An Efficient Overload Relay Control Mechanism based Routing Protocol for Connecting VANET to Internet over IEEE 802.11p

First D.Abada[1], Second A.Massaq[2], Third A.Boulouz[3]

Abstract— The connection of vehicular ad hoc network (VANETs) to Internet is typically established by roadside units (RSUs). Link stability and number of hops are often used as the primary metrics in the relay selection to find the route between vehicles and these RSUs. In case of high vehicles density, basing only on those features, one vehicle may be selected as relay for multiple vehicles and if the number of relay requests exceeds the service capacity of this vehicle, it might get overloaded, which will increase bottlenecks in the network, and affect the connection throughput of VANETs due to continues dropping packets and frequent MAC retransmissions. In this paper, we extend an existing stability based routing protocol which connects VANETs to the Internet via IEEE 802.11p technology with an efficient overload relay control mechanism, with the objective to distribute uniformly traffic load in the network and make efficient use of network bandwidth. The proposed overload relay control based routing protocol reduces significantly the routing overhead and the collision in the network basing on contention-based-forwarding (CBF) for broadcasting control messages. The simulation results show that the proposed protocol enhances throughput, and decreases the packet loss and overhead.

Index Terms— Vehicular ad hoc Networks, routing, link stability, overload relay control, relay selection, CBF

1 Introduction

MANY wireless networking technologies such as WiMAX [1], 3G/4G/5G cellular networks [2], IEEE 802.11-based vehicular ad hoc networks (VANETs) named IEEE 802.11p and so on, are used now to achieve Internet connectivity for VANETs. IEEE 802.11p [3, 4], also known as Wireless Access in Vehicular Environment (WAVE) protocol is an enhancement to the 802.11 physical layer (PHY) and medium access control sub-layer (MAC) to support high vehicular mobility, faster topological changes, and requirements of high throughput in VANETs communication. A halved data rate values of 802.11a are available in 802.11p ranging from 3 to 27 Mbps, and a short-range radio communication of approximately 300m, it divided into seven 10 MHz-wide channels available in the frequency band of 5.85-5.925 GHz allocated for the Dedicated Short Range Communication (DSRC) in vehicle to infrastructure (V2I) and vehicle-to-vehicle (V2V) communication. One is the control channel used for broadcasting transmissions and establishing communications whereas the other six remaining are service channels used to exchange data.

To provide Internet connectivity to VANETs which is characterized with high dynamic topology and frequent route failure, an efficient routing protocol must be designed. Most existing relay selection schemes focus usually on vehicle parameters such as speed, position, direction, and distance to select the furthest relay with high stability in order to connect vehicles to Internet via most stable and fewest hop routes. Nevertheless, in congested scenarios one vehicle may be selected as a relay for multiple vehicles, when the number of relay requests exceeds the service capacity of this vehicle it might become overloaded, thus, the dropping packets, enforcing retransmission and large contention delay may be happened in the network. In this paper, we have extended an existing stability based routing protocol proposed by [5], with an efficient overload relay control mechanism (ORCM). The objectives of this mechanism are to reduce as much as possible to have overload relays which cause bottlenecks in the network, to make efficient use of network bandwidth and to choose highest throughput routes.

The rest of the paper is structured as follows. In Section II we present the related work. Our proposed work is detailed in Section III. The performance of our protocol is discussed in Section IV. Finally, we give the conclusion and future work directions in Section V.

2 Related Work

There are several contributions in the open literature for connecting VANETs to the Internet. The proposed protocols to extend the Internet to VANETs may be classified into two categories, the first based on the stationary gateways which use fixed RSUs that are installed along the route and serve as Internet access point. Each vehicle can communicate directly with the RSU or via multi-hop, the second based on the mobile gateways, in this approach, only some vehicles are equipped with one or more interfaces and act as gateways to other network vehicles.

In the research work [5], the authors proposed an efficient routing protocol for connecting vehicular networks to the Internet which uses the characteristics of vehicle movements to predict the future behavior of vehicles and to select a route with the longest lifetime. The proposed protocol aims to broadcast the advertisement messages through multi-hops in the predefined geographic zone and uses a distributed manner to select relay for the re-broadcasting message, this approach will connect VANETs to Internet on minimizing overhead without flooding network through most stable route. However, in congested scenarios, this approach suffers from bottlenecks because the protocol does not adopt a scheme to use bandwidth and to control overload relay control. In order to surpass this problem, we suggested a new overload relay control mechanism in order to decrease bottlenecks in the network.

In the paper [6] the authors proposed a new approach which integrates VANET with 3G technology in order to connect VANET to the Internet. The proposed approach is based on two mechanisms, a dynamic technique to cluster vehicles according to defined criteria and an adaptive management of mobile gateways. The clustering is performed on two steps, the first step consists of clustering vehicles depending on their relative direction to 3G active regions of base station, the second step for clustering consists to form sub-clusters by the mobile gateways that are within range in each other and that have the received strength signal (RSS) with respect to the base station is greater than a defined limit. The discovery gateways can be done proactively by broadcasting periodically advertisement messages from gateways or reactive by broadcasting solicitation message from sources vehicles. A mobile gateway is selected from other if the RSS with respect to the base station and the stability of the link relative to the source vehicle are higher than the fixed threshold that is specific to each cluster and these two parameters are also better than those of other gateways. This approach avoids saturating base stations allowing just certain vehicles to communicate directly with them. The clustering also allows vehicles to better manage the inter-vehicle communications and thereby mitigate the effect of the redundancy control messages. Also coupling the high data rates of 802.11p-based VANET and the wide coverage area of 3G/UMTS allows vehicles to communicate with UMTS base station using high data transmission rate via large distance. The proposed approach does not implement load control mechanism that can be very useful to avoid saturating a given gateway.

The BCRPV [7] (Broadcast Control-Based Routing Protocol for Internet Access in VANETS) connects the vehicles on the road through the Internet mobile gateways with the objective to make efficient use of the network bandwidth. The establishment of routes is done on a reactive approach, and the geographical information exchanged locally is used to decrease the effect of the flooding network of the reactive approach. To select one node as the relay, the protocol based on the number of gateways in its immediate vicinity and its speed and position relative to the source node to improve the stability of the links. When a node (gateway or ordinary vehicle) of the network is overloaded, it broadcasts a message to ask some nodes using as the relays (or gateway) to try to redirect their traffic to other nodes. In this work, the authors adopted an explicit approach to prevent having overload relays in the network. In this work, the authors introduce a mechanism for controlling overload network, but they don't use an efficient relay selection mechanism, and for gateway discovery, they adopted just reactive approach but in VANETs the hybrid gateway discovery is a most appropriated.

3 Relay Selection Scheme

3.1 Relay Selection Metrics

- Link stability metric estimation

Guarantying to vehicles continuous connections to the Internet is the main objective in VANETs, due to the dynamicity of vehicular networks. For this purpose, we interest for an important parameter in mobile networks called link expiration time, in order to select most stable routes between vehicles and Internet gateway.

The link expiration time (LET) is the estimated period that two nodes maintain the connection between them in the VANET network. In this work we will predict a LET using the location and mobility information provided by GPS [7], for this, we suppose that vehicles are equipped with GPS devices, therefore, if we know position, speed and direction parameters of two neighbor's nodes, we can predict the period of time that the connection can be maintained between these two nodes. The objective of this metric is to select a most stable link between two vehicles. This parameter will be more effective than the others, due to the nature of our protocol.

We consider two vehicles i and j which identify by coordinates (x_i, y_i) and (x_j, y_j), and move in directions θ_i, θ_j $(0 \le \theta_i, \theta_j \le 2\pi)$ with speed v_i and v_j at an instant, respectively, and we consider also R be the wireless transmission range of nodes. According to [8] the LET can be estimated basing on the following formula:

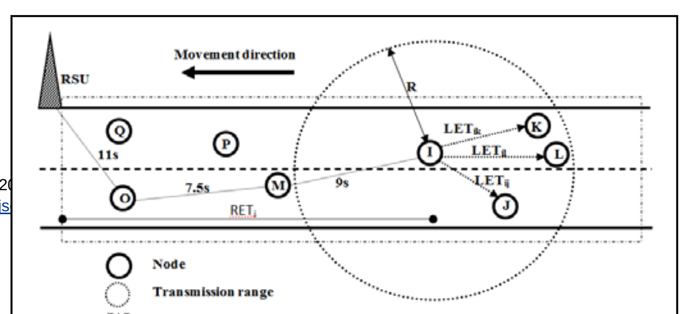
$$LET = \frac{-(ab+cd)+\sqrt{(a^2+b^2)R^2-(ad-bc)^2}}{a^2+b^2} \tag{1}$$

where,

$a = v_i \cos\theta_i - v_j \cos\theta_j$
$b = x_i - x_j$
$c = v_i \sin\theta_i - v_j \sin\theta_j$
$d = y_i - y_j$

Let $R_k = \{(V_0, V_1), (V_1, V_2), ...(V_{N-2}, V_{N-1})\}$, the route from the RSU to the source vehicle, and in each route Rk there are N-1 links between N vehicles, where V_0 is the RSU and V_{N-1} is the source vehicle.

$$RET(R_k) = \underset{i=1}{\overset{N-1}{Min}} LET_{V_{i-1}V_i} \tag{2}$$



For example in Figure, the vehicles O and M are selected as relays to construct the route from RSU to vehicle I. The LET of each link is written over the link. RETI is its route expiration time which equals 7.5s in this case. The vehicle I in this example is selected as a next relay and will rebroadcast the message to its neighbors such as J, K, and L.

- Vehicle traffic load metric estimation

In high vehicles density scenarios in VANET, one vehicle may be selected as a relay for multiple vehicles, if the number of relay requests exceeds the service capacity of the vehicle, it might get overloaded, and eventually dropping the packets and enforcing re-transmissions. The objective of this work is to avoid as much as possible, letting vehicles relays becoming overloaded in the network. For this purpose, we consider two parameters which are able to give local information about traffic load directing to vehicles. In this paper, we take advantage to idle channel rate and average queue occupancy of vehicles.

As explained in [9], [10], one vehicle can observe the idle time or busy time within an observation time interval. The idle time of channel T_{idle} can be computed by one station, it simply keeps counting the amount of time a channel is busy (or idle) during an observation interval time T_{OI}. As it is illustrated in Fig. 2 each vehicle adds all the idle periods δ to compute the total idle time during a time of interval OI.

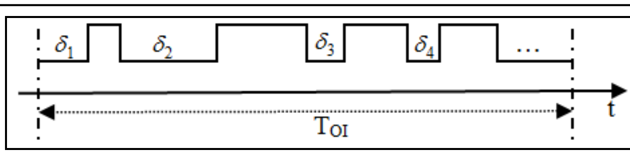


Fig. 2. Computing channel availability.

The channel availability noted Γ can be computed as follows:

$$\Gamma = \frac{T_{idle}}{T_{OI}} = \frac{\sum_{k=1} \delta_k}{T_{OI}} \quad (3)$$

The queue occupancy noted Q is computed as follows:

$$Q = \frac{L}{C} \quad (4)$$

where L is the current queue length and C is a maximum number of packets that can be buffered in the queue for each node. To estimate accurately queue occupancy, we compute its average $\overline{Q}$ through an exponential weighted moving average (EWMA) with smoothing factor α_Q as shown in the following formula:

$$\overline{Q} = \alpha_Q \times Q(t) + (1 - \alpha_Q) \times \overline{Q}(t-1) \quad (5)$$

3.2 Relay Selection And Rebroadcasting

The relay selection scheme as in [5] is completely in a distributed method. Each vehicle can know from the supported information in received message, if it will become relay or no. This method helps in reducing the overhead and collisions in the network, future broadcast messages will not flood the network, and this prevents broadcast storms from happening. The selection of the next hop is performed by mean of the Contention Based Forwarding (CBF) suggested in [11]. As explained in [5], the contention process makes use of biased timers.

For computing a waiting time to set a timer in CBF, we need a mathematical function, which lies each element in]0,∞] to its image in]0,1]. For this purpose, we take advantage to an exponential function that satisfies the given criteria proposed in [5].

The function noted *S*, is used to measure the stability of link formed between two vehicles *i* and *j*, and it depends to LET_{ij} as follows:

$$S = 1 - \exp\left(-\frac{LET_{ij}}{\gamma}\right) \quad (6)$$

where γ is the constant that define the rate augmentation of function. More than γ takes small values, more than functions S moves quickly to 1.

Using LET as the routing metric, we will be sure that the route selected is the most stable. This will improve certainly network performance especially in term of data throughput. However, such a path might have many number hops than the shortest one. When packet relaying involves more hops, since the radio channel is shared among neighboring nodes in the network, it will increase medium access contention, interference, congestion, and packet collisions. Therefore, path length should also be considered when selecting a suitable path based on stability. For this purpose, we decide to combine function *S* with another metric called distance rate [12]. According to the authors, it allows a selection of the shortest path in term of hops. They defined it as follows:

$$D = \frac{d_{ij}}{R} \quad (7)$$

where dij is the distance between vehicle i (sender), and vehicle j (current receiver), and R is the transmission range of vehicles. The global function which will combine both routing metrics, LET and distance rate is defined based on weighted mean to reduce the effect of D as follow:

$$U = \alpha \times S + (1 - \alpha) \times D \quad (8)$$

where α may be selected in $\left]\frac{1}{2},1\right]$ to give more weight for U than D.

In order to prevent selecting overload relay, we will take into consideration the overload relay control metric in the relay selection scheme. To estimate this metric, we define new function noted W which combines the idle channel rate and the average queue occupancy based on the weighted mean. The idle channel rate represents the relative traffic load estimation in contrast of vehicle's neighbors, however, the average queue occupancy represents the local traffic load estimation of the vehicle.

$$W = \beta \times (1-\overline{Q}) + (1-\beta) \times \Gamma \quad (9)$$

where β may be selected in $\left]\frac{1}{2},1\right]$ to give more weight for $\overline{Q}$ than Γ.

For the contention over link stability and available traffic load, we set time of a waiting timer as:

$$t(U,W) = T \times (1-U) \times (1-W) \quad (10)$$

where T is a maximum forwarding time.

Due to the nature of our protocol which aims mainly to connect VANETs through the most stables routes, each vehicle before entering the competition to be relay must check that the LET computed with the source is above than a given threshold LETthresh. To avoid as much as possible letting relays becoming overloaded, each node must have a queue occupancy drops below than certain threshold Qthresh and idle channel rate is above then $\Gamma thresh$.

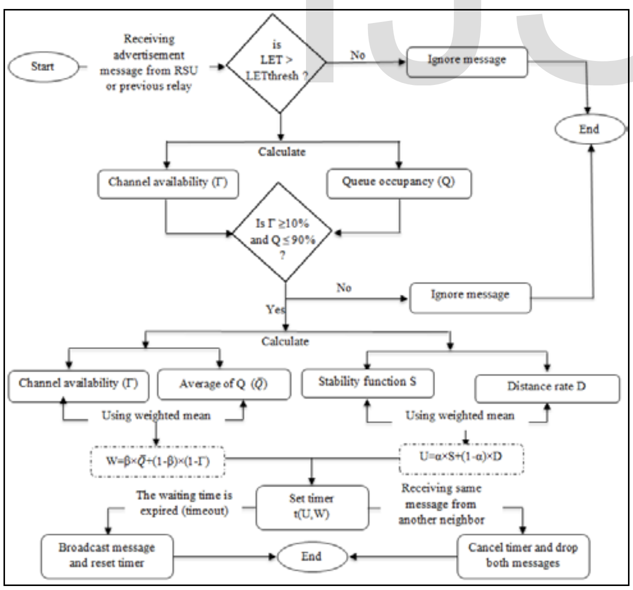


Fig. 3. Flowchart of relay selection scheme.

As detailed in Fig. 3 when receiving a message, a vehicle will wait for the amount of time that is computed by the timer, before re-broadcasting the message. If during this time it receives a message originated from the same gateway with the same sequence number (means that is another vehicle has retransmitted the message), it will cancel the timer and discard both messages. Otherwise, it rebroadcasts the message after the timer has expired, it becomes a relay and the message sent from this vehicle will suppress other vehicles.

4 Overload Relay Control Mechanism

The overload relay control mechanism (ORCM) can be divided into an implicit and an explicit approach. The integration of overload relay control metric in the relay selection scheme is considered as an implicit approach to decrease the overload relay in the networks. Even this integration, one relay may become overloaded during traffic changes, and it is unable to redirect traffic to another less overloaded relay. We aim to extend the ORCM with an explicit approach for reducing having overload relay in the network. ORCM requires that each vehicle verifies periodically its queue occupancy Q. If Q drops above than a certain threshold (Qthresh), the relay will broadcast an alert message to vehicles using it as next hop in order to request some vehicles to redirect its traffic for another relay. As shown in table 1, the alert message includes the speed, the location and the direction of the vehicle source of this alert message and a threshold of link expiration time (RETthresh) which is selected as the RET of the current route.

Upon receipt of the alert packet, a vehicle computes a lifetime value of the link to the source of the alert packet using formula 1. If this value is higher than the value of threshold RETthresh included in the alert packet, the vehicle keeps the source as next-hop, otherwise, it starts the process to elect another relay using the reactive RSU discovery approach which will describe in the next section.

TABLE 1
Alert Message Structure

Field	Description
Source	IP address of source of alert message
Speed	Speed of source of alert message
Location	Position of source of alert message
RETthresh	Threshold of route expiration time

5 Route to the RSU Discovery

5.1 Proactive Discovery Approach

Internet access is provided by gateways located in the long of road called Road Side Unit (RSU). To extend Internet connectivity to vehicles, they initially need to discover a route to communicate with them, for this, an efficient gateway discovery mechanism is required.

As proactive gateway discovery reduces delay and reactive discovery reduces signaling overhead, our work envisages a hybrid gateway discovery mechanism for VANET as in [5,13].

Each RSU broadcasts periodically a message called Road Side Unit Advertisement message (RSU_ADV) within its coverage. Similar to [5], before broadcasting, RSU includes in this message current parameters such as its address, relay address initialized by RSU address, message sequence number, geographic parameters of predefined broadcast zone, and estimated route expiration time (RET), the RET is initially set to large value. The gateway discovery aims at propagating this message using intermediates nodes in this zone. Each vehicle keeps a routing table to manage the different routes to different RSU. This routing table contains same fields as in [5] such as the route expiration time, next hop, message sequence number and the gateway address. When receiving a message, each vehicle acts as a router and attempts to update its routing table. If it does not have any entry with the address of the gateway from which the message was sent, it simply adds an entry to the routing table. If it already has an entry corresponding to the RSU address, it checks the message sequence number. Messages with higher sequence numbers have newer information and should be inserted into the table replacing the old information. However, if a message has the same sequence number as the entry in the routing table, we check to see if it arrived from a better route with greater route lifetime. In this case, the vehicle will update the routing table with the information extracted from the message. Routes are removed from the routing table when their lifetime expires.

5.1 Reactive Discovery Approach

If one vehicle doesn't receive any message from RSU or its neighbors, a reactive discovery must be executed. In this case, an RSU solicitation message (RSU_SOL) is broadcast by exactly the same mechanism as RSU_ADV until it is received by an RSU or any vehicle that is already aware of a route to an RSU. If a vehicle is already connecting to the RSU, it sends an unicast RSU_ADV message to the sender of the RSU_SOL message. Before sending an unicast RSU_ADV message, the vehicle compares its RET of its most stable route to the RSU with the RET integrated into the RSU_SOL message, the minimum of them is the value of the RET that will be included in the unicast RSU_ADV. On receiving the unicast RSU_ADV message, the vehicle updates its routing table. If one vehicle doesn't receive any message from RSU or its neighbors, a reactive discovery must be executed. In this case, an RSU solicitation message (RSU_SOL) is broadcast by exactly the same mechanism as RSU_ADV until it is received by an RSU or any vehicle that is already aware of a route to an RSU. If a vehicle is already connecting to the RSU, it sends an unicast RSU_ADV message to the sender of the RSU_SOL message. Before sending an unicast RSU_ADV message, the vehicle compares its RET of its most stable route to the RSU with the RET integrated into the RSU_SOL message, the minimum of them is the value of the RET that will be included in the unicast RSU_ADV. On receiving the unicast RSU_ADV message, the vehicle updates its routing table. It can happen that the source vehicle receives more than one replay from different RSUs or from the same RSU but with different routes, in this case, the most stable route will be selected. In case the tie, the route with the minimum number of the hop will be selected.

6 Performance Evaluation

To evaluate the performance of our proposed approach, we have implemented our routing protocol in Network Simulator NS2.33. We have compared the protocol developed recently in [5] for connecting VANETs to Internet noted SBRP (Stability Based Routing Protocol), which based only on movement parameters to measure link stability, with and without ORCM and the protocol M-AODV+ [14] which is an extension version of AODV+ [15] proposed to support the reliability of V2V communication in VANETs by enabling V2I and I2I communications as alternative communication links among vehicles when single hop or multi-hop communication in the network is not possible. We have performed some simulations in order to evaluate our proposed mechanism in term of packet delivery rate, end to end packet delay and overhead by investigating the impact of varying the mobility of nodes, the number of sources nodes.

6.1 Simulation Environment

In this present work, we have based on the papers [6]-[16] to give insights on some measurements of the IEEE 802.11p MAC and physical layer using NS2 [17]. The algorithm is simply implemented on the MAC layer of each vehicle. The data rate is fixed to 6Mbit/s. Using MOVE [18] and SUMO [19] we have created our highway scenario of 8000m with two lanes. The simulation period in this work is 460s and we wait for 100s after the beginning of the simulation as the warm up period. All vehicles move from the one end of the highway to the other end in the same direction and the number of vehicles sources is selected randomly to send CBR data at rate 20 packets/s to a node that is part of the wired network and is connected to all the base stations. To simulate both protocols we have scheduled RSU to broadcast the advertisement message every 5s in the predefined broadcast geographic zone which has been considered to be a circle with a radius of 1000m, and the message is broadcasted in the opposite movement of nodes. After a lot of experiments and analyze performed in [5], the adequate values of α , β and γ are given in table II which provides a summary of all simulation environment parameters.

TABLE 2
PARAMETERS VALUES IN THE SIMULATION

parameter	value
Mobility model	highway
Highway length	8km
Number of lanes	2
Maximum speed	10, 20, 30, 40 m/s
Number of nodes	200
Number of sources	20, 40, 60, 80
Number of RSUs	8
Distance between RSUs	1000 m
Simulation time	460 s
Pause time	100 s
Channel	Channel/WirelessChannel
Propagation model	Two Ray Ground
Network Interface	Phy/WirelessPhyExt
MAC	Mac/802_11Ext
Interface queue	Queue/DropTail/PriQueue
Antenna Type	Antenna/OmniAntenna
Interface queue	20
Transmission range	300 m
Routing protocol	SBRP and M-AODV+
Traffic type	CBR
Packet sending interval	0.05 s
Packet size	512 bytes
New parameters	$\alpha = 0.8$, $\beta = 0.7$, $\gamma = \frac{RET}{2}$ [5]
T_{OI}	1 s
T	0,00375 s [20]

To evaluate the performance protocols, we use the following metrics: average throughput, end to end delay and overhead.

- Packet Delivery Ratio (PDR) is the fraction of total number of packets received by the destination nodes to the total number of packets sent by the source nodes.
- End to End packet Delay (E2ED) is the average time required for each data packet sent from source vehicle to reach wired node.
- Normalized Routing Overhead (NRO) is the total number of control packets generated by each protocol per data packets delivered to the destination (wired node).

6.2 Simulation Results

In this section, we present the analyses of the performance of our approach SBRP with ORCM in contrast with routing protocol SBRP without ORCM and M-AODV+ [14]. In one side, to see the impact of varying number of the sources on network performance, we have fixed the maximum speed of vehicles to 30m/s and the number of vehicles is fixed to 200 vehicles. In the other side, in order to see the impact of changing maximum speed, we have chosen randomly 20 sources in 200 vehicles.

1. Packet delivery rate

First, we compare the performance of the routing protocols in term of packet delivery rate by changing the number of vehicular sources and the maximum speed of vehicles in the network.

The Fig. 4 depicts that the packet delivery ratio decreases as the number of sources increases for all protocols, this performance degradation can be explained by the fact that interference and congestion increased when the number of sources increased. Compared to the results in Fig. 5, we observe also that the PDR result gets worse for the three protocols, this is mainly due to the vehicle mobility increase. The Fig.3 and Fig.4 show that SBRP (with or without ORCM) presents better results in term of PDR compared to M-AODV+. This improvement is due to the fact that it considers link expiration time as relay selection metric, in order to choose most stable routes. This reduces frequent disconnections in the network, therefore losses are reduced consequently. As shown in the figures, the SBRP with ORCM improves significantly the PDR result in contrast with SBRP without ORCM. The reason behind this outperformance is that the chosen routes are those having higher bandwidth and the integration of ORCM reduces bottlenecks in the network, which will consequently reduce dropping packet.

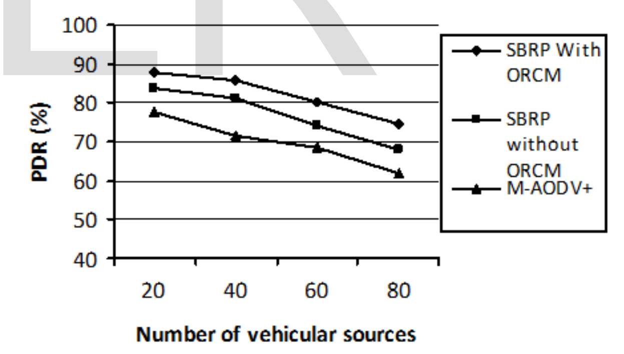


Fig. 4. PDR comparison under different number of vehicular sources.

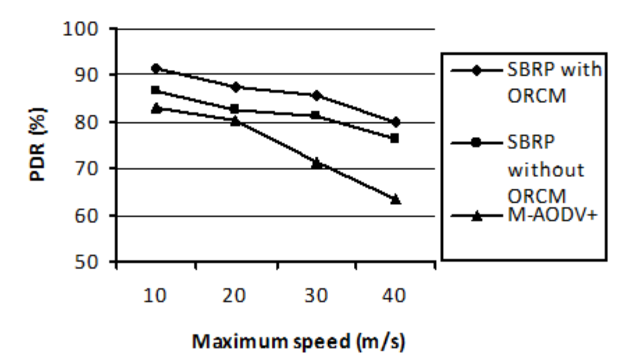


Fig. 5. PDR comparison under different maximum speed.

2. End to end delay

Secondly, we evaluate the performance of the routing protocols in term of the average end to end packet delay with increasing number of vehicular sources and maximum speed.

The Fig.6 and Fig. 7 depict that the average end-to-end delay experienced by data packets increases by increasing number of sources and maximum speed respectively. We observe in the figures that the SBRP (with or without ORCM) provides considerably lower delays compared to M-AODV+. Results in figures show that the average end-to-end delay of SBRP without ORCM is more important than that presented by SBRP with ORCM. The reason of improved end-to-end delay performance by the SBRP with ORCM compared with SBRP without ORCM is that when the ORCM is added to the protocol, it reduces bottlenecks which will prevent frequent retransmissions and longer MAC queues. This avoids the time spent for retransmissions and packets waiting in the queue.

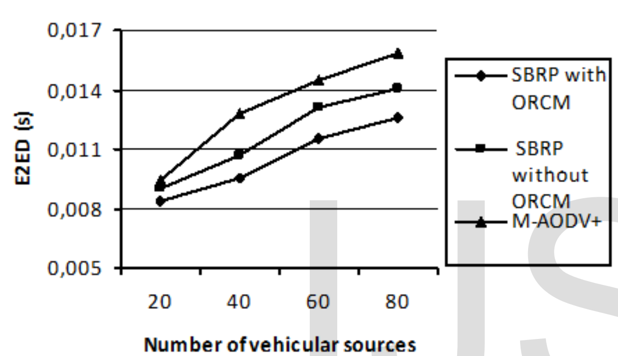


Fig. 6. E2ED comparison under different number of vehicular sources.

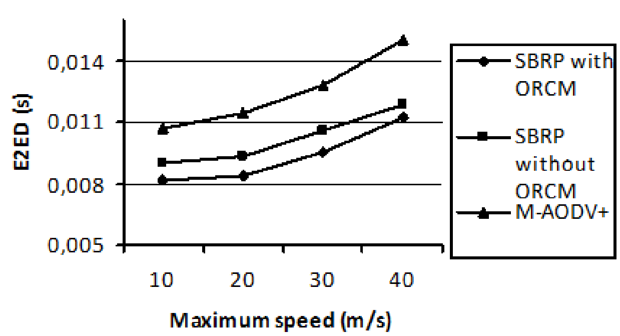


Fig. 7. E2ED comparison under different maximum speed.

3. Normalized routing overhead

Finally, we present the results of normalized routing overhead generated by routing protocols SBRP (with and without ORCM) and M-AODV+, when varying the number of vehicular sources and maximum speed respectively.

As shown in figure Fig.8 and Fig.9, we observe that the protocol SBRP reduces significantly the overhead. However, the M-AODV+ generates more overhead when the number of sources increases and when the maximum speed increases. The overhead generated by SBRP increases slightly, while it increases considerably with M- AODV+. This is due to the fact that the protocol SBRP uses an efficient relay selection scheme which selects only some particular relay to rebroadcast control message. This minimizes control messages required to discover the routes and selects more stables routes. It is shown also that the SBRP with ORCM generates a smaller overhead comparing it with SBRP without ORCM.

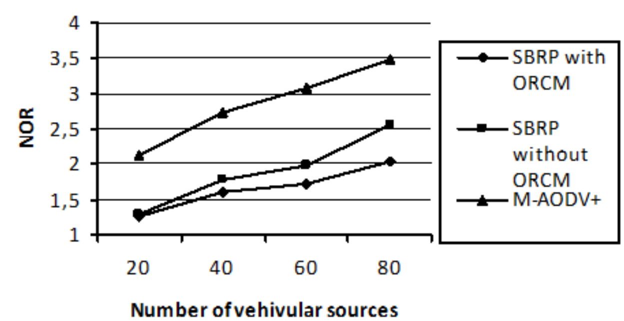


Fig. 8. NOR comparison under different number of vehicular sources.

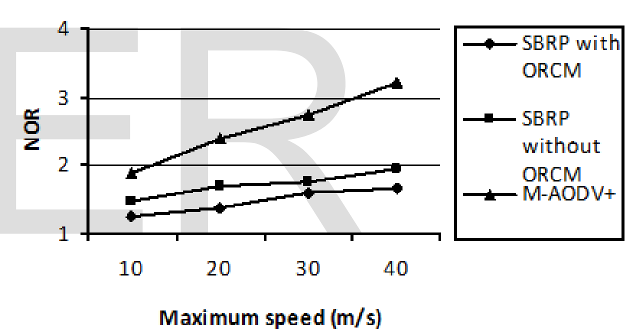


Fig. 9. NOR comparison under different maximum speed.

7 Conclusion

In this paper, we have proposed a new mechanism for overloading relays control, in order to lighten overloaded relays in the network. Indeed, we have included it in an existing stability based routing protocol which connects moving vehicles to Internet through RSUs. The simulation results show that when the ORCM is integrated, the protocol improves significantly network performance in terms of packet delivery ratio, delay, and overhead.

In future work, we plan to evaluate our protocol in the more realistic environment (freeway and urban scenarios) by increasing the number of nodes. Long highway scenarios need to install many RSUs along the road; we aim to couple VANETs with another wireless technology offering wide range of communication such as WiMAX or 5G cellular networks.

REFERENCES

[1] P.D. Dorge, D .S. Dorle, M. B. Chakole, Implementation of MIMO and AMC Techniques in WiMAX Network based VANET System, *I.J. Information Technology and Computer Science*, No. 2, pp. 60-68, 2016.

[2] B. Akbil, D. Aboutajdine, Improved IDMA for Multiple Access of 5G, *International Journal of Communication Networks and Information Security (IJCNIS)*, Vol. 7, No. 3, pp. 138-146, 2015.

[3] G. Araniti, C. Campolo, M. Condoluci, A. Iera, A. Molinaro, LTE for Vehicular Networking: A Survey, *IEEE Communications Magazine*, Vol. 51, N. 5, pp. 148-157, 2013.

[4] Hameed Mir, Fethi Filali, LTE and IEEE 802.11p for vehicular networking: a performance evaluation, *EURASIP Journal on Wireless Communications and Networking*, 2014.

[5] A. Benslimane, S. Barghi, C. Assi, An Efficient Routing Protocol for Connecting Vehicular Networks to the Internet, *Pervasive and Mobile Computing Journal, Elsevier publisher*, 2010.

[6] A. Benslimane, T. Taleb, R. Sivaraj, Dynamic Clustering-Based Adaptive Mobile Gateway Management in Integrated VANET – 3G Heterogeneous Wireless Networks, *IEEE Journal on Selected Areas in Communications*, Vol. 29, No. 3, pp. 559-570, 2011.

[7] A.A. Ba, A. Hafid, J. Drissi, Broadcast Control-Based Routing Protocol for Internet Access in VANETS, *International Wireless Communications and Mobile Computing*, 2011.

[8] W. Su, S.-J. Lee, M. Gerla, Mobility prediction and routing in ad hoc wireless networks, *International Journal of Network Management* , Vol. 11, pp. 3–30, 2001.

[9] N. Benny, J. Gerrit, L. Wim, Bandwidth Estimation in Wireless Mobile Ad Hoc Networks, *Journal of Ubiquitous Systems & Pervasive Networks*, Vol. 6, N. 2, pp. 19-26, 2015.

[10] Y. Wang, A. Ahmed, B. Krishnamachari, K.Psounis, IEEE 802.11p Performance Evaluation and Protocol Enhancement, *IEEE International Conference on Vehicular Electronics and Safety*, pp. 317-332, 2008.

[11] H. Füßlera, J. Widmera, M. Käsemanna, M. Mauvea , H. Hartenstein, Contention-based forwarding for mobile ad-hoc networks, *Elsevier's Ad Hoc Networks*, Vol. 1, Issue 4, pp. 351–369 2003.

[12] A.Iera, A.Molinaro, S.Polito, and G. Ruggeri, A MULTILAYER CO-OPERATION FRAMEWORK FOR QOS AWARE INTERNET ACCESS IN VANETS, *Ubiquitous Computing and Communication Journal*, 2008.

[13] S. kumar, J. Prakash, R. kumar, Y.P. Singh, An efficient Gateway Discovery and Selection Approach Based on Quality of Service Attributes, *International Journal of Engineering Science and Technology*, Vol. 5, No. 06, pp. 1186-1196, 2013.

[14] Jan Wantoro, I Wayan Mustika, M-AODV+: An Extension of AODV+ Routing Protocol for Supporting Vehicle-to-Vehicle Communication in Vehicular Ad hoc Networks, *Communication, Networks and Satellite (COMNETSAT), IEEE International Conference*, pp. 39-44, 2014.

[15] A. Hamidian, Study of Internet Connectivity for Mobile Ad Hoc Networks in NS 2, *Degree of Master*, 2003.

[16] A. Khan, S. Sadhu, and M. Yeleswarapu, A comparative analysis of DSRC and 802.11 over Vehicular Ad hoc Networks, *Project Report, Department of Computer Science, University of California*, pp. 1-8, 2009.

[17] The Network Simulator NS2, http://www.isi.edu/nsnam/ns/.

[18] F.K. Karnadi, Z.H. Mo, K.C Lan, Rapid generation of realistic simulation for vanet , IEEE WCNC, 2007.

[19] Simulation of Urban Mobility, http://sumo.sourceforge.net.

[20] S. Barghi, A. Benslimane, C. Assi, A lifetime-based routing protocol for connecting vanets to the internet, *in: WOWMOM*, pp. 1–9, 2009.