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Risk Zone Selective Emergency Message Forwarding Scheme For VANET

By

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Dedicated to

My father

Dear Dad, I know you can’t see this right now, but I never forget what you taught me. One day I will full fill what you told me.

Approval sheet

This Independent Research entitled as "RISK ZONE SELECTIVE EMERGENCY MESSAGE FORWARDING SCHEME FOR VANET" has been read and approved as meeting the preliminary research requirements of the School of Computing in partial fulfillment for the award of the degree of Master in Computer Networking.

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Acronyms, Abbreviation and Terminology

DSRC: dedicated short range communication

EM: emergency message

GPS: global positioning system

ITS: intelligent transport system

MAC: Medium access control

MANET: mobile ad-hoc network

MOVE: Mobility model generator for Vehicular networks

OBU: On board unit

RN: relay node

RSEMD: risk zone selective emergency message dissemination

RSU: roadside unit

SAE : Society of Automotive Engineers

STRAW: Street Random Waypoint

SUMO: simulation in urban mobility

TraNS: Traffic and Network Simulation Environment

V2I: vehicle to infrastructure

V2V: vehicle to vehicle

VANET: vehicular ad-hoc network

VBN: vehicular backbone network

VEINS: Vehicles in Network Simulation

WAVE: wireless access in Vehicular environment

WSA: WAVE service Advertisements

WSM: WAVE short message

WSMP: WAVE short message protocol

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Abstract

VANET is one of special kind of mobile ad-hoc network which is specifically designed for ITS environment. VANET communication can be V2V or V2I communication. V2V communication is a communication among moving vehicles and V2I communication is a communication between vehicles with infrastructure. VANET applications can be safety and comfort application. Disseminating safety information in VANET heavily relies on broadcasting schemes. Safety application is time critical which needs low delay and can be disseminated on time, so broadcasting is the best option in safety application for VANET. But when we apply simple broadcasting it causes broadcast storm problem in dense network. Due to this selective forwarding scheme to broadcast emergency message is needed. In highway scenario, there is frequent dis-connectivity of link caused by high speed which leads to network fragmentation problem and there is high overhead caused by redundant data transfer in simple broadcasting approach. The aim of this thesis is to design emergency message dissemination scheme with high data delivery ratio, low overhead and low forwarder node ratio.

In this thesis we design multi-hop selective forwarding scheme by using RSU as a forwarder node to solve network fragmentation and we use vehicles which are found only in the risk zone for further forwarding to reduce the unwanted traffic. Algorithms for risk zone identification and forwarder node selection and emergency message dissemination are proposed. To select forwarder node we combine distance, road identifier and travel direction of vehicle. To implement the thesis, we use SUMO simulator for generating mobility and OMNeT++ for network simulator by using Veins framework.

From the simulation, we get 23.6% and 40% Data delivery ratio in our scheme and 14.45% and 22% in the existing scheme with 50 and 30 nodes respectively. From this the proposed dissemination scheme increases the data delivery ratio. Therefore, the proposed scheme has better performances than the existing schemes by increasing the data delivery ratio, decreasing overhead and decreasing forwarder node ratio.

Key word: VANET, emergency dissemination, broadcasting scheme, selective forwarding

Chapter 1

1.1Introduction

Now a day's, intelligent transport system is one of the hottest research areas due to the high number of problems in transportation. A number of people dies, a lot of properties are lost due to traffic problem in the world. So researchers investigate VANET as one of the solutions to decrease the problem.

Vehicular Ad hoc Networks (VANETs) are special kind of Mobile Ad Hoc Networks (MANETs) that are formed between moving vehicles and road side unit. The characteristics of VANETs are high mobility of nodes, time varying density of nodes, frequent disconnections, highly partitioned network and dynamically changing topology [11], [16]. Vehicular communication can be vehicle to vehicle (V2V), vehicle to infrastructure (V2I) or hybrid communication [7], [16], [27]. V2V communication is the type of communication in which vehicles are used as relay node to forward message between them. V2I communication refers to when the vehicle use infrastructure to forward information.

VANET have safety and comfort applications. Any safety application demands exchange of related messages between vehicles. These massages can be classified into two categories: alarm and beacon, which have different dissemination policies and roles in safety improvement. Alarm messages are issued by all vehicles to announce to other vehicles about the previously happened events at a specific location of a road, such as car crash and icy surface, while beacon messages are issued periodically [16]. While alarm messages may be able to inform the driver in time about already happened events in order to prevent more incidents, beacon messages can prevent many incidents before they take place. Moreover, since alarm messages announce events, they are more critical. When there is no good message forwarding and networking mechanisms provided for VANET, it leads high packet collisions, throughput degradation because of the Broadcast storm problem [10], [11].

Now a day's, vehicles are embedded with intelligent system of sensors, Global Positioning System (GPS) and transceivers for transmission and reception of signals [14], [12]. The vehicles which are found far away from the hazard zone have a higher probability of reception of emergency messages and might take decisions such as detour or choosing alternate routes [13].

Disseminating emergency messages for Risk zone in VANET is a critical issue [2]. Due to this many researchers proposed different schemes to disseminate emergency messages. In [6], [7], [15], [16], [36] currently there are flooding based, distance based, counter based, store carry forward based and probabilistic dissemination schemes. Flooding based mainly leads broadcast storm problem due to high number of collision during communication. Distance based and counter based scheme are used in well-connected network. When the network became sparse those two schemes gets network fragmentation problem. To solve network fragmentation problem store carry forward techniques are suggested in [3]. Emergency message are time critical and they need to disseminate a soon as the emergency detected, so store and carry approach leads high delay. Due to this in [9], [17], [18] propose using VBN structure to broadcast the emergency message via the assistance of RSU as the forwarder node. But their scheme have high overhead due to high number of forwarder node. Our proposed scheme solve the above problems by using RSU as a forwarder node and vehicles only in the danger zone can participate for farther forwarding the emergency message. Generally, the proposed work has the following significances.

- Increase the probability of emergency message reception with less duplication.
- It increases number of notified vehicle.
- Minimize overhead

1.2 Statement of the Problem

In VANET, establishing end to end connectivity is difficult due to the random change of topology caused by mobility of vehicles with variation of velocity. In sparse network, there is network fragmentation caused by frequent disconnection. When a vehicle going in highway that the number of vehicle are sparse using V2V communication is not feasible so if an accident happen in highway disseminating the emergency message to the vehicles that come towards the accident is difficult. In most Emergency situation there is less time to create handshake with other nodes in VANET. As emergency message is delivered with fast and with high number of notified vehicle, broadcasting scheme plays a great role in almost all safety application [27]. When we take the common broadcasting scheme like blind flooding which mainly causes broadcast storm problem [1], so designing selective forwarding technique is necessary to solve broadcast storm problem. When the network density is sparse it leads network fragmentation problem. Therefore, emergency message dissemination in VANET with high reception rate, high number of notified vehicle and low overhead is still a challenging task in the research world. The author in [3] suggest the use of two forwarder vehicles to rebroadcast the emergency message because of selecting one forwarder does not guaranty for dissemination of emergency message. In their scheme they consider the crashed vehicle to carry and store the message when there are no vehicles in the transmission range. But consider the crashed vehicle for carry the emergency message leads high delay for emergency message. Due to the nature of emergency message, store and carry paradigm is not suitable for safety application in VANET. Other authors in [9] design road accident prevention scheme (RAP), In their schema they suggest the use of static node for rebroadcasting the emergency message when there is no vehicle in the transmission range of the vehicle which detect the accident and their scheme suggest using static node enhance the emergency message reception rate by removing network fragmentation problem. For farther forwarding the authors suggest speed and position based relay node selection scheme. According to the authors the vehicles which have low speed should be selected as a forwarder node. But as they stated there are a number of vehicle which are traveling with the same speed in the highway. Due to this their scheme leads high number of forwarder node and broadcasting emergency message via more number of forwarder node leads high overhead. Therefore, we propose efficient emergency dissemination scheme which uses RSU to solve the network fragmentation problem and during the forwarder node selection we propose the distance, road identifier and the direction of the vehicle. In our dissemination scheme, few numbers of nodes are selected to rebroadcast the emergency message. It will increase bandwidth utilization, probability of emergency message reception and minimize overhead caused by unwanted duplication.

Generally the following questions are answered in this thesis:

- How to select forwarder node?
- How to disseminate emergency message with low overhead and low forwarder node ratio?

1.3 Objectives

1.3.1 General Objective

The general objective of this thesis is proposing efficient emergency message dissemination scheme for VANET in high way scenario to increase the probability of emergency message reception and to minimize overhead.

1.3.2 Specific Objective

To achieve our general objective, we have specific objectives. Those objectives are:

- Reviewing the existing VANET technology
- Reviewing the Existing Emergency Dissemination scheme in VANET
- Design algorithm to select risk zone
- Design algorithm for selecting forwarder node
- Propose new scheme to disseminate emergency messages
- Test and Evaluate the new scheme in simulation environment
- Compare and contrast the new scheme with existing dissemination scheme

1.5 Methods

1.5.1 Literature Review

To achieve the objectives listed above we review deferent papers about the general VANET technology for understanding the overall technology as well as the existing emergency message dissemination schemes. We review the challenges to disseminate emergency message in VANET.

1.5.2 Design and Implementation

In this phase, the proposed architecture and algorithms to select risk zone, select forwarder node and emergency message dissemination are designed. All the detail architecture of the proposed work is designed in this phase. Because of the difficulty of implementing VANET in a real environment we, implemented the proposed system in network simulation environment. We implement via a realistic simulation SUMO, Veins and OMNeT++.

1.5.3 Evaluation of the Proposed Work

We conduct experiment in simulation environment and evaluated our work in terms of network parameters like network overhead, data delivery ratio and number of notified vehicle. After evaluating our work we compare and contrast with the existing works done on emergency message dissemination schemes

1.6 Scope and limitation

The scope of this thesis focuses on designing emergency message dissemination in VANET mainly for highway scenario. The approach contains algorithms for beacon exchanging, emergency message generation, selecting relay nods to rebroadcast message and identification of risk zone. The scheme will improve the overhead caused by redundancy and increase emergency message notified vehicles.

The thesis will not cover the following issues:

- The dynamic deployment of static node
- security due to beaconing
- node unwillingness

1.7 Application of Results

VANET technology is one of the hottest technologies in the world for intelligent transport system. The new scheme can be applicable to safety application in VANET to minimize the loss of emergency message before reaching to the target or danger zone and increase probability of emergency message reception.

We have tested the scheme in realistic map of Addis-Abeba to Adama with the simulation tool, the scheme can be applicable in intelligent transport system to facilitate the dissemination of emergency message with low overhead.

One of the goals of IT'S is giving care for the passengers, so this thesis have a great roll for this application. Our scheme used for facilitating ITS safety application.

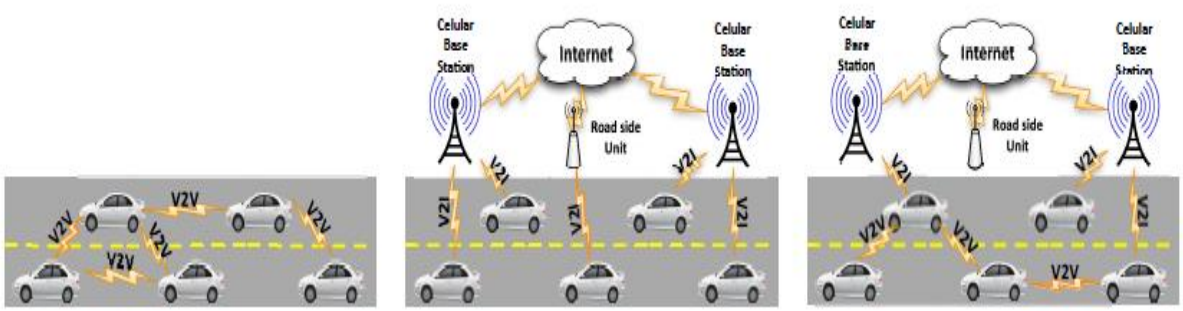
1.8 Thesis Organization

This thesis is organized as follows. In Chapter 2 we present the general overview of VANET technology, standard of VANET, application and challenge of VANET. In addition to this the emergency dissemination schemes are also presented. Chapter 3 introduces related works which are classified by the dissemination scheme with the support of RSU and without RSU. Chapter 4, presents the detail of the proposed model and algorithms. In Chapter 5, simulation study and evaluation of the proposed algorithms are described. In Chapter 6, we present conclusion, contribution and future works.

Chapter 2
Literature Review

2.1 VANET Technology

VANETS are wireless network environment for Intelligent Transportation Systems (ITS) to give different applications via vehicles as a network node [36]. This technology is one of the specific parts of MANET with its own application, characteristics and challenges. VANET technology mainly depends on DSRC (dedicated short range communication) [1], [7], [16], [28]. There are two types of DSRC devices that are used for communication in the VANET: On-Board Unit (OBU) and Road-Side Unit (RSU). OBU is the device which is found in the vehicle or it is a transceiver mounted within a vehicle along with a computational device. To access the wireless channel in the OBU, the vehicle uses Omni directional antenna. The vehicle has also sensors to provide input to the OBU and the sensors can record the local conditions of the vehicle. The other device in DSCR is RSU which is stationary devices that are mounted in roadside and it is similar to an OBU in that it has a transceiver, antenna, processor, and sensors. RSU can use either a directional antenna or an Omni-directional antenna depending on the type of application provided by the RSU. When RSU needs to send a signal only to towards a specific direction, it can have directional antenna. Vehicular ad hoc networks are not pure ad hoc networks. An infrastructure of RSU exists to allow VANET access an external network such as the Internet [1], [7], [15], [16].



(a) Vehicle-to-Vehicle Ad Hoc Network (b) Vehicle-to-Infrastructure Network (c) Hybrid Architecture

Figure 2-1 Architecture of VANET [14]

As shown in Figure 2.1:

- **Vehicle-to-Vehicle (V2V) ad hoc network:** is a way of vehicular communication in which vehicles communicate directly. This way of communication is suitable for vehicles that can directly communicate each other.
- **Vehicle-to-Infrastructure (V2I) network:** is a way of communication in which vehicles communicate with external infrastructures like RSU. This communication mainly exist when vehicle communicate with RSU.
- **Hybrid architecture**: This architecture combines both Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I). In this architecture, vehicles communicate with the roadside infrastructure either in a single hop or multi-hop fashion, depending on the distance.

2.2 Characteristics of VANET

VANET has unique characteristics when compared with other types of MANETs, as the author in [15], [16], [36] expresses, the unique characteristics of VANET include:

A. Predictable mobility

In VANET the network nodes (vehicles) move in a predefined way because roadslayout are fixed and vehicles moving only in the fixed road available. Though the mobility of vehicles can be predictable, there is high network fragmentation caused by high speed in sparse network [36].

B. High mobility and rapid changing topology

Here unlike MANET Vehicles move very fast especially in highways. Thus, they remain within each othercommunication range for a very short time, and linksare established and broken fast which results to rapidchanges in network topology. The rapidchanges in network topology affect the networkdiameter to be small, while many paths may bedisconnected before they can be used.

C. Geographic position available

Vehicles can be equipped with modern, accurate positioning systems integrated by electronic map. Modern vehicles are equipped with GPS to know about their information and the surrounding. From the GPS information vehicles can get their position and their neighbor information.

D. Variable network density

The network density in VANET varies depending on the traffic load, which can be very high in the case of a traffic jam, or very low, as in suburban areas. In urban environment there are various vehicles which travel on the road and in case of highway the number of vehicle are sparse. Due to the variation in number of vehicles, there are variable network densities in VANET.

E. High computational ability

In VANET the vehicles are counted as nodes, so they can hold a sufficient number of sensors and enough communication equipment such as high speed processors, large memory size, advanced antenna technology and modern GPS.

F. Hard Delay Constraints

According to the author in [36], some of the applications in VANET do not require high data rates but has hard delay constraints. Here when the application is safety application it needs small time to disseminate the message to other vehicles as soon as the emergency situation detected.

2.3 Standard of VANET Communication

VANET have standard which support different application. According to [28] the IEEE standard for VANET can be described in Figure 2.2. VANET have different layered architecture depend on its application. A WAVE system is a radio communications system which provides interoperable services to transportation [39]. The services provided by the WAVE standard include communications between vehicles and roadside units, vehicles and other vehicles, and perhaps communications among other WAVE devices. The general WAVE architecture includes IEEE P1609.1, IEEE P1609.2, IEEE 1609.4 and IEEE 802.11p [28], [37]. IEEE1609.2 is about security, IEEE1609.4 is about the MAC layer extension to support multichannel operation, IEEE 802.11p is PHY and MAC layer standard specifically designed for VANET which support IEEE802.11e. LLC (logical link control) layer is used to check the *Ethertype* in sub-network access protocol (SNAP) header and provide to the data to higher layer and MAC layer according to the *Ethertype*.

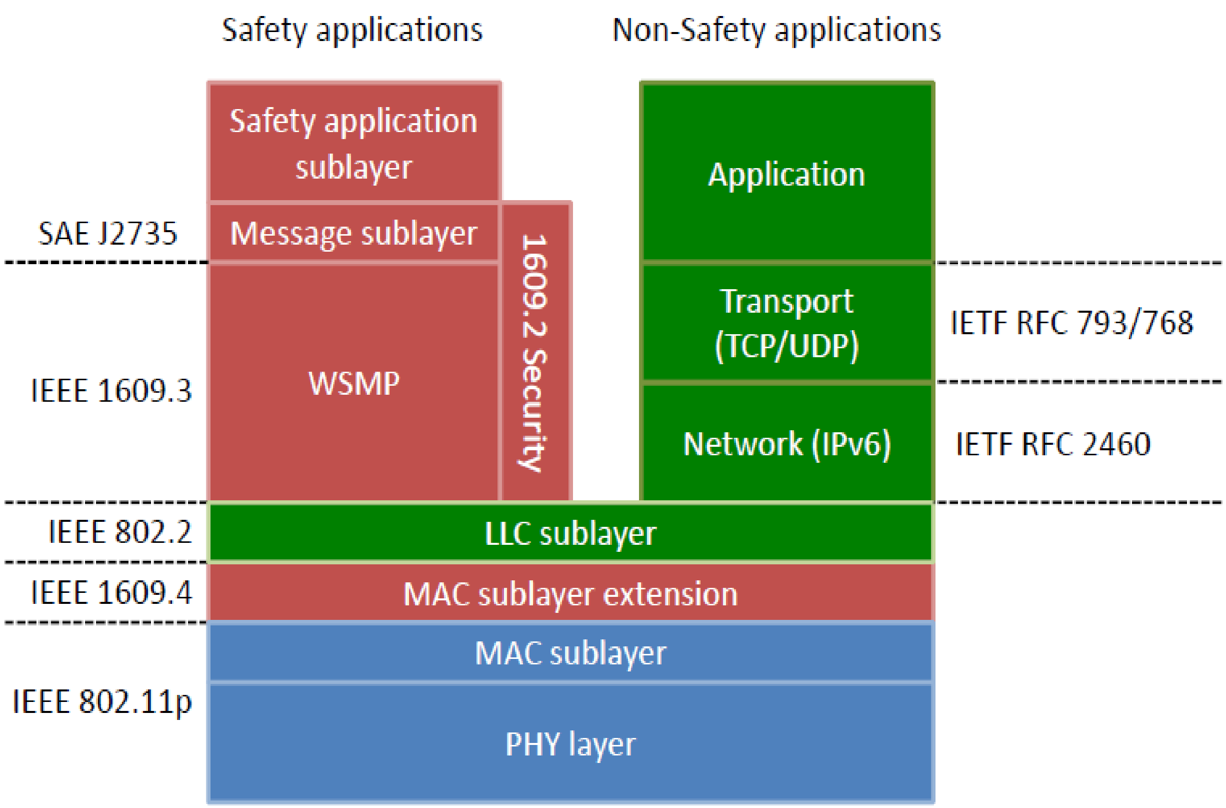


Figure 2-2 IEEE, WAVE/802.11p Standard [28]

From Figure 2.2, the physical layer of VANET is based on IEEE802.11p which is specifically designed to support VANET application. The IEEE 802.11p WAVE protocol proposes amendments to the physical (PHY) and medium access control (MAC) layers of the existing IEEE 802.11 wireless standards to support ITS applications such as: data exchanges among high-speed vehicles and between vehicles and the roadside infrastructure in the 5.9GHz band.

The IEEE MAC layer supports quality of service requirements which is designed specifically in 802.11e. 1609.3 WSMP which is called WAVE short message protocol (WSMP) developed to avoid excessive overhead. The 1609.3 contains WAVE Short Messages (WSM) and WAVE Service Advertisements (WSA). The message sub layer as we see from Figure 2.2, SAE J2735 DSRC message set dictionary which can support around 15 types of messages. Mainly the basic safety message and the periodic message can support by the layer. LLC sub layer provides the data to the network or to the WSMP layer depending on the *Ethertype* extracted from the SNAP header file.

The IEEE1609.4 MAC sub extension layer is used to support multichannel operation, which contains one control channel and six service channels [19], [28].

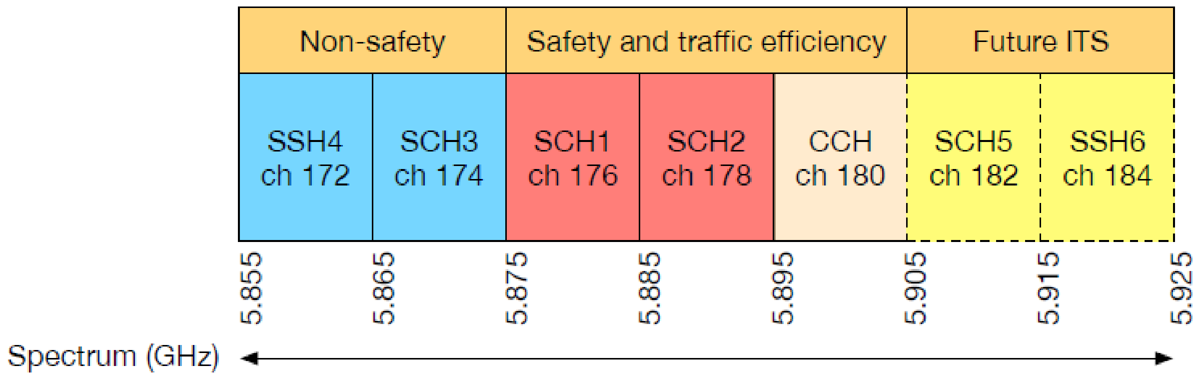


Figure 2-3Multichannel operation in VANET IEEE 802.11p European Standard [20].

As shown in Figure 2.3, there are different channels specifically designed for different applications. Here the CCH (control channel) is a single radio channel used for the exchange of management frames which include WAVE service advertisement and WAVE short messages [28], [37], [38]. In this channel, safety information can be exchanged among the WAVE enabled devices. SCH (service channel) is channel used for the management frame and higher layer information exchanges and IPv6 packets. Unlike CCH, SCH can be defined more than one in a given spectrum as shown in Figure 2-3.

2.4 VANET Application

Based on the type of communication either V2I or V2V or hybrid, VANET have a lot of applications in ITS environment. According to the surveys in [6], [16], [36] VANET have the following applications.

2.4.1 Safety Application

Safety applications include monitoring of the surrounding road, approaching vehicles, surface of the road, road curves etc. The Road safety applications can be classified as:

- **Real-time traffic***:* in this application real time traffic data can be stored at the RSU and can be available to the vehicles whenever and wherever needed This can play an important role in solving the problems such as traffic jams, avoid congestions and in emergency alerts such as accidents etc.

- **Co-operative Message Transfer***:* this application mainly concerns the slow/stopped Vehicle exchange messages and co-operates to help other vehicles. Even though reliability and latency is major concern, this application may automate things like emergency braking to avoid potential accidents. In similar to this application, emergency electronic brake-light may be another application.
- **Post-Crash Notification***:* In this type of application a vehicle which detects an accident broadcast warning messages about its position to trailing vehicles so that it can take decision with time in hand.
- **Road Hazard Control Notification***:* in this type of application vehicles announce other vehicles about information regarding to road feature notification due to road curve, sudden downhill, road slides etc.
- **Cooperative Collision Warning***:* this application used in terms of alerting derivers about the crashed route and they can make their decision.
- **Curve Speed Warning***:* as vehicles equipped with GPS. If the driver approaches to curve and drive with high speed warning message can be shown [36]. Visual symbol or text warning can be display to warn the driver.
- **Traffic Signal Violation Warning:** this application is designed to send a warning message to a driver when it detects that the vehicle is in risk of running the traffic signal. The decision to send a massage is made on the basis of traffic signal status and timing and the vehicle's speed and position. RSU broadcasts the traffic violation warning message to all other vehicles in the neighborhood for further dissemination.

2.4.2 Commercial Applications

Commercial applications are applications which provide the driver with the entertainment and services such as web access, streaming audio and video. The Commercial applications can be classified as:

- **Remote Vehicle Personalization/ Diagnostics***:* It helps in downloading of personalized vehicle settings or uploading of vehicle diagnostics from/to infrastructure.
- **Internet Access***:* VANET can be used to connect to the internet by using static node as router.

- **Digital map downloading:** Map of regions can be downloaded by the drivers as per the requirement before traveling to a new area for travel guidance. Also, Content Map Database Download acts as a portal for getting valuable information from mobile hot spots or home stations.
- **Real Time Video Relay:** On-demand movie experience will not be confined to the constraints of the home and the driver can ask for real time video relay of his favorite movies.
- **Value-added advertisement***:* This is especially for the service providers, who want to attract customers to their stores. Announcements like petrol pumps, highways restaurants to announce their services to the drivers within communication range. This application can be available even in the absence of the Internet.

2.4.3 Convenience Applications

Convenience applications are applications which mainly focus in traffic management to enhance traffic efficiency by boosting the degree of convenience for drivers [36]. The Convenience applications can be classified as:

- **Route Diversions***:* Route and trip planning can be made in case of road congestions
- **Electronic Toll Collection***:* A Toll collection Point shall be able to read the OBU of the vehicle. OBUs work via GPS and the on-board odometer as a back-up to determine how far the Lorries have travelled by reference to a digital map. TOLL application is beneficial for both to drivers and toll operators.
- **Parking Availability***:* Notifications regarding the availability of parking in the metropolitan cities helps to find the availability of slots in parking lots in a certain geographical area.
- **Active Prediction***:* It anticipates the upcoming topography of the road, which is expected to optimize fuel usage by adjusting the cruising speed before starting a descent or an ascent.

2.4.4 Productive Applications

Those kinds of applications are applications which are additional to the above applications. The Productive applications can be classified as:

- **Environmental Benefits**: VANET can be used to generate and acquire environmentally-relevant real-time transportation data, and use these data to create actionable information that support and facilitate "green" transportation choices by transportation system users and operators. Researchers are conducted better define how connected vehicle data and applications might contribute to mitigating some of the negative environmental impacts of surface transportation [6].
- The traveler can downloads his/her email after that he/she can transform jam traffic into a productive task and read on-board system and read if there is traffic stuck and someone can browse the Internet when someone is waiting in car for a relative or friend.

2.5 Message Dissemination Schemes for VANETs

Message dissemination schemes are remarkably influenced in separation of sender and receiver vehicles, because it is mainly influence the radio signal attenuation especially in areas with low vehicle densities, the effect of obstacles like buildings that frequently block signal transmission in urban areas and the instant density of vehicles [6].

Here when the message dissemination scheme is developed for VANETs, the map technology should be considered because it directly influences the mean distance among communicating vehicles and the presence of obstacles. The density of vehicles clearly affects the alert message dissemination protocols since lower densities can lead to packet losses due to poor communications, and higher densities usually lead to broadcast storms [1], [38]. According to the literatures [6], [16], [36] there are many ways to deliver information in VANET. According to the survey in [36] the main data dissemination approaches in VANET are the following:

- **Opportunistic Data Dissemination:** according to this approach Information is retrieved from infrastructure or vehicles probably or opportunistically.
- **Vehicle-Assisted Data Dissemination:** here all vehicles assumed to know information along with them and deliver it either to the infrastructure RSU or to other vehicles when they are encountered. Apart from the wireless transmission to disseminate the message, mobility of vehicles is also involved.

In general speaking those dissemination approaches in safety application depends on broadcasting techniques. According to different literatures the main broadcasting approaches are relay in to two categories. Those approaches are one hop dissemination and multi-hop dissemination.

2.5.1One-Hop Dissemination Scheme

In this type of dissemination scheme the information's only exchange via neighbor vehicles. The information received from other vehicles is not further rebroadcast by the receiving vehicle. Dissemination schemes using single-hop safety messages provide local information, hence requiring additional aggregation algorithms to be feasible in safety applications for covering a wide area [6]. These operations increase the computational overhead of the applications, which may delay the detection and notification of dangerous situations, thus making them unsuitable in many scenarios.

2.5.2 Multi-hop Dissemination Schemes

In this dissemination scheme when a vehicle detects emergency situation, the vehicle inform to its neighbor vehicle and the message should be rebroadcast farther to announce the other vehicles which is not in the transmission range of the first vehicle. As VANET is designed to support safety application, the information is expected to receive by all the vehicles.

2.5.2.1 Classification of Multi-hop Dissemination Schemes.

In VANET, message dissemination is critical issue to quickly inform vehicles about problems that may affect them. There are different dissemination schemes that are designed to mitigate broadcast storms by selecting certain nodes (vehicles) from rebroadcasting using different parameters, thereby reducing contention in the channel, as well as message redundancy and collisions.

- **Flooding:** this is one of the dissemination scheme in which nodes can simply rebroadcast when they receive message. Here when N numbers of nodes are in the network they simply rebroadcast for farther coverage of messages. When vehicles or RSU receive a message which has to be broadcast, initially they check whether the packet is new. If it is new, they rebroadcast; otherwise they discard. Since every node forwards the message, it leads redundancy. The redundancy depends on the density of vehicles found in the transmission range.

- **Counter-based dissemination scheme:** is part of flooding based scheme sometimes called limited flooding. According to this If counter $c \geq (\text{threshold})$ for a received message, rebroadcasting is not allowed for that message.
- **Beacon:** According to this, beacons are periodic messages sent by vehicles to exchange information about their positions, speed, and other basic information's. Those messages have low priority than the alarm messages. Those messages are disseminated in one hope fashion; they are not further rebroadcast by the neighbor nodes.
- **Distance:** according this method, the rebroadcasting of the message depends on the distance between the sender and the receiver. In this dissemination scheme rebroadcasting is not suggest when the separation distance is minimum in order to cover large coverage.
- **Store and Forward:** In this kind of dissemination technique when alert message received by anode, the node store for some time till it gets other node in transmission range. According to this technique a vehicle usually waits to rebroadcast the message until a new neighbor is found. This way mostly used in sparse network scenarios.
- **Probabilistic:** According to this scheme it depends on the probabilistic distributions to determine the probability of broadcasting a given message, depending on the conditions of the transmitting vehicle. Most of the schemes that designed based on this scheme use the Gaussian or the uniform distribution to associate a probability to each message or vehicle.

2.6 Challenges in VANET

VANET have a lot of applications in ITS environment as we expressed above, to fulfill those applications with effective and efficient manner it have its own challenges. In [16], [36] describes bandwidth reservation, packet loss reduction, packet scheduling and QoS control are the main requirements for VANET. Traditional approaches designed for MANET are in efficient and cannot be directly applied for VANET. Mainly the following are the main challenges in VANET according to the survey in [15], [16], [36].

- **Frequent Link Disconnections**: As we expressed in the above section that unlike nodes in MANETs, vehicles are highly mobile and generally travel at higher speeds (i.e., over 100 km/hr) and this causes the frequent topology changes. Due to this, there is failure of link from source to destination. According to the author in [36] assume a source (sender) is travelling at 110 km/hr and its corresponding receiver is travelling at 120 km/hr in the same direction, and if the transmission range is 300 m, the communication can only last for a minute between the sender and receiver vehicles and if the vehicles travelling in opposite directions, a communication link can only be there for less than 5s. Therefore link disconnection is challenging task in VANET
- **Heterogeneity of Applications**: VANET have various applications of safety and infotainment applications. Those safety applications need low latency and high reliability while infotainment applications require better throughput, low packet loss and higher resource utilization. So designing efficient and effective communication approach which can fulfill the requirement of applications is critical issue in VANET.
- **Information Dissemination:** Disseminating emergency (warning) information in VANET is a critical problem. Unlike to other networks such as Internet where data is typically unicasted, the safety information in VANET has a nature which requires broadcasting [27]. Due to the fact that safety message can disseminated to many nodes instead of a single node to create awareness about emergency situation, disseminating the those information using broadcasting scheme is more suitable as compared to a routing approach that employs unicasting [36]. In broadcasting scheme, a vehicle does not require the destination address and the route to a particular destination. Broadcasting reduces the various difficulties in VANET such as complexity of route discovery, address

resolution, and topology management. Though this scheme is good option, it causes blind storm problem in dense network environment. Therefore, designing broadcasting scheme which is capable of addressing those problems is a challenging task.

- **Disruptive tolerant communications**: Currently there are problems, such as higher delay and lower reliability delivery in sparse networks. To increase the delivery reliability, some solutions make use of the carry-and-forward technique, which further increases the information delivery time. Therefore, designing a mechanism without carry-and –forward stratagem is needed in VANET.
- **Standardization of protocols**: when we say VANETs it can be composed of various types of vehicles such as trucks, cars, trams, buses, taxis motorbikes and bicycles. In this scenario, it is important that all of them are able to communicate among themselves using the same protocol. There for creating a standard is challenging task.

Chapter 3

Related work

In Chapter 2, we have seen that there are many ways to disseminate emergency message in VANET and we have seen also the challenges found in VANET. Applying dissemination schemes for emergency message can be with the support of infrastructure or within pure ad hoc manner. In this Chapter, we discuss the message dissemination schemes in two categories: Dissemination scheme that use road side unit and dissemination scheme which did not use Road side unit.

3.1 Message Dissemination Scheme without using Road side unit

Alvin Sebastian [2] proposes context aware multicast protocol for emergency message dissemination which considers endangers vehicles get the emergency message. According to the author's the vehicle that encounters the emergency situation or the accident seen as abnormal vehicle. In the protocol, the vehicle approaching to the endangered vehicle is selected as a relay node. The protocol has high reliability and low latency. The protocol is suitable for the scenario in which the destination vehicle is known. But as one of the role of VANET is to make awareness to vehicles in the road that have dynamically changed and which is difficult to make handshake with other vehicles this approach is not good option when the number of vehicles going sparse. The other thing is in terms of dense scenario when there are a lot of vehicles which approach to the abnormal vehicle, in this case the forwarder node increases and it cause overhead.

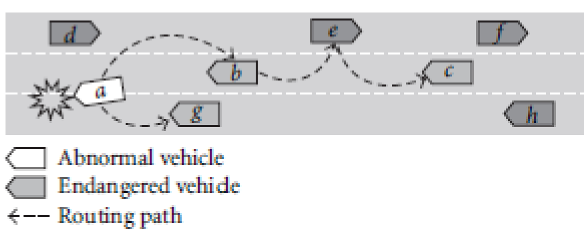


Figure 3-1 Path selection in [2]

As shown in Figure 3.1 when vehicle *a* detects an accident, vehicle g and vehicle b select as relay node. The problem is:

- If the vehicle *e* does not exist in the transmission range of vehicle *b*, the emergency message cannot be disseminated. This leads to high data loss

Another protocol proposed in [3] called efficient Emergency Message broadcasting scheme for VANET, by enabling the farthest vehicle behind the crushed vehicle to make the rebroadcasting of the emergency message. According to this protocol each vehicle assumed to have equipped with GPS and the vehicles broadcast beacon message to the neighbor vehicles. From the beacon message each vehicle knows the neighbor information and stores the information including direction, speed, location and time stamp. When the vehicle goes out of the transmission range of the vehicle each vehicle updates the neighbor information and remove from the neighbor list. Two relay nodes are selected for better performance. To select the relay node the author assumes to follow the following approach:

- When there is a vehicle behind the crushed vehicle in the same direction, the crushed vehicle select the farthest vehicle (FV) as a first relay node and the second farthest vehicle (SFV) as a second relay node.
- If there is no vehicle behind the crushed vehicle in the same direction, but if there are vehicles behind in the opposite direction, it choose the first vehicle as a first relay node and the second farthest vehicle as a second relay node.
- If there is no vehicle behind the CV in both directions, but there are vehicles ahead of it in the opposite direction, it choose the nearest vehicle as a first relay node and the second nearest vehicle (SNV) as a second relay node.
- If none of the above steps are working, the crushed vehicle stores emergency message until a new vehicle comes within its transmission range.

Generally the way of selecting relay node is described as Figure 3.2 below.

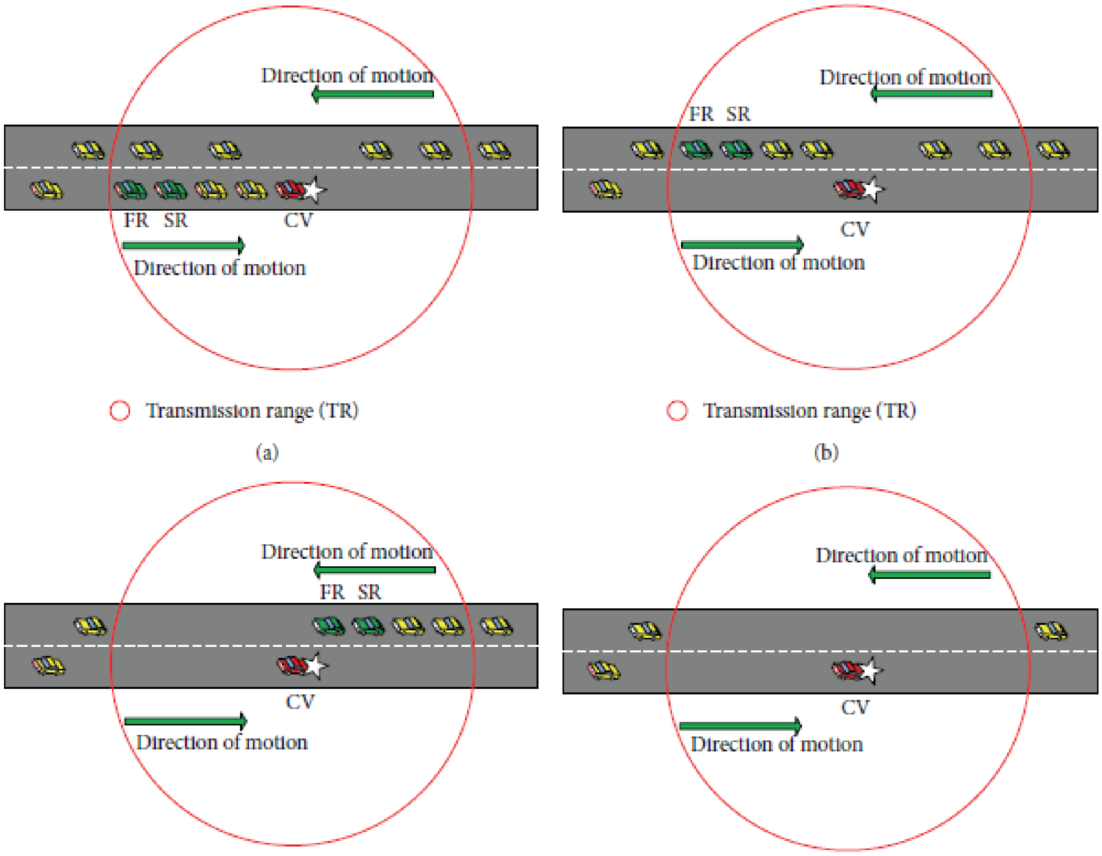


Figure 3-2 Relay node selection [3]

The protocol minimizes danger zone latency and minimizes the beacon over head by minimizing the beacon interval due to prediction of mobility for the vehicle. But the protocol uses the crashed vehicle as relay node when there is no vehicles in the transmission range of the vehicle. When there is no vehicle in the transmission range of the crushed vehicle the emergency message would not disseminate to the endanger vehicle due to this the protocol lead high delay for safety critical message. In addition to this considering the crushed vehicle as a relay node, decrease emergency message reception rate and increase packet loss.

The author in [35] proposes speed based emergency dissemination scheme to minimize the redundant message and to increase reliability. According to the author the vehicle which have high speed can selected as forwarder node. From the simulation result the author get high throughput and high delivery ratio. This approach is suitable for well-connected network. But here in highway scenario most of the vehicles are moving with the same speed, due to this it leads high number of forwarder node in dense network and selecting vehicle with high speed mainly cause link failure because the probability of the node to wait with in the transmission range of other vehicle is low [9]. In sparse network scenario this approach is not good option. Generally, the works done in [2], [3], [35] are suitable for disseminating emergency message in connected network scenarios. VANET topology changes periodically due to the high speed of vehicles, so using V2V communication is not feasible [20].

3.2 Message Dissemination Scheme with using Road side unit

In [17] rapid dissemination of public safety message was proposed. In this paper RSU broadcast the public safety message to vehicles going in a linear highway with its transmission range. To increase the transmission range and the network coverage the authors propose using vehicular Back bone network (VBN) structure. During the VBN structure the vehicle found in the closest to the nominal position selected as a relay node (RN).The paper focuses on a system that is subjected to relatively high vehicular traffic rate. The paper has high throughput and low end to end delay when the number of vehicles is high in the highway. The author assumes distance based relay node selection scheme in addition to the RSU. As the author presents the protocol mainly focus on high vehicular traffic rate, there is more number of vehicles which closest to the normal position. Here when there is more number of forwarder node, the number of packet transmitted over network increases and the number of redundant message increases.

In [18] the authors propose static node assisted stochastic multi-hop emergency message broadcasting scheme which uses RSU to solve network fragmentation problem. According to the paper when RSU receives broadcast message it checks the duplication forward the emergency message by including the broadcast suppression range and minimum broadcast suppression. To select nodes which forward the message, the author use probabilistic relay node selection method. According to the authors each nod maintained its rebroadcasting probability and they compare with the minimum broadcast suspension and they forward the emergency message. From the simulation result their scheme outperforms static stochastic broadcast scheme in terms of delivery rate and when comparing to flooding, their scheme give a better delay and less network usage.

The authors in [9] design road accident prevention schema for highway scenario to disseminate emergency message to endanger vehicles that may affected by the accident with the support of vehicular back bone network. According to the author each vehicle and road side unit equipped with GPS to maintain position and location. Here the road side unit broadcast hello message periodically with its ID and position to all vehicles within the transmission ranges. The vehicle received the hello message send reply to the RSU including its speed, direction, time stamp and vehicle ID. The RSU periodically update the vehicles in its transmission range and generate status report from the vehicle information. From the information the road side unit generate emergency warning message to other vehicles which come to the danger zone. According to the author the areas around the emergency situation count as high danger zone. The RSU sends the emergency message to all vehicles that found in high risk zone and send the other RSU to inform other vehicles outside the transmission range. For farther coverage the RSU select a relay vehicle which can re transmit to the other road side unit. To express more in detail how to select the risk zone we can see the figure from [9].

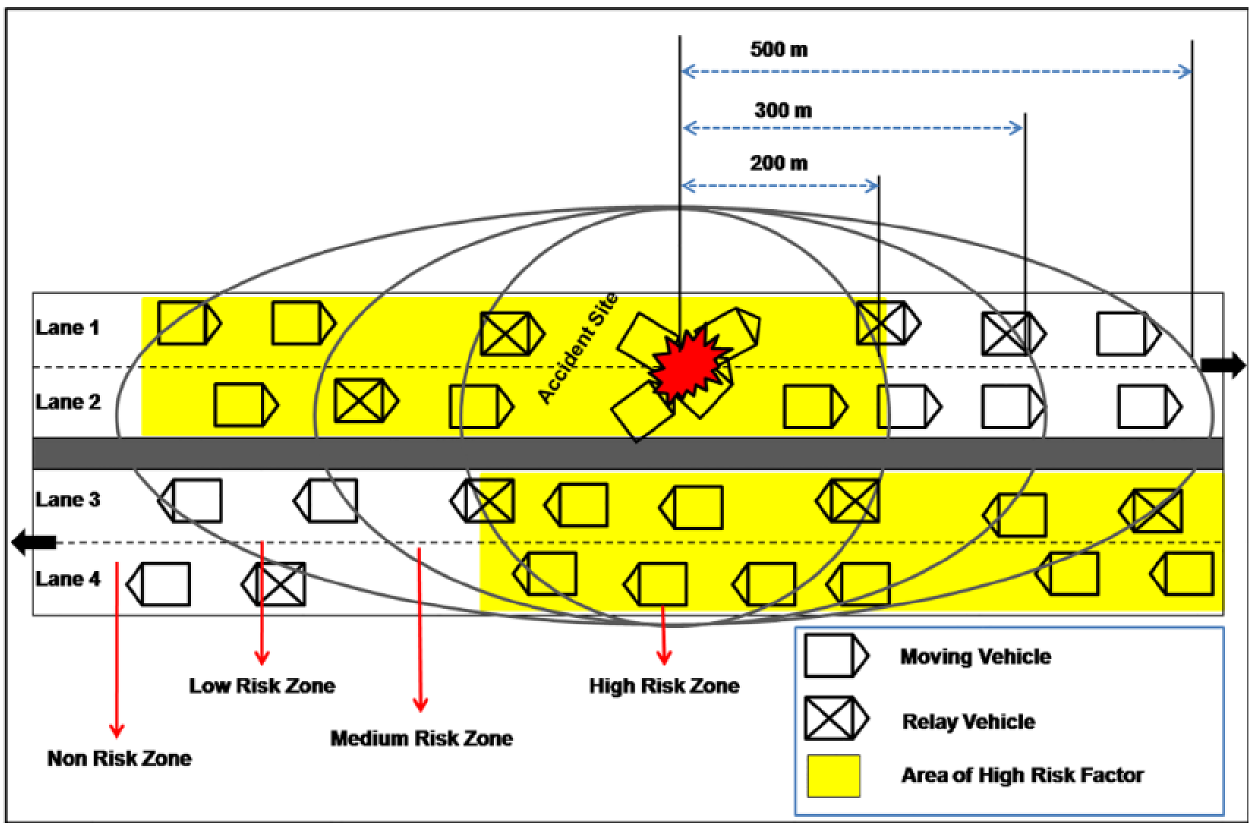


Figure 3-3 Representation of risk zone [9]

As shown in Figure 3.3 the risk zone identification is based on the coverage range of RSU and there are many relay nodes which retransmit the emergency message. From the simulation result the author get low end to end delay and high emergency message reception rate. But when come to the real time scenario the risk zone depends on the direction of the vehicle instead of the coverage range of the RSU and transmission of emergency message by many vehicles lead unwanted packet transmission in the network. Unwanted traffic causes overhead as they state in their future work.

The general comparison among the existing dissemination scheme can express in table 3.1.In table 3.1, the communication type, relay node selection mechanism, strong point and the limitation are presented.

Table 3-1 comparison of the existing related works

Paper	**Year of publication**	**Forwarder node selection**	**Communication type**	**Strong point**	**Limitation**
[2]	2012	Distance	V2V	-low latency	➢ Network fragmentation ➢ Lead high packet loss in sparse scenario
[3]	2013	Distance and Direction	V2V	-Reduce beacon overhead -reduce risk zone latency	➢ High delay in sparse scenario
[9]	2015	Speed and position	Hybrid	-high reception rate - low delay - high emergency message coverage	➢ High overhead ➢ High number of relay node
[17]	2014	Distance	Hybrid	-high delivery ration	➢ High overhead when node increases
[18]	2014	Density to assign probability	Hybrid	-low network bandwidth than flooding -better delivery ratio	➢ High network processing overhead ➢ High delay
[35]	2014	Speed	V2V	-reduce redundant message - low overhead	➢ Suitable only for urban scenario ➢ Network fragmentation

3.4 Summary

Generally, when we see the current emergency dissemination schemes in VANET they have their own significance and limitation for different scenarios. Emergency message dissemination using V2V communication is good when the network is dense and emergency dissemination using RSU have high significance in both scenarios. As we express in the above current dissemination schemes does not full fill the requirement for time critical application VANET which need low end to end delay, low packet loss, high reception rate, low bandwidth requirement and low overhead.

Due to the above requirement there is a need to design new emergency dissemination scheme for VANET which can capable of solving the existing problems. Depend on the above literatures our work use the emergency dissemination scheme that uses RSU approach and address the following points.

- Designing a new way for hared zone identification. As we have seen in the literature the current work design the hazard zone in terms of the coverage area of RSU which leads high bandwidth usage. In the new dissemination scheme, the hazed zone identification is based on the direction of the vehicle and the position of the accident.
- Designing new mechanism to select forwarder node. In the new approach the forwarder node selection is by considering the road identifier, the direction and distance. Due to this the number of forwarder node decreases and increase the coverage of emergency message reception by the support of RSU.
- Designing better emergency message forwarding approach: by combining the above two points the new scheme considers only the vehicle which found in the risk zone participates for forwarding the emergency message. Here when the number of vehicles getting sparse we use RSU to solve network fragmentation problem.

Chapter 4
Design of the Proposed Solution

4.1 Overview

As we have expressed in Chapter 2 and 3, there are many emergency message dissemination scheme proposed for VANET and it's difficult to say one is better than the other. Still disseminating emergency message to notify vehicles: with minimum delay, high number of informed vehicles, low message redundancy needs additional improvements. So in this thesis we design dissemination scheme which is capable of solving network fragmentation problem as well as broadcast storm problem. To solve the problem, we have identified and proposed direction, distance and Road identifier based multi-hop broadcasting scheme. To do this we propose algorithms to select forwarder node and identifying risk zone.

After this overview, in the sections below we describe the details about the techniques and the model developed for the proposed dissemination scheme. In Section 4.2, we describe our proposed system architecture for emergency message dissemination scheme in VANET. In Section 4.3, we describe modules which are used for the successful communication of VANET nodes (vehicles and RSU). In the last Section 4.4, we present the summery about our design.

4.2 Architecture of Proposed Solution

The proposed architecture combines the general and the internal components. Those components have their own functionalities and purposes for disseminating the emergency message to the relevant vehicles.

According to Figure 4.-1, Vehicle and RSU needs each layer of the network for exchanging message. If vehicle 1 detects emergency message, to disseminate this message to n vehicles and RSU, it pass every layer of the network. As we described in Chapter two, we use the IEEE802.11p and WAVE standard to incorporate our scheme. In the architecture show our scheme with dot line and we show how it can incorporate with the standard of VANET.

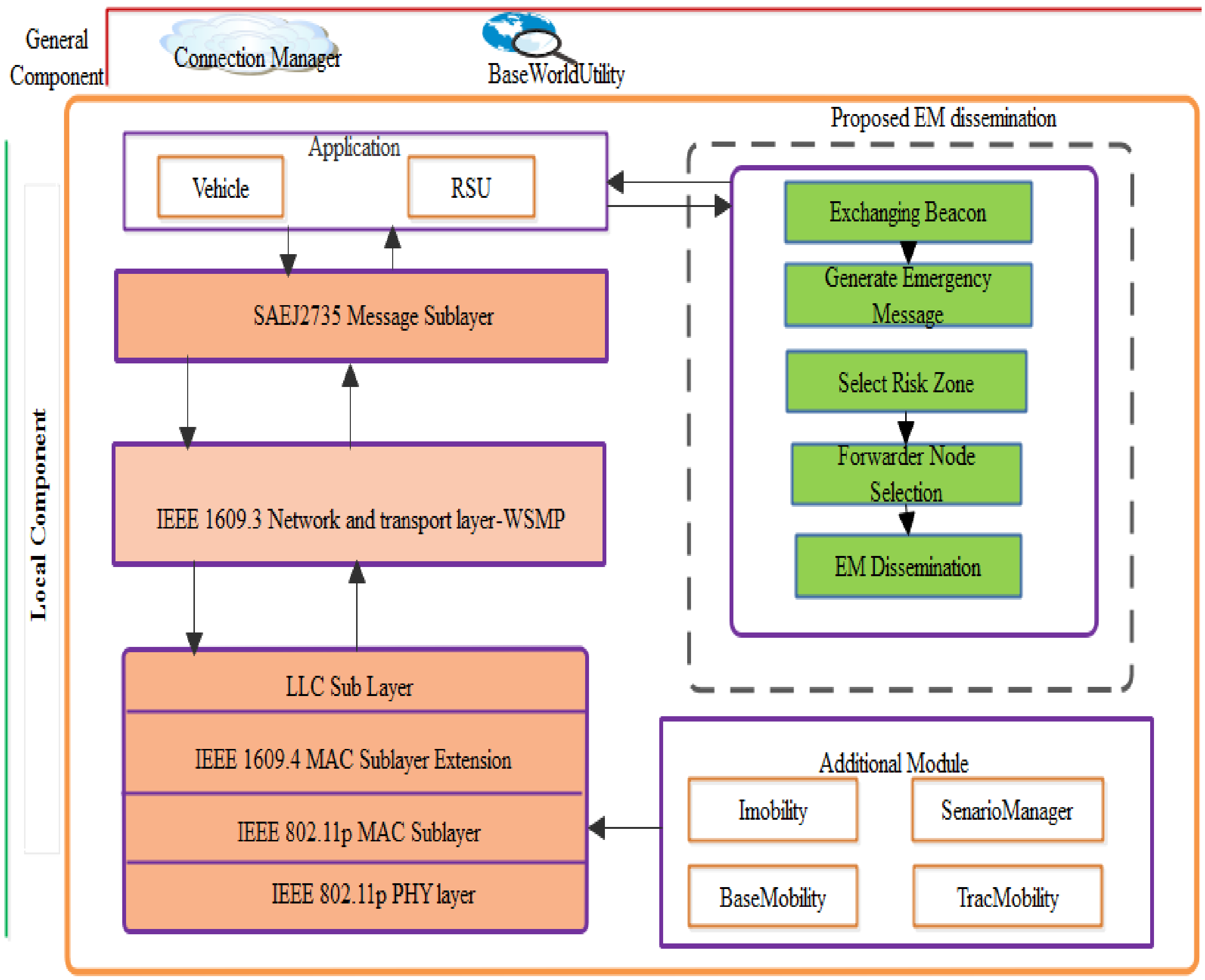


Figure 4-1 proposed architecture

The above Figure 4.1 shows the general architecture of the proposed work for disseminating emergency message in VANET. According to the architecture the new scheme combine both RSU and Vehicle in order to design efficient emergency message dissemination scheme. Vehicles and RSU are expected to have GPS to get information and they have different modules to forward emergency message for the vehicles which can affect by the hazard situation. Here we have stated two different components to implement our design: general component and local component.

General Component shows the public information about the whole network. This component contains connection manager, obstacle manager, radio manager and Base world utility.

- **BaseWorldUtility:** is the basic utility module for the whole network and it provides utility methods and information's used by the whole network.
- **Connection manager:** is the module used to control all connection related information. This module is the central module which coordinates the connection between all nodes and it periodically communicates with the mobility module and channel access.

To disseminate one data each node (vehicle and RSU) have IEEE802.11p Physical layer which is specifically designed for VANET and they have IEEE802.11p and IEEE1609.4 MAC layer for disseminating information by using MAC.802.11p MAC used for assigning the MAC address for each node and IEEE1609.4 MAC used for channel allocation. Safety information in VANET relay on the MAC layer [24], [25], [28]. We use WAVE application and network layer for our dissemination scheme. The message sub layer used to incorporate the emergency message generated by our algorithm. The flow shows the new scheme gets MAC address from IEEE802.11p MAC sub layer and the MAC sub layer contains additional modules listed in the Figure. Then the algorithms in the new scheme install in OBU and RSU as application type.

Generally the flow of information exchange from source node to destination node in the Figure 4.1 above can be described from the sender side and receiver side. Sender side: here the sender vehicle is a vehicle which tries to exchange information to other vehicles. From the sender side sender have message in message sub layer, WSMP add its header file, LLC sub layer checks the SNAP header files and extract depend on the *Ethertype* and send to IEEE1609.4 MAC layer extension. IEEE1609 sub layer extension adds channel access to the data, add access categories for priority and add its own header file and send to 802.11p MAC layer. 802.11p MAC adds it's header including MAC address and sends to PHY. Sender sends to the receiver node. Receiver side: here the receiver 802.11p MAC extract the MAC header file and remove it and send to the IEEE1609.4 sub layer extension, this layer checks access categories and channel number and extract its header file then send to the LLC sub layer. The LLC sub layer checks the *Ethertype* to check for which upper protocol the data can be sent and after checking the *Ethertype* it sends to IPv6 network layer or WSMP. Then WSMP extract its header and send to message sub layer to check the message from dictionary then the data finally in the destination node. After this to rebroadcast the message in the destination node, the node checks whether it is in risk zone or not depend on the received data, and check whether it can allowed to rebroadcast or not in forwarder node identification algorithm, finally the node disseminate to other nodes by applying the above steps.

4.3 Proposed Dissemination Schemes

The proposed scheme is multi-hop dissemination scheme which uses RSU to solve network fragmentation problem. The new scheme minimizes the duplicated number of message received by the vehicles without affecting the number of informed vehicles. In the new scheme the vehicle which found in the same direction, with the same road id and greater distance is selected as a forwarder node, it can reduce the number of forwarder node. Due to the reduction of forwarder node the overhead can be reduced.

4.3.1Beacon Exchange

This is the first phase in which vehicles and RSU exchange their general information. At this stage vehicles exchange information like speed, and position among neighbor vehicles and RSU. The RSU periodically broadcast its own information to vehicles within its transmission range. The arrangement of RSU information can be as follow.

RSUID	*Position*	*Timestamp*

After that the vehicles reply VEHID, position, direction, speed and timestamp to RSU. The information from the vehicle can be as follows:

VEHID	*position*	*Speed*	*Timestamp*

VEHID is the unique identifiers of vehicle.

When a new vehicle enter in to the transmission range of RSU, the neighbor list is updated and when the vehicle goes out of the transmission range the vehicle is removed from the neighbor list.

Generally to handle the beacon exchange we use the following algorithm.

Algorithm for beacon exchange beacon

Input ---->RSUID

Input ---->position

Input ----->timestamp

1. *RSU periodically broadcast its information*
2. *vehicle reply its information*
3. ***If** new vehicle come the transmission range*
4. ***For** each vehicle in RSU*
5. *RSU check the list from the old neighbor*
6. *vehicles is new*
7. *Add to neighbor list*
8.
9. ***ENDFOR***
10. ***Else***
11. *Vehicle out of transmission range of RSU*
12. *RSU update the neighbor list*
13. *RSU delete vehicle from list*
14. ***ENDIF***

Algorithm 4-1 Algorithm for beacon exchange

According to the Algorithm 4-1, in the first line roadside unit periodically broadcast its information and in the next line the vehicle which receive the periodic information reply to the RSU. From line 3-9 when vehicles inter to the transmission range of RSU, the vehicle register as neighbor lists. When the vehicle is out of the transmission range of RSU, the neighbor list can be updated and vehicle information removed from the neighbor list.

4.3.2 Emergency Message Generation

In this phase the vehicle which approach to the emergency situation can generate the emergency message. To generate the emergency message we apply the algorithm in [23].According to the authors, the vehicle can be abnormal if one of the following condition is meeting.

Condition 1: if the position of the vehicle remains the same in two continuous time slot

By combining the above two conditions vehicle generate emergency message. Here we include the block road as emergency message.

The emergency message contains:

- EMID: is the unique identifier for emergency message which used to avoid duplication.
- SourceId: is the identifier for which node generate the emergency message.
- Block road id: the identifier of the road which is blocked by the emergency

EMID	*SourceId*	*Block road id*	*Timestamp*

Input ---->position

1. ***If*** *(VPosition(t2)-VPosition(t1))=0*
2. *Set vehicle abnormal*
3. *Generate message*
4. *Prepare EM*
5. ***ENDIF***

Output: Em

Algorithm 4-2 Emergency message generation

Algorithm 4-2 shows from the entire vehicle, vehicles which stop for some time mean that vehicle whose position is constant within two time intervals considered as abnormal vehicle.

Depending on this, the vehicle generate emergency message and broadcast in its transmission range.

4.3.3 Risk zone Identification

The aim of this phase is to disseminate emergency message to all vehicles that can be affected by the emergency situation. The existing algorithm mainly focuses the position of the vehicle and distance between vehicle and RSU. But this method will have effect on the risk zone identification when the Lane is more than one dimension. Most of the highway contains more than two directions. So our algorithm will enhance the dissemination scheme by considering the direction of the vehicle in addition to speed and position.

Algorithm for risk zone identification

Input: VEHID

Input: vehicle position, direction

1. *Receive message*
2. *Retrieve vehicle roadid*
3. *Find position and direction*
4. ***If** vehicle road==messageId*
5. ***If** vehicle behind accident //*
6. *Add vehicle to risk zone*
7. ***ENDIF***
8. ***ENDIF***

Algorithm 4-3 Algorithm for risk zone identification

According to the algorithm the node which is found in the same direction to the abnormal and road which have the same id with the emergency message can set as risk zone. So, when the vehicle comes towards the emergency message, we say those vehicles are in risk zone. If we consider Figure 4.2 below the vehicle which goes towards right can be set as under risk zone.

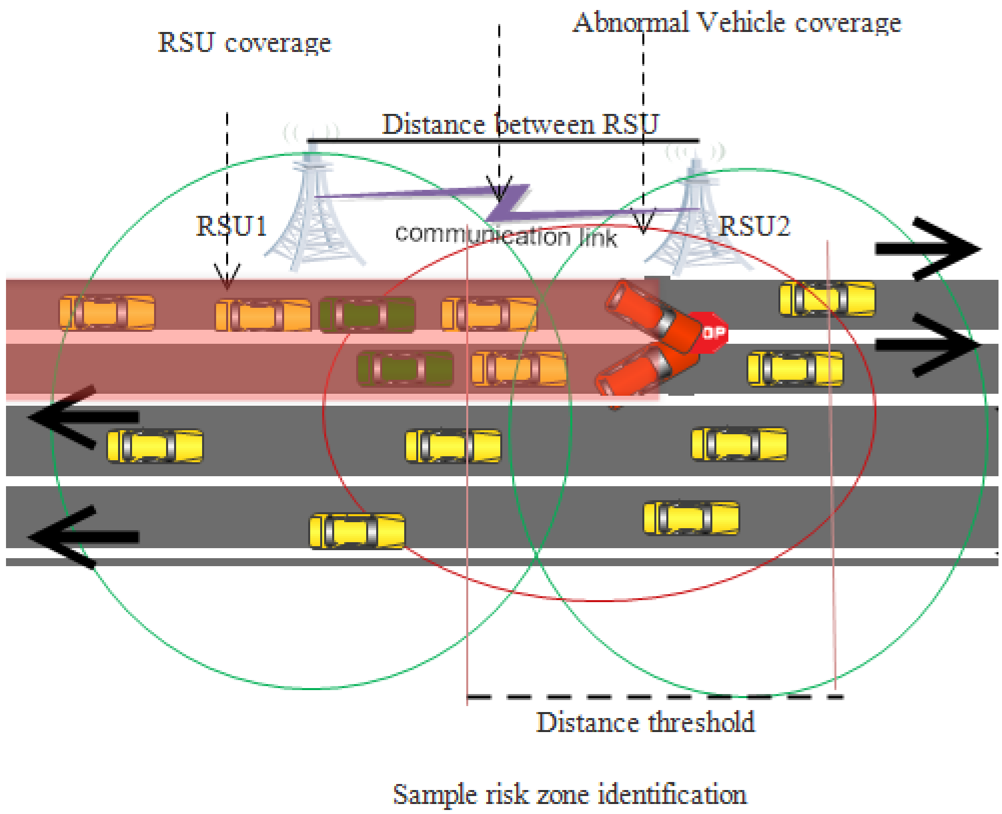


Figure 4-2 risk zone identification

From the above Figure 4-2, as we see the vehicles which slightly cover with red color are in risk zone. According to our algorithm vehicles which is found behind the accident and which have the same road id are under risk zone. In the existing scheme the vehicle found in the transmission range of the vehicle which detected the accident is considered as high risk zone. In existing scheme, risk zone identification is depending on transmission range instead of direction.

4.3.4 Forwarder Node Selection

A forwarder node is anode that can retransmit the emergency message to other vehicles which came to the accident. Disseminating safety message in VANET heavily relay on broadcasting, so selecting best forwarder node is one of the critical issues while disseminating safety information. According to the authors in [3], [9], [24], [25], [35], there are different parameters to select forwarder node: such as speed and position, direction, distance and density. The existing mechanisms have their own significances in different scenario. But all of the existing listed in the above needs improvement to disseminate the emergency message in highway scenario by increasing the notified vehicles and by decreasing the redundant message.

In our scheme, we consider the travel direction, distance and road id as parameter to select the forwarder node. In order to solve the problem related to dis-connectivity, we use RSU as a forwarder node. We select the node which is found in the same side of the block road and which have far distance from the accident node, and RSU.

To get the direction we use the following eq(1).

$$Dir \ = Vpost - Vpost1 \dots\dots\dots\dots\dots\dots\dots\dots\dots. eq(1)$$

Where *Dir* is the vehicle's travel direction, VPos is the vehicle's position in the highway and t is time. If the Dir value is negative then it is concluded that the vehicle is moving towards possible accident site whereas if the Dir value is positive then it is concluded that the vehicle is moving away from possible accident site [9].The distance from the sender can be calculated as eq(2):

D= $\sqrt{(x2 - x1)^2 - (y2 - y1)^2}$…………………..eq(2)

Where D is the distance, (x2,y2) is the position of the receiver and (x1,y1) is the position of the sender. By combining those parameters we design to select best forwarder node to disseminate emergency message. When vehicle detects an emergency situation, it forward to the vehicles under its transmission range and RSU. After that the receiver vehicle and RSU check the conditions whether they allowed to forward the emergency message or not. The overall flow chart for the propose forwarder node selection is described in Figure 4.3.

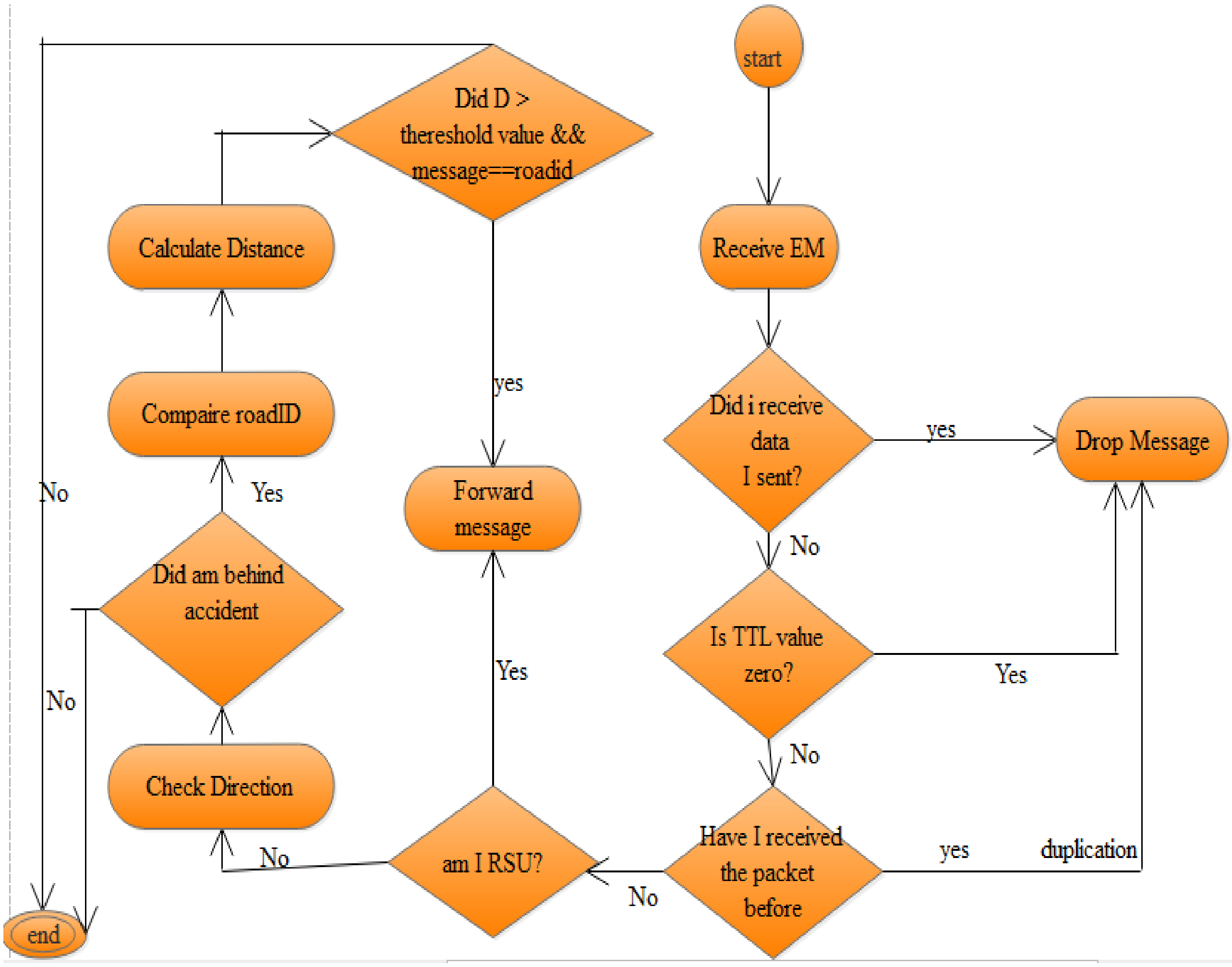


Figure 4-3 Flow chart for nodes to be forwarder node and forward emergency message

As shown from Figure 4-3, when the vehicle receives emergency message it check different condition and finally when vehicle need to rebroadcast the emergency message it compares distance from the source vehicle with threshold value. We use the threshold values stated in [9]. The vehicle which have greater value than threshold value and have the same direction with the emergency situation can forward the emergency message. In terms of RSU, when RSU receives broadcast emergency message:

- RSU check the message is new. RSU compare the broadcast message with the message received before and if the message is new RSU broadcast to the vehicles in its transmission range and the other RSU.
- If the message is duplicate message , RSU drop it and stop rebroadcast

Algorithm for forwarder node selection

Notation

Ttl ->time to live

Dir-……..>direction

D…….> distance

(X2,Y2) and (X1,Y1)……>sender and receiver position

1. *Receive message*
2. ***If** received message is self-message{*
3. *Drop message*
4. *}*
5. ***Else**{*
6. *Check ttl value //time to life*
7. ***If**(ttl value==0){*
8. *Back to step 3*
9. *}*
10. *Check duplication*
11. ***If**(new message ==old message){*
12. *Message is duplicate*
13. *Back to step 3*
14. *}*
15. *Check node type*
16. ***If** (node==RSU){*
17. *Send message*
18. *}*
19. *check node position*
20. *Calculate Dir*
21. *Calculate D=* $\sqrt{(x2-x1)^2-(y2-y1)^2}$
22. ***If** vehicle Dir is behind source node{*
23. ***If** (vehicle road id== message && D >distance threshold){*
24. *Send message*
25. *}}}*

Output : message forwarding by forwarder node

Algorithm 4-4 Algorithm to select forwarder node and forward emergency message

According to Algorithm 4-4, when the node is vehicle from line 8-13 it checks different parameters like distance, direction and block road id and depending on the operation nodes can know whether it can rebroadcast or not. Depending on the above parameters, the vehicle which full file the condition can be selected as forwarder node, if there is no vehicle which full file the condition only RSU can be used as a forwarder node.

Scenarios to select relay node

In order to clarify our work to select a relay node we use the following scenarios.

Scenario 1: assume the accidents are detected and there are vehicles which are around the accident area. Here the accident should be disseminated to other vehicles to create awareness. As we see from the figure if there are many vehicles in the transmission range of the first vehicle which detect the accident, selecting minimum number of forwarder node to reduce redundancy is critical.

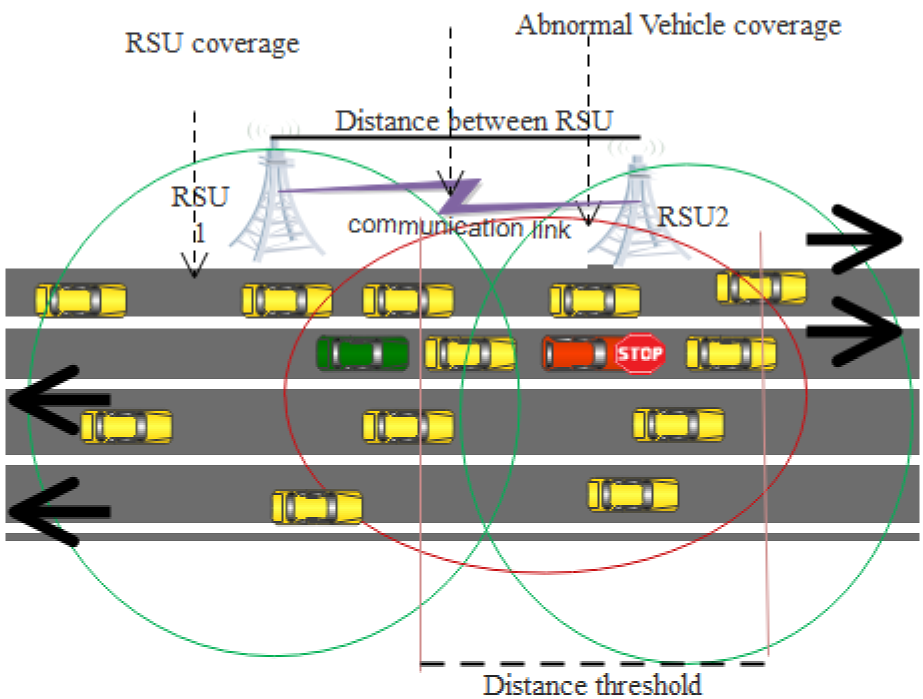


Figure 4-4 Relay node selection according to scenario 1

In figure above the vehicle which have green color and RSU are selected as forwarder node. According to our Algorithm 4-4 first the vehicle which detects the accident broadcast to all vehicles in its transmission range. Then each node knows their direction and calculates its distance and check the distance to the distance threshold. Depend on this as we see the green vehicle is behind vehicle which detect the accident and distance is greater than the distance threshold, so by using our algorithm it is selected as a forwarder node. As we see in Figure 4.4 RSU2 is in the transmission range of the vehicle which detects the emergency situation, so it can be used as forwarder node. Here when the RSU and Vehicle send the same message so there will be duplication but each node check the packet duplication and they can drop if the message is similar.

Scenario 2: assume there is no vehicles in the transmission range of the vehicle which detects the accident, how to disseminate the emergency message further to other vehicles with minimum delay and as soon as accident detects is critical issue. As we see in the following Figure 4.5, there is no vehicle in the transmission range of the vehicle which detects accident and only RSU is in its transmission range.

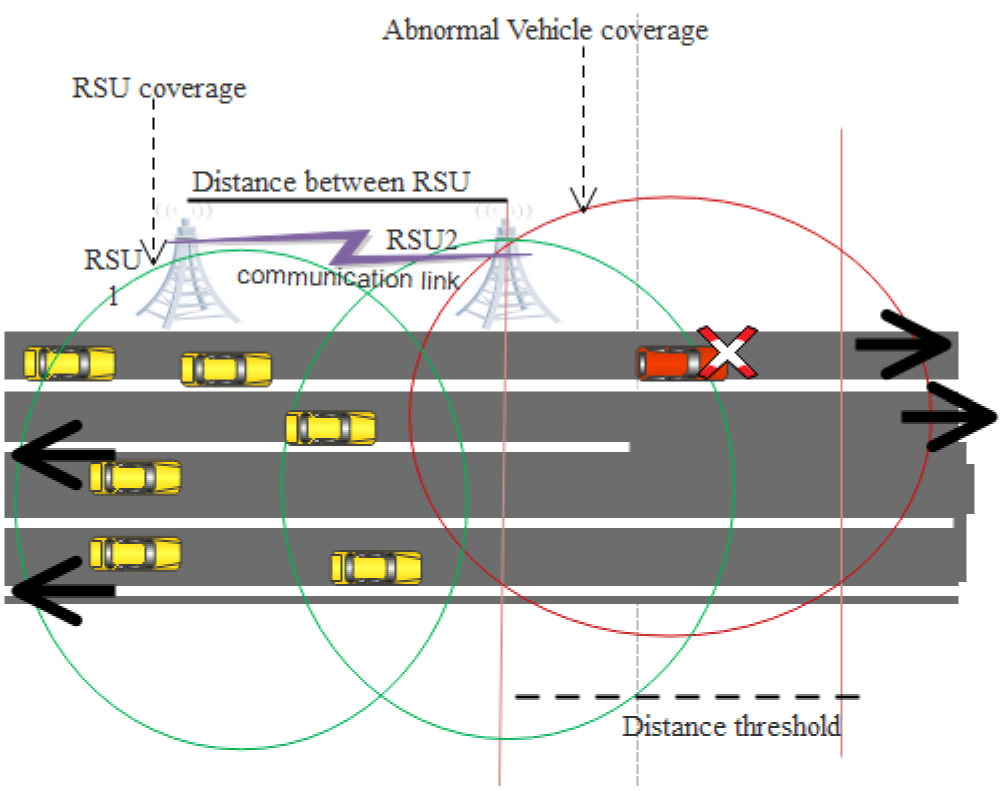


Figure 4-5 Relay node selection in scenario 2

In Figure 4-5 above there is no vehicle around vehicle which detects the accident, here the vehicle broadcast the message when it detects and according to our algorithm RSU2 can forwarding the emergency message to vehicles in its transmission range and to the other RSU. The other RSU and vehicles adapt our algorithm for farther forwarding process.

Scenario 3: Assume the emergency happens in the two lanes and there are vehicles in its transmission range of the vehicle which detect the accident. As we see in the following figure the accident happens in two lanes in which vehicles travelling in the right direction.

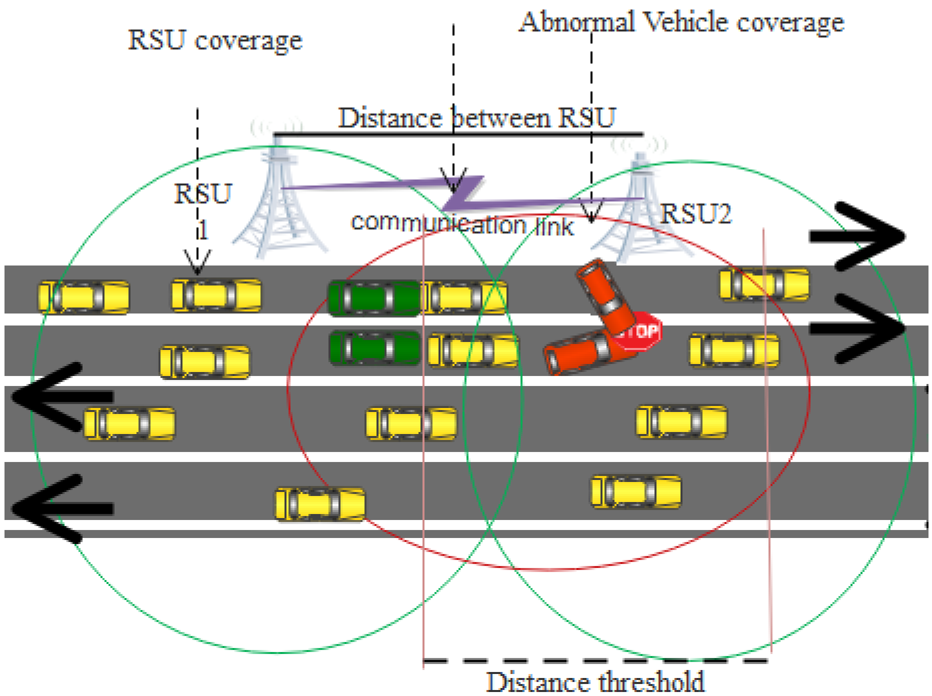


Figure 4-6 Relay node selection in scenario 3

As shown in Figure 4-6, the vehicle which travels towards the right direction detects the emergency situation in both lanes. Then according to our algorithm the vehicle which has green color selected as forwarder node. The vehicle which have green color are beyond the threshold value and they are traveling behind the vehicle which detect the accident, so by considering this feature in our algorithm they are selected as relay node. RSU2 is also member of forwarder node.

4.3.5 Disseminate Emergency Message

Emergency message are disseminated to vehicles to create awareness about the emergency situation and the vehicle which receive the message can act accordingly and the emergency message disseminated with low overhead, less duplicated received message with high number of informed vehicle. As disseminating emergency message to the vehicles affected by the emergency situation is one of the main purposes of VANET, we designed efficient dissemination scheme that can address both connectivity and broadcast storm problems. Here the vehicles aware about the emergency depend on the message. As shown from Figure 4.7, when a vehicle detects emergency, initially the vehicle broadcasts to vehicles in its transmission range. After that every node checks it behavior for further forwarding is allowed or not. In the Figure there are vehicles which receive the emergency message, therefor only few can rebroadcast the emergency message to reduce message redundancy.

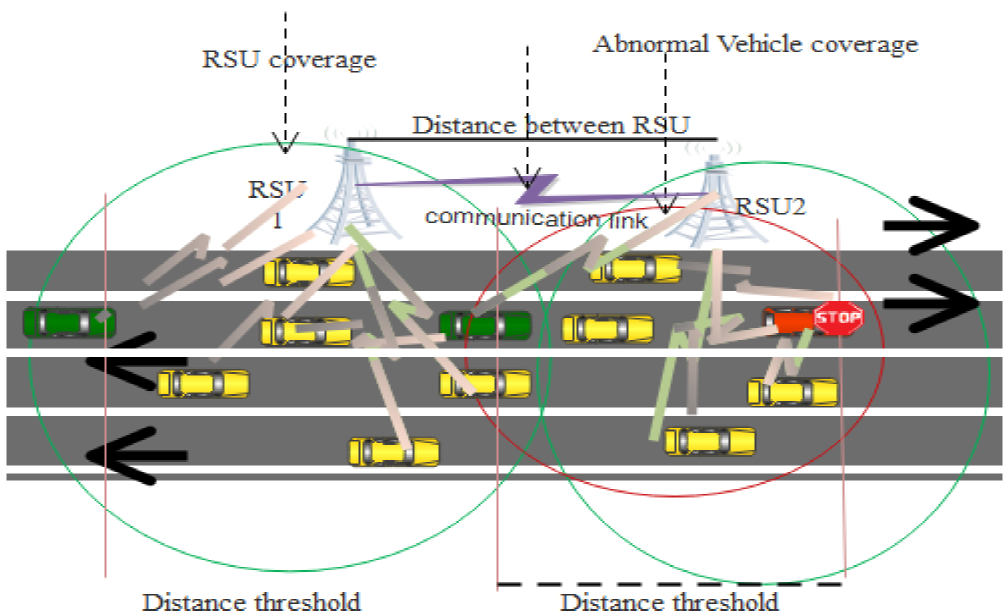


Figure 4-7 Emergency message dissemination

From the Figure 4.7, there is a communication link among vehicles and RSU to disseminate emergency message. As shown in the Figure, the vehicle outside the transmission range of the vehicle which detect the emergency situation can be notified by the forwarder nodes represented as green color and RSU.

4.4 Additional Module

These modules are modules which are imported for successful compilation of our design. These modules are mainly used to incorporate with the mac layer of IEEE11.p.

- **TracSenarioManager:** used for *sumo.lounchd.py* and SUMO to access the realistic mobility model to the network simulation tool.
- **TracMobility**: used in the module created by the *TracSenarioManager*,which can control the mobility of vehicles in the mobility model.
- **Imobility:** is the interference for mobility modules.
- **BaseMoblity:** modules which responsible for mobility related information like position movement base mobility itself and it defines a static mobility pattern means only position not movement.

4.5 Summary

In this Chapter, we have presented the overall architecture of our emergency message dissemination schemes. Initially, we described how our scheme incorporates to the IEEE WAVE standard for safety application. Our scheme is based on IEEE 802.11p physical and MAC layer, which is specifically designed for VANET application. The IEEE 1609.4, used for channel assignment and the message sub layer contains the dictionary of messages supported by the WAVE architecture. In the proposed scheme, we propose algorithms to generate emergency message, identify risk zone and selection of forwarder node.

When a vehicle detects an accident, the vehicle generates the emergency message according to Algorithm 4.2 and to disseminate the message to other vehicles it pass all the layer of WAVE standard. First the OBU and RSU equipped with IEEE802.11p physical and MAC layer, then the vehicle which generate the emergency message add node id from MAC layer as Source address , the IEEE1609.4 MAC extension allocate the channel number, the message sub layer adds the message in to dictionary, the vehicle broadcast the emergency message. The receiver vehicle and RSU can rebroadcast the message according to Algorithm 4.4. Generally, in this Chapter we present the architecture of the proposed scheme and in the next Chapter we present the implementation.

Chapter 5
Implementations and Result Evaluation

5.1 Overview

As we have expressed in the previous Chapters, designing emergency message dissemination scheme which can address broadcast storm problems and connectivity is critical issue in VANET due to the random change in topology and due to the mobility of vehicles in the network. So as we present in Chapter 4, we design dissemination scheme which is capable of disseminating emergency message with minimum number of forwarder node and reduce the message duplication. In our scheme, we consider highway scenario both in dense and sparse network environments.

Simulating in real VANET node is difficult due to lack of smart vehicles and due to the absence of technology. So, we simulate our scheme in VANET simulation environments. The implementation of our work can be presented in detail in the following Section of this Chapter. Section 5.2, describes the development and simulation tool used to simulate our work. Section 5.3, presents the implementation description of the major components. Section 5.4 describes the simulation set up and the analysis of dissemination schemes with respect to different network density. In Section 5.5, summery of the Chapter are discussed

5.2 Development and Simulation Tools

We use different tools by integrating them to perform our dissemination scheme. VANETs simulation requires two types of simulation components those components are Network and mobility.

5.2.1 Mobility Generators

This kind of simulator generates required realistic vehicular mobility traces to be used in network simulator as an input [29], [31]. One of mobility generator is SUMO which described in [30], which is one of open source simulator which is highly portable, microscopic road traffic simulation package designed to support different road networks. Thus, by combining SUMO and open street map, it is possible to simulate traffic in different locations of the globe. The other mobility generator is Street Random Waypoint (STRAW) which provides better simulation outputs by using a (VMD) vehicular mobility model on real US cities and it operates on realistic traffic information. Currently STRAW's implementation is designed for the JiST/SWANS discrete-event simulator but its mobility traces cannot be directly used by other network simulators like ns2 [29], [31]. MOVE (Mobility model generator for Vehicular networks) is also one of the mobility generators which is GNU based mobility generator and which can generate the realistic mobility models for VANETs simulations.

5.2.2 Network Simulator

Network simulator is usually used for simulation the computer networks. They are used for simulating the VANETs by evaluating the performance of network protocols for mobility of nodes and other required technique such as calculate and create the required components in a network such as detailed structure of all nodes (vehicles), sending and receiving packets roles, data traffic transmission, channels, etc. NS-2 is one of a discrete event simulator which was extended by the Monarch research group at Carnegie Mellon University such as: node mobility, a realistic physical layer with a radio propagation model, radio network interfaces, and the IEEE 802.11 MAC protocol using the Distributed Coordination Function (DCF) [29]. The other simulator is GlobMoSim which is one of the network simulators which mainly support simulation environment for both wireless and wired network. GlobMoSim is designed using the parallel discrete-event simulation capability [31]. GloMoSim is built using a layered approach which is similar to OSI seven layer protocol architectures. Between the different simulation layers Standard APIs are used. The widely used QualNet simulator is a commercial version of GloMoSim [29], [31].OMNeT++ is an object-oriented modular discrete event network simulator. OMNeT++ has a component-based design, new features and protocols can be supported through modules. OMNeT++ supports network and mobility models through the independently developed Mobility Framework and INET Framework modules [31]. According to [33] extension of OMNeT++ are designed to support for real-time simulation, network emulation, alternative programming languages like java and c#. OMNeT ++ is free for academic use and is already a platform widely used by the world scientific community.

5.2.3 VANET Simulators

Those simulators are the combination of both mobility and network simulator to support VANET environment. GrooveNet is one of VANET simulator which is an integrated simulator that supports multiple models that characterize communication, travel and traffic control to enable large scale simulations in street maps of any US city [29]. TraNS (Traffic and Network Simulation Environment) is a graphical user interface based tool which integrates traffic and network simulators to generate realistic simulations of VANETs [32]. According to [29], [31], [32], VEINS (Vehicles in Network Simulation) are another simulator that couples a mobility simulator with a network simulator: SUMO is paired with OMNeT++ by extending SUMO to allow it to communicate with OMNeT++ through a TCP connection. In Veins, there is a manager module that is responsible for synchronizing the two simulators. This simulator has two separate events queues. At regular intervals, the manager module triggers the execution of one time step of the traffic simulation, receives the resulting mobility trace, and triggers position updates for all modules it had instantiated.

5.2.4 Selecting Suit of Simulators

Simulating VANETs environment with large number of vehicles potentially transmitting several messages per second and when the number of vehicles is sparse there are several packet losses due to network fragmentation, so simulating the selection of a network communication via simulator is crucial. To select the simulation tool we use the important parameters like user friendliness, scalability, and the interconnect ability of road traffic and network communication.

VEINS was selected due to following features: Online re-configuration and re-routing of cars in reaction to network simulator, Fully-detailed models of IEEE 802.11p and IEEE 1609.4 DSRC/WAVE network layers, Supporting the realistic map and realistic traffic, User friendliness and interconnect ability[29]. VEINS enables running of two simulators in parallel, connected via a TCP socket. VEINS framework developed based on MiXiM. MiXiM is a framework for simulating wireless channels provides detailed models of wireless channels; connectivity, mobility and MAC layer protocols for OMNeT++.

5.3 Prototype Implementation

To test our simulation we use the real map of the road in Ethiopia in Addis-to-Adama express way. There is only one express way found in our country which can support high speed vehicles. We choose this express way to check our emergency dissemination scheme. In figure 5.1, the general map of the Addis Abeba to Adama is shown. We take this map from the open street map by sniping tool.

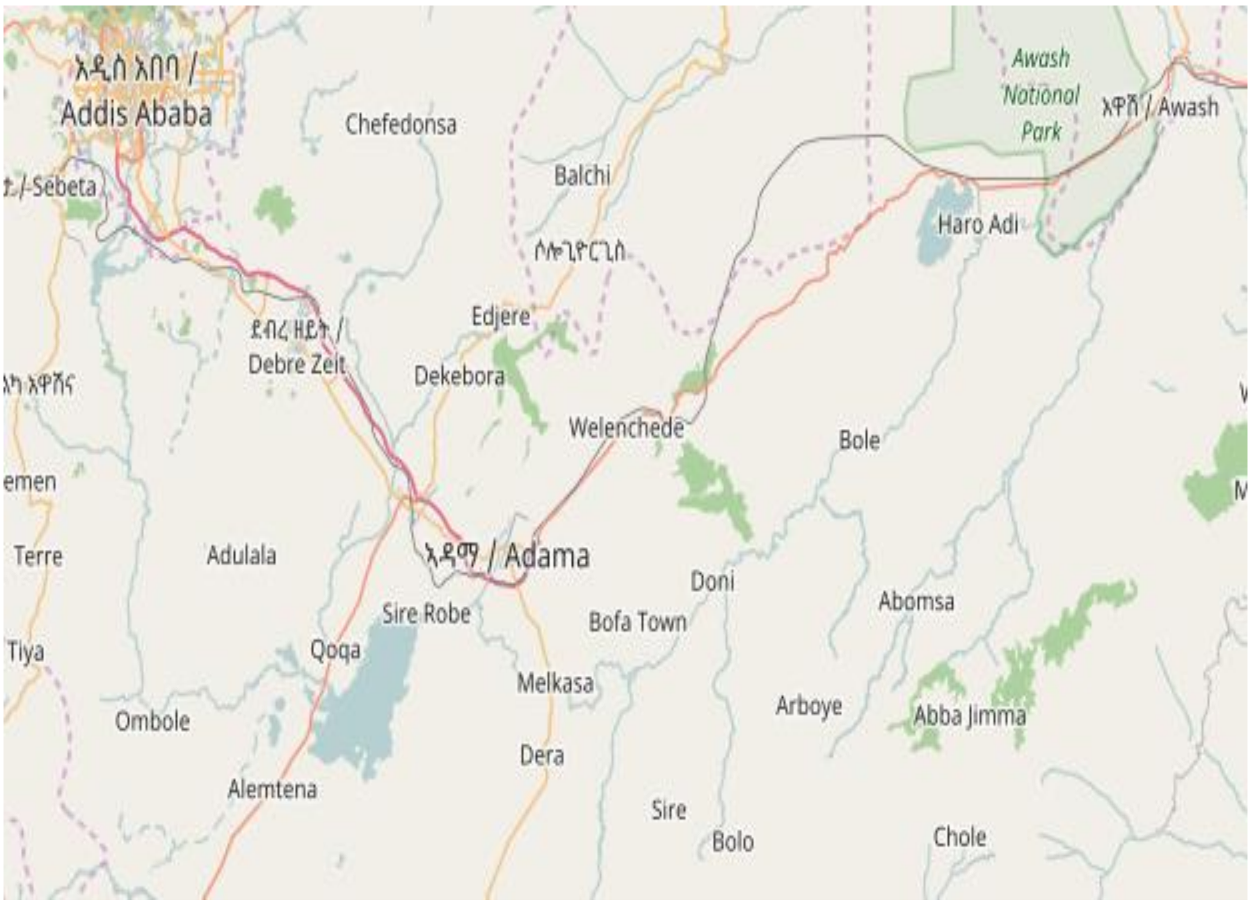


Figure 5-1map of addis-abeba to adama

After this we take the express way as shown in Figure 5-2 below. In Figure5-2, there are lanes which support vehicles to travel in different direction. We take this road architecture to make sure that our design can work on the complex architecture instead of street high way. After downloading the map in the form of .osm file (open street map file) the snapshot of the map is as follows.

Figure 5-2 map of the highway we use

After getting the .osm file, we change the file in to .net file to make it network file. We add type map file to incorporate buildings, water, ocean and other things which may be found in the road. Then we generate a route file which shows the movement of vehicles in the express way.

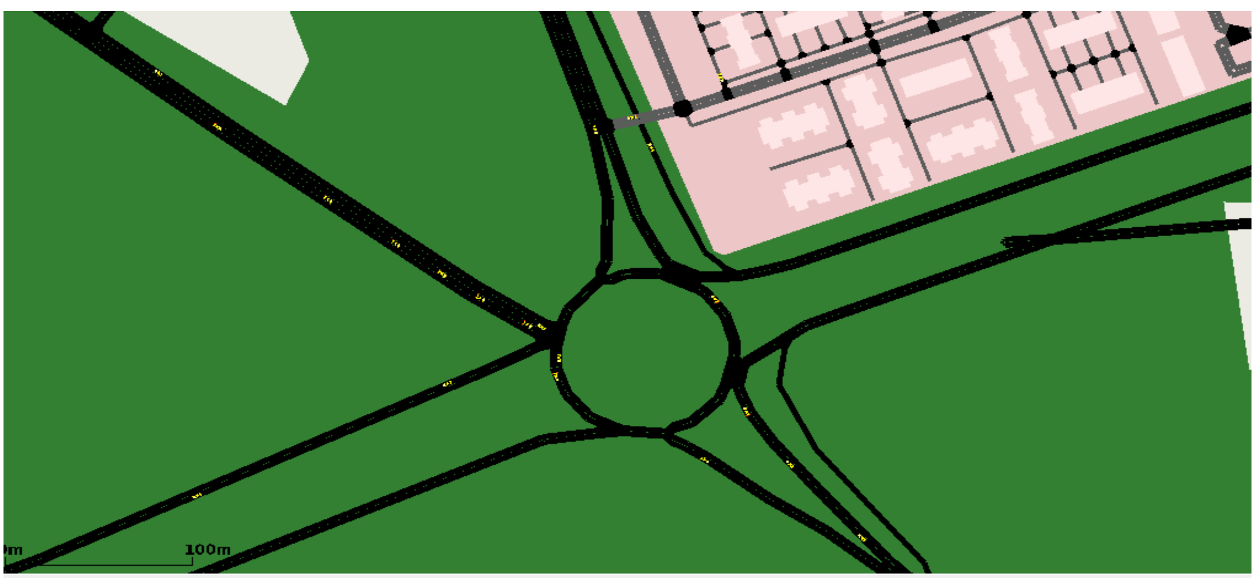


Figure 5-3: Mobility of vehicles in SUMO in Addis-Adama expressway with 100 nodes

From figure 5-3, after generating rout file we configure the configuration file for SUMO and we get the above result. After generating the mobility in SUMO, we create two static nodes and get the mobility of the node from the SUMO using veins in OMNeT++. In Figure 5-4, there are nodes we have seen in Figure 5-3 and two static nodes in OMNeT++.

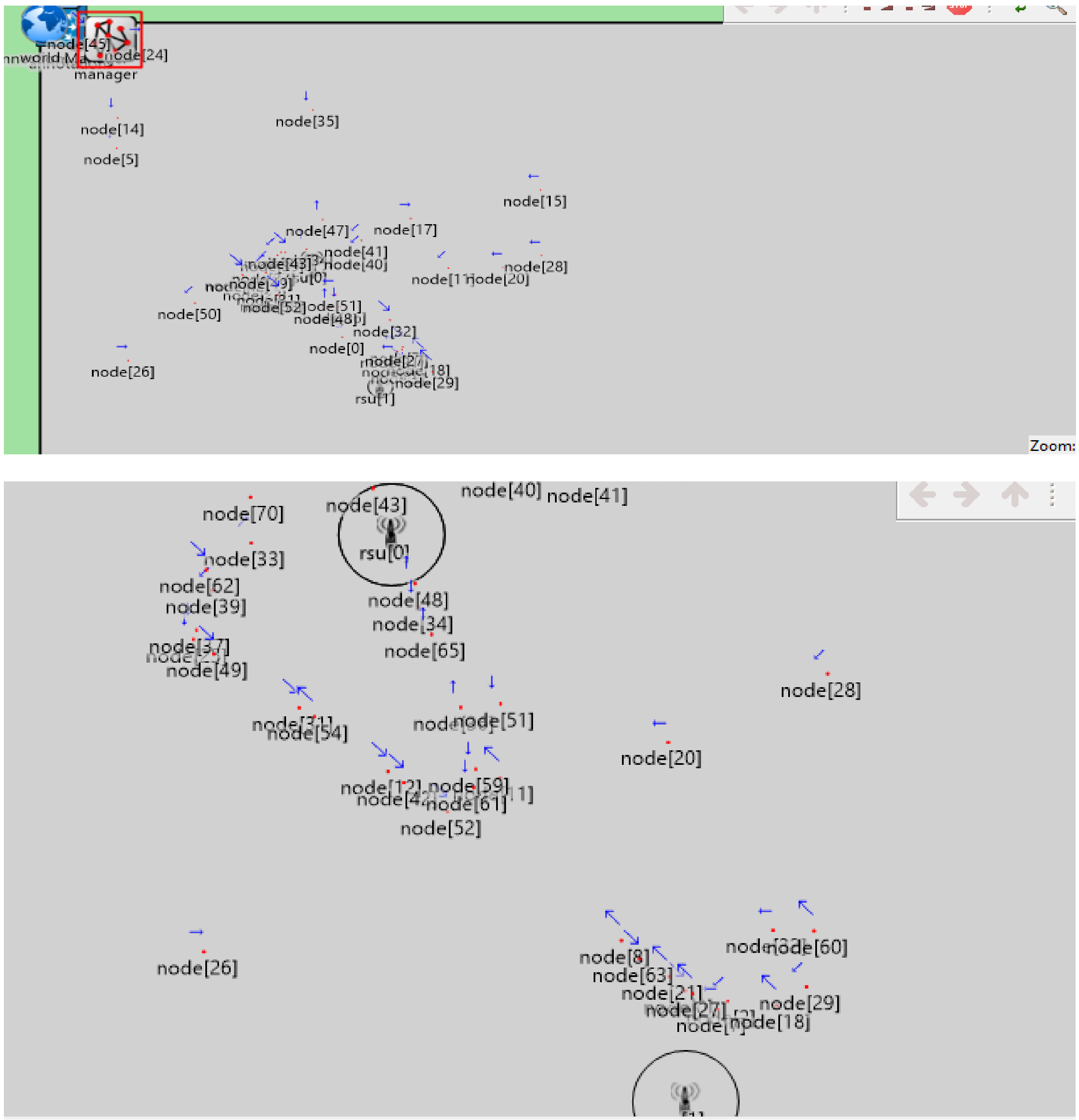


Figure 5-4 Setup VANET nodes

In Figure 5-4 to make communication, each node has different modules. We get the mobility of the vehicle from SUMO using TCP connection by Veins. We import the mobility file from SUMO as we stated in appendix B. When we see the mobility of the RSU, it is a static node. Here we define the RSU as we want depending on the scenario we need to simulate.

As the configuration in appendix B, we place two RSU which have a distance of 500meter and we place the position due to the map we export from the open street map.

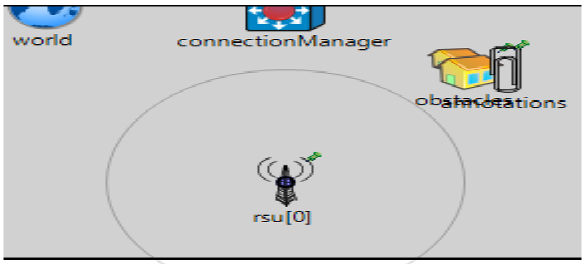
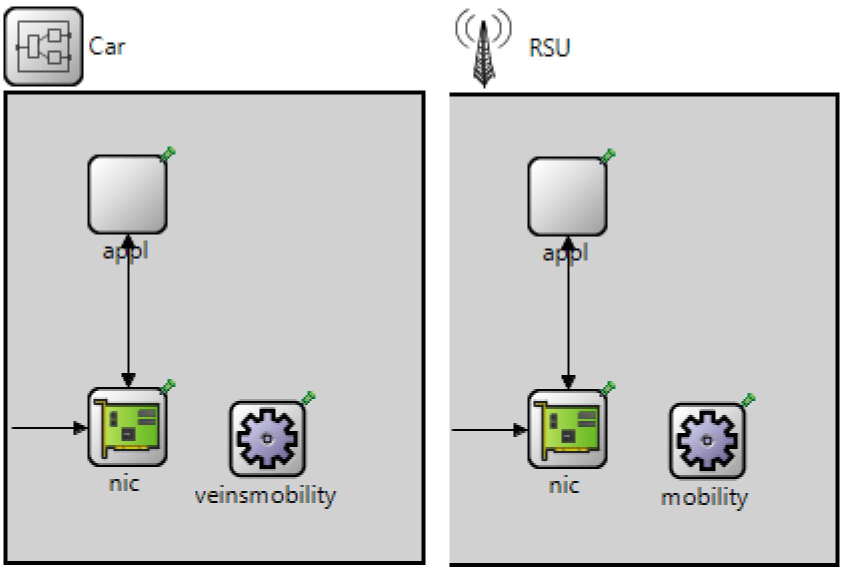


Figure 5-5 RSU configuration

In Figure 5.5, the circle indicates the radius of the RSU. The details are presented in appendix A *rsu.ned* configuration file.

The layered configuration of the scenario is expressed as follows. Figure 5-6, shows the detail component of the node. In the first Figure (a), the vehicle component and in second Figure (b), the configurations of RSU are represented.



a) Vehicle b)RSU

Figure 5-6 RSU and Vehicle layered configuration

According to Figure 5.6 (a) and b, in both way they vehicle and RSU have the same nic type and application. The difference between Figure 5.6 a) and b) is about mobility. The mobility of the vehicles depends on the SUMO mobility generator whereas the mobility of the RSU depends on base mobility configuration which is static.

As we see the Figures 5-6, the communication between RSU and vehicle is using the MAC layer protocol. So the communication is by using node ID.

In order to disseminate the emergency message the abnormal vehicle initially broadcast the message and the vehicle can forward depending on algorithm 4.3 and RSU also uses that algorithm. As we show in our design in Chapter 4, the vehicle which generate emergency message is represented in red color as shown Figure 5-7.

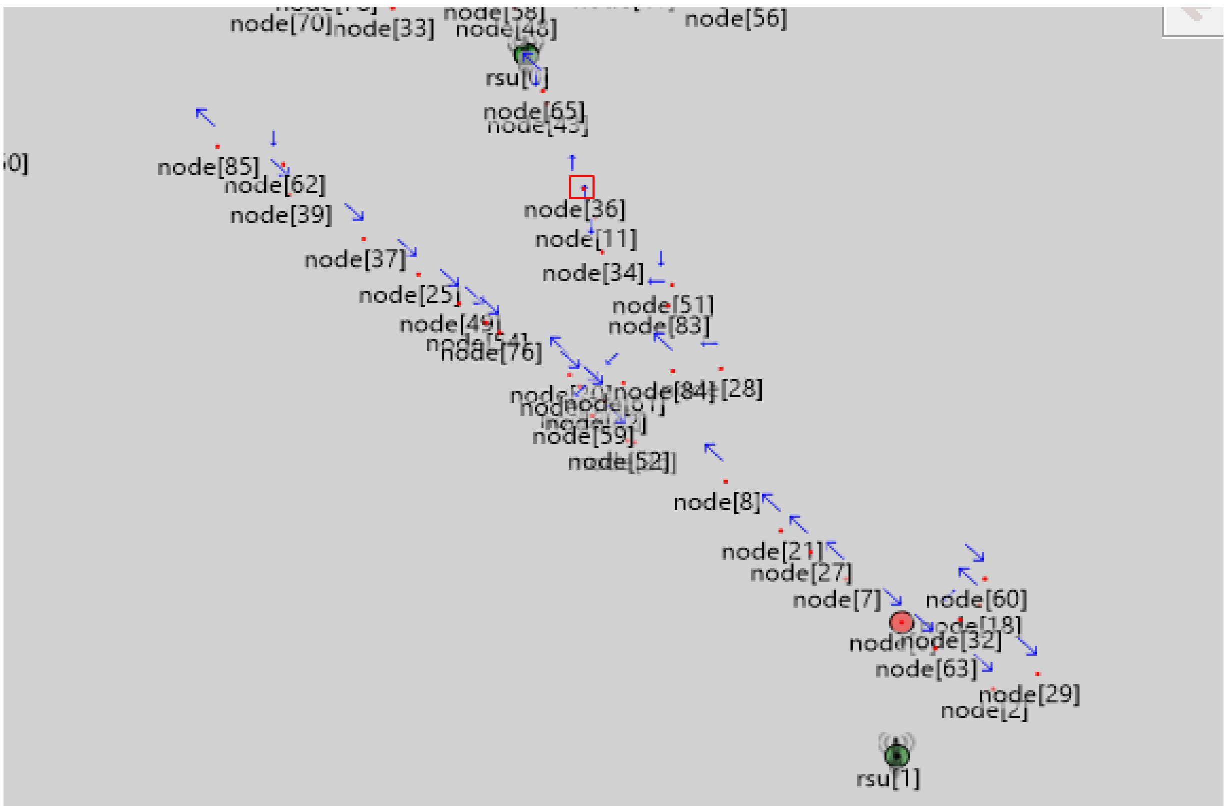


Figure 5-7 sample forwarder node and abnormal node in 100 node scenario

In Figure 5.7, the node which has red color is set as abnormal vehicles and the node which has green color represents the forwarder node. As we see from figure 5.7, vehicles travelling in both direction and when the vehicle detects accident, it can generate and broadcast within its transmission range and depend on algorithm 4.3 in Chapter 4 messages can be further forwarded to other vehicles.

Event#	Time	Src/Dest	Name	Info
#1245	87.806426811395	node[42] --> node[61]	data	id=1037
#1245	87.806426811395	node[42] --> node[65]	data	id=1039
#1245	87.806426811395	node[42] --> node[76]	data	id=1041
#1245	87.806426811395	node[42] --> node[83]	data	id=1043
#1245	87.806426811395	node[42] --> node[84]	data	id=990
#1421	87.808765501023	rsu[0] --> rsu[0]	data	id=1284
#1421	87.808765501023	rsu[0] --> node[11]	data	id=1286
#1421	87.808765501023	rsu[0] --> node[12]	data	id=1288
#1421	87.808765501023	rsu[0] --> node[17]	data	id=1290
#1421	87.808765501023	rsu[0] --> node[20]	data	id=1292
#1421	87.808765501023	rsu[0] --> node[25]	data	id=1294
#1421	87.808765501023	rsu[0] --> node[31]	data	id=1296
#1421	87.808765501023	rsu[0] --> node[33]	data	id=1298
#1421	87.808765501023	rsu[0] --> node[34]	data	id=1300
#1421	87.808765501023	rsu[0] --> node[36]	data	id=1302

Figure 5-8 Sample of emergency message dissemination

In the Figure 5-8 above, node42 and RSU0 is the forwarder node for other nodes through the node id. From the above information we see that the source and destination nodes and the data part contain information transmitted to other vehicles. Under this data there is the block road id.

5.4 Simulation Experiment and Result Analysis

In order to test our scheme we use simulation experiment according to different parameters. To implement our scheme initially we made simulation set up to conduct the simulation. After that we identify and define network parameters. Finally, we analyses and compare our scheme with the existing emergency dissemination schemes.

5.4.1 Simulation Setup

We use OMNET++ 5.0, Veins4.4 and SUMO0.25.0 to conduct the simulation experiment. To set up our simulation we use various numbers of vehicles which traveling in the map we get from SUMO. We use 10, 30, 50 and 100 number of vehicles. In terms of fixed node we use two RSU which are capable of communicating with each other. The distance between the two RSU is 500 meter. As we expressed in our design, we use 802.11p physical and MAC layer. We use 500s for simulation time because this is optimal simulation time for scenarios like the author in [9].There are also default parameters we use in our simulation the antenna power 20Wt and the bit rate is 6Mbps. In appendix B, we list in detail the overall simulation parameters. Generally the simulation parameter in our simulation set up is shown in Table 5-1.

Table 5-1 simulation parameter

Parameters	**Values**
MAC layer	802.11p and IEEE1609.4
Physical layer	802.11p
Number of vehicle	10,30,50,100
Number of RSU	2
Simulation time	500s
Distance between RSU	500m
Transmission range of vehicle	500m
Bitrate	6Mbps
Simulation area	13,000m X 13,000m

5.4.2 Performance Evaluation Metrics and Results

To evaluate our scheme and to compare with the existing dissemination scheme we use different metrics. Those metrics are number of notified vehicle, overhead, and packet delivery ratio, number of forwarder nodes.

- **Forwarder node ratio:** measures the proportion of vehicles which rebroadcast the source data. As the author in [24], [25] describes when the number of forwarder node increases it leads high number of redundant message, due to this there is broadcast storm problem. So taking this metrics is essential to measure the performance of emergency message dissemination scheme. Mathematically as the author in [39] describes, it is the ratio of nodes which rebroadcast the message to total number of vehicle in the network.

$$FNR = \frac{FN}{NV} \ldots \ldots \ldots . \ldots eq(3)$$

Where FNR refers to forwarder node ration, FN is total the number of vehicle which forward the message and NV is the total number of vehicle in the network.

- **Overhead:** this is the average number of packets transmitted at each forwarder node during the simulation. When there is high number of packet transmitted over a network there is high number of unwanted traffic. Due to this we use this metrics to measure our scheme and to compare with the existing scheme.
- **Data Delivery ratio:** is the metrics used to measure the percentage of data message which are successfully received by vehicles over a network. It is calculated by the number of received message (Mrcv) by the number of expected message to be received

(Mexp) [26, 35]. Ideally in VANET dissemination scheme 100%data delivery are expected [26].

$$DDR = \frac{Mrcv}{Mexp} \dots \dots \dots . \dots eq(4)$$

And

$$Mexp = NV \times Msent \dots \dots \dots \dots . . eq(5)$$

Where *NV* refers to the total number of vehicles in the network and Msent refers to the number of sent message during simulation.

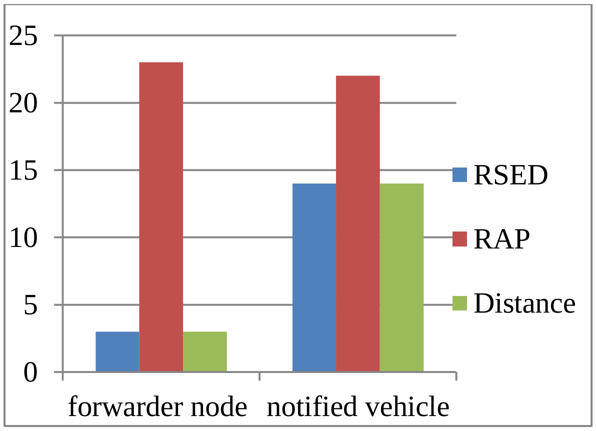
- **Number of notified vehicle:** is the total number of vehicles which are aware of emergency message. As this is one of the main goals of VANET, the number of notified vehicle play a great roll to test the new scheme.

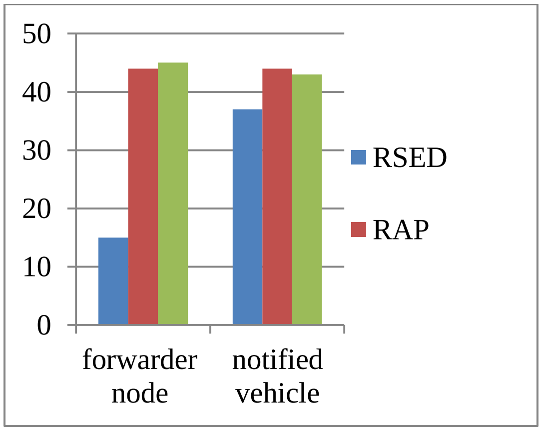
Depending on the evaluation, the performance among distanced based, RAP and the new scheme are evaluated using our simulation tool**.** After simulation the results are recorded in result folder with scalar and vector files.

Result in each Scenario

As we record from the simulation the relation among the three schemes in terms of the number of forwarder node and the total number of notified vehicle can expressed in Figure 5.9.

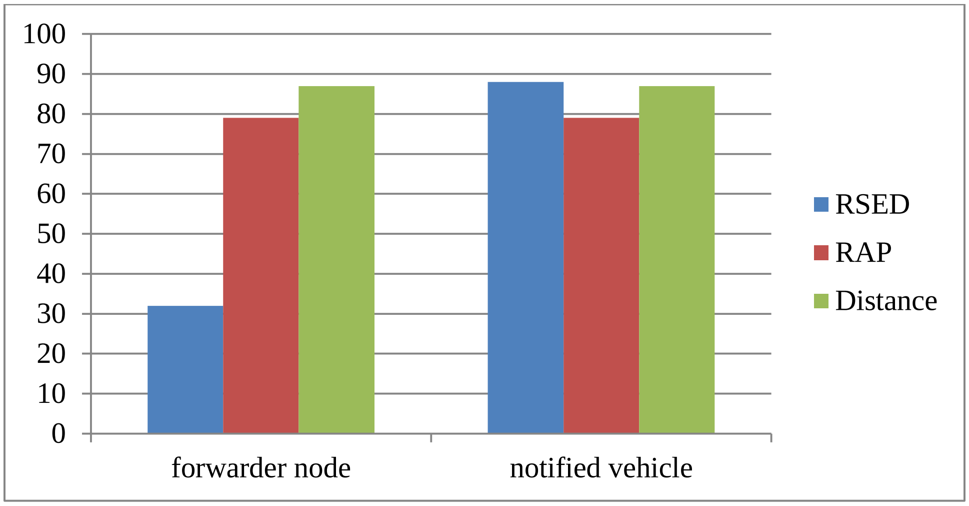
Total number of notified vehicle and forwarder node in each scenario





a) Number of forwarder node and notified vehicle In 30 node scenario

b) Number of forwarder node and notified vehicle In 50 node scenario

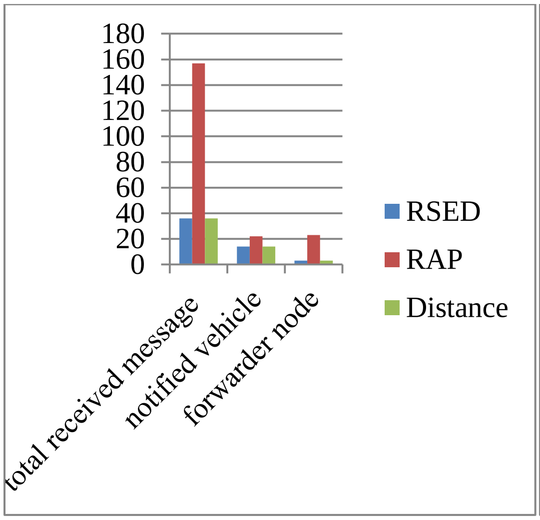


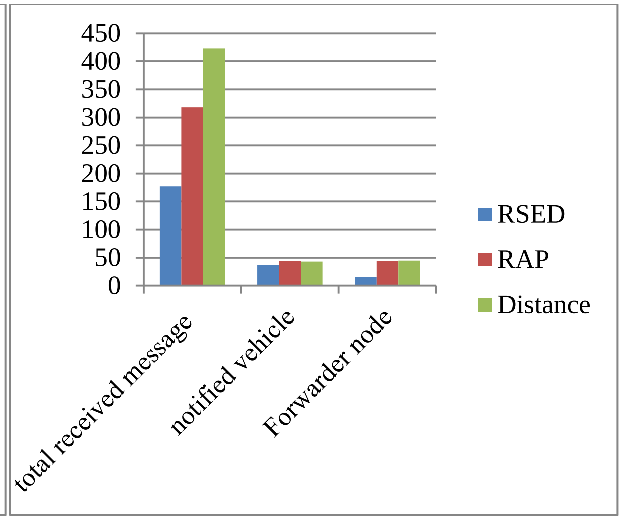
c) Number of forwarder node and notified vehicle In 100 node scenario

Figure 5-9 numbers of forwarder node and notified vehicle in different scenario

According to the Figure 5-9 a) in both forwarder node and notified vehicle the new emergency message dissemination scheme and distance based scheme have nearly similar results. From this we understand that in sparse network scenario our scheme has nearly the same as distance based scheme. In RAP scheme as we see from the Figure due to every node forward the emergency message, the number of forwarder node is almost the same with the number of notified vehicles. From this our scheme and distance based scheme is performing better because with minimum number of forwarder node. According to figure b) and c) distance based and RAP scheme have higher result in forwarder node. Here in dense environment the forwarder node increases in both distance and RAP scheme. In Figure b) distance based and RAP scheme have high number of notified vehicles but due to high number of forwarder node it leads high overhead. In Figure c), our schemes have good performance with minimum number of forwarder node and high number of notified vehicle.

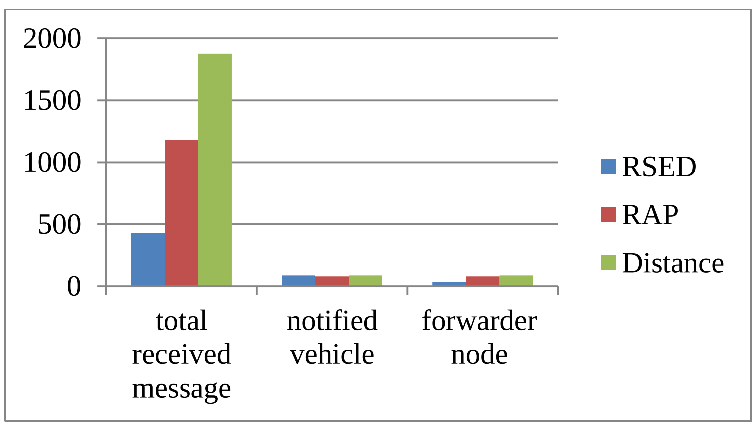
Notified vehicle, total number of received message and forwarder node in each scenario





a) Number of forwarder node, notified vehicle and total received message in 30 node scenario

b) Number of forwarder node, notified vehicle and total received message in 30 node scenario



c) Number of forwarder node, received message and notified vehicle In 100 node scenario

Figure 5-10 Number of forwarder node, received message and notified vehicle In 30, 50 and100 node scenario

As we see from the above Figure 5.10, the number of received message RAP and distance based scheme are higher. In all the three scenarios, the total number of received message is reduced in our scheme. Here as we see in Figure b) and c) though the number of received message in RAP and distance based scheme is high, our scheme can notified with minimum number of received message. From this we can say that the redundant message in RAP and distance based scheme is high.

Table 5.2 shows the average result in each of the scenario after exporting to spread sheet. Based on the result, we analysis the three schemes and we compare them according to the above metrics.

Table 5-2 Average Result recorded from the simulation

Dissemination Schemes	Number of Nodes(#)	Total number of Packet received(#)	Performance metrics			
			Total number Of notify vehicle(#)	Overhead (#packet)	data delivery ration (#)	Forwarder Node ratio (#)
RSED(New scheme)	10	4	3	3	0.2	0.33
	30	36	15	3	0.4	0.1
	50	177	37	9	0.236	0.14
	100	428	88	28	0.153	0.26
RAP scheme	10	3	3	3	0.1	0.33
	30	157	22	23	0.2275	0.76
	50	318	44	44	0.1445	0.88
	100	1181	79	79	0.1494	0.79
Distance based scheme	10	2	2	1	0.2	0.2
	30	36	14	3	0.4	0.1
	50	423	43	45	0.188	0.64
	100	1876	87	87	0.2156	0.63

Overhead

According to the Figure 5-11, the x axis represents the number of vehicle during the simulation and in the Y axis represents the average number of packet transmitted during simulation

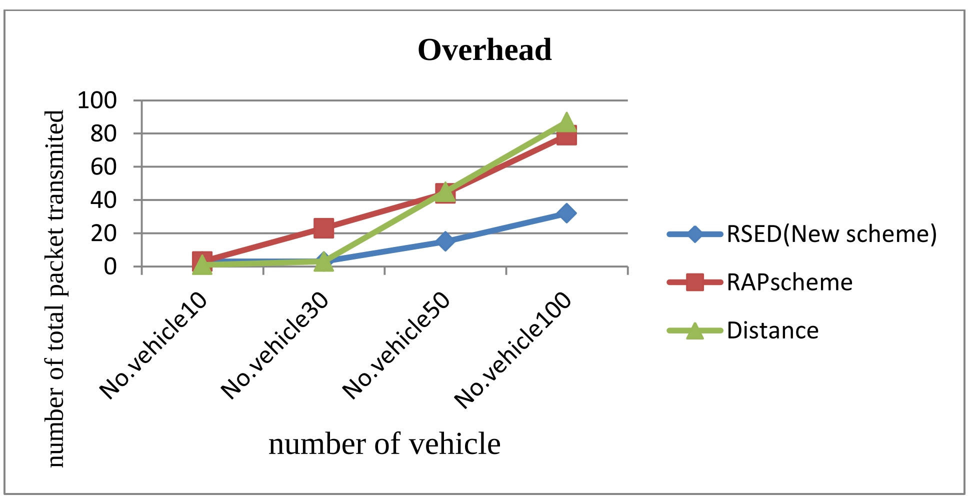


Figure 5-11 Evaluation of three schemes in terms of overhead

As shown in Figure 5-11, the number of packet transmission during a simulation is small in the new scheme. From the Figure 5.11, we see that when the number of vehicle is sparse our scheme have similar result with the distance based dissemination scheme. When the number of vehicles are increasing using RAP scheme and Distance based scheme leads broadcast storm problem which mainly caused by unwanted traffic over a network. The new scheme is the best option by minimizing unwanted traffic over a network. Generally, the new scheme is good option to minimize overhead caused by unwanted and redundant message.

Number of notify vehicle

Here we represent the performance of the three scheme deepens on the number of vehicles which are aware of emergency situation as we see in the Y axis of the graph with respect to the number of vehicles in the network as we see in the X axis of the Figure 5-12.

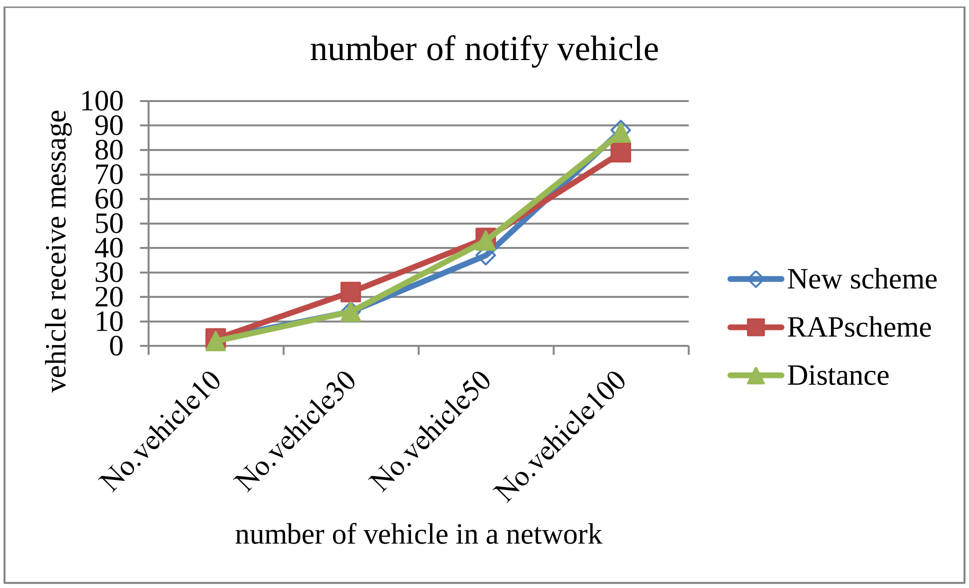


Figure 5-12 Emergency message notify vehicle

From the Figure 5-12, the values we see in the Y axis is the total number of vehicles which receive notification about the emergency situation during the simulation. Here as we see in the Figure our schemes have nearly the same result with the two schemes. The point is as we described in the first Figure 5.11, even though the two schemes have nearly the same result as our scheme they have high number of packet transmission over network. The new schemes are good in terms of notified vehicle with minimum number of packet transmitted over a network.

Data Delivery Ratio

In this metrics we compare the three emergency dissemination schemes with respect to the variation of vehicles in the network as shown X-axis of Figure 5-13. The Y-axis represents the values in each vehicle density for the three schemes.

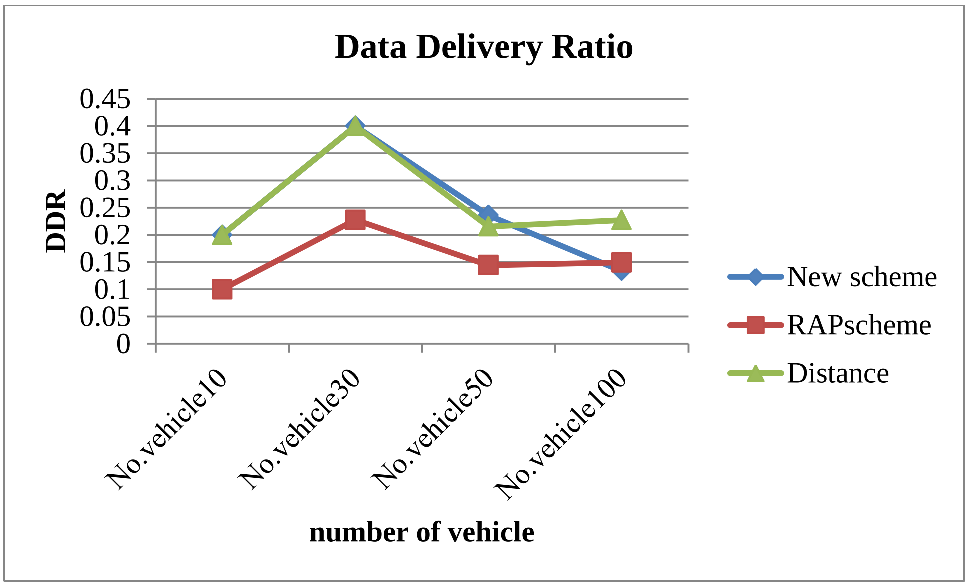


Figure 5-13 data delivery ration

From Figure 5-13, our scheme have better data delivery ratio in sparse network environment. As shown from Figure, when the number of vehicle are high distance scheme have high delivery ratio than other schemes. Therefore, as our aim is to get good data delivery ratio in highway scenario, our scheme gives better performance with less number of duplicate message and high number of notified vehicles. When the number of nodes increase the performance of distance based scheme is better because the number of received message increases with less increase in sent message. In our scheme both the sent message and received message are reduced, due to this the performance decreases.

Forwarder Node Ratio

In this metrics we evaluate our work and compare with other existing dissemination schemes with the variation of vehicle density. As shown in Figure 5-14 below, our scheme has less forwarder node ratio than the two schemes. From this we understand that, our scheme performs better than the two schemes with minimum number of forwarder node. Here the point is as shown from Figure 5-12 above our scheme have good performance to notify vehicles with less number of forwarder node. This decreases the broadcast overhead caused by the redundant flow of information by many forwarder nodes.

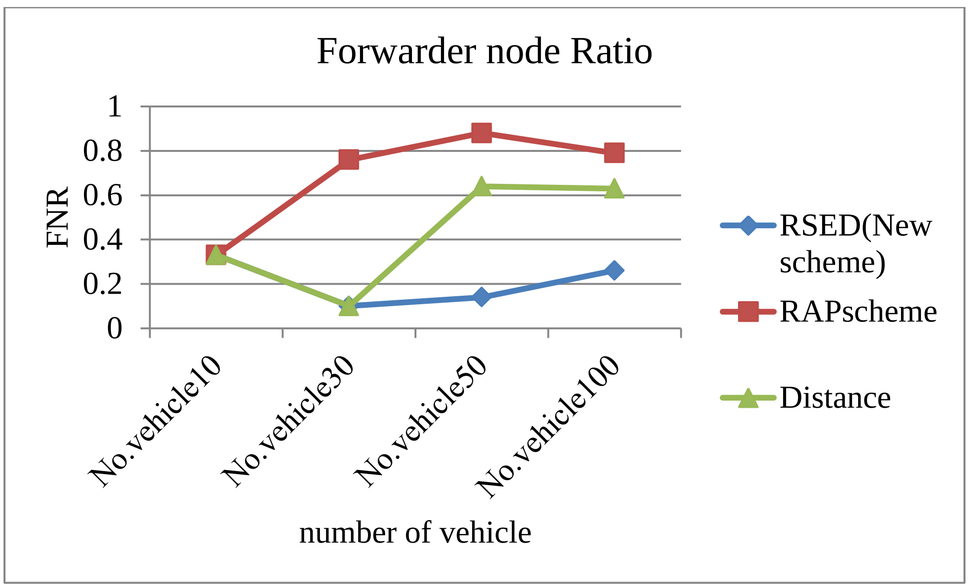


Figure 5-14 Forwarder Node Ratio

As shown in Figure 5-14 when the node density is between 10 and 30, our scheme has the same result with the distance based scheme. But the RAP scheme has high forwarder node ratio because in RAP scheme the number of forwarder node is almost similar with the number of nodes in the network when the node density increases. When the node density increases our scheme has better performance than both distance based and RAP schemes.

5.5 Summary

Generally, we evaluate our scheme by using OMNeT++, VEINS and SUMO simulator. After the simulation we have analysis the performance of our scheme and we compare with the existing dissemination schemes depend on different metrics. We test our scheme in realistic environment which taken from open street map. Our scheme evaluated depends on variation in number of vehicles.

From the simulation result, we can conclude that our scheme have better in terms or forwarder node ratio, overhead and notify vehicles. As the objective of our work is to design emergency message dissemination scheme which minimize overhead without affecting the number of notified vehicles, we get good result from the simulation.

Chapter 6
Conclusion, Contribution and Future Work

6.1Conclusion

VANET is one type of mobile ad-hoc network which designed to solve the problems in ITS applications. As VANET plays great roll in ITS environment, it can be adapted using V2V, V2I and hybrid communication. VANET have different applications such as safety, comfort and commercial applications. To disseminate those applications, VANET needs efficient mechanisms. Safety application in VANET mainly relay on broadcasting schemes. Those broadcasting scheme can be one hop or multi-hop schemes. Even though many researchers try to design dissemination schemes for VANET, still it is a challenging task. As VANET nodes are moving with high speed, there are problems in network fragmentation in sparse network environment and high redundant message, packet collision in high dense network environment.

In this thesis, we design emergency dissemination scheme which can capable of tackling network fragmentation with the support of RSU and which can address the packet duplication by selecting only few vehicles to rebroadcast the emergency message. To select relay nodes we use the road identifier, direction and distance as parameter.

In this thesis, we evaluate and compare our work with the dissemination schemes which use distance and flooding to disseminate the emergency message. To evaluate those schemes we use the parameter network overhead, notified vehicle and data delivery ration with variation of nodes. According to those parameters our schemes have good performance disseminate emergency message. We evaluate our work by using realistic simulation environment using SUMO simulator to generate mobility file from Adama to Addis-Abeba express way. After generating the mobility file we use the file in to the network simulator OMNeT++. To combine those two simulators we use veins framework. Here the mobility generator used as server and the network simulator act as client.

In our scheme, we also design risk zone identification to select forwarder node. Most of the existing work uses distance and coverage range to identify risk zone. In our scheme, we use the direction plus the identifier of the road. To get the direction of the vehicles, we assumed that the vehicles and RSU is equipped with GPS. From the GPS information, we can get the direction of the vehicles. Depending on the direction and the road identifier the vehicle which is found behind the position of accident with the road identifier set as vehicles in risk zone.

Finally, our scheme can be used to disseminate emergency message in highway scenario which have not dense network environment. As we have evaluated our scheme in sparse network environment, our scheme has good performance in different parameters. As one goal of VANET is to disseminate information with less redundancy and with high reception rate, we conclude that our work is better option to disseminate emergency message, with low overhead, good reception rate, and good data delivery ratio.

6.2 Contribution

This thesis have different contribution for the ITS environment to disseminate safety information in highway scenario. Mainly:

- We propose new algorithm to select forwarder node by combining the road identifier, direction and distance.
- We propose new emergency dissemination scheme which can capable of addressing the network fragmentation and broadcast storm problem by reducing the overhead caused by unwanted traffic.

6.3 Future work

Our work has better performance than the existing dissemination scheme to disseminate time critical emergency messages. Our work gives a solution for network fragmentation and it reduces the network overhead caused by redundant message.

Though we have evaluated our proposed work and have improvement than the existing dissemination schemes, it also needs some additional enhancement. Mainly our work can be enhanced in the following aspect:

- RSU deployment: our scheme assumes RSU can capable of communicating each other, but when the number of nodes increase the roll of RSU is not feasible, because vehicles can exchange information with each other without the support of RSU in well-connected network and it mainly cause overhead and the use of RSU is mainly in sparse network environment to solve fragmentation problem. Therefore, deployment of RSU by considering the traffic information is required to use static node efficiently.

- Accident level: our scheme considers only the existence of accident on the road and it needs additional investigation to include the accident level for forwarding the emergency message.
- Node unwillingness: Our scheme assumes that every node can be willing to rebroadcast the emergency message after receiving from the source node. But the node that selected as a forwarder node may not be willing to forward the message to other vehicles; due to this the packet drop will increase. Therefore, our scheme needs future modification by adding this future.

Reference

[1]. Ihn-han "an Intelligent Broadcasting algorithm for early warning message dissemination in VANET " Mathematical problem in engineering ,2014

[2] A.Sebastian "context-aware multicasting protocol for emergency message dissemination in vehicular Network" international journal of Vehicular Technology,2012

[3] Y.wang "An efficient emergency message Broadcasting scheme in VANET" international journal of distributed sensor network, 2013

[4] R.J.Makwana, M.V.Makwana, H.C.patel,"A broadcasting scheme for message dissemination in VANET" journal of engineering research and application vol.2 2015

[5] S.chang and S.lee "distance based stable routing decision scheme in urban VANET "international journal of distributed sensor network, 2015

[6] Julio A. Sanguesa, Manuel Fogue, PiedadGarrido, Francisco J.Martinez,Juan-Carlos Cano, and Carlos T. Calafate A Survey and Comparative Study of Broadcast Warning MessageDissemination Schemes for VANETs Hindawi Publishing Corporation Mobile Information Systems Volume 2016

[7] A.Vasilakos, et al, " Delay Tolerant Networks Protocols and Applications", 2013

[8] Y. Toor, A. Laouiti, & A. Fortelle, "Vehicular Ad hoc networkas: applications and related technical issues" IEEE communication surveys Vol.10, No.3, 3rd Quarter 2008.

[9] Gokulakrishnan ,Ganeshkumar"Road Accident Prevention with Instant Emergency Warning Message Dissemination in Vehicular Ad-Hoc Network" PLoS ONE, December 4, 2015

[10] Rubin I, Yang CY. Lane based backbone synthesis protocols for vehicular ad hoc networks. 13th annual mediterranean ad hoc networking workshop (MED-HOC-NET), 2014, pp.95 – 102.doi: 10.1109/MedHocNet.2014.6849110

[11] Ni SY, Tseng YC, Chen YS, Sheu JP."The broadcast storm problem in a mobile ad hoc network". Proceedings of the 5th annual ACM/IEEE international conference on mobile computing and networking.1999, pp: 151–162.

[12] Fan X, Yang B, Yamamoto R, Tanaka Y."Road side unit assisted stochastic multi-hop broadcast scheme". 16th international conference on advanced communication technology. 2014, pp: 103–108.

[13] Zhuang Y, Pan J, Luo Y, Cai L. "Time and location-critical emergency message dissemination for vehicular adhoc networks". IEEE Journal on selected areas of communication. 2011: 29(1):187–196.

[14] Martinez FJ, et al,"Emergency services in future intelligent transportation systems based on vehicular communication networks". IEEE Intelligent Transportation Systems Magazine. 2010:

[15] Md. HumayunKabir,"Research Issues on Vehicular Ad hoc Network", International Journal of Engineering Trends and Technology (IJETT) – Volume 6 Number 4- Dec 2013

[16] F. Cunha, et al, " Data Communication in VANETs: A Survey,Challenges and Applications" March 2014

[17] Rubin I, Lin YY, Baiocchi A, Cuomo F, Salvo P. "Rapid dissemination of public safety message flows in vehicular networks". Journal of communications, 2014:

[18] Fan X, Yang B, Yamamoto R, Tanaka Y. "Road side unit assisted stochastic multi-hop 2014.broadcast scheme". 16th international conference on advanced communication technology

[19] S. GraÌĹfling, et al,"Performance evaluation of ieee 1609 wave and ieee 802.11p for vehicular communications". In Ubiquitous and Future Networks (ICUFN), 2010 Second International Conference on, pages 344–348, June 2010

[20] A.Festag. "Cooperative intelligent transport systems standards in Europe". Communications Magazine, IEEE, 52(12):166–172, December 2014

[21] V. Kumar, et al,"Applications of VANETs: Present & Future Communications and Network", 2013, 5, 12-15

[22] X. Yang, L. Liu and N. Vaidya, "A vehicle-to-vehicle communication protocol for cooperative collision warn-ing," 1st Annual International conference on Mobile and Ubiquitous Systems: Networking & Services, MOBIQ-UITOUS'04, pp. 114-123.

[23] Ganeshkumar P, Gokulakrishnan P," Emergency situation prediction mechanism: a novel approach forintelligent transportation system using vehicular ad-hoc networks". The scientific world journal.Volume 2015, articleid 218379.doi: http://dx.doi.org/10.1155/2015/218379

[24] J.A. Sanguesa ,et al,"RTAD: A real-time adaptive dissemination system for VANETs" ELSEVIER 2015

[25] C.Zhang, "A New Scheme for Emergency Message Dissemination in Vehicular Ad Hoc Network" Florida State University Libraries,2016

[26] M.Chaqfeh,A.Lakas,"A Novel approach for scalable multi hop data dissemination in vehicular ad hoc networks" ELSEVIER ,2015.

[27] MallikaGandi,M.Ayoub Khan "performance analysis of metrics of broadcasting protocol in VANET" IEEE 26,January 2016

[28] KatrinSjöberg "Standardization of Wireless Vehicular Communications within IEEE and ETSI"IEEE VTS Workshop on Wireless Vehicular Communications Halmstad University, Sweden November 9, 2011

*[29] Syed A. Hussain and A. Saeed "*An Analysis of Simulators for Vehicular Ad hoc Networks*"* World Applied Sciences Journal 23 (8): 1044-1048, 2013

[30] SUMO User Documentation. Available in http://sumo.dlr.de/wiki/SUMO_User_Documentation/ 2017

[31] EvjolaSpaho, Leonard Barolli, Gjergji Mino, FatosXhafa, VladiKolici. (2011). "VANET Simulators: A Survey on Mobility and Routing Protocols". IEEE, 2011 International Conference on Broadband and Wireless Computing, Communication and Applications.

[32] Veins documentation, available on: http://veins.car2x.org/documentation/ 2017

[33] Trans documentationhttp://lca.epfl.ch/projects/trans/ 2017

[34]Omnet++documentation http://www.finmars.co.uk/blog/8-omnet-general-network-simulation 2017

[35] M.Chaqfeh and A.Lakas "Speed Adaptive Probabilistic Broadcastfor Scalable Data Dissemination in Vehicular Ad hoc Networks"IEEE, 2014

[36] Rakesh Kumar1 and Mayank Dave "A Review of Various VANET Data Dissemination Protocols" International Journal of u- and e- Service, Science and Technology Vol. 5, No. 3, September, 2012

[37] IEEE Vehicular Technology Society "IEEE Standard for Wireless Access in Vehicular Environments (WAVE) Networking Services" 30 December 2010

[38] C. Campolo, A.Vinel, et al :"Modeling Broadcasting in IEEE 802.11p/WAVE Vehicular Networks " IEEE COMMUNICATIONS LETTERS, VOL. 15, NO. 2, FEBRUARY 2011.

[39] M. Gandhi and M. Ayoub Khan: "Performance Analysis of Metrics of Broadcasting Protocols in VANET", International Conference on Innovative Applications of Computational Intelligence on Power, Energy and Controls with their Impact on Humanity (CIPECH14) 28 & 29 November 2014

Appendix A: Ned files

*//**Gech.ned** : the overall network definition file for the network*

```
import org.car2x.veins.nodes.RSU;
import org.car2x.veins.nodes.Scenario;

network gech extends Scenario
{
    submodules:
        rsu[1]: RSU {
            @display("p=250,200;b=10,10,oval;r=90");
        }
         rsu[2]: RSU {
            @display("p=350,240;b=10,10,oval;r=90");
        }

}
```

*//**RSU.ned:** network definition for RSU*

```
package org.car2x.veins.nodes;

import org.car2x.veins.base.modules.*;
import org.car2x.veins.modules.nic.Nic80211p;

module RSU
{

    parameters:
       @display("i=device/antennatower");
        string applType; //type of the application layer
        string nicType = default("Nic80211p"); // type of
network interface card
    gates:
        input veinsradioIn; // gate for sendDirect
    submodules:
        appl: <applType> like
org.car2x.veins.base.modules.IBaseApplLayer {
            parameters:
                @display("p=60,50");
        }

        nic: <nicType> like
org.car2x.veins.modules.nic.INic80211p {
            parameters:
                @display("p=60,166");
```

```
        }

        mobility: BaseMobility {
            parameters:
                @display("p=130,172;i=block/cogwheel");
        }

    connections:
        nic.upperLayerOut --> appl.lowerLayerIn;
        nic.upperLayerIn <-- appl.lowerLayerOut;
        nic.upperControlOut --> appl.lowerControlIn;
        nic.upperControlIn <-- appl.lowerControlOut;

        veinsradioIn --> nic.radioIn;
}
```

//Scenario.ned

```
package org.car2x.veins.nodes;

import org.car2x.veins.base.connectionManager.ConnectionManager;
import org.car2x.veins.base.modules.BaseWorldUtility;
import
org.car2x.veins.modules.mobility.traci.TraCIScenarioManagerLaunc
hd;
import org.car2x.veins.modules.obstacle.ObstacleControl;
import
org.car2x.veins.modules.world.annotations.AnnotationManager;

network Scenario
{
    parameters:
        double playgroundSizeX @unit(m); // x size of the area
the nodes are in (in meters)
        double playgroundSizeY @unit(m); // y size of the area
the nodes are in (in meters)
        double playgroundSizeZ @unit(m); // z size of the area
the nodes are in (in meters)
        @display("bgb=$playgroundSizeX,$playgroundSizeY");

    submodules:
        obstacles: ObstacleControl {
            @display("p=240,50");
        }
        annotations: AnnotationManager {
            @display("p=260,50");
        }
        connectionManager: ConnectionManager {
```

```
            parameters:
                @display("p=150,0;i=abstract/multicast");
        }
        world: BaseWorldUtility {
            parameters:
                playgroundSizeX = playgroundSizeX;
                playgroundSizeY = playgroundSizeY;
                playgroundSizeZ = playgroundSizeZ;
                @display("p=30,0;i=misc/globe");
        }
        manager: TraCIScenarioManagerLaunchd {
            parameters:
                @display("p=512,128");
        }


   connections allowunconnected:
}
```

Appendix B: simulation Parameters

```
[General]

cmdenv-express-mode = true

cmdenv-autoflush = true
ned-path = .

network = gech

##########################################################
#              Simulation parameters                     #
##########################################################
debug-on-errors = true
print-undisposed = false

sim-time-limit = 500s

**.scalar-recording = true
**.vector-recording = true

**.debug = true
**.coreDebug = true

*.playgroundSizeX = 13000m
*.playgroundSizeY = 13000m
*.playgroundSizeZ = 50m
```

```
##########################################################
# Annotation parameters                                  #
##########################################################
*.annotations.draw = false

##########################################################
# Obstacle parameters                                    #
##########################################################
*.obstacles.debug = false
*.obstacles.obstacles = xmldoc("config.xml",
"//AnalogueModel[@type='SimpleObstacleShadowing']/obstacles")

##########################################################
#            WorldUtility parameters                     #
##########################################################
*.world.useTorus = false
*.world.use2D = false

##########################################################
#            TraCIScenarioManager parameters             #
##########################################################
*.manager.updateInterval = 0.1s
*.manager.host = "localhost"
*.manager.port = 9999
*.manager.moduleType = "org.car2x.veins.nodes.Car"
*.manager.moduleName = "node"
*.manager.moduleDisplayString = ""
*.manager.autoShutdown = true
*.manager.margin = 25
*.manager.launchConfig = xmldoc("gech50.launchd")

##########################################################
#                       RSU SETTINGS                     #
#                                                        #
#                                                        #
##########################################################
*.rsu[0].mobility.x = 2000
*.rsu[0].mobility.y = 2000
*.rsu[0].mobility.z = 3

*.rsu[1].mobility.x = 2500
*.rsu[1].mobility.y = 3000
*.rsu[1].mobility.z = 3

*.rsu[*].applType = "gechrsu"
*.rsu[*].appl.debug = false
*.rsu[*].appl.headerLength = 256 bit
```

```
*.rsu[*].appl.sendBeacons = true
*.rsu[*].appl.dataOnSch = false
*.rsu[*].appl.sendData = true
*.rsu[*].appl.beaconInterval = 1s
*.rsu[*].appl.beaconPriority = 3
*.rsu[*].appl.dataPriority = 2
*.rsu[*].appl.maxOffset = 0.005s


##########################################################
#            11p specific parameters                     #
#                                                        #
#                    NIC-Settings                        #
##########################################################
*.connectionManager.pMax = 20mW
*.connectionManager.sat = -89dBm
*.connectionManager.alpha = 2.0
*.connectionManager.carrierFrequency = 5.890e9 Hz
*.connectionManager.sendDirect = true

*.**.nic.mac1609_4.useServiceChannel = false

*.**.nic.mac1609_4.txPower = 20mW
*.**.nic.mac1609_4.bitrate = 6Mbps

*.**.nic.phy80211p.sensitivity = -89dBm
*.**.nic.phy80211p.useThermalNoise = true
*.**.nic.phy80211p.thermalNoise = -110dBm
*.**.nic.phy80211p.decider = xmldoc("config.xml")
*.**.nic.phy80211p.analogueModels = xmldoc("config.xml")
*.**.nic.phy80211p.usePropagationDelay = true

##########################################################
#                    WaveAppLayer                        #
##########################################################
*.node[*].applType = "gech"
*.node[*].appl.debug = false
*.node[*].appl.headerLength = 256 bit
*.node[*].appl.sendBeacons = false
*.node[*].appl.dataOnSch = false
*.node[*].appl.sendData = true
*.node[*].appl.distanceThreshold = 300
*.node[*].appl.beaconInterval = 1s
*.node[*].appl.beaconPriority = 3
*.node[*].appl.dataPriority = 2
*.node[*].appl.maxOffset = 0.005s
```

```
##########################################################
#                       Mobility                         #
##########################################################
*.node[*].veinsmobilityType =
"org.car2x.veins.modules.mobility.traci.TraCIMobility"
*.node[*].mobilityType = "TraCIMobility"
*.node[*].mobilityType.debug = true
*.node[*].veinsmobilityType.debug = true
*.node[*].veinsmobility.x = 0
*.node[*].veinsmobility.y = 0
*.node[*].veinsmobility.z = 1.895
*.node[*0].veinsmobility.accidentCount = 1
*.node[*0].veinsmobility.accidentStart = 75s
*.node[*0].veinsmobility.accidentDuration = 30s
##########################################################
 [Config newscheme]
description = "Gech new scheme "
#**.debug = false
**.coreDebug = false
#*.annotations.draw = false


[Config debug]
description = "(very slow!) draw and print additional debug
information"
**.debug = true
**.coreDebug = true
*.annotations.draw = true

[Config Defualt]
description = "RAP dissemination"
#**.debug =settings false
**.coreDebug = false
#*.annotations.draw = false
*.node[*].applType = "TraCIDemo11p1"
[Config Distance]
description = "Distance based dissemination"
#**.debug = false
**.coreDebug = false
#*.annotations.draw = false
*.node[*].applType = "gechd"
*.node[*].appl.distanceThreshold = 300
```