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An Effective Data Dissemination Using Multi Objective Congestion Metric Based Artificial Ecosystem Optimization for Vehicular Ad-Hoc Network

Nagaraj B. Patil
Government Engineering College, Gangavathi-583227, India
E-mail: nagarajbpatil@gmail.com

Shaeista Begum*
Government Engineering College, Raichur-584135, India
E-mail: shaeista.begum@gmail.com
*Corresponding author

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Abstract: Vehicular Ad-hoc Network (VANET) is a growing technology that utilizes moving vehicles as mobile nodes for exchanging essential information between users. Unlike the conventional radio frequency based VANET, the Visible Light Communication (VLC) is used in the VANET to improve the throughput. However, the road safety is considered as a significant issue for users of VANET. Therefore, congestion-aware routing is required to be developed for enhancing road safety, because it creates a collision between the vehicles that causes packet loss. In this paper, the Multi Objective Congestion Metric based Artificial Ecosystem Optimization (MOCMAEO) is proposed to enhance road safety. The MOCMAEO is used along with the Ad hoc On-Demand Distance Vector (AODV) routing protocol for generating the optimal routing path between the source node to the Road Side Unit (RSU). Specifically, the performance of the MOCMAEO is improved using the multi-objective fitness functions such as congestion metric, residual energy, distance, and some hops. The performance of the MOCMAEO is analyzed by means of Packet Delivery Ratio (PDR), throughput, delay, and Normalized Routing Load (NRL). The PSO based geocast routing protocols such as LARgeoOPT, DREAMgeoOPT, and ZRPgeoOPT are used to evaluate the performance of the MOCMAEO method. The PDR of the MOCMAEO method is 99.92 % for 80 nodes, which is high when compared to the existing methods.

Index Terms: Ad-Hoc On-Demand Distance Vector Routing Protocol, Multi Objective Congestion Metric based Artificial Ecosystem Optimization, Packet Delivery Ratio, Vehicular Ad-Hoc Network, Visible Light Communication.

1. Introduction

Nowadays, the usage of vehicles is enormously increasing worldwide. So, there is a huge requirement in the safety applications to solve the accident and traffic problems over the road transportation [1]. VANET is a developing field designed to improve the safety of the road and to support smart road transport based on effective traffic flow management and elimination of congestions and accidents [2,3]. In VANET, the vehicles are operated as autonomous mobile nodes which are linked in the wireless environment. However, these nodes don't present in an identical range and broadcast over the many intermediate nodes [4,5]. Generally, the VANET is dealt with various advantages which broadcast updated traffic related information such as road congestion, crossroads, and accident warnings to the driver and passengers [6]. The communication among the vehicles are happened in peer to peer manner or by acquiring support from the existing RSUs of VANET. The general type of communication is named Vehicle to Vehicle (V2V) communication whereas the other one is Vehicle to Infrastructure (V2I) communication [7,8]. Generally, the VANET uses both the radio spectrum and VLC for transmitting the essential information from one vehicle to another vehicle. Since, the RF has some drawbacks such as high latency, high unreliability, less attenuation and less bandwidth. But, the VLC is used to obtain reliable communication between the vehicles as well as used to improve the data rate [9].

The best wireless standard for vehicular networks namely WAVE is used to perform the communication of V2V and V2I [10]. Therefore, the VANET transmits the information of the traffic that is used to enhance traffic safety and traffic efficiency. But, the vehicle with higher speed creates frequent topology changes in the network that resulted in unstable connection for V2V [11,12]. Therefore, the development of V2V routing for accomplishing an effective and consistent data transfer is considered one of the important tasks in the VANET [13]. Since the safety applications of V2V is depends on the periodic transmission of vehicle status, the VANET's wireless channel is congested with a high amount of nodes [14-16]. In general, each vehicle dynamically alters the transmission constraints such as transmit power and data rate based on the channel condition for minimizing the V2V's channel congestion [17]. The primary focus of this paper is to design an effective congestion-aware AODV routing protocol using optimization.

The major contributions of this research are stated as follows:

- VLC is used as a communication medium in the VANET for improving the data rate during the communication. The problem related to congestion is solved by considering the multi-objective fitness values such as congestion metric, residual energy, distance and number of hops.
- In the VLC-VANET system, the congestion aware routing is performed using the MOCMAEO with AODV to enhance road safety. Here, the MOCMAEO is used because of its effective exploitation and exploration as well as AODV is used because of its lesser computations.
- Hence, the packet delivery of the vehicular networks is improved using the MOCMAEO. Here, road safety is accomplished by transmitting the location of the road where the accident occurred in the network.

The organization of the overall paper is given as follows: Section 2 provides the existing works related to the routing over the vehicular networks. The congestion-aware routing developed by the combination of MOCMAEO and AODV is described in Section 3. Section 4 provides the results and discussion of the MOCMAEO method. The conclusion of this research paper is made in Section 5.

2. Related Works

In recent times, the mathematical model of e-commerce-oriented ecosystem of a 5Ge base station and 5G-IoT ecosystem were developed for communication purposes [18-20]. In that, the process of independent virtual network segment was supported by 5Ge base station which offered the service of terminal–segment information transfer [18]. In 5G-IoT ecosystem, process of information broadcasting was accomplished between the base station and subjects [19] [20]. The related works about the recent techniques implemented for efficient routing in VANET are described as follows:

Srivastava, A., Prakash, A. and Tripathi, R [21] developed the Adaptive Intersection Selection Mechanism (AISM) based on the ant colony optimization. The AISM has generated a stable route instead of generating the long route among two connections. Therefore, the candidate routing paths were ranked by the forward ant packets according to the delay, connectivity probability and PDR. Accordingly, the optimal route among two connections was found with high connectivity. However, the packet distribution over the generated path was found a limitation by means of overhead.

Husain et al. [22] presented the three different geocast routing protocols using Particle Swarm Optimization (PSO). The developed routing protocols were LARgeoOPT, DREAMgeoOPT, and ZRPgeoOPT. The faster convergence was obtained using the PSO and next vehicle (NHV) technique in the LARgeoOPT, DREAMgeoOPT, and ZRPgeoOPT. Therefore, the developed routing protocols were used to improve the packet delivery and delay during the communication. However, this geocast routing protocol was failed to use the congestion metric while generating the path. Because, the network with congestion creates the collision which created the packet loss over the network.

Gnanasekar, and Samiappan, [23] presented the Mean Computing Jaya Algorithm (MC-JA) for identifying the optimal route over the VANET. The network quality metrics such as QoS awareness cost, congestion, collision and travel were considered in the cost model to solve the routing issue. Additionally, the fuzzification of the QoS factor was added to the routing cost. This MC-JA was used to find an appropriate transmission path with less collision. However, the number of packets transmitted over the VANET wasn't analyzed in this work.

Gawas, Mahadev & Gawas, Mahadev [24] developed the selective cross layer design based on Ant Colony Optimized AODV routing technique for VANET. The data obtained from the Media Access Control (MAC) layer, application layer, physical layer, and transport layer were optimized using the cross-layer design. The problem of route selection was solved using the ant colony algorithm and the slot assignment was obtained using the Particle Swarm Optimization (PSO) based MAC scheduling. But, the intermediate node selection was mainly accomplished by only the distance and residual energy of the nodes.

Jose and Grace [25] presented the Exponential Bird Swarm Optimization Algorithm (Exp-BSA) to obtain the dynamic path planning algorithm. This Exp-BSA was used to acquire adequate paths over the VANET topology. Since, the Exp-BSA based path planning has two processes such as travel-time estimating and bi-model for routing of emergency vehicles. Additionally, K-path discovery and the best path selection were involved in the bi-model. Hence, the path was identified by considering the travel time as a fitness function in the Exp-BSA. However, this Exp-BSA was considered only a travel time while generating the path.

3. MOCMAEO Method

In the VLC-VANET method, road safety for the users of the VANET is achieved by developing the congestion-aware routing using the MOCMAEO method. Because, the packet loss of the vehicular network is high when there is high congestion among the vehicles. Therefore, the optimal route from the source to the RSU is identified by considering appropriate fitness functions such as congestion metric, residual energy, distance and number of hops. Meanwhile, the throughput between the vehicles also improved using the VLC as the communication medium for VANET. The flowchart for the VLC-VANET is illustrated in Fig.1.

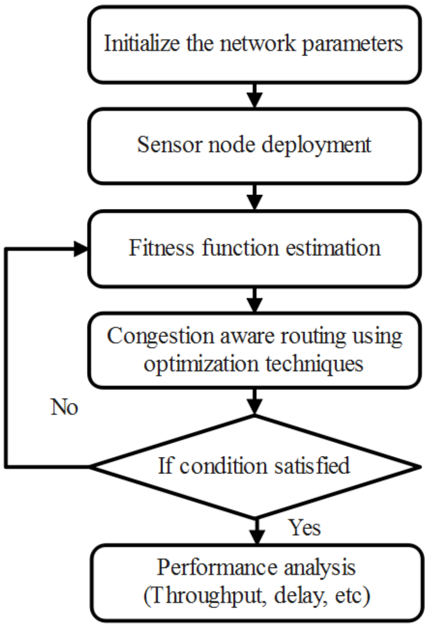

Fig.1. Flowchart for the MOCMAEO Method.

3.1. *VLC-VANET System*

The VLC-VANET system used in the MOCMAEO method comprises the vehicles (mobile nodes) and lighting sources as transmitting/receiving sources. Consider, there is an accident in the road area, then the information about the accident area's location is required to be broadcast over the network. Accordingly, the road safety of the remaining users of the VANET is improved based on the gathered information about the road accident. To transmit and receive the data packets from the nearby vehicles, the mobile nodes and lighting infrastructure are used with the transmitter and receiver in the VLC-VANET system. For instance, the transmitter and receiver of the VLC are used with the vehicle's brake lights and headlights. The need of the VLC is the Line-of-Sight (LoS), mostly in-vehicle communications. Consider, the data packets exist in the light emitted from the transmitter and these data packets are transmitted over the wireless medium. Equation (1) expresses the channel model of this VLC-VANET.

$$H_{LoS} = \begin{cases} \dfrac{(b+1)A}{2\pi Dist^2}\cos^b(\varphi)T(\psi)g(\psi)\cos(\psi) & , 0 \le \psi \le \psi_c \\ 0 & \psi > \psi_c \end{cases} \tag{1}$$

Where the Lambertian emission order is denoted as b; detector area is denoted as A; $Dist$ defines the distance between the vehicles; $T(\psi)$ is the transmission for optical band-pass filter; $g(\psi)$ denotes the concentrator gain; ψ_c denotes the field of view for the receiver; the angle of irradiance and impedance is represented as φ and ψ respectively.

3.2. *Artificial Ecosystem-based Optimization*

AEO is generally a metaheuristic algorithm that simulates the energy flow in the ecosystem based on the three phases as producers, consumers, and decomposers. The producers are any type of green plant which doesn't require acquiring energy from any other organisms. This first phase (i.e., producers) is utilized for enhancing the balance between exploration and exploitation. The animals are denoted as consumers in the second phase. Since they cannot make their food, the animals get energy from the producer/ remaining consumers. In the last phase, the decomposer feeds on both the consumers and producers. This AEO has only on producer and one decomposer. The consumer and decomposer phase of the AEO is used to improve the exploration and exploitation process. The phases of AEO are clearly explained as follows:

A. Producer

A new individual is randomly generated among the best individual (x_n) and randomly selected individual (x_{rand}) that is initialized in the search space. The best individual (decomposer) and lower & upper boundaries of the search space are used to update the worst individual (i.e., Producer). The remaining individuals are directed for searching to the different regions using the updated individual. Equation (2) is used to define the producer phase.

$$x_1(t+1) = (1-a)x_n(t) + ax_{rand}(t) \quad (2)$$

Where $a = (1 - t / MaxIt) \times r_1$, $x_{rand} = r \times (UP - LW) + LW$ and $x_2(t+1) = x_2(t) + C[x_2(t) - x_1(t)]$. In these, $MaxIt$ represents the maximum number of iterations; random number generated among [0,1] is denoted as r_1; coefficient utilized for the linear weighting is represented as a; the amount of populations are represented as n; random number generated among [0,1] is denoted as r, and LW & UP defined the lower and upper boundaries, respectively.

Moreover, the operator C is the Levy flight, which is utilized for improving the level of exploration. Equation (3) is used to define the Levy flight of AEO.

$$C = 0.5 \times (v_1 / |v_2|) \quad (3)$$

Where, $v_1 = v_2 \sim N(0,1)$ which indicates the normal distribution.

B. Consumption

The consumption phase is used for updating the individual solutions of AEO that are used to enhance the exploration phase. There are three types of consumers used in the consumption phase such as herbivore type, carnivore type and omnivore type. In that the herbivore eats both the producers and consumers; carnivore eats only the consumers which has a high energy level; omnivore eats the remaining consumer that has a high energy level and/ or producers. Further, the consumer is classified into any one of the types from herbivore, carnivore and omnivore by using the random selection.

For example, the mathematical expression for the consumer that is chosen as herbivore is represented in the equation (4).

$$x_i(t+1) = x_i(t) + C[x_i(t) - x_1(t)], \qquad i \in [3, \ldots, n] \quad (4)$$

Subsequently, the carnivore and omnivore are expressed in the following equations (5) and (6) respectively.

$$x_i(t+1) = x_i(t) + C[x_i(t) - x_j(t)], \quad i \in [3, \ldots, n], \ j = randi([2 \ i-1]) \quad (5)$$

$$x_i(t+1) = x_i(t) + C[r_2(x_i(t) - x_1(t)) + (1-r_2)(x_i(t) - x_j(t))], \\ i \in [3, \ldots, n], \ j = randi([2 \ i-1]) \quad (6)$$

Where, the generated random number among [0,1] is represented as r_2.

C. Decomposition

In this decomposition phase, the finest solution is used for updating the solutions. The process of decomposition is performed using decomposition factor D and weight variables h and e. The AEO's exploitation is improved using decomposition. The individual's location x_i is updated by using the decomposer x_n as shown in equation (7).

$$x_i(t+1) = x_n(t) + D[ex_n(t) - hx_i(t)] \quad (7)$$

Where, $D = 3u, u \sim N(0,1)$, $e = r_3 \times randi([1 \ 2]-1)$ and $h = 2r_3 - 1$. The r_3 is the random number generated among [0,1].

3.3. *Congestion Aware Routing Using MOCMAEO with AODV*

In this phase, the optimal congestion-aware routing path is generated from the source to the destination. Consider, the source node is near the area where the accident occurred and it is going to transmit the accident information to the destination for enhancing road safety. This congestion aware routing is used to avoid the collision during the data transmission that helps to minimize the packet loss over the VLC-VANET system.

A. Representation and Initialization of MOCMAEO

Initially, the individuals in the MOCMAEO are represented using the possible paths from the source to the destination. The dimension of MOCMAEO's individual is equal to the number of nodes that exist in the transmission path. Consider, the $x_i = \left(x_{i,1}(t), x_{i,2}(t), .., x_{i,dim}(t)\right)$ is the individual i, where each location $x_{i,loc}, 1 \le loc \le dim$ specifies the next-hop node in the transmission path.

B. Derivation of a Fitness Function

There are four different fitness functions are considered in this research such as congestion metric, residual energy, distance and number of hops.

a. Congestion Metric

The occupancy of a buffer is used to compute the congestion between the nodes. The number of packets that exists in each node's buffer is the queue length. The queue length is continuously varied according to the amount of packets entered/ left the network. Therefore, the congestion over the network is identified using the queue length. The node drops all the received packets, when the buffer of a queue is filled with its maximum capacity. Equation (8) is used to calculate the total amount of packets received by the node at time t.

$$CM = \lambda t \tag{8}$$

Where the packets arrival rate is λ and the time is t.

b. Residual Energy

The residual energy is also considered a significant parameter in the fitness function. If the node has higher residual energy, then that node is highly preferable during the communication. Because the intermediate nodes in the routing path have to transmit and receive the data packets between the nodes. The second fitness value i.e., residual energy (RE) of the node is expressed in equation (9).

$$RE = \sum_{i=1}^{dim} E_i \tag{9}$$

Where, E_i defines the residual energy of the node.

c. Distance

Euclidean distance is used to calculate the distance among only two real valued vector. However, the other distance measure e.g. Manhattan distance returns the sum of all real distances among the source and destination which is irrelevant for this routing process. Therefore, Euclidean distance $(Dist)$ is considered as the third objective in the MOCMAEO for identifying the routing path with less distance. Because the energy consumption of the node is increased, when the routing path distance is high over the network.

d. Number of Hops

The number of nodes connected to the respective next-hop node is defined as some hops (NH). The node with less amount of hops are preferred during the routing for balancing the load between the nodes.

In this MOCMAEO, the multiple fitness is converted into single fitness using the weighted sum approach, because each value considered in the routing are conflicting with each other. The fitness value of the MOCMAEO is specified in equation (10).

$$Fitness = \alpha_1 CM + \alpha_2 RE + \alpha_3 Dist + \alpha_4 NH \tag{10}$$

Where, $\alpha_1, \alpha_2, \alpha_3$ and α_4 are the weights allocated to each fitness value. The reason for considering the multiple fitness values are given as follows: 1) congestion metric-This is considered to avoid the collision occurred because of congestion among the nodes, 2) Residual energy is considered to avoid the nod failure or link failure while transmitting the packets, 3) Distance is considered to minimize the transmission delay between the vehicles and number of hops are considered for balancing the load between the nodes.

C. Iterative Process of MOCMAEO

In the iterative process, the paths initialized in the MOCMAEO are updated using the producer phase as shown in equation (1), where the path update of the producer phase mainly depends on the value a. The second individual (x_2) of the MOCMAEO is updated using the levy flight value. Next, the consumer phase takes place as shown in the equation (4), (5) and (6), where the location update of the herbivore, carnivore and omnivore is decided based on the random number. Further, the decomposer phase is initiated as shown in equation (7) after the consumer phase. Subsequently, the fitness function of all the individuals in the MOCMAEO is calculated and the best fitness value is identified among the individuals.

D. Routing Process Using MOCMAEO with AODV

The MOCMAEO based AODV routing method uses three different control messages to generate the path such as Route Request (RREQ), Route Reply (RREP), Route Error (RERR), and hello (HELLO). The RREQ message is forwarded by the source node while initializing the route discovery process. Next, the optimal node which has the best fitness value transmits the RREP message node. The RREP message is received by the source node through the reverse route followed by the source node initiating the data transmission over the VLC-VANET system. Hence, the information about road accidents is transmitted all over the network to improve road safety for VANET users. Thus, the routing path with less congestion is generated for minimizing the packet loss over the network.

4. Results and Discussion

This section shows the results and discussion of the MOCMAEO method. The implementation and simulation of the MOCMAEO method are carried out using MATLAB R2018a software where the PC is operated with the 4-GB RAM and Intel Core processor. In this research, the MOCMAEO with AODV is used to perform the congestion aware routing over the vehicular network for increasing the safety of the users of the VANET. More specifically, the communication between the vehicle uses the VLC as a communication medium while transmitting the data packets. The simulation specifications of the MOCMAEO method are shown in the following Table 1.

Table 1. Simulation parameters

Parameter	Value
Number of nodes	20, 40, 60 and 80
Area	1100 $m \times$ 1100 m
Transmission range	250 m
Location of RSU	Center of the network area
Communication channel	VLC
Packet size	4000 bits
Routing algorithm	MOCMAEO with AODV

In this section, the MOCMAEO method is analyzed for varying nodes such as 20, 40, 60 and 80. The performance of the MOCMAEO method is analyzed by means of PDR, throughput, delay and NRL. The performances of the MOCMAEO method are described as follows:

4.1. Packet Delivery Ratio

PDR is the ratio between the amount of data packets successfully received by the RSU and the amount of data packets generated by the source node. This PDR is expressed in the following equation (11).

$$PDR = \frac{Amount\ of\ data\ packets\ successfully\ received\ by\ the\ RSU}{Amount\ of\ data\ packets\ generated\ by\ the\ source\ node} \times 100\% \tag{11}$$

Fig.2 shows the PDR comparison for the MOCMAEO with DREAMgeoOPT [22], LARgeoOPT [22] and ZRPgeoOPT [22]. From the analysis, it is concluded that the MOCMAEO achieves higher PDR than the existing methods. For example, the PDR of the MOCMAEO for 40 nodes is 99.96 which is high when compared to the DREAMgeoOPT [22], LARgeoOPT [22] and ZRPgeoOPT [22]. The existing methods obtain only lesser PDR because they failed to avoid the collision during the communication. However, the MOCMAEO method uses the congestion metric during routing which helps to avoid the collision.

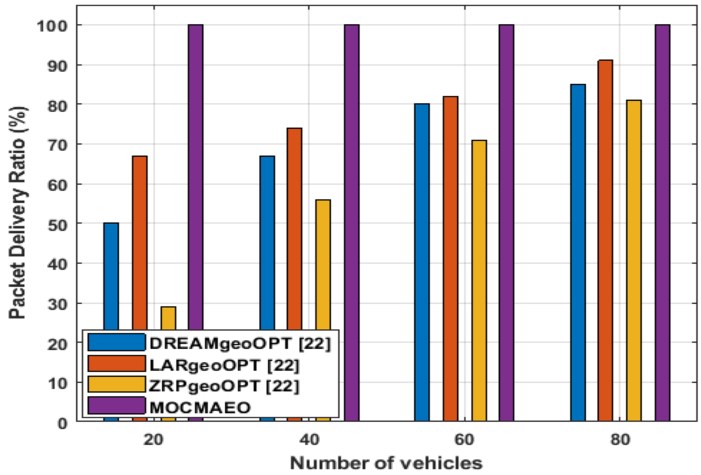

Fig.2. Analysis of PDR for MOCMAEO.

4.2. Throughput

In VANET, the throughput is a number of packets successfully received by the RSU which is expressed by means of kbps.

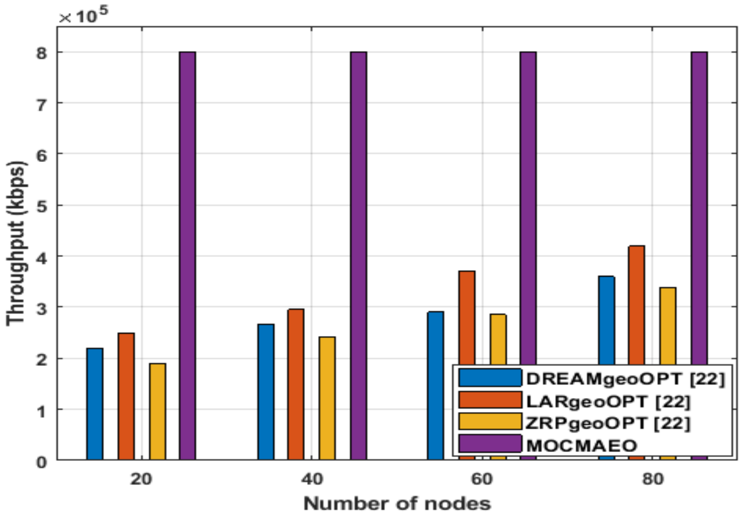

Fig.3. Analysis of throughput for MOCMAEO.

The throughput comparison for the MOCMAEO with DREAMgeoOPT [22], LARgeoOPT [22] and ZRPgeoOPT [22] is shown in Fig.3. The throughput of the MOCMAEO is high when compared to the DREAMgeoOPT [22], LARgeoOPT [22] and ZRPgeoOPT [22]. For example, the throughput of MOCMAEO with 40 nodes achieves 799.807 kbps of throughput that is high when compared to the existing methods. The collision avoidance using MOCMAEO based AODV is used to improve the successful data transmission between the vehicles and RSU.

4.3. Delay

Delay is the amount of time utilized by the VANET during the dissemination of packets, packet retransmission, waiting in queue and memory buffer. In general, the delay is the ratio between the amount of time taken for transmitting the data packets and total packets received by the RSU which is expressed in equation (12).

$$Delay = \frac{Amount\ of\ \ time\ taken\ for\ transmitting\ the\ data\ packets}{Total\ packets\ received\ by\ the\ RSU} \tag{12}$$

Fig.4 shows the delay comparison for the MOCMAEO with DREAMgeoOPT [22], LARgeoOPT [22] and ZRPgeoOPT [22]. From the analysis, it is concluded that the MOCMAEO achieves less delay than the existing methods. For example, the delay of the MOCMAEO for 40 nodes is 0.0269 s which is less than the DREAMgeoOPT [22], LARgeoOPT [22] and ZRPgeoOPT [22]. The existing method obtains high delay, because of rerouting caused by the collision between the vehicles. Unlike, the MOCMAEO method considers the congestion metric and residual energy in the fitness function to lessen the possibility of rerouting over the VANET.

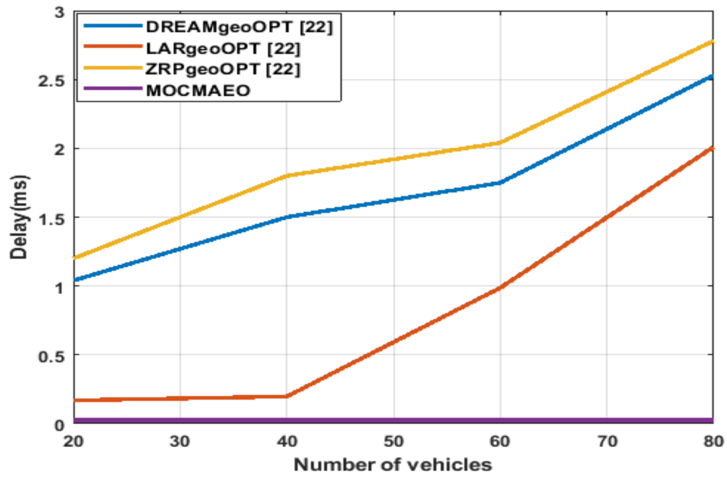

Fig.4. Analysis of Delay for MOCMAEO.

4.4. *Normalized Routing Load*

NRL is the ratio between the number of transmitted control packets and total packets received by the RSU which is expressed in equation (13).

$$NRL = \frac{Amount\ of\ control\ packets}{Amount\ of\ packets\ successfully\ received\ at\ the\ RSU} \tag{13}$$

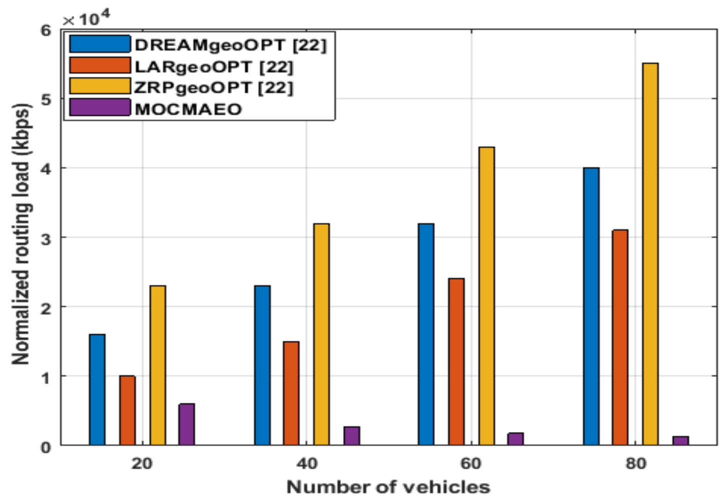

Fig.5. Analysis of NRL for MOCMAEO.

The NRL comparison for the MOCMAEO with DREAMgeoOPT [22], LARgeoOPT [22] and ZRPgeoOPT [22] is shown in the Fig.5. The NRL of the MOCMAEO is less, when compared to the DREAMgeoOPT [22], LARgeoOPT [22] and ZRPgeoOPT [22]. For example, the NRL of the MOCMAEO with 40 nodes achieves 2.73 kbps of throughput that is less when compared to the existing methods. The MOCMAEO method achieves only less NRL because an optimal fitness function considered in the routing requires only less amount control packets.

Table 2 provides the comparative analysis of the MOCMAEO with DREAMgeoOPT [22], LARgeoOPT [22] and ZRPgeoOPT [22]. From the analysis, it is concluded that the MOCMAEO method provides better performance than the DREAMgeoOPT [22], LARgeoOPT [22] and ZRPgeoOPT [22]. For the instance, the PDR of the MOCMAEO is 99.94 % for 60 nodes, which is high when compared to the existing methods. The DREAMgeoOPT [22], LARgeoOPT [22], and ZRPgeoOPT [22] achieve lesser performance because they failed to consider the congestion metric during the routing path generation. The congestion metric used in the MOCMAEO helps to avoid the collision of data packets which is used to improve the PDR. Meanwhile, NRL of the MOCMAEO method is minimized by transmitting only less amount control packets during the route discovery process. The proposed MOCMAEO achieves high PDR and throughput while minimizing the delay and NRL of the VLC-VANET system. Therefore, the MOCMAEO is used to increase the safety of the VANET users based on effective data transmission.

Table 2. Comparative analysis of the MOCMAEO

Performances	Methods	Number of vehicles			
		20	40	60	80
PDR (%)	DREAMgeoOPT [22]	50	67	80	85
	LARgeoOPT [22]	67	74	82	91
	ZRPgeoOPT [22]	29	56	71	81
	MOCMAEO	99.983	99.963	99.944	99.92
Throughput (kbps)	DREAMgeoOPT [22]	220	267	290	360
	LARgeoOPT [22]	250	296	370	419
	ZRPgeoOPT [22]	190	241	285	338
	MOCMAEO	799.809	799.677	799.546	798.922
Delay (ms)	DREAMgeoOPT [22]	1.04	1.5	1.75	2.53
	LARgeoOPT [22]	0.17	0.198	0.987	2.01
	ZRPgeoOPT [22]	1.2	1.8	2.04	2.78
	MOCMAEO	0.0260	0.0269	0.0274	0.0275
NRL (kbps)	DREAMgeoOPT [22]	16	23	32	40
	LARgeoOPT [22]	10	15	24	31
	ZRPgeoOPT [22]	23	32	43	55
	MOCMAEO	6.000	2.736	1.801	1.3

5. Conclusion

In this paper, MOCMAEO based AODV routing is developed to enhance road safety based on the congestion-aware routing approach. This MOCMAEO is used to minimize the packet losses occurred by the congestion between the vehicles. The VLC is integrated into the VANET communication model for improving the throughput during the communication. An optimal data transmission path between the vehicles is identified by considering the congestion metric, residual energy, distance and number of hops. Here, the collision of data packets is avoided by using the congestion metric which helps to increase the PDR of the VLC-VANET system. Meanwhile, the delay during the data transmission is minimized by avoiding node failure during the routing path generation. The MOCMAEO method provides better performance than the DREAMgeoOPT, LARgeoOPT and ZRPgeoOPT. The PDR of the MOCMAEO method is 99.92 % for 80 nodes, it is high when compared to the existing methods. However, the developed routing approach should also required to consider a clustering approach for improving the performances . In future, the cluster based routing using novel optimization approach can be developed to improve the performance of vehicular communications.

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Authors’ Profiles

Nagaraj B. Patil received his B.E. degree from the Gulbarga University Gulbarga Karnataka in the 1993, M.Tech. degree from the AAIDU Allahabad in 2005, and the Ph.D. degree from the University of Singhania,Rajasthan India in 2012. From 1993 to 2010 he worked as a Lecturer, Senior Lecturer and Assistant professor and HOD Dept. of CSE & ISE at SLN College of Engineering, Raichur Karnataka. From 2010 to June 2019 he worked as a an Associate Professor and HOD in the Department of Computer Science and Engineering at Government EngineeringCollege Raichur, Karnataka. He is currently Working as Principal Government Engineering College,Gangavathi, Karnataka from July 2019. His research interests are in Image Processing and Computer Network.

Shaeista Begum received her B.E degree from Bapuji Institute of Engineering and Technology, Davangere, Karnataka in 2005 and M.Tech degree from University of BDT College of Engineering, Davangere, Karnataka in 2007. From 2007 to 2008 she worked as a lecturer in GM Institute of Technology, Davangere, Karnataka. From 2008 to 2010 worked as a lecturer in BKIT, Bhalki, Karnataka. From 2010 to 2011 worked as a lecturer in Women’s Government Polytechnic, Gulbarga, Karnataka. From 2011 to December 2020 she worked as Assistant Professor in the Department of Computer Science and Engineering, Raichur, Karnataka. Presently working as an Assistant Professor & HOD in Department of Computer Science and Engineering, Government Engineering College, Raichur, Karnataka since December 2020. Her research area is Computer Networks and Communications.

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