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Research Article

Optimal Routing Protocol to Reduce Frequent Disconnection Problem with Improvement of Link Quality in Vehicle Network

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ABSTRACT

Vehicular Ad-hoc Networks (VANETs) are currently receiving significant interest from academics because to the escalating traffic issues, particularly in densely populated nations. The rising incidence of accidents necessitates the implementation of an Intelligent Transportation System (ITS) that can effectively minimize and alleviate this trend. The existing routing protocols for VANETs address various scenarios and techniques for establishing dependable communication between vehicles and infrastructures. However, certain conditions, such as the stability of the link between vehicles during packet exchange, have not been well handled. This work presents the Link Reliability Data Forwarding Routing Protocol (LRDF-RP) as a solution to address the issue of frequent disconnections and improve route selection based on reliability in Mobility prediction in VANET. This study encompasses two essential contributions: (1) Enhancing the prediction routing protocol to transmit packets over a dependable route, and (2) Incorporating more logic in the selection of intermediate nodes towards the destination to get an increased Packet Delivery Ratio (PDR). The LRDF-RP employs the Prims Greedy algorithm for forwarding and the Predictive Perimeter method for recovery, with changes made to both algorithms to fulfil the specific demands of VANETs. The approach is evaluated based on several criteria including packet delivery ratio, throughput, end-to-end delay, consumption of energy, and average hop count.

Keywords: frequent disconnection, reliability, delay, data forwarding, greedy algorithm, optimal routing.

INTRODUCTION

With the expanding global economy, the proliferation of automobiles is steadily rising, hence heightening the risks and hazards associated with driving. The worldwide Status Report on Road Safety, issued by the World Health Organisation (WHO), presents comprehensive worldwide statistics on road safety. The study provides information on 182 nations, which collectively represent 99% of the world's population [1]. The research states that the annual global road traffic fatalities resulting from different traffic incidents on roads amount to 1.24 million. The report was officially designated by the UN General Assembly as the fundamental reference for all road safety initiatives to be implemented over the period of 2011-2020There is a predicted substantial rise in the number of Inter-City travels, expected to climb from 3.34 million per day in 2007 to 7.96 million per day by 2021.

This group has provided the adoption of a sophisticated signaling system that makes use of Global Positioning System (GPS) and Geographic Information System (GIS) technology to efficiently control the growing traffic congestion resulting from population growth. Similarly, other major cities throughout the world also experience population increase in traffic [2]. The aforementioned research demonstrate the great desirability of effectively managing both traffic congestion and automobile accidents worldwide. To accomplish these objectives, automobiles now include costly sensors, radars, cameras, and other cutting-edge technologies to enhance safety and comfort while travelling [3]. Lately, there has been an increasing fascination in Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I) applications among businesses and governments globally. This is because of their unmatched capacity to address safety and traffic congestion problems while minimizing operating expenses [4]. Both V2V and V2I technologies have the capacity to be used for commercial and vehicle entertainment applications [5].

VANETs rely on the use of short-range wireless communications for vehicle-to-vehicle communication. The normal range of a radio transmission in VANETs is usually 300 metres. In certain cases, this range might surpass 1,000 metres. Routing scenarios for V2V and V2I communication are crucial to VANET success [6]. The data collected from GPS devices assists in evaluating and choosing the most optimal routes to target locations. By using GPS, every node is allocated its own position together with the location of the target node [7]. VANET services may be classified into the following categories: The services may be classified into two categories: (i) those that enhance safety by delivering risk-avoidance and autonomous driving features, and (ii) those that enhance comfort by giving warnings about road conditions and allowing information exchange and sharing among users [8]. Although certain services have been identified via a system that is managed centrally, autonomous distributed systems that rely on VANET may operate cost-effectively and adapt to a wide range of services. One of the most important factors in the successful functioning of both types of services is the effectiveness of the routing protocols used by VANETs.

The current protocols use beacon messages to periodically detect adjacent nodes and ascertain the most efficient route to a destination. In addition, the transmission protocols that are now in use only consider the velocity of neighboring nodes at the beginning of the transmission. They fail to take into account the stability of the connection with these neighbors throughout the full process of exchanging packets. The issue lies in the fact that relay nodes may face impediments during transmission, leading to a significant loss of data packets owing to a weak signal or the destination being entirely out of range [10]. The necessity of maintaining a steady connection is of the utmost importance in this circumstance, and it need to be taken into consideration while selecting the most efficient path with which to arrive at the target [11]. The current routing strategies lack the flexibility to effectively manage the dynamic situations and varying speeds of vehicles in VANETs, frequent disruptions in communication links, non-line of sight (NLOS) communication, and disconnections in locations with limited network coverage [12].

The subsequent sections of this article are. The literature survey is described in Section 2. The proposed solutions are outlined in Section 3. Section 4 covers the examination of performance and outcomes using comparative research. Section 5 ends with a summary and suggestions for further research.

RELATED WORKS

Maintaining reliable and consistent communication lines between vehicles is challenging due to the dynamic nature of automotive surroundings. The effectiveness of VANETs might be hampered by frequent link disconnections brought on by factors including high vehicle movement, obstructions, signal interference, and congestion. Multiple link prediction methods that anticipate link stability and mitigate the impact of frequent link disconnections have been proposed by researchers as a solution to this issue. The study highlights the need for a novel dynamic link prediction protocol for VANET while analyzing the existing approaches in this literature review.

A novel MAC (Media Access Control) protocol based on a Markov model, called EAPRAD (Enhancing Access Probability and Reducing Access Delay), is presented in [13]. Intermediate nodes are used to proactively anticipate and prevent package collisions for cars traveling in the same direction. It reduces end-to-end delay and beacon lost rate (BLR). In [14] propose roadside unit (RSU)-assisted hybrid emergency message broadcasting (RA-HEMB) protocol for two-way grid roads in urban VANETs. The time needed for broadcasting to identify the nodes in the target region can be greatly decreased. In order to mitigate broadcast storms in VANETs (ABM-V), an adaptive backoff method is proposed in [15]. More precisely, the recipient assesses the anticipated advantage and duplication by merging the array of adjacent entities.

Subsequently, the recipient dynamically modifies the backoff duration by using Dempster-Shafer evidence theory. Ultimately, the recipient with the briefest backoff period assumes the role of the relay and transmits the packet to its neighbouring devices. It greatly decreases the rate of retransmission and redundancy. In [16], an Effective Emergency Message Dissemination Scheme (EEMDS) is proposed for urban VANETs. The technique relies on our mobility measurements to prevent excessive communication and provide a consistent cluster topology. The introduction of estimated link stability is used to select an appropriate relay vehicle, which helps minimise the number of rebroadcasts and communication congestion in the network. The reactive routing strategy presented in [17] for VANETS involves the maintenance of numerous pathways between the source and destination for data transfer.

The use of connection termination time (CTT) has been employed to determine the two most optimal disjoint pathways. In this study, the authors provide an adaptive link-state perception system (ALPS) for VANET. This technique allows the controller to efficiently gather information about the link-state within the beacon interval. The link-state is determined by detecting packet loss on a connection. A fuzzy logic-based link quality evaluation approach is utilised to assess the probability of connection failure. Following the evaluation of the connection, we propose an adaptive threshold adjustment approach to dynamically modify the detection range in order to reduce the cost of detection.

The aforementioned strategies are specifically targeted towards the attributes of this particular network. All approaches assume the usage of GPS because of the inherent mobility they possess. It is crucial to know the precise location of each node in order to make optimal route decisions. Distance and speed are the chosen measurements, as distance represents the rate of progress towards reaching a destination, while speed takes into consideration the behaviour of vehicular networks. Link life, also known as link stability or link quality, is essential for ensuring uninterrupted data transfer by following a path that assures long-lasting communication without disconnection.

PROPOSED LRDF-RP METHOD

This sector provides a detailed discussion of the proposed technique, including a visual representation of its flow and an explanation of the underlying algorithms. This paper intends to establish improvement of link quality in VANET with reducing frequent disconnection problem. In this proposed work, we have created a Link Reliability Data Forwarding Routing Protocol (LRDF-RP) that incorporates the innovative prim's greedy forwarding algorithm. This protocol guarantees effective communication throughout the network. Figure 1 illustrates the operational sequence of the proposed system.

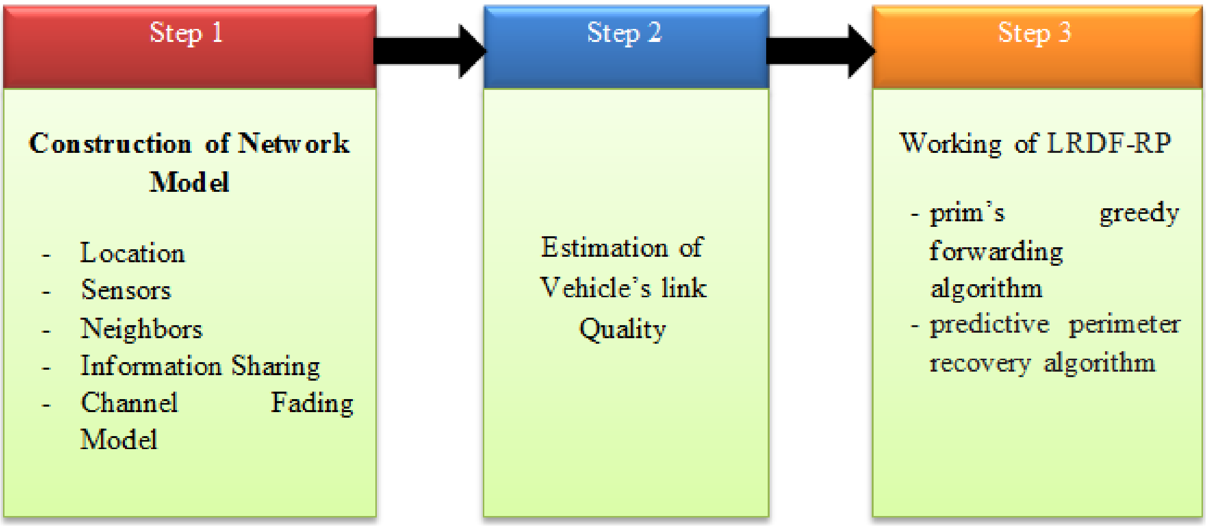

Figure 1: Block Diagram of Proposed LRDF-RP Method

1.1 Network model

- Location and radius: The Global Positioning System (GPS) and On-Board Unit (OBU) were installed in each vehicle, and each had a predefined communication range. The OBU enabled the car to communicate with other cars by sending out a beacon that was within its communication range. The central management organization was contacted by each forwarding node to get destination location information in order to meet routing requirements.

- In order to facilitate communication between vehicles, each vehicle was equipped with a WSN interface that complies with either the 802.11p standard or specific short-range communication protocols. In addition, every vehicle was fitted with an onboard diagnostic interface, which was intended to collect information from a variety of mechanical and electrical sensors located inside the vehicle. There was no infrastructure in the vicinity of the road, and the only way for nodes to communicate with one another is through V2V communication.

- Neighbors and paths: The vehicle's initial position was decided using a random choose from a uniform distribution.
- Nodes share information: The data contained information on the state vectors of modes, including their physical location, destination, and direction.
- Channel fading model: The Nakagami-m model is employed to characterize the attenuation of radio wave transmission. It defines the PDF of the received signal strength, rec, as $P_z(rec) = \left(\frac{n}{P_r}\right)^n \frac{x^{n-1}}{\delta(n)} e^{-\frac{nx}{P_r}}, for\ rec \geq 0. \delta(.)$ represents the Gamma function. The equation $P_r = \frac{P_l \mu}{r^a}$ represents the average received power, where P_t is the transmission power, r is the distance in metres, an is the path-loss exponent, $\mu = gain_t gain_r \left(\frac{C}{4\pi f_c}\right)^2$, C is the speed of light, $f_c = 5.9GHZ$, and m is the fading factor. The CDF of the communication range of vehicles may be determined using the Nakagami-m model, specifically when the received power exceeds a certain threshold. The expression for P_{thres} is given by: $F_{Rec}(r) = 1 - \int_{P_{thres}}^{\infty} P_z(rec)dx = 1 - \frac{1}{\delta(n)} \sum_{i=0}^{n-1} \frac{(n-1)}{(n-1-i)} (\frac{m\, P_{thres}}{P_r})$. The average vehicle reception range, consider channel fading and indicated by K, is determined as:

$$K = \int_0^{\infty} ((1 - F_K(r))\, dr = \frac{1}{a\delta(n)} \sum_{i=0}^{n-1} \frac{(n-1)}{(n-1-i)} \times \delta\left(n - 1 - i + \frac{1}{a}\right)\left(\frac{mP_{thres}}{P_{thres}\delta}\right) \quad (1)$$

- Updating of vehicle direction - Let's examine two neighbouring nodes, X and Y. If two objects are travelling in the same direction, their relative speed, h_rel, falls within the interval $(-h_m, h_m)$, where $h_m = h_{max} - h_{min}$. The PDF of h_{rel} is obtained by derivation.

$$fh_{rel}(h_{rel}) = \begin{cases} \frac{h_{max}-h_{min}+h_{rel}}{(h_{max}-h_{min})^2}, -h_m \leq h_{rel} \leq h_m \\ \frac{h_{max}-h_{min}-h_{rel}}{(h_{max}-h_{min})^2}, 0 \leq h_{rel} \leq h_m \end{cases} \quad (2)$$

If two objects are travelling in opposing directions, their relative speed, h_{rel}, falls within the range of $(2v_{min}, 2v_{max})$. The probability density function (PDF) of h_{rel} is expressed as:

$$fh_{rel}(h_{rel}) = \begin{cases} \frac{h_{rel}-2h_{min}+h_{rel}}{(h_{max}-h_{min})^2}, 2h_{min} \leq h_{rel} \leq h_{min} + h_{max} \\ \frac{h_{max}-h_{min}-h_{rel}}{(h_{max}-h_{min})^2}, h_{min} + h_{max} \leq h_{rel} \leq 2h_{max} \end{cases} \quad (3)$$

To observe the detailed movement patterns of a single vehicle, we break down time into short intervals of equal duration, denoted as ω. Let W_m denotes the distance between vehicles X and Y after m time intervals. Next, the value of $W_m = W_{m-1} + h_{rel}\omega$. To simplify, we assume that the value is equal to 1. Therefore, we may express $W_m = W_{m-1} + h_{rel}$. Therefore, the link connection time is

$$T_{link} = \{m.\omega: X_i \leq RG, 1 \leq i \leq m\} \quad (4)$$

We divide the transmission range RG into h equal intervals, each with a width of $\varepsilon \frac{R}{h}$.

1.2 Estimation of vehicle's link quality

To determine the optimal link for a forwarding route, we utilise the link quality parameter. The link quality between two vehicles is adjusted based on the computed probability of successful data transmission. The quality of a link is determined by the quantity of packets transmitted and acknowledged across that link. The parameter "$prob_{success}$" is the estimated likelihood of successfully transmitting a packet for the link "T_{link}". This probability is calculated using the following formula:

$$prob_{success}.T_{link} = \frac{num_{sucess}}{num_{st}} \quad (5)$$

Where, num_{sucess} represents the count of packets that have been successfully transferred (forwarded) within the time window w, whereas num_{st} represents the count of packets that are supposed to be transmitted within the same time window. During the communication between vehicles X and Y, each beacon message issued by vehicle X includes the count of packets received from vehicle $Y.T_{link}$ channel during the time window w. Vehicle X will calculate this number as num_{sucess}. The probability of successfully sending and acknowledging a packet, pac_{ack}, is defined in equation (6).

$$pac_{ack}.T_{link} = \frac{num_{rec}}{num_{nt}} \quad (6)$$

Where num_{rec} represents the quantity of packets that have been received within a specific time frame, referred to as window w and num_{nt} represents the expected quantity of packets that should be received within the same time frame. The quality of a connection is determined at the moment of beaconing, denoted as $time_{beacon}$, as specified in equation (7).

$$link(X, Y) = (prob_{success}.T_{link} * pac_{ack}.T_{link})t_{time_{beacon}} \quad (7)$$

If a beacon is not received during the duration of beaconing $t_{time_{beacon}}$ (num_{sucess}), and a beacon message from this vehicle is received during $t_{time_{beacon}}$ $T_{link}(X, Y)$ will be null, denoted as $T_{link}(X, Y) = 0$. This will decrease the probability of it being chosen as the next-hop forwarder.

1.3 Link Reliability Data Forwarding Routing Protocol (LRDF-RP)

This section provides a concise explanation of the operational concept behind the LRDF-RP routing protocol. The Three distinct categories of messages are transmitted between the nodes in a network in order to accomplish the intended goals. The HELLO transmission message is periodically sent to neighboring nodes within a 1-hop distance. The interval at which the message is sent is adjusted dynamically based on the zoom out level. A "HELLO-message" is a intermittent broadcast message inside a network that serves to indicate the existence of nodes and provide information such as geographical position, speed, distance, and energy levels. Any TCP/IP layering architecture link-layer change activates the zoom-out HELLO message. Source nodes broadcast Reliable Link Route Request (RLRQ) messages throughout the network. RLRQs are generated when a source node cannot safely and efficiently send data to the destination. Upon reaching the destination, an RLRQ message generates an RLRP message. The RLRP message is a unicast message transmitted by the destination.

- 1-hop HELLO broadcast message: LRDF-RP utilises two distinct forms of 1-hop broadcast messages. Each node in the network generates a 1-Hop HELLO broadcast message regularly. The 1-Hop HELLO message is sent at a periodic interval of 1 second. In addition, a 1-Hop message broadcast is performed with adaptive zoom out when a network change is noticed.

- Reliable link route request: The RLRQ message is disseminated to all adjacent nodes within a one-hop distance in the network. When a source node needs to transmit data to a destination but does not have an ideal route, it broadcasts RLRQ message. If a node either serves as the destination or has a path to the destination, it will transmit a route reply message via unicast upon receiving the RLRQ message. It begins or starts. The method below provides a comprehensive explanation of the entire process of RLRQ.

- Reliable link route reply (RLRP): A reverse table is formed after the destination receives the RLRQ message, and a unicast route reply message is sent using the reverse entries over a reliable path. Until the packet reaches the source node, an intermediate node sends a Unicast RLRP message to the subsequent hop and keeps a forwarding table. Data will be sent by the source node via PGFA and PPRA when it receives the RLRP message.

Algorithm-1: LRDF-RP

```
Set the number of vehicles (N)={1,2,3,4,5,6}
        Initiate 1-Hop HELLO broadcast message
                For each node Nϵ6 do
# assign the position and destination of vehicles
# initiate neighbor table
        Set 1sec interval
                If N_i ≤ 6 then
                        Initiate zoom out HELLO broadcast message
                End if
                End for
Initiate RLRQ
        Source=null; destination=null; packet_information=k

        Request to send data packet
                If source has path to reach destination
                Then; Forward the packet
                        Else
                composite factor with start time
                End
        If the time expires then
                Rebroadcast the packet
        End
        Start unicast RLRP
        Reply with checking backward table
        For
                Source node ←RLRP
                Adopt PGFA&PPRA
                Chose arbitrary vertex
        Construct network = Net'(A, A')
        Compute weights by using eqn (8)
        Forward the packets to destination
        If
                Forwarded packet fails
                Start PPRA
        Else
        Stop the process
                Update the perimeter mode
```

1.4 Prim's greedy forwarding algorithm

Prim's algorithm is a greedy method that begins by choosing a random vertex to serve as the root of the tree. The algorithm proceeds by expanding the tree by the addition of a vertex that is in closest proximity (i.e., has the shortest edge) to the current tree. Additionally, it includes the shortest edge connecting any vertex already present in the tree to the newly added vertex. The procedure concludes after all vertices have been included in the tree. The total of all included edges corresponds to the expense of the least spanning tree. Using the shortest path trees as a foundation, we construct a directed network called $Net'(A, A')$, where A refers the set of nodes in network Nett and A' represents the set of directed arcs. In this network, for every edge $ba\epsilon E$ in Nett, there are two arcs ab and ba. The weights wei_{ab} and wei_{ba} of the origin/destination pairings that use the edge ab in all the shortest path trees, from a to b or from b to a, are computed using the following equations:

$$wei_{ab} = wei_{energy}\left(energy_i^{tran} + energy_j^{rec}\right) + wei_{density}\left(\frac{1}{density_i} + \frac{1}{density_j}\right) + wei_{position}\left(position_i + position_j\right) + wei_{information}\left(information_i + information_j \right. \quad (8)$$

Equation (8) illustrates the cooperation coefficient derived using the parameter values energy, density, position, and information. These parameter values are connected with the weights $wei_{energy}, wei_{density}, wei_{position}, wei_{information}$, respectively.

These parameters form the collection of updated arc weights of the network. If $wei_{ab} = 0$, then the arc ab does not exist. If wei_{ab} is low, it indicates that the associated arc is utilised by only a small number of origin-destination pairs.

If wei_{ab} is high, it indicates that the associated arc is present in a large number of origin-destination pair pathways. Every node in the network has an indegree deg_k^{in}, which is the number of arcs entering the node, and an outdegree deg_k^{out}, which is the number of arcs departing the node k.

$$deg_k^{in} = \sum_{i:ik \in Net'} wei_{ik}$$

$$deg_k^{out} = \sum_{i:ki \in Net'} wei_{ki}$$

Nodes with a low weighted out degree might be seen as possible leaf nodes of the tree. Nodes with a high weighted out degree might be regarded as possible core nodes of the tree.

1.5 Predictive perimeter recovery algorithm

In the planarized network graph, when greedy forwarding fails, it employs a defect testing phase combined with a perimeter forwarding phase. Table 1 displays the packet header fields used in the proposed LRDF-RP for perimeter-mode forwarding.

Table 1: Description of the notation

Notation	description
x	Source node
Des_loc	Destination location
loc_peri	Location Packet Entered Perimeter Mode
loc_face	Point on yR Packet Entered Current Face
$edge$	First Edge Traversed on Current Face
pac_mode	Packet Mode: Greedy or Perimeter

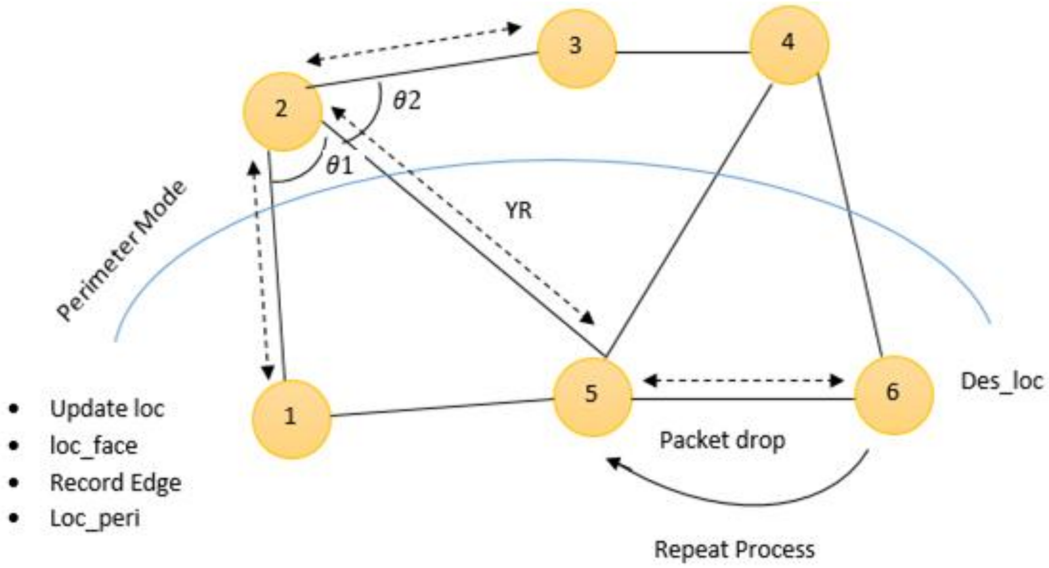

Figure 2: Illustration of Perimeter Recovery Forwarding

Initially, the line is extended from the point x to all adjacent points found in the planarized database. Secondly, the angle is determined by measuring the angle between the positive x-axis, with node x as the source, and the lines estimated towards all the neighboring nodes. The neighbour selected is the one that forms the smallest angle, in the anticlockwise direction, with the positive axis, relative to node x. LRDF-RP routes the packet over consecutive faces of the planar graph, with each face intersected by the line yR. For each face, the traversal use the right-hand rule to locate an edge that intersects with the yR line. At that boundary, the traversal transitions to the neighbouring face intersected by yR. Upon entering perimeter mode, LRDF-RP logs the location loc and the site where greedy forwarding was unsuccessful in the packet. This location is utilised in following hops to ascertain if the packet may be reverted to greedy mode. LRDF-RP tracks the common point on yR between the previous and new faces when sending a packet to a new face. The initial edge that a packet crosses on a new face is now documented in LRDF-RP. Before sending a perimeter-mode packet, LRDF-RP checks its loc_peri to the forwarding nodes. LRDF-RP shifts to greedy mode and returns a packet if the forwarding node or its original table neighbours are closer to loc_peri than Des_loc.

The only purpose of perimeter forwarding is to recover from a local minimum; if the packet reaches a position closer to the point where greedy forwarding failed for that packet in the past, it may restart greedy progress toward its destination. There are two possibilities to consider: either the graph connects x and Des_loc, or it does not. When the graph connects x and Des_loc, moving counterclockwise around the face next to x must result in a point y where yR crosses the other side of the face and arrives at Des_loc. When Des_loc cannot be reached, LRDF-RP detects that the packet's edge $edge$ is being sent repeatedly and appropriately dumps the packet since the destination cannot be reached.

PERFORMANCE ANALYSIS

The experimental demonstration of the proposed LRDF-RP is carried out and as well it is compared with the earlier methods like EAPRAD [13], RA-HEMB [14] and ALPS [16]. The simulation is conducted using the NS2 platform, including the SUMO mobility generator. The performance study focuses on many characteristics, namely energy efficiency, throughput, packet delivery ratio, collision ratio and end-to-end delay. The simulations were conducted using the settings specified in Table 2.

Table 2: Parameter Settings

Parameters	Values
Road length	20 km
Number of vehicles/nodes	10-100
Number of lanes	4
Vehicle speed	60 mph
Transmission range	200 m
Message size	238 bytes
Data rate	5Mbits/sec

Performance Metrics:

- Energy consumption: In this context, the total energy of all hops is measured, and the calculation for this is as follows,

$$Energy = \frac{1}{p}\sum_{n}^{p} E_n$$

Where, p is the number of hops and E_n is the energy of the n^{th} hop.

- Throughput: Data rate is the term used to describe the flow of data over a communication connection. Throughput is a crucial metric in a WSN setting, particularly when nodes are in motion without any concurrent traffic.

Throughput (bits/sec) = $\sum \frac{\text{(number of successful packets)} * \text{(average packet size)}}{\text{Total Time sent in delivering that amount of data}}$

- Packet delivery ratio: The percentage of packets that successfully get it from the source node to the destination node in the network.

$$PDR = \frac{numberofpacketreceivedsuccesfully}{Totalnumberofpacketsforwarded}$$

- Collision ratio: The number of packets that have collisions while traversing a network before reaching their intended destination

- End-to-End delay: The time duration that it takes for a communication to travel from its source point to its destination inside a network is referred to as the delay.

$$Delay = \frac{p}{tn}$$

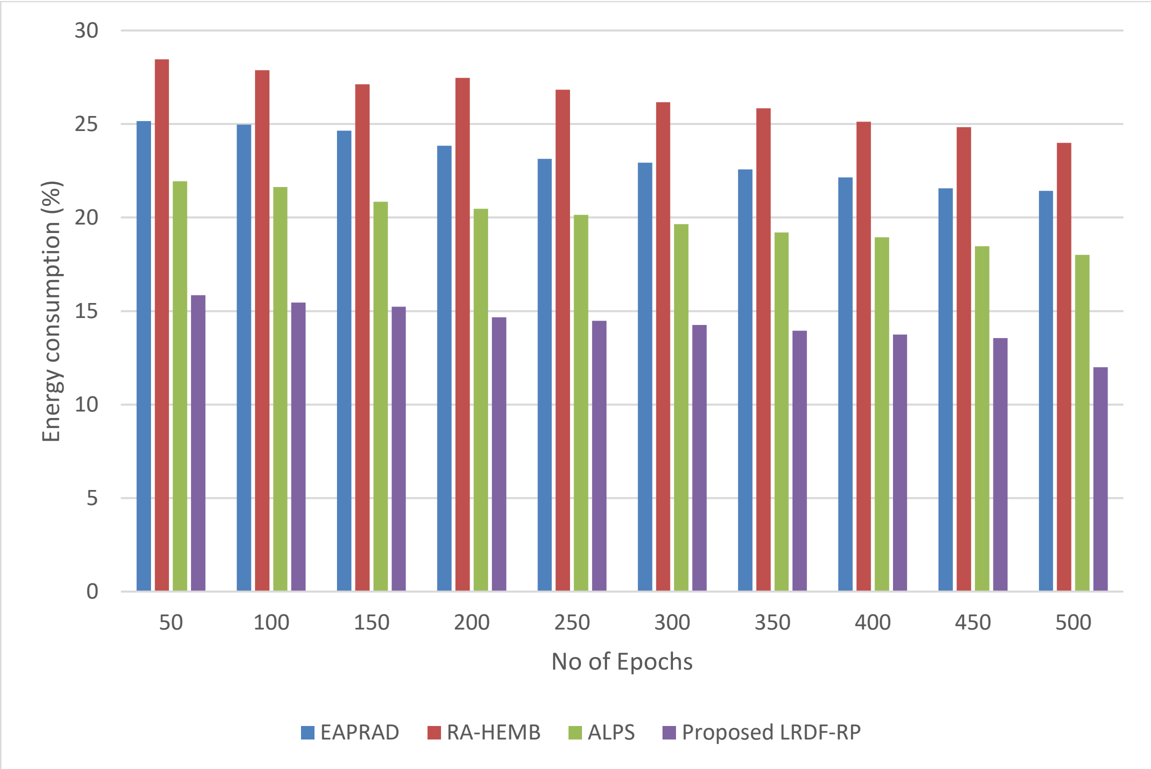

Figure 3: Calculation of Energy consumption

The figure 3 shows the performance of energy consumption. The data shows energy consumption over 500 epochs for four methods: EAPRAD (21.42 units), RA-HEMB (24 units), ALPS (18 units), and Proposed LRDF-RP (12 units). The Proposed LRDF-RP method is the most energy-efficient, consuming the least energy, followed by ALPS. RA-HEMB is the least efficient, with the highest energy consumption. This suggests that in scenarios where minimizing energy usage is crucial, the Proposed LRDF-RP method is highly advantageous.

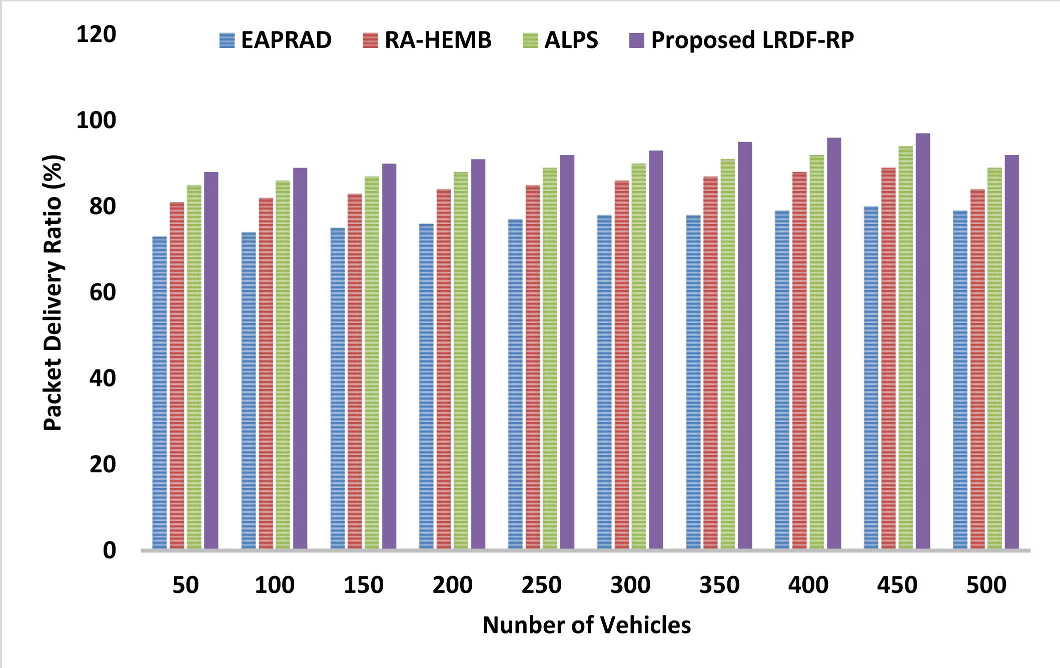

Figure 4: Calculation of Packet Delivery Ratio

The figure 4 displays the packet delivery ratio. The **LRDF-RP** method that has been developed obtains the greatest delivery ratio, which is 92%. This indicates that it is more reliable in terms of providing data when compared to **EAPRAD**, which have a delivery ratio of 79%, **RA-HEMB**, which have an 84% and **ALPS** of 89%. This shows the efficient packet delivery ratio.

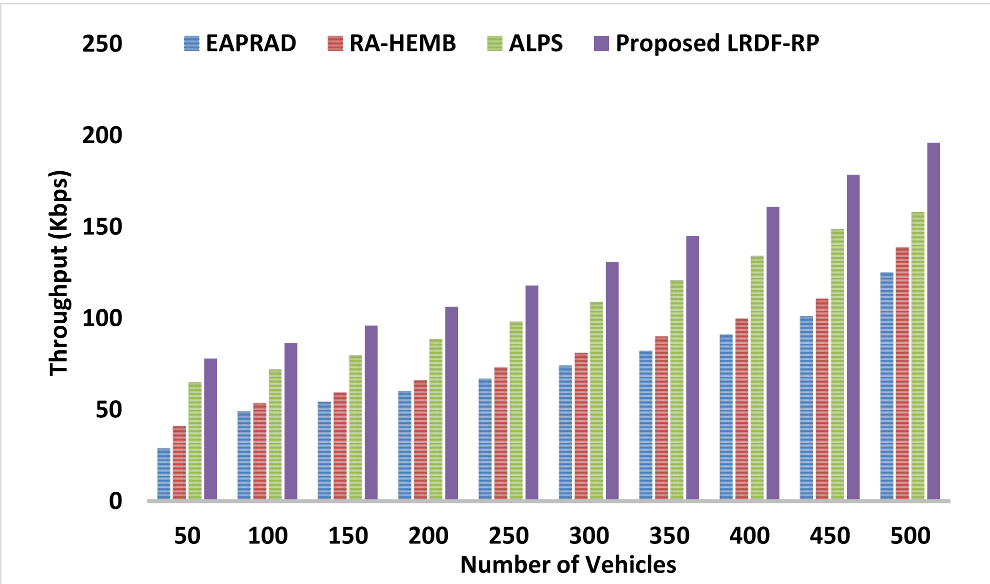

Figure 5: Analysis of Throughput

The figure 5 displays the analysis of throughput. The proposed LRDF-RP, as designed, achieves the greatest throughput of 196 kbps, surpassing the data transmission speeds of EAPRAD at 125 kbps, RA-HAMB at 139 kbps, and ALPS at 158 kbps. This shows the efficient data transmission in the system.

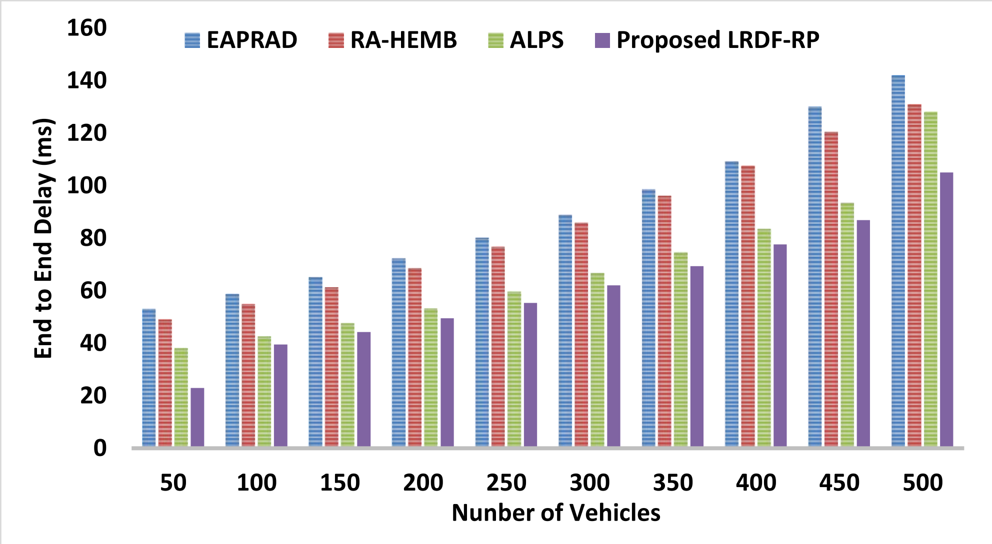

Figure 6: Analysis of end to end Delay

Figure 6 displays the analysis of end to end delay metrics. In comparison to existing method EAPRAD at 142 ms, RA-HEMB at 131 ms, and ALPS at 128 ms, the proposed LRDF-RP has the lowest end to end delay, which is 105 ms. This indicates that the communication mechanism is more efficient.

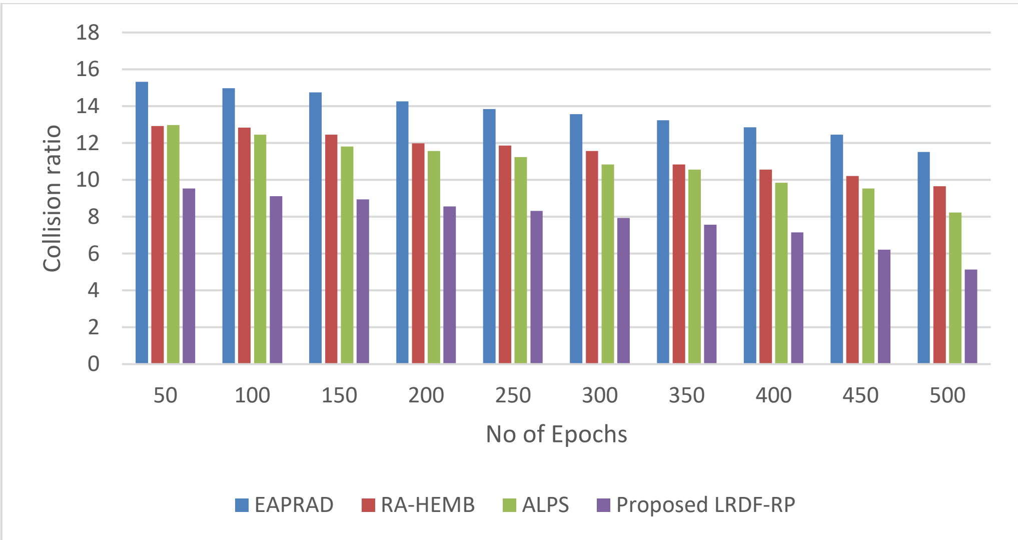

Figure 7: Analysis of Collision Ratio

The figures 7 shows the performance of collision ratio for the proposed LRDF-RP with the existing method EAPRAD, RA-HEMB, and ALPS. The Proposed LRDF-RP model demonstrates superior performance with the lowest error rate of 5.14, significantly outperforming the other models: ALPS of 8.23, RA-HEMB of 9.65, and EAPRAD of 11.52. Table 3 indicates that LRDF-RP is the most accurate and effective model among the four, showcasing its robustness and reliability.

Table 3: Performance Comparison

Parameters	**EAPRAD**	**RA-HEMB**	**ALPS**	**Proposed LRDF-RP**
Energy consumption (Joules)	21%	24%	18%	12%
Throughput (kbps)	125	139	158	196
Packet delivery ratio (%)	79	84	89	92
Collision ratio (%)	11.52	9.65	8.23	5.14
end-to-end delay(ms)	196.28	173.28	148.19	126.19

CONCLUSION

This study proposes a Link Reliability Data Forwarding Routing Protocol (LRDF-RP) to address the issue of frequent disconnections and improve route selection based on mobility prediction in VANET. The primary goal of this study is to enhance the efficiency of the network prior to enabling communication. The steps covered in this system are network development, estimate of vehicle link's quality. The connection between the nodes is formed by transmitting the RLRQ and RLRP signals. During the RLRP, two algorithms, namely Prim's Greedy Forwarding Algorithm (PGFA) and Predictive Perimeter Recovery Algorithm (PPRA), facilitate the accurate reception of packets at the destination. Therefore, the characteristics including delivery ratio, delay, throughput, and energy consumption are computed. These variables are used to establish communication, which lowers the frequency of disconnection and packet loss during data transfer. Additionally, when its results are contrasted with those of a few other established protocols, the proposed method is shown to be effective in producing the intended and promised results. Moreover, it can enhance dependability and reduce the occurrence of undesirable and unreliable routes between the source and destination. In the future, we have made the decision to implement the notion of machine learning in order to enhance the overall performance.

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