A Novel Traffic Congestion Minimization Technique for VANET using Opportunistic Routing and BFO

Aditi Saini
M. Tech Scholar, Department of Computer Science & Engineering, Rayat-Bahra University, Mohali, Punjab, India.

Er. Pritpal Singh
Assistant Professor, Department of Computer Science & Engineering, Rayat-Bahra University, Mohali, Punjab, India.

Abstract – Traffic congestion has emerged as an issue of global interest and both governments and academia are developing innovative solutions to mitigate this issue. This paper proposes a novel congestion minimization technique named MARC-ORBFO which focuses on refining an existing congestion minimization approach that performs routing using an optimal relaying distance function and incurs high packet drops. The proposed congestion minimization algorithm exploits social relationships among the nodes to make next hop selection using dynamic optimization with BFO in order that packet delivery probability is maximized and high packet delivery rates be achieved. The main focus of this research is to show the effectiveness of opportunistic routing and BFO in reducing congestion and achieve better results in comparison to [9]. The proposed technique is simulated using ONE simulator and its performance is evaluated in terms of parameters such as Throughput, Packet Drops, Latency and Overhead Ratio. Simulations reveal that the proposed algorithm achieves 15% improvement in Throughput, 16% reduction in Latency, 43% reduction in Overhead Ratio 15% reduction in packet drops when compared to [9] and hence outperforms [9] in terms of all the considered parameters.

Index Terms – BFO, MSN, Traffic congestion, VANET, V2V

1. INTRODUCTION

Traffic congestion is perceived as a serious issue globally which can be attributed to the drastic impact it causes on environment, economy, health and lifestyle. Traffic congestion is the term supplied to the condition when the traffic volume surpasses the road infrastructure capacity. Government agencies and research community are putting in extensive efforts to bring forth new and innovative solutions to mitigate this serious issue. The issue of traffic congestion estimation and minimization has been the hot topic of research since the past decade because of the potential undesirable effects observed as a consequence of congestion. In this regard, approaches for its accurate prediction appear promising since getting congestion information in advance will help the drivers to take alternative routes thereby avoiding congested roads and achieve reduction in average trip times, fuel consumption and also reduce the severity of congestion.

Conventional congestion estimation techniques [16] [17] were based on deployment of magnetic sensors, radars and inductance loops that captured traffic data and transmitted it to a centralized unit for processing that processed the traffic data and results were then communicated to the drivers via broadcast. However, infrastructure-based approaches have several limitations including susceptibility to damage and sabotage, high initial investment, difficult to maintain and upgrade, delay in capturing and processing results thereby compromising accuracy of congestion estimates, etc. To overcome the limitations of infrastructure-based approach, infrastructure-less approach [16] [17] was introduced that relies on V2V communications for congestion estimation. Infrastructure-less technique is currently utilized in majority of modern researches focused at congestion avoidance/minimization.

The key motivation behind this research is the congestion minimization algorithm based on [9] that uses a fuzzy logic based approach and an optimal relaying distance function for congestion estimation and minimization. The major drawback associated with this approach is that it leads to large number of packet drops since the function used to perform routing selects the next hop without considering the network connectivity aspect of the node. This research is aimed at proposing and implementing a novel congestion minimization algorithm named MARC-ORBFO (Minimization of vehicular traffic Congestion using Opportunistic Routing and BFO for VANET) with the primary objective to reduce packet drops and achieve better results than [9] in terms of parameters such as Latency, Throughput, Packet Drops and Overhead Ratio. The proposed congestion minimization technique works for highway scenarios. The proposed congestion minimization technique exploits the social relations/centrality aspect of the nodes [10] for next hop selection with the help of dynamic optimization with BFO [1] in order that packet delivery rates are maximized and better results are achieved in comparison to congestion minimization algorithm using [9].

2. RELATED WORK

Ramon Bauza et al. (2010) [3], In this paper, a novel congestion estimation technique is proposed that uses V2V communications and fuzzy logic. The proposed technique operates in two phases. In first phase, vehicles periodically exchange beacon messages and compute their local traffic estimates by using a fuzzy logic based congestion estimation system. In the second phase, a cooperative procedure is activated to collect local traffic estimates of different vehicles in case any vehicle's local traffic estimate exceeds a congestion threshold and routing is carried out using CBF. The authors conclude that the proposed technique possesses the capability to accurately quantify traffic congestion intensity.

Antonio A.F. Loureiro et al. (2014) [9], In this paper, a collaborative approach for congestion estimation and minimization has been proposed that operates in two phases. In the first phase, every vehicle estimates traffic congestion locally by using a fuzzy logic based congestion estimation system which takes fractional speed and segment occupation percentage as input and produces level of congestion as output. Second phase involves collection of local traffic estimates of different vehicles once the local traffic estimate of any vehicle exceeds a pre-defined congestion threshold. The authors conclude that the approach successfully reduced average travel times and CO_2 emissions.

Mingjun Xiao et.al (2014) [10], In this paper, a distributed optimal algorithm for mobile social networks (MSN) is proposed wherein an MSN is turned into a network that comprises community homes. In the proposed work, the authors turn routing between lots of nodes to routing between a few community homes. Reverse Dijkstra algorithm is used to compute the minimum expected delivery delay of nodes and achieve the optimal opportunistic routing performance. The authors conclude that the proposed approach substantially outperforms existing solutions.

Azzedine Boukerche et al. (2014) [12], In this work, an efficient and robust data dissemination protocol for highway scenarios has been proposed in the work to disseminate accident warnings on the road.The proposed approach assigns higher priority to vehicles lying in the preference zone and moving in the same direction as the source while the vehicles moving in opposite direction of the source are responsible for storing and carrying the messages. Simulations reveal that the approach achieved significant reductions in fuel consumption, trip time and CO_2 emissions under all accessed scenarios.

Azam Ramazani et al. (2014) [13], This paper proposes a novel context-aware approach to estimation of traffic congestion. The proposed approach uses vehicles as mobile traffic sensors that can estimate their local traffic state. Each vehicle estimates its level of traffic congestion locally through a fuzzy-based system which takes average speed and mean absolute acceleration of the vehicle as input parameters and produces the level of traffic congestion as the output parameter. Simulations reveal that the approach can estimate acceptable and accurate congestion levels in different traffic states.

Allan M. de Souza et al. (2015) [19], This paper proposes a novel technique aimed at avoiding the occurrence of congestion caused by accidents in urban centers. The proposed technique operates over three phases namely information generation, information dissemination and real-time decision making. Comparisons with some existing literature solutions show that the proposed technique outperforms these techniques.

Vinita Jindal and Punam Bedi (2016) [22], This paper reviews several aspects of vehicular networks such as types of communication, standards for wireless access in VANET, classification of routing protocol types, information dissemination protocols and challenges and research areas in vehicular networks. This paper aims to provide a thorough understanding of the different aspects of VANET which can prove useful for the researchers.

Roberto S. Yokoyama et al. (2016) [23], This paper proposes an intelligent traffic system that aims to improve the overall spatial utilization of the road network and achieve reduction in the average vehicle travel costs by avoiding vehicles from getting stuck in traffic. The proposed approach periodically collects information from the vehicles and uses this information to gather awareness about the traffic conditions of an AoI. The proposed work employs the *k*-NN algorithm for computing level of congestion of each road segment. Simulations reveal that the approach achieved substantial reduction in stopped time, travelled time and travelled distance when compared to existing solutions.

3. PROPOSED WORK

This paper proposes a congestion minimization algorithm named MARC-ORBFO (Minimization of vehiculAR traffic Congestion using Opportunistic Routing and BFO for VANET).

3.1 MARC – ORBFO: Working Principle

The proposed congestion minimization algorithm based on MARC–ORBFO exploits social relationships/profiles between the nodes for the selection of next hop with the help of dynamic optimization with BFO to ensure that the selected next hop using this mechanism will maximize packet delivery probability and thereby increase packet delivery rates. The proposed algorithm uses the concept of centrality for next hop selection with the help of dynamic optimization with BFO to achieve high delivery rates and better performance when compared to CARTIM [9].

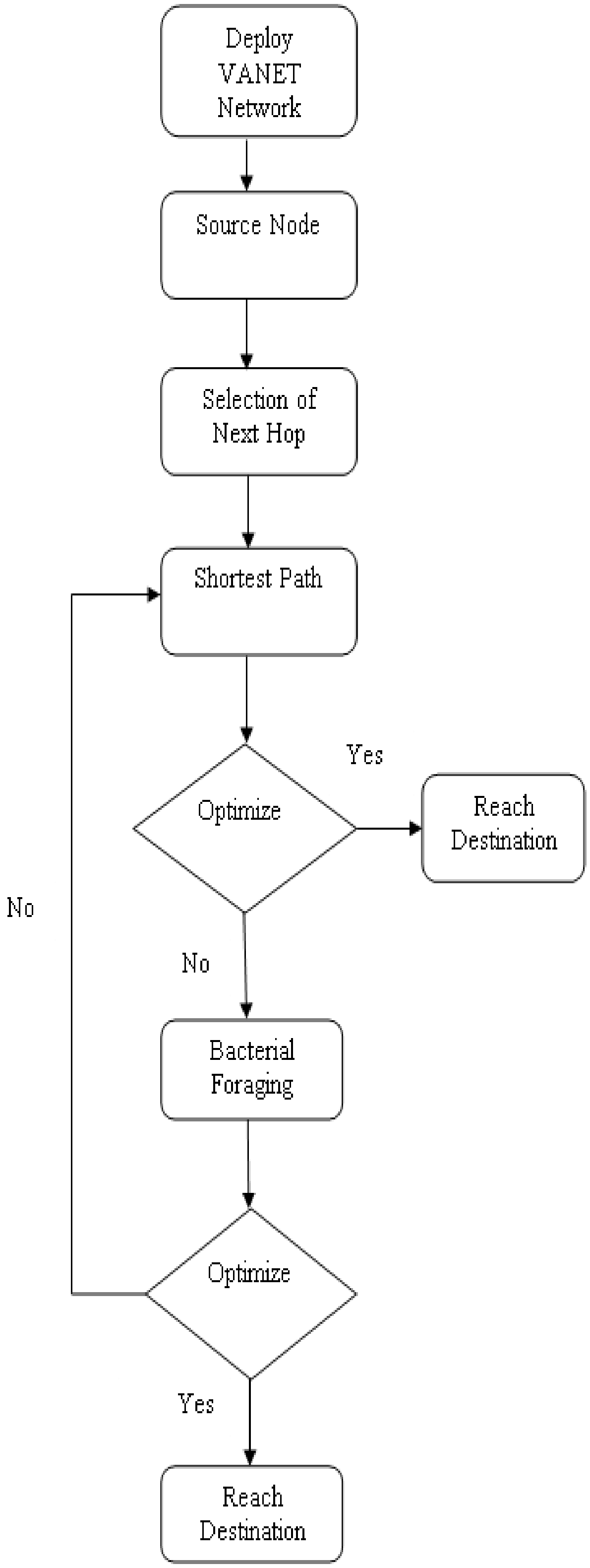

Fig. 1depicts DFD of Process

3.2 Methodology and Flow of Work

Step I: VANET network will be deployed and selection of next hop node will be done from the start node on the basis of optimal relaying distance function in order that shortest path can be found. Next hop node selection will be done only from among those nodes that satisfy the threshold for optimal relaying distance function.

Step II: In case the node to which the packet was forwarded goes out of the communication range or the packet gets dropped, dynamic optimization by BFO will take place for identifying the optimal next hop to which the packet should be forwarded. On the basis of the scenario that is inputted to BFO, BFO will compute the threshold value for centrality.

Next hop node will be selected from a node group having the highest centrality value among all others and the packet will be forwarded to that node.

Step III: In case of another packet drop, the algorithm will iterate to Step I.

Step IV: This process will iterate at each step to find the optimal next hop node.

4. RESULTS AND DISCUSSIONS

The proposed congestion minimization algorithm 'MARC-ORBFO' is simulated using ONE simulator. Simulations were conducted for a duration of 15000 milliseconds for computing all the results. The performance of the congestion minimization technique based on CARTIM [9] and the proposed technique namely MARC-ORBFO have been evaluated and compared in terms of parameters such as Throughput, Latency, Overhead Ratio and Packet Drops.

- Throughput

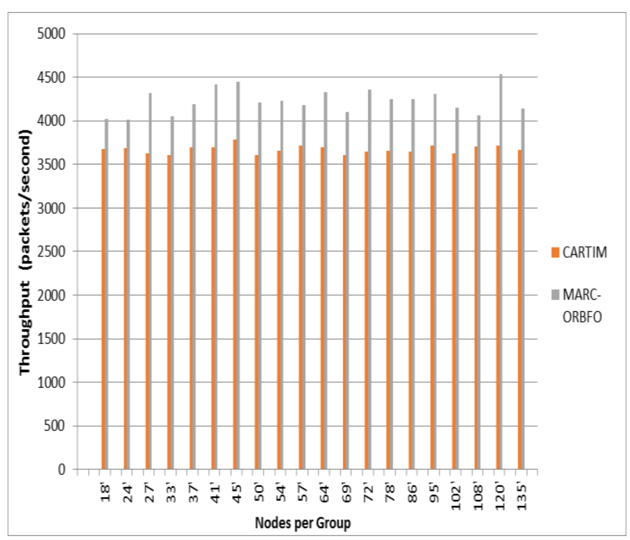

Fig. 2 depicts comparison of CARTIM and MARC-ORBFO in terms of Throughput in packets/sec

Figure 2 depicts the comparison of CARTIM [9] and MARC-ORBFO in terms of Throughput when increase the density of nodes. It will increase and reduce but not in specific pattern when density of vehicle increases but reduce to the limit of 3780.8 packets/sec in case of CARTIM and 4537.07 packets/sec in case of MARC-ORBFO that shows that MARC-ORBFO achieves better results than [9] because of decision by BFO (bacterial foraging optimization).

- Latency

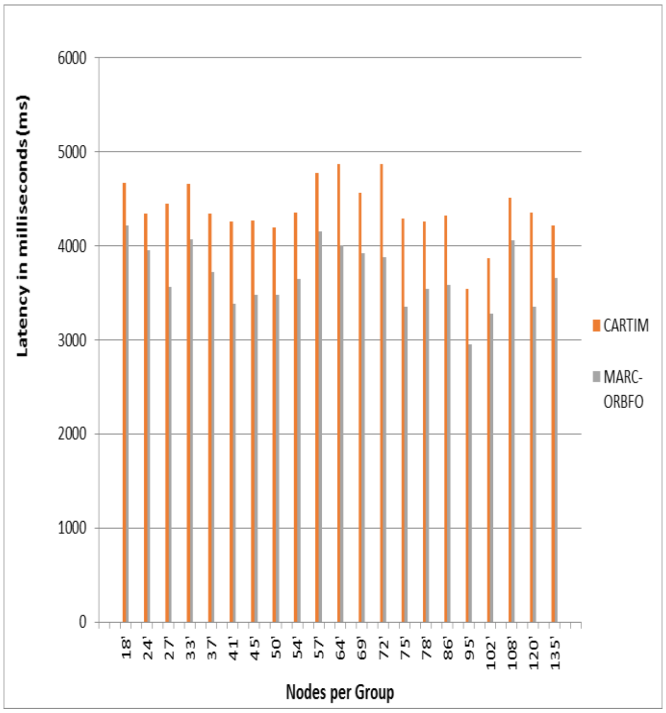

Fig. 3 Depicts comparison of CARTIM and MARC-ORBFO in terms of Latency in ms (Milliseconds)

Figure 3 depicts the comparison of CARTIM [9] and MARC-ORBFO in terms of Latency when increase the density of nodes. It will increase and reduce but not in specific pattern when density of vehicle increases but increase not after maximum limit 4869.84 ms in case of CARTIM and 4214 ms in case of MARC-ORBFO. It not increases as much in case of MARC-ORBFO because of decision by BFO (bacterial foraging optimization).

- Overhead Ratio

Figure 4 depicts the comparison of CARTIM and MARC-ORBFO in terms of Overhead Ratio when increase the density of nodes. It will increase and reduce but not in specific pattern when density of vehicles increases but increase not after maximum limit 1727 in case of CARTIM and 1000 in case of MARC-ORBFO. It not increases as much in case of MARC-ORBFO because of decision by BFO.

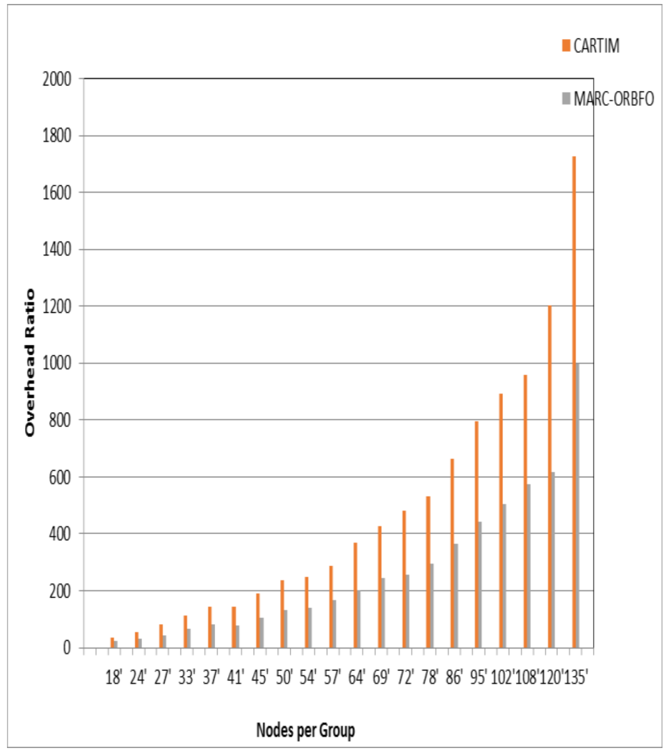

Fig. 4 Depicts CARTIM and MARC-ORBFO in terms of Overhead Ratio

- Packet Drops

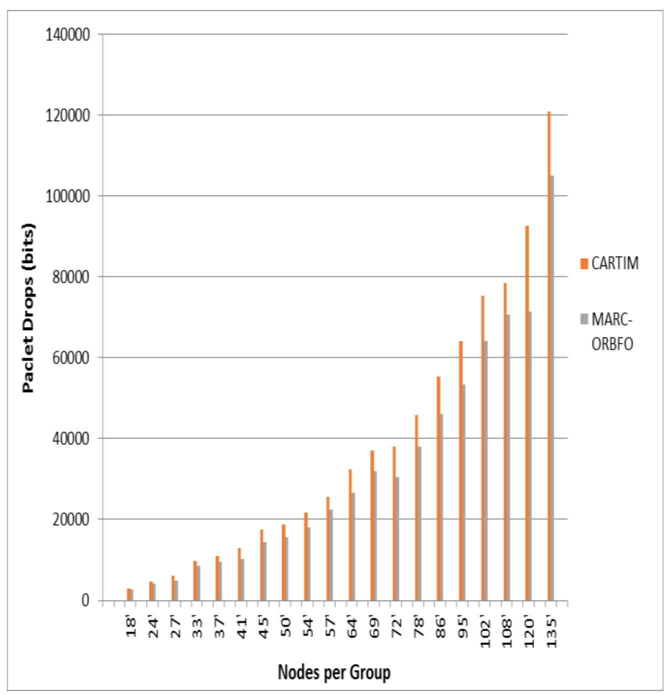

Fig. 5 Depicts comparison of CARTIM and MARC-ORBFO in terms of Packet Drops in bits

Figure 5 depicts the comparison of CARTIM and MARC-ORBFO in terms of packet drops when increase the density of nodes. It will increase and reduce but not in specific pattern when density of vehicles increases but increase not after maximum limit 120000 bits drop under 120 packets in case of CARTIM and 110000 bits drop under 110 packets in case of MARC-ORBFO. Packet drop is lesser in case of MARC-ORBFO because of decision by BFO (Bacterial Foraging Optimization).

- Overall Improvement Percentage

We will now analyze the overall percentage improvement in case of MARC-ORBFO in comparison to technique of [9] in terms of parameters such as Throughput, Overhead Ratio, Latency and Packet Drops.

Parameters	Improvement in Percentage
Throughput	15
Latency	16
Overhead Ratio	43
Packet Drop	15

Table 1 depicts the overall percentage improvement achieved through MARC-ORBFO over CARTIM

As evident from Table 1, we conclude that MARC-ORBFO achieves 15% improvement in Throughput, 16% reduction in Latency, 43% reduction in Overhead Ratio and 15% reduction in packet drops when compared to the base paper technique of [9].

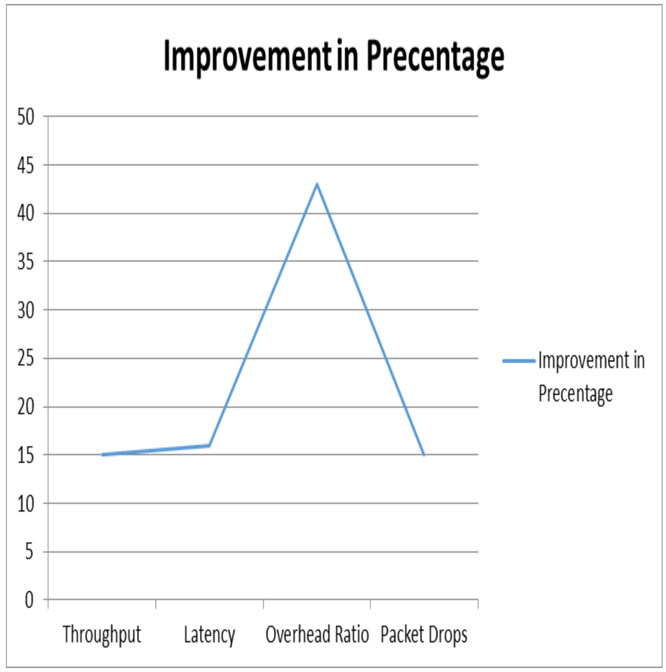

Fig. 6 illustrates the percentage improvement achieved in case of MARC-ORBFO over CARTIM

5. CONCLUSION

Vehicular Ad hoc Networks (VANETs) can provide scalable and cost-effective solutions for applications such as traffic safety, dynamic route planning, and context-aware advertisement using short-range wireless communication. To function properly, these applications require efficient routing protocols.

This dissertation shows that routing protocols which account for VANET-specific characteristics in their designs such as high density and constrained mobility can provide good performance for a large spectrum of applications.

This dissertation implements a novel congestion minimization technique 'MARC-ORBFO' that uses dynamic optimization by BFO and opportunistic routing to achieve better results in comparison to the base paper technique of [9].

The technique is simulated using ONE simulator and simulations reveal that the technique proposed in this dissertation achieves 15% improvement in Throughput, 16% reduction in Latency, 43% reduction in Overhead Ratio and 15% reduction in packet drops when compared to the base paper technique of [9] and hence outperforms the base paper technique in terms of all the considered parameters.

6. FUTURE SCOPE

It would be interesting to test the location service with more demanding scenarios such as the urban scenario using mobility models such as the Manhattan Model that represents a more challenging scenario. For the highway scenario that was used, the insertion of additional obstacles, including the highway's actual geometry (e.g., hills, bridges, curves and so forth) would make the mobility simulation more reliable, enhancing the quality of the tests developed hereafter.

Another interesting effort would be to promote efforts regarding the scalability solution tests, using not only more vehicles (upcharging the network) but more RSUs in order to also test the communication between them. For this to happen, there must be an effort to alter the routing protocol for it to operate multiple interfaces.

Lastly, it matters to mention the security requirement that even though it was not targeted in this work, is of extreme importance in environment a real deployment.

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Author

Aditi Saini is a Research Scholar in the Computer Science & Engineering Department, University School of Engineering and Technology, Rayat - Bahra University, Mohali, Punjab. She has been conferred with the degree of Bachelor of Technology in Computer Science & Engineering from Rayat - Bahra Institute of Engineering & Bio-Technology, Mohali, Punjab in 2014. She has varied interests in the fields of Networking and Software Engineering.