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# Emergency Message Dissemination in Vehicular Networks: A Review

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**ABSTRACT** The number of vehicles on the roads has increased proportionally over the last couple of years and this number is likely to rise due to the increase in population growth and the number of vehicles that are manufacturing every day. This high traffic density leads to several problems, from which effectively disseminating the emergency messages is a major concern. Keeping in view the dynamic characteristics of VANETs, significant challenges are faced in disseminating the message across the network. The major challenges are the broadcast storm problem, hidden node problem and the packet collision. Many studies have been performed to devise an effective and reliable mechanism for disseminating emergency messages in a Vehicular ad-Hoc Network (VANET). Researchers have proposed different models to tackle various types of scenarios for emergency message dissemination. This paper not only reviews some recent contributions to emergency message dissemination in vehicular networks but also discusses various proposed methods based on Intelligent Transportation System (ITS), Internet of Things (IoT), Priority messaging, Clustering approach, Software Defined Network (SDN) and Fog Computing. We have also tried to explore the latest developments in emergency message dissemination using 5G networks.

**INDEX TERMS** 5G, broadcast, clustering, emergency message dissemination, VANET, fog, IoT, ITL, priority, SDN.

## NOMENCLATURE

3P3B	Trinary Partitioned Black-Burst-Based Broadcast Protocol
CB-EMB	Cluster Based Emergency Message Broadcasting Technique
CH	Cluster Head
CW	Contention Window
DD-CPB	Data Dissemination Scheme based on Clustering and Probabilistic Broadcasting
DP-EMB	Distributed Position-Based Protocol for Emergency Message Broadcasting
DV-CAST	Distributed Vehicle Broadcast
EFPBS-5G	Emergency Forwarding to Prevent Broadcast Storm for 5G

EM	Emergency Message
EV-PVS	Emergency Vehicle Priority Based on Visual Sensing
FACP	Fog-Assisted Cooperative Protocol
GPS	Global Positioning System
H	High
H-VFog	Hybrid VehFog
HEMT	Hybrid Emergency Message Transmission
ITS	Intelligent Transportation Systems
IWL-VNMD	Integration of WAVE and LTE in Vehicle Networks for Messages Dissemination
L	Low
M	Medium
MANET	Mobile Ad-Hoc Network
MC-EMD	Multi-Hop Clustering Based Emergency Message Dissemination
NetSim	Network Simulator and Emulator

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NGECS	Next Generation Emergency Communication Systems via Software Defined Network
NS	Network Simulator
OBU	On-Board Unit
OMNeT++	Objective Modular Network Testbed in C++
QS-VFDD	Querying Scheme for Vehicular Fog Data Dissemination
RFID	Radio Frequency Identification
RFS-E5GS	Reference Framework for Social-Enhanced V2X Communications in 5G Scenario
RSU	Road-Side Unit
SPARTaCuS	Service Priority Adaptiveness for Emergency Traffic using Software Defined Networking
SUMO	Simulation of Urban Mobility
TCMIoT	Traffic Control and Management over Internet of Things
TLCSI	Traffic Light Control System for Intersections
TraNS	Traffic and Network Simulation Environment
TSTFL	Traffic Signal Timing using Fuzzy Logic
V2I	Vehicles-to-Infrastructure
V2V	Vehicle-to-Vehicle
V2X	Vehicles-to-Everything
VANET	Vehicular Ad-Hoc Network
VEINS	Vehicles in Network Simulator

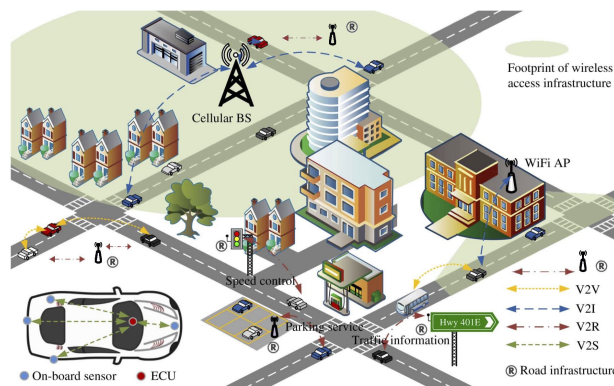


FIGURE 1. Architecture of a VANET.

lead to a significant development in ITS by moving towards a data-driven intelligent transportation system. VANETs has become very useful and popular due to its tremendous applications specifically for safety purpose. Pictorial representation of a VANET is shown in figure 1.

Dissemination of messages in VANET is a common practice to share data and resources among vehicles using the V2V, V2I, and V2X communication approaches. However, due to the dynamic nature of VANET, disseminating the message can lead to a couple of challenges. One such challenge is the broadcast storm problem. It leads to unnecessary broadcasting of the same messages which causes a delay in communication and degrades the throughput of the network. Another issue that arises is the hidden node problem. During the broadcasting of the messages, some nodes do not receive the message because they do not fall under the communication range or channel. To devise a message dissemination mechanism for VANET, one should keep such problems in mind.

Existing VANET dissemination strategies can be arranged into three kinds; push, pull and hybrid. In the push model, data is dispersed proactively by broadcasting the messages periodically. While in the pull model, data is dispersed as per the requirement where the protocol conveys data to the nodes that are geographically far. These protocols also depend on broadcasting for data dissemination at every next hop. Some techniques merge both the dissemination types to facilitate various types of applications. The push-based model is favorable when a quick reaction is required for the safety applications, while the pull-based model is considered for delay-tolerant applications, such as detecting the road congestion or finding a gas station. The pull-based model often requires less overhead, with lesser latency limitations as compared to the push-based model [5]. In delay-tolerant applications, the requester normally sends a query to the broadcast site and gets the response from there. For such applications, as long as the response is returned, the users can easily tolerate the delay.

The fast and successful propagation of emergency messages among the vehicles is very crucial as the lives of nearby citizens are dependent on it. Broadcasting the emergency

I. INTRODUCTION

The traffic density has increased over the last few years due to rapid growth in the world population. It raises tremendous challenges for the traffic management authorities to effectively manage the heavy traffic load [1]. One of the major challenges faced is the congestion of traffic on narrow roads and intersections that causes hurdles in the movement of traffic especially emergency vehicles. Emergency vehicles need to respond for quick emergency services and hence they require clear passage on the roads. A slight delay in the travel time of an emergency vehicle can lead to the loss of precious lives and may also cost financial loss [2]. This demands the implementation of a fast and smooth mobility framework for emergency services in vehicular networks.

Vehicular Ad-Hoc Networks (VANETs) is a type of Mobile Ad-Hoc Network (MANET), designed for vehicular communications. Over the last two decades, many research works have been carried out on VANET due to its numerous applications and benefits. VANET is ideal for both safety and entertainment-based applications [3]. Vehicles in a VANET can not only communicate with other vehicles but also communicate with anything to share and exchange information. VANET is helping to reshape the Intelligent Transportation Systems (ITS) and is considerably improving the efficiency and the performance of transportation systems. ITS offers reliable options for travelers and provides enhanced security [4]. A large amount of traffic data is now available that can

messages to surrounding vehicles in advance can help reduce the number of traffic accidents [6], [7]. It is very important to design transmission methods for emergency messages especially in the case of large scale VANETs [8].

In Section II, we have thoroughly described the VANETs and their characteristics, applications, and challenges. Section III describes the motivation behind this work. In Section IV, we have classified emergency message dissemination techniques and described each technique separately. Section V shows a comparative analysis where the described schemes, respective to their category, are listed in a tabular form. Finally, we concluded the paper in section VI.

## II. VEHICULAR Ad Hoc NETWORK

Vehicular Ad-Hoc Network (VANET) is a self-dependent, infrastructure-less wireless network that falls under the category of Mobile Ad-Hoc Networks (MANET). In VANET, vehicles are considered as mobile nodes that organize and configure themselves and communicate with other vehicles to share information [9]. Due to the dynamic nature of VANETs, they have different characteristics, but they also have several challenges as well. In the following sub-section, we have briefly discussed the characteristics, challenges, and applications of VANETs.

### A. CHARACTERISTICS OF VANETS

Since the node in a VANET is a vehicle, which is less prone to physical attacks, it is unlikely to be compromised [10]. Due to the diversified nature of VANETs, it possesses many characteristics. Some of these characteristics are described below:

#### 1) *Highly Dynamic*

The major characteristic is the frequent change in the network topology due to the high mobility and frequent change in the position of the nodes [11]. High mobility and highly dynamic topology cause frequent disconnections. The rapid change in the network topology and these frequent disconnections make it very difficult to design a reliable routing protocol for VANETs [12].

#### 2) *Criticality of Emergency Messages*

Since the nodes have different velocities and change direction randomly, the communication between them is time-critical. The duration of contact between the vehicles is very small, hence the emergency message dissemination should be proper across the nodes, and they should reach their destination successfully in the least amount of time [13].

#### 3) *Predictable Pattern of Mobility*

The nodes in VANET follow a predefined path of mobility. They align themselves according to the map that is why VANET falls under the category of the geographical type of communication [14]. Using this behavior, we can predict their pattern of mobility.

#### 4) *High Application Requirements*

VANETs have several applications, of which the most prominent is the safety application. Based on real-time

response, efficiency and reliability, these applications have high requirements. End to end quick delivery of services is very critical for safety applications. A slight delay can have negative consequences [15].

#### 5) *No Issue of Energy*

One advantage for the nodes in VANET is that they have ample energy supply and storage. In particular, the nodes in a VANET are vehicles; which have a huge supply of power and have high storage capacity as compared to nodes in ad-hoc networks. Therefore, power and storage is never a constraint for VANETs [16].

#### 6) *Unbound Network Size*

VANETs are highly scalable. We can implement them in small towns and they can spread over multiple cities. They do not have a specific network size and we can say that the size of this kind of network is geographically unbound [11].

#### 7) *Privacy*

The ability of vehicles to communicate with each other can reveal information about the drivers such as their speed, location, direction, etc. Even with the message authentication, the information about the driver's behavior and their privacy should be respected [17].

## B. APPLICATION OF VANETS

Keeping in view the architecture of communication in VANETs, we can use them in several applications. The main objective of these networks is to provide road safety to the citizens. The applications of VANETs are broadly classified into two major categories, one is safety application and the other is non-safety application [18].

#### 1) *Event Driven Safety Messaging*

Ensuring the emergency messages are disseminated across the network at the right time is a critical requirement [19]. Since safety applications are usually related to real-time based scenarios, efficiency and performance of these applications are critically dependant on time.

#### 2) *Infotainment Applications*

Lately, the use of the internet and multimedia has increased manifold. Even when people are traveling from one place to another, they are using entertainment applications that require network connectivity [20]. In this situation, providing infotainment services to the public is also one of the applications of VANETs.

#### 3) *Public Safety*

The major objective of VANET is to provide safety to the public including both the drivers and the pedestrians. Not just road accidents, other things such as carbon emission from vehicles is also a hazard for the health of citizens. Smart traffic management using VANET can help us reduce the carbon dioxide emission and keep the air clean where possible [21].

#### 4) *Traffic Coordination*

VANETs provide us with a better traveling experience. This is achieved by the proper coordination of nodes

present in that network. These nodes share information to make the driver aware of his/her surroundings and to prevent the occurrence of accidents and collisions. Traffic coordination assists the drivers to avoid the congested area and to travel to their destination smoothly [22].

#### 5) *Comfort Application*

VANET helps to deliver information to the drivers at the right place at the right time to make their traveling experience enjoyable and comfortable. This information includes gas station location, rest area, nearby restaurants, weather update, route navigation, parking lot, etc. These services make the trip comfortable for the drivers [23].

#### 6) *Self-Parking*

With the help of VANET, we can have the application of self-parking with which the vehicle can properly park itself without the help of the driver. For the vehicle to park itself, it requires precise location, accurate distance, and speed estimation [24].

#### 7) *Toll Collection Application*

With the help of V2I communication, the RSU can collect the toll tax from vehicles automatically. The vehicles do not have to stop at the toll and pay the tax by hand instead the RSU will detect the vehicle using RFID or from the OBU of vehicle. The RSU also shares the receipt to the drivers about how much tax paid, time and collection point of the toll [25].

### C. CHALLENGES TO VANETS

VANET is playing an important role in effective transportation and emergency traffic management. However, due to its diverse characteristics, VANETs face a number of challenges including security [26] and data management [27]. Some of the challenges are described below:

#### 1) *On-Time Delivery of Safety Messages*

Timely delivery of safety messages is the topmost priority in VANET. Due to the contention in the network, these messages face delays in transmission. There can be serious circumstances for the neighboring vehicles if the safety messages are not delivered on time [28]. The probability of transmission delay increases with the increase in network size.

#### 2) *Highly Dynamic Nature*

Designing a good routing protocol for a VANET is a challenging task. Due to high mobility, random change of path and frequent change in the topology of the nodes, it is very difficult to design a routing protocol for efficient communication [29]. With high velocity, we face more packet losses, delays and the accurate geographical position of nodes becomes difficult.

#### 3) *Network Scalability*

Scalability in VANET is a major concern. If the nodes in the network are increased, the performance of VANET is highly compromised. The addition of new

nodes in the network may lead to congestion in the channel and can cause dis-connectivity [30]. Moreover, as the distance between nodes increases, we need to adopt a different wireless communication standard that is required for long-range communication.

#### 4) *Air Pollution Emission Measurement and Reduction*

Keeping the environment clean and green is the responsibility of every citizen. The concept of VANET can help us devise a mechanism to tackle the rapidly increasing air pollution. Traffic congestion in a certain area can lead to high emission of carbon dioxide that makes the air pollute [31]. VANET can assist us to develop an Adaptive Cruise Control concept which helps in the provision of a friendly environment.

#### 5) *Privacy and Authentication*

To make sure the data and privacy of the user are sustained while using VANET applications multiple types of authentication mechanisms are considered. These mechanisms include various encryption algorithms to secure the user's data [32]. Attackers trying to break into the network and stealing user personal data may compromise the privacy of the users. Ensuring the privacy of users and securing data by authentication is a challenge in VANET.

#### 6) *Network Congestion*

The data is disseminated across the network by broadcasting the messages. Due to the hidden node or the broadcast storm problem, at times the same message is broadcasted several times. So the repeated transmission of messages makes the network congested. Congestion in VANETs significantly affects the performance of applications that are delay-sensitive [33].

#### 7) *Volatility*

Volatility in VANET can be catastrophic for the network. Due to the dynamic behavior of nodes in the vehicular networks and the short span of communication contact between nodes, VANETs become volatile. This may interrupt authentication process and can lead to frequent dis-connectivity [34].

### III. MOTIVATION BEHIND THIS WORK

The motivation behind writing this survey paper is to understand how crucial it is to manage the flow of emergency traffic [35]. To ensure the safety of precious lives and to reduce financial loss, we need to make sure emergency traffic reaches its destination successfully and timely [36]. There is still a requirement for a more efficient and reliable mechanism for emergency traffic management.

Disseminating the emergency messages is a challenging task, keeping in view the challenges faced in VANETs. It is very important to make sure that the network traffic for emergency services successfully reaches its destination in the least possible time. The critical nature of this requirement is the motivation behind this work. This work carries out a brief survey of how messages are disseminated using different techniques, what challenges do they face and what are



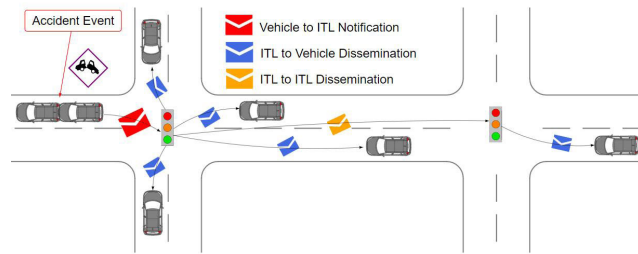


FIGURE 2. Architecture of Message Dissemination using Traffic Lights.

the available models that offer reliable emergency message dissemination in vehicular networks?

#### IV. CLASSIFICATION OF EMERGENCY MESSAGE DISSEMINATION TECHNIQUES

Several techniques help to disseminate emergency messages across the network. These several techniques use different approaches to disseminate the messages. We have classified some of these approaches based on Intelligent Traffic Lights, Internet of Things, Clustering, Priority, Software Defined Network, Fog Computing, and 5G Networks. A taxonomy of these techniques is shown in Fig 2. A study on all approaches is carried out and is described in the following sections.

##### A. EMERGENCY MESSAGE DISSEMINATION BY INTELLIGENT TRAFFIC LIGHTS

Intelligent Traffic Lights (ITL) are used to disseminate the warning message to the drivers to warn them about an emergency. The vehicle that met an accident sends this message to the ITL, this ITL then spreads the message to the nearby vehicles as well as to the other ITLs. When an incoming vehicle tries to approach the accident location, the information is already forwarded to this vehicle before reaching that location.

To ease the flow of emergency vehicles on the roads, many researchers have proposed their schemes by adjusting the traffic lights. Reference [37] have presented an approach for smart cities by integrating the concept of IoT and VANET to control the Traffic Lights and ease the movement of ambulances in cities. Reference [38] introduced a dynamic scheduling algorithm for traffic signal timing. It analyses dense traffic at the intersection and allows the congested traffic to pass first. Several other schemes are proposed for managing emergency traffic by controlling the traffic signal light. Figure 3 shows a representation of how emergency messages are sent using traffic lights. Some of these schemes are described in this section.

- 1) *Fuzzy Logic Scheme (FLS)* [39] – Proposes a Fuzzy Logic-based Traffic Management System (TMS) for real-time response to Emergency Vehicles (EV). The emergency services authority provides the Emergency Level (EL). Traffic statistics and condition is attained by the road network and fetched to the fuzzy logic controller which then calculates the discrete value for Congestion Level (CL). The values of EL and CL are

used to select an Emergency Response Plan (ERP). An emergency vehicle is dispatched by the respective authority as soon as an emergency is detected. The EV contacts the TMS for the state of EL and a suitable route to the emergency location. Once a route is assigned to the EV, the TMS acquires the Average Vehicle Speed (AVS) and Occupancy Level (OL) along the EV route and estimates the value of congestion to calculate the CL. Based on the value of EL and CL, the TMS chooses an ERP for the emergency vehicle. The TMS then takes appropriate actions to ensure immediate response to emergency services. These actions include controlling the traffic lights, assigning a speed limit, clearing the lane, allowing EV to use the reserved lane and re-routing.

*Drawback:* – The drawback of this approach is that it is difficult to implement and operate.

- 2) *Traffic Light Control System for Intersections (TLCSI)* [40] – The authors of this research paper have proposed an extensive traffic control mechanism for emergency cases based on the traffic lights system. The model is used to manage the traffic while an accident occurs at the intersection, using the Deterministic and Stochastic Petri nets. Different sensors, cameras, and warning lights are deployed at the intersection to detect the location of the accident and the number of vehicles on the road. With the help of these, emergency traffic light control policy is defined. The model is constructed for four directions, each with five traffic lights red, yellow and three greens (straight, left and right). Traffic control decisions are taken according to a traffic situation. Emergency warning lights are used in case an accident is detected and warning signals are sent to other nearby vehicles. A traffic-signal based strategy is applied at upstream neighboring intersections to help avoid traffic congestion caused due to road accident.
 

*Drawback:* – The drawback of this scheme is that it is very difficult to deploy the model and implementing it costs high.
- 3) *Traffic Signal Timing Using Fuzzy Logic (TSTFL)* [41] – A new approach for controlling the time of a traffic signal is proposed in this paper for smart cities. The system is called the Smart Traffic Control (STC) that uses fuzzy logic to control the traffic lights in order to reduce the delay faced by emergency vehicles while least effecting the regular traffic. The quickest possible route is evaluated from various traffic data collected by the system. Each and every signal calculates the traffic load for every side of an intersection. The data is analyzed and based on traffic load, the signal lights are controlled to ease out the vehicle congestion at intersection before an emergency vehicle arrives at the intersection. Time of arrival of emergency vehicle, current traffic flow and ordinary's route are the parameters adopted for the fuzzy rule-based system. The system adjusts the traffic signal timing to provide adaptive traffic flow for

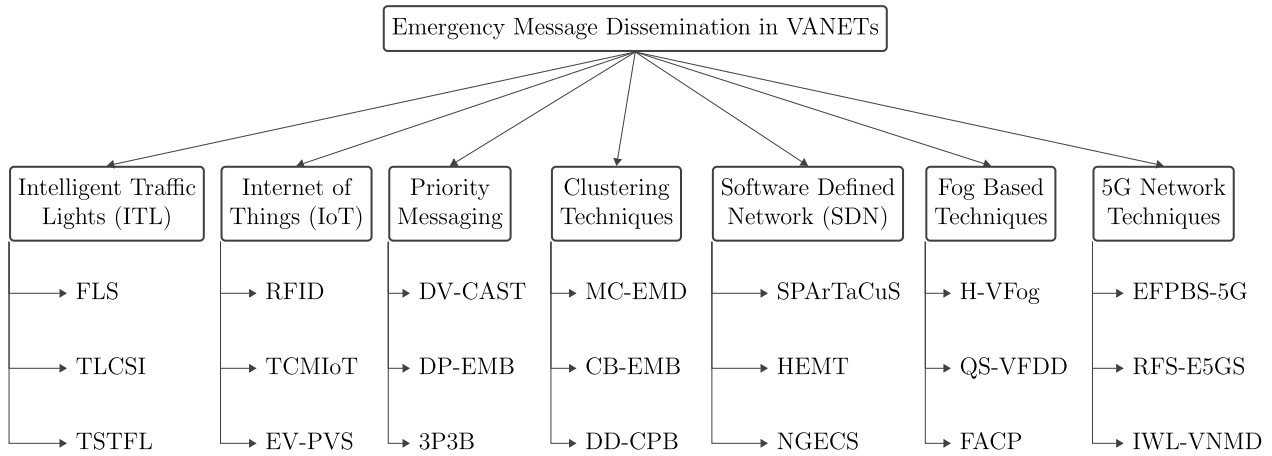


FIGURE 3. A Taxonomy of Emergency Message Dissemination Techniques in VANETs.

the emergency vehicles. The advantage of this system is that not only it significantly reduces the delay in travel time of emergency vehicles, it also reduces delay in the travel time of non-emergency vehicles.

*Drawback:* – The drawback is the unnecessary delay due to the V2I approach, this can be improved by using the V2V communication instead.

*Remarks:* – The intelligent traffic lights technology is good in towns or small cities as it facilitates emergency services and safety information dissemination. But the ITLs are geographically limited as they offer services closer to traffic lights or intersections. For the highways scenario, this approach is not practical and hence is suitable for specific areas.

**B. EMERGENCY MESSAGE DISSEMINATION USING INTERNET OF THINGS (IoT)**

Over the last two decades, IoT has emerged as a useful technology to make our day to day activities easier and efficient. IoT has a massive contribution to transportation, where it plays a vital role in emergency traffic management. Reference [42] has proposed a real-time solution for traffic management by calculating the density of traffic on the roads and high priority is given to a lane where emergency vehicles can travel. The mechanism introduced by [43] includes a smart real-time traffic monitoring system that monitors traffic statistics on a daily and weekly basis and works on early detection of an incoming emergency vehicle. Figure 4 shows the architecture of message dissemination using IoT techniques. Some of IoT based approaches for emergency traffic management are explained in the section.

- 1) *The RFID Technique* [44] – In this research paper, the authors used the Virtual Traffic Light technology to give priority to the emergency vehicles at road intersections. They used RFID technology to identify an incoming emergency vehicle. In this proposed scheme, the RFID readers are placed at the intersections and two linked lights are deployed at both ends of the

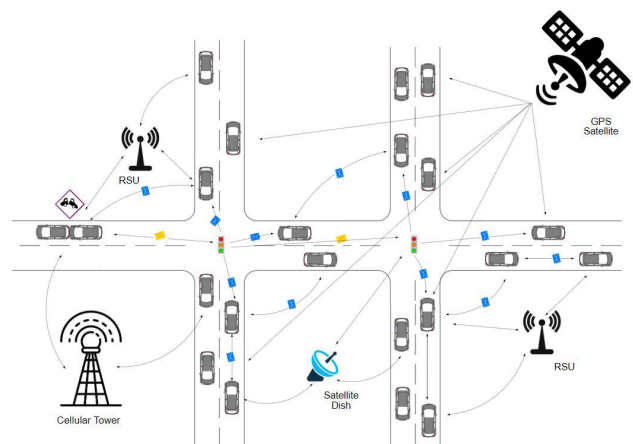


FIGURE 4. Architecture of a Message Dissemination using IoT.

road that joins the two intersections. The RFID reader reads and stores the record of all vehicles passing through the intersection. The methodology uses the Vehicle to Infrastructure (V2I) communication which allows the RFID reader to interact with the On-Board Units (OBU) installed in vehicles to differentiate the type of vehicle approaching. During normal traffic, the traffic lights operate in round-robin as usual. As an emergency vehicle is detected, the RFID reader sends the information to the traffic light controller which generates the green signal for the emergency vehicle so that it can cross the intersection without any delay. The emergency vehicle broadcasts a message stating its departure from the intersection so that the traffic can resume as usual.

*Drawback:* – The drawback of this scheme is that it does not have a significant impact in reducing the emergency service time.

- 2) *Traffic Control and Management Over IoT (TCMIoT)* [45] – This framework consists of a centralized traffic control center that creates a clear path for the

ambulance referred to as Green Corridor. Compared with similar research works, this methodology provides prior knowledge of an emergency vehicle arriving the traffic signal thereby clearing a passage for the ambulance well in time. RFID helps identify and detect an ambulance, identify the destination to the hospital and detect the location of the emergency vehicle. The centralized controlling server acts as a WiMAX base station. The ambulance connects with the base station using an antenna installed separately in the ambulance. In case of an emergency, the ambulance interacts with the base station to collect route to the destination as well as other traffic alerts. The benefit of this methodology is that it utilizes the high range of WiMAX technology which lets the centralized controller alert the traffic signals in advance so that they can conveniently create a Green Corridor for an incoming ambulance.

*Drawback:* – The drawback of this scheme is that it is not suitable for short-range communication.

- 3) *Emergency Vehicle Priority Based on Visual Sensing (EV-PVS)* [46] – This proposed methodology consists of a system called the Urban Traffic Management System (UTMS), that uses wireless technology, several integrated sensors, data processing technologies and advanced techniques to minimize road congestion, fuel consumption, traveling time and to prioritize emergency vehicle. There is a Traffic Management Centre (TMC) that administers the road traffic for both non-emergency and emergency vehicles. Acoustic Sensors collect and send siren sound signals to Road Side Units (RSU), which uses frequency measurement to detect emergency vehicles. A traffic controller collects data like speed, location, traffic density and distance to adjust the traffic lights accordingly. The focus is on Visual sensing methods to determine traffic signal green light and its duration. The emergency vehicle closest to the intersection is detected and the sequence of green light is determined. All the data is forwarded to the traffic management center to manage the road traffic and efficiently disperse the emergency traffic.

*Drawback:* – The drawback of this scheme is that the system needs to be tuned to tackle high traffic density and extreme weather conditions.

*Remarks:* – The IoT technology has stepped into every field due to its wide application range. Disseminating emergency messages using IoT technology can be very efficient. The IoT sensors within vehicles and across the infrastructure can help us acquire the traffic statistics in real-time to devise precise vehicular communication models.

### C. EMERGENCY MESSAGE DISSEMINATION USING PRIORITY MESSAGING

Emergency Messages include emergency events that are transmitted to the citizens who are approaching the location of the incident. Successful and timely dispersion of these

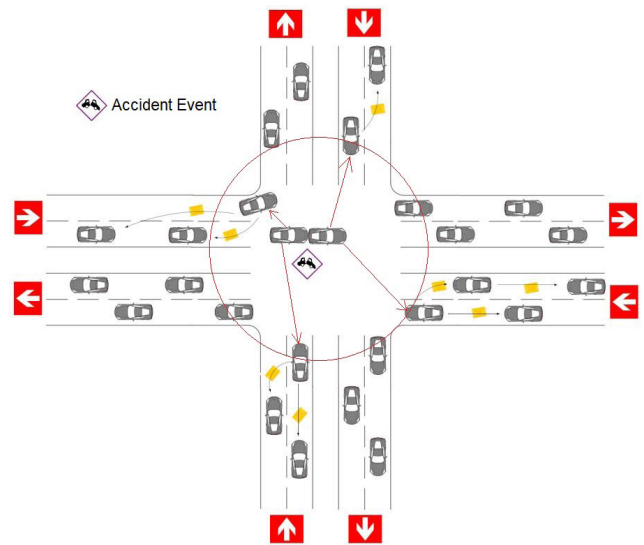


FIGURE 5. Architecture of a Message Dissemination using Priority.

messages can help the citizens avoid the emergency incident location. In [47] the authors have carried out performance modeling for emergency message dissemination using priority in VANETs. Figure 5 shows the architecture of a priority management scheme. Some other schemes are briefly explained in this section.

- 1) *A Distributed Vehicular Broadcast Protocol for Vehicular Ad Hoc Networks (DV-CAST)* [48] – The authors in this paper have introduced a protocol called the Distributed Vehicular Broadcast Protocol (DV-CAST) that is reliable, efficient and scalable. The protocol is designed to handle messages that are broadcasted in a Vehicular Ad-Hoc Network. It uses information from GPS and operates on highways under multiple traffic scenarios i.e. dense or sparse traffic regimes. This scheme aims to devise a routing protocol that can handle both the Broadcast Storm problem and the Disconnected Network problem. The protocol depends only on the single-hop neighbor node and is robust against different kinds of traffic situations. Detecting the neighbor, broadcast suppression and store-carry-forward mechanism are some key components of the protocol. The advantages of this protocol are that it is reliable, efficient, robust against extreme traffic conditions and resilient to network disconnections [49].  
*Drawback:* – The drawback of this protocol is that it has many design parameters and each needs to be properly tuned to offer optimal performance. GPS accuracy has to be ensured so that the neighbor vehicle detection system does not fail.
- 2) *Distributed Position-Based Protocol for Emergency Message Broadcasting (DP-EMB)* [6] – Daxin et al. have proposed a protocol based on the position for broadcasting emergency messages in VANETs. These messages are broadcasted to reduce road accidents. A vehicle encountering an accident can disperse





reliable broadcast protocols that operate on the MAC layer.

*Drawback:* – The drawback of this scheme is that it takes time to select a new cluster head which reduces the effectiveness of this model.

- 3) *Data Dissemination Scheme Based on Clustering and Probabilistic Broadcasting (DD-CPB)* [56] – In this paper, the authors have developed a new approach for data dissemination in VANETs using probabilistic broadcasting. The scheme is based on directional clustering that helps us to resolve issues that arise in message dissemination such as high collision rate, long latency, and inaccurate information sharing. The member in a cluster who receives the EM sends it to its cluster head with a calculated probability based on the number of times the same packet of the EM is received during a specific time duration. When the cluster head receives the EM from the member, it continuously forwards the packet to the clusters that come in the direction of the destination.

*Remarks:* – The clustering technique helps to tackle most of the problems faced in disseminating the emergency message in a VANET. Clustering helps to prevent the hidden node problem and the broadcast storms. Not only this it also helps to avoid the unnecessary broadcasting of messages. The clustering approach is reliable for emergency message dissemination. For the highways scenario, a two-tier clustering technique for VANET is described in [57].

*Remarks:* – The clustering technique helps to tackle most of the problems faced in disseminating the emergency message in a VANET. Clustering helps to prevent the hidden node problem and the broadcast storms. Not only this it also helps to avoid the unnecessary broadcasting of messages. The clustering approach is reliable for emergency message dissemination. For the highways scenario, a two-tier clustering technique for VANET is described in [57].

### E. EMERGENCY MESSAGE DISSEMINATION USING SOFTWARE DEFINED NETWORKS

Software-Defined Networks (SDN) are rapidly emerging as the latest technology that is overcoming traditional network-based approaches. SDN gives us the flexibility to control the network flow based on application requirements. Recently many SDN based emergency traffic management models have been proposed by researchers [58]. The major problem that is faced when an emergency occurs is to reduce the time taken in analyzing the on-location situation to minimize both financial and physical damage [59]. An architecture of SDN based message dissemination is shown in figure 7. A few SDN based emergency traffic schemes are described below.

- 1) *Service Priority Adaptiveness for Emergency Traffic Using SDN (SPArTaCuS)* [60] – In this study, the authors have applied the concept of SDN to prioritize the emergency services. They have proposed

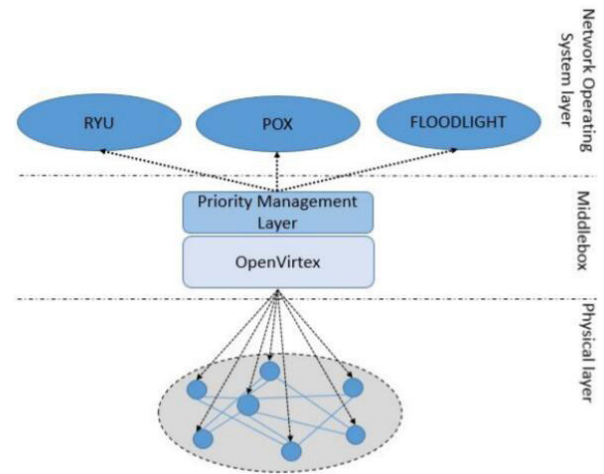


FIGURE 7. Architecture of a Message Dissemination using SDN.

a framework known as SPArTaCuS for smart cities that provides priority to emergency services which are achieved by using a priority management layer in the SDN architecture. Where there is a huge number of users and bandwidth is low, the network traffic gets congested and makes it difficult to connect to emergency service providers in case of any emergency. The SDN framework uses the Open Virtex (OVX) to create virtual SDNs that are categorized based on their traffic types such as helpline or the general public. The OVX is connected to multiple SDN controllers. The virtual SDN is created by the OVX and priority is assigned to each network by the priority management layer. All virtual networks work in parallel to each other and are completely isolated from each other.

*Drawbacks:* – The drawback of this approach is that it is designed only for places where there are a large number of users and this model uses high system resources.

- 2) *SDN-Enabled Hybrid Emergency Message Transmission Architecture in IoV (HEMT)* [61] – In this paper, the authors have proposed a hybrid emergency message transmission scheme in IoV using SDN. The objective is to make the transmission of emergency messages rapid and reliable. The scheme decouples the data plane and the control plane of the SDN into a vehicular network. The scheme uses OBUs, RSU switches, and SDN based centralized controllers to achieve fast and reliable dissemination of emergency messages. Not only this but inter-vehicular multi-hop broadcast communication is also used to increase the message coverage and to eradicate the extra time used to transmit the message in sparsely located RSUs. The accident source vehicle transmits the message to the controller as well as the nearby vehicles. In this case, even if the controller takes time to transmit the emergency message to the vehicle, the source has already transmitted it to the vehicles. This ensures the rapid dissemination of emergency messages and reduces the controller's overhead.

*Drawback:* – The drawback is that when the traffic density increases, the ratio of message coverage is significantly decreased which means the model is not suitable for high density traffic regimes.

- 3) *Next Generation Emergency Communication Systems via SDN (NGECS)* [62] – In this paper, the authors have introduced a novel SDN based framework for an emergency communication system using network virtualization. This framework prioritizes packet switching and allocates dynamic bandwidth to facilitate emergency communication. The proposed architecture comprises several service providers and the framework which consists of service providers that are providing various kinds of emergency services. The users communicate with the service provider to access these services using the SDN network. Each service is running on a different Virtual Local Area Network (vLAN), vLANs help to separate the services from each other. Virtual Machines (VMs) are created to perform virtualization on the end-user device. The virtualization of services is achieved with the help of SDN.

*Drawback:* – The drawback of this model is that its complexity creates multiple points of failure of the system and increases the vulnerability of the system. Hence, this model lacks in providing security.

*Remarks:* – Software Defined Network has brought a revolution in communication. Considering its features, the SDN has gained popularity within a small period. SDN has applications in VANETs as well. Model-Driven architecture is designed for Software Defined VANETs in [63]. Message dissemination in VANET using SDN technology has its benefits and drawbacks. The architecture of SDN helps to reduce the routing overhead. However, the SDN controller is costly to operate.

#### F. EMERGENCY MESSAGE DISSEMINATION USING FOG BASED TECHNIQUES

Recently with the advancement in Fog Computing, researchers are applying the concept of fog computing to disseminate the emergency messages in VANET. One of these significant approaches is provided in [64], the message is disseminated using congestion avoidance schemes. They have utilized a fog assisted architecture for VANET to avoid congestion at peak hours. Figure 8 shows an architecture of message dissemination using Fog Computing. Some other fog assisted schemes for message dissemination are described in the section below.

- 1) *Hybrid-Vehfog: Approach for the Dissemination of Critical Messages in Connected Vehicles(H-VFog)* [66] – The authors of this paper have proposed a hybrid protocol for disseminating the critical messages in VANETs using an approach based on Fog Computing. The protocol addresses the challenges that are faced to forward the critical messages to the nearby nodes about an incident or an incoming obstacle. This tech-

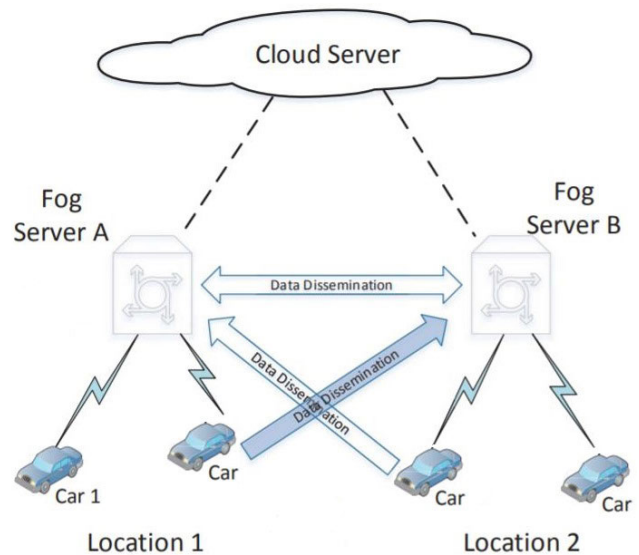


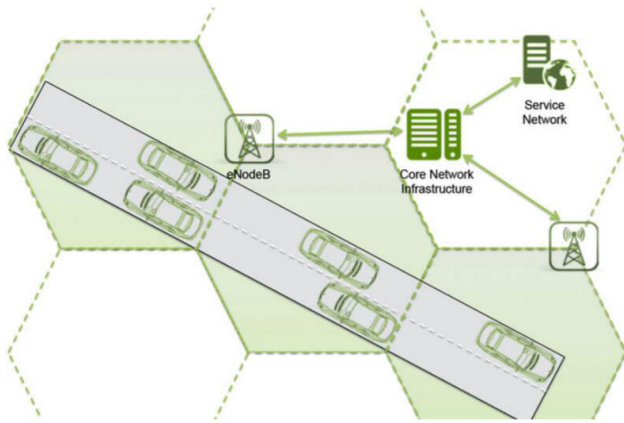
FIGURE 8. Architecture of a Message Dissemination using Fog Computing [65].

nique divides the region into an obstacle zone and a non-obstacle zone. The protocol is designed to disseminate messages in obstacle zone and using a multi-hop technique to disseminate messages in non-obstacle zones. The benefit of this approach is that it dynamically adapts itself to the changing environment which helps to efficiently disseminate messages in VANETs with minimal delay and network overhead.

*Drawback:* – The scheme lacks the capability of operating in a real time environment which means that performance estimation for this model is not efficient.

- 2) *A Privacy-Preserving and Verifiable Querying Scheme in Vehicular Fog Data Dissemination (QS-VFDD)* [67] – In this paper, the authors have introduced a querying scheme for data dissemination in the vehicular network using fog computing. The RSU in this technique is a fog storage device that helps to prevent the association of data and vehicle from which the data originated. Also, there is support for verification of data requests in the batch. The authors have analyzed security performance as well that shows the algorithm helps to retain the privacy, confidentiality, and integrity of the data. Extensive simulation explains the performance of this approach in terms of better efficiency and flexibility. The major concern of this work is to ensure the security of data that is disseminated in a network.
 

*Drawback:* – The drawback of this model is that due to limited bandwidth in VANETs this scheme will have communication overhead which can lead to delay.
- 3) *Fog-Assisted Cooperative Protocol for Traffic Message Transmission in Vehicular Networks(FACP)* [68] – In this paper, the authors have proposed a protocol for the transmission of messages in a vehicular network using a fog architecture. The protocol is called Fog-Assisted Cooperative Protocol (FACP) which is a combination



**FIGURE 9.** Architecture of a Message Dissemination using 5G Network [69].

of the IEEE 802.11p and C-V2X technologies. The sector of roads is divided into clusters and ahead for each cluster is chosen with the help of fog based RSU. The FACP protocol forwards the response and query of traffic in the form of messages to a centralized traffic command center. The proposed protocol cooperates with other nodes and then transmits the message to the forwarding nodes to improve the reliability and efficiency of the communication. This technique helps to reduce the end to end delay and improve message reliability.

*Drawbacks:* – The drawback of this approach is that it is costly and the performance is not significantly improved as the number of nodes in the network increases.

*Remarks:* – The fog based approach can be beneficial when the size of the network is big and a huge amount of data is transmitted. Since the fog is also known as the closer cloud the delay and latency of services can be reduced. Moreover storing the data in the infrastructure will be convenient. In terms of VANETs, the fog storage location needs to be dispersed across the region for better and fast services but this will have a high cost.

### G. EMERGENCY MESSAGE DISSEMINATION USING 5G TECHNOLOGY

5G communication is stepping up to penetrate the market with its incredible communication speed, which is revolutionizing the networking concept. Keeping in view the design of the 5G network, they can be very helpful in VANET especially in the vehicle to infrastructure communication. The architecture of message dissemination using the 5G network is shown in figure 9. Some of the 5G network-based schemes are explained in this section.

- 1) *Emergency Forwarding to Prevent Broadcast Storm in via V2X Communications for 5G (EFPBS-5G)* [70] – The authors of this research paper have proposed a 5G communication mechanism to prevent the

broadcast storm that arises while disseminating the EM. The scheme uses a broadcast protocol to transmit and receive messages in real-time. But broadcasting the messages across the network can lead to a broadcast storm that causes long delays and degrades the performance of the network. The framework introduced is called the Adaptive Forwarding message and Cooperative Safe driving (AFCS). The proposed framework assists in eliminating the broadcast storm by using an adaptive message forwarding technique to reduce the chances of message flooding as well as to ensure the real-time message dissemination.

*Drawback:* – The drawback of this scheme is the high probability of message collisions which will introduce unnecessary re-transmissions.

- 2) *A Reference Framework for Social-Enhanced V2X Communications in 5G Scenario (RFS-E5GS)* [71] – In this paper, the authors have provided a reference system that redesigns the newly introduced 3GPP V2X architecture with the social measurement and is expanded with the innovation of 5G virtualization i.e., SDN and MEC. The structure influences the MEC and SDN to encourage the administration of social connections among V2X elements and to improve information conveyance between them. Rules are given about the beneficial usage of the proposed ideas in a reference testing use case. Nonetheless, the accomplished results can be effectively summed up to other use cases. By and large, the work gives an important early and convenient commitment towards the acknowledgment of 5G-ready Intelligent and Connected Transportation Systems. *Drawback:* – The drawback of this scheme is that as the network size increases the performance of this model is degraded in terms of delay and congestion.
- 3) *Integration of WAVE and LTE in Vehicle Networks for Safety and Non-Safety Messages Dissemination (IWL-VNMD)* [72] – In this work, the authors have divided the general structure of the vehicular network into four different layers and the elements of each layer are portrayed independently. After examining the pros and cons of the IEEE 802.11p protocol and the LTE network in terms of data transmission, this work proposes a model that is dependent on the two wireless communication techniques. Utilizing the IEEE 802.11p protocol to forward the safety messages and the LTE network to forward the non-safety messages. By using this approach the congestion in the channel can be significantly reduced and not only this, but it also ensures the timely transmission of emergency messages. With the persistent improvement of 5G innovation, the future in the 5G period dependent on 802.11p and LTE would be promising. *Drawback:* – The drawback of this scheme is that 802.11p is used to send safety messages and LTE is used only to send non-safety messages. LTE should also be utilized to transmit safety messages as well.



*Remarks:* – Talking about 5G which is itself in a research stage and requires more testing to be mature. 5G in VANET is going to be interesting keeping in view the tremendous applications of the VANETs. Although not much work has been performed for message dissemination using the 5G networks, this approach looks promising in the future.

## V. COMPARATIVE ANALYSIS

In this section, a detailed comparison between various methodologies, for emergency message dissemination mentioned in the previous section, is carried out. We have already explained various proposed techniques and classified them into respective domains. We have discussed emergency message dissemination using Intelligent Traffic Lights, Internet of Things, Priority Messaging, Clustering, Software Defined Networks, Fog Computing, and 5G Networks. Each of the technology is suitable under various circumstances and how it can be beneficial to tackle the problems faced in disseminating emergency messages.

A certain set of parameters are adopted to compare the performance of each method. This analysis shows how various techniques differ from each other. The comparison of different mechanisms against the given parameters is plotted in Table 1. After going through the table, we can conclude that emergency message dissemination using the clustering approach is a suitable solution for message dissemination. The clustering techniques offer a more reliable and efficient solution. Moreover, the clustering mechanism helps to eradicate the problem incurred in message dissemination.

The parameters we have considered for the comparative analysis include delay, latency, throughput, and scalability. Delay is an important parameter to measure the performance of a scheme for disseminating emergency messages. Delay is also linked with the parameter of latency; hence for a network with high latency, the delay will consequently be higher and vice versa. Delay, latency, and overhead together decide the throughput of the network. Lastly, we take the scalability of the technique into account as scalability is also an important factor to consider in VANET.

For ITL, IoT and broadcasting a lot of research work is already done. For SDN, Fog Computing and 5G, there is potential for more work. Minimal Latency and delay are required in VANET so in this case, Fog Computing schemes will be beneficial as they are designed for low delay communication. Talking about 5G which is a hot topic of research these days and considering its advantages over other networks, vehicular communication using 5G will be interesting.

## VI. SIMULATING THE NETWORK TRAFFIC

Many simulators are available to help us simulate our research model and deduce the outcomes [73]. Some of the common simulators that are used in emergency traffic management are described below.

### 1) *Network simulator 2 (NS 2)* [74]

NS 2 is an open-source event-driven tool that is used to simulate various computer communication models.

It supports both wired and wireless networks. NS 2 is very popular and it is very easy to find libraries for NS 2 simulator. It also supports a wide range of protocols. Its working platforms are UNIX, Linux and Windows using Cygwin.

### 2) *NS 3* [75]

NS 3 is a free and open-source discrete event simulator for communication models targeted for the education and research industry. NS 3 was created as a replacement for NS 2 and was made completely isolated from NS 2 by abandoning the backward compatibility of NS 3 with NS 2. The advantage of NS 3 is that it includes the features that are not available in NS 2. Moreover, it is properly maintained as compared to NS 2.

### 3) *Mininet* [76]

Mininet is a simulator used to create virtual switches, links, hosts, and controllers. Mininet helps us create a virtual environment of switches and links to simulate different networking models. It is very flexible in terms of Software Defined Networks (SDN). The advantage of Mininet is that it is simple and inexpensive. Mininet is highly flexible for software-defined network models.

### 4) *QualNet* [77]

QualNet is a tool that is used for training, testing, and planning of network simulation models and mimics the behavior of real physical networks. It supports a wide range of networks. An advantage of QualNet is that it is fast, accurate and has powerful GUI for modeling. The drawback of Qualnet is that it is complicated and not free.

### 5) *MATLAB* [78]

Matlab is a very popular high performance mathematical technical computation tool that is widely used by researchers. It has high-performance architecture and is easy to use. It integrates programming with computation where the problems are addressed in familiar mathematical notations. Matlab makes testing, implementation and debugging of algorithms easy. It also performs visualization and analysis of extension data.

### 6) *NetSim* [79]

NetSim is an end-to-end, full-stack and packet-level simulator that is very helpful for engineers to design networks. It's network libraries contain various protocols and topologies. NetSim makes building and debugging of your code easier and features a GUI interface. NetSim is expensive to operate as well as the users should be properly trained. It requires high system resources. It becomes difficult to operate as the size of the network increases.

### 7) *OMNet++* [80] [81]

OMNet++ is a modular framework, component-based and runs on C++ that is used to building network simulators. Non-commercial use is very common in academic institutes. It's powerful GUI makes the tracing of packets easier as compared to other simulators. It is



**TABLE 1. Traditional comparative analysis of different emergency message dissemination schemes.**

Approach	Technology	OBU	RSU	GPS	WCT	Delay	Latency	Throughput	Scalability
FLS (2015)	Intelligent Traffic Lights	×	×	✓	-	M	M	M	Y
TLCSI (2015)	Intelligent Traffic Lights	✓	✓	✓	-	L	M	M	Y
TSTFL (2018)	Intelligent Traffic Lights	✓	✓	✓	-	H	H	L	N
RFID (2013)	Internet of Things	✓	✓	✓	V/UHF	H	M	L	Y
TCMIoT (2019)	Internet of Things	✓	✓	✓	WiMAX	M	M	M	N
EV-PVS (2016)	Internet of Things	✓	✓	✓	802.15.4	L	H	M	N
DV-CAST (2010)	Priority Messaging Dissemination	×	✓	✓	DSRC	M	M	H	N
DP-EMB (2018)	Priority Messaging Dissemination	×	×	✓	802.11p	M	M	M	N
3P3B (2014)	Priority Messaging Dissemination	×	×	✓	802.11p	H	M	L	Y
MC-EMD (2016)	Clustering Dissemination	×	×	✓	802.11p	M	M	M	Y
CB-EMB (2017)	Clustering Dissemination	×	×	✓	802.11p	H	H	L	Y
DD-CPB (2018)	Clustering Dissemination	×	×	✓	802.11p	M	M	M	Y
SPArTaCuS (2016)	Software Defined Network	×	×	×	-	M	M	L	Y
HEMT (2017)	Software Defined Network	✓	✓	✓	802.11p	M	M	M	N
NGECS (2014)	Software Defined Network	×	×	×	802.11p	L	L	M	Y
H-VFog (2019)	Fog Based	✓	×	✓	802.11p	M	L	M	Y
QS-VFDD (2018)	Fog Based	✓	×	×	802.11p	H	M	M	Y
FACP (2019)	Fog Based	✓	×	×	802.11p	L	M	L	N
EFPBS-5G (2016)	5G Network	✓	×	×	5G LTE	M	M	H	Y
RFS-E5GS (2018)	5G Network	✓	×	✓	5G	H	M	L	N
IWL-VNMD (2017)	5G Network	✓	✓	×	802.11p, LTE	M	L	M	Y

**TABLE 2. Differentiation of network traffic simulators.**

Simulator	Open Source	Scalability	Language Support	Parallel Support	Active Development	802.11p Support
NS 2	✓	Scalable	C++, Tcl	✓	✓	✓
NS 3	✓	Scalable	C++, Python	✓	✓	✓
Mininet	✓	Scalable	Python	✓	✓	✓
QualNet	×	Scalable	C++	✓	✓	✓
Matlab	×	Scalable	C/C++, Java	✓	✓	✓
NetSim	×	Scalable	Java	✓	✓	✓
OMNet++	✓	Scalable	C++	×	✓	✓
SUMO	✓	Scalable	C++	✓	✓	✓
VEINS	✓	Scalable	C++	×	✓	✓
TraNS	✓	Scalable	C++, Java	×	×	✓

simple and easy to operate. It is free when used for non-commercial purposes like education and research.

8) *SUMO* [82]

*SUMO* is a tool that generates a traffic mobility framework and has integrated network simulators. *SUMO* is an open-source, portable and extensively used tool for monitoring continuous traffic analytics. It is designed

for large scale road network simulations. An advantage is that it can evaluate traffic signal lights and forecast traffic statistics. It is used to model traffic management and simulate automatic driving.

9) *VEINS* [83]

*VEINS* is an open-source framework that is used to simulate vehicular networks. It is a combination of

OMNet++ and SUMO and it uses their features to offer a comprehensive model to make the simulation as realistic as possible. It can support the parallel running of the two simulators. VEINS makes the interaction of nodes with running traffic simulation easy. Its development is based on MiMiX and uses the 802.11p communication protocol.

#### 10) TraNS [84]

TraNS is a tool based on GUI that is used in VANETs which combine the traffic (SUMO) and network simulation (NS 2) into realistic traffic mobility simulations. It also stimulates the exchange of information between vehicles to analyze the behavior of different schemes. However, the development of TraNS has been suspended that is why it cannot support the latest versions of NS 2 and SUMO thus, there is no support for this tool as well.

Different Simulators are designed for different environments and each of them has different usage. Every simulator has its pros and cons. The simulators along with their pros and cons are listed in table 2.

## VII. CONCLUSION AND FUTURE WORK

This paper provides a detailed review of recent studies on emergency message dissemination. Various authors proposed different schemes that offer reliable and efficient dissemination of emergency messages. These studies are based on ITS, IoT, Clustering, Priority Messaging, SDN, Fog Computing and 5G Network. For a decisive study, the research was included from the perspective of both normal city and smart city. Each methodology has its pros and cons and can show performance and efficiency under different environments and circumstances. The use of clustering technology can be effective as it offers scalability, security, efficiency, and reliability. Furthermore, there is a potential scope of research on the Fog Computing and 5G Network-based message dissemination techniques as no significant works have been proposed in these domains.

In the future, we plan to devise an ideal model for emergency message dissemination. We are going to utilize the advantages of current research models and try to tackle the disadvantages faced in the mentioned models. We need to work on a model that is scalable and sufficient to handle the data communication needs. A model that has no restraint to challenges and is capable to be deployed in various scenarios.

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