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PAPER

Mobile Adaptive Routing Algorithm for Road-Aware Infrastructure-Assisted Communication in Cognitive Internet of Vehicles

Divyashree M[1,2](✉), Rangaraju H G[3], Revanna C R[1]

[1]Department of Electronics and Communication Engineering, Government SKSJT Institute, Bengaluru, Karnataka, India, Affiliated to VTU, Belgaum, Karnataka, India

[2]Department of Electronics and Communication Engineering, RV Institute of Technology and Management, Bengaluru, Karnataka, India

[3]Department of Electronics and Communication Engineering, Government Engineering College, K R Pet, Karnataka, India

m.divyashree4@gmail.com

ABSTRACT

The Internet of Things (IoT) is expanding the capabilities of traditional vehicular ad-hoc networks (VANET) into the Internet of Vehicles (IoV). However, there are a few challenges that need to be addressed in order to enhance the intelligence of IoV, leading to the development of a new evolving technology called Cognitive Internet of Vehicles (CIoV). In this study, we propose a road-aware infrastructure-assisted and vehicle-to-vehicle (V2V) adaptive routing system to select the most efficient route for delivering data from the source to the destination vehicle, with the aim of reducing data delivery delay. The performance is measured and evaluated based on packet delivery ratio (PDR), average end-to-end (E2E) delay, and normalised routing overhead using MATLAB. By comparing the proposed mobile adaptive routing algorithm (MARA) with existing protocols, it has been examined and found to outperform the existing ones in terms of performance.

KEYWORDS

Internet of things (IoT), vehicular ad-hoc network (VANET), vehicle to vehicle (V2V) communication, cognitive Internet of vehicles (CIoV), mobile adaptive routing algorithm (MARA)

1 INTRODUCTION

The advanced model of edge computing in the Internet of Vehicles (IoV) has the capability to meet the demands of power estimation and task evaluation for vehicles [1]. In cloud-edge computing, Figure 1 illustrates the transmission structure for Cognitive Internet of Vehicles (CIoV).

As shown in Figure 1, let's consider a scenario where there is a two-way road, edge computing devices (ECDs), and vehicles moving on the road. Assume that every vehicle has an evaluation task for offloading to ECDs; therefore, there will be a greater number of such evaluation tasks.

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Each ECD consists of roadside units (RSUs) equipped with data centres positioned alongside the roadway. The RSU serves as infrastructure placed in close proximity to roadways. Its main functions include expanding communication coverage and enabling connectivity for vehicles and other entities [2]. The road is divided into multiple segments based on the coverage area of the RSU with data centres. Each vehicle broadcasts its data to the corresponding ECDs within range. The ECDs then send the collected data to the isolated cloud data centre. Furthermore, the data gathered can be sent from the cloud data center to the transportation control centre [3].

In fact, vehicles have two communication methods to enhance driving and safety on the roads for every driver: vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) [4]. The RSU-based routing protocols are responsible for relaying data traffic to remote vehicles in sparse or detached networks in the CIoVs. Many existing routing protocols struggle to attain a high packet delivery ratio (PDR) within stringent time constraints, primarily due to significant link disruptions, dynamic changes in topology [5], and the rapid movement of vehicles. This presents a significant challenge for researchers when routing data packets within networks [6]. A proper routing algorithm is essential for V2V and V2I communication to minimise data delivery delays and find the optimal route.

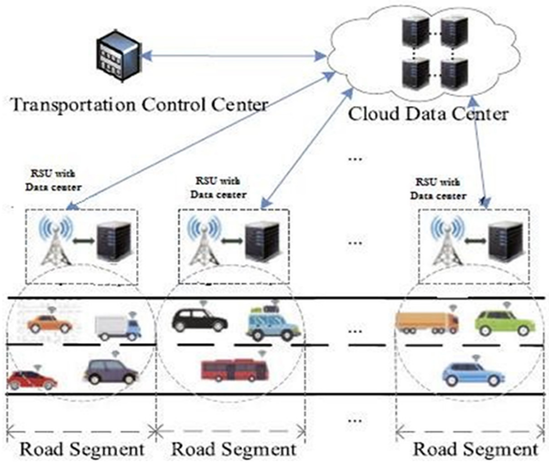

Fig. 1. Cognitive internet of vehicles

In the literature, various studies related to ad hoc routing protocols in inter-vehicular environments were found. These studies mainly focus on topology-based protocols and do not address position-based protocols, which is an important distinction.

In this study, we have evaluated a topology based on position, specifically the location-aided routing protocol (LAR), for CIoV. We have enhanced the LAR protocol, which is one of the most popular on-demand routing techniques. This method uses data regarding the mobility of nodes' locations [7] [8]. The new protocol utilises the rectangular zone to analyse the path to the source and destination, as well as the routing areas [9]. We propose a new effective routing technique that improves quality of service (QoS) and identifies the path from the source to the final destination.

The CIoV has a dynamic environment where swift and reliable data dissemination is fundamental. However, current routing paradigms face challenges due to the lack of coordination between diverse networks, resulting in delays in data delivery and impeding communication and decision-making among vehicles. A robust routing algorithm is crucial to seamlessly integrating infrastructure support and harness the adaptive potential of V2V communication for safety, efficiency, and practicality in real-world scenarios.

The aim of this paper is to develop a road-aware infrastructure-assisted and V2V adaptive routing algorithm to minimise data delivery delays.

The paper is structured as follows: Section 2 provides an exploration of various protocols through a comprehensive literature survey. In Section 3, the focus is on the current, existing protocol. Section 4 introduces our newly proposed protocol, detailing the data forwarding strategy, neighbour tables, route discovery process, and practical implementation of the developed routing algorithm. The evaluation of the suggested protocol's performance is discussed in Section 5. Concluding insights and summaries are consolidated in Section 6, while Section 7 outlines potential pathways for future exploration and expansion.

2 LITERATURE REVIEW

To minimise vehicle response time and enhance network lifetime, Sankar Sennan et al. [10] proposed the mobility-aware dynamic clustering-based routing (MADCR) protocol for IoVs. This protocol involves creating clusters and selecting channels. Clusters are formed based on Euclidean distance, followed by channel selection using the mayfly optimization algorithm. Ultimately, the chosen channel collects and transmits the vehicle's data to the RSUs, which are connected to the Internet. The three proposed algorithms are compared with the efficiency of the protocol suggested by Aadil et al. [11], namely the CIoVs derived from Dragonfly Optimizer, Comprehensive Learning Particle Swarm Optimization, and Ant Colony Optimization. As documented in [4], the proposed MADCR protocol has demonstrated improvements, enhancing the PDR by 5%–15% and reducing end-to-end (E2E) delay by 5–80 ms.

For effective data delivery and high performance, Kiran Afzal et al. [12] proposed an approach to construct a model of vehicular ad hoc networks that requires interconnection with unmanned aerial vehicles (UAVs). In the V2V communication framework, UAVs are compared with various routing protocols, such as the ad hoc on-demand distance vector (AODV) routing protocol, the optimised link state routing (OLSR) protocol, and the destination-sequenced distance vector (DSDV) protocol, which have been analysed by Nayyar et al. [13]. Subsequently, the relationships between vehicles and aerial nodes have been taken into consideration for the same reason. The current approach performs well when the grid size is large, with respect to throughput and average packet drop ratio. Utilising UAVs in vehicular ad hoc networks can offer advantages, especially when managing a large number of aerial nodes. Moreover, their proposed model has the potential to offer advantages in terms of reducing MAC/PHY overhead compared to established routing protocols, particularly in scenarios with a large number of aerial nodes in the network.

Piyush Chouhan et al. [14] proposed a road awareness method called multipath routing with extension (MDR-Ext), which establishes the vehicle network using the master of control (MOC). The Brink Controller (BC) receives regular vehicle information to determine the most efficient path for data packets to be communicated between vehicles. The MOC controller interprets the path and updates it according to the values of the BC. The proposed method effectively prevents network breakdowns caused by mobility. By employing the extension strategy, multipath routing can achieve a PDR of up to 95.7% and throughput of up to 4244.456 kbps while maintaining low normalised routing overhead and consuming less energy. MDR-EXT for MOC with the Brink controller offers superior performance compared to table-driven routing with the extension (TDR-Ext) and dynamic on-demand routing with the extension (DODR-Ext).

Yashar Ghaemi et al. [15] developed a time delay-based multipath routing (TMR) scheme that identifies faster routes for packet delivery from the source to the final destination vehicle with minimal latency. The algorithm prioritises message notifications over regular messages and selects routes with short round-trip times (RTT) within the RTT threshold. The proposed method aims to prevent vehicle-related accidents and minimise data congestion, especially for common messages, by reducing packet redeliveries. The proposed protocol is compared to various protocols, including improved road segment-based geographical routing, efficient geographic-aware source routing, ad hoc on-demand multipath distance vector, q-learning-based multi-objective optimisation routing, and an energy-efficient multipath routing protocol for mobile ad hoc networks using the fitness function. The proposed TMR protocol has the potential to improve performance using various comparative methods, with enhancements ranging from 5% to 26%.

Jianhang Liu et al. [16] presented a real-time effective information traffic routing (RTEIT) system that determines the optimal route by selecting the relay node and transmitting the data packets towards their destination. Real-time effective information traffic routing introduces a new network attribute called “effective information traffic,” which can assess the connectivity of nodes based on efficiently generated paths. Furthermore, to prevent sudden interference in transmission, a new method was suggested to estimate the link status by considering various parameters such as direction, speed, and location data. Eventually, by considering the node utility as the benchmark for routing decisions, the assessment is based on the status of the links and the efficiency of traffic data. The simulation results indicate that RTEIT performs more effectively than greedy perimeter stateless routing (GPSR), movement prediction-based routing (MOPR), and maxduration-minangle GPSR (MM-GPSR) in terms of packet loss rate, E2E delay, and network yield.

Ravie Chandren Muniyandi et al. [17] proposed an evaluation based on a heuristic method to eliminate inaccurate global positioning system (GPS) location values and accept precise ones. The location-aided routing (LAR) protocol is used because it utilises the location of source nodes and destination nodes to find the requested and expected zones, respectively. According to the node mobility model, the suggested routing protocol known as rectangle-aided location-aided routing (RALAR) is based on a moving rectangular zone. Furthermore, the genetic algorithm (GA) was used to determine the optimal time-out variable to optimise the proposed RALAR procedure. The outcomes were compared using the most widely used VANET protocols, LAR and Kalman-filter-aided-LAR (KALAR), for performance measures such as PDR, average E2E delay, routing overhead, and average energy usage. According to the findings, the recommended RALAR protocol outperformed the KALAR in terms of a 4.7% higher PDR, a 60% lower average E2E delay, 15.5% reduced routing overhead, and 10.7% lower energy usage. The findings demonstrated that in the VANET environment, the RALAR protocol outperformed both the KALAR and LAR protocols in terms of standard network performance metrics.

Gurumoorthi et al. [18] proposed a hybrid routing protocol called cache agent, which integrates location-based routing and geocasting based on direction and distance. The protocol selects the next hop vehicle to send packets before they arrive at predicted locations and uses a geocast zone to search for and send packets to the destination. With existing protocols such as the improved directional location-aided routing protocol (ID-LAR) [19], multi-metric geographic routing (M-GEDIR) [20], and fuzzy logic-based directional geographic routing (FL-DGR) [21], the simulated results were compared to note the improved performance of the proposed protocol. This protocol offers improved performance in terms of PDR, average delay, retransmission ratio, and hop counts.

3 EXISTING PROTOCOL

Abbas M. T et al. [3] have proposed a novel infrastructure-based hybrid road-aware routing protocol (IARAR) designed to establish a systematic model for evaluating path lifespan. This protocol aims to address the limitations of V2V communication and V2I communication. At the same time, it incorporates the characteristics of both reactive and proactive routing. Roads are divided into road segments, each with a unique segment ID. Vehicles on each segment send a request, and neighbours within communication range will reply with their details. A routing table will be created for each vehicle based on the received response. When the source vehicle has information to send, there are two possibilities: the destination may be another vehicle or an RSU. The source vehicle checks if the destination is in the same road segment. If so, it sends information directly to the destination vehicle; otherwise, it sends it to the nearest RSU. If the destination vehicle is on a different road, the source vehicle sends information to the intersecting RSU-I. The RSU with the destination vehicle will respond to the intersecting RSU. Then, the intersecting RSU sends information to the RSU, which responds.

Vehicle-to-vehicle communication and V2I communication are established by utilising RSUs at junctions or in a multi-hop pattern, depending on the existing paths. The process of distributing local data improves the efficiency of finding links and reduces extra overhead in both wired and wireless networks. The vehicular movement file was generated using SUMO, and the simulation was conducted using NS3.

The IARAR is an innovative approach to improving communication in vehicular networks. However, it has limitations, such as sensitivity to network dynamics, simulation environment constraints, and limited evaluation scenarios. Furthermore, the protocol may not be robust in dynamic network scenarios due to its sensitivity to network dynamics. Further refinement could enhance the comprehensive evaluation across diverse scenarios.

4 PROPOSED MOBILE ADAPTIVE ROUTING ALGORITHM

4.1 Road-aware V2V routing within a road segment

The mobile adaptive routing algorithm (MARA) is utilised for V2V communication, building on the benchmark set by LAR. Roads are divided into sections with different segment IDs. Each road segment is created by considering the start of the segment (SoS) and the end of the segment (EoS). Node mobility has been generated. The request zone is formed by setting a threshold within SoS and EoS named X_{SoS} and X_{EoS}. The nodes within the request zone are simply called safe nodes (communicable nodes). Safe nodes along the road segment broadcast requests, and other safe nodes respond with their details, including vehicle ID, velocity, and position. Dijkstra's shortest path algorithm is used to find the optimal route from the source to the destination node.

4.2 Neighbor tables at road level

Roads are divided into segments, each with a unique ID. In Figure 2, vehicles within the same road segment engage in V2V communication, while communication between road segments of the same road involves vehicle-to-RSU communication.

Communication between road segments of two different roads is considered vehicle-to-intersecting RSU communication, utilising intersecting RSU. Road segment tables were created for the vehicles to generate the link state packets (routing table). The generated link state packets for each vehicle are shown for all three scenarios and are illustrated in Figure 2.

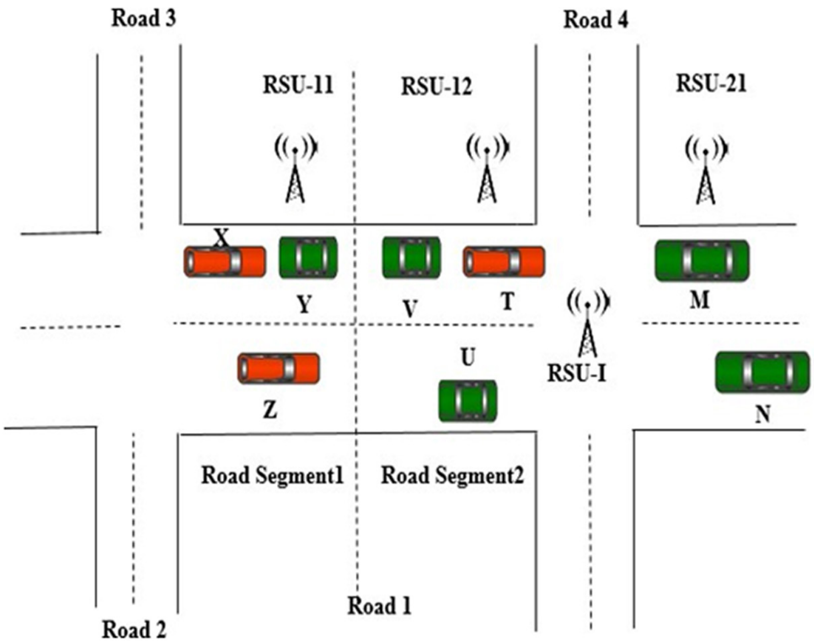

Fig. 2. RSU nodes at road level

Primarily, to find contiguous data, each vehicle transmits link state requests in sequence. In response, the neighbours send parameters such as vehicle ID, road ID, speed, and position of the vehicle, and the RSUs send details such as road ID, unit ID, and position. Using the information obtained from the neighbours and the RSUs, the vehicles construct the link state packets. Neighbour link state packets are then transmitted within the segment of the road section by intermediate nodes. By utilising the link state packets of neighbouring nodes, link state packets for road levels are created. Now, vehicles can acquire link-state packets from various road segments.

Table 1. Neighbor table at road level

Source	Neighbours
X	RSU-11, Y
Z	X, Y
Y	RSU-11, X,Z
RSU-11	X,Y, RSU-12
RSU-12	RSU-11, RSU-I, V,T
V	RSU-12, T
U	V, T
T	RSU-12, V,U

(Continued)

Table 1. Neighbor table at road level *(Continued)*

Source	Neighbours
RSU-I	RSU-12, RSU-21
M	RSU-21, N
N	M
RSU-21	RSU-I, M

In scenario 1, V2V communication, involves each vehicle broadcasting road-level link state packets to its respective RSUs within the road segment. In scenario 2, if the destination vehicle is in a neighbouring segment, the source vehicle communicates via the neighbour-RSU using level link state packets. For scenario 3, if the destination vehicle is in a segment of a different road, then the source vehicle communicates via an intersecting-RSU (RSU-I) using level link state packets. All three scenarios are presented in Table 1 in relation to Figure 2.

4.3 Route discovery mechanism

For the route discovery process, the proposed protocol uses both route requests and route replies. Before sending the route request, the source vehicle first checks its own routing table to determine the destination vehicle. The routing table assessment for source X is depicted in Table 2.

Table 2. Routing table with respect to source X

Target Node	Neighbour Node
Y	Y
Z	Y
V, T, U, M, N	RSU-11
RSU-12, RSU-21	RSU-11
RSU-I	RSU-11

If the destination vehicle is within the segment of the road, the data packets are sent directly. If both the source and destination vehicles are on different segments of the road, a route discovery task is initiated by forwarding a route request to RSUs. By utilising the road segment neighbour tables, the route discovery task proceeds by sending route requests to RSUs on all connected roads. After accepting route request messages, the RSUs scan their routing tables to identify the destination. Upon identifying the destination on the road segment, the RSUs respond by forwarding a route reply packet. When a deadlink situation occurs, RSUs take charge of recovering the route by forwarding route requests to other neighbouring roadside units.

In summary, the route discovery mechanism involves a multi-step process in which source vehicles utilise the infrastructure of RSUs to find a route to their destination. This process utilise the routing tables and neighbour tables to efficiently locate the destination and establish a communication route from the source to the final destination vehicles, even when they are on different road segments within the CIoV network.

4.4 Implementation of MARA routing algorithm

Algorithm 1: Mobile Adaptive Routing Algorithm

```
Assign: n= 0
Input: Source Node S (n), (Xp, Yp), tp
Output: Path of the route
Step-1: Calculate the radius Rt and distance dis(S, O).
Step-2: Choose one of the request zones by distance
ratio formula.
Step-3: To get the values of Rt and t0, set the columns of RQ
packet as described.
Step-4: Transmit the RQ Packet.
Step-5: After node n1 accepts the RQ packet
Step-6: Call broadcasting_rx Function to Find No. of Safe
Vehicles, Total Distance, RSU_id, velocity
Step-7: If Source(S) and Destination (P) found in the
route then
Step-8: Assign Road Segment1(1)=Safe_vehicle;
Road Segment1(2)=total_distance; Road Segment1(3)=rsu_id;
Road Segment1(4)=velocity; Goto Step-10;
Step-9: If Source(S) and Destination (P) not found in the
route then Goto Step-7;
Step-10: Execute Dijkstra.
Find Cost1, Distance1 and Path1 Update Cost2,
Distance2 and Path2
Step-11: Assign First Shortest Path1= Cost1; Second Shortest
Path2= Cost2
Step-12: End.
```

Execution of Dijkstra algorithm in MARA.

Algorithm 2: Dijkstra

```
Step-1: Assigning all the vehicles as not visited ones;
Step-2: Assigning the chosen starting vehicle with a current
distance as zero and the other vehicles as infinity;
Step-3: Set the starting vehicle as the current vehicle;
Step-4: Take the current vehicle, examine all of its
neighbor's which are unvisited and estimate their distances by
appending the current vehicles distance to the weight of the
edge that links the neighbor vehicle and the current vehicle,
Step-5: Measure the estimated distance with the current
distance set to the neighboring vehicle and assigns it to the
neighboring vehicle's new current distance,
Step-6: Finally, observe all of the current vehicles unvisited
neighbor's, and set the current vehicle as visited,
Step-7: If the destination vehicle is set as visited then end,
else, select the unvisited vehicle that is spotted with the
minimal distance, set that as the new current vehicle, and
redo the procedure from step 4.
```

The notations for the algorithm above are listed in Table 3 for reference. The algorithm above aims to discover the shortest path. Initially, the algorithm starts with the node "n" initialised to 0. The input includes the source node, the position of the destination node, and the time at which the position of the destination node is obtained. The radius of the expected zone, R_t, and the distance between S and O are computed using the distance ratio formula [22] given in Eq. (1).

$$\delta = \frac{\sqrt{(x_o - x_s)^2 + (y_o - y_s)^2}}{R_t} \tag{1}$$

When $\delta 1 < \delta < \delta 2$, the distance between the source and the final destination nodes (in meters) is limited, and request zone is represented as a rectangle. Therefore, the data transfer is limited to a smaller area, which in turn reduces the likelihood of data conflicts and resource usage. The main purpose of the message is to communicate directly, providing an excellent opportunity to choose the most efficient route.

Table 3. Notations

Variable Name	Description
N	Initialization variable, the number of rediscovery times
S	Source Node
P	Destination Node
Xp,Yp	Position of Destination
Tp	Time when (Xp, Yp) is obtained
R_t	Radius of the expected zone
O	Center of the circular expected zone
dis(S,O)	Distance between S and O
RQ	Request Packet
To	Time when (Xo, Yo) is obtained
N	Initialization variable, the number of rediscovery times
S	Source Node

When using the route request packet, the radius of the expected zone and the time at which the centre of the circular expected zone is obtained are determined. After transmitting the route request packet, when node n1 accepts the request, it begins to determine the following parameters: number of safe vehicles, total distance, RSU_ID, and velocity. If the source and final destination are located within the route, then all the RSUs are assigned the specified parameters. Otherwise, this process is repeated until the route is found. The Dijkstra algorithm is used to find the shortest path to a destination by considering cost, distance, and path as parameters. Once found, the algorithm updates the values. As a result, cost1 is assigned to the first shortest path, cost2 to the second shortest path, and so on. Thus, the best route has been found.

5 EXPERIMENTAL EVALUATION

5.1 MATLAB simulation

Our proposed system is implemented in MATLAB 8.1 (v-2020) Runtime, enabling the creation and simulation of numerical applications with GPU architectures of compute capability 3.5 to 9.x. MATLAB, used for the Vehicle Dynamics Blockset, provides the Virtual Vehicle Composer app for configuring and parameterizing models. It also offers prebuilt workflows for Kinematics and Compliance (K&C) testing and calibrating models. Vehicular mobility is achieved by utilizing various simulation parameters as outlined in Table 4. The performance of the proposed MARA algorithm is evaluated based on parameters [3] such as PDR, control routing overhead, and average E2E delay. The research is conducted using an i7 processor, with a simulation area of 2000x30 meters, 5 RSUs operating at speeds ranging from 18 to 149 km/h, and a transmitting packet size of 512 bytes. Three different scenarios exist within RSU, neighbour RSU, and intersecting roadside unit.

Table 4. Simulation structure

Parameters	Value
Simulation area	2000x30m
Simulation time	340s
Number of RSUs	5
Number of vehicles	15–100
Vehicles speed	18 Km/h–149 Km/h
Data packet size	512bytes
Communication range	180–250m

5.2 Metrics

Packet delivery ratio. Packet delivery ratio is the ratio of data packets received by the destinations to those sent by the sources [9].

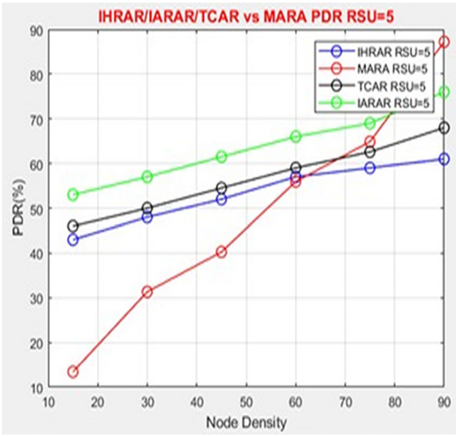

Fig. 3. Packet delivery ratio of IHRAR, MARA, TCAR, and IARAR

The MATLAB simulation results show the PDR in relation to discrete node density, as depicted in Figure 3. Whether in low or high node densities, Figure 3 shows that MARA outperforms the IHRAR, TCAR, and ARAR protocols. Therefore, when the PDR is high, the discovery of neighbours will be fast, and there will be more opportunities for the source vehicle to send data to neighbouring vehicles. Therefore, it enhances the efficiency of communication among vehicles.

Control routing overhead. Control routing overhead is defined as the ratio between the total number of control packets generated by each node and the total number of data packets received by the destination nodes in the network [9].

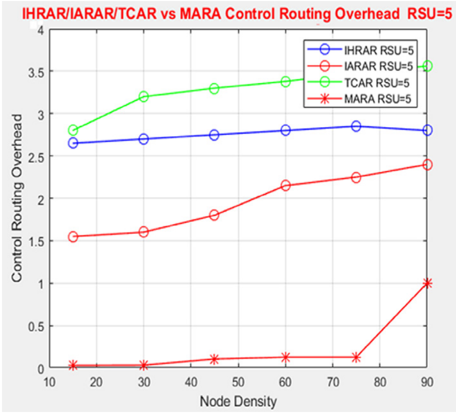

Fig. 4. Control routing overhead of IHRAR, MARA, TCAR, and IARAR

Figure 4 demonstrates the overhead in routing calculated for the protocols MARA, IHRAR, TCAR, and IARAR. However, it has been observed that the routing overhead of MARA is lower compared to IHRAR, TCAR, and IARAR. MARA discovers routes outside the road segments and manages the routing table for road segment levels only when necessary. This characteristic makes MARA an appealing option for vehicular networks, where minimising overhead is essential for efficient and reliable communication.

End-to-end delay. End-to-end delay refers to the percentage of time that a data packet takes to reach its destination [9].

In terms of E2E delay versus node density, TCAR's performance is poor compared to the three protocols, IARAR, IHRAR, and MARA, as illustrated in Figure 5. There was a sudden decrease in delay from Node 30 for all the protocols, but MARA had the shortest delay period compared to other protocols such as TCAR, IARAR, and IHRAR. This is because MARA manages the calculation of paths during the route discovery process using intersecting RSUs, resulting in faster and more direct communication. This reduces the time taken to establish and transfer data along these routes.

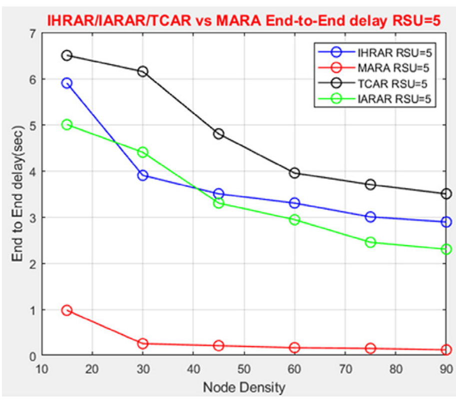

Fig. 5. End-to-end delay of IHRAR, MARA, TCAR, and IARAR

5.3 Comparisons

Considering Figure 3 in the plot, Table 5 presents an overall comparison of all four protocols in terms of packet delivery ratio.

Table 5. PDR – IHRAR, MARA, TCAR, and IARAR

PDR						
IHRAR	43.00	48.00	52.00	57.00	59.00	61.00
MARA	3.42	31.31	40.26	55.92	64.86	87.23
TCAR	46.00	50.00	54.50	59.00	62.60	68.00
IARAR	53.00	57.00	61.50	66.00	69.00	76.00

Table 6 presents a comprehensive comparison of the four protocols in terms of control routing overhead, as depicted in Figure 4.

Table 6. Control routing overhead – IHRAR, MARA, TCAR, and IARAR

Control Routing Overhead						
IHRAR	2.65	2.70	2.75	2.80	2.85	2.80
MARA	0.02	0.03	0.10	0.12	0.12	1.00
TCAR	2.80	3.20	3.30	3.38	3.48	3.56
IARAR	1.55	1.60	1.80	2.15	2.25	2.40

Similarly, Table 7 presents the overall comparisons of all four protocols in terms of E2E delay, as depicted in Figure 5.

Table 7. End-to-end delay – IHRAR, MARA, TCAR, and IARAR

End-to- End Delay						
IHRAR	5.90	3.90	3.50	3.30	3.00	2.89
MARA	0.97	0.25	0.21	0.16	0.15	0.12
TCAR	6.50	6.15	4.80	3.95	3.70	3.50
IARAR	5.00	4.40	3.30	2.94	2.45	2.30

6 CONCLUSION

MARA is a location-aided routing protocol designed to minimise data delivery delays in the CIoV. It considers communicable nodes within the request zone and minimizes routing overhead in V2V and V2I communication, ensuring uninterrupted connections and updating the corresponding route path. MARA discovers the shortest path, a novel road-aware routing strategy, and can improve routing performance in the CIoV by selecting a stable route. Simulation results show a high PDR, reduced control routing overhead, and a decrease in E2E delay, indicating reliable and efficient communication. Unlike other routing protocols such as TCAR, IRAR, and IHRAR, MARA, does not require specialised distribution of roadside units.

7 FUTURE SCOPE

The limitations include a lack of consideration for energy efficiency and the handling of traffic congestion. Addressing these issues is crucial for maximising CIoV's potential. The future scope involves enhancing the proposed methodology with an energy-efficient scheduling strategy to detect task offloading, aiming to achieve energy savings for edge computing devices (ECDs) such as RSUs with cloud for local processing. Additionally, it includes traffic congestion prediction.

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9 AUTHORS

Divyashree M is Research Scholar in Department of Electronics and Communication Engineering, Government SKSJT Institute, Bengaluru, Karnataka, India, and currently working as Assistant Professor in Department of Electronics and Communication Engineering at RV Institute of Technology and Management, Bengaluru, Karnataka. She completed B.E in Telecommunication Engineering from GSSSIETW, Mysuru and M.Tech in Digital Electronics & Communication Systems from VTU-Regional Center, Mysuru. She has teaching experience of about 7 years. She has published 07 papers in international, national journals and conferences. Her areas of interest include Wireless Communication, Wireless Ad-hoc Networks, and Internet of Things (E-mail: m.divyashree4@gmail.com).

Dr. Rangaraju H G is currently working as Associate Professor in Electronics and Communication Engineering Department at Government Engineering College, K R Pet, Karnataka, India. He Received B. E. degree in Electronics and Communication Engineering from SIT, Tumkur, M. E degree in Electronics and Communication Engineering from University Visvesvaraya College of Engineering, Bengaluru university and Ph. D degree from Visvesvaraya Technological University, Belagavi. He has more than 20 years of experience in Teaching and Industry. He has to his credit two patents and more than 25 research publications in National/International Journals and Conferences. Now, He is guiding four research scholars for their PhD degrees under VTU. His major areas of interest include VLSI Design, Signal Processing, Communications, and Wireless Networks.

Dr. Revanna C R from Chikmagalur District of Karnataka State, India. He is currently serving as Assistant Professor and Head of Department in Electronics and Communication Engineering at Government SKSJ Technological Institute, Bengaluru. He has teaching experience of 25 years in various institutions under the Department of Technical Education GoK. He has obtained his PhD degree for his study on Cryptography from Jain University, Bangalore. He has been engaged in research since a decade and published many articles in renowned international journals in different domains. He is a member of BOE for different universities and academic institutions. He is a reviewer in many international journals and has chaired international conferences. He is actively involved in formulation of HEI enabled Institutional National Innovation and Startup Policy.