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ENHANCING AODV ROUTING PROTOCOL BASED ON DIRECTION AND VELOCITY FOR REAL-TIME URBAN SCENARIO

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ABSTRACT

Vehicular ad-hoc network (VANET) considers as a promising technology to support the communication between vehicles, and between vehicles and road side units. A reliable routing algorithm for such networks is challenging task because of high mobility and periodic changes of the network topology. To improve the performance of ad-hoc on demand vector (AODV) protocol in VANET, the routing overheads should be reduced by reducing the transferred control packets that consumes portions from the available bandwidth. In urban environments, the network topology plays an essential role in traffic optimization in terms of mobility patterns, and also in the connectivity and available infrastructure. Further, the road intersections come with many configurations and their definition significantly affects mobility and connectivity. However, the increased number of nodes and movements in such environments will add additional routing overheads to the current overheads in AODV protocol. In this paper, URBAN-AODV (U-AODV) routing protocol is proposed for use in real map topology VANET for urban conditions as in USA, Chicago city. In proposed U-AODV protocol, new fields based on velocity and direction of vehicles are added in request packet and routing table to decrease the transferred control packets. The performance of the proposed protocol is studied and compared with the original AODV using different metrics and statistical tools in real-time world urban VANET control vehicles mobility in two lines and urban intersections. Results demonstrate that U-AODV has dissimilar values in overhead ratio in both density and vehicles velocity, while in end to end (E2E) delay metrics the U-AODV was faster than original AODV and cause low ratio in delay in both different vehicle density and velocity.

Keywords: *NS2, VANET, AODV, Urban, Overhead.*

1. INTRODUCTION

Today, people around the globe are highly concern about the traffic and motion conditions on the roads. Many of the people suffer with the risk of their life during travelling, and this is just because of the mismanagement of the terms and conditions for the traffic rules [1].

Many researchers contribute their valuable thoughts and research in order to improve the lifestyle of traffic and traffic rules. VANET is a sub-part of Mobile Ad-hoc Network (MANET) but its vibrant network planning and node progress individuality characteristics differentiates it from other available ad-hoc networks [2].

Inter Vehicle Communication system (IVC) such as VANET systems as part of intelligent transport system (ITS), become an exciting field of research area in Japan, EU and US with many issues in order to achieve variety of applications with high level of accuracy in efficient manner, the essential goal of these different applications is to make the transportation system more efficient and secure [1][3][4].

To simulate the motion of participating nodes, the mobility models are used and play a fundamental role in the simulation of VANETs. Even with recent research focusing on development of mobility models that better correspond to real-world situations, they still have a limited understanding of the level of detail required for modeling and simulating VANETs [3].

In VANET, vehicles act as fast moving nodes in the network; therefore these wireless equipped vehicles creates an energetic network in which every vehicle/node uses direct wireless program for communicate with each other. Due to the difference in the network topologies, MANET protocols may degrade the performance of the VANET network. Further, many parameters in VANETs affect the duration and accuracy of the delivered packets. A data packet simply choose the next hop according to its packet header, in which the complete route list is stored. Further, environments such as urban, have many problems and obstacles, such as intersections, that significantly affects on mobility and connectivity in VANETs [6]. However, the complete node-based route makes this routing protocol suffer from routing overhead and lead to scalability issues. Topology routing protocols such as AODV [10] use node-to-node link's information to forward the packets from source to destination. These traditional routing protocols with node-centric concept cause frequent broken links and need to be improved for using into the VANETs [4].

In this paper, URBAN-AODV (U-AODV) routing protocol is proposed for VANETs in Urban scenarios. In the proposed protocol, new fields for velocity and direction of vehicles, are added to decrease the overhead packets and reduce delays. In this protocol, two mobility parameters related to a two-dimensional Urban area are involved to choose a next hop. U-AODV routing performance is evaluated using extensive simulation experiments, and compared with the standard AODV in real map city, which has high rate changes in the topology and density of vehicles. The study is carried out by VANET simulator based on NS-2 and SUMO [7], generated by OpenStreetMap [8]. The rest of this paper is organized as follows: Section 2 discusses problems and obstacles in Urban and Highway Environments, Section 3 outlines the related works. AODV and U-AODV are explained in Sections 4, 5, while the simulation models, including urban mobility and network evaluation models, are presented in Section 6. Section 7 concludes the paper.

2. HIGHWAY AND URBAN ENVIRONMENTS

Highway and urban environments have various and different characteristics, therefore, different routing strategies are developed for VANETs [13]. Automatic adoptability of routing strategies based on environment is also a research area, as highway routing strategy less applicable in urban and wise versa. In Urban scenario, obstacles are more due to city building, vehicle density, and speed is various than highway. Behavior in urban differs from highway environment in the following major aspects:

- Scenario: in an urban environment, there are junctions and corners with buildings, affecting the signal propagation. In a highway, most of times there are no obstacles, a vehicle can forward a message to any other vehicle within the transmission range. In spite of that, there have been studies that shown that the vehicles themselves consider as obstacles to the propagation [6].

- Mobility pattern: in urban environment topology of squares and avenues located near each other and there are a lot of streets. So, vehicles have many available options to take, for instance, it can make a turn to a various road or it can move straight-ahead. In contrast, in a highway environment, there are no crossroads only a few entrances and exits. Thus, most of the time, the vehicles can only stay in the same road and there are no sharp turns. From a routing perspective, the node can select many different available options to forward information in urban environment, while, in a highway, most of the times the same set of vehicles may be used to forward information.

- Mobility properties: the speed of vehicles is low inside towns and villages, usually limited to 50 km/h, or even lower depending on country legislation, while in a highway, the limits are about 120 km/h. When the velocity is higher the time of connection with a vehicle travelling in the opposite direction, or a fixed Access Point (AP) decreases significantly. Table 1 shows a comparison for VANETs in urban and highway scenarios.

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Table :1 Urban and Highway Property

Attribute	Urban	Highway
Velocity	Low	High
velocity variance	High	Low
Number of vehicles	High	Low
Obstacle	Many	Few
Link connectivity	Frequently disconnect	Maintain
Possibility of Mobility	Many	Few
Possibility of providing paths	Many	Few

3. RELATED WORKS

In [14], the authors have applied and analyzed the performance of the two existing routing protocol for AODV (single Path) and AOMDV (multipath). These existing protocols are compared in terms of PDR, PLR, E2E and throughput for different city scenario with changing topography and traffic density in the network. To design realistic mobility model, they considered city scenario that pose the fast changing topology. The used network provides two types of connectivity, Vehicle to Infrastructure (V2I) and Vehicle to Vehicle (V2V) over a wireless communication standard IEEE 802.11p. This provides Road Side Unit (RSU) to broadcast emergency message received from adjacent node or vehicle from the network. However, these results show the comparative performance of both existing routing protocols, which are widely used in applications such as traffic management and emergency rescue operations.

In [15], a velocity-supported routing protocol is proposed and determines its packet forwarding based on the relative velocity between the forwarding node and the destination node. The area for packet forwarding is determined by predicting of the future movement of destination node according to velocity and its location information. The route stability and reduce the control head of VANETs for such protocol enhanced in [13]. The packet structure is modified in [16] by adding two fields in RREQ packet second node IP address to reduce overhead. The modified routing protocol IAODV ensures giving timely and accurate information to drivers in V2V communication.

The performance of AODV routing protocol is improved in [17], where the mobility characteristics were added to make the AODV protocol suitable to VANETs. Specifically, these characteristics are direction, acceleration, speed and link communication quality between the vehicles. Thus, these mobility features help to select the best route between source and destination. In [18], the authors introduces a method to decrease the unnecessary overhead packets, which produce collision and packet loss. The approach involves each node to attach the geographical position of destination for all created RREQ packet. This packet is received only by node available in communication range. This method reduces overhead as proved in different scenarios. The routing performance in terms of packet delivery ratio, delay, throughput and total energy for various routing protocols is calculated in [19] for VANETs in Khartom city. Tests aimed to achieve more convenient protocol in traffic jam area. The extensive simulations are based on a recently cellular automata model for mobility and provides a comprehensive analytical framework. The predictions of such framework also shed light on which type of applications such as safety and non-safety can be supported by urban VANETs.

The authors in [11][20][21] suggested a modifications on AODV protocol by involvement a direction and speed of the vehicle [11][20][21] to minimize the number of next hop selection in route discovery phase and select a route, which is reliable and more stable than others [22] [23]. However, most these protocols for VANETs were focusing on the highway mobility model. Several routing protocols in [24] are compared from a qualitative perspective concerning only their use on an urban environment, while in [25][26] several solutions for a highway environment are presented and compared.

4. AODV ROUTING PROTOCOL

AODV is one of the most important and popular on-demand routing protocol, which is included in the classification of the reactive routing protocol. In this protocol, route is established when it requires. It keeps routes as long as they are desirable by the sources. The AODV mechanism brief as source node send Route Request (RREQ) message to their neighboring nodes. The node send

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back Route Reply (RREP) to the sender node. If any kind of error occurs during transmission, then Route Error (RERR) message send back to the sender node [9]. The route to destination is determined, if there is a node that wants to transmit data using RREQ packet that is sent by source. If there is active route to the destination, the receiver will reply the messages with RREP packet.

AODV routing protocol provide the change in link situation very easily, and also in overhead has great advantage over simple protocols, which need to keep the entire route from the source to the destination host in their messages. It can undergo the large delays during route manipulation and consume more bandwidth when the network size increases [10]. Reactive routing protocols such AODV tend to reduce the control overhead at the cost of increased latency in finding new routes [12]. However, AODV has several characteristics among other routing protocols such as [11]:

- finding routes only as needed.
- Using of Sequence numbers to track accuracy of information.
- Keeping only track of next hop for a route instead of the entire route.
- Using periodic HELLO messages to track Neighbors.
- Using RERR message react to fast changing in network topology and updating affected host.
- Loop free by using sequence number.

In addition, AODV tries to keep the overhead of the messages as much as small. If node has the route information about active routes in the routing table in the network, then, the overhead of the routing process will be minimal. In the route discovery, the RREQ and RREP messages, which are responsible of it. AODV reacts relatively quickly to the topological changes in the network and updating only the hosts that may be affected by the change, using the RRER message [11].

5. THE PROPOSED U-AODV ROUTING PROTOCOL

Since VANET has a dynamically fast changing topology as compared to MANET, so AODV is first need to be improved before deploying into the VANET [5]. In the route discovery phase, when a source node wants to send packets to a destination node, it has to obtain the route to the destination node, in U-AODV route discovery the route must be selected carefully according some parameters.

5.1 Route Discovery Phase Algorithm

When the source vehicle S has data to send, it first looks if recent node is a destination will send reply, S will send RREP until reach original RREQ source and establish connectivity, else looks at its routing table. If there is a valid route to the destination D, then it will use it, else a new route discovery process starts. The source vehicle broadcasts a new RREQ message to the available neighbor vehicles, adds its location information and velocity to request new fields. Once the RREQ is received by the neighbor vehicle, also filled its information and check velocity and direction results, if different surely cause failure link, else calculates the velocity and direction based on equations (1) and (2) respectively, to find link weight based on equation (3) shown in next section. Then, chose output value according to threshold ratio from all available values, and creates/updates to suitable routes value saved in routing table new field.

The set of all possible links differences in direction and velocity is checked, then the optimal route will be chosen at source node based on link stability criteria. In other words, if there are multiple routes available, we choose the most reliable route that satisfies the reliability threshold determined by the processes. If many routes satisfy the reliability threshold, then we could choose the route that has the least value.

5.2 Route Request Packet (RREQ) Processing

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

In this strategy, the difference in speed and direction is calculated between source node and all surrounding nodes according to formula 1 and 2 respectively. Finally, computing the link weight for this approach using equation 3.

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

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where *S.calc* represents speed calculation, *Sv* represent speed weight and *Si* , *Si+1* represents speed of current node and next neighbor respectively.

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

where *D.calc* represents direction calculation, *Dv* represent direction weight and *Di*, *Di+1* represents direction of current node and next neighbor respectively.

$$Link\ Weight = S.calc + D.calc ; \quad (3)$$

5.3 U-AODV Packet Fields

There are many fields added to different type of packet to achieve the goal of enhancement. These new fields play an essential role to evaluate the performance of U-AODV in routing. In order to fulfill the requirements of our proposed reliability-based scheme

1. Extend U-AODV routing table entries by adding field as shown in table 2, Link _weight contains the value of the link reliability between the sender and nearest neighbors of this RREQ.

Table :2 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 (eg. valid , invalid, repairable, being repairable)
Network interface.
Hop count
Next Hop
List of precursors
Life Time (expiration or deletion time of the route)
Link weight

2. Extend route request packet fields to store information by adding three new fields to its structure as shown in table 3.

- X-Pos, Y-Pos contain the coordinates of the vehicle that generates this RREQ.
- Speed contains the current velocity of the vehicle that generates this RREQ.

Table :3 U-AODV route request packet

The final format of RREQ
Type |J|R|G|D|U| Reserved | Hop count
RREQ ID
Destination IP Address
Destination Sequence Number
Originator IP Address
Originator Sequence Number
x-pos
y-pos
Velocity

5.4 U-AODV Main Algorithm

When the source vehicle S has data to send, first looks at its routing table. If there is a valid route to the destination D, then it will use it, else a new route discovery process starts. The source begin to collect information about all neighbor velocity and position for each one by using GPS technique to get values of link weight between source and its neighbors.

According to values of Link weight results, the next hop selection and RREQ packet transmission will be start. Each vehicle receive RREQ and it intermediate node not the destination, it will forward the RREQ packet to its neighbors until reach the destination. When RREP packet return in reverse path, the U-AODV routing protocol destination node generates RREP packet, if node receive reply as it isn't source node that generate REEQ, then forward RREP back across the reverse routes. In the end, the source node reached and gets the route. Hence, the connectivity established. Below the algorithm that explain the modification in route discovery phase.

Algorithm :1 Route Discovery of U-AODV
1. **Step 1:** If routing table of source contains a route to destination, send RREQ Else go to step 2
2. **Step 2:** get information about speed and position from GPS
3. Calculate link weight between current node and neighbors
4. IF (Si =True and Si+1 =True) || (Di = False and Di+1 =True)
5. discard RREQ
6. return false (moving away) ;

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7. END IF
8. IF (Si = False and Si+1 =True) || (Di = True and Di+1 =True)
9. discard RREQ
10. return false (so fast);
11. END IF
12. IF (Si = False and Si+1 =True) || (Di = True and Di+1 = False)
13. discard RREQ
14. return false (moving away && fast);
15. END IF
16. Else (SVi and SVi+1) && (DVi and DVi+1) =(True || False)

17. SL= s-vector*| Si - Si+1 |
DL= d-vector * |Di – Di+1 |
Link weight = SL + DL
Set to rtable = Link weight
18. IF Link weight > Link weight threshold
19. discard RREQ
20. Else
21. create RREQ packet and broadcast it to its neighbors
22. IF neighbor is destination then
23. Go to **step 3** :send back a RREP packet to the vehicle sending the RREQ
24. END IF
25. END IF
26. update (Si , xpos , ypos)
For all vehicles node receiving RREQ and link weight < threshold node no.
27. Forward RREQ
28. END IF
29. Step3 while (vehicle N receives RREP) and (N != S)
30. Forward RREP on the reverse path
31. store information about the vehicle sending RREP in the rtable
32. Step4 source receives RREP
33. source updates its rtable based on the vehicle sending the RREP
34. Step5 S establishes connectivity with D
35. END IF

In this algorithm, node i is represented by the source node. By the calculation, the source node gets information and calculate the link weight formula between it and all its neighbors. From the previous analysis, the link of two vehicles with the similar speed and the same direction will be more stable. The researcher set appropriate threshold number if the link weight value less or equal, the source node selects this neighbors to be next hop to carry RREQ packet. Figure 1 and 2 show the section of the next hop according to velocity and direction parameters.

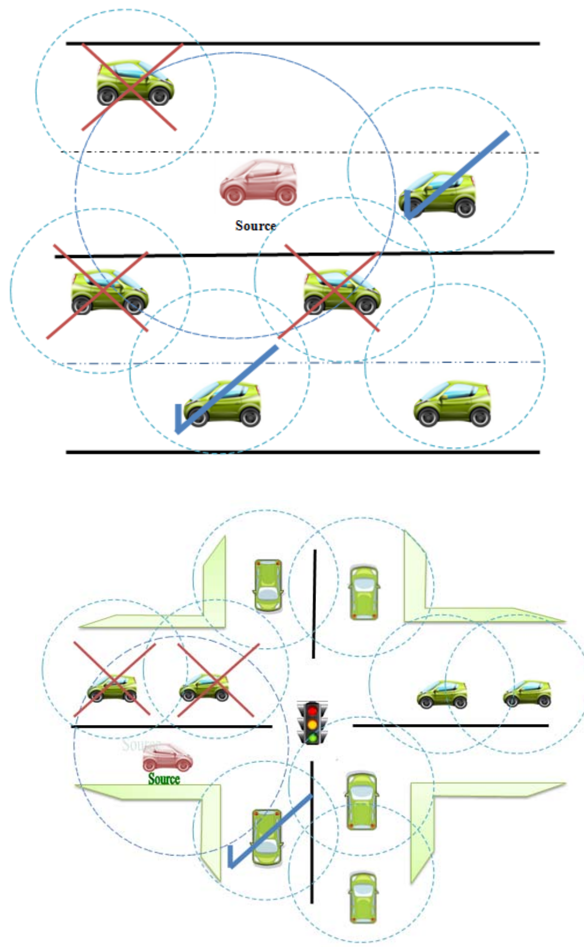

Figure :1 Appropriate next neighbor selection

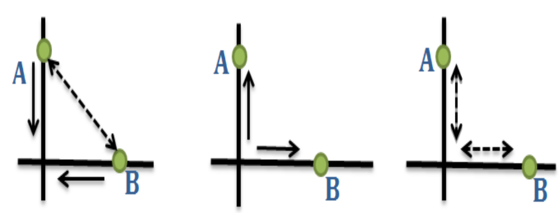

Figure :2 Appropriate next neighbor selection

6. METRICS OF MOBILITY MODEL

U-AODV selects OpenStreetMap mobility model, which is a well-known mobility model for VANETs. In this model, several horizontal and vertical streets existence in the simulation field and mobile nodes are moving on the lanes of the streets. For each street, it has several lanes in both directions, the vertical and horizontal streets may cross with each other at the intersection. The mobile nodes are supposed to move ahead, back, turn left

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or turn right with certain probability on the intersection. The selected scenario map has a vertical and a horizontal street with an intersection. Each street has two directions be made of a lane as brief below**:**

Case One:

When two Vehicles traveling in directions away from each other. In this case the links may breaks in short time. Figure 3-a.

Case Two:

When the vehicles traveling in same direction, in this case there are three different scenarios:

1. The vehicles moving within the coverage range in similar speeds, so the links between them will still active for long time. Figure 3-b.

2. The vehicles traveling in different speeds. In this situation the link will break as soon as the first vehicle (the faster one) passed the coverage distance. Figure 3-c.

3. When the distance between vehicles equal to 0, it is mean the nearest distance between the source and the receiver.

Case Three:

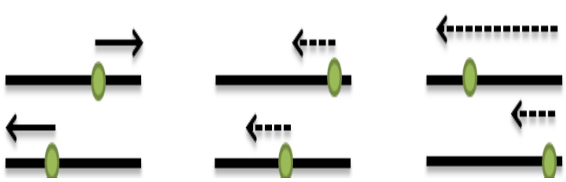
When the vehicles traveling in perpendicular directions, in this situation there are two different scenarios:

1. The vehicles moving towards streets cross, in this situation the vehicles moving to be nearer from each other until reaching the nearest point at the streets cross, than they traveling away from each other. Figure 4-a.

2. when movement in opposite direction away from the intersection. Figure 4-b.

3. The vehicles traveling moving away or approaching in different in different speed and distance. Figure 4-c.

4. When the vehicles stopped waiting the green lights. It will be three stopping directions and only ones moving, the distance among nodes will be short and their movements will be nears and slow.



a. different direction b. same direction and velocity c. same direction with various of velocity

Figure :3 Two Lines Probability

Figure:4 three possible configurations when two vehicles travel in the perpendicular directions as urban intersection

7. FUNDAMENTAL SIMULATION STRUCTURE

The simulation system structure is shown in Figure 5. The behavioral of simulators stream and analyzer block (SUMO) generates the movement pattern of the vehicles, then SUMO first using map data of OpenStreetMap (OSM) and based vehicle mobility, traffic, flow, etc. in Chicago city nodes and connections implemented on NS2 simulator. In this simulations, the standard IEEE 802.11 is used with Two Ray Ground Propagation Loss Model. SUMO and scenario generated by OSM. The project that used to create and distribute free geographic data for the world is called the OPEN STREET MAP. It is saved as .osm file. to conduct simulation experiments and performance evaluation.

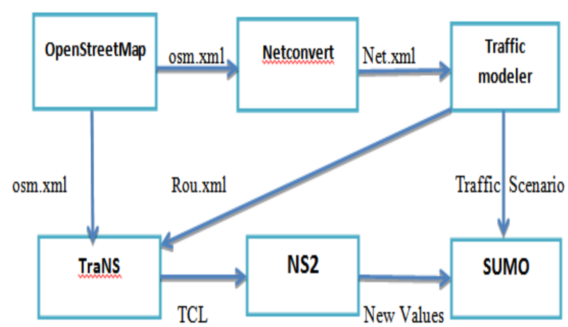


Figure : 5 Simulation System Structure

8. VANET SCENARIO DEFINITION

In this paper, urban VANET scenarios created from real areas of the downtown of Illinois, Chicago, USA, see figure 6. These instances cover two different situations (straight and intersection) of the same metropolitan area and they have different number of vehicles moving through the roads. SUMO is used to generate the realistic simulation mobility models in figure 7, where vehicles move following the real traffic rules (traffic lights and signs) .

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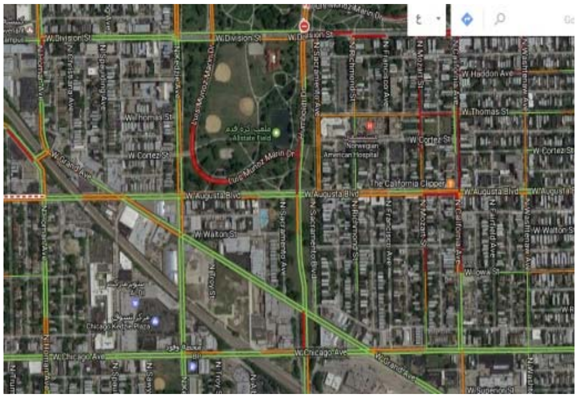

Figure : 6 Scenarios' map in real view GPS, of Illinois, Chicago, USA

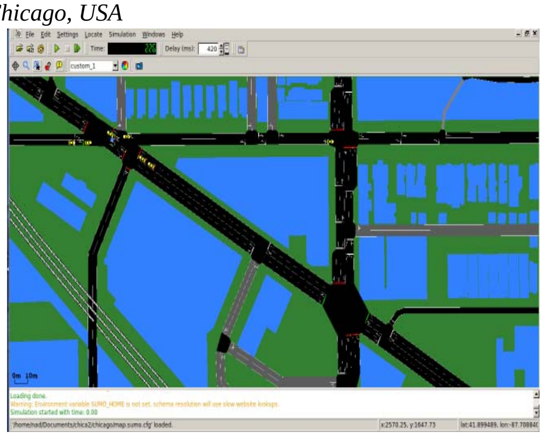

Figure :7 SUMO GUI of scenario

The simulation parameters is listed in table 4, during (400 ms) with velocities between 0 and 60 km/h. Additionally, each VANET scenario, experimented with density of node between 0 and 60 node, these situations differ from each other by the network data traffic overhead (data flows) generated during the simulations. The carried out scenario details applied on urban VANET simulations by means of VANET simulator based on NS-2 tool, such as NAM and trace file data, which are used to analyze a particular behavior of the network, users can extract a relevant subset of text-based data and transform it to a more conceivable presentation.

Table :4 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
MAC Type	IEEE 802.11
Routing Protocols	AODV, U-AODV
Transport Protocols	TCP
Traffic Model	FTP
Simulation Area(Topologies)	4391 m X 2772 m Grid, Real Map
No. of vehicles	10, 20, 30, 40, 50,60
Mobility of Vehicles	Real-time urban mobility
Varying Vehicle speed	10, 20, 30, 40, 50, 60
No. of vehicles	10, 20, 30, 40, 50 km/h

9. SIMULATION RESULTS AND DISCUSSION

Performance metrics are used to analyze the simulation results in details [27], the performance metrics are determined from the output files of NS-2 network simulator**,** the AWK language is employed to analyze and determine metrics such as time delay E2E and routing control overhead [27][28], to evaluate various mobility details on the AODV ad-hoc routing protocol.

9.1 Routing Control Overhead

Routing control overhead is the ratio of total generated routing control messages to the total number of data messages supposed to be received.

Routing control overhead= Total generated routing control / Total data received (4)

Routing control overhead is one of important performance metrics considered in our evaluation. Both routing protocols are affected by the network topology changes. 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. These extra route discovery processes generate more routing control overhead.

9.1.1 Effect of network size on routing control overhead

The control overhead of the proposed U-AODV routing protocol is calculated and compared with original AODV under real urban map topology. Figure 8 shows the amount of control overhead generated by U-AODV, where the drawback of simple enhancement can be attributed to the greater congestion and intermodal interference in a dense network of cities.

Periodically updating the network topology increases bandwidth overhead. Number of vehicles will be varying from 10 to 60. The larger number of vehicles refers to an optimal choice that may be available. The intersections state need more than velocity and direction factor to make next hop decision. The U-AODV strategy is not impacted as expected in highway environment due to urban complexity conditions.

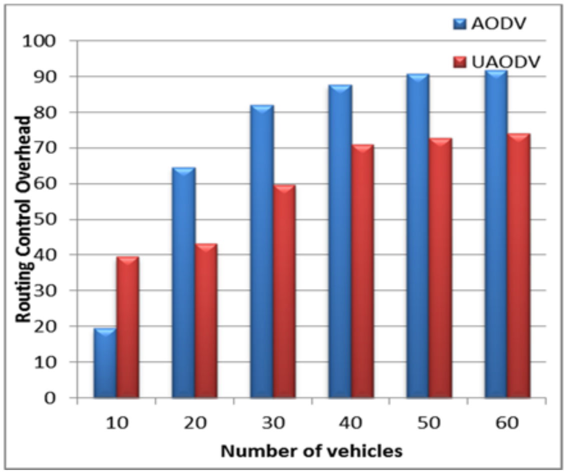

Figure :8 Effect Change on density Respect to Routing Control Overhead

9.1.2 Effect of vehicle's velocity on routing control overhead

The overhead ratio increases with the increasing in speed of vehicles as the updating in vehicles velocity increases bandwidth overhead. Figure 9 shows no big difference between two protocols in overhead ratio with the increasing in velocity.

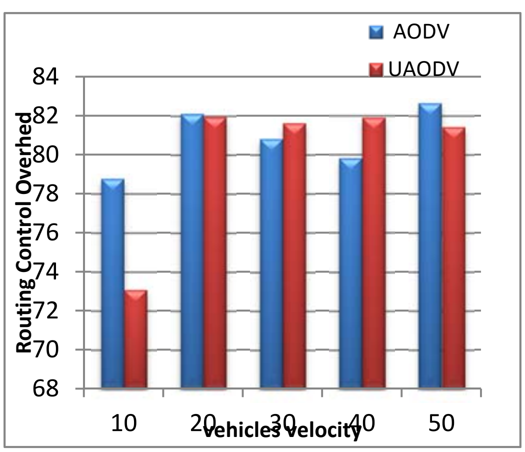

Figure :9 Effect Change on Velocity Respect to Routing Control Overhead

9.2 Average End-To-End Delay

The average end-to-end delay is the time that taken to successfully broadcast the data packets from source to destination [29]. This metric includes every potential data packet delay from source to destination, such as the propagation delay, queuing at the interface, buffering during the route discovery latency, transfer time, and retransmission delay at media control (MAC). The average end-to-end delay is calculated as:

Average end-to-end delay = (time at which packet received – time at which packet sent) (5)

9.2.1 Effect number of vehicles change on E2E

The simulation results for the effect number of vehicles on E2E are shown in figure 10, which shows that the U-AODV performs better than AODV for most times of simulation. Although the improvement converges in high density, this good behavior in U-AODV always will avoid the delay that may be happened .

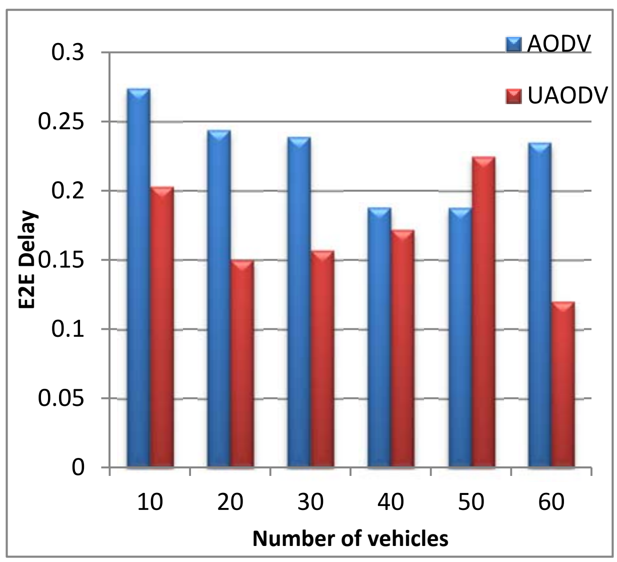

Figure : 10 comparative of end to end delay according to different vehicle density

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9.2.2 Effect of speed change on E2E

The simulation results for the effect of speed change on E2E are shown in figure 11. From this figure we can notice, firstly, that the two routing protocols start with closely E2E delay. Then, after network starts with sending packets and determine speeds of vehicles, we can also see the U-AODV performs better than AODV for most times.

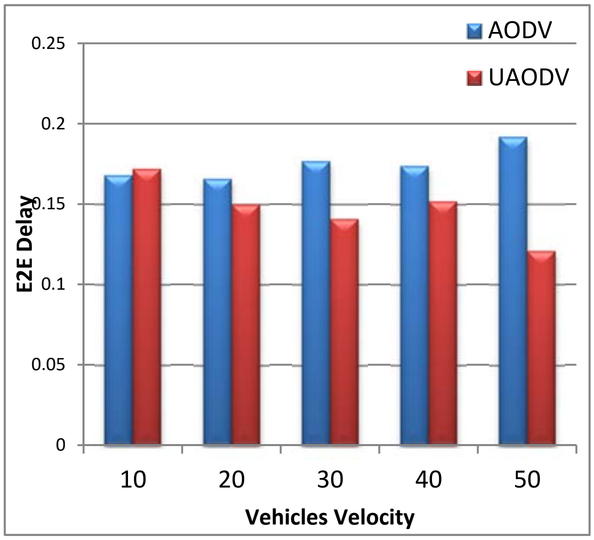

Figure :11 Effect of Change on Velocity Respect to E2E delay

9.3 DISCUSSION AND DIFFERENCES WITH OTHER WORKS

In this section, we will give a brief discuss our results and differences from other works. This discussion will further explain the behavior and performance of the proposed U-AODV protocol.

The best performance result of U-AODV in urban intersection, where the environment contains a larger number of vehicles. In this environment, the U-AODV has significant small value of overhead, and E2E delay, comparing with original AODV. Additionally, the evaluation results reveal that the U-AODV is faster than conventional AODV and causes low delay even if the vehicle speed periodically increased. The proposed U-AODV scheme has also small computational results providing less end to end delays than AODV. However, U-AODV with speed and direction in highway scenarios has a disadvantage in overhead compared to the conventional AODV, since it takes into account all urban road possibilities to choose next hop.

The schemes with velocity and direction parameters in other works, are implemented as mention previously on highways environment, in our study the proposed protocol is applied on real map of specific USA/ Chicago city, which represented as an urban environment that have more complexity than highway. Further, the modifications discussed carefully by proposed a various environment parameters that make AODV compatible with VANETs. The improvements are implemented to route discovery and selection phase to boost the performance of the standard AODV through various strategies to work with the VANETs. Those strategies are select especially in urban scenarios as is most of the papers are adopted a highway scenarios exclusively.

10. CONCLUSIONS

The paper focuses on modifying and enhancing AODV routing protocol to be more convenient and suitable in VANETs, using Global Positioning System (GPS) to acquire node position and velocity information of the network participants. This enhanced version of AODV has been called Urban-AODV (U-AODV), and it is basically depend on adapting work on real urban environment city of Chicago, which is one of the highly congested region. The traffic mobility model for the real world and network model were done by using two popular VANET's simulator tools (SUMO and NS2).

Simulation results demonstrate that UAODV outperforms significantly the AODV routing protocol in terms of better control packet overhead, End-to-end delay (E2E), and maintaining a reasonable ratio of the generated route request packet (RREQ) at discovery phase. For future work, we can add more impacting parameters to the routing protocol to support urban environment structures, and other performance metrics that related to QoS can be also simulated and tested with different traffic scenarios.

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