fields in beacon messages are used in broadcasting. Two sets of tests are also conducted to evaluate the performance of the proposed method with the following parameters:

1. **Number of vehicles:** To evaluate the performance of the proposed method in various network densities; in this set of experiments the number of vehicles were varied in the range of 100 to 300. The number of CBR connections to generate data traffic was 20 different streams with a transfer rate of one packet per second.
2. **The number of different connection pairs:** To evaluate the performance of the network in various number of data transmission streams; in this experiment the number of CBR connection pairs was varied from 10 to 50 with the generation rate of one packet per second. The number of vehicles, in this case, was 200.

Table 3. Parameters of the PHY/MAC layer

MAC/PHY	DCF of IEEE 802.11	IEEE 802.11 p
Transmission Range	250 m	300 m
Transmission Power	1 w	10 mw
Sensitivity	-78 dBm	-89 dBm
Channel Frequency	2.4 GHz	5.89 GHz
Data Rate	2 Mbps	6 Mbps
CW slot time (σ)	20 μ sec	16 μ sec
CW minimum size	15 slots	32 slots
CW maximum size	1024 slots	1024 slots
SIFS time	10 μ sec	32 μ sec
Antenna gain	4 dB	4 dB
Antenna height	1.5 m	1.5 m
Noise floor	-99 dBm	-96 dBm
SINR for preamble capture	4 dB	4 dB
SINR for frame body capture	10 dB	10 dB
Path Loss Factor	1	1

Table 4. Parameters of the Nakagami Model

GAMMA0_	GAMMA1_	GAMMA2_	D0_GAMMA_	D_1GAMMA_
2.0	2.0	2.0	200	500
M0_	M1_	M2_	D0_m_	D1_m_
1	1	0.75	80	200

Table 5. Simulation Parameters

Simulation Parameter	Value
Number of Vehicles	100, 150, 200, 250, 300
Simulator	NS-2.35
Simulation Area	2000 m × 2000 m
Mobility Generator	C4R
Minimum Speed	40 km/h
Maximum Speed	80 km/h
Number of Connection Paris	10, 20, 30, 40, 50
Simulation Time	300 second
Queue Length	50 packets
Packet Size	512 Byte
Mobility Model	Krauss and Downtown Model
Propagation Model	Nakagami-m
Packet Generation Rate	1 packet/second
λ	1 second

Performance Evaluation for a Varying Number of Vehicles

Figure 3 shows the delivery ratio for different nodes in the network with a minimum speed of 40 km/h and a maximum speed of 80 km/h. The delivery ratio for the all routing methods increases by increasing the number of nodes. This is because at low node densities there is a higher probability for singular nodes to fail in transmitting data and by increasing the node density there will be less singular nodes. As shown in Figure 3, the proposed method (named ABOR in the Figure) shows a better performance than the other three methods. ABOR reduces the collision rate in the wireless channel by reducing the transmission rate of the beacon messages according to the inter-vehicle network characteristics. As a result, the delivery ratio of ABOR compared with the other methods is improved. Based on Figure 3, ABOR has improved the packet delivery ratio on average by 20% compared to the APU method, by 11.7% over the CAPU method and by 33.6% compared to the AODV-R method. It is worth noting that the achieved improvement by the proposed method increases by increasing the number of vehicles, since by increasing the vehicle density the probability of collision and competition between nodes to send the message will increase.

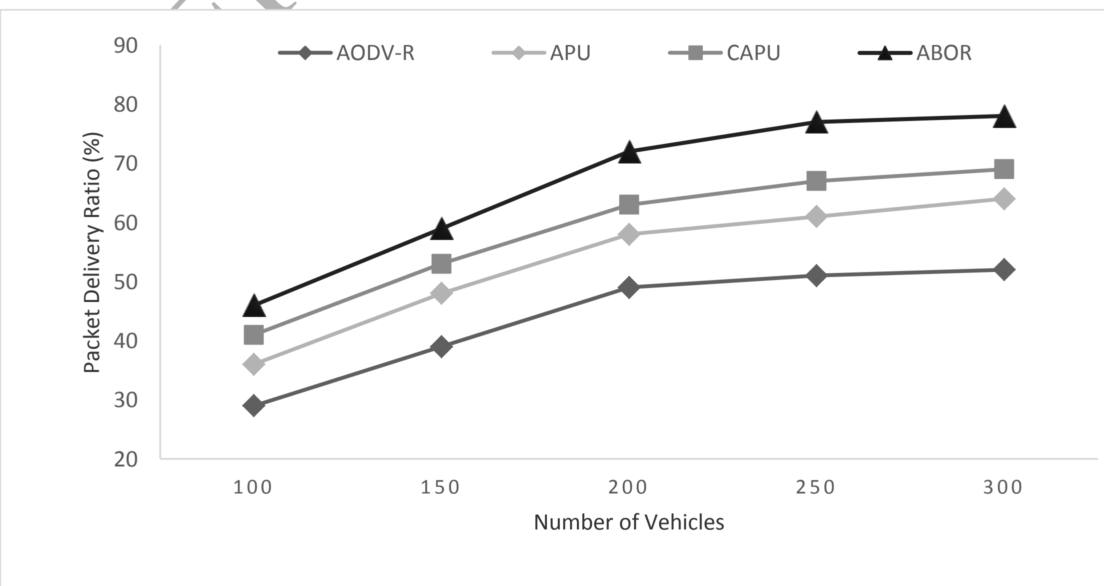

Figure 3: Delivery ratio in terms of different number of vehicles

Table 6 shows the delivery ratio of the three routing protocols, i.e., the proposed method (ABOR), DV-CAST and the method in [22]. As shown in Table 6, increasing the number of nodes, the proposed method has a better performance than the other two methods. Based on the results shown in this Table, the proposed method has improved the packet delivery ratio on average by 14% and 6.8% compared to the DV-CAST protocol and the method implemented in [22], respectively.

Table 6. Delivery ratio in terms of different number of vehicles

Protocol / No. of Vehicles	100	150	200	250	300
DV-CAST	46.2	57.8	68.4	74.6	79
Angle-Based [22]	48.6	64.1	75	78.7	81.5
ABOR	**49**	**67**	**83**	**85.2**	**87.5**

Figure 4 shows the average end-to-end delay for different number of vehicles. In general, increasing the number of vehicles, the delay for routing protocols is reduced, because the probability of the lack of communication links in dispersed environments increases and the network will face partitioning problems. By increasing the number of vehicles from 200 to 300, the average end-to-end delay for the routing protocols tends to be stable. Given that the AODV-R is an on-demand routing protocol, it is clear that the end-to-end delay in this method is higher than the other protocols such as ABOR, APU, and CAPU. Compared to the APU, CAPU and AODV-R methods, ABOR shows 64%, 59% and 82% better performance, respectively.

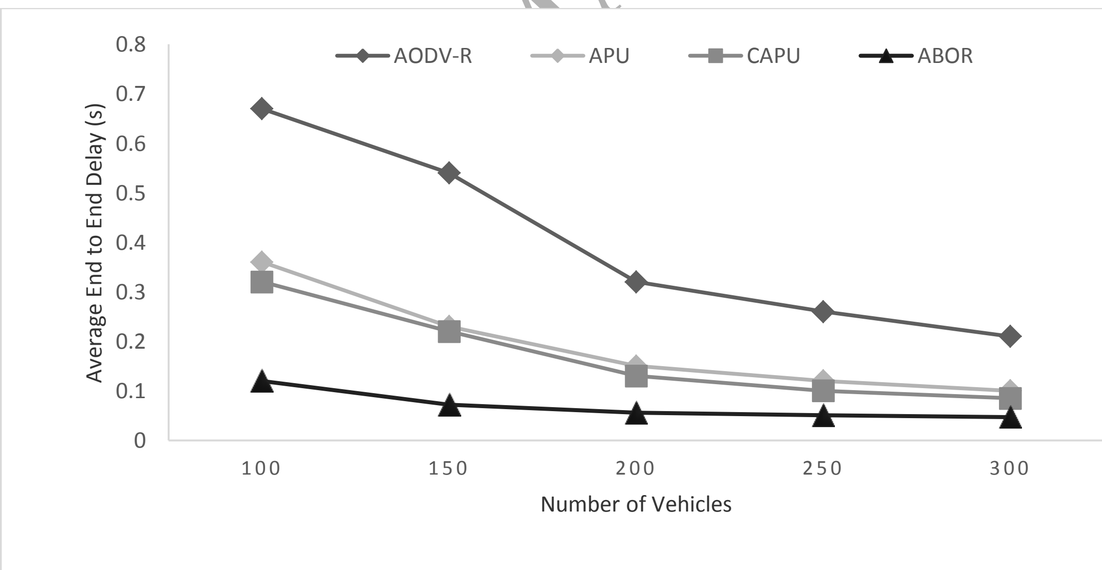

Figure 4: Average end-to-end delay in terms of different number of vehicles

Table 7 shows the average end-to-end delay for different number of vehicles of the three routing protocols. As shown in Table 7, increasing the number of nodes, based on aforementioned explanations, the end-to-end delay for routing protocols is reduced. However, the proposed method has a better performance than the other two methods. Based on the results shown in this Table, the proposed method has improved the end-to-end delay on average by 32.3% and 21.1% compared to DV-CAST and method in [22], respectively.

Table 7. Average end-to-end delay (second) in terms of different number of vehicles

Protocol \ No. of Vehicles	100	150	200	250	300
DV-CAST	0.071	0.067	0.061	0.055	0.049
Angle-Based [22]	0.067	0.063	0.056	0.047	0.043
ABOR	**0.063**	**0.054**	**0.043**	**0.038**	**0.031**

Figure 5 compares the number of beacon packets produced in terms of the different number of vehicles for ABOR, AODV-R, APU and CAPU routing protocol. As shown in Figure 5, due to the implementation of the two rules in sending beacon messages, the proposed method has significantly reduced the sending rate of the beacon messages while maintaining the delivery ratio and end-to-end delay at appropriate levels. Considering that the AODV-R uses packets (RREQ, RREP, RRER, HELLO) during routing, the number of control packets sent in this method is more than other methods. Figure 5 shows that in a sparse environment, due to partitioning, the network of the communication links has a shorter lifetime, so, the beacon-sending ratio is high. However, increasing the number of vehicles from 200 to 300, the production of beacon messages reaches a stable state. In the scenario of 100 vehicles, since the beacon rate is set based on the link lifetime (algorithm 1 in the proposed method), and in lower densities the lifetime of the links is reduced, the sending rate of beacon messages in this case is increased. Moreover, in the absence of the neighboring nodes, the smaller forwarding set will be formed, which results in less employment of the second algorithm in reducing beacon messages rate. Upon increasing the number of vehicles from 150 to 250, due to increasing the probability of the link availability (the lifetime of the links between the nodes increases), the beacon sending rate will be reduced. In fact, according to the experimental data, it appears in the range of 150 to 250 vehicles the network conditions become stable. By increasing the number of vehicles from 250 to 300 at a fixed rate of sending data packets, due to the less likelihood of a node being in the different forwarding sets, the number of nodes that are in more than one forwarding set decreases. As a result, the second rule can be applied to fewer vehicles. Therefore, more beacon messages will be sent in this case which is shown in Figure 5. As shown in this Figure, the proposed method compared to APU, CAPU, and AODV-R methods reduces the transfer rate of beacon messages on average by 19%, 30%, and 41%, respectively.

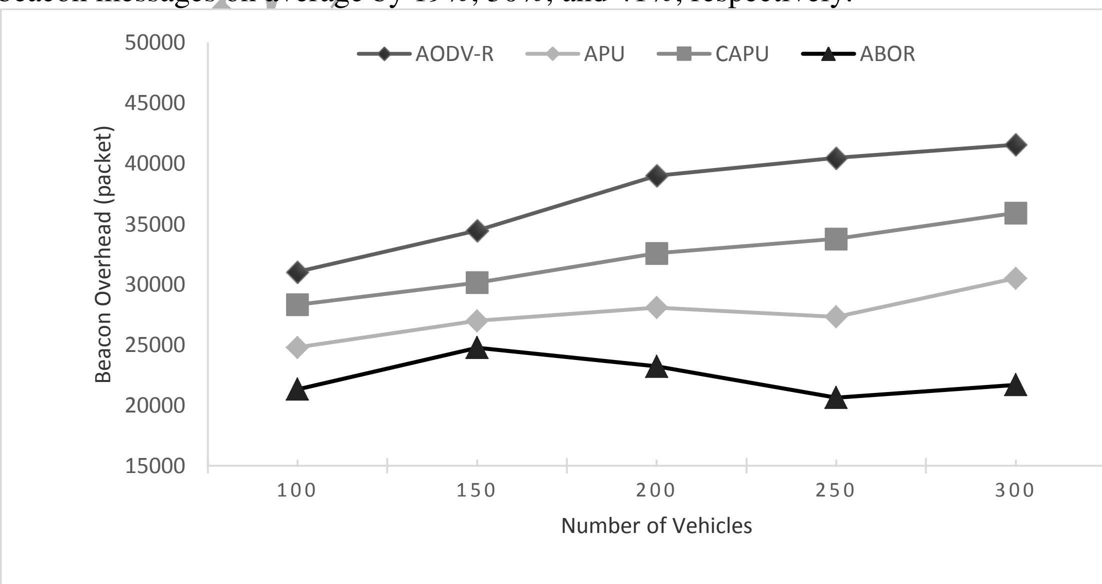

Figure 5: Number of beacon packets produced in terms of the different number of vehicles

Table 8 shows the number of beacon packets produced in terms of different number of vehicles. As can be seen in this Table, the frequency of sending beacon packets generated in DV-CAST and method in [22], is constant (1 Hz), while in the proposed method, the frequency of beacon messages is varied. Based on aforementioned descriptions, proposed method has a better performance than the other two methods. According to the results shown in this Table, the proposed method reduces number of beacon packets on average by 48.2% compared to both DV-CAST and method in [22].

Table 8. Number of beacon packets (packets) produced in terms of different number of vehicles

Protocol / No. of Vehicles	100	150	200	250	300
DV-CAST	30000	45000	60000	75000	90000
Angle-Based [22]	30000	45000	60000	75000	90000
ABOR	**25456**	**29842**	**33664**	**30540**	**35878**

Figure 6 illustrates the normalized routing overhead for different number of vehicles in which the data packets are exchanged between vehicles for gathering information on the network. Since utilization of the periodic beacon (control) packets leads to an inefficient use of bandwidth and causes a contention problem, designing a routing protocol that can handle the routing overhead is very important. The routing overhead depends on two factors: the total number of beacon (control) packets and the packet delivery ratios. In the proposed method, by employing the first rule and increasing the network density, the probability of the availability of links and their lifetimes between the vehicles are longer and the vehicles are within the communication range for longer periods of time. This reduces the number of the transmitted beacon packets. On the other hand, reducing the number of beacon packets reduces the contention. This reduction in contention increases the data delivery ratio. The proposed approach, by increasing the delivery ratios and reducing the number of control packets, has reduced the normalized routing overhead significantly compared to the APU, CAPU, and AODV-R methods. Upon increasing or decreasing the number of beacon packets, the normalized overhead will also change, and hence the aforementioned explanations for Figure 5 are also valid for variations in Figure 6 as well. As shown in Figure 6, the normalized routing overhead in the proposed method is decreased on average by 30%, 35% and 66% compared to the APU, CAPU, and AODV-R methods, respectively. Table 9 compares the normalized routing overhead in the proposed method with DV-CAST and method in [22]. As shown in Table 9, the normalized routing overhead in the proposed method is decreased on average by 48%, and 43.7% compared to DV-CAST and method in [22], respectively.

Table 9. Normalized overhead for different number of vehicles

Protocol / No. of Vehicles	100	150	200	250	300
DV-CAST	0.97	1.16	1.31	1.5	1.7
Angle-Based [22]	0.92	1.04	1.19	1.42	1.65
ABOR	**0.85**	**0.73**	**0.66**	**0.58**	**0.67**

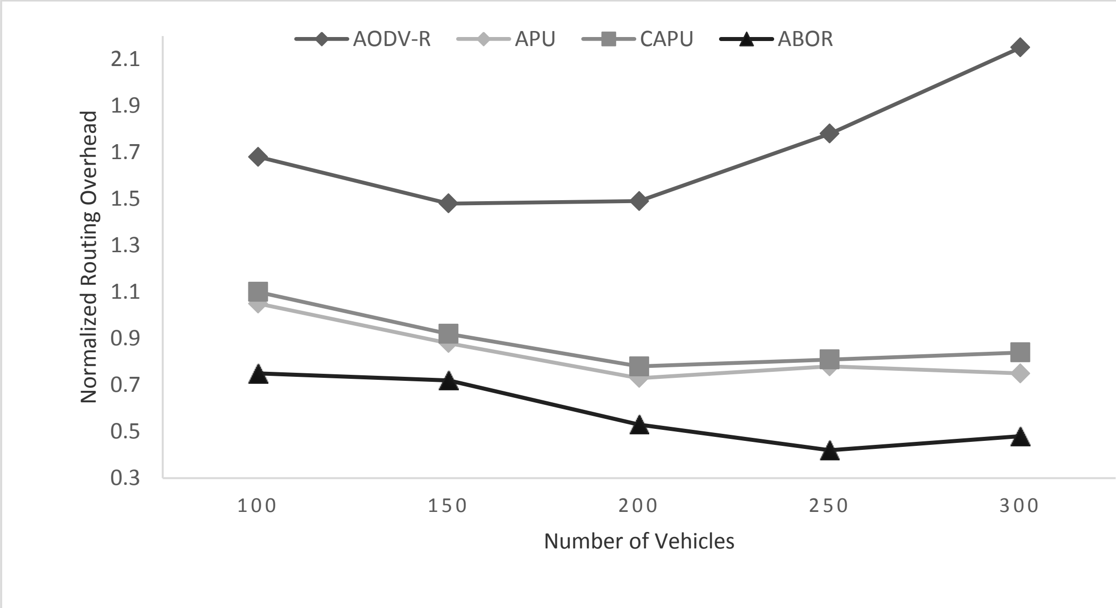

Figure 6: Normalized overhead for different number of vehicles

Performance Evaluation for Varying the Number of CBR Connection Pairs

In this series of tests, 200 vehicles are considered at speeds of 40 km/h and 80 km/h. The reason for using 200 vehicles is to reduce network partitioning probability. Figure 7 shows the packet delivery ratio for various number of CBR connection pairs. Considering the increase in the CBR connection pairs, the delivery ratios for the all routing protocols are reduced. The reason for decreasing the delivery ratio is the loss of packets due to the limited buffer space. Also, with increasing traffic flow from the source to different destinations, the chances of contention in channel is increased. These two issues reduce the package delivery ratio for the three routing methods. However, the proposed approach, given the reduction in the beacon sending rates in the first rule and the upgrading of the characteristics of nodes in the path of forwarding data packets, reduces the number of beacon packets and makes efficient use of bandwidth while maintaining the accuracy of the topology. This reduces the chances of collision and contention, as a result the delivery ratio increases. According to Figure 7, performance of the proposed method (ABOR) in different traffic flows is improved on average by 21% compared to the APU method, by 15% compared to the CAPU method, and by 36.4% compared to the AODV-R method.

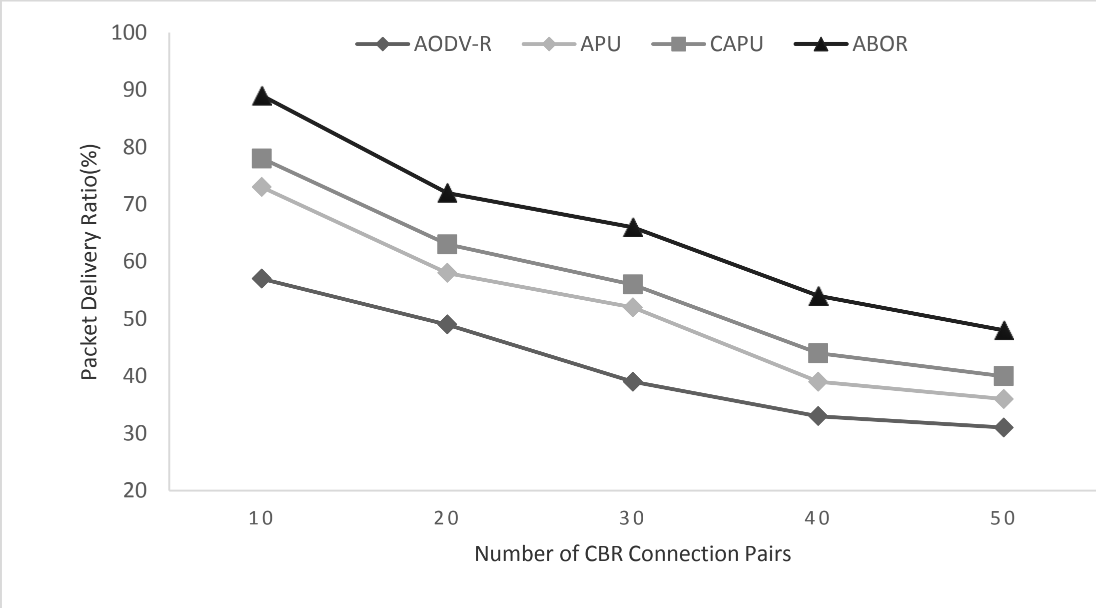

Figure 7: Packet delivery ratios for different number of traffic flows

Table 10 shows the delivery ratio of the proposed method compared with DV-CAST and the method in [22]. As shown in table, increasing the CBR connection pairs, the delivery ratios for the all routing protocols are reduced. Based on the results shown in this Table, the proposed method has improved the packet delivery ratio on average by 20% and 8% compared to the DV-CAST protocol and the method implemented in [22], respectively.

Table 10. Packet delivery ratios for different number of traffic flows

Protocol / No. of Vehicles	10	20	30	40	50
DV-CAST	81	68.4	61	56	41
Angle-Based [22]	87	75	69.2	62.5	49
ABOR	**94**	**83**	**74**	**65.8**	**53**

Figure 8 shows the delay for different flows at different speeds. With increasing the number of traffic flows, the delay is increased for all methods. This can happen due to network partitioning or buffer overflow due to increased packet-forwarding rates. Given that the partitioning effect of the network in this experiment is decreased, in the case of increasing traffic flows there is buffer overflow due to the limited size of buffer space. This also increases the delay. Despite the increase in the delay, our proposed design causes 55%, 50%, and 78% higher reductions compared to the APU, CAPU, and AODV-R methods, respectively.

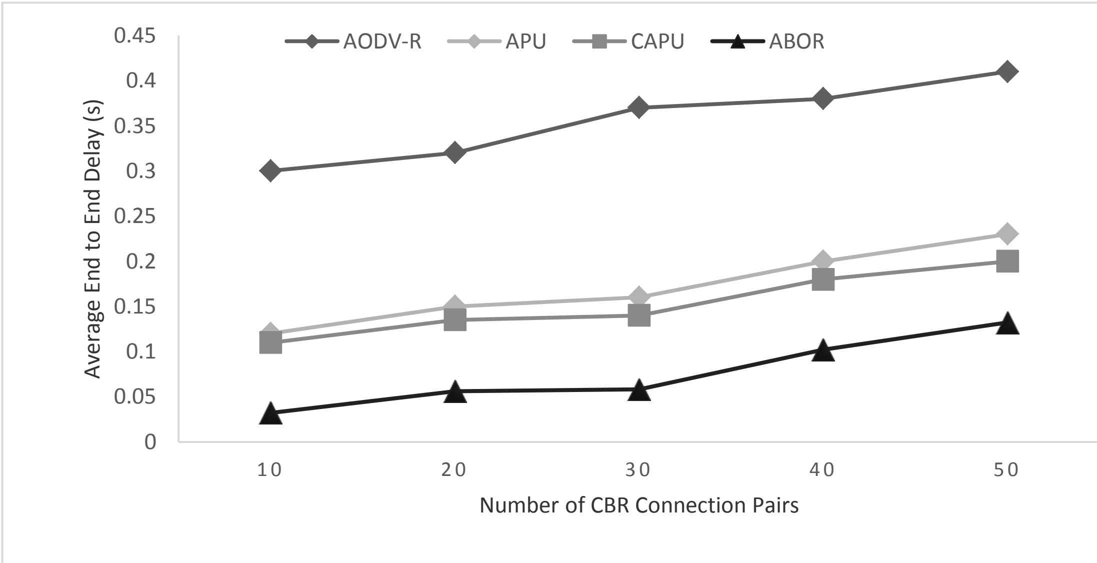

Figure 8: Average end to end delay for different number of traffic flows

Table 11 shows the average end-to-end delay for different traffic flows. Based on aforementioned explanations, the proposed method has a better performance than the other two methods. According to the results shown in this Table, the proposed method has reduced the end-to-end delay on average by 43% and 20.9% compared to DV-CAST and method in [22], respectively.

Table 11. Average end to end delay (second) for different number of traffic flows

Protocol / No. of Vehicles	10	20	30	40	50
DV-CAST	0.048	0.061	0.079	0.098	0.123
Angle-Based [22]	0.041	0.049	0.066	0.082	0.108
ABOR	**0.025**	**0.039**	**0.058**	**0.071**	**0.093**

Figure 9 compares the beacon packets generated in the three routing protocols. As shown in Figure 9, upon increasing the traffic flow from 10 to 30, the beacon packets are increased and tend to be stable due to the deployment of the second rule and the participation of the candidate forwarding set in sending the beacon messages. Despite the increase in the number of transmitted beacons, ABOR method decreases the number of beacon packets on average by 23%, 35% and 53% more than the APU, CAPU, and AODV-R methods, respectively.

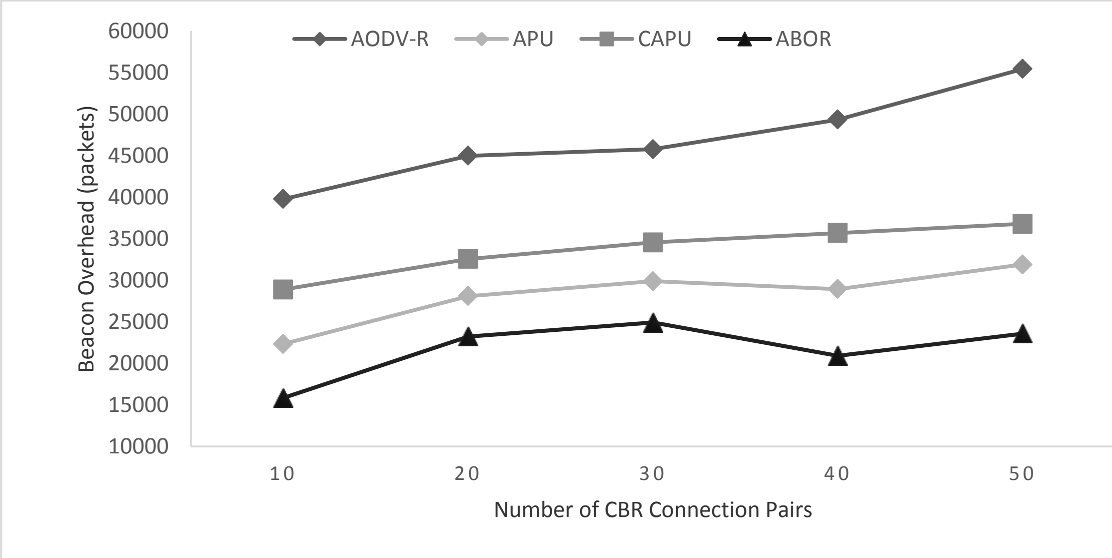

Figure 9: Number of beacon generated for different number of traffic flows

Table 12 shows the number of beacon packets produced in terms of the different traffic flows. As can be seen in this Table, number of beacon packets generated in DV-CAST and method in [22], in different scenario are constant. According to the results shown in this Table, the proposed method decreases the number of beacon packets on average by 44.9% compared to both DV-CAST and method in [22].

Table 12. Number of beacon (packet) generated for different number of traffic flows

Protocol / No. of Vehicles	10	20	30	40	50
DV-CAST	60000	60000	60000	60000	60000
Angle-Based [22]	60000	60000	60000	60000	60000
ABOR	**21834**	**33664**	**36643**	**34490**	**38654**

Finally, Figure 10 shows the normalized routing overhead (NRO) in the four routing protocols. As can be seen, the APU, CAPU and AODV-R methods significantly reduce NRO when the traffic flow increases from 10 to 30. However, ABOR method, despite the increasing number of sent beacon messages, due to increase in the number of nodes that forwarding set rule (second rule) can be applied, provides much less routing overhead than the APU, CAPU, and AODV-R methods even at high number of CBR connection pairs. This is because, according to the second rule of ABOR (algorithm (2)), the nodes that have persistently higher ranks in the different forwarding sets (two consecutively received data packets), do not take any action (the beacon message is not sent). On the other hand, with increasing the number of traffic flows, the probability that number of nodes in both of forwarding sets to be similar, will increase. Therefore, by employing the second rule in the proposed method, the nodes that have persistently higher ranks in the forwarding set, avoid sending beacon messages. Thus, the number of beacon messages will be decreased, which leads to less routing overhead. Considering Figure 10, the proposed method reduces the normalized routing overhead on average by 33%, 40%, and 68% compared to the APU, CAPU, and AODV-R methods, respectively. Table 13 compares the normalized routing overhead in the proposed method with DV-CAST and the method in [22]. As shown in this Table, the normalized routing overhead in the proposed method is decreased on average by 53.4%, and 51.7% compared to DV-CAST and method in [22], respectively.

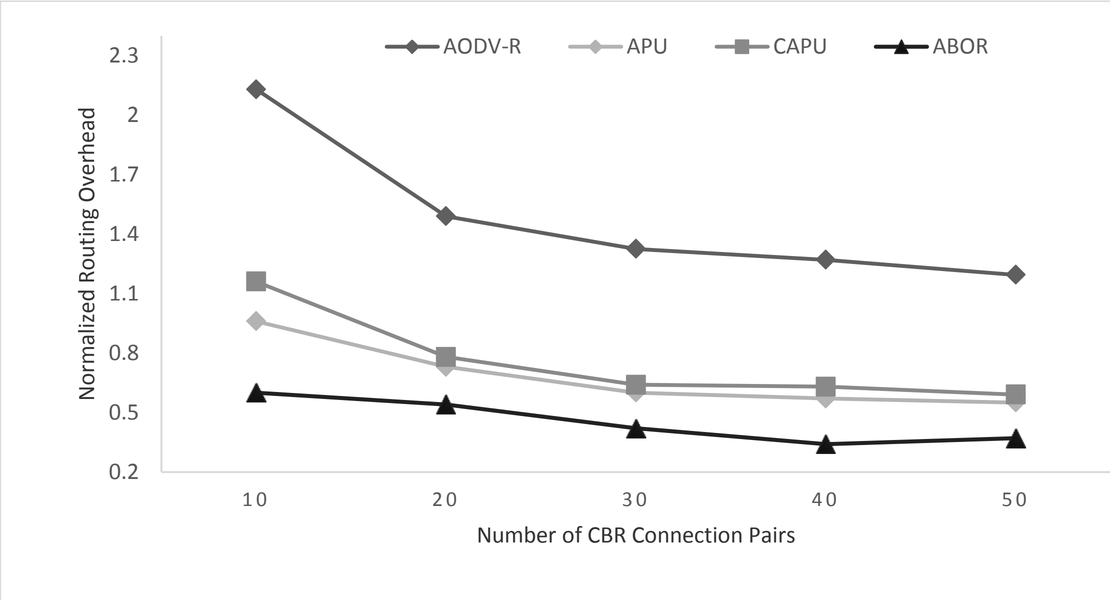

Figure 10: Normalized overhead for different traffic flows

Table 13. Normalized overhead for different traffic flows

Protocol / No. of Vehicles	10	20	30	40	50
DV-CAST	2.33	1.28	0.99	0.81	0.93
Angle-Based [22]	2.07	1.17	0.87	0.72	0.78
ABOR	**0.88**	**0.66**	**0.55**	**0.44**	**0.51**

The above simulation results indicate that the proposed adaptive beacon broadcasting has improved all aspects of quality of service (QoS) in ad hoc networks. Its particular importance is perhaps its lower overhead for different traffic flows. This can increase traffic flows, as well as increasing real traffic connections and lowering end-to-end delay, which all are instrumental in delivering high quality real traffic such as video streaming over ad hoc networks [32].

Conclusion

One of the challenges in VANET communications, is using periodic beacon messages in the fixed time intervals. In this regard, beacon's adaptive schemes emerged as an important issue for providing good Quality of Service and positional accuracy of vehicles. This paper presents a beacon update strategy in an opportunistic routing environment, which is adaptive to the inter-vehicle network characteristics (vehicle speed and direction) and the traffic flow. The proposed method is based on two rules. The first rule uses the estimation of the lifetime of communication links to send beacon messages. By employing this rule, the beacon-forwarding rates, is adapted to the characteristics of inter-vehicle networks and different environments (sparse and dense). In this strategy, to maintain the accuracy of the positions of vehicles, a positioning mechanism is used to obtain the positions. The second rule deals with the nodes in the forwarding set of received data packets. By using this rule, the node which receives two consecutive packets and is among the high ranked nodes of forwarding set of the packets avoids sending beacons in the next transmission interval. In the first test, throughout extensive simulations, it has been shown the proposed method for a varying number of vehicles increases the packet delivery ratio on average by 20%, 11.7%, and 33.6%; reduces average end-to-end delay by 64%, 59%, and 82%; reduces number of beacon messages by 19%, 30%, and 41% and decreases normalized routing overhead by 30%, 35%, and 66% compared to the APU, CAPU, and AODV-R methods, respectively. Also, for a different traffic flow the proposed method increases packet delivery ratio on average by 21%, 15%, and 36.4%; reduces average end-to-end delay by 55%, 50%, and 78%; decreases number of beacons sent by 23%, 35%, and 53%, and normalized routing overhead is decreased by 33%, 40%, and 68% compared to the APU, CAPU, and AODV-R methods, respectively. In the second experiment, it has been shown the proposed method for a varying number of vehicles increases the packet delivery ratio on average by 14%, and 6.8%; reduces average end-to-end delay by 32.3%, and 21.1%; reduces number of beacon messages by 48.2%, and 48.2%, and decreases normalized routing overhead by 48%, and 43.7%, compared to DV-CAST, and method in [22], respectively. Also, for a different traffic flow the proposed method increases packet delivery ratio on average by 20%, and 8%; reduces average end-to-end delay by 43%, and 20.9%; decreases number of beacons sent by 44.9%, and 44.9%, and normalized routing overhead is decreased by 53.4%, and 51.7%, compared to DV-CAST and method in [22], respectively. Some of future works in the field of adaptive beacon broadcast in opportunistic routing strategy for VANETs may include the following aspects:

- Using different urban scenarios and different mobility models and considering the impacts on the beacon transmission rates and protocol performance during data dissemination.
- Separately analyzing each rule in ABOR method and verifying their impacts on the accuracy of routing and quality of service such as delivery rate and end to end delay.
- Proposing a mathematical model to illustrate the effect of the forwarding set on the routing overhead and the accuracy of positional information of the nodes that are along the data forwarding path.

Reference

[1] M. Ren, L. Khoukhi, H. Labiod, J. Zhang, and V. Veque, “A mobility-based scheme for dynamic clustering in vehicular ad-hoc networks (VANETs),” Vehicular Communications, vol. 9, pp. 233-241, 2017.

[2] N. Chakchouk, “A Survey on Opportunistic Routing in Wireless Communication Networks,” IEEE Communications Surveys & Tutorials, vol.17, no. 4, pp. 2214-2241, 2015.

[3] X. Zhang, X. Cao, L. Yan, and D .K.Sung, “A Street-Centric Opportunistic Routing Protocol,” IEEE Transactions on Mobile Computing, vol. 15, no. 7, pp. 1586-1599, 2016.

[4] C. Wu, X. Chen, Y. Ji, F. Liu, S. Ohzahata, T. Yoshinaga, and T. Kato, “Packet Size-Aware Broadcasting in VANETs With Fuzzy Logic and RL-Based Parameter Adaptation,” IEEE Access, vol. 3, pp. 2481-2491, 2015.

[5] O. Rehman, and M. Ould-Khaoua, and H. Bourdoucen, “An adaptive relay nodes selection scheme for multi-hop broadcast in VANETs,” Computer Communications, vol. 87, pp. 76-90, 2016.

[6] C. Wu, S. Ohzahata, and Y. Ji, “Joint Fuzzy Relays and Network-Coding-Based Forwarding for Multihop Broadcasting in VANETs,” IEEE Transactions on Intelligent Transportation Systems, vol. 16, no. 3, pp. 1–13, 2015.

[7] C. Wu, S. Ohzahata and T. Kato, "VANET broadcast protocol based on fuzzy logic and lightweight retransmission mechanism," IEICE transactions on communications, vol. 95, no. 2, pp. 415-425, 2012.

[8] D. Couto, D. Aguayo, J. Bicket, and R. Morris, "A high throughput path metric for multi-hop wireless routing," in Proc. ACM/IEEE 9th Annual International Conference Mobile Computer Networks, pp. 134–146, 2003.

[9] S. Biswas and R. Morris, "ExOR: Opportunistic multi-hop routing for wireless networks," in Proc. ACM SIGCOM Computer Communication Review, vol. 35, no. 4, pp. 133–144, 2005.

[10] X. Cai, Y. He, C. Zhao, L. Zhu, and C. Li, "LSGO: Link state aware geographic opportunistic routing protocol for VANETs," EURASIP Journal on Wireless Communications and Networking, vol. 2014, no. 1, pp. 1–10, 2014.

[11] R. Draves, J. Padhye, and B. Zill, "Routing in multi-radio, multihop wireless mesh networks," in Proc. ACM Mobile Computing and Networking, pp. 114–128, 2004.

[12] M. Naderi, F. Zargari, V. Sadatpour, and M. Ghanbari, "A 3-Parameter Routing Cost Function for Improving Opportunistic Routing Performance in VANETs," Wireless Personal Communications, vol. 97, no. 1, pp. 109-123, 2017.

[13] M. Eiza and Q. Ni, "An evolving graph-based reliable routing scheme for VANETs," IEEE Transaction on Vehicular Technology, vol. 62, no. 4, pp. 1493–1503, 2013.

[14] Q. Chen, S. Kanhere, and M. Hassan, "Adaptive position update for geographic routing in mobile ad hoc networks," IEEE Transactions on Mobile Computing, vol. 12, no. 3, pp. 489–501, March 2013.

[15] M. Chaqfeh and A. Lakas, "A novel approach for scalable multi-hop data dissemination in vehicular ad hoc networks," Ad Hoc Networks, vol. 37, pp. 228-239, 2015.

[16] A. Boukerche, C. Rezende, and R. W. Pazzi, "Improving neighbor localization in vehicular ad hoc networks to avoid overhead from periodic messages," in Global Telecommunications Conference, GLOBECOM 2009, IEEE, pp. 1–6, 2009.

[17] C. Sommer, O. K. Tonguz, and F. Dressler, "Traffic information systems: efficient message dissemination via adaptive beaconing," IEEE Communications Magazine, vol. 49, no. 5, pp. 173–179, 2011.

[18] R. S. Schwartz, A. E. Ohazulike, C. Sommer, H. Scholten, F. Dressler, and P. Havinga, "On the applicability of fair and adaptive data dissemination in traffic information systems," Ad hoc Networks, vol. 13, pp. 428–443, 2014.

[19] Z. Qiang, Z. Hongli, D. Xiaojiang, Z. Zhigang and S. Shen and J. Ru, "Contention-based adaptive position update for intermittently connected VANETs," Global Communications Conference (GLOBECOM), 2014 IEEE, pp 51-56, 2014.

[20] S. A. Ali Shah, E. Ahmed, F. Xia, A. Karim, M. Shiraz, and R. MD Noor, "A Survey: Adaptive Beaconing Approaches for Vehicular ad hoc Networks," IEEE Systems Journal, vol. 12, no. 2, pp. 1263-1277, 2018.

[21] O. Tonguz, N. Wisitpongphan, F. Bai, "DV-CAST: A distributed vehicular broadcast protocol for vehicular ad hoc networks," IEEE Wireless Communication, vol. 20, no. 17, pp. 47-57, 2010.

[22] E. G-Lozano, C. Campo, C. Garcia-Rubio, and A. Cortes-Martin, "Bandwidth-efficient techniques for information dissemination in urban vehicular networks," In Proceedings of the 11th ACM symposium on Performance evaluation of wireless ad hoc, sensor, & ubiquitous networks (PE-WASUN '14). ACM, New York, NY, USA, pp. 61-68, 2014.

[23] H. Saleet, O. Basir, R. Langar, and R. Boutaba, "Region-based location service management protocol for VANETs," IEEE Transactions on Vehicular Technology, vol. 59, no. 2, pp. 917–931, 2010.

[24] M. H. Eiza, Q. Ni, T. Owens, and G. Min, "Investigation of routing reliability of vehicular ad hoc networks," EURASIP Journal Wireless Communication Networks, vol. 2013, no. 1, pp. 179, Jul. 2013.

[25] The Network Simulator: ns2, Accessed: 2015-01-28. [Online]. Available: http://www.isi.edu/nsnam/ns/

[26] A. Pardo Calvo, J. Carlos Cano, T. Calafate, P. Manzoni, M. Fogue, "USER GUIDE: CityMob for Roadmaps, Teruel, March 2011]," Available**:** www.grc.upv.es/Software/c4r/usermanual.pdf.

[27] Sumo: Simulation of Urban Mobility, Accessed: 2015-01-28. [Online]. Available:

www.dlr.de/ts/sumo/en/

[28] S. Krauss, P. Wagner, and C. Gawron, "Metastable states in a microscopic model of traffic flow," Physical Review E, vol. 55, no. 5, pp. 5597–5602, 1997.

[29] S D. Krajzewicz, G. Hertkorn, C. Rossel, and P. Wagner, "SUMO (Simulation of Urban MObility), An open-source traffic simulation," in Proc 4th MESM, Sharjah, UAE, Sep. 2002, pp. 183–187.

[30] S. A. H. Tabatabaei, M. Fleury, N. Qadri, M. Ghanbari, "Improving propagation modeling in urban environments for vehicular Ad Hoc networks," IEEE Transactions on Intelligent Transportation Systems, (Special Issue on Exploiting Wireless Communication Technologies in Vehicular Transportation Systems), vol. 12, no. 3, pp. 705-716, 2011.

[31] C. Wu, S. Ohzahata, and T. Kato,"Flexible, Portable, and Practicable Solution for Routing in VANETs: A Fuzzy Constraint Q-Learning Approach," IEEE Transactions on Vehicular Technology, vol. 62, no. 9, pp. 4251–4263, 2013.

[32] N. N. Qadri, M. Fleury, M. Altaf, M. Ghanbari, "Multi-source video streaming in a wireless vehicular ad hoc network," IET Communications, Special issue, vol. 4, no. 11, pp.1300-1311, (July 2010).

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