Check for updates

Received: 16 June 2020 | Revised: 10 November 2020 | Accepted: 24 November 2020

DOI: 10.1002/dac.4714

RESEARCH ARTICLE

WILEY

A smart transportation system in VANET based on vehicle geographical tracking and balanced routing protocol

Satheshkumar Kandasamy[1] | **S. Mangai**[2]

[1]Vivekanandha College of Engineering for Women, Anna University, Tiruchengode, India

[2]Velalar College of Engineering and Technology, Erode, India

Correspondence
Satheshkumar Kandasamy, Vivekanandha College of Engineering for Women, Anna University, Tiruchengode, India.
Email: sathvIdhantha223@yahoo.com

Summary

In present scenario, Vehicular Ad-hoc Network (VANET) has obtained extensive attention because of its unique characteristics that handle high mobility of vehicles, reaping topological changes and frequent route breakages or failures. Hence, for providing smart transportation with enhanced traffic regulation and safety, a new position-based routing protocol called Traffic Dynamism-Balanced Routing Protocol (TDBRP) for VANET has been proposed in this paper. Moreover, the work concerns the instantaneous scenario of urban cities with the bidirectional and multilane roads. Efficient junction selection algorithm (EJSA) has been incorporated based on the traffic dynamism for establishing optimal route paths between nodes, hence, forwarding the data packets efficiently. Furthermore, the novel EJSP and the route framing between junctions are established on the basis of information gained from two-hop neighbors, which tends to reduce end-to-end delay and enhances packet delivery ratio (PDR). The TDBRP has been implemented and evaluated in Network Simulator (NS 2.34). And the results are examined and compared with some existing protocols like Geographic Source Routing (GSR), Enhanced Greedy Traffic Aware Routing protocol (E-GyTAR), and Anchor-based Street and Traffic-Aware Routing (A-STAR). The outcomes outperform the existing works by minimizing the routing overhead and end-to-end delay by an average of 16% and 13%, respectively, and increase the PDR value by an average of 25% than others. The proposed protocol also evidences that the two-hop neighbor information-based packet forwarding provides better result and efficient routing than neighbor information.

KEYWORDS

efficient junction selection algorithm (EJSA), Traffic Dynamism-Balanced Routing protocol (TDBRP), traffic regulation position, Vehicular Ad-hoc Network (VANET)

 © 2021 John Wiley & Sons Ltd.

1 | INTRODUCTION

In General, Vehicular Ad-hoc Networks (VANETs) are self-configured networks, comprised of mobile nodes that are able to communicate in environments, which are infrastructure less. Developments in wireless technologies has aided to incorporated the abilities of wireless communication networks to moving vehicles[1] allowing them to exchange information among others in infrastructure-less domain, thereby deployment cost could be reduced in considerable manner. Further, IEEE 802 committee[2] has provided a standard for Wireless Access in Vehicular Environment (WAVE), which is stated as IEEE 802.11 p.[3] There exist multiple wireless technologies like blue tooth, WiMax, Wi-Fi, and Satellite Digital Audio Radio Systems (SDARS). But, among all, VANETs use a system called dedicated short range communication (DSRC),[4] because it requires providing communication between vehicle to infrastructure and vehicle to vehicle. Moreover, the DSRC system has low latency and it has the capacity to transmit messages in several directions. A two-hop neighborhood information-based routing protocol is proposed for real-time wireless sensor networks. The approach of mapping packet deadline to a velocity is adopted as that in SPEED; however, our routing decision is made based on the novel two-hop velocity integrated with energy balancing mechanism.

VANETs are applied in numerous applications for enhancing the operations of transportation model and providing the road protection measures.[5] On the other hand, it also supports some commercial chatting, browsing, video and game downloading applications.[6,7] The VANET is technically relevant to MANET (Mobile Ad-hoc Networks), but in case of high-mobility speed of nodes, dynamic network nature, recurrent changes in topology, and inevitable mobility that is based on traffic regulations and road layout, the VANET stands different from MANET. Moreover, VANET does not have energy constraints, as the nodes called vehicles have chargeable energy sources. The general VANET architecture has been portrayed in Figure 1.

Typically, this work takes in the potential of VANETs to improve the traffic guideline and traffic safety that affords a system with smart transportation. Moreover, the distinct features of VANET has been analyzed and explored for developing a new position-based routing practice called Traffic Dynamism-Balanced Routing Protocol (TDBRP) for bidirectional and multitrack roads in VANET. Moreover, the protocol considers the position, velocity, and direction of

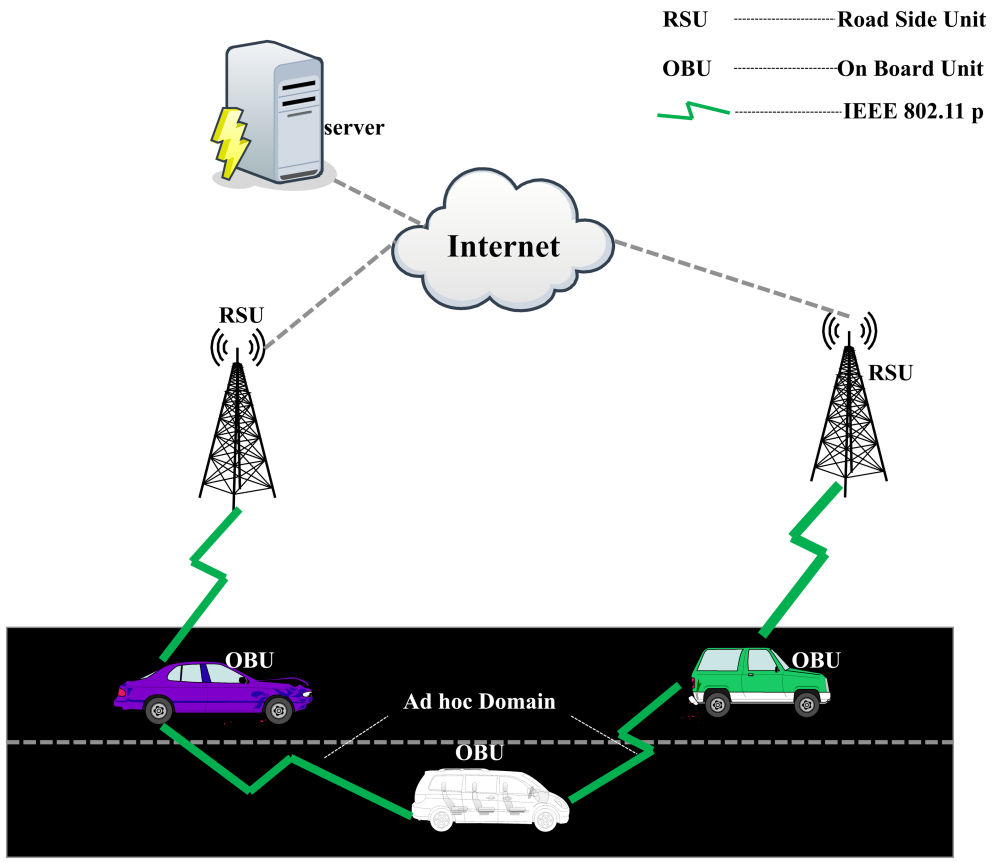


FIGURE 1 General architecture of VANET

the vehicles to decide on the junction for transmitting the data packets. It comprises two significant mechanisms to perform: (1) Efficient junction selection algorithm (EJSA) and (2) two-hop information-based routing.

Based on urban scenario, the EJSA finds out the directional and nondirectional traffic flows. Such determination of traffic dynamisms helps in framing the shortest optimal route path between nodes that decrease the end-to-end delay and improves delivery ratio. The proposed protocol also evidences that the two-hop neighbor information-based packet forwarding provides better result and efficient routing than the one-hop neighbor information. Moreover, TDBRP uses density of traffic and topological structure of road for optimal data relay in VANET. It is applicable for both the delay sensitive and delay-tolerant applications that include infotainment, accident alerts, and so forth.

The remainder of the paper is organized as follows: Section 2 deliberates the problem statement briefly; Section 3 contains the information about existing routing protocols in VANET. The working process of TDBRP is given in Section 4. Section 5 provides the simulation results and comparative analysis and Section 6 concludes the paper with some pointers to future enhancement.

2 | PROBLEM STATEMENT

However, an instant comes where there is a plenty amount of vehicles coming from a reverse direction and giving connectivity, when there are large number of moving vehicles. Hence, the developed protocol should determine the geographically nearest route toward destination, in which existing protocols are lacking to process. Another issue can be stated as the protocol may not consider the vehicle's direction of running during the process of junction selection; nevertheless, it considers the closest intersection point toward the destination as next junction. These aforementioned issues may cause local maximum problem, reduction of PDR and increasing delay. In order to solve such issues, this paper suggested a new protocol called TDBRP.

3 | RELATED WORKS

Due to the effective applicability in various applications, VANET has become an important research domain for people in industry and academics. Since recent vehicles are designed with Global Positioning System (GPS), navigation systems and digital maps, all nodes in the network are responsive to its location-dependent address called LDA through GPS.[8] Hence, the accessibility of vehicle's position induces to study position-based routing protocols for VANET.

Fubler et al. and Kargl,[9,10] have analyzed and compared the results acquired from the performances of position-based routing and ad hoc routing protocols. The results depict that the position-based routing protocols carry out well in networks with high dynamism. Geographic Source Routing (GSR)[1] has been developed for routing in the urban cases. For obtaining the information about the location of the destination, Reactive Location Service (RLS) has been used. Moreover, the source node has the knowledge of the positions of all the intersections from source to destination with the help of digital maps. The shortest path between the source and destination has been determined by the Dijkstra's shortest path algorithm. But, before path selection, the protocol does not concern about the vehicular traffic density.

Anchor-based Street and Traffic Aware Routing (A-STAR)[11] has been implemented by the authors particularly for vehicle-to-vehicle communication in urban environments. Position-based routing protocol has been the base for the A-STAR protocol, in which the vehicles are taken to find the anchor routes of denser connectivity. Moreover, the A-STAR overcomes the limitations noted in GSR protocol and provides a mechanism for estimating new anchor route initiated with the local maximum to which the data packets are to be transmitted.

Another city environment-based routing protocol is given in Bilal et al.,[12] which is termed as Enhanced Greedy Traffic- Aware Routing (E-GyTAR) protocol. The protocol finds the optimal route through the enhanced junction selection method. Based on the mechanism, the vehicle on the existing junction chooses the subsequent on the basis of the number of vehicles that are running in the path toward destination. But in case that there is an opposite vehicle flow and none is running toward the destination, then an efficient route could not be selected. This may increase delay and reduce packet delivery rate.

In Gong et al.,[13] the working principle of Directional Greedy Routing Protocol has been demonstrated. It considers the vehicle track and provides high rate of weight to the vehicle that is running to reach the destination node. Further, it utilizes a methodology called carry and forward, whenever the data packets are jammed on to a local maximum and executed fine in a city environment.

Reliable Directional Greedy Routing Protocol (RDGR) has been developed and described in Prasanth et al.[14] It is stated that it enhances the route reliability, increases PDR, and reduces the route breakages. It improves the work process of general Greedy Routing Protocol by adding a new parameter called link stability. Moreover, in RDGR, the vehicular node at initiation or an intermediary node are needed to select the next neighbor node, which is capable of providing link stability with high-performance speed.

A novel routing protocol named Hybrid Location aided Routing Protocol (HLRP) has been developed in Mangai and Tamilarasi[15] that utilized GPS-enabled MANETs. Moreover, the nodes are formed into clusters and efficient packet transmission has been done between nodes with respect to the location and position of the nodes. In a distinctive way, Ant Colony Optimization (ACO) has been incorporated in Mangai et al.[16] for implementing Dynamic Core based Multicast Routing Protocol (DCMP) in ad hoc networks. ACO algorithm is induced to determine the shortest path between vehicular nodes, as the ants find optimal route to reach their foods.

Further, for avoiding accidents and vehicle collision in a better way, the protocol discussed in Mangai and Tamilarasi[17] has provided a model called Improved Location-aided Cluster-based Routing Protocol with the Intrusion Detection System enforcement (ILCRP-IDS). The concept of IDS is utilized for making the VANET environment highly secure. The authors have analyzed and developed an improved accident indication system for VANET in Mangai et al.[18] It provides some valuable knowledge to the proposal of new protocol models for VANET for providing efficient communication for intelligent transportation.

4 | TRAFFIC DYNAMISM-BALANCED ROUTING PROTOCOL (TDBRP)

TDBRP is junction-oriented geographic routing protocol that uses GPS to determine the vehicle position. Further, the location and the position of the destination vehicle can be found by the Grid Location Service (GLS).[19] Each vehicle node is employed with an on-board navigation system for obtaining the location point of the junctions nearby. The TDBRP for VANET has been developed for managing the traffic flow and providing a smart transportation system to the people. It also affords some valuable street level knowledge based on the information obtained through the digital maps. Moreover, the designed protocol contains two modules of operations, namely, (1) implementation of efficient junction selection algorithm (EJSA) and (2) route framing between junctions. TDBRP is junction-oriented geographic routing protocol that uses GPS to determine the vehicle position. Further, the location and the position of the destination vehicle can be found by the GLS. Each vehicle node is employed with an on-board navigation system for obtaining the location point of the junctions nearby. It also affords some valuable street level knowledge based on the information obtained through the digital maps.

4.1 | Efficient junction selection algorithm (EJSA)

In the proposed TDBRP, dynamic junction selection has been established using EJSA. The mechanism considers the direction of the vehicle flow and the nondirectional flow based on the road traffic density. Perhaps, the probability of directional and nondirectional traffic flow occurrences toward a particular destination on city environment equally happened. Hence, it is significant to be considered while framing communication in VANETs. The source vehicular node S in a Junction JN utilizes the preloaded digital map for finding the next neighbor junction's location, and its position will be identified using the system of location service. Following, a curve metric will be determined by the vehicular node S from every nearest junction to the corresponding vehicular node D at destination. Further, grade points are assigned for the junctions based on the directional flow of the moving vehicles points to the destination. The junction with maximum or highest grade point (GP) is considered as the next target junction, which is almost nearer to the destination vehicular node D. It is also to be stated that the traffic density will also be higher for the junctions with higher grade points. The EJSA is given in Table 1.

From the above algorithm, the grade point for a junction is estimated using the following equation to identify the next target junction NT_{JN} in an effective way.

TABLE 1 Efficient junction selection algorithm (EJSA)

Input: Traffic density area, $\boldsymbol{A}$
Output: Next target junction ($\boldsymbol{NT_{JN}}$)
1. Begin
2. Take Grade_Point (GP) ← 0
3. Take Weight_Factors $(a,b) \leftarrow a + b = 1$
4. For all nominee junction (JN) do
5. Set $Dist_{nn}$ ← curve-metric distance between NN_{JN} and the destination vehicular node D
/* NN_{JN} denotes the next nominee junction */
6. Set $\boldsymbol{Dist_{ct}}$ ← curve-metric distance between the present JN ($\boldsymbol{CT_{JN}}$) and the target $\boldsymbol{D}$
7. Compute $\boldsymbol{Dist_{prox} = \frac{Dist_{nn}}{Dist_{ct}}}$
/* $Dist_{prox}$ determines the distance proximity of the next nominee junction to the vehicular node D */
8. Set $\boldsymbol{TTD}$←number of vehicles between $\boldsymbol{NN_{JN}}$ and $\boldsymbol{CT_{JN}}$ in both directions
/* TTD denotes total traffic density */
9. Compute $\boldsymbol{GP < a \times (1 - Dist_{prox}) + b \times TTD}$
10. If $\boldsymbol{GP < a \times (1 - Dist_{prox}) + b \times TTD}$ then
11. Set $NT_{JN} \leftarrow NN_{JN}$
12. End
13. End
14. Return NT_{JN}
15. End

$$GP < a \times \left(1 - Dist_{prox}\right) + b \times TTD$$

where $Dist_{prox} = \frac{Dist_{nn}}{Dist_{ct}}$ determines the distance proximity of the next nominee junction to the vehicular node D, TTD denotes the total traffic-density between the in progress JN (CT_{JN}) and the neighbor or next nominee junction NN_{JN}, in which the traffic flow would be toward or away from the destination. The parameters a and b are considered to be the weight factors, hence, it is given $a + b = 1$. Further, the junction that has the greater grade point is chosen as the next target junction in the designed VANET that can also be stated as the geographically closest junction to the target vehicular node. In accordance with that, the EJSA of TDBRP frames the optimal route path with minimal length to the destination based on the traffic density of the city environment.

4.1.1 | Group-based traffic density computation

The proposed routing protocol utilizes the Infrastructure Free Traffic Information System (IFTIS)[15] for computing the traffic density between the defined junction pairs. In this process, the road space between two junctions is partitioned into small circles called units of equal sizes. It is portrayed in Figure 2. The vehicles that come under same unit form a group. Moreover, the volume of the unit corresponds to the communication range of the moving vehicular nodes that may be around 200 m. The units may intersect in such a way that each node belongs to the minimum one of the units. And any vehicular node that comes nearer to the center of the unit is considered as the group leader, as long as it is closer to the center.[20]

The center of the unit is highlighted by small blue circles in Figure 2 called as peak zones. The JN_{SP} and JN_{EP} are the two junction points, in which the propagation of road density data packet (RDDP) and group density data packet (GDDP) has been accomplished, respectively. It is also to be stated here that only the group leaders are allowed to generate and update the GDDP by incorporating the details of the entire vehicles, which are moving toward and away from the direction of the target vehicular node. The GDDP is initiated by the vehicle that is started departing from the road. The packet contains the road ID, group ID, duration of transmission, and list of group centers, directional and non-directional densities of vehicles based on the defined group. The data format of GDDP is given in Figure 3. The RDP

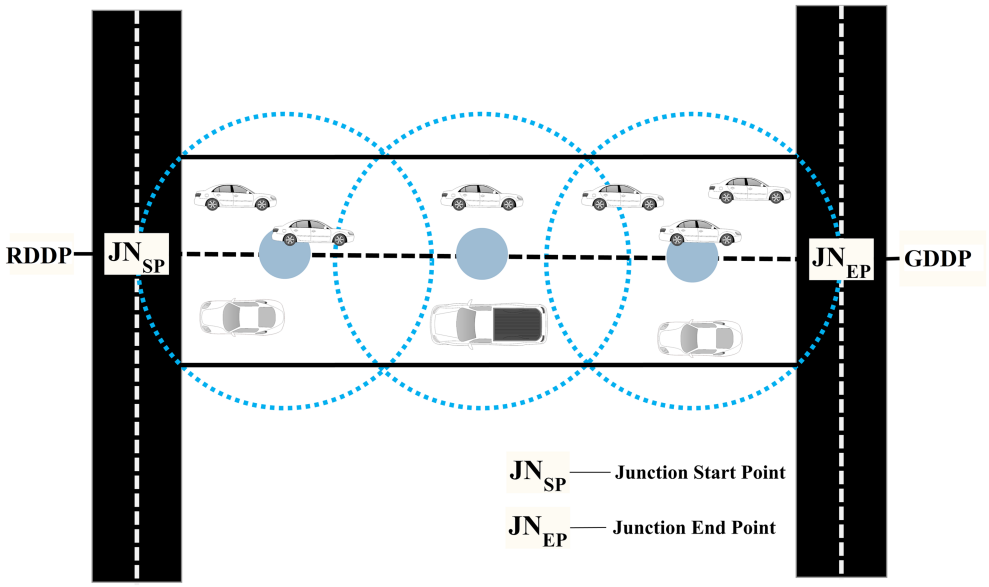


FIGURE 2 Illustration of group-based traffic density computation

Group Density Data Packet (GDDP)		
Road ID		Group ID
Direction	Central Position of Group	Total Density of Group
Duration	Directional Density	Non-Directional Density

FIGURE 3 Group density data packet format

and GDDP packets pass through the unit centers to reach the next junctions. The overall group-based traffic density computation is effectively illustrated in Figure 2.

As mentioned, RDDP is the road density data packet, which is to be traveled along the road toward destination. In this case, for a road "x," if the onward direction flow of road density ($R_x\uparrow$) is not existing, then nondirectional density that is termed as ($R_x\downarrow$) will be taken for routing. When both cases are obtainable, then the flow rate "λ" of both directional vehicle motion are determined. If $\lambda \geq 1$, then road density at the flow toward destination is greater and it is preferred to be traveled; in other case, the reverse path will be taken for processing. Hence, all the vehicular nodes around the corresponding junctions (JNs) are designed with overall road density ($R_{x\ tot}$) in both nondirectional and directional flows. In this way, the road density packet has been constructed. Further, the steps involved in packet forwarding are as follows:

- When vehicular node V_1 tends to forward the GDDP packet between two defined JNs, that is from JN_{SP} (junction starting point) to JN_{EP} (junction end point) as in Figure 2 of the assumed traffic density area A. It starts forwarding the GDDP packet from JN_{EP} to the JN_{SP}.
- The node V_1 can be possible being as the group leader. If V_1 is the group leader, then it will confer with the neighbor node and revise the GDDP by affixing the total density of group $|V_i|_{total}$ to which it stays, along with the density of directional flow $|V_i|\uparrow$ and the nondirectional flow $|V_i|\downarrow$. Following, the node V_1 forwards the GDDP to the next nearest group leader and so on.
- When the GDDP delivers at the group leader of the final unit, the GDDP will be updated and the values of mean and variance for the relevant unit density will be evaluated. After that, evaluated density will be sent to the junction end.

- In a case, if V_1 has no proper neighbor vehicular node nearer to the subsequent unit, it will have the GDDP till it identifies a vehicle node, which is closer to the subsequent unit.
- When another junction (JN_{SP}) is arrived, the GDDP is transformed into road density data packet (RDDP), which is further broadcasted around the junction.

4.2 | Route framing between junctions

After the process of efficient junction selection, the proposed TDBRP employs routing based on two-hop neighbor data. Using the process of greedy approach, the data packets are transmitted between two determined intersections of roads. For that point, all data packets are indicated with the location points of the immediate JN subsequent. Moreover, every vehicular node in VANET holds a table that stores the route path flow, position, and velocity of each adjacent vehicular node. The aforementioned table is revised with the new entries of neighbor nodes in periodical manner with the indication of beacon messages. Before transmitting packets, the source node refers the table for the currently expected positions of the other adjacent vehicles.

The TDBRP uses two-hop neighbor information; thereby, it keeps up the two hop neighbor table by substituting one-hop neighbor updates with beaconing messages. The vehicular source node refers the table and incorporates greedy mechanism to forward the data through its neighbor to the next neighbor, which is nearest to the destination. The following Figure 4 deliberates the overall work process of the TDBRP for proving communication between the source and destination in VANET with the assumption of eight junctions. It is explicit from the figure that the proposed protocol considers both the directional and nondirectional flow of vehicles unlike traditional VANET routing mechanisms, along with the dynamism in traffic density in city environment.[21]

5 | RESULTS AND DISCUSSIONS

For evaluating the performance of the proposed TDBRP, the simulation work is carried out in Network Simulator tool NS-2.34. The simulation criteria pertain to the urban traffic scenario. The results are compared with the traditional VANET routing protocols such as GSR, E-GyTAR, A-STAR, and Intelligent Transport System for Emergency Breaking System (ITSEBW), which is the previous research of this work, for providing an evidence for the efficiency of the affirmed work. Further, the mobility model for the designed simulation setup should replicate the appropriate features and vehicle activities based on VANET. The simulation model determines the activities of vehicular nodes in accordance with the other nodes based on the infrastructure employed. Table 2 summarizes all the significant simulation parameters and the initial setup ranges.

The experimental analysis has been carried out on the basis of the decisive factors such as packet delivery ratio (PDR), routing overhead, consumption of node energy, and end-to-end delay. In general, PDR is defined as the ratio of the successful reception of data packets at the destination node form the transmitted source. The calculation of PDR is based on the received and generated packets as recorded in the trace file. In general, PDR is defined as the ratio between the received packets by the destination and the generated packets by the source. In this performance evaluation, the reliability of the affirmed work has been determined by computing its PDR with respect to increase in number of nodes and mobility speed of the vehicular nodes considerably. The PDR comparison between models is shown in Figures 5 and 6. The obtained evaluated results are given in Tables 3 and 4, from which the values are used to generate graph comparisons.

It is obvious from the graph that the TDBRP model attains higher value of PDR than the other, hence it provides effective routing by utilizing both the directional and nondirectional flows of vehicle with respect to the traffic densities of the city environment. From Figure 5, when the speed of node mobility increases, there is considerable level of decrease that can be found in PDR, showing the impact of mobility on results. In the next PDR comparison provided in Figure 7, the proposed routing protocol has achieved better results than the conventional protocol results. That is, it produced 25% (in average) higher PDR than the rest.

Routing overhead denotes the rate of total control packets produced to the amount of data packets reached the target, at the time of whole simulation. Figure 7 plots the values obtained for routing overhead for all five routing protocols with respect to mobility speed. It is explicit from the graph that the TDBRP outperforms others by providing minimum values of routing overhead, due to the effective consideration of traffic density while

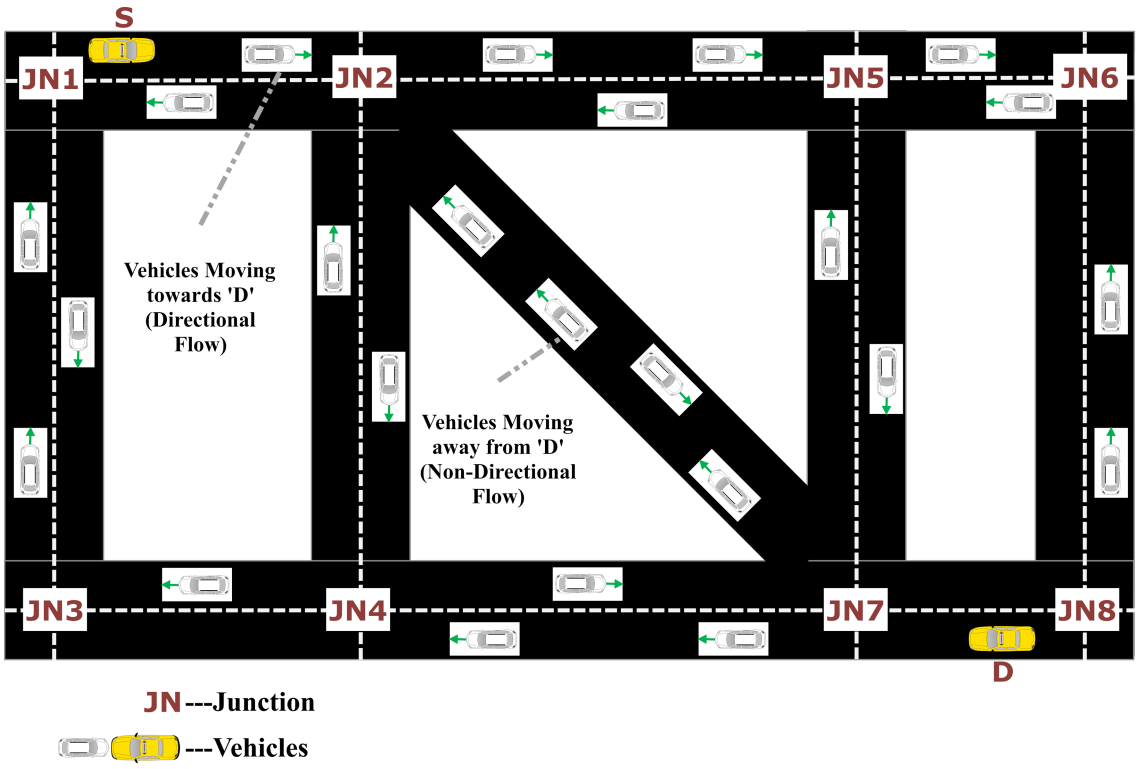


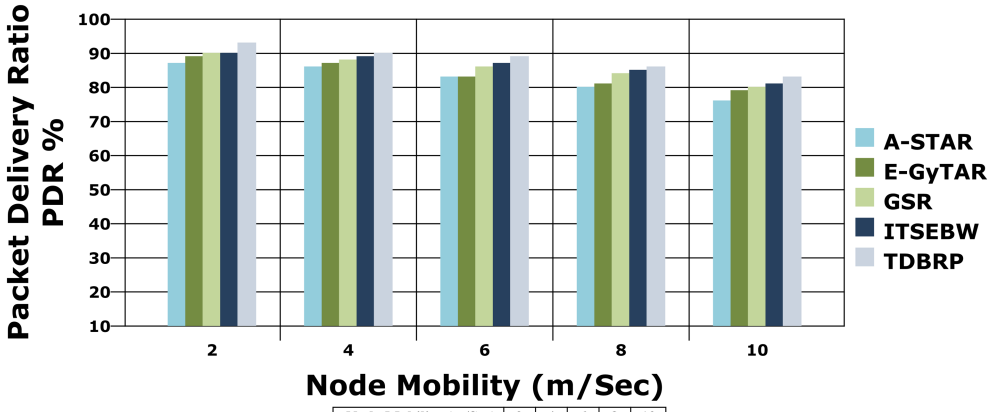
FIGURE 4 Working process of traffic dynamism-balanced routing protocol (TDBRP) for smart transportation system

TABLE 2 Simulation parameters with initial setup

Parameters	Initial values
Simulator	NS-2.34
Simulation area	3000 m × 2900 m
Simulation time	300 s
No. of roads	36
No. of junctions	22
No. of vehicles	75 to 150
Vehicle speed	30 to 60 km/h
MAC protocol	802.11 DCF
Capacity of channel	2 Mbps
Mobility model	Random waypoint
Transmission range	256 m
Propagation model	Two-way ground
Traffic type	16 CBR connections
Packet size	128 bytes
Weight factors (a,b)	(0.5, 0.5)

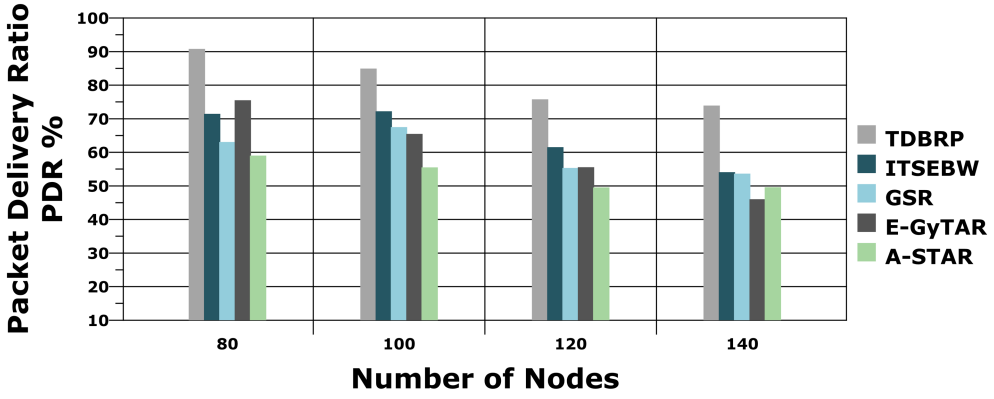
framing routes through the EJSA. The obtained values through experimentation have been given in the table 5 for reference.

Following that, the amount of energy consumption of the adduced work is computed as the ratio of total energy utilized and the number of data packets obtained. Here, energy consumption is examined based on vehicular node mobility and the time. The results are described in Figure 8, by increasing node mobility speed. From the graph, it is to be



Node Mobility (m/Sec)	2	4	6	8	10
A-STAR	87	86	83	80	76
E-GyTAR	89	87	83	81	79
GSR	90	88	86	84	80
ITSEBW	90	89	87	85	81
TDBRP	93	90	89	86	83

FIGURE 5 Packet delivery ratio versus node mobility



No. of Nodes	80	100	120	140
TDBRP	91	85	76	74
ITSEBW	71	72	61	54
GSR	63	67	55	53
E-GyTAR	75	65	55	46
A-STAR	59	55	49	49

FIGURE 6 Comparison between models for PDR against number of nodes

TABLE 3 Results obtained for PDR evaluation with respect to mobility

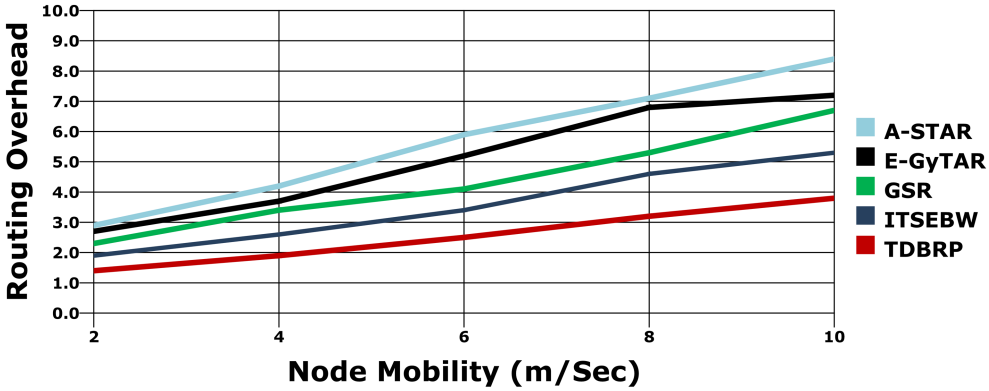
Node mobility (m/sec)	2	4	6	8	10
A-STAR	87	86	83	80	76
E-GyTAR	89	87	83	81	79
GSR	90	88	86	84	80
ITSEBW	90	89	87	85	81
TDBRP	93	90	89	86	83

Abbreviations: A-STAR, Anchor-based Street and Traffic-Aware Routing; E-GyTAR, Enhanced Greedy Traffic- Aware Routing; GSR, Geographic Source Routing; ITSEBW, Intelligent Transport System for Emergency Breaking System; PDR, packet delivery ratio; TDBRP, Traffic Dynamism-Balanced Routing Protocol.

No. of nodes	80	100	120	140
TDBRP	91	85	76	74
ITSEBW	71	72	61	54
GSR	63	67	55	53
E-GyTAR	75	65	55	46
A-STAR	59	55	49	49

TABLE 4 Evaluation results for PDR based on number of nodes

Abbreviations: A-STAR, Anchor-based Street and Traffic-Aware Routing; E-GyTAR, Enhanced Greedy Traffic- Aware Routing; GSR, Geographic Source Routing; ITSEBW, Intelligent Transport System for Emergency Breaking System; PDR, packet delivery ratio; TDBRP, Traffic Dynamism-Balanced Routing Protocol.



Node Mobility (m/Sec)	2	4	6	8	10
A-STAR	2.9	4.2	5.9	7.1	8.4
E-GyTAR	2.7	3.7	5.2	6.8	7.2
GSR	2.3	3.4	4.1	5.3	6.7
ITSEBW	1.9	2.6	3.4	4.6	5.3
TDBRP	1.4	1.9	2.5	3.2	3.8

FIGURE 7 Routing overhead versus mobility speed

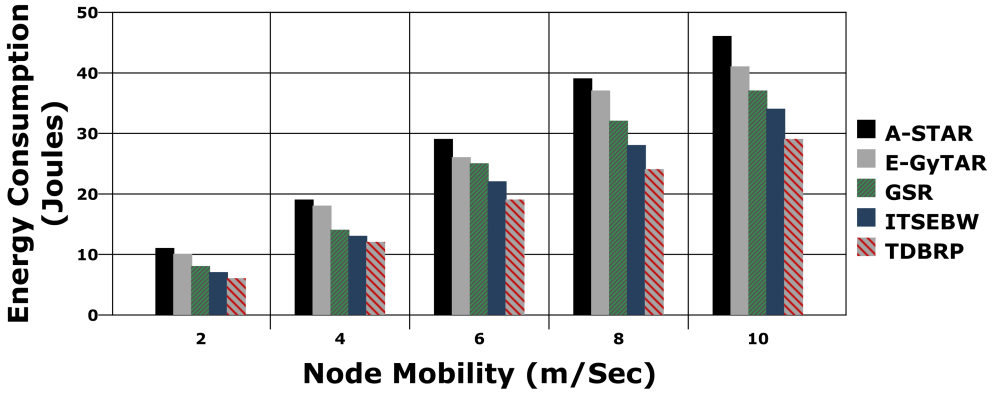
Node mobility (m/sec)	2	4	6	8	10
A-STAR	2.9	4.2	5.9	7.1	8.4
E-GyTAR	2.7	3.7	5.2	6.8	7.2
GSR	2.3	3.4	4.1	5.3	6.7
ITSEBW	1.9	2.6	3.4	4.6	5.3
TDBRP	1.4	1.9	2.5	3.2	3.8

TABLE 5 Values obtained for the analysis of routing overhead

Abbreviations: A-STAR, Anchor-based Street and Traffic-Aware Routing; E-GyTAR, Enhanced Greedy Traffic- Aware Routing; GSR, Geographic Source Routing; ITSEBW, Intelligent Transport System for Emergency Breaking System; TDBRP, Traffic Dynamism-Balanced Routing Protocol.

stated that the TDBRP consumed minimal or lesser energy than the compared protocols, since the optimal consumption of energy could be achieved by the incorporation of junction selection algorithm, and the values are provided in Table 6.

Finally, end-to-end delay comparison is shown in Figure 9 (values presented in Table 7). Typically, end-to-end delay can be defined as the average time taken by the data packet to be sent out from the source vehicular node to the specified target across the VANET. In the initial stage, the TDBRP model involves 3.4 msec of delay. Moreover, the graph exemplifies that as the time increases, the model constantly balancing the delay and it can be explicitly viewed that the protocol attaining minimum delay on packet transmission. Hence, it makes the TDBRP a better VANET routing protocol for providing smart transportation.



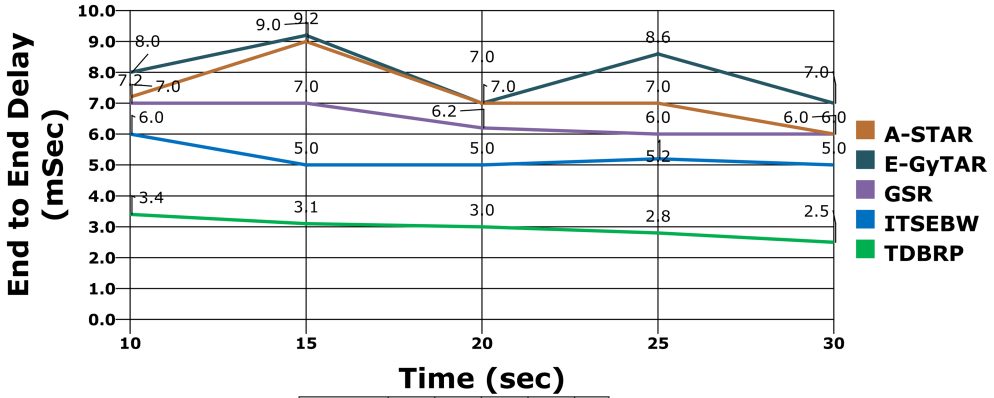
Node Mobility (m/Sec)	2	4	6	8	10
A-STAR	11	19	29	39	46
E-GyTAR	10	18	26	37	41
GSR	8	14	25	32	37
ITSEBW	7	13	22	28	34
TDBRP	6	12	19	24	29

FIGURE 8 Comparison between models for energy consumption

TABLE 6 Evaluation results for energy consumption

Node mobility (m/sec)	2	4	6	8	10
A-STAR	11	19	29	39	46
E-GyTAR	10	18	26	37	41
GSR	8	14	25	32	37
ITSEBW	7	13	22	28	34
TDBRP	6	12	19	24	29

Abbreviations: A-STAR, Anchor-based Street and Traffic-Aware Routing; E-GyTAR, Enhanced Greedy Traffic- Aware Routing; GSR, Geographic Source Routing; ITSEBW, Intelligent Transport System for Emergency Breaking System; TDBRP, Traffic Dynamism-Balanced Routing Protocol.



Time (sec)	10	15	20	25	30
A-STAR	7.2	9.0	7.0	7.0	6.0
E-GyTAR	8.0	9.2	7.0	8.6	7.0
GSR	7.0	7.0	6.2	6.0	6.0
ITSEBW	6.0	5.0	5.0	5.2	5.0
TDBRP	3.4	3.1	3.0	2.8	2.5

FIGURE 9 Comparison for end-to-end delay

TABLE 7 Results for end-to-end delay

Node mobility (m/sec)	10	15	20	25	30
A-STAR	7.2	9.0	7.0	7.0	6.0
E-GyTAR	8.0	9.2	7.0	8.6	7.0
GSR	7.0	8.0	6.2	6.0	6.0
ITSEBW	6.0	5.0	5.0	5.2	5.0
TDBRP	3.4	3.1	3.0	2.8	2.5

Abbreviations: A-STAR, Anchor-based Street and Traffic-Aware Routing; E-GyTAR, Enhanced Greedy Traffic- Aware Routing; GSR, Geographic Source Routing; ITSEBW, Intelligent Transport System for Emergency Breaking System; TDBRP, Traffic Dynamism-Balanced Routing Protocol.

6 | CONCLUSION AND FUTURE WORK

In this paper, an efficient routing protocol called TDBRP for VANET has been developed for managing the traffic flow and providing a smart transportation system to the people. The protocol has been designed based on the analysis that has been made with the existing routing protocols in VANET. Moreover, the protocol includes two modules of execution: firstly, implementation of EJSA, in accordance with the directional and nondirectional flows of traffic density; secondly, route framing between junctions based in the two-hop neighbor information table. Hence, the TDBRP forwards packet through the efficient junctions to the target vehicular node, which are chosen from the effect of traffic dynamism and the vehicular density on roads. The comparative analysis has been made with its own results and the results obtained from the conventional routing protocols such as GSR, E-GyTAR, and A-STAR. The simulation results demonstrate that the proposed protocol attains higher PDR and reduced delay than the compared models. Further, the routing overhead has also been considerably low based on the comparison, since the model enhances the packet forwarding process by utilizing the information gathered by the vehicular nodes at two-hop distance. The TDBRP is finally improved to increasing the number of vehicles as well to reduce the delay and to improve the throughput.

The work can be further extended by raising the number of vehicular nodes and analyzing the results based on the aforementioned decisive factors such as PDR, delay, routing overhead, and consumption of energy. Another direction of future enhancement could be designing the protocol to work or adapt with both the city and highway road scenarios.

DATA AVAILABILITY STATEMENT

There is no specific dataset used here. Everything is simulated.

ORCID

Satheshkumar Kandasamy https://orcid.org/0000-0001-8745-6737

REFERENCES

1. Lochert C, Hartenstein H, Tian J, Fussler H, Hermann D, Mauve M. A routing strategy for vehicular ad hoc networks in city environments. In: *Proceedings of IEEE on Intelligent Vehicles Symposium, USA*; 2003:156-161.
2. Bilstrup X, Katrin A. *A Survey Regarding Wireless Communication Standards Intended for a High-Speed Vehicle Environment*. Halmstad University Technical Report; 2007.
3. Jiang D, Delgrossi L. IEEE 802.11p: towards an international standard for wireless access in vehicular environments. In: *Proceedings of Vehicular Technology Conference*; 2008:55-59.
4. Cseh C. Architecture of the Dedicated Short- Range Communications (DSRC) protocol. In: *Proceedings of IEEE Vehicular Technology Conference*; 1998:45-49.
5. Wang Y, Lin C, Hwang W, Tao C, Chou L, Practical Routing A. Protocol for vehicle- formed mobile ad hoc networks on the roads. In: *Proceedings of 8th IEEE International Conference on Intelligent Transportation Systems*; 2005:161-165.
6. Mahlknecht S, Madani S. On architecture of low power wireless sensor networks for container tracking and monitoring applications. In: *Proceedings of 5th IEEE International Conference Industrial Informatics*; 2007:353-358.
7. Zimmer T. Personal information and the design of vehicle safety communication technologies: an application of privacy as contextual integrity. In: *Proceedings of AAAS Science & Technology in Society*; 2005:222-226.
8. Blazevic L, Giordano S, Boudec L. Self organized routing in wide area mobile ad-hoc network. In: *Proceedings IEEE Symposium on Ad-Hoc Wireless Networks (Globecom)*; 2001:44-49.
9. Fubler H, Mauve M, Hartenstein H, Kasemann M, Vollmer D. Location based routing for vehicular ad hoc networks, Computer Journal of ACM SIGMOBILE. *Mob Comput Commun Rev*. 2003;7(1):47-49.
10. Kargl F., *Vehicular Communications and VANETs, Talks 23rd Chaos Communication Congress*, (2006).

11. Seet C, Liu G, Lee S, Foh H, Wong J, Lee K. *A-STAR: A Mobile Ad Hoc Routing Strategy for Metropolis Vehicular Communications, Networking Technologies, Services, and Protocols; Performance of Computer and Communication Networks, Mobile and Wireless Communications*; 2004:989-999.
12. Bilal S, Madani SA, Khan IA. Enhanced junction selection mechanism for routing protocol in VANETs. Arab. *J Inf Technol*. 2011;8(4): 422-429.
13. Gong J, Xu CZ, Holle J. Predictive directional greedy routing in vehicular ad hoc networks. In: *Distributed Computing Systems Workshops, 2007. ICDCSW '07*. 27th International Conference on June; 2007.
14. Prasanth K, Duraiswamy K, Jayasudha K, Chandrasekar C. Improved packet forwarding approach in vehicular ad hoc networks using RDGR algorithm. *Int J Next-Gen Netw (IJNGN)*. 2010;2(1):64-77.
15. Mangai S, Tamilarasi A. Hybrid Location aided Routing Protocol for GPS enabled MANET clusters. In: *Proceedings of INCOCCI 2010, Kongu Engineering College, Perundurai, Erode, T.N., India*; 2010:404-409.
16. Mangai S, Tamilarasi A, Venkatesh C. Dynamic core multicast routing protocol implementation using ant colony optimization in ad hoc wireless networks. In: *The Proceedings of the International Conference on Computing, Communication and Networking* held during 18th -20th December at Chettinad College of Engineering and Technology, Karur; 2008.
17. Mangai S, Tamilarasi A. Vehicle monitoring and traffic collision avoidance system using ILCRP-IDS in VANETS. In: *Proceedings of National Conference on Telecommunication in Health Care Engineering*. Erode, T.N., India: Velalar College of Engineering and Technology; 2011.
18. Mangai S, Suganya A, Sabeena AM. *An Improved accident notification system in VANETS, in Proceedings of National Conference on Smart Systems (NCS2)*. Kangayam, T.N., India: Faculty of Engineering, Erode Builder Educational Trust's Group of Institutions; 2011.
19. Li J, Jannotti J, Couto D, Karger D, Morris R. A scalable location service for geographic ad hoc routing. In: *Proceedings of ACM/IEEE MOBICOM'2000*; 2000:120-130.
20. Jwaifel AMJ, Ghareeb I, Shaltaf S. Impact of co-channel interference on performance of dual-hop wireless ad hoc networks over $\alpha-\mu$ fading channels. *Int J Commun Syst*. 2020;33:e4500. https://doi.org/10.1002/dac.4500
21. Cicioğlu M, Çalhan A. Energy-efficient and SDN-enabled routing algorithm for wireless body area networks. *Comput Commun*. 2020; 160:228-239. https://doi.org/10.1016/j.comcom.2020.06.003

How to cite this article: Kandasamy S, Mangai S. A smart transportation system in VANET based on vehicle geographical tracking and balanced routing protocol. *Int J Commun Syst*. 2021;34:e4714. https://doi.org/10.1002/dac.4714