ISSN: 2321-7782 (Online)
Volume 3, Issue 12, December 2015
International Journal of Advance Research in Computer Science and Management Studies
Research Article / Survey Paper / Case Study
Available online at: www.ijarcsms.com

Vehicular Ad-Hoc Network (VANET): A Review Based on Performance Parameters

Komal Mehta[1]
Research Scholar, Electronics Engineering
G H Raisoni College of Engineering
Nagpur, India

Dr. P. R. Bajaj[2]
Director
G H Raisoni College of Engineering
Nagpur, India

Dr. L. G. Malik[3]
HOD CSE, Dept.
G H Raisoni College of Engineering
Nagpur, India

Abstract: ***Vehicular Ad Hoc network (VANET) is based on the principle of mobile Ad Hoc network (MANET) consisting of collection of vehicles acts as a routes communicating with roadside units for providing Vehicle-To-Vehicle (V2V) and Vehicle-To-Infrastructure (V2I) communications. VANET could be considered as component of the intelligent transportation system (ITS) and an application of MANET, VANET has become enormous attention from both the academia and industry [1]. The main function of VANET is to provide all-around connectivity between the mobile users on the road. VANET has some major applications like safety, traffic monitoring information sharing and management, platooning, vehicle tracking notification services, driving assistance and mobile internet access [2]. The performance of these applications is measured by some parameters. Selection of the parameters depends on the area of the particular application. This paper provides the survey of VANET based on the various performance parameters.***

Keywords: VANET; performance parameters; routing protocol; optimization; Nature Inspired Bio-Computing.

I. INTRODUCTION

Vehicular Ad-Hoc Network (VANET) is a sub branch of a Mobile Ad-Hoc Network (MANET), which incorporate the new techniques among the mobile vehicle nodes or Infrastructure based units(RSU) for betterment of the VANET's applications. The usefulness of any application or techniques can be analyzed by certain parameters, these parameters basically called performance parameters. Routing is a major concern in VANET. There are so many techniques already existing for routing but after that still it is a much highlighted topic among researchers. The effectiveness of any routing protocol is analyzed by performance parameters. So this paper provides the review of these routing protocols according to the performance parameters.

Performance parameters are the criteria for judging the efficiency of any particular technique. The engineer can select few parameters individually or the combination of certain parameters. The performance parameters can be divided in different groups according to the research challenges in the VANET. There are so many research challenges like:

- Wireless Access Technology
- Spectrum Allocation
- Routing
- Security and Privacy of the data

Wireless Access Technology and spectrum have certain parameters like:

- Data Latency

- Efficient Bandwidth Utilization
- Time to Live
- Transmission Power

For analyzing routing based protocols there are some parameters which can be used

- End-to-End Delay
- Packet Delivery Ratio
- Routing Load
- Control Overhead
- Number of Packets Dropped
- Jitter
- Throughput

Security and Privacy have certain parameters like:

- Link Reliability and Stability
- Data Quality
- Encryption and Decryption
- Packet Size
- System Profit

II. Related Work

This paper consist the literature review based on the performance parameters.

A. Packet Delivery Ratio

1) *iCARII: Intersection-based Connectivity Aware Routing in Vehicular Networks, 2014:* Authors Nizar Alsharif and Xuemin (Sherman) Shen provide an infrastructure based Connectivity Aware Routing (iCARII) protocol. Using centric cellular networks in vehicular communication applications provide more reliable communication but increases data explosion and network overload. A feasible solution is using VANETs for mobile data offloading when connectivity to infrastructure is guaranteed. iCARII integrates real-time locations and mobility information to estimate a minimum network connectivity lifetime and average delivery delay per road using a distributed algorithm and updates location centers using LTE channel. It enables mobile data offloading from LTE cellular network to VANETs. It shows the significant improvement of VANET performance in terms of packet delivery ratio and end-to-end delay with a negligible cost of routing overhead. In sparse VANETs, iCARII achieves higher PDR on the cost of higher delivery delay as it selects connected paths even with long trajectories [16].

2) *Flexible, Portable and Practicable Solutions for Routing in VANETs: A Fuzzy Constraint Q-Learning Approach, 2013:* PFQ-AODV protocol is designed for point to point communication for this the protocol checks whether the wireless link good or bad. This is done by considering mainly three metrics; these are the available bandwidth, link quality and relative velocity movement. It uses portable fuzzy constraint Q-learning protocol based on AODV routing that learns the optimal route by employing a Q-learning algorithm using hello messages and RREQ messages. It provides

improved packet delivery ratio and end to end delay in compare of AODV, QLAODV and AODV-L, but as the number of nodes increase or the speed of vehicle increase the delay also increases due to control overhead packets [21].

3) *Traffic Aware Optimized Zone Based Hierarchical Link State Routing Protocol for VANET, 2013:* Muhammad Shoaib and Wang-Cheol Song have proposed zone based hierarchical routing protocol for reducing network overhead by optimization of time interval for distribution of network control packets based on traffic awareness and mobility. Zones are formed by division of geographical segments that focusing on inter and intra-zone topology for stable in high speed due to frequently changing topologies. In ZHLS two levels of topology are defined using Link State Packets (LSPs) consisting of information about its neighboring nodes and zones and broadcasted within the zones in a specific period. After receiving a LSP update their LSP database. If does not exist, adds new LSPs and removes the out dated LSPs. The packet delivery ratio is good for the dense network but in sparse network its performance degraded also if a single link changes among the nodes (although the links are stable) it will broadcast entire LSP in each zone in order to keep routing table up-to-date which again increases the control overhead.[23]

4) *Road Topology Based Performance Analysis of Distance Vector Routing Protocols in VANET, 2013:* AOMDV (modification of the AODV protocol for computing multiple loop-free and link disjoint paths.) is better protocol for any of road topology such as highway, intersection or bridge. DSDV gives better performance than AODV when node density increased from low to high. Routing overhead of DSDV decreases where ever it increases for AOMDV as node density increases in all topologies. AOMDV protocol gives better efficiency for all possible topologies but as the number of nodes increases the routing overhead and delay both increases [10].

5) *A Stable Routing Protocol Using Segment by Segment Way in VANET, 2012:* Yun Ge et al have proposed a stable routing protocol (SRP) to provide stable route between source and destination using segment-by-segment way for highway scenario. Each node in SRP maintains a k-hop vicinity routing table. When a source node and a destination node are in the same vicinity, it implements proactive routing. Otherwise, route discovery has three phases: the source to anchor phase, the anchor to anchor phase, and the anchor to destination phase using location-based routing. For route maintenance, global route maintenance have used to reduce the path length. SRP protocol achieves higher data packet delivery ratio and shorter average path length by consuming relative more routing overhead. However, when no. of vehicle increases traffic density, path length, multi hop connection and routing overhead also increases. So it causes for short lifetime connection. Also if source and destination are in a different direction providing the stable route by segment is not easy [4].

6) *TIBCRPH: Traffic Infrastructure Based Cluster Routing Protocol With Handoff in VANET, 2010:* Tiecheng Wang and Gang Wang have developed dubbed Traffic Infrastructure Based Cluster Routing Protocol with Handoff (TIBCRPH). It utilizes the existing traffic infrastructures to form the cluster network. When vehicle moving across the cluster to reach destination, the selection of cluster head of that vehicle in each cluster is by calculating the dot product of velocity vector of a vehicle and its two neighboring cluster-heads, direction vector using hand off process by considering speed, direction and velocity of corresponding vehicle. For improving packet delivery author only uses one hop range at the node and the entire packet transmission take place through the intersection only. There are so many assumptions taken by the author and they also not simulate it on the real environment. Also the selection of dynamic cluster head for each vehicle based on handoff metric creates time delay if the existing cluster head leaves from the cluster [20].

7) *A New Cluster Based Routing Protocol for VANET, 2010:* YuyiLuo et al have proposed a Cluster Based Routing Protocol for VANET based on position and clusters. Geographic area is divided to form a foursquare grids and vehicle in a grid is elected to be the cluster head for routing the data across grids using routing table saved insource then send the packet to the optimal neighbor cluster header using the geographic information repeated this process until it arrives

at the destination node. However, when forwarding the packets each vehicle have to retain the up-to-date information about the routing table saved itself because of having no discovery process for finding the route. So it increases the network traffic when increasing no. of vehicles. If any cluster header leaves from the grid due to high mobility, determining the dynamic neighbor cluster header will cause for packet delay [22].

B. Bandwidth

1) *Bandwidth Impact on Bee Swarm Routing for Vehicular Ad hoc Networks,2012:* Salim Bitam has proposed to study the impact of the bandwidth on the robustness of the found routes discovered by the routing protocol. For providing the quality of service the author used QoSBeeVanet routing protocol. The robustness and the effectiveness of this proposal is evaluated by changing the required bandwidth along the vehicle movement. Simulation study in a realistic propagation model indicates that QosBeeVanet outperforms for packet delivery ratio and average end-to-end delay but due to transmission of additional control packets used to ensure the quality of service the normalized overhead load increases [17].

2) *HHLS: A Hybrid Routing Technique for VANETs, 2012:* Hybrid Hierarchical Location Service (HHLS) was made between Greedy Perimeter Stateless Routing (GPSR) as a geographic routing protocol and Hierarchical Location Service (HLS) as a location-based service. The major difference between HHLS and HLS/GPSR is implemented in three functions. The first function Poslookup handles the querying of destination's position; it looks into the local cache memory of the current node and updates the packet information with the destination's position. Then, the second function GPSREmit manages the creation and emission of new packets, it verifies at first, whether the sender has fresh or non-fresh information about the destination's position and then starts the routing of packets. If not, the function starts a new position query and places the packet into a buffer while the query is taking place. The function forwardPacket handles the forwarding of packets, it is called whenever a packet reaches an intermediary node, it verifies whether this node has a fresher position of the target and eventually updates the packet's information with it. Otherwise, if they reached node is in the same region of the destination, a new query must launch to retrieve the new position of the target [5]. The bandwidth needed for the routing layer and for the MAC layer is lower in HHLS than in HLS. This is due to the efficiency of the HHLS mechanism which launches the location query as late as possible. Mobility prediction is missing and due to resend the packet to the old location when the number of nodes increases the PDR decreases, average latency increases.

C. End-to-End Delay

1) *Probability Distribution of End-to-End Delay in a Highway VANET, 2014:* Reza Shahidi and Mohamed Hossam Ahmed find the probability distribution of the end-to-end information propagation delay of a message in a store-carry-forward highway VANET to calculate the probability that the end-to-end delay is less than given threshold. Author also calculated the Cumulative Distribution Function (CDF) of the end-to-end propagation delay T_d, F_{Td} (t), of a message travelling in a store-carry-forward VANET over a fixed distance on a highway. Author states that inter-vehicle message transmission within the communication range is assumed to be instantaneous (tens of milliseconds). Therefore, the only delay in message propagation occurs when a vehicle doesn't have any vehicles ahead of it within the communication range. Author shows that the analytical results which he found are close to simulation results. These results are important for propagating messages to vehicles in a timely manner and guaranteeing quality of service for various Internet applications [12].

2) *Enhanced Optimized Link State Routing Protocol for VANET using Fuzzy Rough Set,2013:* Komathy Karuppanan and Mahalaksmi S. focuses on adopting rough set to reduce the vagueness in the dataset. Traditional rough set has some drawbacks like difficulty in handling real valued attributes, information loss, and difficulty in identifying noisy data.

That's why author used Fuzzy rough set. System handles the problem of indiscernibility that are due to uncertainty exists in the dataset [15]. FR-OLSR has shown a significant performance improvement in terms of packet delivery and delay to be apt for data services on roads. But in sparse network PDR reduced due to less forwarder extend weaker connectivity.

3) *Opportunistic Service Promotion for End-to-End Delay Minimization in IEEE 802.11p Vehicular Networks, 2012:* Mohammad A. Salahuddin and Ala Al-Fuqaha propose a novel opportunistic service promotion technique for IEEE 802.11p (WAVE) to dynamically route lower priority packets through higher priority queues while meeting the required QoS w.r.t delay for all queues and underlying network link layer bounds [13]. In this paper the methodology entails formulating the opportunistic service promotion technique as an Integer Linear Programming (ILP) problem, to show the correctness and feasibility of it. Author proves that the end-to-end delay and effective throughput of the proposed service promotion technique performed better over classical WAVE implementation. The author used static priority assignment which shows a much difference in probability (traffic splitting parameter) and Weights (service splitting parameter) at distinct Access Categories

4) *Border-Node Based Movement Aware Routing Protocol, 2012:* It uses AMAR to choose the knowledge of mobility prediction and the concept of border-node within the sender's communication range to minimize the number of hops between source and destination is chosen from B-MFR. In city scenario or in situations where traffic density is very high, probability of two or more border nodes which are equidistant from the destination increases, this is a problem in B-MFR. To eliminate such type of problem BMAR uses the concept of AMAR. Now the border node which is moving with high speed and in the direction of destination will be chosen as a next hop node. Since the traffic density is high, again a conflict may occur. BMAR resolves it using the probability factor. Probability of changing the direction at intersection is high so BMAR discards the nodes with intersection in their route. If it does not suit in the situation then the node with highest successful transmissions is selected as next hop node [6]. Authors only proposed this algorithm, simulations not done.

5) *VADD: Vehicle-Assisted Data Delivery in Vehicular Ad Hoc Networks, 2009:* Vehicle-assisted data delivery (VADD) is based on the idea of carry and forward, where nodes carry the packet when routes do not exist and forward the packet to the new receiver that moves into its vicinity. Being different from existing carry and forwarding approaches, it makes use of the predictable mobility in a VANET, which is limited by traffic pattern and road layout [3].

D. Throughput

1) *A Mobile Infrastructure Based VANET Routing Protocol in the Urban Environment,2010:* JieLuo et al [26] have developed a mobile infrastructure based VANET (MIBR) routing protocol by making full use of the buses as a key component in selecting an optimal route which consists of a sequence of road segments and forwarding packets hop-by-hop through each road segment in the selected route. It estimates the hop count of each road segment by the expectation bus density and road length. When selecting the next forwarding road segment near the junction, it does not consider about the direction of vehicle as a result the vehicle on road is opposite to the direction of destination or the road may be one way road. Also velocity of vehicle is not considered. The throughput of MIBR is better than two channels because channel 2 has less congestion due to buses only compose 20% of all vehicles, and MIBR prefer choosing a bus as the next hop. Expectation bus density leads to inaccuracy of statistical data impacts on network performance.

2) *ACAR: Adaptive Connectivity Aware Routing for Vehicular Ad Hoc Networks,2008:*Qing Yang et al [25] have proposed this protocol that selects an optimum route adaptively consisting of road segments based on the quality of the

network transmission which is determined by the statistical and real-time density data gathered using on-the-fly density collection mechanism. Then for forwarding, each road segment in the selected route select the next hop path that minimizes the packet error rate of the whole route. ACAR makes use of the adaptive path selection mechanism, so the inaccuracy (10% was used in this case) of density data does not impact the network performances. It is well suitable for high dynamic topology changes. However, the transmission quality of each road segment based on real density and statistical data is estimated through sending the beacon packets periodically to every neighbor nodes. So the unparticipating nodes consume the network resources for control messages. While discovering and maintenance the routes in the presence of moving vehicles increases overhead.

3) *A Stable Routing Protocol to Support ITS Services in VANET Networks, 2007:* Tarik Taleb et al. uses the information on vehicle's movement information i.e. position, direction, speed and digital mapping of roads to predict a possible link-breakage event prior to its occurrence. Author grouped the vehicles according to their moving directions. Along the connection path, if an intermediate routing node changes its direction and belongs to a different group, the link rapture happens; it may degrade the throughput of the network. To avoid this Receive On Most Stable Group-Path (ROMSGP) dynamically searches for the most stable route that includes only vehicles from the same group so control messages are only forwarded within the same group only [14]. ROMSGP selects the stable and durable path so fewer path breaks and handoffs occur which increases the performance in term of high stability, reduced control overhead and high throughput. Author assumed that the roads are straight there are no curved segments like mountain areas. The selection of the path is depending on the Link Expiration Time (LTE), path with the longest LET is considered as the most stable link. But in some applications like safety application VANET require short delay path rather than durable path. ROMSGP cannot work in absence of GPS or signal cutoff conditions.

E. Route Stability

1) *Service-aware Multi-constrained Routing Protocol with QoS Guarantee Based on Fuzzy Logic, 2008:* It considers the QoS requirements asked by different kinds of services and takes different network state parameters as the constraint conditions. Zuo Jing et al. propose new route informing mechanism to support route update; speed of packet sending is adjusted as the output of the fuzzy system [19]. The author not considers the route stability, initially the design was taking care of it but while implementation the author selected packet buffer occupancy rate more important than route stability. Authors also find out the results for low mobile speed.

F. Safety

1. *HyBR: A Hybrid Bio-inspired Bee swarm Routing protocol for safety applications in Vehicular Ad hoc NETworks (VANETs), 2013:* To address the drawbacks of topology-based and geography based routing approaches, the hybrid routing protocol called Hybrid Bee swarm Routing (HyBR) protocol for VANET has been designed. HyBr is a unicast and a multipath routing protocol which guarantees requirements of VANET safety applications HyBR combines two fundamental routing methods namely; topology-based routing and the geography-based routing in order to reap their benefits on one and avoid their drawbacks at the same time. HyBR is a hybrid protocol which applies a topology-based routing approach when the network density is high (e.g., city-based VANET) and applies a geography-based routing approach when the network is not dense (e.g., highways). Using GPS devices, outdoors or through other means, each node saves the position information of all VANET nodes in a table called a positions table which is updated whenever the network topology changes. Moreover, each node possesses its own routing table which contains the various routes toward the desired destination. Only the next hop toward the destination is indicated [7].

2. *Localization Technique in VANETs Using Clustering (LVC), 2010:* This is a protocol of localization in VANet when no GPS information is available, based on clustering and has the advantage to use a single coordinates system. It based

on the clustering technique and uses the trilateration method for the establishment of the relative positions of the nearby nodes. This solution can be executed in three phases:

Phase 1: Selection of the first cluster head to be the center of the system and calculate the relative positions of all its neighbors in the group.

Phase 2: According to the first cluster head selected in the previous step, we choose the other cluster heads (CH) and their coordinates in the system.

Phase 3: This step will execute only if the chain of cluster heads is broken.

Simulation results show that the rate of calculated positions reaches at most 92,5 % with a position error does not overtake 8 m [11]. Every time when the number of vehicle increases the number of sent messages also increases. The error rate is also proportional to the velocity of the vehicles.

G. Communication Overhead

1) *PSR: Proactive Source Routing in Mobile Ad-Hoc Networks, 2011:* It can provide node with the cost of network structure information for source routing at a communication overhead similar to or even less than a proactive distance vector routing protocol. In PSR, nodes maintain and exchange BFSTs periodically. The full dump message containing the entire spanning tree is of the size O(|N|), which is in fact much less frequently broadcast than a compact differential updates. While achieving these objectives, PSR yields the same transportation capability as the more expensive protocols like OLSR and DSDV [1]. It has a disadvantage that the data packet is dropped immediately after the link layer reports a transmission error so that the UDP packet delivery ratio and TCP throughput decreases.

H. Flow of Traffic

1) *Self-Organization in Traffic Networks by Digital Pheromones, 2007:* The pheromone principle of ant colonies cannot be adopted for the traffic system exactly as it works in nature, though: Whereas the aim of the ant system is the exploitation of a source of food no matter where this source is located, vehicles try to reach a distinct destination as quickly as possible. The route through the road network to the destination has to be considered, as well, thus making the decision model for the vehicles more complex but letting the principle of stigmergy still be valid. The hypothesis of self-organization within a smart collective of vehicles, enhance the flow of traffic in a road network with increasing numbers of smart vehicles. The experiment finally validated the concept of self organization within a smart collective of vehicles [9].

I. Quality of Service(QoS)

1) QoS Swarm Bee Routing Protocol for Vehicular Ad Hoc Networks, 2011:In this paper, QoSBeeVanet, a new quality of service multipath routing protocol adapted for the vehicular ad hoc networks. It is based o ideas of the autonomic bee communication. Simulation results taken with NS2 in realist urban settings were shown that QoSBeeVanet outperforms DSDV and AODV two of the current state-of-the-art protocols, in terms of end-to-end delay, packet delivery ratio, and normalized overhead load. It focuses on a quality of service routing protocol suitable to the vehicular ad hoc networks. It is reactive, distributed and topology based protocol. QoSBeeVanet outperforms the standard proactive and reactive routing protocols DSDV and AODV in terms of end-to-end delay and packet delivery ratio. In terms of Normalized Overhead load the DSDV performs better than proposed protocol. The obtained results have been shown that the proposed protocol is more adequate to the transmission in realistic vehicular networks which require the QoS guarantees compared to DSDV and AODV [8].

2) *Towards Connectivity Improvement in VANETs using Bypass Links, 2009:* One important problem faced in ad hoc networks is network partitioning, causing the formation of isolated clusters, and preventing devices in different clusters

from communicating. Usually, devices composing the ad hoc network are provided with other communication interfaces rather than Wi-Fi and/or Bluetooth that allow them to connect to remote devices, such as GPRS/HSDPA. Additionally, there exists some network infrastructure in cities or roads that could be used by VANETs (e.g. hotspots). By taking advantage of these technologies and infrastructures, devices could be able to form a hybrid network, establishing remote links between them (called bypass links) in order to improve the network connectivity by joining, for example, separate clusters [24]. Cellular Genetic algorithm is used to solve the problem of optimizing the number and location of these remote connections for maximizing the QoS of the network. The approach proposed in this paper requires quite long computation time.

J. Network Load

1) *An Adaptive Connectivity Data Dissemination Scheme in Vehicular Ad-hoc Networks, 2011:* Wang Ke et al [18] have proposed adaptive connectivity data dissemination scheme for reducing the redundant copies of messages in hotspot areas by adjusting the hop limit of messages copies. Hotspot areas with high density of nodes are discovered based on vehicle movement process then using the contact of nodes, hotpot information will be spread. The nodes calculate the network connectivity by the distributed nodes density perception algorithm, then hop limit function is established on the basis of the Euclidean distance and nodes density between the nodes and hotspot and the hop count of the message transmitted will be limited dynamically.

III. Conclusion and Future Work

By referring above papers it was found that:

A. Most of the work done related to the routing protocols in VANETs is limited to vehicles a few hops away. There are some of the protocols which use the position information of the vehicle for forwarding the packets, whereas as some protocols use the mobility information of vehicles to carry the packets and forward it to the next available neighbor.

B. The designed topology based protocols have main limitation is discovery of routes with a high latency and high transmission delay especially when the network is less dense.

C. There is also a drawback of dropping of packets immediately the link layer shows some error in some routing algorithms.

D. The geographic based routing provide stability of route but it also have some drawbacks like, difficulty in finding an optimal next hop node, recovery strategies, long route formation etc.

E. In paper [20] mainly focusing on selection of cluster head using hand off processing existing infrastructure by considering speed, direction and velocity. When each vehicle moving across the cluster have to calculate hand off metric by considering the speed, direction and velocity for selecting the cluster head to transmit the data packet to the destination. It decrease packet delivery ratio and increases time delay. It forms the cluster using existing infrastructure. So, when forwarding data through cluster head does not consider about sparse and dense network of each cluster. It affects the movement of vehicles. According to speed, direction and velocity of each vehicle, dynamic changing of cluster head is a towering process. Also it has a routing loop problem when selecting neighbors for forwarding packets.

F. As in paper [22] if any node does not receive any LEAD or APPLY message there will be more nodes in a grid to become cluster head. It forms the grid without having any statistical data leads to inaccuracy of density data impacts on the network performance. When forwarding the packets, each vehicle have to retain the up-to-date information about the routing table saved itself because of having no discovery process and need to add the information of each node in the route to routed packet which increases the size of the packet will increase packet overhead in dense networks. So it increases the network traffic when increasing no. of vehicles. It does not consider about mobility of vehicle will cause for frequent network disconnections.

G. If fuzzy logic is used as in paper [21], tuning of fuzzy membership function and rules is required for making the protocol suitable for certain scenarios.

H. Most of the swarm based routing algorithms are performing very well in the chosen environment about the environment is not realistic in most of the cases.

I. Hybridization of ad hoc algorithms with NIBC is a good option for providing accurate and fast optimization results.

J. Classical methods have several disadvantages for solving complex problems like insecure convergence properties, long execution time, and algorithmic complexity. Besides, the solution can be trapped in local minima to overcome such problems researchers started using evolutionary and heuristic algorithms.

K. Evolutionary algorithms have their own disadvantages like; No guarantee for finding optimal solutions in a finite, Parameter tuning mostly by trial-and-error or Population approach may be expensive.

L. In recent years, the improved performance of routing mechanisms in ad hoc networks was one of the main issues. This is reflected by the appearance of hundreds of protocols in the literature of which only a few have been subjected to standardization.

References

1. Binitha S, S Siva Sathya," A Survey of Bio inspired Optimization Algorithms", International Journal of Soft Computing and Engineering (IJSCE) ISSN: 2231-2307, Volume-2, Issue-2, May 2012.
2. Xi Yu, HuaqunGuo and Wai-Choong Wong, "A Reliable Routing Protocol for VANET Communications" In Proceedings of the 7th International of Wireless Communications and Mobile Computing Conference (IWCMC), pp. 1748 – 1753, 2011.
3. Jing Zhao, Student Member, IEEE, and Guohong Cao, Senior Member, IEEE," VADD: Vehicle-Assisted Data Delivery in Vehicular Ad Hoc Networks" IEEE Transactions on Vehicular Technology, Vol. 57, No. 3, pp. 1910-1922, May 2008.
4. YunGe, Xin Fan and Xing Wang, "A Stable Routing Protocol Using Segment-by-Segment Way in VANET", International Conference on Computer Science and Information Processing (CSIP), IEEE, pp. 1078-1081, 2012.
5. Marwane Ayaida, Mohtadi Barhoumi, Hacène Fouchal, Yacine Ghamri-Doudane and Lissan Afilal, "HHLS: A Hybrid Routing Technique for VANETs", IEEE Global Communications Conference, GLOBECOM'12, 2012.
6. Monika, Sanjay Batish & Amardeep Singh, "Border-node based Movement Aware Routing Protocol", International Journal of Computer Science and Informatics, pp. 2231 –5292, Vol-1, Iss-4, 2012.
7. Salim Bitam, Abdelhamid Mellouk, Sherali Zeadally, "HyBR: A Hybrid Bio-inspired Bee swarm Routing protocol for safety applications in Vehicular Ad hoc NETworks (VANETs)", Journal of Systems Architecture, Nov. 2013.
8. Salim Bitam, Abdelhamid Mellouk, "QoS Swarm Bee Routing Protocol for Vehicular Ad Hoc Networks", In the Proceedings of IEEE ICC 2011.
9. Wolfgang Narzt, Ursula Wilflingseder, Dieter Kolb, Horst Hortner,Gustav Pomberger Oliver Seimel Jan Wieghardt Roland Haring, "Self-Organization in Traffic Networks by Digital Pheromones", International IEEE conference on Intelligent Transportation Systems (ITSC), 2007.
10. Nayana. P .Vaity, Dnyaneshwar. V. Thombre, "Road Topology Based Performance Analysis of Distance Vector Routing Protocols in VANET", International Journal of Advanced Computational Engineering and Networking, 2013.
11. Nasreddine. Lagraa, Mohamed. Bachir. Yagoubi and Sarah. Benkouider, "Localization Technique in VANETs Using Clustering (LVC)", IJCSI International Journal of Computer Science Issues,July 2010.
12. Reza Shahidi and Mohamed Hossam Ahmed, "Probability Distribution of End-to-End Delay in a Highway VANET", IEEE Communications Letters, 2014.
13. Mohammad A. Salahuddin and Ala Al-Fuqaha, "Opportunistic Service Promotion for End-to-End Delay Minimization in IEEE 802.11p Vehicular Networks", GC'12 Workshop: The 8th Broadband Wireless Access Workshop, 2012.
14. Tarik Taleb, Ehssan Sakhaee, Abbas Jamalipour, Kazuo Hashimoto, Nei Kato and Yoshiaki Nemoto, "A Stable Routing Protocol to Support ITS Services in VANET Networks", IEEE Transactions on Vehicular Technology, 2007
15. Komathy Karuppanan, Mahalaksmi S. "Enhanced Optimized Link State Routing Protocol for VANET using Fuzzy Rough set", Advances in Computing, Communications and Informatics (ICACCI), 2013.
16. Nizar Alsharif and Xuemin (Sherman) Shen, "iCARII: Intersection-based Connectivity Aware Routing in Vehicular Networks", IEEE ICC 2014 - Mobile and Wireless Networking Symposium, 2014.
17. Salim Bitam, "Bandwidth Impact on Bee Swarm Routing for Vehicular Ad hoc Networks", Multimedia Computing and Systems (ICMCS), 2012.
18. Wang Ke, Yang Wei-dong, Liu Ji-Zhao, Zhang Dan-tuo, "An Adaptive Connectivity Data Dissemination Scheme in Vehicular Ad-hoc Networks", Computational Intelligence and Security (CIS), 2011.
19. Zuo Jing, Chi Xuefen, Lin Guan, Li Hongxia,"Service-aware Multi-constrained Routing Protocol with QoS Guarantee Based on Fuzzy Logic", International Conference on Advanced Information Networking and Applications – Workshops, 2008.
20. Tiecheng Wang and Gang Wang. "TIBCRPH: traffic infrastructure based cluster routing protocol with handoff in VANET" In Proceedings of 19th Annual Wireless and Optical Communications Conference (WOCC), IEEE, pp. 1-5, 2010.

21. Celimuge Wu, Satoshi Ohzahataand Toshihiko Kato, "Flexible, Portable, and Practicable Solution for Routing in VANETs: A Fuzzy Constraint Q-Learning Approach", IEEE Transactions on Vehicular Technology, vol. 62, NO. 9, NOV 2013.

22. YuyiLuo, Wei Zhang and Yangqing Hu, "A New Cluster Based Routing Protocol for VANET", Second International Conference on Networks Security, Wireless Communications and Trusted Computing, vol. 1, pp. 176-180, IEEE. 2010.

23. Muhammad Shoaib and Wang-Cheol Song, "Traffic Aware Optimized Zone based Hierarchal Link State Routing Protocol for VANET", 24th International Symposium on Personal, Indoor and Mobile Radio Communications: Mobile and Wireless Networks, IEEE, pp. 3117 – 3122, ISSN: 2166-9570, 2013.

24. Bernabe Dorronsoro, Patricia Ruiz, Gregoire Danoy, Pascal Bouvry, and Lorenzo Tardon "Towards Connectivity Improvement in VANETs using Bypass Links", Evolutionary Computation, CEC'09, 2009.

25. Qing Yang, Alvin Lim, Shuang Li and Jian Fang and Prathima Agrawal, "ACAR: adaptive connectivity aware routing protocol for vehicular ad hoc networks." In Proceedings of 17th International Conference on Computer Communications and Networks, IEEE, pp.1 – 6, ISSN: 1095-2055, 2008.

26. JieLuo, XinxingGu, Tong Zhao and Wei Yan, "A Mobile Infrastructure Based VANET Routing Protocol in the Urban Environment", In Proceedings of International Conference on Communications and Mobile Computing (CMC), IEEE, vol. 3, pp. 432-437, 2010.

AUTHOR(S) PROFILE

Komal Mehta is pursuing PhD from G.H. Raisoni College of Engineering, Nagpur, India. She has 11.5 years experience and currently working in Bhagwan Parshuram Institute of Technology, Delhi. Her research interest includes Vehicular Ad Hoc Network, Bio-Inspired Computing and Microwave Engineering. She has 3 National Conference, 4 International Conference and 1 international Journal publications to her credit.

Dr. P. R. Bajaj holds a PhD degree in Electronics Engineering. She has 25 years experience and is currently working as Director, G. H. Raisoni College of Engineering, Nagpur, India. Her research interests include various domains like Soft Computing and optimizations, Hybrid Systems & Applications of Fuzzy logic in areas of Intelligent Transportation Systems. She is currently guiding 4 Doctoral students & 6 have been awarded PhD & 20 have completed M.Tech. She has also been instrumental to design and development of ITS systems in public and private sector like toll collection/toll audit /highway traffic management system and AITS by applying Soft/hybrid Computing. She has more than 100 publications in refereed International Conferences/Journals and 3 book chapters with citations 350 plus and h ratio 8.

Dr. Latesh Malik has completed Ph.D. (Computer Science & Engineering) from Visveyaraya National Institute of Technology in 2010. She is gold medalist in B.E. and M.Tech. She is currently working as Professor & Head of Department in Department of Computer Science & Engineering at G.H. Raisoni College of Engineering, Nagpur University, Nagpur, MS, India. She has teaching experience of 19 years. Mrs. Latesh Malik is life member of ISTE, CSI, ACM and presented 22 papers in international journal and 39 papers in international conference. She is recipient of 1 RPS and 1 MODROBs by AICTE. She guided 26 PG projects and 8 Ph.D. students are registered under RTM Nagpur University.

