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Enhancement AODV Routing Protocol at the VANET within an Urban Scenario

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***Abstract**— a vehicular ad hoc network (VANET) is a potential technology for supporting communication in vehicle-to-vehicle as well as vehicle-to-roadside units. Because of high mobility and periodic variations in the design of networks, creating a reliable routing strategy for these networks is one of the key challenges in VANETs. The Ad Hoc On-Demand Distance Vector (AODV) routing protocol's scalability and on-demand route discovery technique make it a popular choice in VANETs. However, AODV has limitations that might impair the performance of VANETs, including major control overhead and higher delays throughout the network. This work introduces an improved AODV routing protocol created especially for the VANETs. This paper analyzes the impacts of modifying the Contention Window (CW) settings for the density to discover ways to enhance the performance of the 802.11p transmission about receiving probabilities and latency. We show that the proposed CW specified in the IEEE 802.11p standard works well in almost all evaluated situations. The proposed protocol (P-AODV) also demonstrates robustness in extremely dynamic settings involving a range of traffic densities and patterns of movement.

Index terms— AODV, RSU, VANET, V2I, and V2V.

I. INTRODUCTION

The Vehicular Ad-hoc Network (VANET) is an evolution of the Mobile Ad-hoc Network (MANET) communication wireless technology. Vehicles in VANET can exchange information with neighbors, which is known as vehicle to vehicle, or with nearby infrastructure, which is a vehicle-to-infrastructure. The network topology constantly changes to track vehicle movement and velocity.

As a result, every node (vehicle) will continuously update the routing table based on the velocity information, delay of the packet, and range between nodes to overcome the issue of transferring packets created by modifications to this node [1].

VANET provides new authority to the Intelligent Transport System (ITS) and allows vehicles to interact with one another and transmit data. Transmission efficacy depends on a critical aspect known as routing, which facilitates data transmission from one vehicle to another [2].

VANET is produced by collaborating vehicles and infrastructure, known as roadside units (RSU) that aid in data transfer. RSU is a stationary device along roadways supplied having no less than one network equipment for short-range wireless communications that uses IEEE 802.11p and has 75 MHz of Dedicated Short-Range Communication (DSRC) frequency on 5.9 GHz. RSU collects and analyzes traffic data from smart vehicles within its service area. Furthermore, RSUs can be a gateway to other network technologies, like the Internet [3]. Vehicles within VANETs can connect at distances ranging from 100 to 1000 meters. As a result, these kinds of networks are designed to have two communication devices: Onboard units (OBUs) are put into vehicles, and roadside units (RSUs) are fixed nodes located at a road junction or traffic light. RSUs act as an access point for messages, whereas vehicles act as a network link, the source, or endpoint [4].

Deploy RSUs at road junctions and roadside to process vehicle-to-infrastructure connections, gather with analyze smart vehicle traffic data, transmit messages to cars, and provide prompt notification for safe vehicle driving. Because of the huge cost of developing as well as managing RSUs, determining where and how many RSUs to install is essential. A conflicting multiobjective issue exists when optimal RSU distribution necessitates a minimum number of RSUs with high coverage of the procedure for operating a vehicle [5].

Distinguish VANETs by frequent and rapid dynamic topology caused by vehicle movement and channel fading. Link stability test frequently uses mobility characteristics (speed, direction, position) with the influence of the fading channel ignored [6]. VANET networks address communication demands in transport systems to enhance driving and road safety for drivers on the road. Moreover, forwarding is essential in a VANET network for identifying and keeping a communication channel between two separate nodes [7].

One of the most popular and difficult fields of study for vehicle manufacturers and ITS designers is vehicular ad-hoc networks (VANET). The availability of such networks allows many applications, including applications for safety, movement, plus connection, to utilize transportation systems more effectively and safely. Furthermore, due to the fast velocity of the vehicle and the repeated disconnections status, the VANET system has a dynamic and unpredictable network architecture. The optimal routing protocol should be chosen for safety applications like congestion detection. Before implementing multiple routing protocols in the real world, it is critical to test and analyze them using VANET simulation software. Much research has been undertaken to analyze and study the efficacy of various routing methods using simulation programs to choose the most appropriate protocol for vehicular communications.

A. Problem statement:

When designing and assessing the transmission protocols aimed at these applications, delay, and availability are the two most important criteria that must be considered compared to other VANET applications. Information processed in safety applications is hugely crucial and may damage human life. However, there is a trade-off between dissemination dependability and delay. In this study, we coupled the effects of vehicle mobility with fading channel statistics on link stability and showed some of the past efforts associated with the subject mentioned above.

The rest of this manuscript has been structured in the following order: Section II depicts routing in vanet, and Section III provides a synopsis of the related works. Section IV gives a detailed description of the routing protocol for AODV. Section V shows our methodology and the suggested AODV routing protocol; Section VI describes the Fundamental simulation structure; Section VII shows analysis results and discussion; and finally, some concluding remarks are provided in Section VII.

II. ROUTING IN VANET

In a VANET, data packet routing among mobile nodes is crucial because mobile routers and their mutual connections might vary rapidly. Furthermore, mobile nodes' links point to permanent infrastructure changes regularly, necessitating the use of a protocol for dynamic routing to efficiently enable connections [8]. Routing techniques for VANETs are primarily classified as location-based algorithms or topology-based routing algorithms.

The location-based routing method makes routing decisions depending on data on a vehicle's location. It selects the packet's transmission route based on the node's location which is to receive the packet and the position of a nearby node.

The topology-based routing algorithm makes choices regarding routing primarily by utilizing the network topology established by communications linkages between nodes [9]. They are categorized based on the location and function for which they are best appropriate.

Topology-based methods are divided into three types: reactive, proactive, as well as hybrid. In reactive the majority of the nodes are unidentified regarding this protocol. It just stores the data of nodes that flow through it. Protocols of this sort include Dynamic MANET Demand “DYMO”, Dynamic Source Control Routing “DSR”, and Ad-hoc On-Demand Distance Vector “AODV” [10].

III. RELATED WORKS

On VANET, numerous algorithms have been used in a variety of ways to improve route selection. The deployment of enhanced AODV on VANET is the topic of some pertinent research work discussed in this section. It shows how the effectiveness of VANET routing protocols has improved.

AODV routing protocol's performance is enhanced in [11], and many mobility features are introduced to make the AODV protocol appropriate for VANETs. Those features are direction, acceleration, velocity, and connected vehicle quality. As a result, these movement aspects aid in determining the optimal path from source to destination.

The author in [12] estimates the routing performance for VANETs in Khartoum city regarding the ratio of packet delivery, latency, energy, and throughput of multiple protocols for routing. The tests were intended to provide more efficient processes in congested places. The extensive simulations provide a comprehensive analytical framework based on a recent cellular automata mobility model. The predictions of such a framework also offer insight into the sorts of applications that urban VANETs have, like safety and non-safety.

The author in [13] offers a distance-based routing strategy for urban areas considering packet-avoided collisions at intersections and path selections based on flexible waiting times.

A trust-based VANET Optimized Node Selection Routing Protocol (ONSRP) suggested by the author in [14], they created an upgraded routing system that protects the network from experiencing frequent communication connection failures. According to the result, ONSRP routing has an improved performance metric compared to the previously described current protocols for routing.

The author in [15] proposed new AODV routing protocols to increase route reliability and reduce route control overhead. In this work, they employed two-step improvement in discovering and selecting routes. This approach makes a significant impact by reducing the amount of broken connections. Nevertheless, this strategy needs to deliver sufficient results regarding the delivery of packets ratio. Furthermore, evaluating the suggested method's performance does not account for additional performance matrices, like throughput and latency.

To decrease latency, boost throughput, and minimize packet loss, this study [16] introduces and optimizes the VANETS multi-cast broadcast method. While it analyzes the Improved Protocol (MAODV) as well as contrasts its performance with the conventional AODV in VANETs,

To make AODV more compatible and appropriate for implementation in VANETs, the [17] explores potential improvements and suggests several environmental criteria. To improve the functionality of the AODV protocol and enable it to be used by VANETs, the authors suggested and built a new Route Discovery as well as a Choosing Phase. Developed and evaluated, especially in the Urban Highway environment, are the suggested AODV changes. Consequently, Urban-AODV, or U-AODV, is the name given to the newly updated AODV protocol. Additionally, it reduces the AODV's connection and routing control overhead in the case of urban or city traffic.

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The author in [18] proposed a method by using fuzzy logic to increase the accuracy of AODV routing algorithms. They fed the trajectory, velocity, and length to the target of the vehicle into a fuzzy logic controller. In terms of average E2E, their suggested protocol surpassed the initial AODV, as well as AODV and FCAR in terms of the delivery of packets rate. Nonetheless, the suggested approach outperformed FCAR in terms of average E2E latency.

IV. ROUTING PROTOCOL FOR AODV

It is a wireless network forwarding solution that operates on demand and stores router data in traditional tables for routing [4]. The responsive protocol is ad hoc on-demand distance vector routing (AODV). It is a self-configuring, multi-hop routing method. It can route multicast as well as unicast traffic. It chooses the path based on hop counts. A path is discovered using the flooding principle.

AODV sends an RREQ (route request) packet for the nearest nearby node within the communication range. Nearby nodes determine if the node is new or has reached its destination and respond in a transmit fashion. Minimum hop count criteria will be used to choose routes [19]. Depending on hop count and sequential number, the source in the AODV protocol chooses the optimum path from its starting point to the destination.

Due to significant node mobility, connection failure is a considerable risk, which reduces service quality. When a route crashes, a routing message of failure is returned for a node of route-initiating and the route establishment procedure is restarted from the beginning [20]. The AODV protocol allows the network's nodes to build routes for new zones quickly and reduces node maintenance of routes for locations that are no longer in use. That makes nodes move regularly and acknowledge if a modification within the network's topology or even a connection break arises [21].

V. THE PROPOSED AODV ROUTING PROTOCOL

This section introduces the transmission technique we developed to deal with the issues mentioned in Section I, *A*. In the proposed model, each vehicle stores a neighboring database depending on its current position. The packet will be sent to the next-hop neighbor, as shown in Fig. 1. If a vehicle fails to receive data from a hop's neighbor within a specified period, the connection will be lost.

A. Route:

To predict the route, we will utilize the graph G (V, E) concept, which consists of the roadway intersection point (j ∈ J) and sections of the road (c ∈ C), where each segment is connected to the intersection place.

After that, to reduce the need for traffic management, build a blocker road. Therefore an 802.11p MAC should offer a stable and effective channel connection method to serve many applications. Rapid changes in topology and the mobility of nodes within a network make it challenging to utilize wireless mediums efficiently. An 802.11p MAC streamlines connection form via skipping channel scans and authenticating operations to guarantee the timely transmission of delay-sensitive safe messages as shown in Fig. 2. In this case, build a road topology using Sumo with NS-2.35.

B. Packet:

To send a data packet, a contention window (CW) size is increased by two from its beginning value (CWstart) till it reaches a maximum value (CWend).

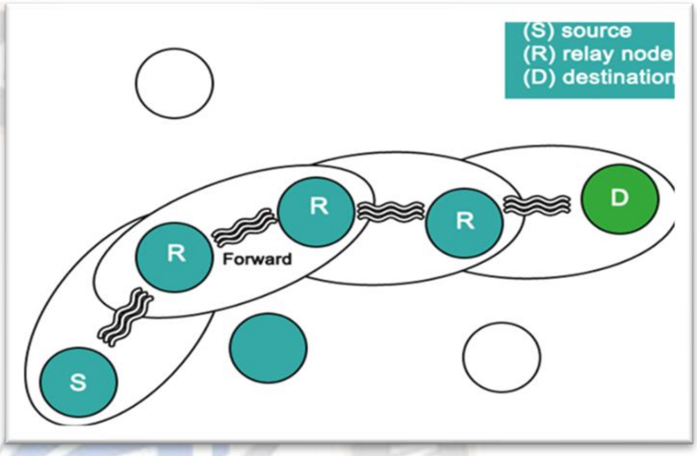

Fig. 1. Source send packet in VANET

The CW is reset to its original value if packets need to be lost due to exceeding the highest amount of access to the channel or when the transmission succeeds.

Since there is no RTS/CTS handshaking technique used during the broadcasting, there is no receipt node that will transmit ACKs in reply to the source node. Therefore, a sender cannot determine if all receiver nodes have received the packet correctly. Once a busy channel is detected, it only does a single back-off step, like the first channel access attempt. As a result, the planned broadcast packet must go through at most one back-off operation.

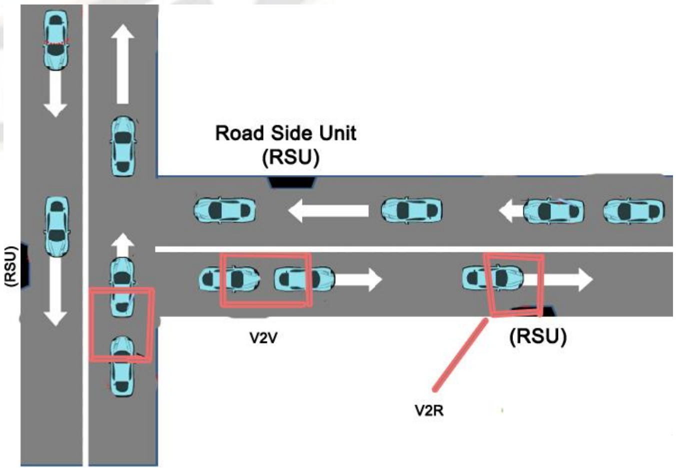

Fig. 2. Routing the packet in VANET

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The two most significant functions defining the behavior of the TCP Scalability method are as follows:

1. Whenever an ACK arrives, the first Function is executed and the window for congestion is expanded.

   Void (*cong_avoid) (struct tcp_sock *sk, unsigned int ack, int good_ack, int rtt, int in flight);

- [Ack]: represents the total number of bytes accepted in the last acknowledgment.
- [good_ack]: that assesses if the current event is typical.
- [Rtt]: the RTT determined by the most recent ACK.
- [in_flight]: It refers to a packet that was in transit before their most recent ACK.

2. When a TCP flow finds a loss, the second function occurs and returns the flow's slow-start threshold following the packet loss.

- Unsigned int (*ssthresh) (struct tcp_sock *sk);

C. Optimal Path Choice:

Step 1: Determine the path

Inputs: the ID of the initial node (S) as well as the destination node (E).

Outputs: the best path via the starting point toward the destination.

Begin

If (ID of E = ID of N)

Forward packet to E;

else

Set limited square scanning road;

scanning _road = [Rmin, Rmax , Rmin, Rmax];

Send RREQ to E inside scanning _road;

Turn on (BROADCAST_TIMER);

Measure path exploring, packet drop, and connection;

if

(p max -p other > F)

returning route via connection exploring Pmax;

else

When a link is found, remove routes p other < pmax -p threshold;

returning path with delay in packet d_min;

End of.

End of.

End procedure selecting a path

D. Next Hop selection

Procedure 2: Next Hops selections
Inputs: include the neighbors' placements and velocities.
Output: the best next-hop relaying node.

begin
do
if (E transferring a road section = E present road_ section)
else
go toward the intersection node N;
else
transmit the packet towards the following nexthop_node N;

while (The destination of the node isn't the forwarding node);
Deliver the packets to the target ;

end if
end if
end while

end the next of hop selection

VI. FUNDAMENTAL SIMULATION STRUCTURE

Vehicle mobile as well as network traffic models are simulated and utilized using Simulation of Urban Mobility (SUMO) tools for producing the roadways and speed of vehicles, Vehicular networks like VANET mobility simulations using Network Simulator which here (NS-2.35) tools for give a network model.

Data from SUMO generates a mobility trace that NS-2 version 2.35 may instantly utilize to imitate real-world vehicle motions. NS-2 was used to evaluate the effect of SUMO mobility models on VANET routing protocols. So, it is critical to employ a realistic movement pattern to accurately represent the performance characteristics of those procedures.

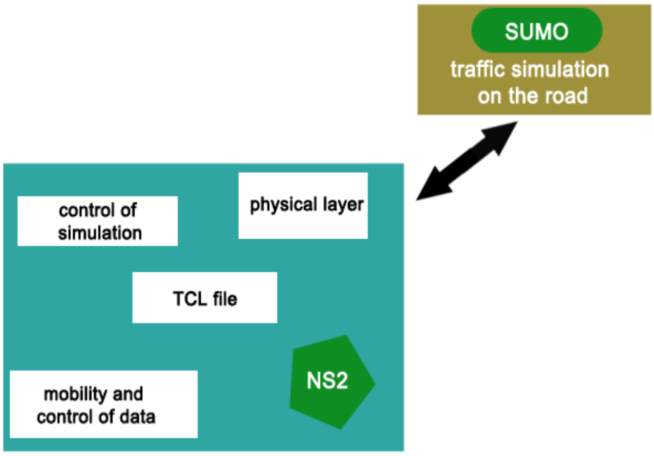

Fig. 3. Objectives Module Networks using Tcl (ns2) and Urban Mobility Simulator (SUMO)

International Journal on Recent and Innovation Trends in Computing and Communication
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Three VANET simulators are used to simulate scenarios. Ubuntu 12.04 includes Netedit and SUMO as mobility simulators and NS-2 as a traffic simulator as shown in Fig. 3. In this case, employ NS-2 to evaluate various mobility metrics such as the packet delivery ratio, throughput, and latency. Furthermore, a routing protocol (AODV) is simulated. On a map, the edge (road) links nodes. An edge's attributes include the number of lanes, speed restriction, road priority, and length of road.

After that, all information is stored in a file called net.xml in sumo. While the speed of the vehicle, direction of movement, and time of departure are stored in a file called rou.xml, both files are used to create a sumo.xml file which is used to generate mobility. TCL file that includes all information about the vehicle to use later in NS-2 which utilized the translated motion traces to build the TCL file and (NAM) Network Animator file, as seen in fig. 4.

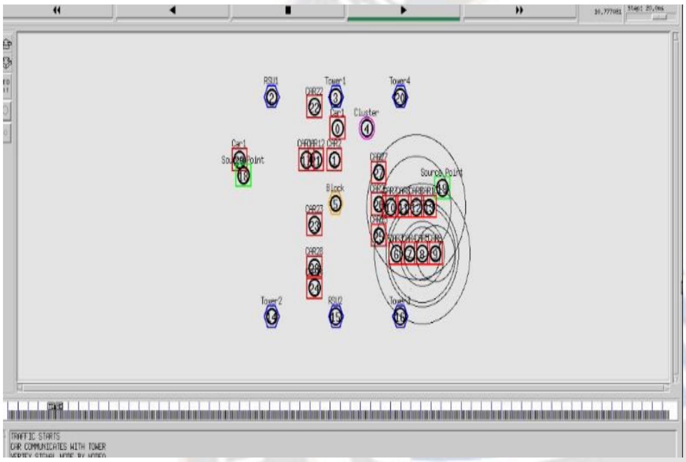

Fig. 4. Simulation scenario in VANET

TABLE 1
SETTING PARAMETERS IN THE NS-2 SIMULATOR

PARAMETERS	VALUES
operating of system	Linux (Ubuntu 16.04)
version of simulator	NS-2.35 for IEEE 802.11Ext
Number of vehicles	(10, 20, 30, 40, and 50)
Road Segments	4
Speed of vehicles	20 m/sec.
Radio propagation model	Propagation/TwoRayGround
Network interface type	Phy/WirelessPhyExts
Packet Size	512
Traffic Type	UDP-CBR
Ex. Time	100 second
Type of Antenna	Omni-Antenna
Transmission Range	1000*1000 m
Routing Protocol (Proposed)	P-AODV

VII. ANALAZY RESULTS AND DISCUSSION

Routing protocol performance is quantified using a performance entity that includes throughput, e2e-delay, delivery ratio, etc. In general, when traffic loads grow, the protocol for routing must convey additional information throughout a network, leading to increased transmissions over the medium of wireless and more conflicts with the loss of packets.

Likewise, high mobility limits for RP (routing protocols) performance necessitate continually changing paths. The end-to-end delay of high-traffic mobile structures also gets higher because of the high frequency of collisions, which necessitates further frequent repeated transmissions during a link layer, this causes delays, which are very closely related to network size since a large network contains longer paths on average, demanding additional hops so therefore higher delays.

- Packet Delivery Rate (PDR): The rate of delivery is a measurement of all source node packets that are successfully transmitted and received at destination nodes. Fig. 5 shows the PDR is better in our proposed AODV when increasing vehicle numbers.

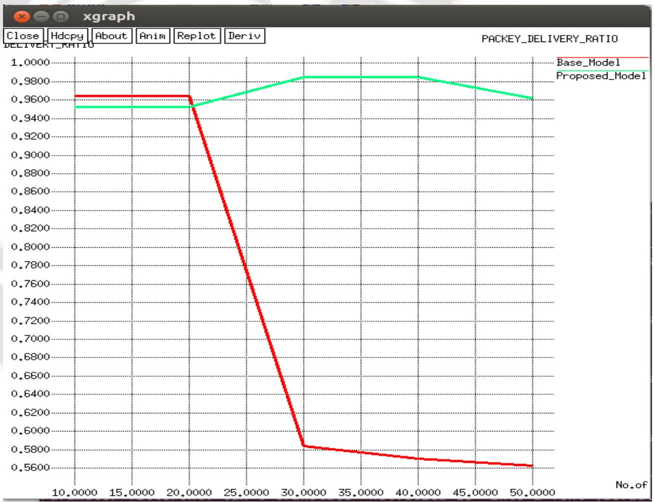

Fig. 5. Packet delivery ratio versus no. of node

- Aggregate Throughput: Total bytes successfully received at the sink divided by the whole period are used to determine throughput, Fig. 6 shows throughput stability in the proposed protocol, unlike the conventional protocol, which increases throughput by increasing vehicle numbers.

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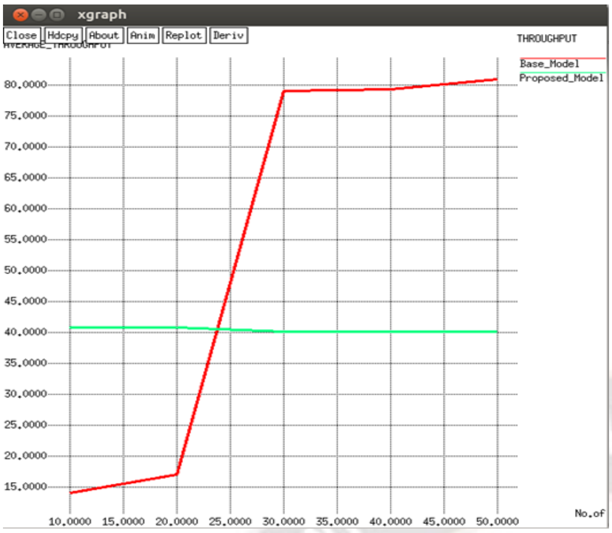

Fig. 6. Throughput versus no. of node

- Average E2E Delay: the average of how much time it takes a packet to transmit from the start point to the destination. Fig. 7 shows how the delay rate in the proposed protocol is less than the conventional AODV with a rise in the number of vehicles on roadways which is around 105 ms in the case of 50 vehicles, compared to 230 ms in the case of the traditional protocol.

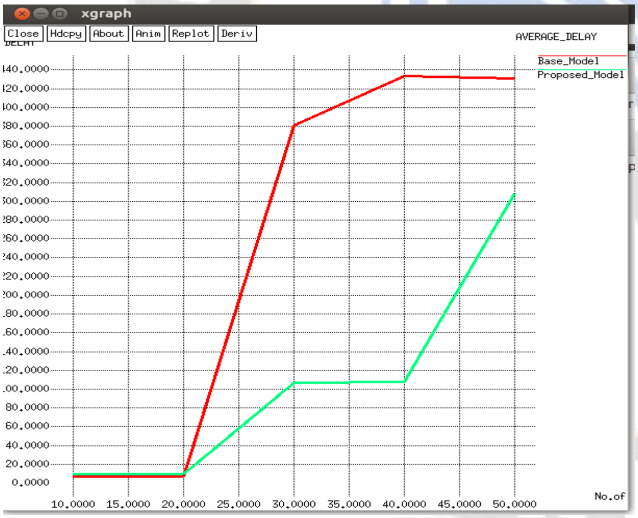

Fig. 7. The Delay versus no. of node

- Routing Overhead: the number of routing packets (non-data) generated by the protocol for discovering and maintaining routes. Which is less in the case of our proposal, as shown in Fig. 8.

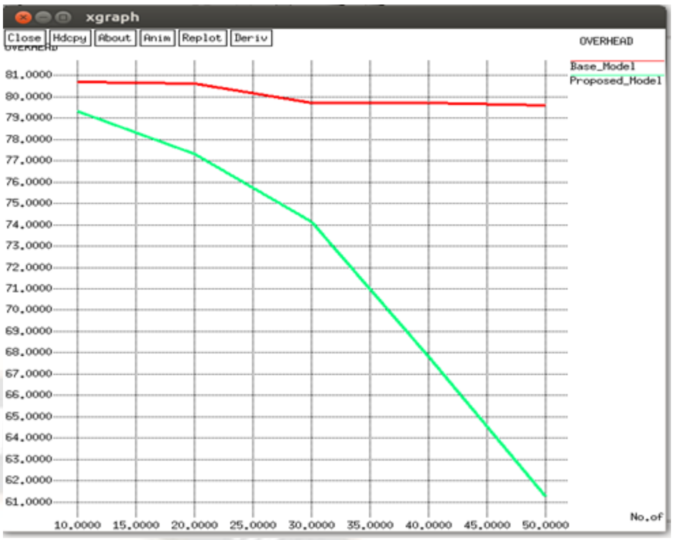

Fig.8. The Over-head versus no. of node

- Energy Consumption: the total energy consumed during the whole process. In our protocol, shown in Fig. 9, we observed relatively low energy in most cases, especially when the number of cars increased.

Fig. 9. The energy spent versus no. of node.

VIII. CONCLUSIONS

In this part, we will briefly examine our results and how they differ from previous efforts. P-AODV exhibits its highest performance in metropolitan intersections, where there are more vehicles in the surrounding area. The improved AODV protocol described in this work provides a promising response to the issues with routing in VANETs. The protocol increases routing efficiency, lowers control overhead, predictive mobility modeling, and prioritizes forwarding. The results of this study aid in the creation of routing protocols for VANETs that are more efficient, promoting the development of intelligent transportation systems and opening up a wide range of cutting-edge applications for connected cars and smart cities.

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