
An Optimized Routing Algorithm for Internet of Vehicle (IoV) Environment

Ravi Shankar Shukla^{1,*}

¹Department of Computer Science, College of Computing and Informatics, Saudi Electronic University, Saudi Arabia

Email: ravipraful@gmail.com

Abstract

Internet of Vehicles (IoV) is the later application of VANET and is the fusion of the Internet and IoT. With the advancement in innovation, individuals are investigating a traffic environment wherever they would have the extreme cooperation with their environment including other vehicles. The Internet of Vehicles (IoV) was created so that vehicles can communicate with each other in an infrastructure environment. The prerequisite is to form a more secure trip in an IoV environment with the least delay and high packet delivery rate. This guarantees that all information is received with negligible delay to maintain a strategic distance from any mishap. This paper presents a new position-based routing algorithm called Position-Based Connectivity Aware Routing (PBCAR) for IoV that covers sparse and coarse regions of vehicles. It takes advantage of the Internet and street format to progress the execution of routing in IoV. The PBCAR algorithm uses a GPS real-time chasing system to find traffic information for forming position-based paths from the source node to the destination node. The PBCAR algorithm has been simulated using SUMO and Network Simulator and compared with AODV and GPSR. The results show that the PBCAR algorithm obtains exceptional results considering the several simulation parameters.

Received: January 20, 2025 Revised: February 27, 2025 Accepted: April 05, 2025

Keywords: Ad-hoc network; IoV; IoT; VANET; Routing algorithm

1. Introduction

IoV is another form of VANET and is the coalition of Internet and IoT. VANET is a kind of wireless network where vehicles interact with each other with roadside units for consistent and hasty communication. It is an ample demand in disaster or urgent situations. Based on need, an Internet of Vehicle (IoV) is a heterogeneous wireless network that establishes among the vehicles. Each vehicle must put together wireless transceivers and computerized control components that let the vehicles act as network nodes and then only these vehicles can contribute in a IoV environment. Every vehicle has a limited wireless network range of a few hundred meters, therefore in order to communicate from one location to another over a greater distance; communications must be routed over the Internet. This requires a real-time transmission of messages from source to destination. Nowadays, mostly applied mobility models are established on the simple random patterns model that may not illustrate vehicular mobility in the realistic approach. Vehicle-to-vehicle (V2V) communication is effective for a number of reasons, including better bandwidth, short range, and low cost of communication. An Internet of Vehicle (IoV) is a subtype of VANET, is made up of several cars that travel and communicate with one another in the absence of a fixed infrastructure. The ad hoc networks have the advantage because it does not require any permanent infrastructure. Another significant criterion that we may use to characterize IoV is its high mobility node count, potential large-scale network, and variable network intensity. The Internet of Vehicle also has the benefit of a wide range of apps for multimedia, internet access, convenience of driving, and road safety.

The following characteristics are comprised in the PBCAR algorithm:

1. The Road Side Unit (RSU) is put beside the street. These RSU's are settled framework items with better transmission coverage as compared to transmission coverage of vehicles. The significance of RSU goes on when vehicular interaction is not feasible between vehicles. This empowers the interaction from vehicle to RSU (or vice versa).
2. A Mobile Vehicle (MV) is put along the main road. The MVs are mobile infrastructure units with higher transmission coverage as compared to the RSU. The significance of MV arises when there is no vehicular communication or vehicle to RSU is possible. This allows communication from vehicle to MV (or vice versa).
3. There are three sorts of communication probability within the PBCAR.
 - Vehicle to Vehicle (V2V) communication occurs when vehicles frame an ad hoc region. Vehicle-to-RSU (V2R) communication is performed when there is no inter-communication is possible amongst vehicles. This instance occurs, as vehicles are more distant to each other and does not able to frame an ad hoc area.
 - Vehicle to MV communication emerges when destination vehicle isn't joined under RSU excluding source vehicle.

It is not always viable that there is an exceedingly vehicular ad-hoc network is form. The PBCAR algorithm solves the issues for later instance.

2. Related Work

In spite of continuously ongoing inquire about, certain argues are even being confronted in VANET counting security, and minimal inactivity. Here just going to talk about a few problems of VANET as well as IoV which affect the arrange execution.

One of the utmost concerns is path optimization in vehicular ad-hoc systems. Path optimization exists broadly deciding the efficient path in relation to fewer cost and smallest way with less delay. The path optimization is exceedingly energetic topology and unusual development of vehicles, it has ended up vital to offer a methodology that may relieve such problems for well spread of data inside vehicles collaboration and the encompassing situation. An optimized path, generally utilize calculations to decrease the conceivable outcomes and help select the path.

Designing an effective routing algorithm has been a focus of extensive research in VANETs,. The node-centric MANET protocols AODV [1], DSDV [2], DSR [3], and OLSR [4] adhere to the topological establishment of end-to-end pathways. By utilizing the fixed movements of vehicles and the relative velocities between nodes, solutions have been proposed to enhance VANET performance [5, 6, 7]. Using this data, a node with a high relative velocity to the target is chosen. Numerous routing protocols, which can be categorized in a number of ways based on different factors—such as the route information, the quality of services, originality of the protocol, the methods employed, the network simulation, etc. have been created and employed for VANET settings. The vehicular ad hoc routing protocols are grouped into five groups: geocast-based, cluster-based, broadcast, topology-based, and position-based built on the routing algorithms. Based on the features and methods employed by the routing protocols, this classification was created.

Topology-based steering conventions employments methodologies to supplant the area administrations. For illustration, An AODV directing convention was planned that is upgraded with Geocast capacities for vehicular systems. Geographic Source Directing (GSR) [8] presents a steering convention. Reenactments stood utilizing vehicular development designs of a certain portion of the Berlin town gotten employing a activity stream test system. Assessing with the steering conventions of AODV and DSR, GSR outperformed regarding conveyance latency and rate. On behalf of these methodologies, changes must be made to the topology-based conventions in arrange for the steering procedures to operate legitimately. The refinement between [9] and [8] is that the last mentioned ponders vehicle advertisement ad-hoc systems in urban settings, while the previous analyzes vehicular advertisement ad-hoc systems for thruway situations.

Scalability is achieved by cluster-based routing techniques [10, 11]. There are several clusters in cluster-based routing, and each cluster has a cluster head. Communication both within and between clusters is under the cluster head's purview. While the cluster head handle inter-cluster communication, intra-cluster communication occurs directly between nodes within the cluster [12].

In Geocast Routing, a particular enabling packet delivery from source to destination via flooding and geocasting. This algorithm is an area-based steering in which packages are transported within a designated geographic area. By defining the sending zone and controlling flooding inside it, geocast directing confines the arranged clog and lowers message overheads. Several guiding computations fall under this category, including those of [13], the Inter-Vehicular Geocast Convention (IVG) [14], and [15].

Broadcast directing is used to distribute information about traffic, weather, emergencies, and street conditions among several motors. Flooding is generally used in these kinds of conventions, however as the organized measure

increases, it poses problems with transfer speed. Novel conventions are thus suggested to show progress in transfer speed usage. A few examples of broadcast are BROADCAST [16], Urban Multi-Hop Broadcast (UMB) [17], and Vector Based Following Discovery (V-TRADE) [18].

Analysts from both the scholarly world and commerce have been looking into potential arrangements for the issues confronting VANETs for a number of a long time. In arrange to offer moved-forward arrangements for information transmission, higher throughput, and optimized ways, overviews have been conducted and calculations put forward. The writing that addresses issues and deterrents related to vehicular advertisement ad-hoc systems, the Web of Vehicles, portability models, and applications of these systems would be the center of this portion. We will also talk almost a few strategies or approaches that diverse analysts have recommended to reduce the issues in this field.

For a long time, analysts from the scholastic field and industries have been exploring specific conceivable techniques to unravel the issues that are ensuing confronted in vehicular Ad-hoc networks. The several studies were done to supply improved arrangements for information conveyance, superior output, and improved paths. This area will center on the pertinent writing based on issues confronted in vehicular systems. IoV, versatility models utilized, and applications of such systems and procedures or strategies projected by different analysts to play the issues being confronted in this area.

VANET's versatility brings up many fundamental questions. Nowadays, most people choose to use their own vehicles, which results in a wide and convoluted arrangement because of the increased number of vehicle hubs in the VANET topology. The navigation convention finds it difficult to fully cover all moving cars with such an increase [19]. This may have an impact on the overall way the plan is carried out, with some areas under the authority of the routing convention functioning well, while some cars are deprived of the effective routing convention because of the extreme adaptability of the plan.

As vehicles are constantly entering and exiting the arrangement, the vehicle hub thickness in VANET is consistently abnormal. A few of the routing in VANET are intensely wide due to path characteristics same way better street circumstances and the most brief way to a specified goal. Such a circumstance can block the activity arranged, expanding organized complexity, whereas the other courses may be meagerly dense which comes about in uneven hub conveyance within the organized [20]. Such sort of portability and topological adjustments make it worrying to have an optimized coordination that is beneficial in taking care of such sorts of steering issues in the VANET environment.

Subject to the organized necessities, a grouping of flexibility representations was proposed for vehicular promotion and has its own properties [21]. These characteristics might consolidate the plan in which the transportability interior takes place in which a vehicle can move in an organized way to control the movement depending upon such characteristics and flexibility is chosen for the establishment.

The author in [22] proposed a location based VTARA which is a VANET class directing convention for metropolitan and interstate situations and shows the advantage of street format to progress for execution of steering in VANETs. The calculation employments a real-time GPS framework to get activity data for making street-based ways from source to target pairs. The enhanced sending was utilized to make out the sending hub near the street design that shaped the way to provide the information bundles. VTARA calculation forwards information along the street design and takes genuine activity on the street into consideration.

The author of [23] talked about a WiMAX arrange and ad-hoc vehicle organize, which is displayed in this article. He recommended a steering calculation composed of two forms: a route search process and a stack adjusting prepare. Whereas the proposed cross breed organizes directing strategy maximizes the normal packet provide proportion, it too minimizes other parameters such as the normal inactivity and course length.

[24] suggested a unique heterogeneous planning for the IoV that is established on the basis of various wireless communication crossing points that are accessible. The future compatibility of vehicular communication with multiple contemporary network protocols is one of its most important criteria. By altering simulation duration and mobility rates, the suggested heterogeneous planning beat the standing wireless technologies when examined separately on the derivation of extraordinary output and small delay in contrast to standard WAVE designs, 4G/LTE, and long-range WiFi. The architecture makes sure that the finest connectivity is provided, which can frequently meet user needs and serve a larger number of customers. Future vehicular networks will find great potential in the suggested RoF-based design with multi-interfacing, which concurrently guarantees the integrity, interoperability, and dependability of the networked devices in an IoV context.

In [25] discusses the challenge-solution for security and privacy on the Internet of Vehicles. Because intelligent transportation security is so vital to human life and quality of life, it is examined from many angles, particularly in the context of the Internet of Vehicles. The targets, nature, issue, location, and suggested solutions are all taken into consideration when classifying an attack. They are connected to security-focused protocols, making it simple

to describe the solution, explain security protocols, and give the most significant body of knowledge on the topic. PSO and ACO are both considered in the vehicular network [26] to improve VANET performance. Using ACO, several routes are created with a uniform vehicle intensity from the source to the destination. A novel strategy has been put out in [27] and contrasted with the current algorithms. The suggested algorithm performed better in terms of longevity, stability upgrade, throughput, and delay time reduction.

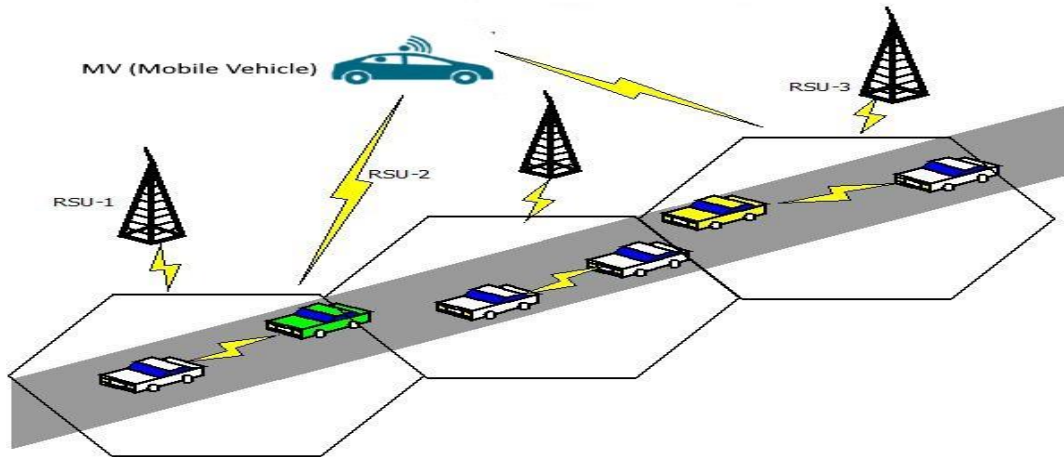


Figure 1. Proposed Heterogeneous Wireless Architecture for IoV

3. Proposed Routing Architecture

The suggested Position-Based Connectivity Aware Routing (PBCAR) improves the communication in IoV for rural and main road scenarios shown in figure1. The intent of PBCAR is to provide unbroken interaction concerning two vehicles perhaps close or remotely aside respectively on rural and main road. Utilizing an existing technology for vehicular communication in rural and main roads might be ineffective as technologies have their own benefits and weaknesses. Utilizing WLAN offers a speed up to 54 Mbps and limited access for a few meters (until 250 m). This will sign of packet loss owing to network disconnectivity while an inaccessible intensity of vehicles is unusual as compared to urban setups, thus vehicles may be incapable of maintaining ad hoc region for interaction. So, WLAN will not offer effective communication because of its restricted coverage. In comparison to wireless LAN, the MV is equipped with a 4G/5G network, has a range of up to 20 km or more by the high transmission speed, and supports high-speed vehicular movement up to 120 Km/h. The MV has the advantage of supporting high-speed roaming and has a good coverage capability of about a number of kilometers. Thus, we have utilized services of MV and wireless LAN as a strong complement network.

Therefore, PBCA combined WLAN and MV technologies for effective data transfer on main and rural roads in order to offer vehicular protection and entertainment facilities. The suggested network architecture for PBCAR is comprised of two unique radio access technologies. The two dissimilar wireless networks confirm distinct data speeds and cell dimensions. The bottom level, as depicted in Fig. 1, is made up of a high-bandwidth wireless cell with a restricted handling area (100–300 m). Therefore, the bottom level utilizes 802.11p standard for V2V or V2RSU (vice-versa) communication. The upper level of PBCAR architecture contains of mobile vehicle network for high-speed data transfer. The main reasons to use MVs are that it allows for high-speed roaming and the necessary setup is placed along the roadside.

The PBCAR architecture utilizes the active mobile vehicle network that is positioned beside the edge of the rural and main road for communication. The highest level of PBCAR architecture signifies broadband technology, which supports much higher bandwidth through a greatly varied coverage area, normally 20 km. In the proposed PBCAR deployed the mobile vehicle equipped with a broadband network near the roadside on rural and main road scenarios. In the suggested PBCAR, these source and destination pairs are chosen at random. According to the suggested algorithm, a source node uses beacons or hello packets to determine its neighbor nodes' location by using GPS. To find out the positions of its neighbors, the source node sends out beacons or hello packets to each one of them. When a neighbor node receives a hello packet, it responds to the source node by sending back a hello packet that includes its position and additional data. Thus, the source vehicle learns the location of its next neighbors in this way. Subject to the space between source and destination nodes, the source node might have straight communication with the destination using traditional VANET communication or may interact with the

mobile vehicle broadband network using its dual mode interfaces V2V or V2MV communication. In PBCAR, it is anticipated that all vehicle is equipped with GPS and set up with dual mode network interface cards, one for mobile vehicle networks and the other for Wireless LAN (IEEE 802.11p). Additionally, because every vehicle is equipped with an IEEE 802.11p interface card, which provides a transmission range of 250 m, the range of mobile vehicles equipped with a 4G/5G system maybe 20 km or greater and it is assumed that all RSU has 1000 meters of coverage.

3.1 Description of PBCAR Algorithm

The PBCAR algorithm uses the network design shown in Fig. 1 to send information from a specific source to an actual destination node. In the PBCAR, a source node is informed of the position of the destination and about its neighbor nodes via GPS by means of beacons or Hello packet correspondingly. The Source sends a Hello packet or signals to every neighbor to discover the position of the neighbor. The neighbor node acknowledges the Hello packet by responding to the source node and sending back the Hello packet that holds the information about the node and their location. Therefore, the PBCAR works greatly in the mentioned heterogeneous architecture wherever two distinct wireless technologies are combined. The aim of the PBCAR algorithm is effectively send data from a source to a specific destination vehicle and experience the resources accessible on the internet without failing the connectivity of the network.

3.2 Case Analysis for PBCAR Algorithm

Let TR_{max}^V and TR_{max}^{RSU} be the maximum transmission coverage of the vehicle and Road Side Unit individually. The RSU are close to streets, whereas vehicle places vary, the GPS data is employed to decide the position of any vehicle in the form of longitudes and latitudes place of a vehicle. Let $d_1 = d(V_i, V_j)$ stand the distance relating to any two vehicles $i \neq j$, in addition $d_2 = d(V_i, RSU_r)$ be the distance between roadside unit RSU_r to vehicle $i \neq r$, and $d_3 = d(V_i, MV_s)$ be the distance between Mobile Vehicle Network Station and the vehicle $i \neq s$ for every $i, j, r, s = 1, 2, 3, \dots \infty$.

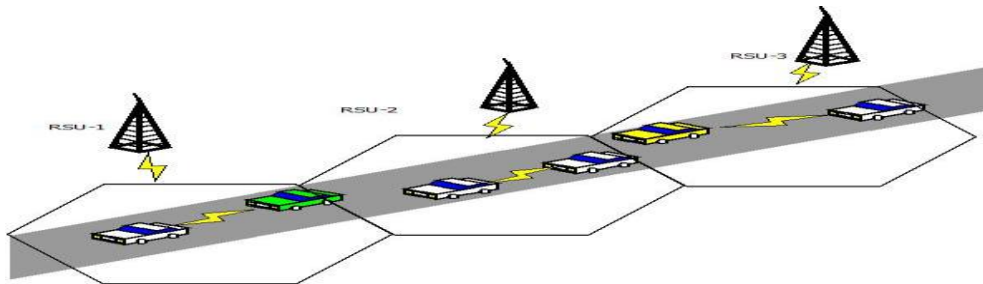


Figure 2. Source and Destination is within ad hoc region or registered under same or different RSU

Case 1: Destination vehicle D_i is in the transmission range of Source Vehicle S_i : If $d_1 < TR_{max}^V$, then no matter whether V_S and V_D are registered with the same or different Road Side Unit (RSU), V_S will directly communicates the data packets to V_D , if V_D is in the transmission range of V_S . In this V_s and V_d are in an ad hoc region shown in figure 2.

Case 2: V_s and V_d are not in Adhoc

$d_1 > TR_{max}^V$ and $d_1 < TR_{max}^{RSU}$, then $TR_{max}^V < d_1 < TR_{max}^{RSU}$, thus V_s and V_d are not able to form an ad-hoc region but V_s and V_d are registered with same Road Side Unit (RSU). If $d_2 = d(V_i, RSU_r) < TR_{max}^{RSU}$, then V_s sends the message to RSU and RSU delivers the message to V_d because V_d is in the range of RSU. The V_s and V_d can send and receive the message until this case exists.

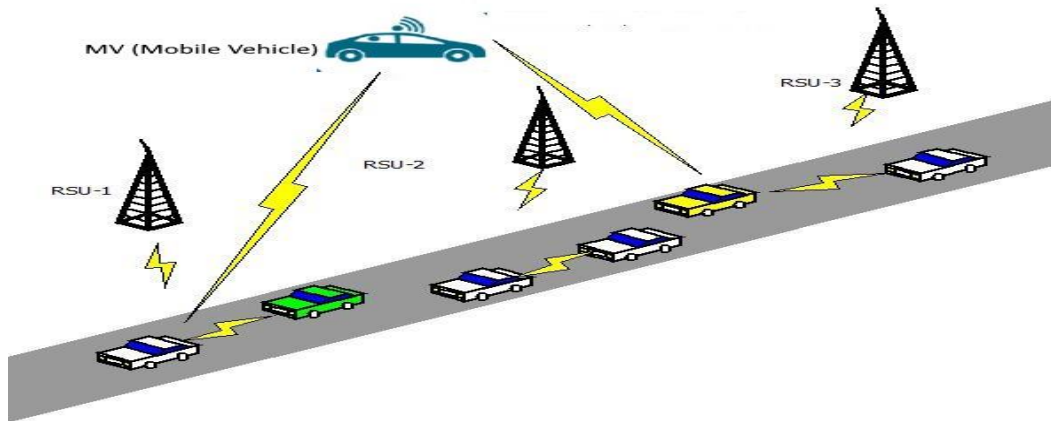


Figure 3. Source and destination far away from each other

Case3: The V_s and V_d are far away from each other:

If $d_1 > TR_{max}^V$, $d_1 > TR_{max}^{RSU}$, $d_1 < TR_{max}^{MV}$ and $d_3 = d(V_i, MV_s) < TR_{max}^{MV}$. Thus, V_s and V_d are far away from each other the role of mobile vehicle broadband station comes into play. The Source V_s will now utilize the broadband service, which has high bandwidth to send the data packet to the destination V_d . The Mobile vehicle broadband station checks their registration database whether the V_d is registered under it, if V_d is registered under it then the broadband station delivers the data packet to V_d . If V_d is not registered under it, then the broadband station forwards the data packet to another broadband station and a similar process continues until V_d receives the data packet. Therefore, the proposed PBCAR will reduce the delay, improve the packet delivery ratio also minimize the number of hops as shown in figure 3. The flowchart for Position-Based Connectivity Aware Routing (PBCAR) is shown in figure 4.

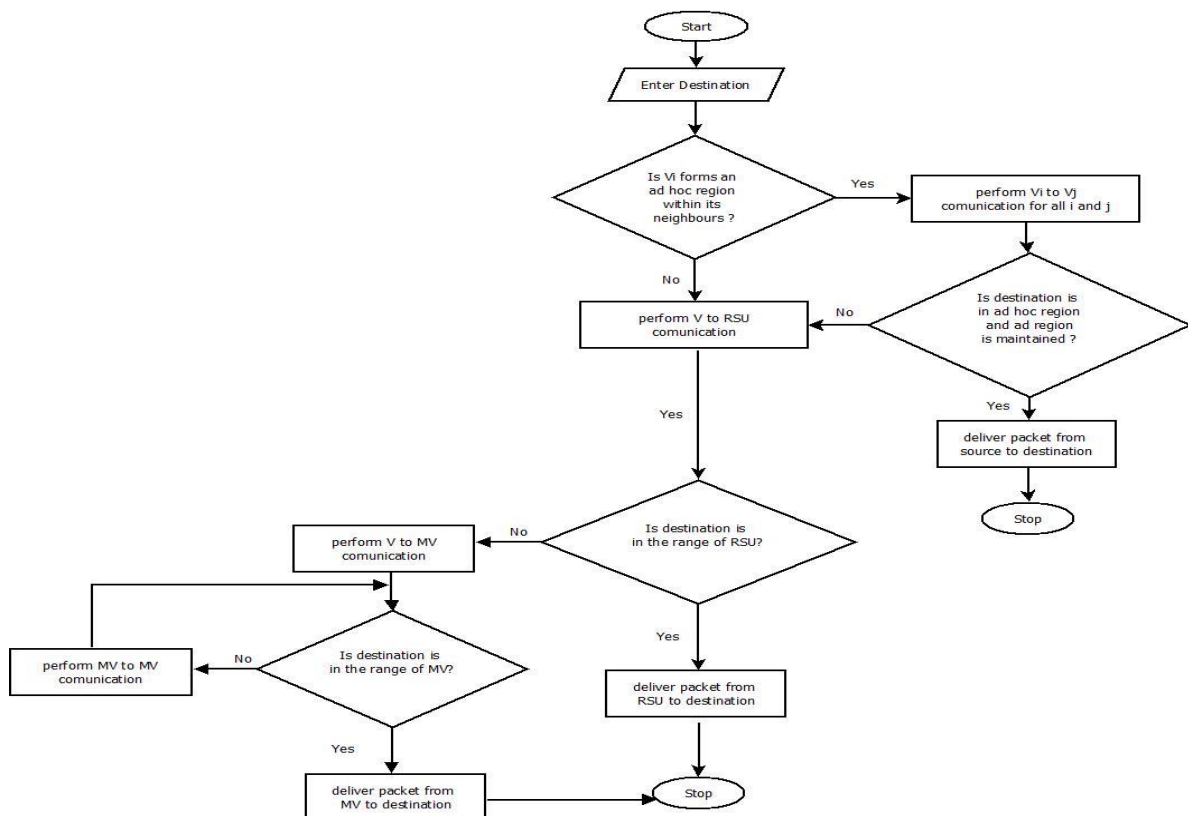


Figure 4. Flowchart for Position-Based Connectivity Aware Routing (PBCAR)

Pseudocode for PBCAR Algorithm

Position-Based Connectivity Aware Routing (PBCAR)

Let S and D be source and destination vehicles.

1. S initiates the routing procedure to access the heterogeneous network and calculates the distance between itself and D
2. IF S and D are in each other's communication range THEN S forwards the packet to D directly
3. ELSE IF S and D are under the same RSU AND do not form ad hoc network THEN S forwards the packet to its RSU. RSU

forward the packet to D

4. ELSE S and D are registered under different RSU THEN

S first sends data packet to the Mobile Vehicle Network under whom it is registered. Mobile Vehicle Network will forward the data packets to D if D is registered under it. Otherwise Mobile Vehicle Network forwards the data packet to another Mobile Vehicle Network which has a large bandwidth capacity, which in turn sends the data packet to D, the process will continue until the destination D found

END IF

3.3 Performance evaluation

This section presents the results of the execution of the PBCAR with SUMO and the Network Simulator. The performance is assessed with the main road and city situation taken into account without any hindrances. To analyze the performance of different routing parameters and assess the performance of the proposed PBCAR algorithm with topology-based (AODV) and location-based (GPSR) routing protocols.

3.4 Simulation setup

A realistic mobility model is generated by considering a transportation scenario involving cities and highways. The scenario depicts both highway traffic and typical urban conditions found in cities. It creates a two-lane road. The model takes into account the primary traffic pattern, vehicle speed, lane changes, and the possibility that a fast car may pass a slow-moving one. To create the vehicle movement patterns, the simulation scenario is configured to a 4 * 4-kilometer region instance that includes a city and a highway.

The developments of the vehicle hubs are created using an open-source tiny space-continuous time discrete vehicular activity generator bundle called SUMO. To determine the speeds and placements of the vehicles, SUMO applies a collision-free vehicle in the resulting demonstration. SUMO receives the outline, the calculations surrounding the speed limits, and the number of pathways for each street section on the outline as input. To obtain finer-grained hub developments, the first several thousand of the SUMO yield are eliminated. The SUMO yield is converted into input records for the NS-2 test system's hub movement.

Table 1: Different simulation constraints considered for assessing the PBCAR

Variable	Values
Simulation area	4 * 4 km
Number of vehicle	160
Simulation duration	3500 s
Vehicle transmission range	100 m
RSU transmission	500 m
Mobile Vehicle Network	20 KM
Traffic CBR:	rate 0.5–5 kbps
Packet size	The size of packet varies from network to network, but in this simulation a fixed size (512 bytes) is used.
MAC protocol	IEEE 802.11p
Vehicle speed	10– 120 Km/h

The simulation setup uses the IEEE 802.11p standard at the MAC layer. The shadowing propagation model is used to characterize physical propagation at the physical layer. The IEEE 802.11p standard at the MAC layer for the remote setup is utilized. At the physical layer, we utilized the shadowing engineering demonstration to describe physical stimulation. The tests ran in arranged with distinctive hub densities from 10 to 160 hub situation speaks to generally scanty and thick systems. The required localities inside the development records and their network topology diagrams from Google maps are taken as indicated in fig 1. The straightforward movement patterns of vehicles within the genuine world are considered. The recreation parameters considered to assess the execution of PBCAR are given in Table 1. The assessment strategy, the metric for comparing the conventions, and the investigation of reenactment are in the next section.

4 Result Analysis

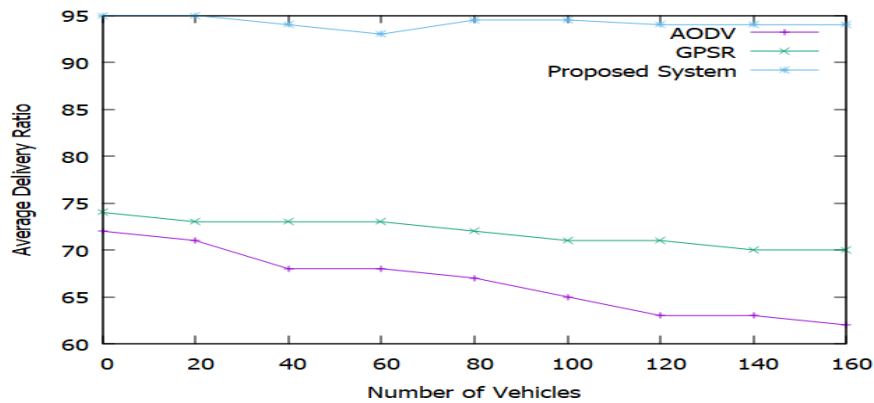


Figure 5. Average delivery ratio versus number of vehicles

4.1 Average Packet Delivery Ratio

Figure 5 appears that the proposed PBCAR performs better way than other routing protocols for diverse hub densities (10 to 160 vehicles) since the vehicular activity is sensible around street design. Proposed PBCAR accomplishes higher packet delivery since it has the extra advantage that the vehicular hubs utilize high-speed mobile vehicle networks for sending the packets toward the destination if vehicles are not able to form an ad-hoc network. Hence, the majority of the packets that were sent will reach the destination yielding a smaller number of packets drop rate. The packet delivery falls for AODV and GPSR while the number of hubs increases.

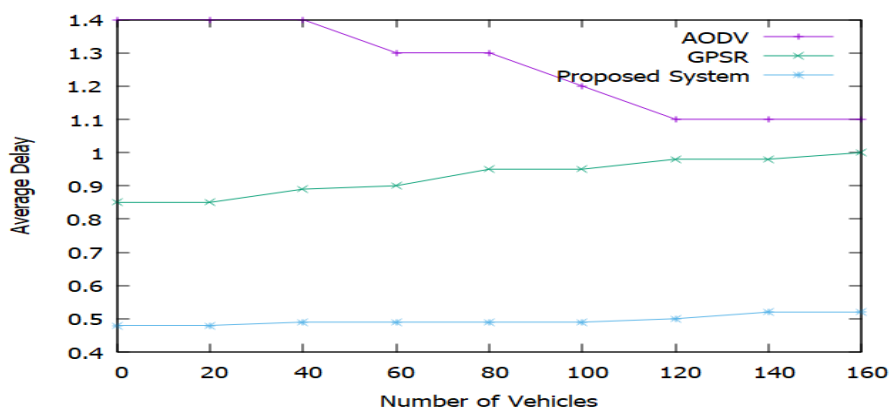


Figure 6. Average delay versus number of vehicles

4.2 Average Delay

Figure 6 shows the execution in terms of delay. The figure shows that the finest execution in terms of delay up to a density of 100 vehicles. The contention on the wireless channel can visible here with the expanding values for normal delay in GPSR and AODV individually. This indicates the delay in accepting packets sometime recently

coming to their destination. AODV endures from higher delay as hub densities increase due to broken paths or setting up very unused paths to the destination. In the case of GPSR delivers the packets in a greedy way toward its goal hence it is less influenced by delay. The proposed PBCAR performs in a better way than other routing protocols since it employs a mobile vehicle network when a vehicular ad hoc region is not formed between source and destination vehicles. Hence, PBCAR is less influenced by end-to-end delay.

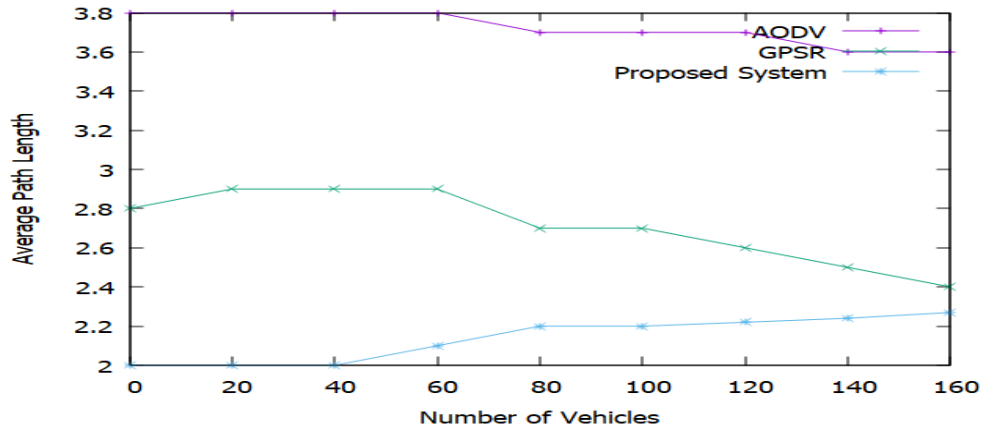


Figure 7. Average path length versus number of vehicles

4.3 Average Path Length

Figure 7 shows the normal path length of packets up to 40 vehicles. The PBCAR has the least normal path length than the other routing protocols due to the proximity of the mobile vehicle network to forward the packet to the target node when selecting the hub. A path that built up with PBCAR is utilized until the source considers it as the broken path. The PBCAR can assess the quality path through a mobile vehicle network. The AODV and GPSR do not take advantage of mobile vehicle networks of the portability nature of vehicular Ad hoc networks. Hence, they have longer path lengths as compared to PBCAR.

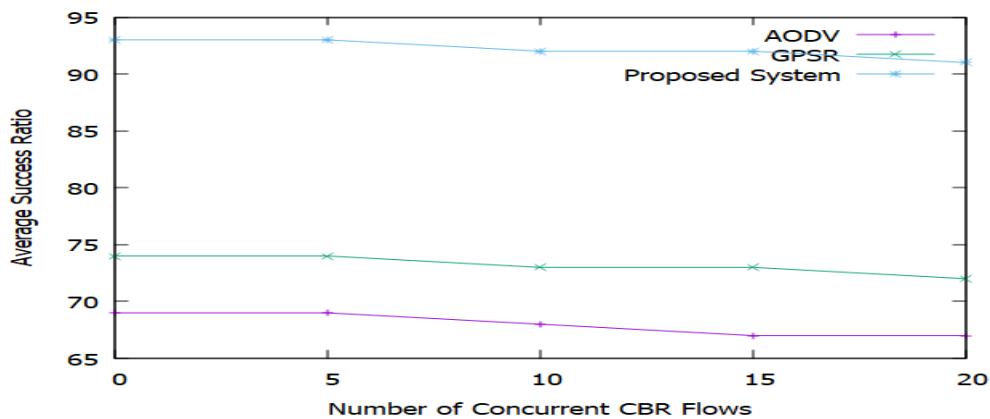


Figure 8. Average success ratio versus Number of flows

4.4 Impact of Number of Flows

The assessment of protocols execution is appeared in Fig. 8 is based on the number of concurrent streams. The packet transmission rate is usual for all the protocols. Generally, minimizes the number of streams, the protocol execution stands better in connection of packet conveyance ratio. The PBCAR performance execution has way well than the other among conventions. AODV appears the most elevated drop in conveyance proportion from the 1-flow to the 20-flow simulation. AODV convention has higher normal delay of the transmitted information as route does not exists. The execution of GPSR is better as compared to AODV in terms of conveyance proportion since its forward packets in greedy way. Hence, GPSR continually keep up lower normal delay. Conversely,

PBCAR normal delay is more delicate to the included stream, which keeps up a little normal delay. So that, the PBCAR has the least in conveyance ratio with the simulated protocol.

5 Conclusion

One of the main issues with IoV is network connectivity and effective routing because of the rapid changes in network topology, erratic vehicle speeds, and high traffic density on roadways. The Position-Based Connectivity Aware Routing (PBCAR) described in this paper facilitates consistent message delivery from the source to the destination vehicles across two wireless network technologies by enabling complete connectivity on the Internet of Vehicles (IoV) environment for rural highway scenarios. The suggested PBCAR enhances the user experience minimizes radio access network bottlenecks (if any exist) and route the data packet intelligently from source to destination.

Funding: “This research received no external funding”

Conflicts of Interest: “The authors declare no conflict of interest.”

References

- [1] C. E. Perkins and E. M. Royer, “Ad hoc on-demand distance vector routing,” in *Proc. 2nd IEEE Workshop Mobile Comput. Syst. Appl.*, New Orleans, LA, USA, 1999, pp. 90–100.
- [2] C. E. Perkins and P. Bhagwat, “Highly dynamic destination sequenced distance vector routing (DSDV) for mobile computers,” in *Proc. ACM SIGCOMM Conf. Commun. Architectures Protocols Appl.*, London, U.K., 1994, pp. 234–244.
- [3] D. B. Johnson and D. A. Maltz, “Dynamic source routing in ad hoc wireless networks,” *Mobile Comput.*, vol. 353, no. 5, pp. 153–161, 1996.
- [4] T. Clausen and P. Jacquet, “Optimized link state routing protocol (OLSR),” in *Proc. IEEE Intelligent Transport. Syst. Conf.*, 2003.
- [5] K. T. Feng, C. H. Hsu, and T. E. Lu, “Velocity-assisted predictive mobility and location-aware routing protocols for mobile ad hoc networks,” *IEEE Trans. Veh. Technol.*, vol. 57, no. 1, pp. 448–464, 2008.
- [6] V. Namboodiri and L. Gao, “Prediction-based routing for vehicular ad hoc networks,” *IEEE Trans. Veh. Technol.*, vol. 56, no. 4, pp. 2332–2345, 2007.
- [7] T. Taleb, E. Sakhaee, A. Jamalipour, K. Hashimoto, N. Kato, and Y. Nemoto, “A stable routing protocol to support ITS services in VANET networks,” *IEEE Trans. Veh. Technol.*, vol. 56, no. 6, pp. 3337–3347, 2007.
- [8] C. Lochert et al., “A routing strategy for vehicular ad hoc networks in city environments,” in *Proc. IEEE Intelligent Vehicles Symp.*, Columbus, OH, USA, 2003, pp. 156–161.
- [9] H. Fubler et al., “Location-based routing for vehicular ad hoc networks,” in *ACM Mobicom*, 2002.
- [10] A. Daeinabi, P. A. G. Rahbar, and A. Khademzadeh, “VWCA: An efficient clustering algorithm in vehicular ad hoc networks,” *J. Netw. Comput. Appl.*, vol. 34, no. 1, pp. 207–222, 2011.
- [11] C. R. Lin and M. Gerla, “Adaptive clustering for mobile wireless networks,” *IEEE J. Sel. Areas Commun.*, vol. 15, no. 7, pp. 1265–1275, 1997.
- [12] F. Li and Y. Wang, “Routing in vehicular ad hoc networks: A survey,” *IEEE Veh. Technol. Mag.*, vol. 2, no. 2, pp. 12–22, 2007.
- [13] L. S. Briesemeister and G. Hommel, “Disseminating messages among highly mobile hosts based on inter-vehicle communication,” in *Proc. IEEE Intelligent Vehicles Symp.*, Dearborn, MI, USA, 2000, pp. 522–527.
- [14] A. Bachir and A. Benslimane, “A multicast protocol in ad hoc networks inter-vehicle geocast,” in *Proc. 57th IEEE Semiannual Conf. Veh. Technol.*, vol. 4, Jeju, South Korea, 2003, pp. 2456–2460.
- [15] C. Maihofer et al., “Abiding geocast: Time stable geocast for ad hoc networks,” in *Proc. 2nd ACM Int. Workshop Veh. Ad Hoc Networks*, Cologne, Germany, 2005, pp. 20–29.
- [16] M. Durresti et al., “Emergency broadcast protocol for inter-vehicle communications,” in *Proc. 11th Int. Conf. Parallel Distrib. Syst.*, vol. 2, Fukuoka, Japan, 2005, pp. 402–406.

- [17] G. Korkmaz et al., “Urban multi-hop broadcast protocol for inter-vehicle communication systems,” in *Proc. 1st ACM Int. Workshop Veh. Ad Hoc Networks*, vol. 2, Philadelphia, PA, USA, 2004, pp. 76–85.
- [18] M. T. Sun et al., “GPS-based message broadcasting for inter-vehicle communication,” in *Proc. Int. Conf. Parallel Process.*, vol. 2, Toronto, Canada, 2000, pp. 279–286.
- [19] A. Ahamed and H. Vakilzadian, “Issues and challenges in VANET routing protocols,” in *Proc. 2018 IEEE Int. Conf. Electro/Information Technol. (EIT)*, Rochester, MI, USA, May 2018, pp. 0723–0728.
- [20] A. Awang, K. Husain, N. Kamel, and S. Aissa, “Routing in vehicular ad-hoc networks: A survey on single- and cross-layer design techniques, and perspectives,” *IEEE Access*, vol. 5, pp. 9497–9517, 2017.
- [21] N. Chowdhary and P. D. Kaur, “Addressing the characteristics of mobility models in IoV for smart city,” in *Proc. 2016 Int. Conf. Computing, Commun. Math. Problems Eng. Autom. (ICCCA)*, Greater Noida, India, April 2016, pp. 1298–1303.
- [22] R. S. Shukla, N. Tyagi, A. Gupta, and K. K. Dubey, “A new position based routing algorithm for vehicular ad hoc networks,” *Int. J. Telecommun. Syst.*, pp. 1–16, Springer US, 2015.
- [23] R. S. Shukla, “Routing algorithm in hybrid network for VANET under load distribution,” *Indian J. Comput. Sci. Eng. (IJCSE)*, vol. 13, no. 3, pp. 964–980, May-Jun 2022.
- [24] H. H. Raza Sherazi et al., “A heterogeneous IoV architecture for data forwarding in vehicle to infrastructure communication,” *Hindawi Mobile Inf. Syst.*, vol. 2019, Article ID 3101276, 12 pages, 2019.
- [25] S. M. Karim, “Architecture, protocols, and security in IoV: Taxonomy, analysis, challenges, and solutions,” *Hindawi Security Commun. Networks*, vol. 2022, Article ID 1131479, 19 pages, 2022.
- [26] B. Ranjan Senapati and P. Mohan Khilar, “Optimization of performance parameter for vehicular ad-hoc network (VANET) using swarm intelligence,” in *Nature Inspired Comput. Data Sci.*, pp. 83–107, Springer, Cham, 2020.
- [27] B. Dappuri, M. Amru, and A. M. Venkatanaga, “A stable routing algorithm based on link prediction method for clustered VANET,” in *Recent Trends Adv. Artif. Intell. Internet Things*, pp. 85–95, Springer, 2020.