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Research paper

Urban-AODV: an improved AODV protocol for vehicular ad-hoc networks in urban environment

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Abstract

The Vehicular Ad-hoc Network or VANET is a special breed of Mobile Ad-hoc Networks (MANETs), which is used as a communication technology by the vehicles on roads to create a mobile network. VANETs have countless benefits and have tremendous potential to improve road safety, traffic efficiency, with added convenience and conform both for drivers and passengers on the road. From the architectural de-sign point of view, the communication is either Vehicle-to-Vehicle (V2V) or Vehicle-to-Infrastructure (V2I). Due to the dynamic nature of VANET, routing protocols in these networks have become an active area of research, posing various challenges and issues that need to be addressed. Most of the existing MANETs routing protocol need significant modifications to implemented them in the VANETs scenarios. For instance, Ad-Hoc on Demand Distance Vector (AODV) is one of the popular routing protocols that can be used in VANETs environment; however, it requires some enhancements in various aspects to make it suitable for VANETs communication paradigm. In this paper, we discuss these possible modifications, and propose various environmental parameters that when applied to AODV can make it more suit-able and compatible to be used in VANETs. We have proposed and implemented a new Route Discovery and Selection Phase to enhance the performance of the AODV protocol to make it usable by VANETs. The proposed modifications to AODV are implemented and tested specifically for the Urban Highway scenario. Therefore, our newly modified AODV protocol is known as Urban-AODV or U-AODV, as it fulfills the requirements in an Urban or city traffic scenario. We simulated U-AODV, and concluded that our proposed U-AODV reduces the average end-to-end delay, maximize packet delivery ratio and enhance link stability. Furthermore, it minimizes the communication over-head and routing control overhead of AODV in the urban/city traffic scenario.

Keywords: *Route Selection; Route Reply; Route Request; Highway; Urban*

1. Introduction

VANETs are gaining popularity and importance due to the increase of traffics and vehicles on roads, which further increase the risk of traffic jams and road accidents. Therefore, VANETs and its related issues has been a hot research area in the last few years, and researchers are addressing various challenges related to VANET and looking for new and improved solutions. Technically, VANET is a special type of wireless ad-hoc networks that enables vehicles to communicate using wireless technology and specialized hardware. In these self-organizing networks, vehicles act as nodes that may send, receive and route data within-in. vehicle-to-vehicle without an existence infrastructure. This connected system of vehicles is enable the Intelligent Transportation System (ITS) to share a data among nodes, therefore VANETs are also known as Inter-vehicle Communication(IVC) system F. Li and Y. Wang [1].

Due to the unique characteristics such as high dynamic topology and mobility, VANET is different from the traditional MANETs in many aspects. For instance, in VANETs the vehicle's movement is higher thus the links tend to be broken, and which results in high degree of topological changes. This frequent topological changes can cause periodical disconnection especially within the Urban/city scenarios where the node mobility predicable to the traffic networks and their regulation. The computational and transmission power for VANETs are higher than MANETs. The communication range is limited between nodes, therefore multi-hop approach from source to destination is important. Therefore, due to these characteristics, in VANETs represent a challenge routing factor should be resolved, H. Moustafa and Y. Zhang[2].

In most of the VANAT applications, routing protocols are important both from the architectural and deployment perspective, because in real time environment higher routing delay is not acceptable. Therefore, designing efficient routing protocols has been a serious concern and hot research area for researchers in academia and industry, Bobanet al., [3].

Although, VANET is a type of MANET, but due to VANET's unique requirements and features, it is different from the traditional ad-hoc network in many aspects. For instance, one of the main distinguishing characteristic of the VANETs environments are frequent change in the network topology due to high speed of vehicles movement, the results in communication link breakage. Recently, various routing protocol have been proposed to improve the efficiency of routing in VANETs, specifically in urban environment. AODV (Ad-hoc On Demand Vector) routing protocols is one of the most widely used and discussed reactive routing protocol designed specifically for MANET. However, since VANET environment are more complex and much more accuracy is required, therefore, the protocol designed for MANETs cannot be directly used for VANETs due for various reasons, M. C. Weigle and S. Olariu[4].

For instance, the movement of nodes in MANET is random in any direction, while in VANET, the node's movement is limited to only roads and streets. Similarly, the change of topology in VANET is faster than in the MANET due to the higher speed of node in VANET. Vehicles in VANET are usually equipped with the GPS (Global Positioning System) on-board sensors that provide speed, direction, and location information for the connected vehicle, S. Al-Sultanet al.[5]. Thus, in case of applying AODV routing protocol directly in VANETs will leads to poor performance due to the distinguishing features and characteristics. In the past many researchers, such as [6-9]proposed a routing protocols (X-AODV) for vehicular ad-hoc networks that improves the Ad hoc On-demand Distance Vector (AODV) routing protocol. These papers proposed a modification on the AODV to make it suitable to be used for VANET mobility model. Most of them focusing on the high way mobility model, however they avoided the complex urban environment. While, some of these papers proposed an approach of modification by involvement a direction and speed of the vehicle(B. Ding et al; O. Abedi et al.[10], [11]) to minimize the number of next hop selection in route discovery phase and select a route which is more reliable and stable than other routes, M. H. Eizaet al.[6].

Urban Road Intersections configurations have significant effects on mobility and connectivity simulations. The topology of the urban environment plays a fundamental role in traffic optimization, not only in terms of mobility patterns but connectivity. The complexity of the problem, start by defining the main parameters that need to optimize. So traffic in urban environment have several issues and challenges that do not exist in highways scenario A. Fonseca and T. Vazão[12]. To address these issues, this paper proposes three strategies to choose a next hop node; while each strategy involves various mobility parameters which related to a two-dimensional area that matches the urban scenario especially strategy 2, and 3.

The rest of the paper is arranged as follows: section 2 describes the related work, mainly focusing on an improvement of AODV performance. Section 3 describes the proposed strategy which involved the motivation of AODV for VANETs environment, distance factor, route request, route reply processing, and route discovery algorithm. Section 4 explains the performance evaluation of the proposed U-AODV protocol, and section 5 discussed the matrices used for evaluation. Finally, section 6 present the discussion, results and conclusion.

2. Related work

In this section, the related work discussed either suggest to improve the AODV reliability or suppose it as a reference for comparison. For mobile ad hoc networks (MANET), the AODV reliability is discussed in S. Jianget al.[13]. In this paper the critical issue for routing in MANET is discussed in terms of how to select a reliable path that is more stable and last longer than others. The prediction-based link availability estimation algorithm is proposed to develop a selection process and verified through simulation. This enhancement in this paper forwarded for MANET environment and does not related to VANET.

For vehicular ad hoc networks (VANETs),T. Taleb et al.[14], used the heading of the vehicle as an important parameter to avoid breakage of the link prior to the event. Vehicles are classified into groups with respect to their velocity vector. When the vehicle turns form one group to another and a route may be broken, the proposed strategy selects most reliable route that involve other vehicles from the same group.

In O. Abedi et al.[11], the authors incorporate various mobility parameters to minimize the next hop selection in route discovery phase. Direction and the vehicle's position represent the elements that used to decrease the control messages in the network. Among these parameters the authors focusing on the direction as a superior one to choose the next hop node during the route discovery phase. So this paper does not meet the urban environment where the direction parameter is not enough to cover the mobility urban.

B. Liet al.[15] introduces a new routing protocol that supporting the concept of reduction a network congestion by decreasing the packet control in order to reduce packet delay. The enhanced protocol broadcasts a data packets as well as packet control during repair maintenance occurring. By this way the protocol is not only set up a route but also reduce the delay.

B. Moussaoui [9]is another work that focusing on minimizing the congestion in the network through reducing unnecessary rebroadcast of control packets. Each vehicle appends geographical location of the destination to each packet control which forwards to the same region or in the way towards. So the protocol mitigates the reduction of retransmissions in the network. The two above papers focusing on the reduction congestion in VANET and does not tackle the adoption of AODV in city area.

B. Dinget al.[10]presents an approach that included two optimization steps, one for discovery process and the other for route selection process. The velocity and direction of the node are involved for optimization. During the first step the improvement occurs by lowering the participant nodes in route selection next hop, whereas the second step is the source node obtains multiple routes to destination node, and will choose the most stable one among them. The approach is adopting a highway scenario environment and avoiding a two-dimensional urban scenario.

All the above papers do not clearly adopting the enhancement of the AODV routing protocol to implement in the two-dimensional urban environment. This paper is further enhancing this approach by adopting the complicated two-dimensional urban environment and discussing all the mobility parameters that affect the behavior of AODV routing protocol.

3. The proposed urban-AODV strategy

The main objective of the proposed protocol is to reduce the broadcast of the control messages and to avoid link failure. Urban AODV (U-AOD) protocol designed to implement and work in the city scenarios where the mobility is one of the main parameter involved in routing.

3.1. Motivation of AODV for vanes

U-AODV routing protocol is enhanced to accommodate the VANETs requirement. The new protocol (U-AODV) adds the mobility parameters: speed and direction mobility metrics to improve the next hop selection in the route discovery phase. The B. Dinget al.[10] improves the AODV to work with the VANETs environment. The approach is dependent on the two parameters direction and speed that supports the high way VANETs exclusively. This paper takes into account another important element that optimizes the AODV routing protocol to suit the urban environment.

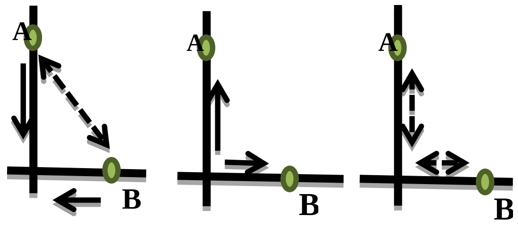
As mentioned previously, by using GPS in vehicles can obtained mobility metrics (speed, position, and direction) which are used in routing approach in this paper. Vehicles that have higher difference in speed may no longer stay in connection, and which causes link breakage. Any two vehicles can communicate with each other if they are in communication range, so vehicles that in similar velocity relatively stay keep in touch much longer than others and the link more stable between them.

The direction of vehicle's movement plays an important role in route stability. The vehicles in opposite direction quickly loss the link between them, while vehicles moving in the same direction stay linked much more than others. This paper will add another element which is a distance between the sender and receiver, if the distance is increased continually then the receiver will not participate in route while in case the distance is decreased then this vehicle will take part in the route discovery phase.

3.2. Involvement of distance factor in route discovery phase

Working with a two-dimensional urban scenario is more complex and considers as a key challenge in VANATs. Most of the researchers have focused on the analysis of network connectivity in simple highway scenario where vehicles roaming in two-way directions. Very few of them proposed an approach that supports the urban mobility. J. Breuet al.[16] have point out that one of the parameters that affects the time of two vehicles stay in connection is the distance between them. In urban environment, the network roads impose a two-dimension scenario, which is similar to Figure 1 below. As mentioned previously Ding et al.[10] proposes an approach that incorporate the velocity and direction of the vehicle to improve the AODV protocol to implement in highway, and avoid discussion in the urban VANET environment.

To decide a vehicle participation in routing process in two-dimension roads like intersection, we suggest a distance factor between the sender and receiver to be included. The distance is decreased when the vehicles are approaching to each other, while in moving away the distance is increased. In the first case, the vehicle is included in routing decision while in the second the vehicle is excluded. Depending on this idea the distance factor added to mobility parameters to cover the mobility urban scenario. By using this new parameter, we developed our strategy to take a distance as a main factor to decide next hop selection in route discovery phase.



a: Approaching b: Moving away c: Neither

Fig. 1: Three Possible Configurations when Two Vehicles Travel in the Perpendicular Directions as Urban Intersection.

In order to fulfill the requirements of our proposed reliability-based strategy, we extend U-AODV routing messages route reply (RREP) and the routing table entries as follows:

1) RREP message is extended by adding three new fields to its structure as shown in Table 1.
   - X-Pos, Y-Pos contain the coordinates of the vehicle that generates/processes this RREP.
   - Speed contains the current velocity of the vehicle that generates/processes this RREP and original RREQ.
2) Routing table is extended by adding two fields as shown in Table 2.
   - Link _weight contains the value of the link reliability between the sender and closets neighbors of this RREQ.
   - Total link weight contains accumulate links value in reply route.

Table 1: Extended RREP Message for U-AODV

The final format of RREP
Type |R|A| Reserved |Prefix Sz| Hop Count
Destination IP Address
Destination Sequence Number
Originator IP Address
Lifetime
x-pos
y-pos
Sv

Table 1: Extending U-AODV Routing Table

The Final Format of routing table
Destination IP address
Destination sequence number
Valid Destination Sequence Number flag
Other state and routing flags (for example valid , invalid, repairable, being repairable)
Network interface.
Hop count (number of hops to reach the destination).
Next Hop
List of precursors
Life Time (expiration or deletion time of the route)
Link weight
Total Link weight

3.3. Route request packet (RREQ) processing

The Source node collects a mobility metrics: velocity and position location of all the surrounding nodes by using GPS and other on-board sensors in vehicles. As mentioned previously, these parameters significantly affect the route stability. These metrics are involved in three different strategies to compute the three different link weight values between it and all its neighbors. Each strategy includes various parameters and they are discussed below:

1) In this strategy, we calculated the difference in speed and direction between the source node and all surrounding nodes according to formula 1 and 2 respectively. And finally compute the link weight for this approach according equation 3.

$$S.calc = Sv * | Si - (Si+1) | \quad (1)$$

Where S.calc is the speed calculation, Sv is the speed weight and Si , Si+1 are the speed of current node and next neighbor Respectively.

$$D.calc = Dv * | Di - (Di+1) | \quad (2)$$

Where D.calc is the direction calculation, Dv is the direction weight and Di, Di+1 are direction of current node and next neighbor respectively.

$$\text{Link Weight1} = S.calc + D.calc \quad (3)$$

2) The second strategy will add to strategy one, the distance between the sender and receiver. The distance computed according to formula 4 and the link weight will be according to the formula 5.

$$DT.calc = DTv * |DTi - (DTi+1)| \quad (4)$$

Where DT.calc is the distance calculation, DTv is the distance weight and DTi DTi+1 are the distance of current node and next neighbor respectively.

$$\text{Link Weight2} = DT.calc + \text{Link weight1} \quad (5)$$

3) Third strategy will limit to distance metric between the source and receiver with each hop. If the current distance less than previous distance the node is come closer and vice versa. According to this idea the node will participate in routing process if come closer and excluded if not. The node Distance calculates depend on the formula 4 and the link weight value will be in the form of formula 6.

$$\text{Link Weigh3} = D.calc \quad (6)$$

For all three strategies the value of Link Weight is computed for all the neighbors of the source node. If the neighbor vehicle which have the same velocity, similar direction, and the distance is decreasing then the link is more stable. Though, according to formulas of strategies, the amount of the link value is smaller as the link is stable and vice versa. A threshold value for link weight is suggested to distinguish the participant node or not in next hop selection. The link value above the threshold value will be excluded in next hop selection, whereas blow threshold will be included. Experimental method used to select a suitable value of threshold. A threshold value selected based on the best behavior of the U-AODV.

3.4. Route reply packet (RREP) processing

To enhance the U-AODV routing protocol in route reply packet, our approach is to choose the route with longest lifetime. This parameter is important to make the route more reliable for data transmission. And this is achieved through select a route can exist longer than other routes.

In previous section link weight values determined according to three different strategies, in order to optimize the RREP message the value; total link weight should be computed by extending the formulas 3, 5, and 6 respectively to equation7. For every strategy elected the total link weight change with respect to link weight value.

$$\text{Total Link weight} = \sum_{i=2}^{N} Linkweightx \qquad (7)$$

In equation7, x represents the selected strategy number, j is the sequence number of the nodes in the route, and N is the total existence node in the route. When the destination node generates a RREP message, and adds these fields: a total link weight which sets to zero, velocity, direction, and the position information in the RREP packet. During the reverse routing selection, each node received RREP packet will calculate link weight, update an accumulated total link weight, insert its own velocity, position, and direction in RREP packet and finally sends back on. In each node's routing table, the value of accumulated total link weight is stored.

This process will repeat till reached the source node; finally, the source node will get multiple routes to destination with different total links weight values. To select more reliable route, the source node chooses the minimum total link weight value. Using this approach, the stability of the route is calculated along the whole route, which efficiently gives a most stable route.

3.5. Route discovery phase algorithm

All the steps for the route request processing and route reply process are depicted below in the modification in route discovery phase with procedures of the three strategies.

Algorithm (1) Modification in Rout discovery Phase with Procedures for three strategies

Input: S want to connecting with D
Goal : Established connectivity route from S to D
Variables declaration :S is a source vehicle, D id destination vehicle, r_table is routing table, x refers to a strategy number
Step1:
IF *r_table of S contains a route to D*
send RREQ
Else
Go to step 2
Step2: Gets information and calculate the Link_weight x for the source
Get_informations(node, neighbor)
Get_ Speed (node);
Get_Speed (neighbor);
Get_ Position (node);
Get_ Position (neighbor);
//From GPS get information about the neighbor nodes within a transmission range and calculate:
Link_weight x (speed, direction, distance)
Step 3: While (Link_weight x(node)< threshold value)
Next_Hop_selection (node)
Send_RREQ_Packet (node)
Step5: For all nodes N receiving RREQ
If (N!=D) and (Link_weight x(node)< threshold value)
forward RREQ
END IF
END For
Generate RREP Packet and make calculations in step 5
Step5: while(node N receives RREP and N != S)
–Calculate Link_weight x
–Adds its own speed and position in RREP packet
–Update and store accumulate total link weight in the r_table
–Forward RREP on the reverse paths
Step6:S receives RREP
S updates its r_table based on the vehicle sending the RREP and chooses the minimum total link route to send a data.
Step7:S establishes connectivity with D
END IF

4. Performance evaluation

To examine the performance of the U-AODV in comparisons to the original AODV protocol;ns-2.35[17], and SUMO[18],V. Bondre et al. microscopic with OpenStreetMap[19] (OSM) software are used.NS-2 generates a communication trace file and a NAM (Network animator) file as its output. It is important to generate realistic movement traces in order to rigorously evaluate VANET protocols because the overall performance depends on the connectivity which, in turn, relies on the movement traces and the output trace file describes the network topologies as log events that exhibit the output of the nodes communicating with each other.

OSM is free package software and an open source data that supports the real road networks for the whole world. Moreover, OSM offers a service that provides a real road network that chooses to simulate the specific area in the world. SUMO generates a movement pattern of the vehicles in the roads.

The simulator stream behavior starts from SUMO by using the data map of OSM with the mobility parameters like vehicle mobility, traffic, flow, etc. the output file enters the NS2 to implement the connections of the selected city nodes. Two types of output files are produced form NS2: trace and animation files. Table 3 summarizes the default values of the various simulation parameters. Region of scenario actually selected as shown in Figure 2. Scenario is run five times and the average is taken for the results. The original AODV and modified U-AODV are Applied in real world map OSM urban city include roads and intersections.

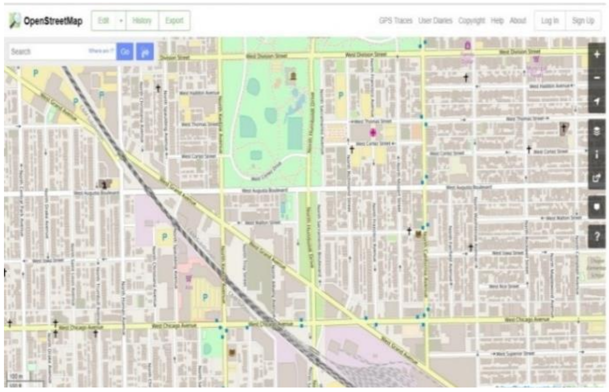


Fig. 2: Scenarios' Map from OpenStreetMap.

5. Performance matrices

Five evaluation metrics are considered to explain the main characteristics of the proposed routing protocol U-AODV:

- Average End-to-End (E2E) delay: This metric includes the average time for every potential data packet delay from source to destination.
- Average Packet Delivery Ratio (PDR): this metric refers to the number of received packets at the destination node over the total number of packets that sent by the sender for any given traffic flow.
- Link Stability: this metric is computed by calculating the average number of link failures during the routing process. This metric shows the efficiency of the routing protocol in avoiding link failures.
- Generated overhead: Measured in terms of the number of control packets (RREQs) generated and relayed in the network Generated overhead. Increases with the increase of the network size for both protocols.
- Routing control overhead: represents the ratio of the total routing control messages over the total data messages supposed to be received.

Table 2: Simulation Parameters

Parameters	Simulation Value

Simulation Environment	Ubuntu 14.04
Simulator	NS-2.35, SUMO
Simulation Time	400 Second
Antenna Model	Omni directional antenna
Radio Propagation Model	Two Ray Ground
Transmission Range	250 m
MAC Type	IEEE 802.11
Interface Queue Type	Priority Queue (50 Packets)
Routing Protocols	AODV, U-AODV
Transport Protocols	TCP
Traffic Model	FTP
Simulation Area(Topologies)	4391 m X 2772 m Grid, Real Map
For Varying Vehicle Density	
No. of vehicles	10, 20, 30, 40, 50,60
Mobility of Vehicles	Random real time urban topology veloci-ty
For Varying Vehicle velocity	
No. of vehicles	10, 20, 30, 40, 50, 60
Mobility of Vehicles	10, 20, 30, 40, 50 km/h

6. Analysis of simulation results

Five metrics are chosen to evaluate the U-AODV routing protocol with the original AODV routing protocol each of them represented an indication for the behavior of the proposed U-AODV protocol.

6.1. Average end-to-end delay (E2E)

Average E2E is compared with network density and the velocity respectively. For the first comparison the simulation results for the influence number of vehicles on E2E are shown in Figure 3. The graph in Figure 3 clearly shows that the U-AODV performs better than AODV for the simulation time. However, the increase in high density produces higher overhead, but still U-AODA performs better the traditional AODV

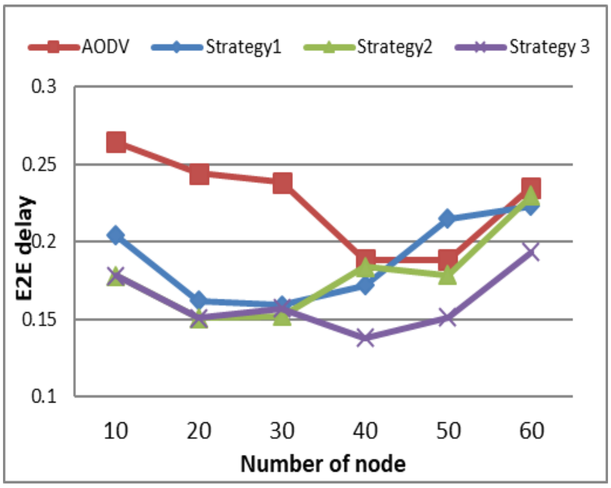


Fig. 3:E2E Delay versus Network Density.

These results can be considered as the most reasonable results for effect E2E delay of two routing protocols (AODV and U-AODV). Strategy2 have some delay due to three parameters which take a time to calculate in comparison with the strategy 3where one parameter is considers. The graph also shows that strategy1 has larger delay. For the second comparison E2E delay versus the velocity of the vehicles is shown in Figure 4.From this figure the impact of velocities of vehicles is showing that the U-AODV performs better than AODV for most times that belong to reach destination.
It's clear that the increasing in velocity for the nodes does not degradation in enhancing of U-AODV as we can see in the Figure 4. Also the Strategy 3 has a better performance than other strategies and this is because this strategy depends on one parameter (distance only).

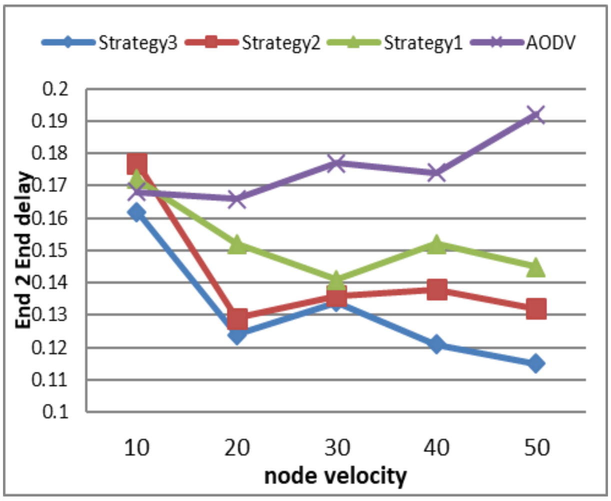


Fig. 4:E2E Delay versus Vehicle's Velocity.

6.2. Average packet delivery ratio (PDR)

This metric measures the success of packet delivery from the source to a destination. Higher PDR values indicate that a routing protocol is complete and correct. The impact of velocity varying on the PDR is illustrated in Figure 5. We can see the two routing protocols (U-AODV and AODV) behavior, because of the increasing broadcasting control packet caused by packets dropped and collision. The performance of U-AODV obviously is better than the AODV when the velocity of vehicles is increased. The U-AODV keeps its behavior by selecting more reliable route in spite of high velocity. All strategies achieve higher performance with respect to the original AODV. Original AODV always broadcasting a control messages which causes a collision, whereas U-AODV select a route that prone to reliable and achieve long connection time.

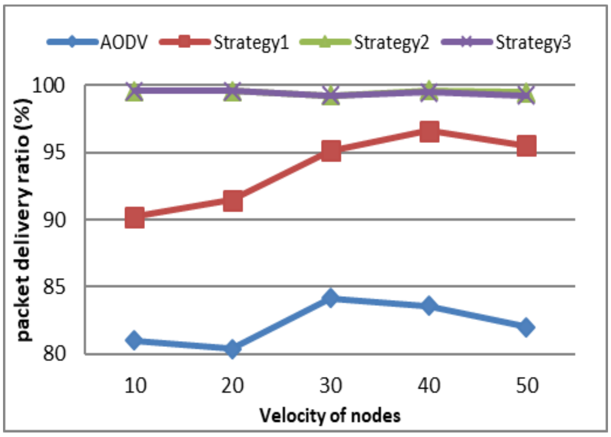


Fig. 5:PDR versus Vehicle's Velocity.

6.3. Link stability

Link stability represents the average number of link failures during the routing process. This metric shows the efficiency of the routing protocol in avoiding link failures. When a link failure occurs, route error message (RERR) is generated for the purpose of repairing the current route or launching a new route discovery process. The essential goal in this research is to achieve link stability, and to analyze the newly proposed U-AODA with three strategies. Improving link stability increases overhead and enhance delivery ratio in addition it reduces packet loss ratio.
A route is stable when its nodes have connection for expected time that needed for data transmission and the routes life time strongly depends on their links connectivity. A link is stable if their node satisfying these three conditions: their moving directions are same, their positions are in acceptable states and as close as possible, and finally difference of their velocity is endurable with regard to their

positions and direction. When a link failure occurs, RERR message is generated for the purpose of repairing the current route or launching a new route discovery process.
Table 4 shows that AODV has higher average number of link failures than three strategies of U-AODV. The optimum route selection algorithm in AODV is highly prone to link breakages when the network topology becomes more dynamic. On the other hand, U-AODV processes all the possible routes to the destination and chooses the most reliable route.
For both AODV and U-AODV, the average number of link failures increases when the velocity increases. However, U-AODV responds better than AODV to the changes of the network topology and keeps a lower rate of link failures.

Table 3: Comparative Vehicle's Velocity with the Link Stability

No. node	AODV	Strategy1	Strategy2	Strategy3
10	38	20	6	6
20	15	8	4	4
30	66	16	4	2
40	42	12	4	4
50	150	22	6	6
60	202	26	4	4

6.4. GENERATED OVERHEAD

The number of route request (RREQ) generated and relayed in the network is considers as generated overhead metric. It is clear that the number of broadcast RREQ affected the performance of overall the network by flooding the network by RREQ message in the route discovery phase. So decreasing RREQ message as possible as to avoid this manner and represents an enhancement routing criteria.
The Figure 6 proves the above fact that supports our conclusion on the impact of network size on the performance of our proposed U-AODV protocol. This figure shows superior performance of U-AODV even under increasing the size of the network. Standard AODV still suffers from this problem, which shows that it is unsuitable for bigger size network.

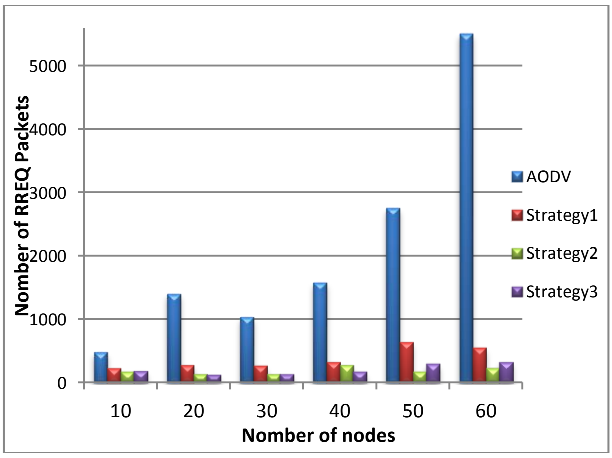


Fig. 6: Impact of VANET's Size on Number of RREQ Generated.

6.5. Routing control overhead

Routing control overhead is the performance metric considered in our evaluation process. Figure 7 shows the average ratio of the routing control overhead for both AODV and U-AODV. The two routing protocols are affected by the changes of the network topology. In U-AODV, the routing algorithm uses less routing control messages to establish the most reliable route, so it is expected to have lower routing control overhead than AODV.
The speed of vehicles and the overhead ratio increased in parallel, periodically updating the network topology increases bandwidth overhead. Figure 7 illustrates the difference between two protocols in overhead ratio and degree of improvement. Strategy1 appears close to standard AODV routing protocol and this is because its component (velocity and direction) parameters are not satisfying the urban environment, while strategies 2 and 3 are achieved better performance when the velocity increased.

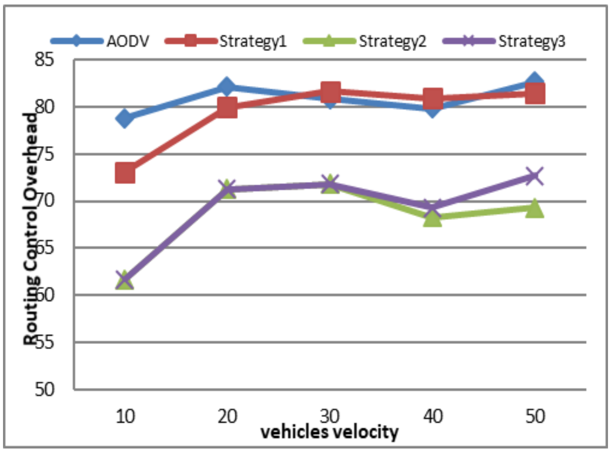


Fig. 7: Routing Control Overhead versus Vehicle's Velocity.

7. Discussion the results and conclusion

In this section, we will give a brief discussion about the results and the analysis performed in the previous section. This discussion will further explain the behavior and performance of our proposed U-AODV protocol.
The first strategy implemented as mention previously on highways environment, in our study this strategy simulated on real map of specific USA/ Chicago city which represented as an urban environment. The results prove that the routing in the urban environment imposes additional mobility parameters such as distance for enhancement. To cope up this problem the strategies 2 and 3 have involved distance parameter that supports a two-dimension environment and this is proved the effectiveness of our U-AODV in all metrics successfully.
In order to reduce the overhead generated by the unnecessary rebroadcast the of control messages (i.e. RREQ) our proposed protocol U-AODV proves the ability to decreasing the network congestion with respect to the original AODV protocol in route discovery phase. And this is because the participating nodes restricted in a certain number rather than whole network nodes.
The link stability is crucial characteristic in routing for VANET, U-AODV taking an account this goal especially in route reply massage and avoid link failure. On the other hand, our solution (U-AODV) behaves better as the velocity of the nodes increased in scenario.
Another major drawback of ad-hoc networks especially VANETs is link breakage. The proposed U-AODV protocol avoids this problem as compared to the standard AODV protocol. The behavior of strategy1 on highway environment shows good performance; the strategy2 considers the hybrid strategy which is suitable to implement on highway and urban territory. Finally, strategy3 proves its good performance due to have lower computational cost as it depends on the distance factor only. Form the above discussion, we can conclude that Distance is one of the most important factor which helps to improve AODV routing protocol to make it workable in urban environment in VANETs.
In future, we will take the acceleration and heading angle of the vehicle into consideration to find the most suitable route. Furthermore, we will perform a comparative study to analyze the impact of mobility factors which influence the routing selection.

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