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Multihop broadcasting of emergency message dissemination in Vehicular Adhoc Networks

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ABSTRACT
Vehicular Adhoc Network (VANET) is a distinct type of Mobile Adhoc Networks (MANET) that makes use of moving vehicles as nodes to create a mobile network. The vehicles that are in radio range of each other can communicate with one another. Timely message dissemination is extremely important for the delivery of critical information. Generally, data dissemination in VANET is broadcast oriented. Multihop broadcasting can be used to spread emergency messages. In this paper, the proposed work is compared with the existing approaches using NS2. The simulation results show the reduction on transmission delay and improved packet delivery ratio.
Keywords—VANET, broadcasting, dissemination

1. Introduction
VANETs offer wireless communication between vehicles and Road Side Units (RSU). Vehicle-to-Vehicle (V2V) communication takes place among the vehicles. Vehicle-to-Infrastructure (V2I) communication involves the exchange of information between vehicles and RSU. There are frequent disconnections and topology change in VANETs. Therefore, routing protocols used in MANETs are not suitable for VANETs as in MANET's protocols there may be an implicit assumption of network connectivity. Intermittent connectivity, frequent changes in network topology and low reception rate are the features that differentiate VANETs from other types of Adhoc networks.
Data dissemination refers to single source node streams data to one or more link nodes. When an emergency event occurs, the warning message ought to be disseminated to all vehicles in danger in the zone of interest as possible. The objective of data dissemination is to efficiently spread-out a given message from source node to the rest of the nodes in the network by exploiting multi-hop communications [1]. Data dissemination refers to spreading the data or information over distributed networks. Data dissemination in VANETs improves the efficiency of traffic system and quality of driving. It is tough for vehicles to communicate among themselves due to large number of vehicles on road [8]. It becomes very challenging task for vehicles to transmit information over the network [2]. Normal messages are not time critical. Emergency/Safety messages are time critical and it should reach at the earliest [14].

Table 1. Data dissemination techniques

Approaches	Applicability	Drawbacks
V2I/I2V	Spreads information about the road conditions, enquire information about nearby restaurant, parking lot, etc.	Highly expensive, requires lot of infrastructure to be installed, latency issues.

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V2V Forwarding	During the low traffic conditions, flooding approach is good for delay sensitive application and suitable for sparse networks. Relaying is preferred for congested networks.	Flooding is not suitable for dense networks. Reliability is difficult in relaying.
Opportunistic	Suitable for entertainment applications.	As the vehicle density increases, server load increases. Flooding and storm problems occur.
Geographic	Less suitable for safety applications.	High latency, low success rate in message delivery and broadcast storm
Cluster based	Reduces delay and storm issues	High computational cost to connect the clusters with each other.
Peer to peer	Suitable for content dissemination. Does not cause message storm.	Decrease bandwidth and storage capacity per node quickly.
QOS based	Safety related application	During data communications, QOS based clustering algorithms are required to maintain the stability of the clusters.
Delay based	Improves packet arrival ratio. Reduces retransmission of packets. Deals with broadcast storm problem.	If the protocol is not designed accurately, the timer Quantization effect may result in stopping the dissemination.
Probability based	Forward packets with certain probability to reduce information redundancy.	Higher density may lead to more communication redundant and the broadcast storm.

Some of the main issues during dissemination of data includes High mobility, Data delivery, Data transmission over mesh nodes, Data passing through different structures is tough and Data Collection. Vehicles move with an excessive speed and the topology changes. There is a frequent topology disconnection. The vehicle density is low during night in urban areas and both day and night in sub-urban areas. Vehicle density is high in urban areas during rush hours in a day. When large number of vehicles requests same data at same time, data delivery becomes challenging. When vehicles operate in limited bandwidth, the network gets disconnected. All the nodes are not connected for long time and over the desired distance to ensure smooth flow of information. It is tough to transmit data over mesh nodes. It is difficult to maintain different structures like tree, grid, and clusters for data dissemination. The problems may arise due to dense or sparse network at random points in the vehicular network zone. This will cause network disconnection and partition. The data is collected from different sources before dissemination. As the vehicle speed is high, it becomes challenging to collect the information when the number of vehicles is more.

The rest of the paper is structured as follows: Section 2 presents some of the existing literature surveys that are closely related to this paper. Section 3 reviews existing dissemination schemes such as one-hop and Multihop approaches. Section 4 presents the Multihop broadcasting dissemination schemes. Section 5 presents the proposed work. In Section 6, performance metrics are used to assess existing broadcast dissemination schemes and shows our simulation results and the results are compared with the proposed method. Lastly, Section 7 concludes this paper.

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2. Literature Review

Table 2 presents some of the existing literature surveys that are closely related to this paper.

Table 2: Existing survey

Author name	Approach used	Advantages	Disadvantages
Osafune et.al [9]	Flooding protocol	Forwards packets efficiently.	Scalability issues
Yu and Cho [10]	Flooding method based on time	Considers priority for forwarding messages.	Delay in selecting vehicle for rebroadcasting Emergency messages.
Muthamizh et.al [11]	Spanning tree-based broadcasting protocol	Reduce end to end delay by reducing duplicate message.	As the number of vehicles in the traffic increases, there will be delay in message delivery.
Nakorn et al [12]	Density aware reliable broadcasting protocol	Performs periodic beaconing.	Each vehicle stores rebroadcasting message. The message overhead is high.
Sanguesa et al [13]	Nearest Junction Located	Topology and Location information of receiving nodes are used.	It does not provide optimal performance in sparse scenarios.

3. Single hop broadcasting vs Multi hop broadcasting

Dissemination schemes are categorized into two: One-hop and multi-hop. One hop messages are periodically exchanged by neighbor nodes and that are not forwarded to other vehicles. Each node broadcasts messages stored on their On Board Unit (OBU) to its one-hop neighborhood. Sender and receiver vehicles must guarantee mutual authentication, integrity checks and data confidentiality. The message is not flooded through the network. Vehicle's one hop communication radius is limited by factors like communication power and building obstacles.

Multi hop broadcasting will send warning message to its neighbors and this message will be rebroadcasted by receiving vehicles in a multihop manner to notify the nearby vehicles. Packets are spread through multiple hops, where different vehicles act as relay nodes. Reliability and trustworthy of disseminated data are required. As the intended coverage range of emergency message is large, the message should be disseminated hop by hop among connected vehicles on a road. Best way is multicast broadcast using relaying. All the vehicular nodes may not be able to receive the broadcasted data in single hop because of the limited radio communication range. So multihop communication is required.

The main advantage of using broadcasting protocols is that a vehicle does not need to know a destination address and a route to a specific destination. This eliminates the complexity of route discovery, address resolution, and topology management, which are difficulties in VANETs [6]. The following table contains the list of data dissemination broadcasting protocols in VANET [4] [7] [8].

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Table 3: Broadcasting protocols in VANET

Protocol	Type	Description
TrafficInfo	Single hop Broadcasting	Focuses on the selection and aggregation of information.
Trafficview	Single hop Broadcasting	Designed for enabling the traffic information exchange among vehicles.
Collision Ratio Control Protocol (CRCP)	Single hop Broadcasting	Each vehicle disseminates the traffic information periodically.
Abiding Geocast Protocol	Single hop Broadcasting	Designed to disseminate safety messages within a useful area where these messages are still relevant.
Urban Multi-hop Broadcast (UMB)	Multi hop Broadcasting	Designed to solve the broadcast storm, hidden terminal and reliability problems.
Slotted 1-Persistence Broadcasting Protocol	Multi hop Broadcasting	It broadcasts the packet according to an assigned time slot.
Fastest Vehicle	Multi hop Broadcasting	It uses speed information of each vehicle for message transfer and distance of the selected vehicle from the destination vehicle.
Autocast	Multi hop Broadcasting	It is the rebroadcast probability that is determined from the number of neighbors around the vehicle.
Speed Adaptive Probabilistic Algorithm (SAPF)	Multi hop Broadcasting	SAPF is based on vehicle speed, to optimally reduce message delivery delays caused by increased contention in areas with high density vehicle.
Broadcasting over Dynamic Forest (BODYF)	Multi hop Broadcasting	It relies on a tree topology (Spanning forest).
Vector-base TRAcking DEtection (V-TRADE)	Multi hop Broadcasting	The vehicle classifies its neighbors into multiple classes based on position and moving direction.
Simple and Efficient Adaptive Data Dissemination Protocol (SEAD)	Multi hop Broadcasting	It combines delay and probability based dissemination schemes. There is no beacon exchange.
Simple and Efficient Cluster Head Adaptive Data Dissemination Protocol (SECADD)	Multi hop Broadcasting	It tackles the broadcast storm problem by reducing excessive broadcasts. No becaconing exchange is required.

4 Multihop dissemination schemes

The emergency messages are assigned high priority for the purpose of data dissemination. The Multihop dissemination schemes are classified as store and forward, beacon based, topology based, flooding based and probabilistic based. Emergency messages are broadcasted where all the nodes in

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the coverage area of the sender are expected to receive the message.

Table 4: Emergency message classification

Code	Category	Comment
1	Safety of life	Emergency Break warning/Avoidance
2	Safety of life	Road Slippery
3	Safety of life	Collision ahead
4	Safety	Intersection warning
5	Safety	Transit vehicle signal priority
6	Non safety	Heavy work in progress
7	Non safety	Slow traffic

Vehicles moving with high speed may exceed 120 km/hr, even if these vehicles are very from danger, they may reach very soon, here the timely message dissemination is important to avoid danger. Emergency message which carries information about the incident contains timestamp at which the message is generated, type of message and the duration of validity. If the message is duplicate, message is discarded. Message validity is calculated based on the number of hops and the value of the time stamp parameter.

5 Proposed Work

Any node can falsely broadcast a message that never happened. The content of the message can be altered by the attacker. Autonomous vehicles can be targeted with these attacks. To avoid this issue, clustering-based message dissemination is used. The vehicles form a cluster based on the geographical area. Cluster Head is given administrative credentials to transfer the messages to the nodes in the cluster. Cluster Members (CM) are the vehicles other than cluster head. The main advantage of using clustering approach identifies the intruders and they are stopped from broadcasting false alerts. Vehicles are clustered dynamically in order to handle the broadcast storm problem.

Algorithm for Emergency Message Dissemination

Parameters used:

CN-Current Node, S – Source, RV-Receiver Vehicle, TV- Transmitter Vehicle, CH-Cluster Head, CM- Cluster Member, D- Distance, N-Node

Input: Cluster nodes

Output: Emergency Message Dissemination

If vehicle detects a dangerous situation and schedules a msg,

If (CN =CH) then

Send warning msg to its neighbors

CH forwards to CM and neighboring CH

RV rebroadcast

Else (if CN = CM) then

Send msg to CH

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Else

If (N!= CM)

// calculate the Distance

If D (RV, S) < D(TV,S)

Broadcast the msg

Else

Discard the msg

End if

End if

End if

If sparsely connected network

Nodes rebroadcast

End if

If networks disconnected

Nodes store the broadcasting packet

Waiting time for t milliseconds

If (node finds another node in its broadcast range)

Broadcast the msg

Else

Discard the packet

End if

End if

Source vehicle initiates the dissemination process by broadcasting the packets containing life critical information. If the receiver node is closer to the source node than the transmitting node, then the message scheduling can be cancelled. The received packet is discarded as its transmission is not required anymore. Clusters help to improve the connection lifetime by grouping together vehicles with similar attributes like speed, location and direction of travel.

6 Result and Analysis

Slotted 1-Persistence Dissemination Protocol (S1PD) yields significant decrease in the number of redundant broadcasts. In S1PD, the transmission range is divided into various areas designated as “slots”. Incoming packet format contains source vehicle ID and a local packet ID. The packet header contains the GPS coordinates of the vehicle and Broadcasting Node ID. Each vehicle contains a data buffer to store original data packets received or generated by the local application running on the transmitter vehicular node. Whenever the packet reaches the vehicle, it checks

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whether the message ID is known by the cluster head. The received redundant message is discarded after the redundancy ratio parameter is updated. The disadvantage is that S1PD suffer from Timeslot Boundary synchronization problem [15].

A Simple and Efficient Adaptive Data Dissemination Protocol (SEAD) is a hybrid protocol that combines delay and probability-based dissemination schemes. It depends on distance, direction and vehicle's density. There is no beacon exchange. SEAD has high packet delivery ratio and acceptable delay. It can also minimize the bandwidth consumption. Simple and Efficient Cluster Head Adaptive Data Dissemination Protocol (SECADD) tackles the broadcast storm problem by reducing excessive broadcasts. The nodes relay the packets with the help of intermediate nodes. No beaconing exchange is required [3].

Table 5: Simulation Information

Simulation information	**10 nodes**	**20 nodes**
Simulation length in seconds	10	10
Number of sending nodes	10	20
Number of receiving nodes	10	20
Number of packets generated	3171	4992
Number of packets sent	3139	4878
Number of packets forwarded	80	135
Number of packets dropped	202	796
Number of packets lost	146	76
Average packet size	206.1254	174.88
Average End-to-End Delay in seconds	0.157	0.352

Transmission Delay

When the packets are transmitted between two nodes, the average delay between the sending node and the receiving node is called the average end to end delay. The average end-to-end delay is calculated using the formula as follows:

$$\text{AE2ED} = \frac{\sum_{i=1}^{n} timeOfPacketReceived_i - timeOfPacketSent_i}{totalNumberOfPacketsReceived}$$

If the value is higher, the network is experiencing congestion and it causes the routing protocol to perform inefficiently. Figure 1 presents the end-to-end delay comparison performance between

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protocols. The transmission delay is the important metric for the reliability of safety data dissemination in VANET, Proposed work outperforms than other protocols approach on time is taken by vehicle to rebroadcast the message and received at the destination node.

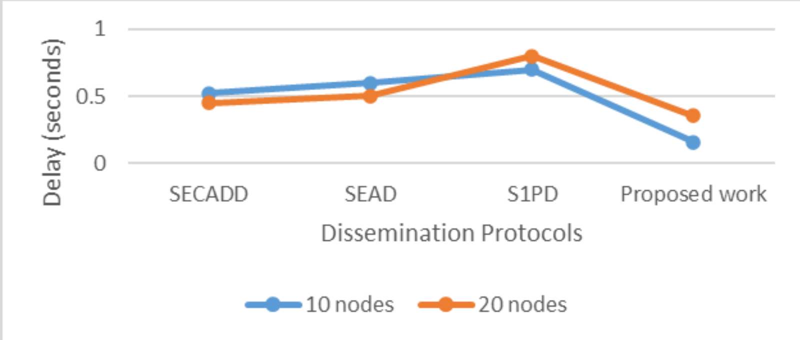

Fig. 1. Transmission Delay

Number of forwarders

Fig.2 shows the simulation results, the forwarding ratio drastically degrades with the proposed approach, compared to SECADD, SEAD and S1PD when the number of node increases. The broadcast performance is better when the forwarding nodes selection is smarter. This shows the impact of the forwarding nodes choice on reducing unnecessary broadcasts. SECADD and SEAD shows better performance when compared to S1PD. Reducing the number of re-forwarders might have a major impact on the broadcast latency.

Packet Forwarding Rate=Number of packets forwarded/ Total number of packets

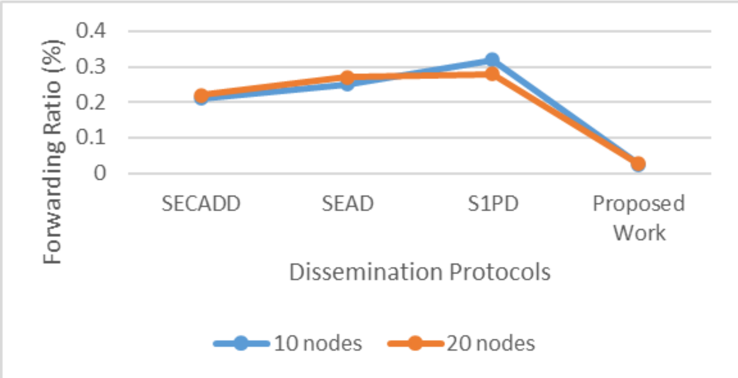

Fig. 2. Forwarding ratio

Packet Drop Rate

The proposed approach has a low packet drop ratio compared to SECADD, SEAD and S1PD. This observation shows that the proposed work alleviates the broadcasting storm impact by reducing the network collision and contention. S1PD has a better drop ratio compared to SECADD.

Packet drop rate= Number of packet lost/ Number of packets sent *100

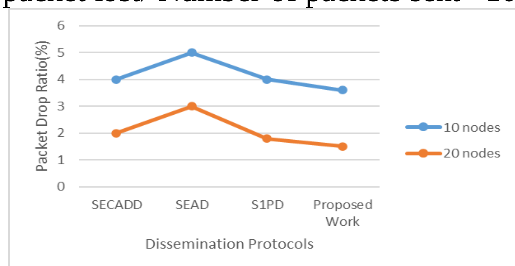

Fig. 3. Packet Drop Ratio

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Successful Transmission (PDR)

One demand for a much better data dissemination protocol is to achieve the packet delivery ratio close to 100%. However, increasing the forwarder nodes might result in overload link bandwidth, hence network contention and collision. Proposed work shows the better packet delivery ratio, while reducing the number of forwarding nodes.

Packet delivery ratio= Packets received by destination/ Packet sent by source *100

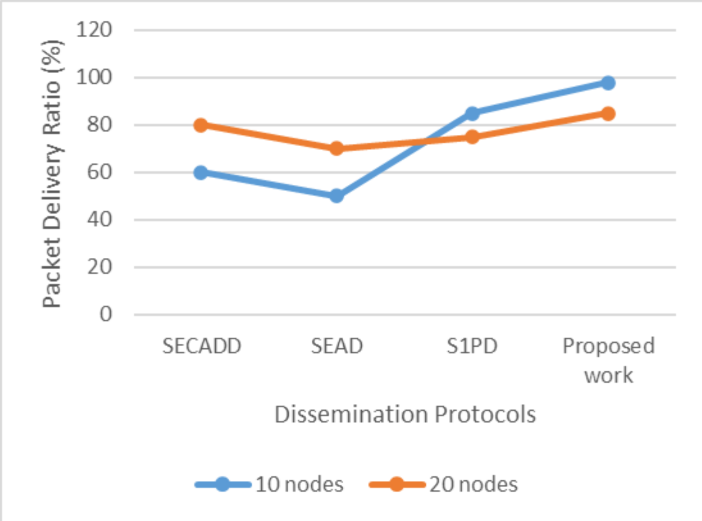

Fig. 4. Packet Delivery Ratio

7 Conclusion

Data dissemination in VANETs improves the efficiency of the traffic system and the quality of driving. Data dissemination in vehicular networking environments is a challenging task, mainly due to unstable network topology, frequent fragmentation and a large number of vehicles on road. It becomes a very challenging task for vehicles to transmit information over the network. The main issue that remains as a challenge in vehicular networks is exchanging of information in a scalable fashion. This paper focuses on the dissemination of emergency messages that are time critical. Our proposed work is based on clustering to reduce network congestion and delay. The proposed work has reduced delay and packet drop ratio when compared with other existing techniques.

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