International Journal of Computer Networks and Applications (IJCNA)
Volume 5, Issue 2, – August (2022)

**RESEARCH ARTICLE**

# Information dissemination strategies for safety Applications in VANET: A review

Mehul Vala
Phd scholar (EC), Atmiya University Rajkot

Dr. Vishal Vora
Associate Professor (EC), Atmiya Univerisity Rajkot

**Abstract – The Intelligent transportation system (ITS) aims to improve the performance of the transportation systems. Vehicular ad hoc networks (VANETs) are the potential mechanism by which ITS can realize its goal. VANET supports the idea of communication among moving vehicles. The next generation Vehicles is equipped with many embedded sensors, high processing power and wireless communication capabilities. These communication and computing capabilities has potential to enhance transportation safety, efficiency and provide infotainment while on the road. In VANET moving vehicles form ad-hoc networks through wireless connection for exchanging critical information. Safety related information dissemination is one to many communication, so multicasting or broadcasting schemes are utilized for information dissemination. Delivery of safety related messages must be fast and reliable. This criterion draws the researchers' focus to develop efficient dissemination schemes. This review paper discusses safety related data dissemination strategies, along with comprehensive classification, challenges and future research direction.**

**Index Terms – VANET, ad hoc network, broadcasting, beacon, multi-hop, data dissemination.**

## 1. INTRODUCTION

The ultimate goal of the intelligent transportation system (ITS) is to improve the performance of the transportation systems[1]. Vehicular ad hoc network (VANET) is the potential technology by which ITS can realize its goal. In VANETs, vehicles are intelligent in the sense that they are equipped with processing and communication technologies. VANET supports the idea of communication among moving vehicles[2]. Moving vehicles form ad-hoc networks through wireless connection for exchanging critical information. The standards that govern this communication are called wireless access in vehicular environment (WAVE). WAVE standards are actually a combination of Dedicated short range communication (DSRC) and IEEE 1609 standards[3]. Fig-1 shows DSRC protocol stack. The wireless connectivity can be categorized as Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) connectivity depending on connection between two moving vehicles or vehicles and stationary nodes[4]. The DSRC standards support both V2V and V2I communications with ranges up to 1000 m. It supports data rates from 3 to 27 Mb/s over a bandwidth of 10MHz[5]. Though DSRC supports V2I communication, installation of road side infrastructure is a costly affair. So to make it practically viable technology, infrastructure less pure ad hoc communication is preferred among researchers[6]. Practical range of transmission is less than 1 km and in certain situations the safety messages need to be sent to longer distances. In such a situation multi-hop broadcasting is crucial, hence it is drawing the attention of many researchers into developing efficient and reliable dissemination schemes beyond the transmission range of sender[7].

The structure of the paper will be as follows: Section 2 provides overview of VANET technology. Section 3 describes the classification of data dissemination strategies. Section 4 covers Safety data dissemination methods. Discussion and future scope covered in section 5 and finally section 6 concludes the paper.

## 2. VANET OVERVIEW

Vehicular ad hoc network (VANET) is a special case of mobile ad hoc networks (MANETs), in which every moving vehicle forms wireless connectivity with other moving vehicles for information sharing purposes[3].

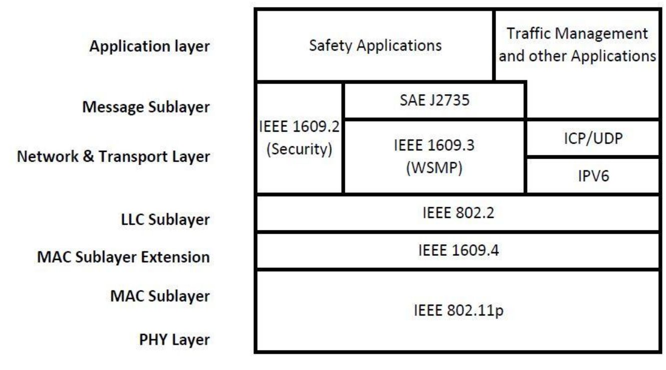


Figure 1 DSRC-protocol stack

RESEARCH ARTICLE

2.1 VANET Architecture

All the devices that constitute VANET architecture are defined as

- *On Board Unit (OBU):* OBUs are installed into vehicles. It establishes wireless connectivity with other OBUs and RSUs while on the move.
- *Road Side Unit (RSU):* RSUs are installed at regular intervals on roads and constitute Infrastructure in vanet. Technically RSUs are similar to OBUs but stationary in nature and used to establish wireless connectivity with moving vehicles. It may work as a bridge for Internet connection. Maximum DSRC range is $1$ Km. So to realize fully connected networks, RSUs need to be placed at every kilometer interval and raise the cost.

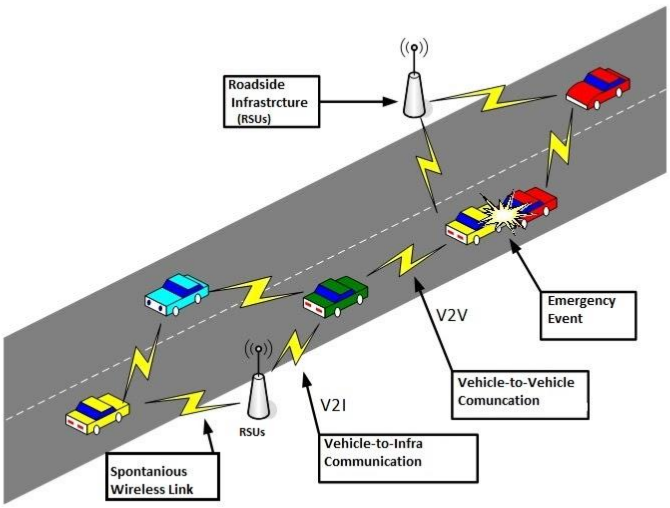


Figure 2 VANET Architecture

Smart vehicles are equipped with many sensors and processing devices which can collect and process crucial information. Through the use of V2V and V2I communication as shown in Fig-2, they can share it with other vehicles. For example vehicles can share its location, speed, direction to other vehicles for cooperative safety application realization.

2.2 VANET Standard

DSRC standards are designed for short to medium range of communication and its aim is to offer least delay and high data rate in VANET. The US Federation of Communication commission (FCC) has allocated 75 MHz of spectrum at 5.9 GHz (5.85 - 5.925 GHz) for V2V and V2I communication. DSRC standards are further composed of two standards IEEE 802.11p and IEEE1609. IEEE 802.11p governs the operation of Medium access Control (MAC) and Physical (PHY) Layers while IEEE1609 governs higher layers functions for vehicular communication[8].

2.2 VANET Applications

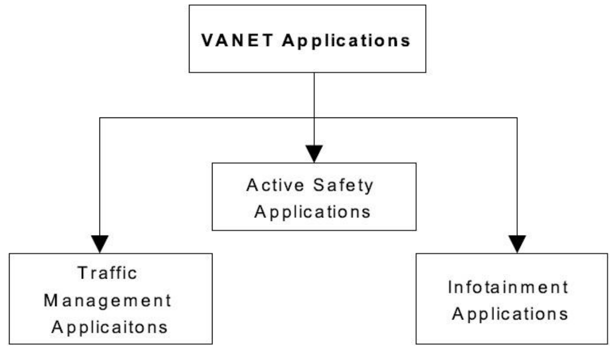


Figure 3 VANET Applications

Overall VANET applications can be broadly classified into three categories as show in Fig-3 [5].

2.2.1. Active Safety applications:

The main aim of active safety applications is to reduce life threatening accidents by providing warning to drivers so as to avoid collisions. Information like vehicle positions, speed, braking events etc can be shared to other vehicles. By processing collective information, vehicles can locate the hazards. Few representative active safety applications are shown in the Fig-4.

2.2.2. Traffic management applications:

This category of applications attempt to reduce road congestion, increase fuel efficiency, and support cooperative navigation. Few example applications are Speed limit warning, optimal speed for green light, cruise control, platooning.

2.2.3. Infotainment Applications:

This class of applications covers local as well global service offered to drivers. For example Nearest Fueling station, Internet access.

Three different classifications are presented above for vanet applications. The goal of VANET is to be able to provide all three classes of services with respective QoS requirements. Active safety applications are time sensitive applications and speedy propagation in networks is very crucial. It requires propagating the information beyond the transmission range of sending vehicles also. It is where multi

RESEARCH ARTICLE

hop information dissemination strategies need to be implemented[9].


Figure 4 Active Safety applications

## 3. DATA DISSEMINATION STRATEGIES

In VANET safety related applications, the shared data is usually important to a group of nodes. Due to High dynamic topology, and short wireless link lifetime traditional routing strategies will be ill suited for VANET applications. Hence most of the research work explores broadcasting based data dissemination strategies.

We can classify these information dissemination strategies into two broad categories. *Single-hop broadcast* and *Multi-hop broadcast* [7].

Both of the above strategies differ by the way information disseminates in networks.

### 3.1. Single-hop broadcast

In this method, the sender shares the information to its immediate neighbor vehicles. Receiving vehicles kept this information for own use. Periodically some of the information broadcasted to its single-hop neighbor vehicles. Many safety-related applications are implemented through Single-hop broadcast for example, braking event warning, Blind spot warning, lane change warning etc. Based on the frequency of broadcast single-hop broadcast strategies can be divided into *Fixed broadcast* and *Adaptive Broadcast* [10].

#### 3.1.1 Fixed broadcast

In fixed broadcast vehicle periodically broadcast crucial information to its immediate neighbors. The vehicles that receives these information, update their data base with these new information. At some fixed interval they also send few information with their neighbors. So by cooperatively sharing information to single-hop neighbors they ultimately enhance the transport safety. Here as the broadcast interval is fixed key design interest toward information selection and information aggregation. Selection of fixed interval is needed to be optimum. It should not promote congestion in network neither it should create scarcity of data[11].

#### 3.1.2. Adaptive Broadcast

In adaptive broadcasting, the broadcast interval is selected based on the need. Suppose it detects that the congestion is there in network then broadcast rate is reduced.

Single-hop broadcast schemes utilize store-and-forward strategy to convey information. Hence they are best suited for applications, where information needs to be shared to short distance and timing criteria is not very strict.

### 3.2. Multi-hop Broadcast

In proposed DSRC standard, the transmission range is 1 Km for communication, but experimental result shows that practical range is not more than 300 m. in such case to propagate safety related messages to longer distance multi-hop message forwarding schemes need to be utilized. In an ad hoc network, central coordination is missing, so establishing multi-hop message dissemination in VANET is a challenging task. The severity of the problem increases in extremely dense and sparse networks which are typical in vehicular communication[12].

Broadcast mechanism in its native sense is simple flooding. In simple flooding the sender broadcast the data to all single-hop neighbors. In Multi-hop broadcasting this data further propagated to receiver's neighbors and so on. In simple flooding, many vehicles broadcast the same packets and waste bandwidth. Plus in dense network, such kind of flooding easily creates congestion in the network. Sometimes it is referred to as broadcast storm problems.

Plain flooding leads to following problems in information dissemination[13].

- Excessive Redundant data
- Channel Contention
- Large Packet drops
- Delay in message delivery

Table 1 shows detail comparison between Single-hop broadcast and Multi-hop broadcast schemes.

RESEARCH ARTICLE

| Broadcast category | Characteristics | Advantage | Application |
|---|---|---|---|
| Single-hop broadcast | • Message exchange between immediate neighbor only<br>• Message exchange rate can be fixed or adaptive as per design.<br>• Delay tolerant scheme | • Less Redundancy<br>• Avoid broadcast storm problem | • Cooperative awareness applications such as Blind spot alert, Lane Change, Collision warning |
| Multi-hop broadcast | • Message exchange beyond 1-hop distance.<br>• Can cover large area through multi-hop message propagation<br>• Broadcast storm problem | • Time sensitive message can be conveyed to long distance. | • Emergency applications e.g., post-crash Alert, road condition Alert etc. |

Table-1: Comparative analysis of Single-hop and Multi-hop broadcast schemes

## 4. SAFETY MESSAGE DISSEMINATION METHODS

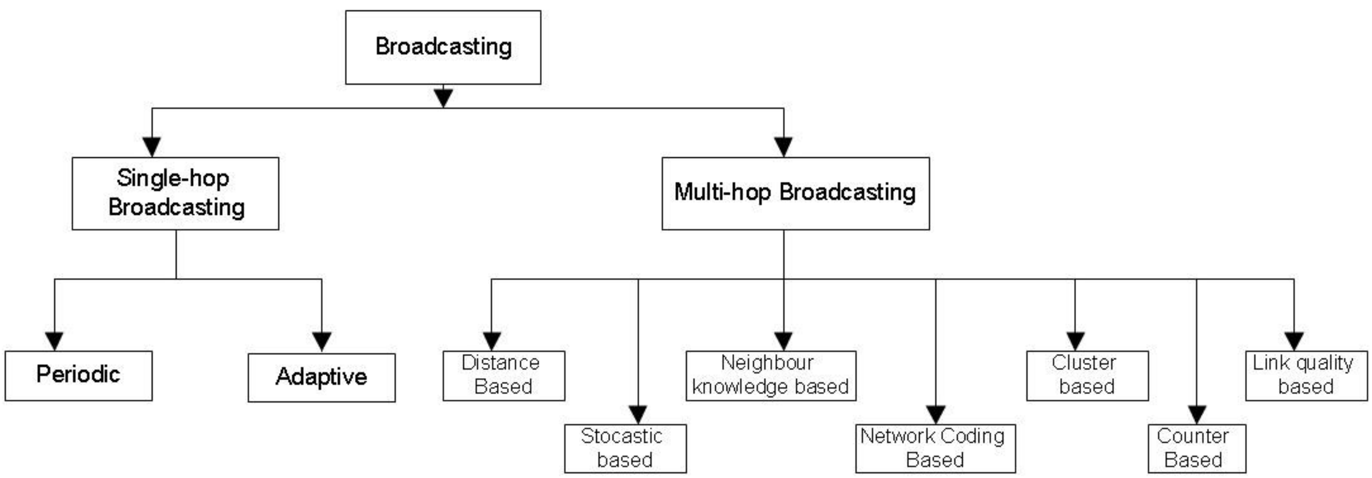


Figure 5 Complete Broadcast Classifications

As discussed above, plain broadcasting is very inefficient and leads to broadcast storm problem in network. To alleviate these problems, methods of selective broadcasting are practiced. In which upon receiving the packets at one-hop distance, out of all receiving nodes, one or few nodes are selected as a relay candidate to further broadcast the packets. Other nodes keep the data for their own use.

The popular selection strategies practiced in literature for relay node selection are: *Distance-dependent*, *Link quality based*, *Probability-based*, *Counter-based*, *Cluster-based*, *Network-coding based*, *Neighbor knowledge based* and *Hybrid* strategies as shown in Fig-5

***Distance-dependent:*** Based on the distance between sender and receiver, the farthest node is selected to relay the message. By selecting the farthest node for relaying, largest area can be covered with minimum-hop count.

***Link Quality Based:*** Realistic channel conditions considered for next hop selection. The next broadcasting node is selected based on received RSSI value or other channel conditions in this method.

RESEARCH ARTICLE

***Probability-based:*** Among the available nodes for relaying messages, different probabilities are assigned to every node for relaying the message. The node with highest probability will broadcast the message and other nodes will discard their scheduled broadcast when they hear the relay nodes broadcast. The probability assignment strategy is dependent on different parameters such as distance, density of vehicles, direction, and speed.

***Counter-based:*** In counter based scheme, whenever any node receives a broadcast packet, it first sets a random wait time before relaying it further. In wait time duration it will count the number of retransmissions of same packets. If the total retransmission is less than predetermined threshold then node will rebroadcast it, otherwise discard the broadcasting.

***Cluster-based:*** In this method, a group or cluster is formed among neighbor vehicles having common features. The common features include but not limited to relative velocity, acceleration, position, direction, Vehicle density, transmission range etc. A Cluster Head (CH) is selected within all Cluster members (CM). On behalf of all cluster members, only cluster head will broadcast the message toward other clusters.

***Neighbor knowledge Based:*** In this method, vehicles exchange among them several key information such as position, direction, speed. By processing this information, every vehicle forms knowledge about its surrounding network condition. Based on acquired knowledge vehicles choose the optimum node as a relay candidate.

***Network-coding Based:*** In this method transmitted data is encoded and decoded to enhance network throughput. Here relay nodes combine several received packets before transmitting. In this sense the aim is to reduce net transmission compared to broadcasting without network coding.

***Hybrid:*** To improve performance and alleviate limitations of above mentioned methods, sometimes researchers combine more than one method in the relay node selection process. All such methods belong to the hybrid category.

4.1. Beacon Assisted Vs Beacon-less

All the methods used for relay node selection can be either be beacon-assisted or beacon-less. Beacon assisted methods requires periodic exchange of *Hello Messages*, While Beacon-less methods do not have any such requirements[14]. Periodic exchange of beacons increase overhead but at the same time it improve performance. The Bandwidth is very precious resource in VANET, so to reduce wastage of bandwidth beacon-less methods can be utilized[15].

Following section refers and classifies papers based on beacon-less and beacon-assisted data dissemination strategies.

4.1.1. Beacon Assisted Protocols

DV-CAST exchanges periodic messages to one-hop neighbors and generate local topology knowledge. It stands robust against diverse traffic conditions. Each node continuously checks the local topology to find out any node in same or opposite direction to broadcast. It apply store-carry-forward mechanism when no node available in sparse network. Otherwise it applies rebroadcast suppression and efficiently forwards the packet. Weighted p-persistent suppression scheme used to reduce broadcast storm problem. The direction and position information beacons are needed to continuously exchange. In diverse scenario of dense and sparse network the optimum frequency of these beacon messages is very crucial in deciding performance of proposed work [16].

Inter-Vehicle Geocast (IVG) shares information of position, direction and acceleration to calculate the area of interest. From this area it selects the best forwarding nodes. Timer-based approach is used for broadcasting the messages. Whenever any message received and it is first time received, node will wait for specific time. Upon expiration of timer node will retransmit the message. Timer based next forwarder selection scheme reduces redundant transmission [17].

In Distributed Optimized Time (DOT) based approach beacon assisted timeslot density control is provided. Thus it addresses the scalability issue for dense traffic reducing the density of vehicles in each time slot. One-hop neighborhood infor mation exchanged thorough beacons to select the farthest vehicle for rebroadcast [18].

MOZO is a clustering based protocol[19], in which through hello messages vehicles collaborate with each other to form dynamic moving zones. The moving zone consists of vehicles having similar moving patterns and connected with one-hop link. Captain vehicle maintain the Combined Location and Velocity Tree (CLV-tree) to estimate position of vehicles in cluster. Whenever a vehicle leaves the cluster it is updated into the Leaving Event queue (LE). Though compared to position sharing less data needs to be exchanged, but it still needs neighbor information to perform data dissemination.

Major problem beacon assisted protocol faces is the frequent contention and broadcast storm. AddP adjust the retransmission rate based on node density to reduce broadcast storm problem. In addition to this AddP also select best suitable candidate to relay the packet based on local density and distance. To alleviate hidden node problem it propose transmitted packet monitoring mechanism to confirm if relay node has transmitted the message or not. Network coding based data aggregation mechanism utilized to reduce duplicate packets propagating in the network [20].

RESEARCH ARTICLE

Zhang in[21] have proposed an Adaptive Link Quality based Safety Message (ALQSM) forwarding scheme for vehicular network. In this, physical channel connectivity checking method is proposed. Based on the calculated connectivity probability among vehicles different score is assigned to potential forwarders. the score oriented priority method will select an optimal forwarder. This method aims to reduce the contention during broadcasting among different vehicles.

Data dissemination scheme presented In[22] is based on clustering and probabilistic broadcasting (CPB). a clustering algorithm form cluster of vehicles closely moving in same directions, which allows vehicles to exchange received messages with cluster head. During this phase probabilistic forwarding is used where probability is calculated based on how many times the message is received during defined interval. Only cluster head will forward the received message towards its transmission direction.

The Enhanced Counter-based broadcast protocol in Urban VANET (ECUV) improve data dissemination for urban VANETs use a road topology based approach to select the best relay nodes to coverage capabilities in urban Vehicle to Vehicle (V2V) scenarios. This protocol avoid broadcast storm problem by reducing the transmission probability in high vehicle density as well increase coverage in low density scenario[23].

4.1.2. Beacon-Less Protocols

SEAD utilize beacon-less method to estimate node density and based on estimated node density it dynamically define probability of rebroadcast. The redundancy ratio is computed at each node to find out node density as per given equation[24].

$$R = \frac{Total\ received\ messages\ (Original + Duplicated)}{Total\ new\ messages\ (Original)}$$

The locally measured metric offers a beacon-less and adaptive dissemination scheme that helps in reducing broadcast storm problem. The distance between sending and receiving nodes is utilized to compute wait time while node density will be used to compute retransmit probability. In this sense it is a hybrid beacon-less protocol.

Range Based Relay node Selecting (RBRS) protocol describe emergency warning dissemination protocol. The receiver node will refrain from immediate broadcasting and wait time for random time before retransmission. The wait time will be inversely proportional to the distance between sending and receiving vehicles. In this way the chosen relay vehicle will be the farthest vehicle from the sender. In cases when boundary vehicles are not available then chosen relay vehicle will wait unnecessarily longer time and the provided coverage area will be less due to close distance from the sender. It helps in reducing broadcast storm problem by discarding the scheduled transmission, when node hear the same message transmission by other relay node[25].

SAB protocols provide estimation of traffic conditions by speed observation through negative correlation between them. Three versions of Speed Adaptive Broadcast (SAB) protocols namely; Probabilistic-SAB, Slotted-SAB and Grid-SAB provided. Grid-based SAB provide lowest redundancy of packets among three proposed protocols. Without extra beacon overhead, this paper addresses the issue of scalability and reliability[26].

In [27] author represent a novel way to optimally use bandwidth by reducing large number of data packets, thus reducing the wastage of bandwidth. A Fuzzy based Beaconless Probabilistic Broadcasting Algorithms (FBBPA) is proposed. In which the broadcasting probability is calculated by considering distance, direction, angular orientation and buffer load. The packet having highest probability in buffer will be transmitted first.

DRIVE aims to mitigate the broadcast storm problem and network partitions by disseminating data within an Area of Interest (AoI). It does not require vehicles to maintain a neighbor table instead it uses a sweet spot to alleviate the broadcast storm problem and increase coverage range. Vehicle that is located within sweet spot is more likely to disseminate data and enhance coverage compared to distance based broadcasting [28].

In[29], wang designed a distributed relay selection method, by considering the locations, channel quality, velocities, and message receiving statuses of vehicles, to improve performance in highly mobile vehicular ad hoc networks. An instantly decodable network coding for the next relay vehicle to retransmit packets, resulting significant improvements in both network throughput and transmission delay. Simulation results show that the proposed strategy effectively reduces the delay of data dissemination in highway scenarios.

In [30] Beaconless Traffic-Aware Geographical Routing Protocol (BTA-GRP) protocol is proposed which tries to eliminate mobility induced unreliability in vanet. BTA-GRP is a improved geographic routing strategy which adapted to high mobility and link disconnection issues. It considers traffic density, distance and direction for next broadcast node. The protocol is suitable for dense as well sparse traffic.

RESEARCH ARTICLE

| *Protocol* | *Strategy* | *Forwarding Method* | *Objective* | *Scenario* | *Simulator* |
|---|---|---|---|---|---|
| IVG[17] | Beacon-Assisted | Distance-based | Broadcast storm | Highway | Glomosim |
| DVCast[16] | Beacon-Assisted | Neighbor knowledge | Broadcast storm & Disconnected network | Highway & Urban | Ns-2 |
| AddP[20] | Beacon-Assisted | Density and Distance Based | Broadcast storm & Hidden node | Highway & Urban | OMNeT++ |
| DOT[18] | Beacon-Assisted | Location-Based | Redundancy reduction | Highway | - |
| ALQSM[21] | Beacon-Assisted | Link Quality Based | Redundancy reduction | Urban | OMNET++ |
| CPB[22] | Beacon-Assisted | Clustering & Probability Based | Delay reduction, Improve Coverage | Highway | Ns-2 |
| MoZo[19] | Beacon-Assisted | cluster based | Broadcast storm | Highway & Urban | Ns-2 |
| ECUV[23] | Beacon-Assisted | Counter based | Broadcast storm | Highway & Urban | - |
| RBRS[25] | Beacon-less | Distance-based | Delay reduction | Highway | - |
| FBBPA[27] | Beacon-less | Fuzzy based | Delay reduction | Highway & Urban | Ns-2 |
| SEAD[24] | Beacon-less | Probability based | Broadcast storm | Highway | Ns-3 |
| SAB[26] | Beacon-less | Density based | Scalability, redundancy reduction | Highway & Urban | OMNeT++ |
| DRIVE[28] | Beacon-less | Location based | Overhead reduction | Highway & Urban | OMNeT++ |
| NCRS-NC[29] | Beacon-less | Network coding based | Delay reduction | Highway | - |
| BTA-GRP[30] | Beacon-less | Position base | Delay reduction, Disconnection issue | Highway & Urban | NS-2 |

Table-2 Comparative analysis of different information dissemination approaches

## 5. DISCUSSION AND FUTURE SCOPE

The message dissemination process will depend heavily on type of traffic, type of application and its QoS requirements. The forwarding strategy may be single-hop or multi-hop depending on the distance between sender and receiver as well performance criteria. The elected scheme needs to assure that all neighbor nodes have received crucial information through broadcast without network congestion, excessive delay and with good efficiency.

Single-hop communication can provide acceptable throughput but data delivery time is large due to the store-and-forward nature of communication. Hence it is suitable for delay tolerant applications, while performing poorly in delay-sensitive applications.

Due to limitations of single-hop communication, considerable research activities are ongoing toward multi-hop data dissemination schemes. A good multi-hop dissemination strategy will elect only a subset of neighbor nodes to re-broadcast the message in the network. The redundancy rate and congestion in the network is dependent on the elected scheme of dissemination.

## 6. CONCLUSION

This review paper provides review about VANET technology. Discussion on VANET architecture, VANET protocol stack and Applications provided. This review paper highlights importance of VANET in establishing ITS applications. Broadcasting is the basic mechanism for information dissemination in vehicular network. Due to high mobility and no centralized coordination, the task of message dissemination becomes very challenging. Safety related application is utmost important among all and need special consideration. A comprehensive classification of safety message dissemination is provided. Choice between Beac on less strategy and beacon assisted strategy is a trade of between

RESEARCH ARTICLE

reliability and bandwidth saturation. To efficiently utilize available bandwidth beacon-less schemes are suitable.

REFERENCES

[1] G. Dimitrakopoulos and P. Demestichas, "Intelligent transportation systems," *IEEE Veh. Technol. Mag.*, vol. 5, no. 1, pp. 77–84, 2010.
[2] H. Hartenstein and L. P. Laberteaux, "A tutorial survey on vehicular ad hoc networks," *IEEE Commun. Mag.*, vol. 46, no. 6, pp. 164–171, 2008.
[3] G. Karagiannis *et al.*, "Vehicular networking: A survey and tutorial on requirements, architectures, challenges, standards and solutions," *IEEE Commun. Surv. \& tutorials*, vol. 13, no. 4, pp. 584–616, 2011.
[4] K. C. Dey, A. Rayamajhi, M. Chowdhury, P. Bhavsar, and J. Martin, "Vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication in a heterogeneous wireless network--Performance evaluation," *Transp. Res. Part C Emerg. Technol.*, vol. 68, pp. 168–184, 2016.
[5] S. Al-Sultan, M. M. Al-Doori, A. H. Al-Bayatti, and H. Zedan, "A comprehensive survey on vehicular ad hoc network," *J. Netw. Comput. Appl.*, vol. 37, pp. 380–392, 2014.
[6] W. Liang, Z. Li, H. Zhang, S. Wang, and R. Bie, "Vehicular ad hoc networks: architectures, research issues, methodologies, challenges, and trends," *Int. J. Distrib. Sens. Networks*, vol. 11, no. 8, p. 745303, 2015.
[7] S. Panichpapiboon and W. Pattara-Atikom, "A review of information dissemination protocols for vehicular ad hoc networks," *IEEE Commun. Surv. \& Tutorials*, vol. 14, no. 3, pp. 784–798, 2011.
[8] S. Zeadally, R. Hunt, Y.-S. Chen, A. Irwin, and A. Hassan, "Vehicular ad hoc networks (VANETS): status, results, and challenges," *Telecommun. Syst.*, vol. 50, no. 4, pp. 217–241, 2012.
[9] S. Latif, S. Mahfooz, B. Jan, N. Ahmad, Y. Cao, and M. Asif, "A comparative study of scenario-driven multi-hop broadcast protocols for VANETs," *Veh. Commun.*, vol. 12, pp. 88–109, 2018.
[10] M. Naderi, F. Zargari, and M. Ghanbari, "Adaptive beacon broadcast in opportunistic routing for VANETs," *Ad Hoc Networks*, vol. 86, pp. 119–130, 2019.
[11] B. Pan, H. Wu, and J. Wang, "FL-ASB: A Fuzzy Logic Based Adaptive-period Single-hop Broadcast Protocol," *Int. J. Distrib. Sens. Networks*, vol. 14, no. 5, p. 1550147718778482, 2018.
[12] L. Wu, L. Nie, J. Fan, Y. He, Q. Liu, and D. Wu, "An efficient multi-hop broadcast protocol for emergency messages dissemination in VANETs," *Chinese J. Electron.*, vol. 26, no. 3, pp. 614–623, 2017.
[13] T. Saeed, Y. Mylonas, A. Pitsillides, V. Papadopoulou, and M. Lestas, "Modeling probabilistic flooding in vanets for optimal rebroadcast probabilities," *IEEE Trans. Intell. Transp. Syst.*, vol. 20, no. 2, pp. 556–570, 2018.
[14] B. Paul, M. Ibrahim, M. Bikas, and A. Naser, "Vanet routing protocols: Pros and cons," *arXiv Prepr. arXiv1204.1201*, 2012.
[15] R. Fracchia, M. Meo, and D. Rossi, "Vanets: To beacon or not to beacon?," in *IEEE Globecom Workshop on Automotive Networking and Applications (AutoNet 2006)*, 2006.
[16] O. K. Tonguz, N. Wisitpongphan, and F. Bai, "DV-CAST: A distributed vehicular broadcast protocol for vehicular ad hoc networks," *IEEE Wirel. Commun.*, vol. 17, no. 2, pp. 47–57, 2010.
[17] A. Bachir and A. Benslimane, "A multicast protocol in ad hoc networks inter-vehicle geocast," in *The 57th IEEE Semiannual Vehicular Technology Conference, 2003. VTC 2003-Spring.*, 2003, vol. 4, pp. 2456–2460.
[18] R. S. Schwartz, K. Das, H. Scholten, and P. Havinga, "Exploiting beacons for scalable broadcast data dissemination in VANETs," in *Proceedings of the ninth ACM international workshop on Vehicular inter-networking, systems, and applications*, 2012, pp. 53–62.
[19] D. Lin, J. Kang, A. Squicciarini, Y. Wu, S. Gurung, and O. Tonguz, "MoZo: A moving zone based routing protocol using pure V2V communication in VANETs," *Ieee Trans. Mob. Comput.*, vol. 16, no. 5, pp. 1357–1370, 2016.
[20] R. Oliveira, C. Montez, A. Boukerche, and M. S. Wangham, "Reliable data dissemination protocol for VANET traffic safety applications," *Ad Hoc Networks*, vol. 63, pp. 30–44, 2017.
[21] X. Zhang, Q. Miao, and Y. Li, "An adaptive link quality-based safety message dissemination scheme for urban VANETs," *IEEE Commun. Lett.*, vol. 22, no. 10, pp. 2104–2107, 2018.
[22] L. Liu, C. Chen, T. Qiu, M. Zhang, S. Li, and B. Zhou, "A data dissemination scheme based on clustering and probabilistic broadcasting in VANETs," *Veh. Commun.*, vol. 13, pp. 78–88, 2018.
[23] L. Khamer, N. Labraoui, A. M. Gueroui, S. Zaidi, and A. A. A. Ari, "Road network layout based multi-hop broadcast protocols for Urban Vehicular Ad-hoc Networks," *Wirel. Networks*, vol. 27, no. 2, pp. 1369–1388, 2021.
[24] I. Achour, T. Bejaoui, A. Busson, and S. Tabbane, "SEAD: A simple and efficient adaptive data dissemination protocol in vehicular ad-hoc networks," *Wirel. Networks*, vol. 22, no. 5, pp. 1673–1683, 2016.
[25] T.-H. Kim, W.-K. Hong, H.-C. Kim, and Y.-D. Lee, "An effective data dissemination in vehicular ad-hoc network," in *International Conference on Information Networking*, 2007, pp. 295–304.
[26] M. Chaqfeh and A. Lakas, "A novel approach for scalable multi-hop data dissemination in vehicular ad hoc networks," *Ad Hoc Networks*, vol. 37, pp. 228–239, 2016.
[27] A. Srivastava, A. Prakash, and R. Tripathi, "Fuzzy-based beaconless probabilistic broadcasting for information dissemination in urban VANET," *Ad Hoc Networks*, vol. 108, p. 102285, 2020.
[28] L. A. Villas, A. Boukerche, G. Maia, R. W. Pazzi, and A. A. F. Loureiro, "Drive: An efficient and robust data dissemination protocol for highway and urban vehicular ad hoc networks," *Comput. Networks*, vol. 75, pp. 381–394, 2014.
[29] S. Wang and J. Yin, "Distributed relay selection with network coding for data dissemination in vehicular ad hoc networks," *Int. J. Distrib. Sens. Networks*, vol. 13, no. 5, p. 1550147717708135, 2017.
[30] S. Din, K. N. Qureshi, M. S. Afsar, J. J. P. C. Rodrigues, A. Ahmad, and G. S. Choi, "Beaconless traffic-aware geographical routing protocol for intelligent transportation system," *IEEE Access*, vol. 8, pp. 187671–187686, 2020.

Authors

**Mehul Vala** received his B.E. degree (Electronics & Communication) from Saurashtra University, India in 2008 and Master in Engineering (Communication System) from Gujarat Technological University in 2015. He is currently pursuing Ph.D. degree from Atmiya Univerisity, Rajkot, India. His research interests include vehicular ad hoc networks and broadcasting in vehicular ad hoc networks.

**Dr. Vishal Vora** received Ph.D. degree in 2017. He has 16 years of teaching experience and is presently working as an Associate Professor in the Department of Electronics & Communication Atmiya Univeristy Rajkot, India. His research interest includes Embedded Systems, VLSI Design, IoT and Intelligent Transportation System. He has authored many publications in national/ international journals and conference proceedings. He has guided many research scholars leading to M.E./M.Tech.