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# An Intelligent Transport System in VANET using Diffusion Model Integrated Zone Partitioning System

[1]Dr. Mary Jacob, [2]Dr. Gopika. S, [3]Kurian George Cheripurathu

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**Abstract:** With the significant rise in the number of vehicles on the road, the Vehicular Ad-Hoc Network (VANET) is turned into one of the most important study areas. Numerous VANET applications are used to enhance traffic flow, vehicle security, emergency alerts to drivers, accident avoidance, and other comfort-related, non-safety application. By adopting smart transport systems, the major goal of these applications is to modernise many operations related to road traffic, vehicles, drivers, passengers, and pedestrians. The goal of this project is to develop an intelligent vehicular transport system that will increase comfort, road safety, and navigation. A data diffusion model is proposed to transmit emergency messages based on critical zone partitioning for intelligent transport system in Vehicular Ad-Hoc Networks (VANETs). This research illustrates the broadcasting technique of the proposed system. To analyze the proposed system performance a Data diffusion model is created. Partitioning the urgent zone and transmitting emergency messages based on priority are discussed. The objective of this research work is to improve the Packet Delivery Ratio, Throughput, Routing Control Overhead, Packet Loss Ratio and Average One-hop Delay metrics. The system model for the proposed Diffusion Model Integrated Zone Partitioning (DMIZP) technique, the experimental result analysis determines the efficiency of the proposed approach.

***Keyword:*** *Routing, zone partitioning, VANET, diffusion method, quality, energy, and data transmission.*

## 1. Introduction

The Vehicular Ad Hoc Networks (VANETs) is a special kind of Mobile Ad Hoc Network (MANET), where the fast-moving vehicles act as nodes and communication link between them is the edge connecting the nodes. VANET is an important component of Intelligent Transport System (ITS). The vehicles in VANETs possess the characteristic features of restricted vehicle-based mobility pattern such as course of road and regulations of traffic [1]. These striking features of VANET result in its high mobility rate of vehicles and frequent topology changes of the network. The principal objective of VANET lies in its suitability and applicability contributed towards the facilitation of comfort and safety to the vehicle drivers on the road [2, 3].

Since the 1980s, academics have been captivated by the idea of using wireless communication in cars. In recent years, we've seen a significant surge in investigation and advances in the field. Several factors have contributed to this advancement, including widespread adoption of IEEE 802.11 technology solutions and subsequent cost reductions; vehicle manufacturers' adoption of information systems to address security, ecologic, and comfort issues; and large regional and national governments' commitment to assign radio spectrum for vehicle wireless communication [4]. Although cellular networks provide drivers and passengers with comfortable voice communication and basic information, they are not well-suited for some straight vehicular or automotive connections. Vehicular Ad Hoc Networks (VANETs), that offer direct connection between automobiles and to / from Road Side Units (RSUs), can transmit and receive hazard alerts or data on the current traffic situation with little delay [5]. VANET featuring inter-vehicle, vehicle to roadside, and inter-roadside communication are depicted in Figure 1.

*1,2,3Assistant Professor, Department of Computer Science, Kristu Jayanti College, Bengaluru*

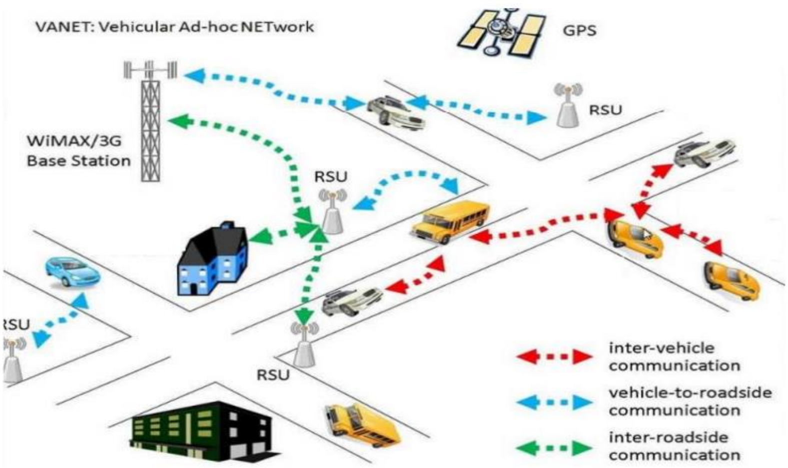


Figure 1. Vehicular Ad Hoc-networks with intervehicle, vehicle to roadside and inter roadside communication

Mobile systems must function in more unrestricted and dynamic surroundings as they become more widely utilized and omnipresent in various aspects of our life. Vehicular Ad Hoc Networks (VANETs) are one example of this, where applications must be used amid the chaotic and constantly changing circumstances of road traffic [6]. The focus is on distributed systems for VANETs wherein data is created and utilized in-network and where the application's outputs are time-critical and must be kept exact, even when the input data changes rapidly and unexpectedly. In this research, a detailed overview of VANET, its application, and problems are covered. This research also covers platoons, security risks, allocation of resources, trust management strategies, and VANET optimization techniques [7].

In this research, data diffusion model is proposed to transmit emergency messages based on critical zone partitioning for intelligent transport system in Vehicular Ad-Hoc Networks (VANETs). This research illustrates the broadcasting technique of the proposed system. To analyze the proposed system performance a Data diffusion model is created. Partitioning the urgent zone and transmitting emergency messages based on priority are discussed [8]. The objective of this research work is to improve the Packet Delivery Ratio, Throughput, Routing Control Overhead, Packet Loss Ratio and Average One-hop Delay metrics. The system model for the proposed Diffusion Model Integrated Zone Partitioning (DMIZP) technique, the experimental result analysis to determine the efficiency of the proposed approach is discussed in the following sections of this research [9].

## 2. Related Works

A. BENGAG et al. (2020) presented two novel methods for improving the traditional GPSR protocol by reducing the interlocking problem and establishing a dependable way that will increase PDR and efficiency and reduce routing overhead. Two routing techniques are suggested A new hop node is directly chosen by E-GPSR and DVAGPSR based on location as well as other important characteristics of participating nodes. By modifying the number of cars in a real-world urban setting, the E-GPSR and DVA-GPSR protocols demonstrate that they are superior GPSR in terms of PDR, throughput, and overhead routing [10].

Suchi Johari et al. (2020) Discussion of novel TDMA MAC VANET protocols that facilitate vehicle organisation, communication, and message impact reduction. Linkages, accidents, and an unbalanced network load are all caused by the movement of vehicles and the density of traffic. Technology for dynamic time slot synchronisation, bandwidth control, message prioritisation, and frequency management In VANETs, MAC protocols provide secure message transmission, low message collision rates, and the avoidance of risks. TDMA and MAC protocols are categorised in this study as distributed, hybrid, and centralised protocols. There includes a thorough analysis of a variety of consequences, including 2-way traffic loads, multi-channel utilisation, and access problems. The operation procedure and efficiency characteristics are also described by TDMA MAC protocols [11].

M. A. Karabulut et al. (2020) When there is a lot of traffic and high data rates are needed, CSMA/CA experiences a collision. Orthogonal Frequency Division Multiple Access (OFDMA) is consequently suggested. The use of OFDMA improves performance and reduces delay by lowering the possibility of a serious traffic accident. This paper proposes an innovative OFDMA-based Efficient Cooperative MAC (OEC-MAC) protocol for VANETs. There are options for assigning sub-carrier channels and for gaining access. Mechanism is used to pick the best relay in addition to the proper transmission mode. There are defined new control messages to promote cooperative communication. Analysis based on the Markov Chain Model evaluates the effectiveness of the OEC-MAC protocol. According to several findings, the OEC-MAC protocol guarantees appreciable output gains and complies with the rigorous 100 ms VANET safety message delay requirement (sm). Additionally, by lowering PDR, contact effectiveness is increased. With current protocols, numerical results are quantitatively compared. Results from the proposed OEC-MAC protocol have been demonstrated to be superior to those of the current protocol, particularly in heavy traffic areas [12].

S. Kumar and H. Kim (2020) Time Division Multiple Access (TDMA) Multi-Channel MAC was recommended by VeMAC. VeMAC struggles because to overhead, excessive entry collision, and sluggish collision detection. As a result, in this study, we propose a brand-new MAC protocol called Hybrid for VANET Bitmap-MAC (BH-MAC). By employing a fixed-size bitmap, BH-MAC can describe slot state with fewer overhead packets. It makes advantage of the CSMA technique for TDMA slot reservations to lessen access collisions. New transmission error intrusion detection is also used by BH-MAC. It imitates the BH-MAC protocol in NS3. According to the results, the BH-MAC outperforms VeMAC in terms of throughput, channel access speed, and access collision reduction [13].

J. M. Lim et al. (2020) The present VANET schemes lack flexibility and employ static parameters in the dynamic VANET architecture. Due to the frequent disruptions and quick changes in topology in VANET, cognitive and adaptive MAC scheduling VANET MAC is used since it enables it to update the transmission parameters and can accommodate different topology modifications. The SINR (Signal to Noise & Interference Ratio) is suggested to alter by the Adaptive VANET MAC (AdMAC), which was intended to display the VANET transmission environment and traffic density. SINR tweak to increase the VANET MAC's confinement window size. An metropolitan map of Kuala Lumpur, Malaysia, is used to simulate both crowded and uncongested traffic. Findings demonstrate better adaptability in product performance rate and medium periods in the proposed AdMAC [14].

## 3. Proposed Methodology

In Vehicle Ad hoc Networks (VANETs), the dissemination of time-sensitive information, such as traffic warning messages, is crucial and difficult. It is important because the lives of those who use the roads are at risk, and it is difficult because of a mix of highly dynamic mobility patterns, which lead to quickly changing network topologies, combined with the quick movement of cars and highly dynamic traffic patterns. Applying a diffusion model to alert messages makes it possible to predict how alarm signals are disseminated across cars, providing a chance to adopt the best techniques for recovering from accidents. As a result, a data diffusion model is created for a warning message based on floods. The data diffusion model issues such as real time safety, urgent messages causing drastic accidents are because of the delayed urgent message. This delay can be minimized based on the emergency factor, the messages are labelled and the emergency messages are distributed to the nearby vehicles in VANETs. Based on the accident zone, the roads are partitioned into three zones namely Red Orange Yellow (ROY).

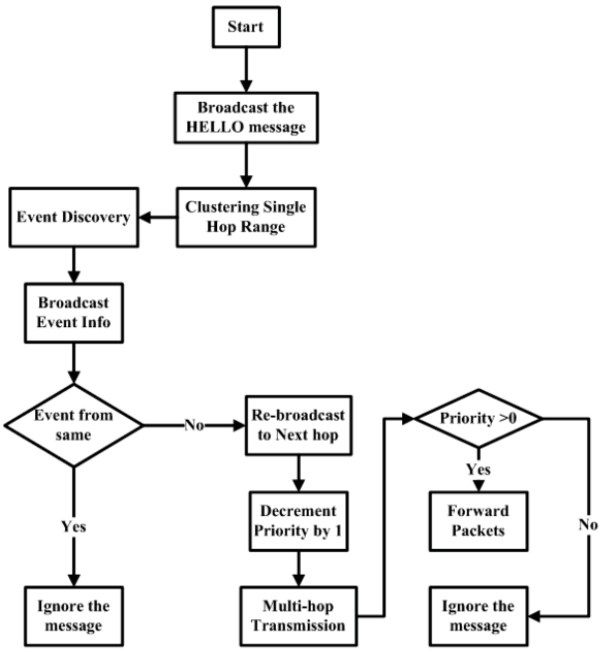


Figure 2. Flowchart of Proposed Methodology

The workflow consists of a basic model, which describes the interaction between the source and destination points to distribute emergency messages. A novel model proposed to the dissemination of emergency messages to the nearby vehicles to handle the dynamic traffic situations. At first, the HELLO message is broadcasted all the vehicles in the network to check connection of the other devices. Then, the clustering is performed to the devices within the single hop range. Rebroadcasting is carried out into the next hop and the event information is validated based on priority level. When the event is discovered from the same location then the message is ignored otherwise the information is broadcasted to the next hop. Later, multi-hop transmission is initiated, the priority is assessed and if the priority is high then the packets are forwarded else the message is ignored. Priority level validation and message forwarding is performed in the minimum time.

*Basis Network Model*

The data dissemination model for VANETs is proposed to broadcast emergency messages to the vehicles in the Road Side Units (RSU). The RSU assists in content distribution by utilizing the On-Board Units (OBUs). Each vehicle is equipped with an OBU, which detects road traffic accidents and then broadcasts emergency messages to nearby vehicles. All the vehicles in this architecture can share the data to the other vehicles and RSU. A set of vehicles communicate with the help of roadside infrastructure through wireless communication. The input to this wireless communication is vehicles. The initial zone is updated and the tme period is varied for each vehicle communication. The parameters considered for developing the mobility model are velocity, acceleration and speed. In this study, mobility model is considered as macro model and it operates on the average speed for all the vehicles. The alter message distribution is based on the transmission range. It is assumed that each vehicle has the ability to communicate with each other either directly or indirectly.

*Emergency Message on ROY Zone*

The event of road traffic accidents or intersection points initiates an emergency message. With the help of these messages, the road is partitioned into ROY zone. The value of alert message is high for R zone vehicles since its close to the accident region. The value of alert message is medium in O zone vehicles and the value of alert message is least in Y zone since it is outside the urgent zone. Due to the mobility of vehicles and dynamic traffic the vehicles is labelled based on ROY model. The zone length is dynamic since it depends on the type of message, traffic density and the speed of the vehicle. . In the ROY model, the vehicles such as B, C and D are in the R zone, the vehicles E, F, G and H are in the O zone and the vehicles J and I are in the Y zone. The vehicle B forwards an emergency message to C and D vehicles, then vehicle D forwards to the nearest vehicle E, which then forwards to F, G and H. Let A represent the vehicle and the ROY model of A vehicle is represented as $A_{ROY}$. After the zones are separated, the diffusion model is created with message value and priority is assigned.

$$A_R = (B, C, D)$$

$$A_O = (E, F, G, H)$$

$$A_Y = (I, J)$$

The urgent zone partitioning model for E vehicle, the model $E_{ROY}$ is created as

$$E_R=(F, G, H, I)$$

$$E_O=(J, K)$$

$$E_Y=(L, M)$$

The Generalised Bass Model and the data diffusion model are comparable. The Generalised Bass model describes the interplay between adopted users and potential users as the process through which new items are accepted by consumers. The Generalised Bass model is not directly relevant to VANETs because it is a business model. It is used into the Generalised Bass model to explain how alert messages spread among VANETs. Due to the similarities between the two models, the data diffusion process in the proposed DMIZP approach is the same as the buy process in the Generalised Bass Model.

It is referred to as alert dispersion when a change notification is conveyed among the cars. The idea of innovators and imitators is another significant connection between the Bass model and the distribution of alarm messages. The innovators in the proposed DMIZP approach are the first cars to get alert messages of an accident, and the imitators are the vehicles that receive alert messages from innovator vehicles. The distribution of alert messages will be impacted by the mobility model of the vehicles.

The importance of the alert message determines its value. Time and distance to the accident scene have an impact on how important the alarm message is. The significance of the alarm message is diminished as time passes or as the distance increases. The diffusion model with message value decreasing with time may be created utilising the diffusion function as indicated in Eqn 1 by applying the same methodology as the Generalised Bass Model in the suggested strategy.

$$\frac{f(t)}{1-F(t)} = [p + qF(t)]x(t)$$

Where f(t) is the density function of the random variable t, t is the time to first dissemination of the alert message, F(t) is the cumulative distribution function, p and q are the diffusion parameters and x(t) is the current value of the alert message.

Based on the Generalized Bass model, the value of the alert message is specified as in the Eqn 2.

$$x(t) = 1 + \beta \frac{V\prime(t)}{V(t)}$$

where V (t) is value at time t and V'(t) is the change in value at time t. We define

$$V(t) = V(0)(1-\tau)^{\,t}$$

$$V'^{(t)} = V(0)(1-\tau)^{\,t} In(1-\tau)$$

where τ is the percentage of value deduction per time units. Therefore, The Eqn. (2) is modified as shown below:

$$x(t) = 1 + \beta * In(1-\tau)$$

where β as the diffusion value parameter and it reflects the effect of value in accelerating and decelerating the diffusion process. β is a constant number which is determined as a system parameter.

Based on the Generalized Bass model, Eqn. (1) can be solved by using boundary condition F(0) = 0, the cumulative distribution function is calculated as shown in Eqn. (3).

$$F(t) = \frac{1 - e^{-(x(t)-X(0))(p+q)}}{1 + \frac{q}{p} e^{-(p+q)(X(t)-X(0))}}$$

where, X(t) is referred to as the cumulative value of the alert message and Eqn. (2) can be reformed as given below:

$$X(t) = t(1 + \beta In(1-\tau))$$

The proposed data diffusion model consists of a closed system with total count of N vehicles. First, one vehicle receives the alert message and the remaining N-1 vehicles are not aware of the alert message. Through event discovery model, the remaining N-1 vehicles will receive the alert message. The probability of staying and shifting the state is estimated. Finally, based on the calculation of the value for the alert message from Eqn. (4). the alter message can be broadcasted to the ROY zones.

**Vehicle Management Strategies for Restoring a Connection**

Vehicle management strategies are employed to restore the connection under the maximization of the platoon sizes by merging the two consecutive platoons. The platoons in out of coverage are merged with help of the deployed RSU or opposite vehicles with the intention of driver. It is considered that the two platoons $p_r$ and $p_{r-1}$ which are in out of the range as shown in the Figure 3.4. This disconnected vehicular network (platoon) restores its connection either using an RSU or an opposite vehicle. This proposed model is called Roadside and Opposite vehicle Assist Platoon (ROAP). Information about preceding platoon is received by the leader vehicle of the successive platoon through RSU or opposite vehicle as explained in the following two cases.

Case i): RSU Assisting

Consider the Leader vehicle $C_r^1$ of successive platoon approaches an RSU at the time period of $t_{TA}$. The vehicle receives information of preceding platoon from an RSU. Using velocity $v_{r-1}^{q-1}$ and time of leaving ($t_{TL}$)information of the tail vehicle in preceding platoon, inter-platoon spacing ($I_r$) has been calculated as in Equation 5.

$$I_r = \int_{t_{TL}}^{t_{TA}} v_{r-1}^{q-1}\, dt$$

Case ii) Opposite vehicle Assisting

The opposite vehicle is having high relative velocity with tail vehicle of platoon. Due to high relative velocity, the message transmissions suffer from the Doppler Shift effects. The standard IEEE 802.11p is used for vehicular communication. It operates at the carrier frequency 5.9 GHz with data rate from 6 to 27 Mbps. The effects of Doppler shifts have been analyzed. The Doppler shift ($F_d$) is defined as in Equation 6.

$$F_d = \frac{\Delta_v cos\Theta}{c} F_c$$

Received signal frequency ($F_r$) is given in Equation 7

$$F_r = F_c + \frac{\Delta_v cos\Theta}{c} F_c$$

$\Delta_v$=$V_t$+$V_w$ is the relative speed between the tail vehicle and opposite vehicle. $F_c$ is the carrier frequency. Θis the angle between the moving direction of an opposite vehicle to the direction of a tail in the opposite lane with respect to that opposite vehicle.

If Θ varies from 0° to 90°, then the opposite vehicle is moving towards the tail vehicle. Then the received frequency is greater than the carrier frequency. If Θ varies from 90° to 180°, then the opposite vehicle is moving away from the tail vehicle. The channel is significantly changing during the time period $T_c$ due to the Doppler shift. This time period is called Coherence Time period ($T_c$). In other words, it is defined that the time period at which channel is approximately constant. Then, the channel is characterized with coherence time ($T_c$) as in Equation 8.

$$T_c = \frac{1}{4F_d}$$

The shift is significantly less for higher values of angle Θ. It is observed that coherence time is low for higher values of Doppler shift at relative speed ranges from 50 Km to 200 Km. The coherence time decreases at higher relative speeds. It implies that the channel is frequently changed at higher relative speeds. The lowest coherence time 0.23 ms is observed at an angle of 0°. This is the worst condition of the channel instability. It supports the data rate of 6 to 27 Mbps. Then, the one-bit duration time is varied from 37 ns to 166 ns. The number of bits supported in the worst condition of channel stability for the bit duration 37 ns is 6.21 Kbps and for the bit duration 166 ns is 1.34 Kbps. This data rate is more sufficient for transmitting short messages like emergency messages, beacons, speed, and position related information etc. Even at high relative speeds, the data transfer is possible from an ongoing vehicle to an opposite vehicle.

Consider the Leader vehicle $C_r^1$ approaches the opposite vehicle at time period $t_{TA}$. Leader vehicle receives information about velocity $v_{r-1}^{q-1}$and time of leaving ($t_{TL}$) of the tail vehicle $c_{r-1}^{qr-1}$of preceding platoon. Then, Inter-platoon spacing ($I_r$) is calculated as in Equation 9.

$$I_r = \int_{t_{TL}}^{t_{TA}} v_{r-1}^{q-1} dt + \int_{t_{TL}}^{t_{TA}} v_w dt$$

If inter platoon spacing is less than threshold spacing ($I_r$<$l_{th}$) then the merging of two platoons is proceeded with driver's behavioral constant Kb. The driver's behavioral constant Kb is based on the intention of the driver to take part in the merging of platoon. Further, the analysis of driver's behavior is left as future study. In this approach, its value is assigned in between 0 (low intention) to 1 (high intention).

For merging two platoons, the error distance to be covered with velocity change $v_{HIGH}$ by the leader vehicle of succeeding platoon from the stable velocity $v_{std}$. This error distance ($\varepsilon_r$) is described as in Equation 10.

$$\varepsilon_r = I_r - R$$

## 4. Result and Discussion

The experiments have been, executed on Intel (R) Core i7 -2670, frequency: 2.20 GHz, RAM: 8GB and the operating system is Microsoft Windows 7. The network scenario is modelled and investigated using NS 2.34 network simulator tool. The proposed methodology is compared with existing techniques in terms of Average One-hop Delay, Routing Control Overhead Packet Delivery Ratio, Packet Loss Ratio, and Throughput.

Packet Delivery Ratio

Packet Delivery Ratio is a ratio between the total numbers of packets transmitted to the total number of packets delivered successfully which increases with the Simulation Time. Table 2 shows the comparative study of the Packet Delivery Ratio by varying the Simulation Time in the existing BPAB and UMBP techniques and the proposed DMIZP technique.

Table 2. Packet Delivery Ratio and Simulation Time

| Node | E-GPSR | DVAGPSR | OEC-MAC | DMIZP |
|---|---|---|---|---|
| 100 | 74 | 79 | 83 | 91 |
| 150 | 76 | 84 | 82 | 92 |
| 200 | 79 | 85 | 85 | 92.87 |
| 250 | 80 | 88 | 88 | 93 |
| 300 | 83 | 89 | 91 | 94 |

Figure 3. Packet Delivery Ratio and Simulation Time

Throughput

Throughput is the total number of packets sent to the destination in a particular period. Table 3 demonstrates the comparison of the existing BPAB and UMBP techniques and the proposed DMIZP technique for the performance metrics Throughput by varying the Simulation Time.

Table 3 Throughput (Bytes per Second ) and Simulation Time

| Node | E-GPSR | DVAGPSR | OEC-MAC | DMIZP |
|---|---|---|---|---|
| 100 | 0.68 | 0.871 | 0.766 | 0.93 |
| 150 | 0.69 | 0.851 | 0.769 | 0.955 |
| 200 | 0.694 | 0.875 | 0.774 | 0.96 |
| 250 | 0.7 | 0.876 | 0.791 | 0.99 |
| 300 | 0.72 | 0.891 | 0.812 | 1.23 |

Figure 4. Throughput (Bytes per Second ) and Simulation Time

Packet Loss Ratio

The ratio is calculated on the base of the number of missing data packets to the total number of sent data packets is known as Packet Loss Ratio. Table 4 illustrates the comparative study of the existing BPAB and UMBP Technique and the proposed DMIZP technique for the performance metrics Packet Loss Ratio by varying One-hop Distance. Fig. 5 shows the percentage of Packet Loss Ratio by varying the One-hop Distance for the existing BPAB and UMBP techniques and the proposed DMIZP technique. The percentage of packet loss ratio is minimum in UMBP compared to BPAB technique.

Table 4. Comparison of Packet Loss Ratio

| Node | E-GPSR | DVAGPSR | OEC-MAC | DMIZP |
|---|---|---|---|---|
| 100 | 41 | 26 | 31 | 19 |
| 150 | 48 | 28 | 32 | 21 |
| 200 | 44 | 41 | 33 | 25 |
| 250 | 46 | 44 | 36 | 27 |
| 300 | 47 | 46 | 38 | 29 |

Figure 5. Comparison of Packet Loss Ratio

Average One-hop Delay

The time taken during emergency message transmission to single-hop neighbours is One-hop Delay. A hop happens when each packet is passed to the next device in the network. The average One-hop Delay is assessed during the transmission of emergency messages between source and destination. Table 6 illustrates the relative study of the existing BPAB and UMBP Technique and the proposed DMIZP technique for metrics Average One-hop Delay by varying the vehicle density.

Table 5 Average One-hop Delay and Vehicle Density

| Node | E-GPSR | DVAGPSR | OEC-MAC | DMIZP |
|---|---|---|---|---|
| 100 | 7.765 | 5.765 | 5.675 | 3.71 |
| 150 | 7.561 | 5.561 | 5.459 | 3.53 |
| 200 | 6.541 | 5.541 | 4.409 | 2.53 |
| 250 | 6.597 | 5.597 | 4.296 | 1.45 |
| 300 | 7.162 | 5.981 | 4.711 | 1.67 |

Figure 6. Average One-hop Delay and Vehicle Density

## 5. Conclusion

In this paper, the proposed DMIZP technique is applied to resolve the issues in broadcasting of emergency messages to the vehicles in the ROY zone. The concept of this Data diffusion model are based clustering the neighbourhood nodes based on ROY zones and transfer emergency messages to the vehicles in the ROY zone. The novelty of the proposed DMIZP method can be considered on the Bass model parameters are mapped to the proposed DMIZP approach. The value of the alert message depends on the distance of the relay vehicles. The experimental results proved that the Proposed DMIZP approach outperforms the other existing methods.

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