



# PSO Optimized Geocast Routing in VANET

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## Abstract

High speed of vehicles in vehicular ad hoc network (VANET) makes the dissemination of information from source to destination a very challenging task. The moving vehicles share a predefined road layout, therefore data packets are needed to forward within a particular geographical region only. The geographical region so identified is known as geocast region. Many authors have investigated geocast routing protocols in VANET to ensure effective and efficient transmission of information to a geocast region. The existing geocast routing protocols have limited success due to highly dynamic characteristics of vehicular network and suffer from number of limitations such as scalability and overhead for routing. To reduce and overcome these problems some bio-inspired soft computing techniques have been developed to route the information from source to destination in an optimize manner. In this paper, we have developed and analyzed three geocast routing protocols using particle swarm optimization (PSO) approach named as LARgeoOPT, DREAMgeoOPT, and ZRPgeoOP.

**Keywords** VANET · Geocast routing · Scalability · Overhead · PSO

## 1 Introduction

Computer networking is one of the areas where bio-inspired techniques have been widely used [1, 2]. Particularly these techniques are applied to solve the routing problems for transmission of safety messages timely and reliably in an optimal fashion for vehicular ad hoc

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networks [3–5]. An important aim of vehicular networks is to support safety applications. These applications are provided using multi hop broadcast to transfer warning information. There are problems of redundantly received messages whereas maintaining good latency and connectivity which is very difficult due to the vehicles mobility and the wireless channel. Some authors proposed periodic rebroadcasts, however, they have not acquired the optimal time period that carefully considers the tradeoffs between reception reliability and transmission overhead [6]. In this work, we proposed optimized geocast routing protocols LARgeoOPT, DREAMgeoOPT, and ZRPgeoOPT applying PSO. This paper is organized in following sections. Related work is given in Sect. 2. Model and work plan is described in Sect. 3. In Sect. 4 we have explain particle swarm optimization and geocasting. Simulation and result analysis of the optimized protocols are presented in Sect. 5. In Sect. 6, we have done comparative analysis of the result. In the last the Sect. 7 gives the conclusion and future direction.

## 2 Related Work

Table 1 summarizes the work related to optimization-based routing algorithms at network layer that is presented with a special focus on VANET. As shown in Table 1 many authors did research on geocasting using optimization techniques and mainly particle swarm optimization (PSO) [7–9], ant colony optimization (ACO) [10], bee swarm optimization [11] and genetic algorithm [12] have been applied on routing protocols to optimize parameters such as packet delivery ratio(PDR),throughput, delay, routing load, lost packets etc. Further it has been observed that PSO is applied on VANET routing protocols in a geographical region [9, 13]. Some authors applied PSO on geocast routing protocols using NS2 and MATLAB. In the present work, the PSO has been applied to geocast routing protocol in VANET obtaining location information of the vehicles using GPS. Other geocast routing protocols like geocasting in vehicular ad hoc network, bee optimized fuzzy geographical routing protocol for VANET, to optimize route from source node to destination node and find out packet delivery ratio (PDR), throughput, delay, routing load parameters in vehicular ad hoc network using NS2 or MATLAB. It is observed that particle swarm optimization with optimized geocast routing protocols perform better than non-optimized geocast routing protocols for parameters like packet delivery ratio (PDR), throughput, delay etc., in VANET. These results enable us to select location of the best next forwarder with the help of GPS in PSO to maximize PDR, throughput and minimize delay, routing load, lost packets in network.

Based on the related literature work authors have concluded the following:

Approaches: efficient heuristic, broadcast, Euclid distance, optimal route, next node selection with PSO, ACO and GA optimization techniques.

Protocols: MAZACORNET, BIOSARP, DREAM-DS

Optimization techniques: PSO, ACO, GA

Simulators: NS-2, MATLAB.

Our contribution: In [6], author proposed periodic rebroadcasts, however, they have not acquired the optimal time period that carefully considers the tradeoffs between reception reliability and transmission overhead. We have used PSO with next vehicle (NHV) approach and designed fitness function in such a way that its convergence is fast and it easily find the local as well as global maxima Therefore to reduce the delay and increase the throughput and delivery ratio we have developed location based geocast routing protocols

**Table 1** Related works on geocast routing protocol with optimization in VANET

S.no.	Authors	Protocol	Technique	Parameters	Simulation tool	Approach	Year
1.	Zakamain et al. [7]	Optimal Configuration for Urban VANETs Routing	PSO	PDR, NRL, delay, DPR	NS2 and C++	Iteration based	2014
2.	Manickavelu et al. [14]	Algorithm for route recovery in MANET	PSO	Delivery ratio, delay, drop	NS2	Node and link lifetime prediction based	2014
3.	Kairwartya et al. [5]	Multi objective Dynamic Vehicle Routing	PSO	Throughput and delay	MOVE	Time Seed Based	2015
4.	Lobiyal et al. [15]	Parameter Value Optimization of Ad hoc on Demand Multipath Distance Vector Routing	PSO	Delay, NRL, PDR	C++, NS2	Route detection & forwarding node based	2015
5.	Li et al. [10]	Adaptive vehicular routing protocol	ACO	Delivery, delay, overhead	MATLAB	Route selection based	2013
6.	Saravanan et al. [11]	Bee optimized Fuzzy geographical routing protocol for VANET	ACO	Throughput, delay, number of hop	MATLAB, NS2	Next hop selection based	2014
7.	Kairwartya et al. [4]	Geocasting in vehicular ad hoc networks using PSO	PSO	PDR and NRL	MOVE, SUMO	Next hop vehicle (NHV) based	2014
8.	Rana et al. [16]	MAZACORNET: Mobility aware zone based ant colony optimization routing for VANET	ACO	PDR, scalability, delay	MATLAB	Zone based scalability	2013
9.	Alsabaan et al. [12]	Optimization of Fuel Cost and Emissions Using V2V Communications	GA	Throughput and delay	MATLAB	Efficient heuristic based	2013
10.	Saleem et al. [17]	Novel Biological inspired self-organized Secure Autonomous Routing Protocol (BIOSARP).	ACO	Delay, packet overhead	NS2	Broadcast based	2012

**Table 1** (continued)

S.no.	Authors	Protocol	Technique	Parameters	Simulation tool	Approach	Year
11.	Zhou et al. [18]	Genetic algorithm based on extended sequence and topology with the help of Directed diffusion protocol.	GA	Packet delivery ratio	VC++	Euclid distance based	2010
12.	Kalambe et al. [19]	DREAM based DS	PSO	Delay, NRL, DPR throughput	NS2	Optimal route	2015

with PSO named as DREAMgeoOPT, LARgeoOPT and ZRPgeoOPT. The performance of developed protocols are evaluated using MATLAB with VanetMobiSim in terms of packets delivery ratio (PDR), throughput, delay, normalized routing load (NRL) and dropped packets ratio (DPR). RSU stand for Road Side Unit, which is used in the case sparse network to help in forwarding the information by storing the information at RSU until some forwarder vehicle come in the range of RSU. Overhead is the set of extra packets needed to transfer the actual data from source vehicle to destination vehicles within a geocast region. The fitness function used in PSO is aggregate minimizing function and that is the reason PDR is used with negative sign. Packet size used in the optimization is taken 1 KB. Constant Bit Rate (CBR) is considered as 8 packets/s. If Packet size is decreased than the overhead to transfer the data will increase, as number of packets would be more for deliver the same amount of data.

### 3 Model and Work Plan

Creating network model with similar behavior nodes, choosing statistics, data to be collected and running the simulation with the help of particle swarm optimization (PSO) has been shown in the Fig. 1.

Figure 2 shows the vehicles movement traces obtained using VanetMobiSim with parameter shown in Table 2. These traces are used in MATLAB to simulate the behavior of vehicular nodes using PSO optimized routing protocols with parameters shown

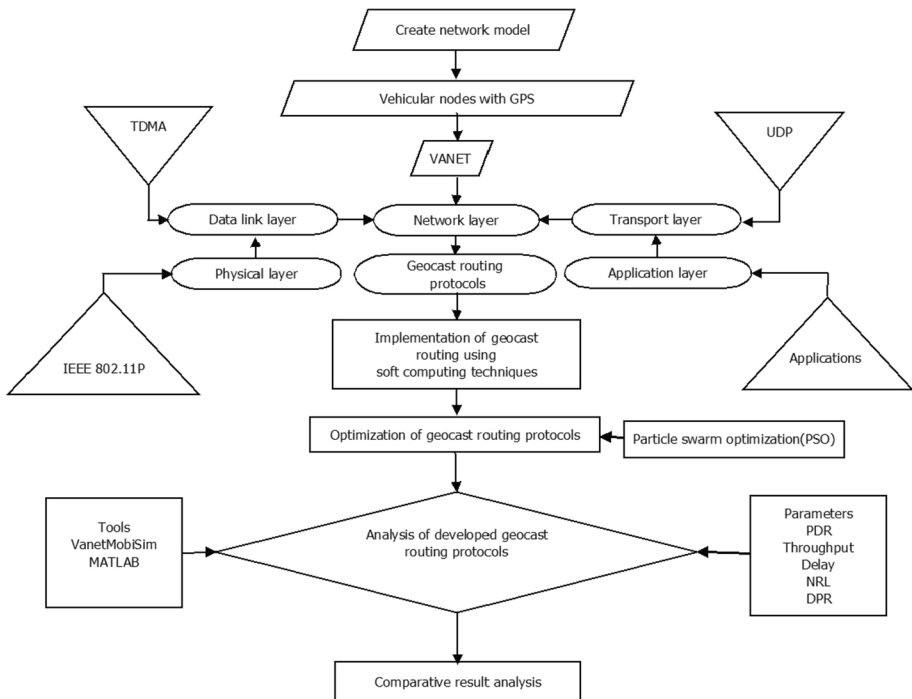


Fig. 1 Flow sheet of geocast routing protocols using PSO

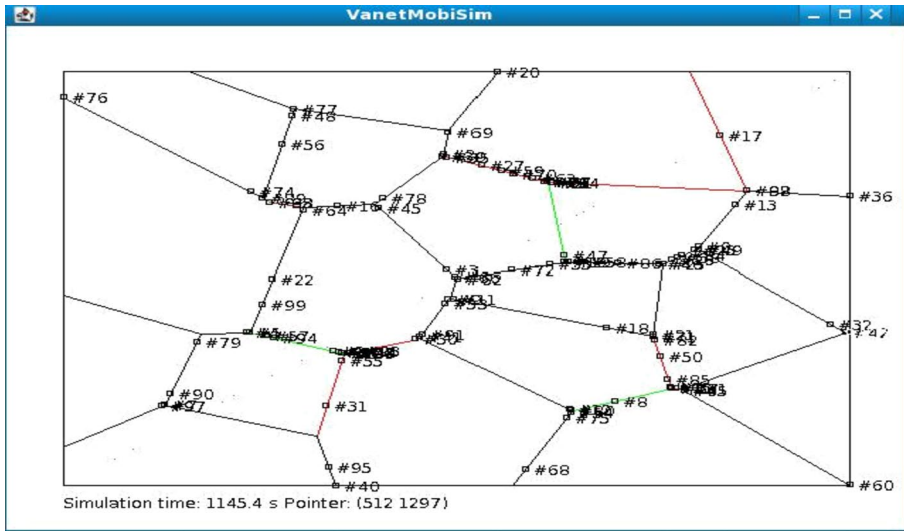


Fig. 2 Simulation scenario of vehicular nodes

Table 2 VanetMobiSim parameters for analysis of optimized geocast routing

Parameter	Value
Acceleration threshold value	0.25 m/s <sup>2</sup>
Politeness factor	0.55
Safe deceleration value	4.5 m/s <sup>2</sup>
Safe headway time	1.5 s
Movement step recalculation	1.0 s
Jam distance	2.5 m
Comfortable deceleration	1.0 m/s <sup>2</sup>
Maximum acceleration	0.6 m/s <sup>2</sup>
Vehicle length	4 m

in Table 3. PSO is chosen for Geocasting in VANET because PSO searches a space for optimal position by adjusting the velocity of each vehicle of vehicular network considering vehicle’s previous best position and neighbor’s previous best locations. We have used PSO with next vehicle (NHV) approach and designed fitness function in such a way that its convergence is fast and it easily find the local as well as global maxima Therefore to reduce the delay and increase the throughput and delivery ratio we have developed location based geocast routing protocols with PSO named as DREAMgeoOPT, LARgeoOPT and ZRPgeoOPT. Vehicles can communicate among each other without use of infrastructure by using multi-hop communication strategy bounded with their transmission range.

Performance evaluation of LARgeoOPT, DREAMgeoOPT, and ZRPgeoOPT protocols with particle swarm optimization has been done considering packet delivery ratio, throughput, delay, normalized routing load, dropped packet ratio parameters.

**Table 3** Simulation parameters for analysis of optimized geocast routing protocols

Parameter	Value
Simulator	MATLAB15a
VANET MAC protocol	IEEE802.11p
Mobility model	IDM_IM
Transmission range	250 m
Simulation area	1100 m × 1100 m
Channel	Wireless
Antenna Type	Omni-directional
Simulation time	1100 s
Packet length	512 B
Data rate	10 packets/s
Pause duration	5 s
Bandwidth	2 Mbps
Type of Traffic	Constant Bit Rate
Vehicle speed	60 km/h
Type of Interface queue	DropTail based on Priority
Size of Interface queue (packets)	60
Number of vehicles	10, 20, 30, 40, 50, 60, 70, 80
Routing protocols	LARgeoOPT, DREAMgeoOPT, and ZRPgeoOPT
Maximum connection	90%

## 4 Particle Swarm Optimization and Geocasting

PSO is a soft computing technique which generally based on swarming theory of bird flocking and fish schooling. The development of PSO is based on continuous optimization of nonlinear functions in mind. PSO searches a space for optimal position by adjusting the velocity of each vehicle of vehicular network considering vehicle's previous best position and neighbour's previous best locations. In the case of vehicular ad hoc network (VANET) optimization with PSO vehicular nodes are considered as particles.

### 4.1 PSO Based Geocasting in VANET

Next hop vehicle (NHV) selection is the one of the most important task in geocast routing as a number of constraints such as frequent topological changes, shadowing effects, interference, predefined forwarding direction, high buildings, very high speed of vehicles etc. are involved in VANET [3, 4]. Various different techniques have been investigated by researchers for NHV selection [20, 21]. To develop geocast routing protocols, we have implemented particle swarm optimization (PSO) with fitness function that maximizes delivery ratio, throughput and minimizes delay, routing load, dropped packets using MATLAB with VanetMobiSim for selecting an optimal next hop vehicle (NHV) to forward the information towards geocast region timely.

## 4.2 PSO Based Geocast Algorithm for Optimization and Fitness Function

For end to end transfer of urgent messages in a geocast region, next hop vehicle selection concept is used because in most cases there are situations when source and destination are not in direct transmission range of each other.

Let  $V_{curr}$  represents the current time velocity and  $X_{curr}$  represents the current time location of a vehicle. For forwarding the message towards the destination, the next velocity  $V_{next}$  and next location  $X_{next}$  of the vehicle in the same dimension can be calculated using Eqs. (1) and (2).

$$V_{next} = V_{curr} + k_1(X_{local\ best} - X_{curr}) + k_2(X_{global\ best} - X_{curr}) \quad (1)$$

$$X_{next} = X_{curr} + V_{next} \quad (2)$$

In Eqs. (1) and (2),  $k_1$  and  $k_2$  are random positive numbers,  $X_{local\ best}$  and  $X_{global\ best}$  are previous best locations of the vehicle and its neighbor respectively.

Particle swarm optimization (PSO) is implemented to find the optimal value of next hop vehicle (NHV) in search space of vehicular network. The optimization is carried out using a fitness function,  $Q_{NHV}$  represented by Eq. (3).

$$Q_{NHV} = -w_1(PDR) - w_2(Tput) + w_3(Delay) + w_4(NRL) + w_5(DPR) \quad (3)$$

where PDR represents packet delivery ratio, Tput represents throughput, Delay represents delay incurred to transfer the packets from source to destination, NRL represents normalized routing load, DPR represents the dropped packet ratio are performance parameters.  $w_1$  to  $w_5$  are weight used with respective performance parameters.

The objective of the fitness function  $Q_{NHV}$  in Eq. (3) is to maximization of PDR, Tput and minimization of Delay, NRL, DPR. The Eq. (3) is aggregate minimizing function and that is the reason PDR, Tput are used with negative sign and Delay, NRL, DPR are used with positive sign.

### 4.2.1 Development of PSO Based Geocast Algorithm

PSO is applied on geocast routing protocols in vehicular ad hoc network and IEEE802.11p is used as a communication protocol which is especially developed for VANET. The steps of the PSO based algorithm for geocast routing are explained as:

**Step 1** In the geocast search space initialize the population array of vehicles (particles)

The population ( $X_i$ ) is the number vehicles considered for the VANET. In this work we have taken 8 sets of 10, 20, 30, 40, 50, 60, 70, 80 vehicles, therefore for each set value of  $i$  varies from 1 to 10 for set 1, from 1 to 20 for set 2, from 1 to 30 for set 3, from 1 to 40 for set 4, from 1 to 50 for set 5, from 1 to 60 for set 6, from 1 to 70 for set 7 and from 1 to 80 for set 8.

**Step 2** Start loop

**Step 3** Evaluate the fitness function

$$Q_{NHV} = -w_1(PDR) - w_2(Tput) + w_3(Delay) + w_4(NRL) + w_5(DPR)$$

for each vehicle (particle) to find out the optimized value.



**Step 4** Compare the vehicle's evaluated fitness value with its previous best ( $Pbest_i$ ) value.

If current value is better than  $Pbest_i$ , then

$$\text{Set } Pbest_i = X_{next}$$

(evaluated from Eqs. 1 and 2).

**Step 5** Find out the vehicle (particle) with best success so far in the neighbourhood and assign its value to  $X_{global\ best}$ .

**Step 6** Update the velocity and location of the vehicle (particle) according to the equations:

$$\text{Velocity } V_{next} = V_{curr} + k_1(X_{local\ best} - X_{curr}) + k_2(X_{global\ best} - X_{curr})$$

$$\text{Location } X_{next} = X_{curr} + V_{next}$$

**Step 7** If a criterion is fulfilled the exit the loop stated in step 2.

**Step 8** End loop.

## 5 Results and Analysis

In this paper the performance of above three geocast routing protocols (GeoLAR-DF, GeoDREAM-DF, and GeoZRP-DF) have been examined using particle swarm optimization (PSO) with fitness function that maximizes delivery ratio, throughput and minimizes delay, routing load, dropped packets named as LARgeoOPT, DREAMgeoOPT, and ZRPgeoOPT. The developed protocols have been implemented using VanetMobiSim and MATLAB15a. The comparative analysis of these geocast protocols are compared with other reported protocols using PSO of other authors in terms of PDR, throughput, delay, NRL and DPR in VANET. It is observed that our optimized protocols (LARgeoOPT, DREAMgeoOPT, and ZRPgeoOPT) perform better than other reported protocols because we have applied PSO with fast convergence on geocast routing whereas others applied PSO on unicast routing in VANET.

The results are analyzed in terms of PDR, delay, throughput, normalized routing load (NRL) and dropped packet ratio (DPR) in VANET. For the analysis of geocast routing protocols with and without optimization in VANET vehicular nodes are considered from 10 to 80.

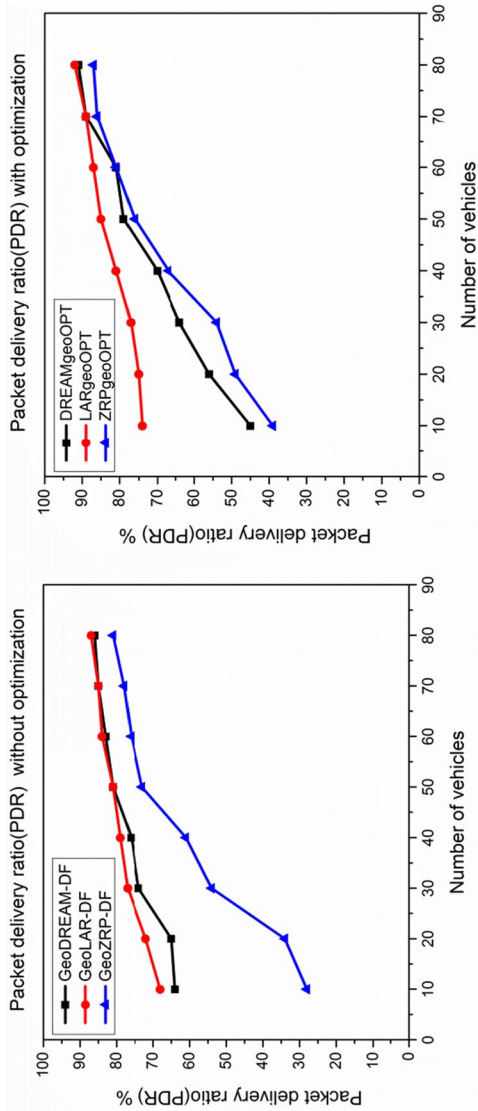
### 5.1 Packet Delivery Ratio (PDR)

It is obtained by dividing number of the data packets successfully delivered by the number of total data packets generated. Mathematically it can be represented as:

$$PDR = (TPD/TPG) \times 100 \quad (4)$$

where TPD=Total data packets received successfully, TPG=Total data packets generated.

Packet delivery ratio is calculated according to Eq. 4 and demonstrated in the graph as shown in Fig. 3. It is clear from the Fig. 3a that initially PDR increases with the increase in the number of the nodes. With smaller number of nodes, link is not established from source to destination. As soon as the nodes density increases, the communication link is established and maintained for a long time. Due to that, routing protocols



**a** PDR of geocast routing without optimization **b** PDR of geocast routing with optimization

**Fig. 3** Packet delivery ratio (PDR) of geocast routing with and without optimization

show good performance. As the number of nodes is increased further, PDR starts to drop, since a lot of vehicles access the wireless link. The PDR graph also shows that LAR performs better than DREAM whereas the performance of ZRP is the lowest in both the optimized and without optimized geocast routing. As depicted by graphical representation in Fig. 3a, b, it is clear that the PDR is improved smoothly with the increase of number of nodes when PSO is applied on geocast routing protocols. It is observed that protocols DREAMgeoOPT, LARgeoOPT and ZRPgeoOPT perform better than geocast routing protocols GeoDREAM-DF, GeoLAR-DF, GeoZRP-DF.

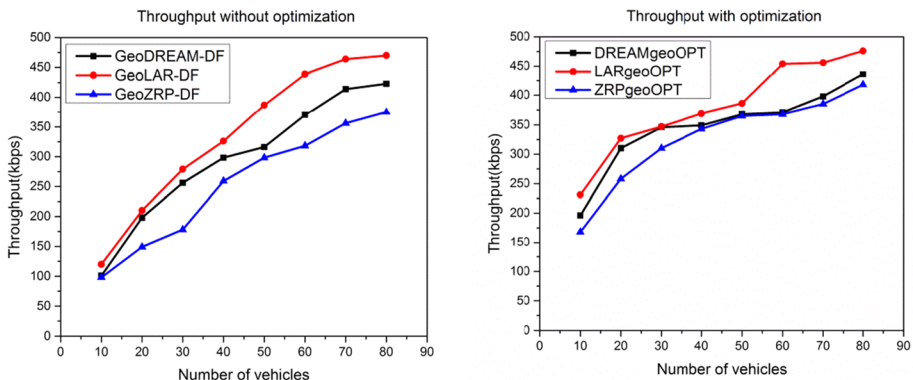
### 5.2 Throughput

Throughput of the VANET is successfully received packets in terms of kbps. Mathematically throughput can be represented as:

$$Throughput = SP/TL \tag{5}$$

where SP is the total number of packets transmitted successfully, TL is the timestamp recorded in last transmitted packet

The throughput of the routing protocols is calculated using Eq. 5. Optimized geocast routing protocols as shown in Fig. 4b demonstrated improved performance than geocast routing protocols without optimization, as shown in Fig. 4a. It is evident from the Fig. 4a that when node density is up to 30, the throughput is below 300 kbps, and LAR performs better than DREAM and ZRP. As soon as node density is in the range of 30–60, ZRPgeoOPT shows higher throughput in comparison to DREAMgeoOPT and LARgeoOPT since the less number of nodes easily establish the link in the case of ZRPgeoOPT whereas beyond 60 nodes LARgeoOPT performed better than geocast routing protocols GeoDREAM-DF, GeoLAR-DF, GeoZRP-DF without optimization. As depicted by graphical representation in Fig. 4a, b, it is clear that the throughput is improved smoothly with the increase of number of nodes when PSO is applied on geocast routing protocols.



(a) Throughput of geocast routing without optimization (b) Throughput of geocast routing with optimization

Fig. 4 Throughput of geocast routing with and without optimization

### 5.3 Delay

Delay is the total time taken by the network in memory buffer, waiting in queue, packet retransmission and propagation of packets. In other words, delay can be represented as the difference of the time stamps between arrival and transmission of the packets.

Mathematically delay can be represented as:

$$Delay = ST/NP \tag{6}$$

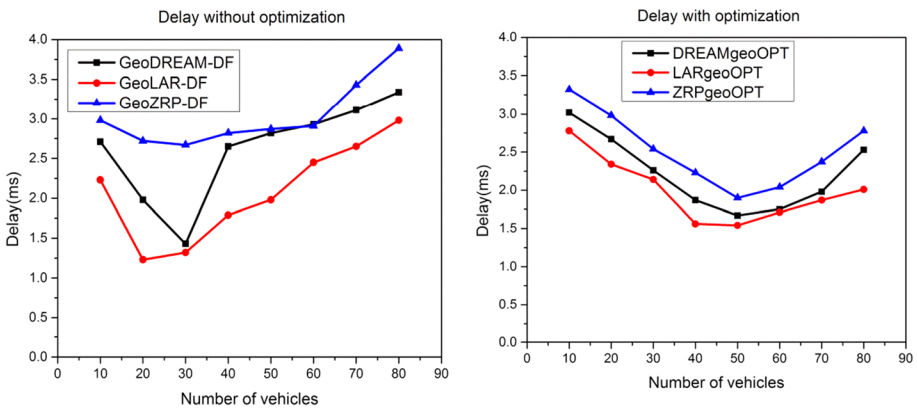
where ST=Total time taken by the packets to deliver, NP=Total Number of packets received

The delay of routing protocols is calculated according to the Eq. 6. Optimized geocast routing protocols DREAMgeoOPT, LARgeoOPT and ZRPgeoOPT as shown in Fig. 5b represent less delay and demonstrate better performance than geocast routing protocols GeoDREAM-DF, GeoLAR-DF and GeoZRP-DF without optimization as illustrated in Fig. 5a. The above graph in Fig. 5a exhibits that as the numbers of nodes are increased, the delay increases. Up to node density 60, ZRPgeoOPT continuously shows highest delay since the path discovery phase takes longer. In comparison to ZRPgeoOPT and DREAMgeoOPT, LARgeoOPT in city scenario depicted less delay. When node densities are 10–60 nodes, there is a big difference in delay incurred in LARgeoOPT and DREAMgeoOPT in comparison to ZRPgeoOPT, whereas as the number of nodes increases beyond 60, there is a sharp increase in the delay for all the three routing protocols and there is very less difference in the delays of DREAMgeoOPT, LARgeoOPT and ZRPgeoOPT.

### 5.4 Normalized Routing Load (NRL)

Normalized routing load (NRL) is equal to the contribution of the control packets in the network generated for route request, route reply, and route error, etc. The NRL can be calculated by dividing the total control packets transmitted with total received data packets.

Mathematically NRL can be represented as:



(a) Delay of geocast routing without optimization (b) Delay of geocast routing with optimization

**Fig. 5** Delay of geocast routing with and without optimization

$$NRL = ST/SR \tag{7}$$

where ST = Total routing packets transmitted, SR = Total data packets received

Graph represented in Fig. 6 represents normalized routing load (NRL) where highest routing overhead is incurred by GeoZRP-DF in comparison to other with optimization and without optimization geocast routing protocols calculated using Eq. 7. It is observed from the above figure that NRL increases as soon as the wireless channel is shared by more number of vehicular nodes. LARgeoOPT showed the lowest overhead in comparison to other with optimization and without optimization geocast routing protocols. It is evident from the above graph that optimized geocast routing protocols DREAMgeoOPT, LARgeoOPT and ZRPgeoOPT as shown in Fig. 6b demonstrate better performance than geocast protocols without optimization as shown in Fig. 6a.

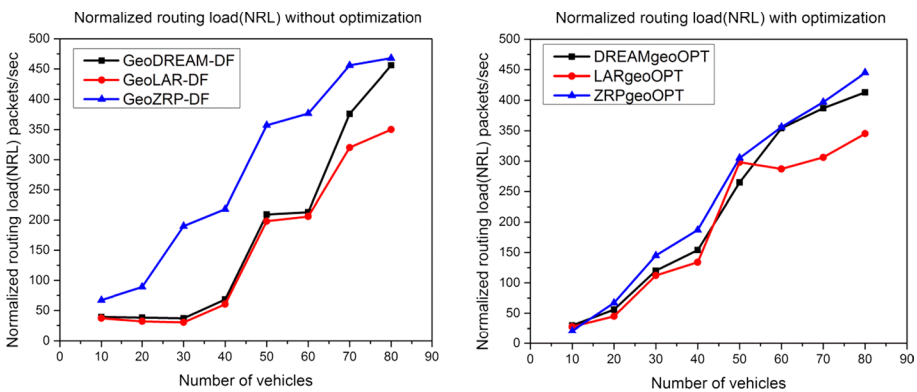
### 5.5 Dropped Packet Ration (DRP)

The dropped packet ratio (DPR) is the ratio of dropped packets to source generated packets. In other words, DPR is the total number of the packets lost during communication in the network. Mathematically DPR can be represented as:

$$DPR = SD/SG \tag{8}$$

where SD = Sum of dropped packets by routers, SG = Sum of packets generated by CBR sources.

DPR is calculated according to Eq. 8 and represented graphically in Fig. 7. Initially, DPR is high at less number of nodes. When number of nodes is increased, more number of nodes can communicate with each other; therefore DPR decreases. As soon as more nodes join the network to communicate, DPR further increases, due to the fact that now more number of packets are generated and flow in the network, and there is a competition for sharing the channel, and high number of collisions would be there. GeoZRP-DF has shown the highest DPR, while LARgeoOPT has lowest DPR. Geocast routing protocols without optimization GeoDREAM-DF, GeoLAR-DF and GeoZRP-DF routing protocols as shown



(a) NRL of geocast routing without optimization

(b) NRL of geocast routing with optimization

Fig. 6 NRL of geocast routing with and without optimization

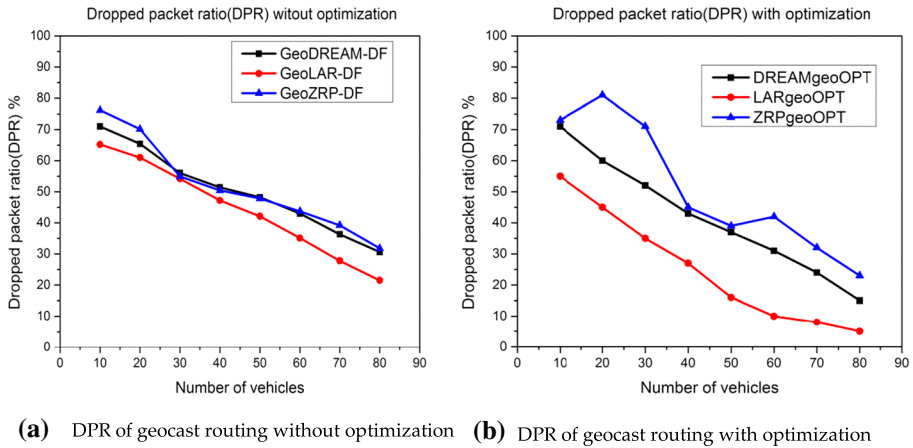


Fig. 7 DPR of geocast routing with and without optimization

in Fig. 7a represents higher DPR. Therefore optimized geocast routing protocols reduces the number of dropped packets as shown in Fig. 7b.

### 6 Comparative Analysis of Result with Other Authors' Work

The comparative analysis of optimized geocast protocols developed using particle swarm optimization technique and geocast protocols optimized and proposed by other researchers are summarized in Table 4 and their graphical representation in terms of parameters such as PDR, Odelay, throughput, NRL, and DPR are compared by graphs given in Figs. 8, 9, 10, 11 and 12.

The comparative performance analysis in terms of packet delivery ratio of developed optimized geocast routing protocols DREAMgeoOPT, LARgeoOPT, ZRPgeoOPT and protocol proposed [7] are given in Fig. 8. It is observed from the graphical representation that developed optimized protocols show better performance in terms of successful delivery of packets of a message.

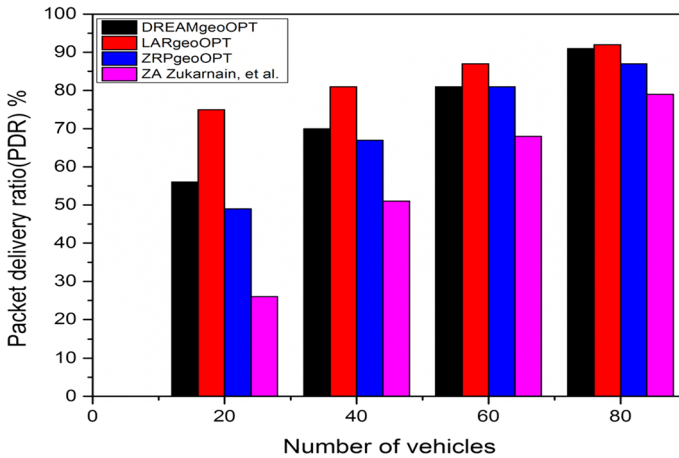
The performance analyzed in terms of throughput of developed optimized geocast routing protocols DREAMgeoOPT, LARgeoOPT, ZRPgeoOPT with protocol proposed by Raw et al. (2013) are given in Fig. 9. It is observed from the analysis that our developed protocols optimized with PSO outperform the protocols [20].

The comparative analysis of performance in terms of delay of optimized geocast routing protocols DREAMgeoOPT, LARgeoOPT, ZRPgeoOPT and protocol proposed by Kalambe et al. (2015) are given in Fig. 10. It is observed that our protocols reduces the delay and it implies that messages would be transmitted in less time using our developed protocols in comparison of protocol in [19].

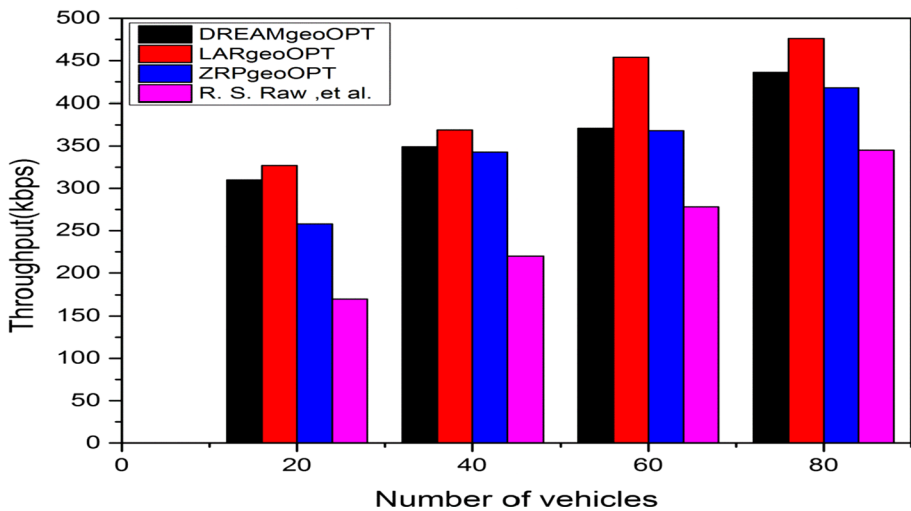
The comparative analysis of performance in terms of normalized routing load of developed optimized geocast routing protocols DREAMgeoOPT, LARgeoOPT, ZRPgeoOPT and protocol proposed by R Singh, et al. are given in Fig. 11. As demonstrated in this graph our developed protocols reduces the normalized routing load (NRL) by approximately 20–30% and this decrement shows that there is a less requirement of

**Table 4** Comparative analysis of developed protocols with other optimized routing protocols

S.no.	Authors	Protocol	Approach	Parameters (for number of nodes)				
				PDR (%)	Throughput (kbps)	Delay (ms)	NRL (kbps)	DPR (%)
1.	Zukarnain et al. [7]	ZRP-based Routing	PSO	26 (20), 51 (40), 68 (60), 79 (80)	Not calculated	Not calculated	Not calculated	Not calculated
2.	Raw et al. [20]	LAR based P-GEDIR	PSO	Not calculated	180 (20), 167 (40), 230 (60), 300 (80)	1.9 (20), 2.5 (40), 3.02 (60), 3.48 (80)	Not calculated	Not calculated
3.	Kalambe et al. [19]	DREAM based DS	PSO	Not calculated	Not calculated	1.8 (20), 2.08 (40), 2.6 (60), 3(80)	36 (20), 56 (40), 59 (60), 65 (80)	73 (20), 56 (40), 45 (60), 29 (80)
4.	Our approach	DREAMgeoOPT	PSO	50 (20), 67 (40), 80 (60), 85 (80)	220 (20), 267 (40), 290 (60), 360 (80)	1.04 (20), 1.5 (40), 1.75 (60), 2.53 (80)	16 (20), 23 (40), 32 (60), 40 (80)	60 (20), 43 (40), 31 (60), 15 (80)
		LARgeoOPT		65 (20), 74 (40), 82 (60), 91 (80)	250 (20), 296 (40), 370 (60), 419 (80)	0.17 (20), 0.198 (40), 0.987 (60), 2.01 (80)	10 (20), 15 (40), 24 (60), 31 (80)	45 (20), 27 (40), 10 (60), 5 (80)
		ZRPgeoOPT		29 (20), 56 (40), 71 (60), 81 (80)	190 (20), 241 (40), 285 (60), 338 (80)	1.2 (20), 1.8 (40), 2.04 (60), 2.78 (80)	23 (20), 32 (40), 43 (60), 55 (80)	81 (20), 45 (40), 42 (60), 23 (80)



**Fig. 8** Result analysis in terms of packet delivery ratio (PDR)



**Fig. 9** Result analysis in terms of Throughput

extra packets to transfer a message from source vehicle to destination region in comparison with protocol in [19].

The comparative analysis of performance in terms of normalized routing load of developed optimized geocast routing protocols DREAMgeoOPT, LARgeoOPT, ZRPgeoOPT and protocol proposed in [6] are given in Fig. 12. It is observed from the analysis developed protocols in this lowers the number of dropped packets which is an indication of more packets are received by destination vehicles in comparison with protocol in [19]. It is observed that some other optimized and fog computing based routing as reported in recent years [22, 23].



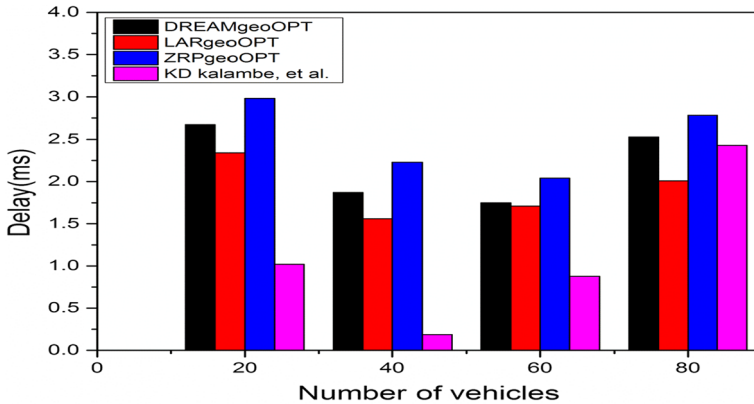


Fig. 10 Result analysis in terms of delay

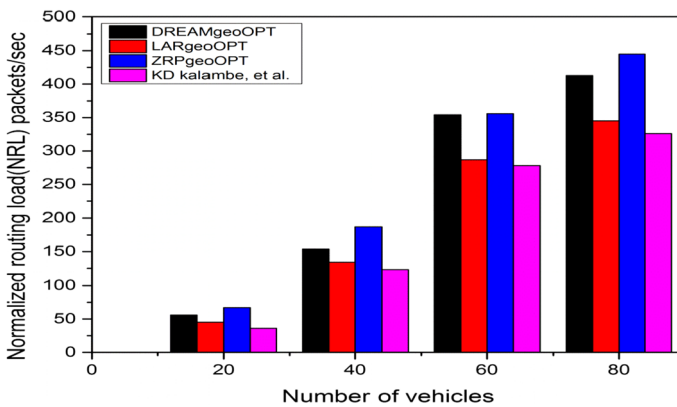


Fig. 11 Result analysis in terms of normalized routing load (NRL)

### 7 Conclusions

In the present work we have developed three location based geocast routing protocols in VANET and named as DREAMgeoOPT, LARgeoOPT, ZRPgeoOPT. Our developed protocols compared with protocol given by zukarnain et al. in terms of PDR show 13%, 19% and 9% respectively increased average packet delivery, generate 58%, 67% and 55% respectively more average throughput in comparison with protocol proposed by Raw and Das, produces 4%, 17% and 14% respectively less average delay and it implies that messages would be transmitted in less time and show better performance in comparison with protocol given by Kalambee et al. The comparative analysis in terms of normalized routing load of developed DREAMgeoOPT, LARgeoOPT, ZRPgeoOPT and protocol proposed by Kalambee et al. show 55%, 24% and 86% respectively average decreased normalized routing load (NRL) and represents 13%, 28% and 11% less average DPR. Less number of dropped packets is indications of more packets are received by destination vehicles of a geocast region. The performance of our protocols founded better because fitness function used in PSO reduces the delay, routing load, dropped packets and increased the throughput, packet

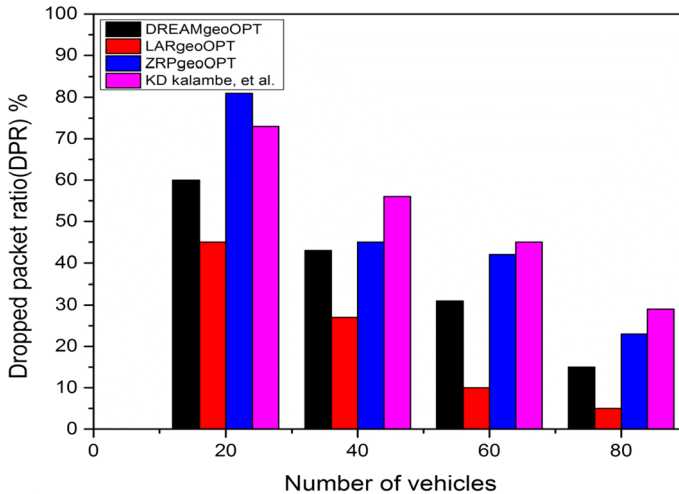


Fig. 12 Result analysis in terms of dropped packet ratio (DPR)

delivery ratio because the convergence of PSO is fast and local maxima is obtained in less time.

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