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Design and implementation of a routing protocol for VANET to improve the QoS of the Network

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Abstract: -Wireless communication Technology is very fast emerging for deploying and developing new as well as traditional applications. Most people are doing research on the Internet of Vehicles (IoV). Vehicular ad hoc Network (VANET) is a part of IoV, It scopes to reach internet access to make use of the available service on the road along with the improvement in safety, convenience and comfort or even entertainment. While travelling has become a very popular area of research as it lay the foundation for the intelligent transportation system. In VANET, the mobility of the vehicle is high hence the network is dynamic. Therefore, the connectivity between the two vehicles and the roadside unit (RSU) keeps changing, increasing the links and reducing the network quality of Service (QoS).In this context, a more effective routing protocol is needed that would be improved the VANET quality of Service (QoS). In this paper, a routing protocol is designed and implemented to improve the QoS of the VANET network. Here the VANET packet is routed to the destination using multiple Onboard unit (OBU) of vehicles and roadside units (RSU). The proposed process is simulated using MATLAB 2022a and shows the performance of the improvement of QoS parameters like end-to-end delay, packet delivery ratio (PDR), normalized routing load (NRL), energy usage (EU) and throughput is better than the previously implemented routing protocol such as SDIoV (SDN Enabled Routing for Internet of Vehicles), and well-known protocol AODV.

Keywords: *IoV, VANET,IoV, Mobility, SDIoV and AODV.*

1. Introduction

Intelligent transport systems (ITS) increase the deficiency of the traditional and new transport systems using modern wireless communication technology called internet of vehicle (IoV)[1][2][3]. It can be beneficial to experience reduced accidents, less traffic congestion and more comfort [1]. Nowadays vehicles can communicate among themselves and with infrastructure such as humans or the internet of things (IoT) or smartphones. This infrastructure-based technology is made possible with the technology of vehicular ad-hoc networks or VANETs[4][5][6][7]. However, VANET is a novel class of technology of Wireless communication or Wireless Sensor Networks (WSN)[8][9][10] as well as the principal of Mobile Ad-Hoc Networks (MANETs)[11][12]. Vehicles are equipped with wireless transceivers through which information is exchanged with their neighbour vehicles. If necessary, routing packets are transferred to the destination through the

Vehicle, instead of a direct connection. In VANET infrastructure [3][4], it is not essential to use single-hop communication, it can be used roadside unit (RSU) and it is a stationary unit, and it is also participating in transferring data when the distance is larger or absent of vehicles in the range and it improves route stability. Such type of infrastructure-based architecture has some potential application in a real-world environment like essential emergency alert, road safety, accessing entertainment and its comfort, platooning, traffic monitoring and management, information service, blind crossing and prevention of collision and the most important being navigating the location of the particular destination.

VANET was first introduced in 2001[13] using the car-to-car ad hoc mobile communication and network. Each Vehicle was used as a relay among other Vehicles for transferring data from source to destination. In VANET, using infrastructure-based architecture two types of communication were introduced: Vehicle to Vehicle (V2V) and Vehicle to the roadside or vice-versa (V2I/I2V). VANET is a support key framework called an intelligent Transportation Network. The VANET infrastructure-based architecture is shown in Figure 1[5]. VANET can use a range of communication for transferring data from source to destination like vehicle communication, Global Positioning System (GPS) and short-range vehicle communication protocol is used like IEEE 802.11, IEEE 802.15, WiFi, Bluetooth and WiMAX [4][5].

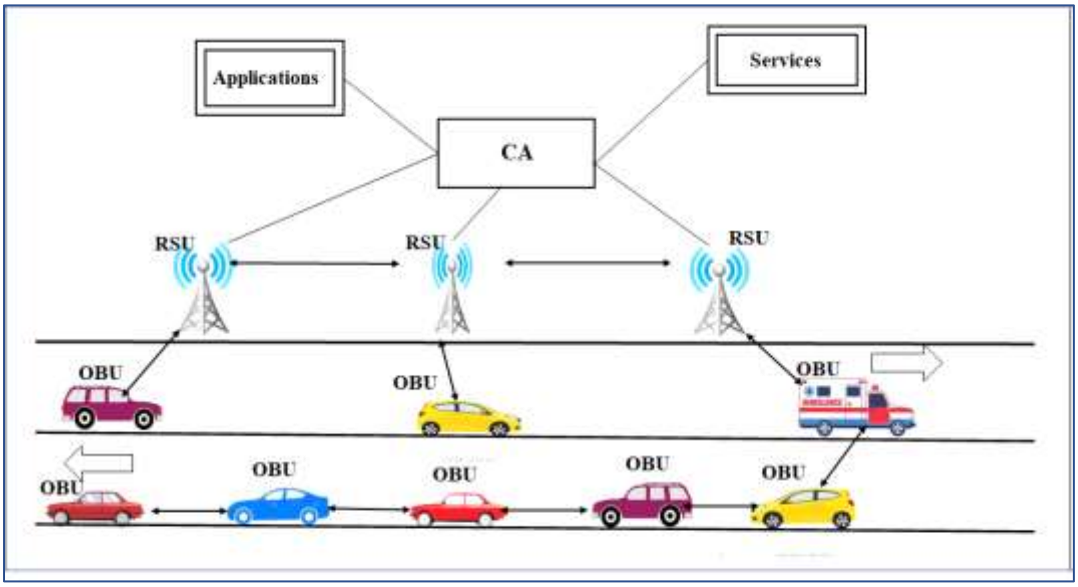

Figure 1: VANET commutation architecture

To develop routes with better quality and high probability connection, the longevity of path lifetime and low end-to-end delay, along with high mobility of the VANET technology some stable routing protocols are proposed [14][15][16], However, previously proposed routing protocol for mobile ad-hoc network routing protocol is applied in VANET, and their performance is poor in VANET. In topology-based routing protocols like optimized link state routing (OLSR)[15] and ad-hoc on-demand-based routing (AODV)[14][17], dynamic-based routing is the most popular node-based path in VANET, but route instability is also observed in this environment. Hence, In VANET, because of the high mobility link, there is frequent communication change and it gets broken. Therefore, with high packet drops, the overhead of the route and failure of data loss significantly increases. Hence proper routing of the VANET for data transfer from source to destination is required.

In the urban area [18][19][20][23], different geographical routing protocols are proposed. There are some well-known routing protocols such as Greedy parameter stateless routing (GPSR) [21], distance effect algorithm for mobility (DREAM) [22] and location service (DLS) [23]. Here, presented protocols do not perform well in a city environment; sometimes it cannot find the closest node which acts as the next forwarder node. The main problem with VANET is electromagnetic obstacles and its high mobility. In the literature review, a few numbers of road-based routing protocols have been designed to transfer data from source node to destination node, and they fail for VANET's different constraints like high vehicular traffic flow, high mobility, read density management and others. From this point of view, we proposed a routing protocol that is not only suitable for the road-based environment but also improves QoS characteristics like increasing network end-to-end delay, packet delivery ratio (PDR), normalized routing load (NRL), energy usage (EU) and throughput of the overall network. The paper is organized as follows, Section 2. Literature reviews of the previously published work. Section 3. Introduced motivation and contribution to the work. Section 4 and Section 5 represent the methodology and energy model of the proposed work, respectively. Section 6, discussed the Simulation setup of the work and the next section introduced the performance of the proposed work i.e. experimental result discussion in section 7. The last section concluded the whole work with future direction.

2. Literature Survey:

Vehicular Ad hoc network (VANET) is mainly used for road safety and comfortability. Quality of Service (QoS) in routing is important for transmitting a beacon message from source to destination in regular intervals. In that context, different routing protocols are developed for transmitting data.

Hsieh and Wang[24] have proposed a road-based QoS-aware multipath routing protocol for urban VANET (RMRV). The RMRV protocol can find multiple paths according to the road layout and select the most suitable path in an intelligent manner. Authors included a space-time planner graph approach for identifying the connectivity of RSU or road section thus a path for a future lifetime and life period can be delivered. However, the routing paths are explored by a flooding mechanism, which causes a huge overhead and decreases exploration efficiency.

Naumov and Gross [25] proposed a connectivity-aware protocol (CAR) that is designed for inter-vehicle communication in urban areas. When a routing path to the destination is required, the source initiates a routing broadcasting beacon message. This message stores the velocity vector of the mobile nodes through which it passes to reach the destination. When the current node velocity is different from the previous forwarding nodes, then two modes are set as an anchor pair and added to the header of the routing message. Whereas a broadcast beacon message is transferred to the destination using the shortest delay, followed by the route being selected as a routing path while intermediate nodes by which the message is passing are set as an anchor pair. Therefore, the CAR routing protocol is a source-initiated routing protocol and it stores a complete record of the routing path. Due to VANET rapid change of route is observed, hence CAR is not suitable for large-scale urban scenarios. The CAR routing protocol is an improvement of network overhead and reduced network congestion.

Zhao and Cao [26] proposed Vehicle-Assisted Data Delivery in Vehicular Ad Hoc Networks (VADD) protocol for VANET, which is a multi-hop data delivery protocol, in fact, if the network is frequently disconnected and mobile. The mechanism of packet forwarding in this protocol varies with the position of the forwarder node.

However, in the forwarding mechanism, the vehicle makes a routing decision at the intersection and packet forwarding is done to the road which has a minimum packet delivery delay. Here, used traffic parameters are road length, road traffic density, the estimation delay and average vehicle velocity. Linear system equation (n×n), using Gaussian elimination method is set as a road model where n is denoted as a junction number. If the junction is selected the forwarder node of the road attempts to select the next relay node and node closest to the intersection is given priority. If there is no forwarder node in between transmission range the packet is carried until it gets a suitable neighbor or forwarder node. However, the VADD has some disadvantages, the first one is if the scope of the area is linearly increased, its complexity increases and it performs poorly for large scale networks. The performance of the VADD protocol in terms of packet delivery ratio, delay and protocol overhead is much better compared to the hybrid-VADD protocol.

Saleet et al. [27] proposed Intersection-based Geographical Routing Protocol (IGRP) for VANET. IGPR protocol is based on faithful selection for road crossing where the packet is transferred to the Gateway of the internet. The selection of the road crossing is made in a manner that maximizes the connectivity probe- the ability of the selected path while satisfying QoS parameters in terms hope to count, end-to-end delay, bit error rate (BER) and bandwidth. Here, geographical forwarding is still applied to transfer packets between any two crossings within the path, which reduces the selection process of the path to the independent mobile node movement. However, the drawback of the IGPR is when optimization of QoS by formulated using Mathematical model.

Sun et al. [28] proposed Adaptive Routing Protocol based on QoS and vehicular Density (ARP-QD) protocol which is roadside intersection based multi-hop routing protocol. The basic thought is to determine the best path for end-to-end packet delivery. It is satisfied with the condition of improvement of QoS parameters by considering hop count, link duration simulations and reduced network overhead. ARP-QD can store high neighbor information in the header based on the local vehicular density. In summary, a recovery strategy with carry-and-forward is utilized when the routing path breaks. Thus, only using global distance is not enough to show the complete QoS routing path and packet delivery ratio may suffer from congestion in the upcoming road segment.

Toutouh et al. [29] has focused on energy-awareness and green communication protocols. They introduced OLSR protocol for energy-efficient routing of VANET. The experimental result shows significant improvement in energy consumption without significant loss of any other QoS parameter.

Elhoseny andShankar [30] have proposed an energy-efficient routing protocol in VANET via clustering model. VANET is a dynamic and rapidly changing topology network. This protocol incorporates clustering concept for gathering nodes and making the network increasingly vigorous. In nodes with energy shortage at some point in the network, execution is a problem due to topology changes which reduce node lifetime and network lifetime. At that point, K-Medoid Clustering model is introduced, and a clustering-based energy-efficient routing protocol for optimizing V2V communication is proposed. In this protocol, efficient nodes are picked out from each cluster using metaheuristic algorithm. Moreover, this protocol improves network lifetime and node lifetime.

Sivasubramanian et al. [31] has proposed an Adaptive Routing Scheme (ARS) protocol for VANET. ARS scheme included the average Bit Error rate expressed as in Nakagami-fading channel (ABERN-m) algorithm Reliable Routing (RR) of Reliable routing algorithm (RR). It predicts the link quality of the VANET. Due to the rapid changes in the topology of VANET, the amplitude of the received signal changes by reflection, scattering, diffraction and noise of the receiver antenna. In ARS protocol, network lifetime is increased to improve remaining battery energy (EER) by using the energy-efficient routing (EER) protocol. Here is used Canberra Distance Measure (CDM) instead of the Euclidean Distance Measure (EDM) and it improves the accuracy of the distance measurement in the mobile node of the VANET. By using ARS scheme protocol real-time road traffic can be better managed and the QoS of the network is also enhanced.

Abbas et al. [32] have proposed an optimal routing protocol for IoV and it reduced. The authors developed a scalability and flexible architecture. This Software-defined network and internet of vehicle architecture enable handling highly dynamic networks in an abstract way. Here, first, a unique property has been proposed to increase the performance of routing strategies. The concept of edge controller is introduced as an operational backbone of the vehicle grid in the Internet of vehicles, to have a real-time vehicle topology. Then, a novel mathematical model is used to estimated not only the shortest path but also the durable path. The performance of this protocol can be calculated in terms of availability and reduced routing overhead and it also minimizes the path failure in the network.

Kandali et al. [33] have proposed a Modified K-Means Clustering Algorithm and Continuous Hopfield Network for VANET(KMRP)scheme is a clustering-based routing protocol designed for a highway scenario. A modified K-Means algorithm is used to structure the cluster and cluster heads are chosen through the utilization of neural networks. All the member nodes of every cluster transmitted the data to their cluster head and the acquired data is aggregated and shipped to subsequent cluster heads. KMRP decreases the quantity of control packets in the neighbourhood and reduces neighbourhood overhead. Throughput is enhanced by minimizing traffic congestion. In addition, the cluster's stability in excessive density and mobility and minimum transmission delay ensures better Packet Delivery Ratio.

Sing et al. [34] Hybrid Genetic Firefly Algorithm-Based Routing Protocol for VANETs (HGFA) is a firefly algorithm-based routing protocol for each sparse and dense network scenarios where the probability of subsequent node determination relies on the frequency and depth cost of firefly flashes. It finds shortest route between two nodes based totally on the absolute best value in object function. Initially created object function value is chosen as beginning cost in the process. Vehicles are represented through columns and supply nodes are represented through rows in this area. After that, subsequent node is chosen primarily based on highest value of fitness function listed at source to transmit data. Whenever subsequent node is finalized, backward path is accompanied to get returned starting node. Depends on vehicle's speed and population feature cost is updated. HFGA performs better in terms of packet delivery ratio, throughput and transmission time than Firefly and PSO techniques as it utilized gain of each GA and firefly algorithm.

Al-Ahwaland Mahmoud [35] In AODV source node relays Route REQuest message (RREQ) amongst all nearest nodes to find first-rate route for the demanded destination node to minimize number of relays. After receiving the request destination node reply back with Route REPly message (RREP) message to source node. Both RREQ and RREP are accountable for path establish phase. The entries are updated into routing table for the subsequent hop. After certain time unutilized entries in routing table are eliminated. If the route failed an error message (RERR) revert back to origin node with affected node details to recommence alternate quality route by source node.

From the observations of previously published QoS-based routing protocols of VANET in reputed journals, we can see that it is very important to solve the following problems: 1) Need for appropriate QoS routing protocol: how to efficiently explore networks and search candidate routing paths with the limited number of overhead and enhancement of network lifetime.2) how to estimate real-time road QoS in dynamic environments.

Table 1: Comparative survey of the previous VANET routing algorithm

Author Details	**Year of publication**	**Name of the routing protocol**	**Mobility Support or not**	**Comparing Protocol**	**Simulator Used**	**QoS parameter**
Hsieh and Wang [24]	2012	RMRV	N/A	RBVT (Road-Based using Vehicular Traffic)	Qual Net 5.0	End-to-end delay, packet delivery ratio, network lifetime.
Naumov and Gross [25]	2007	CAR	Yes	GPSR	Ns-2 simulator	Packet delivery ratio, Delay, routing overhead.
Zhao and Cao [26]	2008	VADD	yes	Hybrid -VADD	Ns-2 Simulator	Packet delivery ratio, Delay, routing overhead.
Saleet et al. [27]	2011	IGRP	yes	GPSR,GPCR, and OLSR	MATLAB	end-to-end delay, hop count, and Bit Error Rate (BER)
Sun et al. [28]	2015	ARP-DQ	Yes	GPSR	NS-2 simulator	Deliveryrate, Transmission rate,
Toutouhet al. [29]	2012	OLSR	N/A	NA	C++ and	Energy packet Delivery ratio.
Elhosenyand Shankar [30]	2020	NA	NA	Dragonfly Algorithm (DA)	Ns-2	Energy, packet delivery ratio,
Sivasubramanian et al. [31]	2020	ARS	Yes	SSD-TD MA CLAO-TCP, SSD-TD MA	NS-2	Energy,Delay, Packet delivery ratio
Abbas et al. [32]	2020	SA-IoV	Yes	Hybrid road-aware routing proto- col (HRAR)	SUMO simulator	Routing overhead, Packet delivery ratio,End to end delay
Kandali et al. [33]	2021	KMRP	Yes	Hybrid routing scheme using imperialist competitive algorithm and	NS-2	Throughput, average End-to-End delay, Packet Delivery Ratio.

				RBF neural networks (ICA-RBF) A reliable multi-level routing protocol with tabu search (RMRPTS)		
Sing et al. [34]	2022	HGFA	yes	PSO, Firefly	NS-3	Transmission time, Packet delivery ratio,Average Throughput.
Al-Ahwaland Mahmoud [35]	2022	AODV	-	Ad-hoc On-Demand Multipath Distance Vector (AOMDV)	NS-2	Sent Packets, Normalized Routing Load, Packet delivery ratio,Average End to end delay,Average Throughput.

3. Motivation & Contribution:

The Quality of Service (QoS) is essential for transmitting a message from source to destination at frequent intervals. There are many QoS-aware routing protocols reported for VANET. In RMRV [24] protocol is most suitable path is selected through intelligence among multiple paths based on the road layout. It has an overhead problem that leads to less efficiency as routing paths are explored using a flooding mechanism. Whereas CAR [25] routing protocol is a source-initiated routing protocol that improves network overhead and congestion through routes for VANET are frequently changed so for the large-scale scenario it is not suitable. VADD [26] is a multi-hop data delivery protocol, even if the network is frequently disconnected and mobile. But for large areas, performance degrades and complexity increases. The IGPR [27] and ARP-QD[28] are roadside intersection-based multi-hop routing protocols. But optimization of QoS is not reached as suffered from congestion. In [29][30] energy-efficient routing protocols are proposed but the routing overhead is more, making it less effective in real-life scenarios.In ARS[31] scheme included the average Bit Error rate expressed as in the Nakagami-fading channel (ABERN-m) algorithm of the reliable routing algorithm (RR). Canberra Distance Measure (CDM) is used instead of Euclidean Distance Measure (EDM) and it improves the accuracy of the distance measurement in the mobile node of the VANET through network performance in terms of data delivery is not sufficient. In this context, we proposed an energy-efficient QoS-aware routing protocol for the VANET environment, which has minimum overhead with less delay enhanced network lifetime real-time road in dynamic environments. The main contributions of this paper are as follows:

- To design and implemented routing protocol. This protocol is used to communicate for V2V, V2I and vice versa.
- The evaluation of the energy-efficient routing protocol is simulated in MATLAB 2022a and considering realistic scenarios, where data is transferred from variable source node to fixed destination node through V2V or V2I communication.
- This proposed routing algorithm improves of Quality of Service (QoS) in the network. It is compared with previous routing protocols SDIoV3, SDIoV7 and popular routing protocol AODV and we get a

satisfactory result with respect to network characteristics like end-to-end delay, packet delivery ratio (PDR)., Normalized Routing Load (NRL), Energy Usage and Throughput.

4. Methodology

4.1. Problem Outline:

In light of the aforementioned research challenge, we have proposed a QoS-aware routing protocol for the real-time dynamic scenario of VANET with minimum network overhead. Our proposed algorithm is not only maximizing network lifetime but also enhances throughput and packet delivery ratio, and minimize send-to-end delay, routing load and energy consumption of the overall network. In figure 2. the proposed scenario, all vehicles have OBU (On Board Unit) by which they can communicate with each other and RSU (Road Side Unit) within the communication range of it. A vehicle sends data either to the next forwarding vehicle or to RSU as per closeness. RSUs are placed throughout the road with equal distancing and connected to each other through wireless communication. The following are the assumptions used in the network model:

- Here, vehicles are represented by $V1, V2 \dots . Vn$, can move within the speed range as defined for the road.
- We considered different roadside scenarios like one way traffic and two-way traffic.
- Network quality of service (QoS)parameters are measured for the proposed algorithm and improvement is compared with the previously proposed algorithm.
- The destination place is called the sink node and it is denoted with$S$. It is static and placed at the end of the road.
- The smart device is used in the VANET framework as OBU has limited energy.
- RSUs, represented by $R1, R2, R3, \dots . Rm$ are fixed has no power limit as they are rechargeable.
- Euclidean Distance method to find out the distance between different vehicles in the VANET.
- According to Euclidean distance method minimum distance between two nodes among vehicles, RSUs and Sink is considered to transmit data.

$D = \sqrt{(V_{x_2} - Vx_1)^2 + (V_{y_2} - V_{y_1})^2}$ or $D = \sqrt{(V_{x_2} - Rx_1)^2 + (V_{y_2} - R_{y_1})^2}$ and so on.

Minimum distance $d = \min(D)$ is considered.

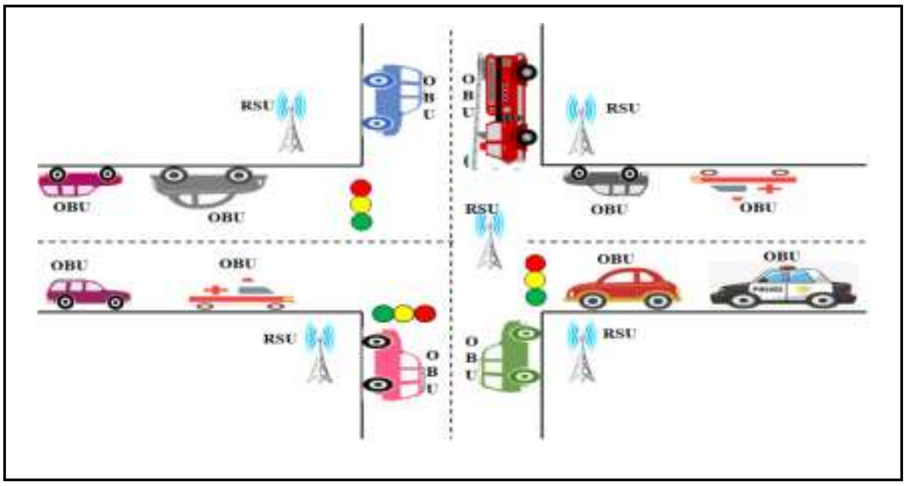

Figure2: proposed scenario: two-way traffic with crossing.

4.2. Proposed Algorithm:

In the proposed algorithm, the $V1(x,y), V2(x,y), \ldots, Vn(x,y)$vehicles are running towards the destination station or sink node, which might be a hospital or any emergency services. Each vehicle moves with a velocity towards the destination. The RSUs are represented by $R1(x,y), R2(x,y), R3(x,y), \ldots.., Rm(x,y)$ and destination station or sink node is represented by $S(x,y)$ .The transmission range is T.Whenever node Vi has energy more than threshold energy i.e. 0.05j [because as for the energy model the data transfer of single hoping minimum energy is used to consume 0.0437 j hence here, assumed 0.05j], nodeVi calculates the destination from self and RSUs or destination node with in transmission range (threshold value) and transmits the data to the nearest node, or if the other node is also vehicle, it sends data to the longest node within the transmission range. This node is considered forwarder node and this process continues till finding the destination node it minimizes the hop count which affects the network performance matric. The proposed algorithm is executed for a specified time and velocity to compare with existing algorithms.

```
BEGIN
Initialize all vehicles' positions $V1(x,y), V2(x,y), \ldots, Vn(x,y)$
initialize each vehicle's direction$\overrightarrow{V_1}, \overrightarrow{V_2}, \cdots, \overrightarrow{V_n}$
Initialize the speed/velocity of each vehicle$V1(vel), V2(vel), \ldots, Vn(vel)$
Check RSU placement$R1(x,y), R2(x,y), R3(x,y), \ldots.., Rm(x,y)$
Check Sink position $S(x,y)$
Assume $transmitting\ range = T$
Calculate distance between Sink and RSUs$Dsr = \sqrt{(S_{x_2} - Rx_1)^2 + (S_{y_2} - R_{y_1})^2}$
Calculate distance between vehicles $Dv = \sqrt{(V_{x_2} - Vx_1)^2 + (V_{y_2} - V_{y_1})^2}$
Calculate distance between Vehicle and RSUs $Drv = \sqrt{(V_{x_2} - Rx_1)^2 + (V_{y_2} - R_{y_1})^2}$
Calculate distance between Sink and Vehicle $Dsv = \sqrt{(S_{x_2} - Vx_1)^2 + (S_{y_2} - V_{y_1})^2}$
for j=1:timemax
for i=1: V                              /* $V1, V2, \ldots, Vn\ldots$ */
Calculate the distance of each vehicle from the others,
if$V(i).E > Eth$   /* $V(i).E$ residual energy of $Vi$ and $Eth$ is minimum energy needed to communicate next node*/
    if$V(i).Dv \leq T$
        if$V(i).Dsv < V(i).Dv$
$V(i).Df = V(i).Dsv;$
        elseif$V(i).Drv < V(i).Dv \&\& V(i).Dsv > V(i).Dv$
            $V(i).Df = V(i).Dr;$
        elseifV(i).Drv>V(i). Dv&&V(i). $Dsv > V(i).Dv$
$V(i).Df = max(V(i).distance);$
        End if
    Econsume=Econsume+(ETX*(V(i).Data))+(Efs*(V(i).Data)*(V(i).Df)$^2$); /* Total Energy Consumption*/
```

```
    End if
  $Data = Data + V(i).Data$          /* Data transferred by Node i*/
  End for                            /* End of $V1, V2, \dots, Vn$ */

  Calculate End to End Delay $= \sum_{i=1}^{n} \frac{Time\ packet\ received_i - Time\ packet\ sen_i}{Total\ no\ of\ packet\ received}$
  Calculate Packet Delivery Ratio(%) $= \frac{No\ of\ received\ packets}{No\ of\ sent\ packets} * 100$
  Calculate Energy Usage $= \frac{Total\ Energy\ Consumed(J)}{Vehicle\ Speed(Km\ per\ hr)}$
  Calculate Throughput $= \frac{Total\ No.Pkt\ Received}{Total\ Time}$
End for                  /* End of execution time*/
END                      /* End of Algorithm*/
```

5. Energy Model:

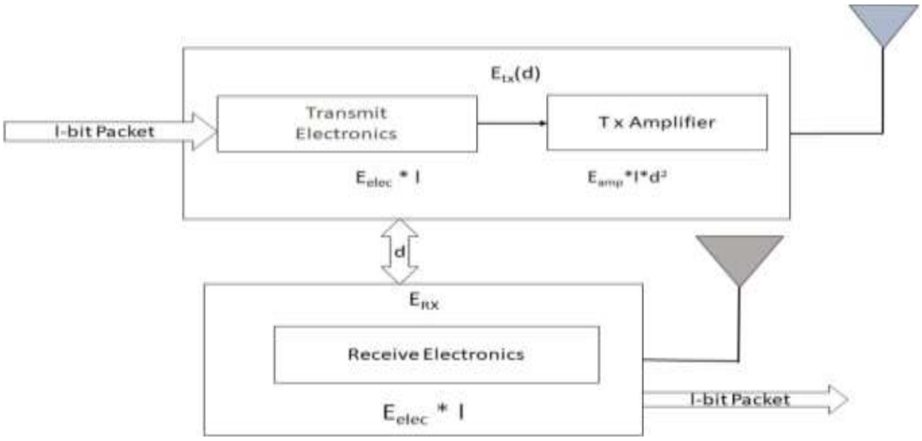

Figure 3: Energy Model of wireless communication

The details for the first-order Energy Model of a homogeneous network for each free space propagation and multi-direction propagation, an aggregation and energy dissipation network model are used. In figure 3 [33] illustrated how much power it takes to send and receive 'l' bits of data over a distance of d. The energy used for transmission in free space propagation is proportional to d^2, although it is proportional to d^4 in multipath propagation due to the use of several paths by the transmitting signal to reach the Sink.

In equation (1), E_{elec} is an electronic device. Both free space (fs) and multi-path (mp) losses are dependent on the transmitter amplifier variant as well as the corresponding node distances in both the transmitter and receiver circuits(d).

To transmit 'l' bits of information packet to d distance, the power intake E_{Tx} from node to CH or to BS is:

$$E_{Tx}(l,d) = lE_{elec} + l \in_{fs} d^2, d < d_0 \quad (1)$$

$$= lE_{elec} + l \in_{mp} d^4, d \geq d_0$$

Here E_{elec} is the dissipated energy per bit which is used to run the transmitter or the receiver circuit, $\in_{fs}$ and $\in_{mp}$depend on the transmitter amplifier model we use, and d is the transmission distance between the nodes and its CH or between CH and Sink.To receive 'l' bit message the following equation (2) is used

$$E_{Rx}(l) = lE_{elec} \qquad (2)$$

From the equation (1) and equation (2) we get$E_{Tx}(l, d)$ at $d = d_0$and d_0 is represented in equation (3)

$$d_0 = \sqrt{\frac{\in_{fs}}{\in_{mp}}} \quad (3)$$

Where, d_0 is the threshold distance that defines propagation transition from direct direction to multi-path version when the transmission distance is less than threshold distance than the free space channel version is used in any other case, multipath fading channel version is used. Parameter values used for the first-order energy model are listed in Table 2.

Table2: Different energy parameters of first-order energy model

Parameter	**Parameter values**
Energy consumption for data aggregation (E_{DA})	5nJ
electronics transmission and reception energy consumption (E_{elec})	50nJ
amplifier energy consumption $\in_{fs}$	10pJ/bit/m^2
amplifier energy consumption$\in_{mp}$	0.0013pJ/bit/m^4

6. Simulation Setup:

A simulation has been performed to compare the proposed work with an existing algorithm like SDIoV3 and SDIoV7 [32] for the dynamic scenario.3000 m long 500 m width road has been considered and we checked for the destination position is set at the end of the road i.e., (3250, 500) with different number of RSU where RSU is positioned at a different location shown in figure4.

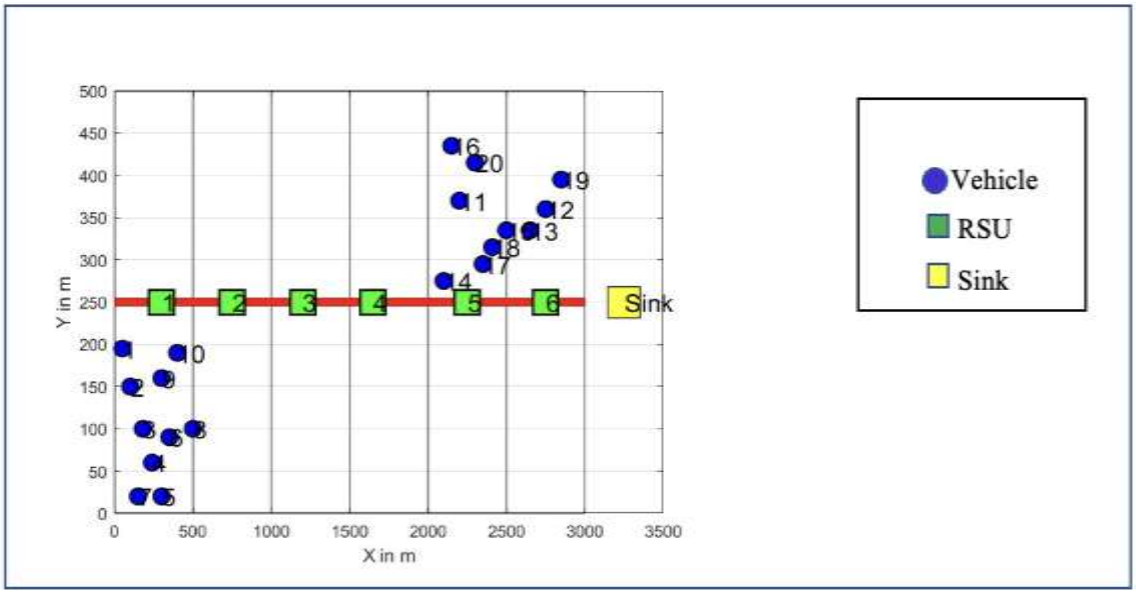

Figure 4: MATLAB deployment

The simulation set-up parameter is shown in table 3. We compare our proposed algorithm with SDIoV3 and SDIoV7 [32] for the active scenario. Comparisons with respect to different QoS parameters of the network. Initially, 20-100 vehicles are considered with 10J initial energy that can communicate with each other within the range of 50-250 meters with different speeds. The proposed algorithm is implemented or simulated using MATLAB R2022a. Each Vehicle is having equal parameters at the start of the simulation.

Table3: Simulation setup parameter.

Parameter	**Parameter values**
Simulator	MATLAB 2022a
Network Area	3000m×500m
Initial Base Station position	(3250m,250m)
Number of RSU	3-7
OBU transmitting range	50 m
RSU transmitting range	250 m
Vehicle's speed	4–25 km/h
Initial Energy for Nodes	10Joule
Number of deployed nodes	20-100
Number of packets	5-15
Size of data message	512bits

7. Experimental Results:

7.1. End-to-End Delay Matric:

End-to-End delay is defined as the total time taken by the network in a memory buffer, ready queue, packet retransmission and propagation of packets. Another way to represent delay is the time needed to transmit a packet from source to destination measured by End-to-End Delay [31]-[36]. Equation (4) represents the average end-to-end delay.

$$\text{Average End} - \text{to} - \text{End delay} = \sum_{i=1}^{n} \frac{Time\ packet\ received_i - Time\ packet\ sen_i}{Total\ no\ of\ packet\ received} \qquad (4)$$

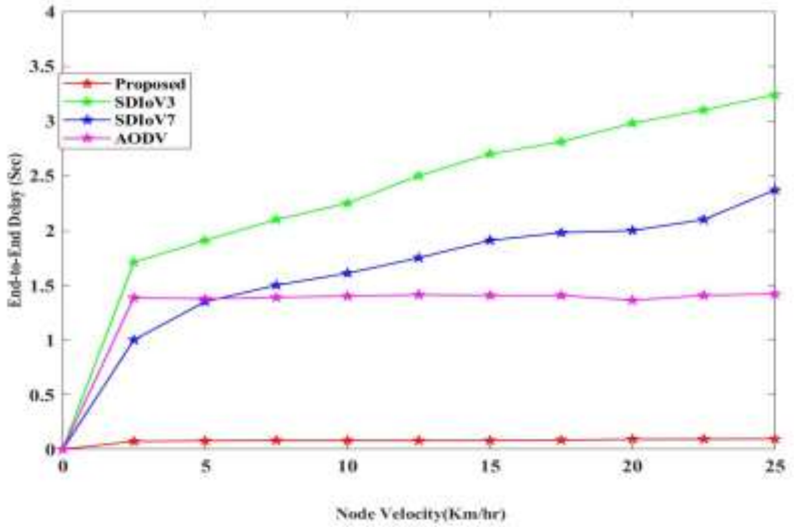

Figure5: End-to-End Delay matric

Figure 5 shows the End-to-End delay comparison between the proposed protocol, both versions of SDIoV and AODV. The end-to-end delay depends on the number of hops and network congestion. With increased node velocity congestion of traffic may occur and packets will transmit from one node to another node using multi-hop which leads to more delay. Our proposed algorithm achieves minimum end-to-end delay in comparison with SDIoV3, SDIoV7 and AODV as the number of hops is minimized by using a minimum distance communication strategy. Minimum end-to-end delay benefitting faster distribution of data packets within the network which makes it more applicable whenever the fastest data delivery to the destination is important. From figure 5, it depicts that our proposed protocol represented by red colour has much less end-to-end delay compared with both versions of SDIoV represented by a green and blue colour line and AODV pink colour line respectively for vehicle speeds5 km/h to 25 km/h.

7.2. Packet Delivery Ratio :

Packet Delivery Ratio (PDR) is a measure of how effective a protocol is delivering packets to the application layer. It is ratio of total number of packets delivered to destination and total number of packets sent by source [31]-[36]. Mathematical representation of PDR is using equation 5.

$$PDR(\%) = \frac{No\ of\ received\ packets}{No\ of\ sent\ packets} * 100 \qquad (5)$$

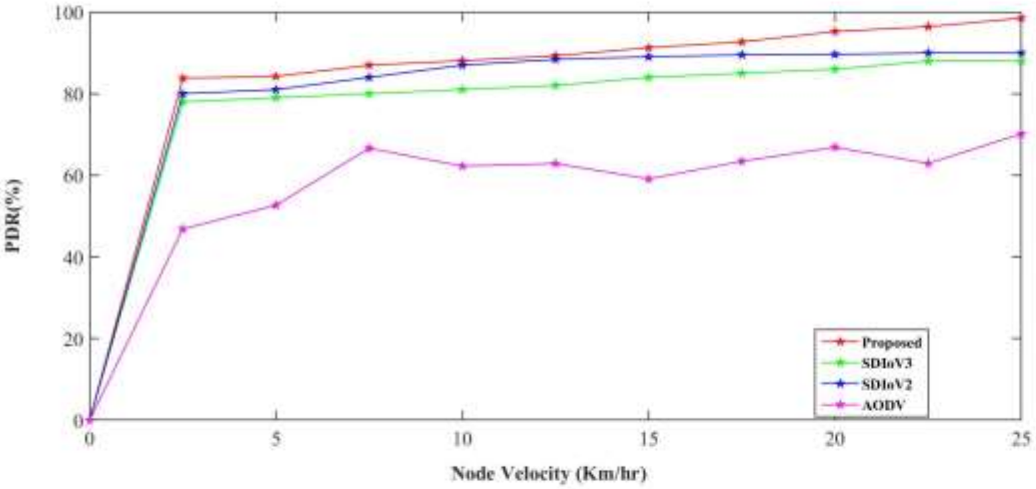

Figure 6: Packet delivery ratio (PDR) matric

A Packet delivery ratio is shown in figure6 for discrete node (vehicle node) speed varied from 5 km/h to 25 km/h. Figure 6X-axis denotes node velocity whereas Y-axis denotes PDR in percentage which illustrates that our proposed algorithm represented by red colour always outperforms with respect to both versions of SD-IoV represented by blue and green colour and AODV represented by pink irrespective of vehicle speeds. Here, the packet delivery increased rapidly with increased node velocity as the neighbours will be found faster for the increased speed of the source vehicle, which means the data packet will have a higher probability of reaching intermediate vehicles.

7.3. Normalized Routing Load (NRL):

Normalized Routing Load (NRL) matric is defined as the contribution of the control packets in the network generated for route request, route reply, and route error, etc. is equal to Normalized Routing Load (NRL). It is calculated the extent of routing information being up to date inside the protocol [31]-[36].
Mathematical representation of NRL is using equation 6.

$$NRL = \frac{No\ of\ routing\ packets\ sent}{No\ of\ data\ packets\ received} \quad (6)$$

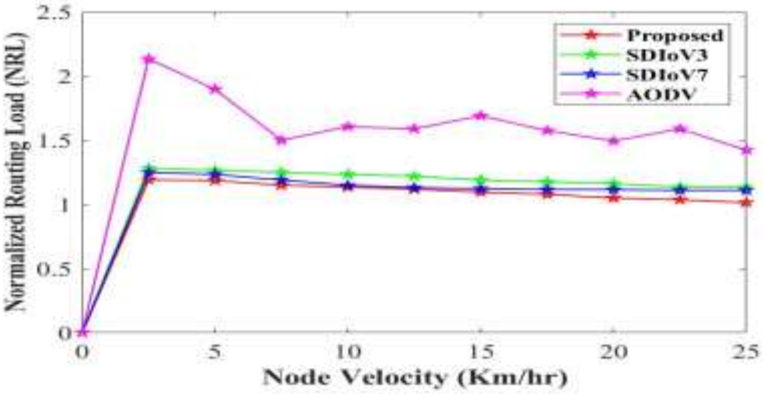

Figure 7: Normalized Routing load(NRL) matric

Figure 7 shows the Normalized routing load (NRL) for all protocols, where the X-axis represents the Velocity of the vehicle in Km/h and the Y-axis represents the Normalized Routing Load. The proposed algorithm has a lower routing overhead shown in red colour with respect to both versions of SD-IoV shown in blue and green colour and AODV shown in pink colour. A lower NRL value implies better load distribution in the network. It is observed that the NRL decreases with average vehicle speed as the packet receiving probability is increased with the increased velocity of the vehicle.

7.4. Energy Usage (EU):

The measurement of energy consumption of the node per vehicle speed during packet transmission from source to destination in the network is called energy usage (EU). Speed of vehicle [Km/hr] represented by X-axis in the graph and.EU[J] represented by Y-axis in the graph represents [31]-[36] and is shown in equation 7.

$$EU = \frac{Total\ Energy\ Consumed(J)}{Vehicle\ Speed(Km\ per\ hr)} \quad (7)$$

Figure 8 shows that our proposed algorithm has a lower EU than AODV with respect to vehicle speed. It is also observed, the proposed algorithm has stable energy consumption with the increased node velocity with respect to the existing one. Lower energy consumption implies lower intra-node communication overhead into the network which leads to better performance of the network.

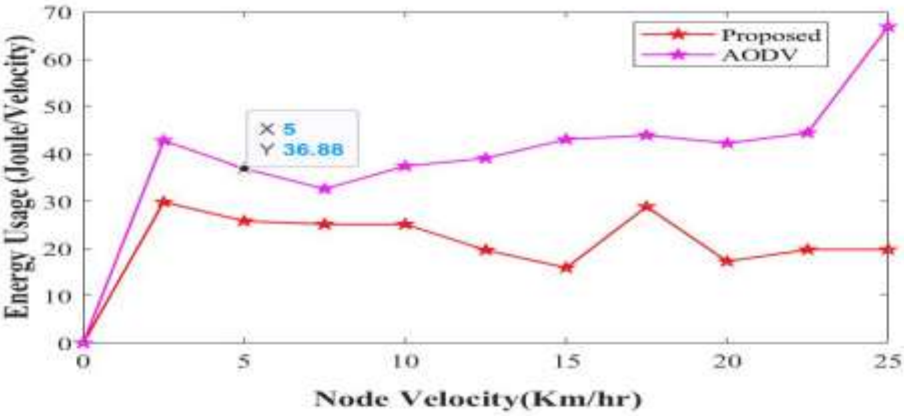

Figure 8: Energy consumption matric

7.5. Throughput:

The throughput of the VANET isa successful packet reception rate in the destination in terms of kbps. It can be calculated as per the following equation [31]-[36] and shown in equation 8.

$$Throughput = \frac{Total\ No.Pkt\ Received}{Total\ Time} \quad (8)$$

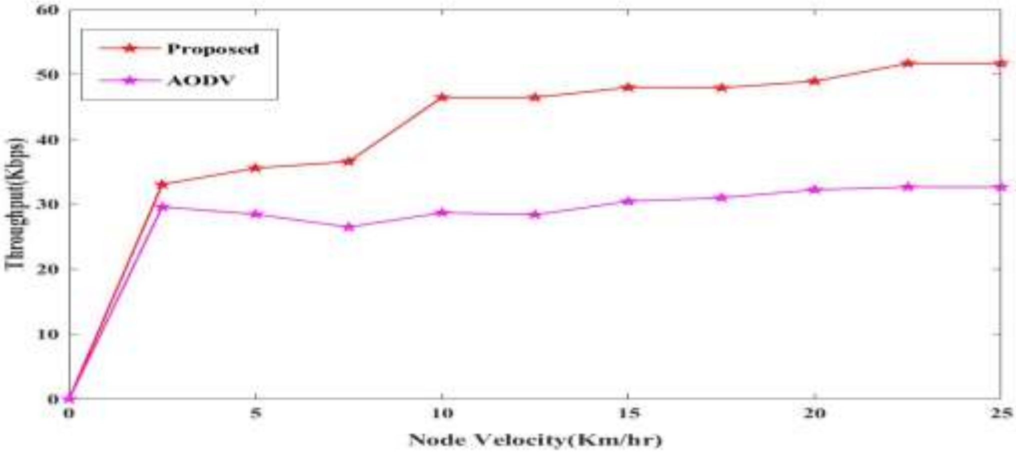

Figure 9: Throughputmatric

Figure 9 represents that our proposed algorithm has much better throughput than AODV with respect to vehicle speed. The throughput of the proposed algorithm is increasing effectively with the increased node velocity in comparison with the existing one. Higher throughput implies lower congestion in the network which means data packets will have a higher probability of reaching the destination.

8. Conclusion:

The Vehicular Ad-hoc Network (VANET) is formed by the instantaneously available vehicle without any supporting infrastructure to be laid on and is pillared using the proposed methodology that ensures a perfect routing protocol establishment, this path is enriched with highly stable better bandwidth optimization and enhances the network characteristic. The vehicular network that is used for preventing of unwanted sudden incidents and providing better comfortability by giving information regarding congested roads and the safe roads to be taken is a trending entailment for the cities experiencing heavy traffic. In this paper, we have designed and implemented distance-basedenergy-efficientrouting protocol for VANET.This protocol enhances the quality of service of the network. The performance of theprotocol is compared with the two versions of SDIoV i.e. SDIoV3 and SDIoV7 and also with AODV get a better result. Future work includes considering the effects of acoustic signals such as refraction, multipath and propagation speed variability on performance. Other effects that will be considered are node dynamics, position estimation errors and time-synchronisation errors. We also want to verify the results of the simulation in real experiments.

Declarations

Ethical Approval

Not applicable

Competing interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Authors' contributions

TP and RS contributed to writing—the original draft, software and implementation of the protocol. TP, RS and SS contributed to conceptualization, writing—review and editing. SS contributed to the investigation and validation. All authors contributed to software, methodology and compile paper.

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Availability of data and materials

All data included in this study are available upon request by contact with the corresponding author.

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