An efficient data dissemination scheme for emergency messages for Internet of Vehicles

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Abstract

IoV is smart integration of human, vehicles, and other things around on global level like IoT but in IoV it is limited to vehicles only. Due to high mobility and frequent change in topology causes churn behavior which leads to network unsuitability. In case of emergency message dissemination delay incur due to fast topology change, network congestion and less connection lifetime among vehicles. Proposed clustering based data dissemination scheme for emergency messages based on destination based clustering in which vehicle with similar destination grouped to gather and form cluster, then cluster head elected basis of weighted matrix using interest compatibility. Cross road communication start when vehicle receive emergency message in order to reduce delay and disseminate the accident information to other vehicles heaving same route, so other vehicles take timely action to avoid any inconvenience. Simulation results show that our proposed scheme shows better results in term of less incur during emergency message dissemination and for normal data exchange, data delivery ratio, covered area for information exchange.

Dedication

To my parents,
Without whom this success would not be possible.

Certificate of Originality

I hereby declare that this submission is my own work and to the best of my knowledge it contains no materials previously published or written by another person, nor material which to a substantial extent has been accepted for the award of any degree or diploma at NUST SEECS or at any other educational institute, except where due acknowledgement has been made in the thesis. Any contribution made to the research by others, with whom I have worked at NUST SEECS or elsewhere, is explicitly acknowledged in the thesis.

I also declare that the intellectual content of this thesis is the product of my own work, except for the assistance from others in the project's design and conception or in style, presentation and linguistics which has been acknowledged.

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List of Symbols

Abbreviations

V2V	vehicle to vehicle
V2I	vehicle to insfrastructure
RSU	road side unit
OBU	on board unit
CH	cluster head
CM	cluster member
UN	unregistered node

Nomenclature

l	Fading parameter
d_{ab}	Distance between vehicle a and b
r_t	Receive signal strength
$IC_{x,y}$	Interest compatibility between vehicle x and y
px_k	Indicate interest of each vehicle
$AvgIC_a$	Average interest compatibility between vehicle a and its neighbor
$AvgD_a$	Average distance between vehicle a and its neighbors
$AvgV_a$	Average velocity of vehicle a and its neighbors
TR_a	Transmission Range of Vehicle a
V_a	Velocity of vehicle a
V_b	Velocity of vehicle b
N	Total number of vehicles
ARD_a	Average distance between relative destination of vehicles
CT_{max}	Maximum Connection time

Chapter 1

Introduction

Internet of Vehicles (IoV) extends VANET applications, structure and scale in other words it can be seen as superset of VANET. To enhance travel comfort and inform people about real time traffic information. IoV mainly focus on information exchange among vehicles, humans and road infrastructure due to these distinct characteristics it is different from traditional intelligent transportation system (ITS) as shown in fig.1.1. Vehicle networking plays important role in different real-life scenarios like usually drivers need to know about traffic situation ahead to avoid any inconvenience by adjusting route. Advance technologies of IoV applications helps to reduce fuel consumption and air pollution,also provide time critical information to avoid accidents [1]. As the use of vehicles increases on regular basis which leads to increase in road accidents and more road side congestion. These issues are considered as main problem of present society [2]. According to the reports in 2011 USD 121 billion cost of extra fuel and time is consume due to congestion in 498 U.S urban areas, and 56 billion pounds of CO2 produced during congestion which pollute environment and cause cost [3]. Connected vehicles shows promising approach in order to reduce congestion on roads via intelligent traffic control and management [4]. In VANET vehicles can exchange information directly like V2V communication or indirectly like V2I communication in which vehicles communicate through infrastructure [5]. Its challenging task to design efficient data dissemination scheme due to challenges occur. Unlike Mobile Adhoc Network (MANET) the mobility is very high and network topology changes rapidly, which results to frequent network disconnection [5]. These factors lead to immoderate transmission delay and packet loss, secondly spectrum scarcity also effects the overall network performance. So due to limitation in wireless range vehicle use multi hops to convey its message to other vehicle which raise scalability issues. Due to increase in number of vehicles/km broadcast storm problem arises, so unnecessary bandwidth utilization leads to spectrum scarcity [5]. Dissemination of information is in public interest because group of vehicles interested in specific traffic related information, for example if accident happened on the road then this information need to send to other vehicles heaving same route to avoid any inconvenience [6]. Different data dissemination techniques proposed by the researchers [7] [8]. According to the characteristics of moving vehicles without any centralize control with network growth network stability issues and broadcast problem introduce and degrade the performance of overall network. The solution of these problem is to provide access point on the road responsible for scheduling and manage network, but these access points adds additional deployment and maintenance cost. So to achieve the properties of infrastructure based network without deploying any physical infrastructure use clustering technique. Clustering technique helps to increase the connection life time by grouping the vehicle with same attributes, like speed, location and direction etc. vehicles exchange complex information with no harms. In clustering instead of sending the data packet to its destination node just need to send this packet to its cluster head and then cluster head is responsible for delivering this packet to its destination. But there are still some issues need to address like for cluster stability vehicles need to be grouped based on parameters which helps to enhance the network stability and channel fading also take into consideration [9]. In this thesis proposed clustering based data dissemination scheme for emergency messages using destination based clustering and cross road communication among vehicles in case if emergency situation happened. By groping vehicles having similar destination leads to make more stable network as compared which results to improve packet delivery ratio and improve latency due to more stable clustering. In this work we propose cluster based emergency message dissemination scheme, which introduce minimum delay. Fast and reliable EM dissemination can be achieved through by determining most suitable vehicle to forward message, so the message disseminate in entire network by introducing minimum delay.

1.1 Motivation

Due to high mobility and frequent change in topology causes churn behavior which leads to network unsuitability. In case of emergency message dissemination delay incur due to fast topology change, network congestion and less connection lifetime among vehicles. Delay incur while emergency message dissemination due to network congestion, broadcast storm problem, frequent disconnection, packet loss and average transmission delay increases. These

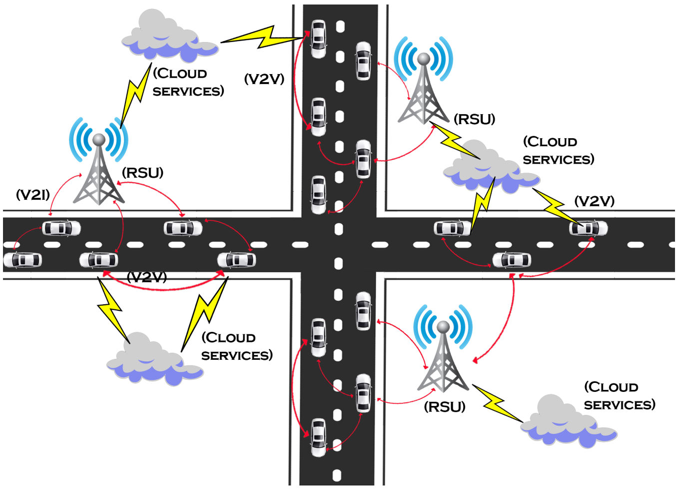

Figure 1.1: IoV Architecture

factors effect the dissemination of message to handle these issues several solution proposed and some of them address some issues but crate overhead which leads to network congestion and redundant message reception at single node. IoV is smart integration of human, vehicles, and other things around on global level like IoT but in IoV it is limited to vehicles only.

1.2 Problem Defination

Additional delay incur during emergency message dissemination. Safety messages need to disseminate to other vehicles having same route but away from accident location as soon as possible.

1.3 Objectives and Research Goals

- Define Cluster formation mechanism
- Define Cluster head election mechanism
- Channel fading model
- Emergency message dissemination scheme

1.4 Thesis Organization

The work has been organized as follows. Chapter 2 covers the basic background information about the data dissemination schemes and protocols. Chapter 3 covers the literature review chapter 4 explains the propose scheme which include cluster formation, head selection and emergency message dissemination algorithms also discuss channel fading model and head election mechanism and their mathematical modeling chapter 5 discuss environment setup and simulation results.In chapter 6 discuss about conclusion and future work.

Chapter 2

Background Information

In this chapter complete background information about research topic discussed. about all the information related to specific research topic discussed in detail. (IoV) extends VANET applications, structure and scale in other words IoV extend the characteristics of VANET . To enhance travel comfort and inform people about real time traffic information. IoV mainly focus on information exchange among vehicles, humans and road infrastructure due to these distinct characteristics it is different from traditional intelligent transportation system (ITS). Vehicle networking plays important role in different real-life scenarios like usually drivers need to know about traffic situation ahead to avoid any inconvenience by adjusting route. Advance technologies of IoV helps vehicle to avoid accidents, reduce fuel consumption and air pollution [1]. As the use of vehicles increases on regular basis which leads to increase in road accidents and more road side congestion. These issues are considered as main problem of present society [2]. According to the reports in 2011 USD 121 billion cost of extra fuel and time is consume due to congestion in 498 U.S urban areas, and 56 billion pounds of CO2 produced during congestion [3]. Connected vehicles shows promising approach in order to reduce congestion on roads via intelligent traffic control and management [4].

In VANET vehicles can exchange information directly like V2V communication or indirectly like V2I communication in which vehicles communicate through infrastructure [5]. Its challenging task to design efficient data dissemination scheme due to challenges occur. Unlike Mobile Adhoc Network (MANET) the mobility is very high and network topology changes rapidly, which causes frequent network disconnection [10]. These factors lead to excessive transmission delay and packet loss, secondly spectrum scarcity also effects the overall network performance. So due to limitation in wireless range vehicle use multi hops to convey its message to other vehicle which raise scalability issues. Another problem raises when node density increases which is called broadcast storm problem. Broadcast storm problem waste spectrum resources which leads to spectrum scarcity [11]. Dissemination of information is in public interest because group of vehicles interested in specific traffic related information, for example if accident happened on the road then this information need to send to other vehicles heaving same route to avoid any inconvenience [6]. Different data dissemination techniques proposed by the researchers [7] [8].

According to the characteristics of moving vehicles without any central control as network grow network stability issues and broadcast problem introduce and degrade the performance of overall network. The solution of these problem is to provide access point on the road responsible for scheduling and manage network, but these access points adds additional deployment and maintenance cost. So to achieve the properties of infrastructure based network without deploying any physical infrastructure use clustering technique. Clustering technique helps to increase the connection life time by grouping the vehicle with same attributes, like speed, location and direction etc. vehicles exchange complex information with no harms. In clustering instead of sending the data packet to its destination node just need to send this packet to its cluster head and then cluster head is responsible for delivering this packet to its destination. But there are still some issues need to address like for cluster stability vehicles need to be grouped based on parameters which helps to enhance the network stability and channel fading also take into consideration [9].

Chapter 3

Literature Review

In this chapter state of discuss state of art literature review. Although VANET has huge potential to address the safety related issues and to improve traffic efficiency with less operational cost but could not able to attract much commercial attraction [12]. The reason behind the less commercial interest because its adhoc based network architecture [13].Multiple reasons effect the popularity of VANET like, lower latency, reliability, cloud computing limited personal device compatibility. [14], [15], [16]. Due to rapid development in internet of things (IoT), the standard vehicular ad-hoc network turning into internet of vehicles (IoV). Promises for large improvement in road safety and traffic efficiency different data dissemination schemes proposed. Different applications have distinct requirement according to their development purpose like some application are delay sensitive and timely action required in case of accident happen on road or in case of some other catastrophic event happen, so the other vehicles in network needs to inform. Dua et al. [17] purpose protocol for QoS data dissemination in which data packet send from sender to receiver as fast as possible. Weights are assigned to routes so that vehicles can decide which route is suitable. So the presented protocol solve the broad cast problem and vehicle can also choose the alternate route if current route have accident or other issues. O.A. Wahab et al. [18] proposed cluster based QoS data dissemination protocol, in order to make stable cluster there is trade-off between QoS and mobility. the main advantage of this protocol is that during data dissemination cluster remains stable also taking in account QoS [19] In order to dealt with the broadcast storm problem effectively, delay based data dissemination proposed in which relay node selected in distributed manner and generally these schemes are timer based. Less number of redundant message produce and packet delivery ratio increases. P. Salvo et al. [20] propose protocol, vehicles in network forward message to other vehicles in network based on information inside the packet header. A. Baiocchi et al. [21]

propose the model to control and set dimension of message flow and the data rate limit is set through this model to limit network load. N. Wisitpongphan et al. [22] proposed probabilistic broadcasting approach based on timer to control network congestion, packet lose and to minimize end to end delay. O.K. Tonguz et al. [23] proposed protocol for vehicular networks that work in distributed manner to disseminate information. Protocol works in both dense and sparse network conditions because it works on the basis of local topology, which enhance packet delivery ratio and network scalability. S. Panichpapiboon et al. [24] propose protocol reduce the number of redundant packets by using the inter vehicle spacing distribution in real traffic scenarios. A. Mostafa et al. [25] this paper propose probabilistic rebroadcast of messages is done by considering vehicles density, distance from above vehicle and transmission range parameters, which collectively effect rebroadcast the data packet and less number of packet rebroadcast due to collision, determine the success of rebroadcast. R.S. Schwartz et al. [26] proposed solution to resolve the broadcast storm problem and frequent network disconnection by using carry and forward model. perform well in both dense and sparse network conditions. C. Liu et al. [27] propose protocol for road safety and fast emergency message dissemination. to sure low delay in emergency message by using directional greedy broadcast approach. A. Mondal et al. [28] In this approach vehicle disseminate data as response message after it receive data request, but this technique add additional computation overhead. S. Bai et al. [29] purpose protocol helps to overcome the broadcast problem by considering multiple reliable forwarders and use cooperative forwarding mechanism in case if any node fails to send data. Proposed technique helps to disseminate the safety message with small delay. Several issues in VANET like handling mobility, connection life time and network stability etc. handle by using clustering based data dissemination algorithm proposed by L. Zhang et al. [30] smart geo cast algorithm which helps to reduce redundant messages at receiver end without missing important information. For stable network clustering plays important role. To achieve stability J. P. Singh et al. [31] propose hybrid clustering approach in which cluster head selection and cluster formation done based on vehicles mobility and number of links. To overcome vehicles mobility and bad channel condition B. Hassanabadi et al. [32] proposed algorithm for long time cluster stability and low channel error rate. One of the major issue among others in VANET is broadcast storm problem. D. Jin et al. [33] proposes the efficient clustering algorithm, mechanism for maintaining cluster also discussed and how safety message disseminate in network with minimum delay .

Table 3.1: safety messages dissemination techniques

Author(s)	Objective	Scenario	Architecture	Simulation	Advantages
Fogue et al. [34]	Minimize safety message dissemination time and increase number of vehicles receive safety message.	Urban	V2V	NS-2	Improve safety message dissemination.
Manuel et al. [35]	Identify the factors effect the dissemination of warning messages.	Urban	V2V	NS-2	Spot density of vehicles, broadcasting scheme, periodicity of beacon and priority effects safety message dissemination.
Christoph [36]	flooding make network congested so instead of flooding the messages use adaptive beaconing protocol	Urban	V2V/ V2I	OMNET++ /Veins/ SUMO	Shows better results as compared to flooding less number of redundent messages.
Zhu et al. [37]'	To minimize delay of warning message.	Highway	V2V	NS-3	Less delay incur while warning message dissemination.
Bingyi et al. [38]	Suitable gate selection for dissemination of emergency messages	Urban	V2V	OMNET++/ Veins/ SUMO	Selection of suitable gateway near situation happened and use parallel multi point scheme to disseminate message
Bousbaa [39]	Remove unnecessary barrier in vehicular communication for safety message dissemination	Urban	V2V	NS-2	lessen the interference which helps to disseminate message in less time.
Gupta et al. [40]	To make network stable mobility aware clustering used and channel scheduling to avoid collision.	Highway	V2V	NS-2	Stability of network improve
Oliveria et al. [41]	improve reliability of network	Highway	V2V/ V2I	OMNET++/ Veins/ SUMO	Safety message disseminate efficiently and packet delivery ratio increase.

Chapter 4

Methodology

4.0.1 Assumptions and system model

In this section assumptions consider to build scenario and system model are discussed.

Assumptions

- Radio device is mounted on each vehicle for wireless communication.
- Vehicles can exchange information like speed, location, and direction through periodic beacons.
- By bartering beacons vehicles send speed,location and direction.
- Road Side Units (RSU) not required in V2V communication.

Radio device, beacon exchange and setting pre-trip destination these assumptions have been mentioned in multiple works. As proposed work mainly focuses on V2V communication so there is no need of Road side unit (RSU). These assumption considered in multiple work. No RSU required because in V2V communication road side assistance is not required and it reduce the cost of infrastructure.

System Model

- Network Model: In this scenario communication among vehicle is V2V so there no need of road side assistance. Emergency messages dissemination among vehicles considered. In given scenario, consider urban environment with multiple lanes, intersections and on both sides of road traffic flows as shown in Fig. 4.1 shows multiple cluster with their own cluster heads elected based on weighted matrices. Where vehicle a send warning message to appropriate vehicle for rapid delivery by adopting smart path to deliver maximum number of vehicles heaving same route to avoid congestion. In figure Fig. 4.1 P,Q,R and S are cluster heads exchanging information with cluster members.

- Channel Model: Effect of fading as signal cover distance calculated by using Nakagami-m distribution model X. Zhang et al. [42]. It uses gamma distribution; different channel conditions consider by using configurable parameters. Successful transmission between vehicle a and b assuming channel fading as in (4.1).

$$Pr_{ab}^{f}(d_{ab}) = 1 - F_d(r_{_T}, l, \Phi) = e^{-lr_T/\Phi} \sum_{a=1}^{l} \frac{((lr_{_T})/\Phi)^{a-1}}{(a-1)!}, \qquad (4.1)$$

In above equation $F_d(r_{_{RT}}, l, \Phi)$ shows cumulative distribution function of receiving signal strength. . r_t represent threshold value of the receiving signal. Where average signal receiving strength indicate by Φ. l shows the fading parameter and $d_{_{ab}}$ indicate the distance between vehicle a and vehicle b. The value of fading parameter depends on the distance between two vehicles. Fading parameter values varies accordingly as distance fluctuate.

$$l = \begin{cases} 3, & d_{ab} < 50\text{m}eter \\ 1.5, & 50\text{l} \leq d_{ab} < 150\text{m}eter \\ 1, & d_{ab} \geq 150\text{m}eter \end{cases} \qquad (4.2)$$

- Interest Compatibility: Interest of each vehicle varies from other, some vehicles prefer the parking information and other interested in congestion on road or accident information. . Pk_i shows the vehicles interest, to calculate interest compatibility among vehicle cosine similarity formula used to identify vehicles heaving same interest.

$$IC_{x,y} = \frac{\sum_{i=1}^{n}(px_k.py_k)}{\sqrt{\sum_{i=1}^{n}(px_k)^2 \sum_{i=1}^{n}(py_k)^2}} \qquad (4.3)$$

To elect appropriate head interest compatibility is used. Here $\vec{V_i}$ shows the interest of vehicle v_i

$$\vec{V_i} = (v_i^1, v_i^2, ..., v_i^k) \qquad (4.4)$$

interest vector of V_i is given in eq. 4.5

$$\vec{V_j} = (v_j^1, v_j^2, ..., v_j^k) \tag{4.5}$$

Now cosine similarity formula eq. 4.6 gives

$$similarity = \cos(\theta) = \frac{\vec{V_i}\vec{V_j}}{\mid \vec{V_i} \mid\mid \vec{V_j} \mid} \tag{4.6}$$

4.6 used to find the similarity among vehicle interests.

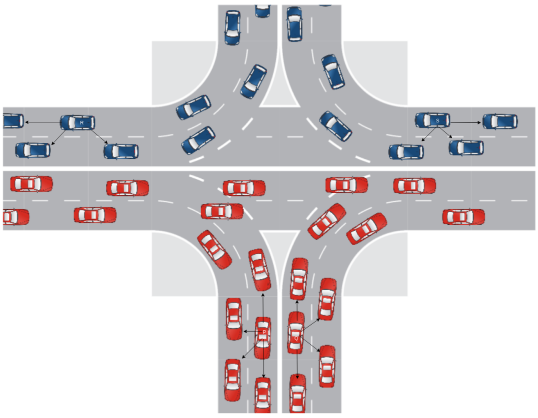

Figure 4.1: Network Topology.

4.1 Proposed Solution for data dissemination

In this section, an efficient data dissemination scheme is proposed for emergency message, to reduce delay incur while disseminating message destination based clustering and cross road communication is used.

Clustering Scheme

VANET introduce some challenges like high mobility and fast topology change cause frequent disconnection and unstable the network. Clustering provide better solution to address these issues. In clustering vehicles having similar interest are grouped together. Grouping of vehicles is based on their speed, direction and destination. Stability of network is achieved by clustering without clustering it is difficult to attain network stability because vehicles with similar parameters helps to maintain stability. Reasonable connection time is necessary for exchange of information, if mobility is high and topology changes frequently it is difficult to maintain connection among vehicles to exchange information. After cluster formation among vehicles heaving same interest are grouped together the process of appropriate cluster head election start. In this paper we propose cluster head election technique based on weighted matrices, then algorithm for data dissemination is proposed to avoid traffic congestion and inform other vehicles heaving same route if accident happen. This scheme helps vehicle to take action according to situation as any hazardous situation occur.

4.1.1 Emergency messages dissemination algorithm

Congestion occur in multi hop environment due to broadcast problem. Vehicle on the reception of message broadcast the information to other vehicle leads to spectrum scarcity and network congestion occur due to redundant information. Unfair spectrum utilization effects the overall performance of the network. Redundant messages utilize the spectrum availability and in case of emergency message dissemination which is time critical and need to disseminate on priority basis faces delay.

Emergency messages needs to send as any hazardous situation happen to inform other vehicles heaving same route to avoid any mishap. Number of techniques present to address the issue of data dissemination, but delay and coverage area needs to improve so that within less time more number of vehicles inform.

To minimize delay, incur while emergency message dissemination, we present novel safety message dissemination technique to inform other vehicle heaving same route so that they can take timely action to avoid any hazardous situation. We propose cross road safety information scheme in which warning message disseminate fast, cover large area and utilize minimum channel bandwidth by reducing less number of redundant messages.

In the beginning of simulation vehicle heaving same parameters as speed, destination and direction are grouped together to form cluster. Cluster formation algorithm used to form cluster then cluster head election process starts in which vehicle with high weighted matric elected as cluster head. Emergency message received by vehicle treated according to the status of vehicle.

Emergency message received at cluster head

If message received at cluster head first it verifies weather it is send by its member or neighbouring cluster head .if message send by its member then send this message to neighbouring cluster head including across the road and to its own cluster members. contrary if message received by neighbouring cluster head then check neighbour road id from where it receive .if road id is same then need to send this across the road as well as to its members.

Emergency message received at cluster member

Cluster member received emergency message send to its cluster head. On reception at cluster head it takes action accordingly and disseminate the message across the network. Cluster member no need to check road id from where it receives, send it to the cluster head to disseminate.

Emergency message received at inferior node

Inferior node simply broadcast the emergency message with road id then within its range if any cluster head or cluster member exist they take action accordingly.

4.2 Clustering Scheme

In following section we introduce clustering scheme with following facets.

4.2.1 Node status

There are four types of status that node can have in following clustering scheme as follows:

1. Inferior Node (IN): Where node does not belong to any particular cluster is referred as inferior node;

2. Cluster Head (CH) : The leader of the cluster;
3. Cluster Member (CM) : A node which is already member of CH;
4. Gateway Node : A node that linked with at least two cluster heads.

4.2.2 Beaconing for neighbor discovery

Nodes send beacons to each other periodically to exchange information, so that they can find common interest for stable cluster formation and head selection. beacon contains information like speed, location, destination, node Id and road id etc. By the means of this information nodes maintain neighbor information.

4.2.3 Cluster head election

To achieve longer network life time election of suitable cluster head is important. The cluster head is elected on the basis of two factors, interest compatibility and probability of successful packet transmission. in order to achieve stable cluster interest compatibility of the same cluster nodes is necessary like node destination, speed, location etc. interest compatibility among vehicles can be computed using (4.3). while the channel model determine successful reception of packet by using Nakagami (4.1). Cluster head eligibility is calculated by using (4.7)

$$AvgIC_a = Avg.IC_a Avg.D_a.Avg.V_a.Avg.ARD_a \tag{4.7}$$

Where $Avg.ICa$ shows the average of interest compatibility and it is calculated by determining IC between vehicle a and its neighboring vehicles n . Where N shows the total number of nodes

$$Avg.IC_a = IC_a nN \tag{4.8}$$

The average distance between vehicle a and its neighbor vehicle n is computed using (4.9)

$$Avg.D_a = \frac{\sum_n \sqrt{((x_n - x_a)^2 + (y_n - y_a)^2}}{N} \tag{4.9}$$

Average velocity among vehicle a and its neighboring vehicles n can be calculated by using (4.10). where V_a shows the velocity of vehicle a and v_n shows the velocity of its neighbor.

$$Avg.V_a = \frac{\sum_n |V_a - V_n|}{N} \tag{4.10}$$

Now to find the average distance between the relative destination of vehicle a and its neighboring vehicles n by using (4.11).

$$ARD_a = \frac{\sum_n \sqrt{((x_n - x_a)^2 + (y_n - y_a)^2}}{N} \tag{4.11}$$

By using cosine similarity matrix vehicles can know the interest of other vehicles and compute interest compatibility weighted matrix the node with high weight is elected as the cluster head and its CM's have similar destination.Relative destination is determine with respect to some reference point while final destination find through with help of GPS. when cluster member find another cluster head with more similar destination it becomes its member.

Algorithm 4.1 explains the formation of cluster when a CH receives request from IN.

Algorithm 4.1 Algorithm – Cluster Formation

$destination_i \leftarrow$ Destination of CH_a
$direction_a \leftarrow$ Direction of CH_a
if (IN_b receives the CHA from CH_a) **then**
    IN_b sends CMR to CH_a
end if
if (CH_a receives CMR from IN_b) **then**
    $destination_b \leftarrow$ calculate destination of IN_b
    $direction_b \leftarrow$ calculate direction of IN_b
    if (their destination and direction is same) **then**
        CH_a send confirmation message IN_b
    else
        discard the CMR
    end if
end if

Algorithm 4.2 Algorithm – Cluster Head Election

```
IN_b Calculate the clustering matrix interest compatibility IC_ab start its timer T_b
flag ← 1
while T_b > 0 do
    if (b receives CHA from CH_a) then
        flag ← 0
        goto Algorithm 4.1
    end if
end while
if (flag = 1) then
    b is elected as CH
    b broadcast CHA
end if
```

Cluster formation and maintenance

Its challenging task to form and maintain cluster. Due to mobility of vehicles the topology of the network changes frequently and causes churn behaviour. in order to overcome these issues we incline to built cluster among those vehicle whose destination resemble. Destination based clustering provide benefits in for of cluster stability and cluster lifetime duration enhance. The relative destination between vehicles by using some reference point, while final destination find by using GPS which is mounted on every vehicle. At start node realize their status. The cluster head CH start advertising and nodes who receive advertisement of CH and currently not the member of any cluster head or advertising CH has more similar destination this node b send CMR to advertising cluster head a. At reception of CMR at cluster head a it checks weather destination is similar and driving direction is same then a add it into its CM list otherwise discard the request. After accepting request CH send conformation to its newly added member.. CH send it update location and other parameters through beaconing at regular intervals. if any CM not receive beacon from its CH for some intervals it means CH is not in the range and make itself inferior node.

4.3 Emergency message dissemination algorithm

This section present the proposed algorithm for emergency message dissemination. In case of emergency the traditional techniques introduce delay like probability based forwarding take more time to dissemination message in case accident happen on the road because additional computation involve at every node. So we present efficient emergency message dissemination scheme.In case of emergency node can send message across the road i.e vehicles traveling in opposite direction can receive the accident message so as vehicles are moving in opposite direction they disseminate the message faster as compared to other techniques. Algorithm and its explanation given as follows.

Algorithm 4.3 Algorithm – Emergency

message ← incoming message
if ($message_{type}$ = emergency) **then**
    if (*message* received at CH) **then**
        Forward *message* to its CMs and its neighboring CHs including in opposite direction CHs
        Change its route
    else if (*message* received at CM) **then**
        Forward *message* to its CH
        Change its route
    else if (*message* received at IN) **then**
        Broadcast *message*
        Change its route
    end if
end if

If the received emergency message at cluster head and have same r_{id}, then sent this message to neighbor cluster heads and own members.Every cluster head maintain neighbor CH list which include also the opposite flow cluster heads within its range. Only emergency message can send to opposite direction in order to save time, so that it timely reached the targeted vehicles means to those vehicles whose route contain the same r_{id} on which emergency situation happened. Another case appears when emergency message received by cluster member then it simply send to its cluster head. If inferior node received message it broadcast it.

The connection time between CH's in opposite directions calculated using (4.12) . where CT_{max} shows the maximum connection time, V_a is speed of vehicle a and V_b is speed of vehicle v_b .

$$CT_{max} = \frac{TR_a}{V_a + V_b} \tag{4.12}$$

The formula of maximum connection time CT_{max} shows that with the increase in speed connection time decreases. Proposed algorithm also perform well when one side of road get congested connection time increases because if slow speed on the other side of road. The ovrall system working shown in fig. 4.2

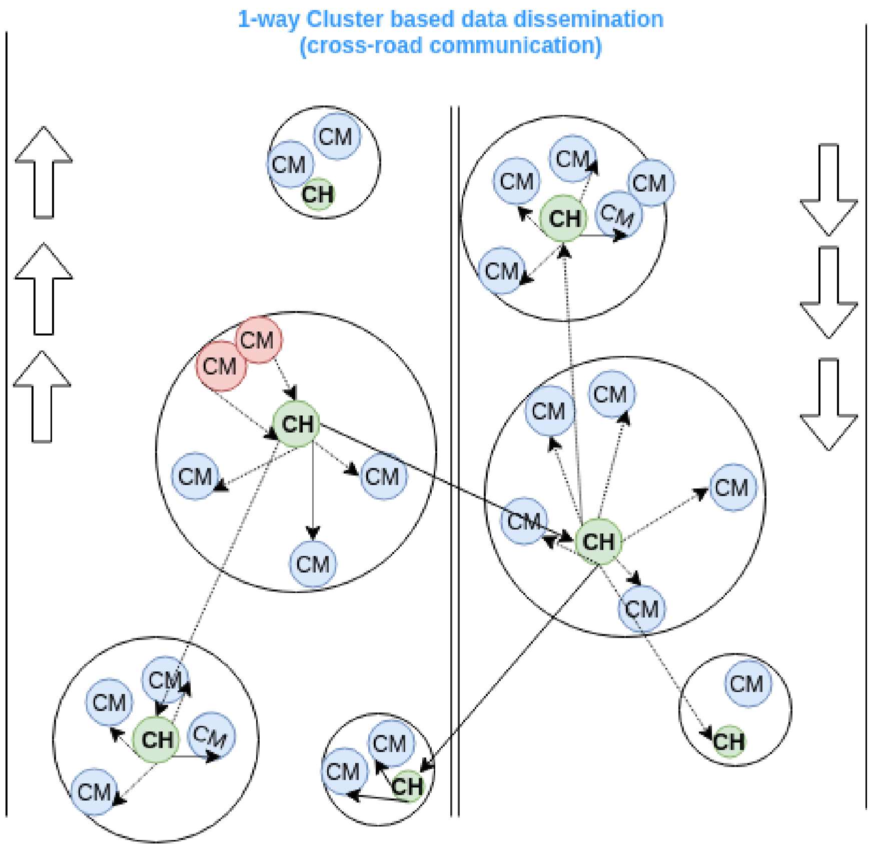

Figure 4.2: Proposed Technique

Chapter 5

Results & Discussion

5.1 Evaluation

This section present the simulation results of our proposed scheme and compared with CPB protocol L. Liu et al. [43]. Proposed and CPB both implemented in OMNET++ using VEINS and SUMO for network and traffic simulation. SUMO shows the traffic movement on the road and connected with veins via TCP socket the movement of vehicle on sumo reflected in OMNET++ C. Sommer et al. [44]. Veins implement $IEEE1609.4$ $DSRC/WAVE$ and standards of $IEEE802.11p$

Simulation scenario:

In simulation scenario we use Islamabad city map which is imported by using open street map(OSM) . In which vehicle movement is schedule from source to destination via different edges. Routes of vehicles designed in such a way that route end after 500s and number of vehicles per kilometer is between 10-150. vehicle speed varies from 5-50 m/s results are gather by setting parameters accordingly. transmission range is set to 250m for individual vehicle.

The OMNET++ worksapec shown in fig. 5.1 Vehicle communication shown in fig. 5.2 vehicles exchange information and send beacons to each other for periodic updates. Here in figure. 5.3 show traffic distribution on road network.

Result analysis

As from above fig. 5.4 it is noticed that in the starting the information coverage is remains low but with the increase of node/Km routing path is

Table 5.1: Simulation Parameters

Parameters	Values
Transmission Range	250 m
Number of Vehicles	20-125 / Km
Simulation Time	500 sec
Data Transmission rate	6 Mps
Vehicle speed	5-50 m/sec
MAC Model	IEEE 802.11p WAVE
Packet Interval	0.1,0.5,1 m/sec

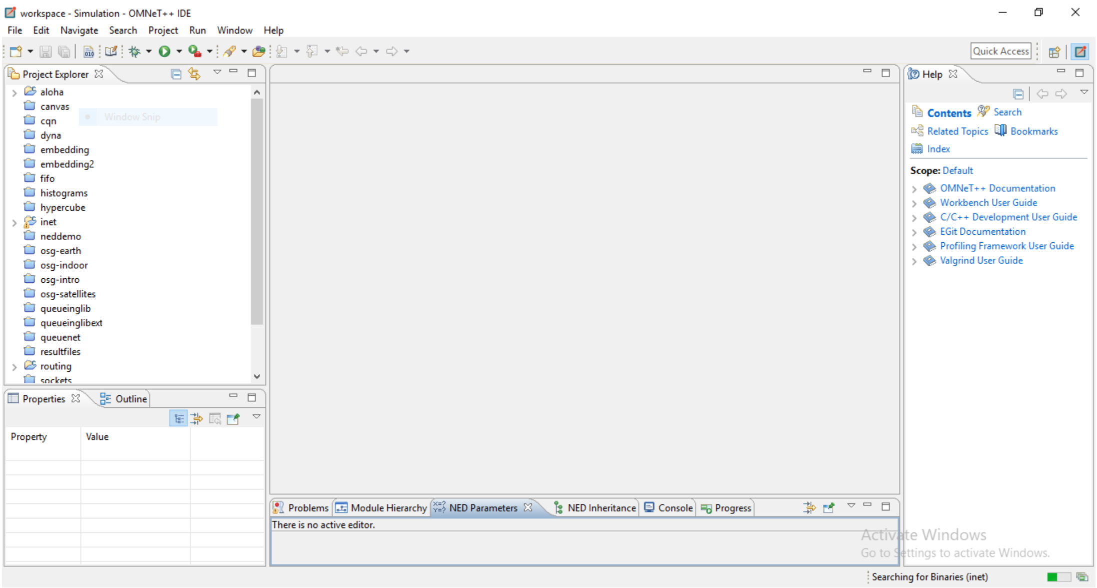

Figure 5.1: OMNET++ Architecture.

established among nodes which improves the overall coverage.

Fig. 5.4 represent the comparison between flooding and proposed scheme in term of information coverage. Initially proposed scheme covers less area as compared to flooding but as the density of vehicles increases proposed scheme perform better. On the other hand, flooding performance degrade with increase in vehicles density. In ad hoc networks due to high mobility and fast topology changes vehicles need to connect in form of stable and reliable network. Proposed scheme perform better because nodes make cluster which maintain and connect more vehicles in efficient way as compared to flooding.

Decline in coverage is noticed after 75/km due to large number of messages. So with the increase of density more delay incur due to congestion. As compared to CPB proposed technique perform better in dense environment

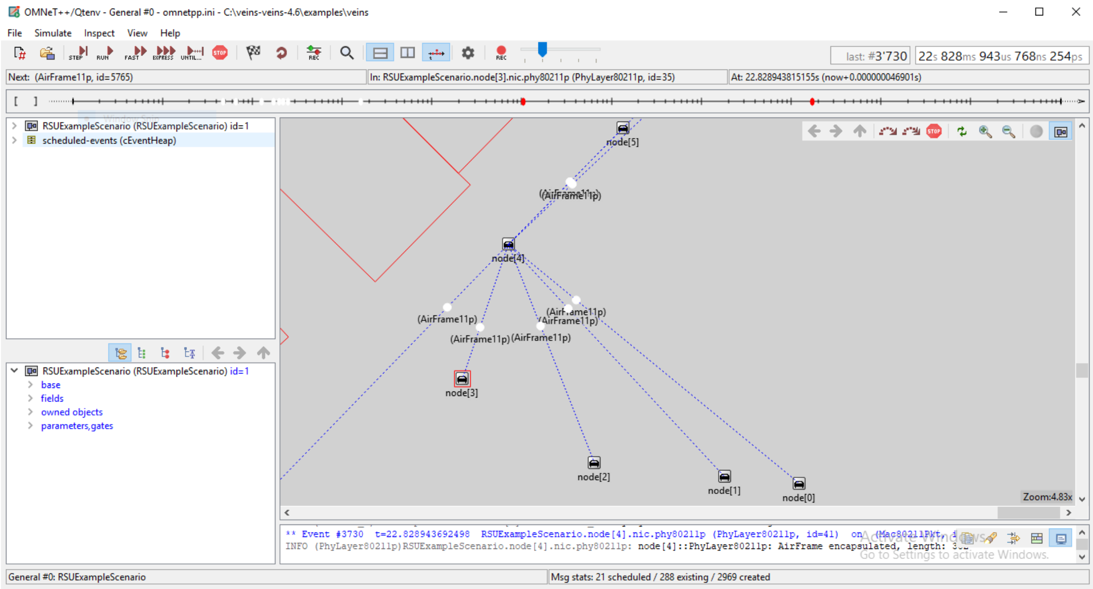

Figure 5.2: Vehicular Communication

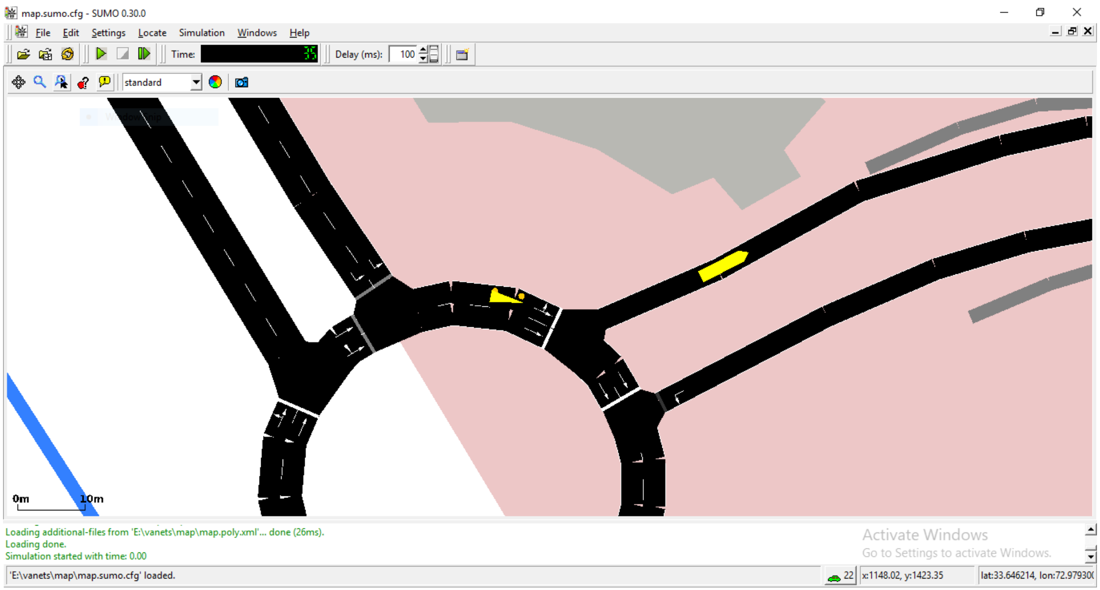

Figure 5.3: SUMO

and can accommodate more number of nodes without declining the coverage area.

Fig. 5.5 shows performance of DV-CAST and proposed scheme based on information coverage area. DV-CAST performance throughout the simulation remains low as compared to proposed scheme. In DV-CAST vehicle

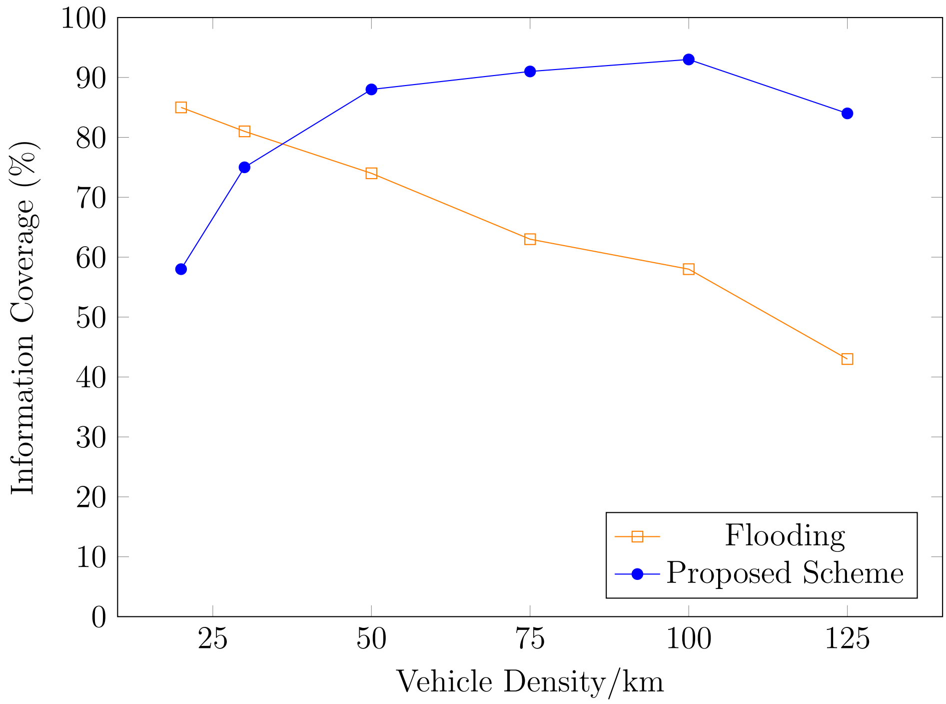

Figure 5.4: Information coverage vs Vehicle density.

further from node have more probability to send data but as the density of vehicle increases network become more congested and more number of node eligible for data dissemination.

As simulation progress the performance of proposed scheme is better but when density increase delay incur which leads to less information coverage but still perform better then DV-CAST.

Fig. 5.6 shows the performance comparison among proposed and CPB scheme in term of information coverage. Simulation result shows our proposed scheme perform better. In CPB while data dissemination additional computational overhead involves at individual node, so thats why the performance degraded as the number of nodes increases. Proposed scheme performs slightly better because less computation overhead involve in data dissemination thats why small difference in performance occur.

Fig. 5.7 shows average transmission delay with respect to the node density. In CPB technique due to probabilistic forwarding which involve computation on every node causes delay and it increases with the number of nodes/km. Another reason our proposed technique works better because CPB even in dense network is that cluster member send packets to its CH by using probabilistic forwarding algorithm , and due dense network more

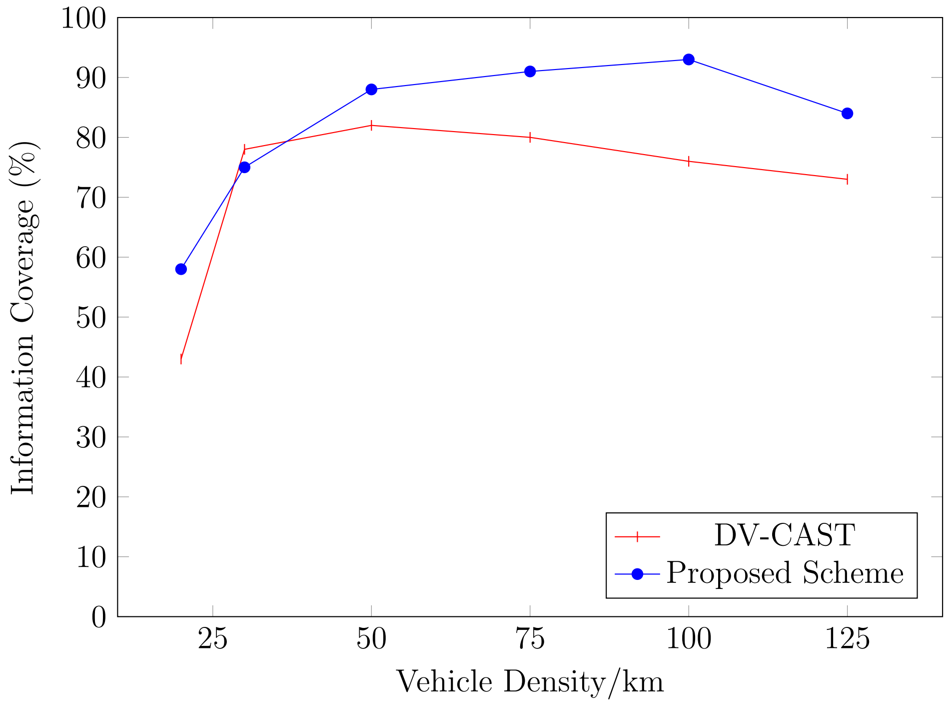

Figure 5.5: Information coverage vs Vehicle density.

congestion, packet loss and re transmission occur.

Fig. 5.7 represent the performance analysis between flooding and proposed scheme in term of average transmission delay. Initially flooding disseminate messages with less delay and more delay incur in proposed scheme. As simulation progress the delay in proposed scheme is reduce and delay in flooding scheme occur more as compared to proposed scheme. Proposed scheme shows slightly better results as compared to flooding because with the increase in density in flooding collision increase which results re transmission of packet, so thats why proposed scheme shows better results in dense environment.

In fig. 5.8 discuss the results of proposed and DV-CAST scheme in term of average transmission delay. More delay incurs in DV-CAST because as node density increases more number of re transmission occur due to packet collision and network traffic. While in proposed scheme less number of message generate because of clustering mechanism as a result network congestion and packet collision not occur which improve overall performance of the network.

Fig. 5.9 show the comparison between proposed scheme and CPB in term of average transmission delay incur while transmitting the emergency message and the effect of node density on delay. Because both schemes use clus-

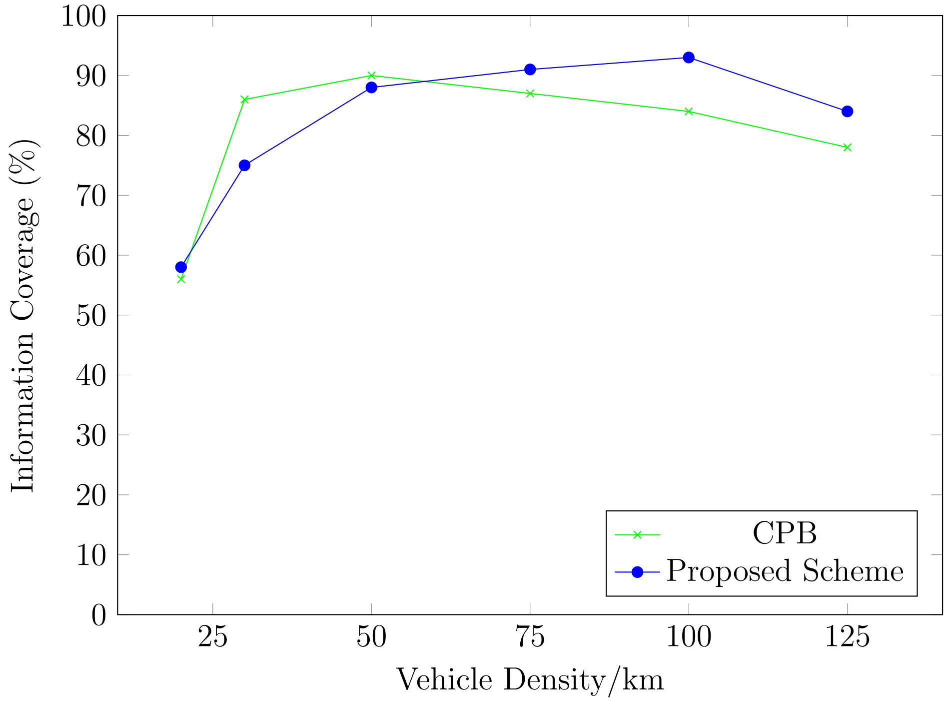

Figure 5.6: Information coverage vs Vehicle density.

tering technique to avoid network congestion and packet collision so thats why performance difference in small when node density increase. At low vehicle density proposed scheme works better because less computational overhead involve and vehicles transmit data as they receive without any additional delay.

Fig. 5.12 shows the effect on packet delivery ration if number of nodes varies. At start as less number of nodes moving so network is sparse thats why coverage is less thats number of packets not able to deliver. At beginning proposed technique deliver less packets as compared to CPB but as the node density increases packet delivery ratio improve in proposed technique because network become less congested as compared to CPB with same network density.

Fig. 5.10 shows the relation of node density with packet delivery ratio. Comparison between proposed scheme and flooding shows that proposed scheme outperforms flooding in term of packet delivery ratio. In flooding packet delivery ratio decreases rapidly as the node density increases as compared to proposed scheme because in flooding number of collision increases due to network congestion and packet loss occur frequently which trigger re transmission and degrade overall network performance in term of packet

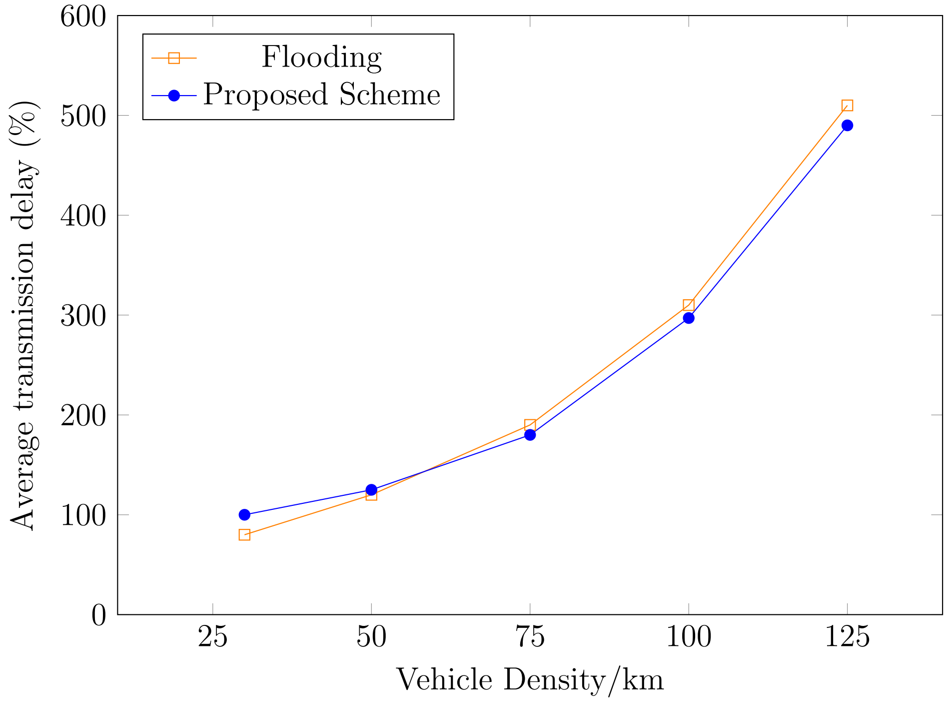

Figure 5.7: Average transmission delay vs Vehicle density.

delivery ratio.

Fig. 5.11 shows the comparison among proposed and DV-CAST scheme in term of node density. Proposed scheme shows better results in term of packet delivery ratio. Due to clustering mechanism in proposed scheme vehicles organized in such manner which generate less traffic. While in DV-CAST no clustering scheme used to network stability and reliability which leads to more network traffic because every node broadcast the message it receive leads to broad cast storm problem.

Fig. 5.12 represent the packet delivery ratio among proposed and CPB scheme in term of density. Initially proposed scheme packet delivery ration is less as compared to CPB, but as the density of node increases proposed scheme works better. While CPB performance degraded at high density because when more number of vehicles involve in data dissemination then more computational overhead introduce. Due to high mobility and frequently changing topology of network computational overhead plays critical role to degrade performance.

Fig. 5.15 shows the impact of velocity on packet delivery ratio. Proposed scheme works better in less speed but with the acceleration packet delivery ratio effect this occur because in high mobility because network lifetime is

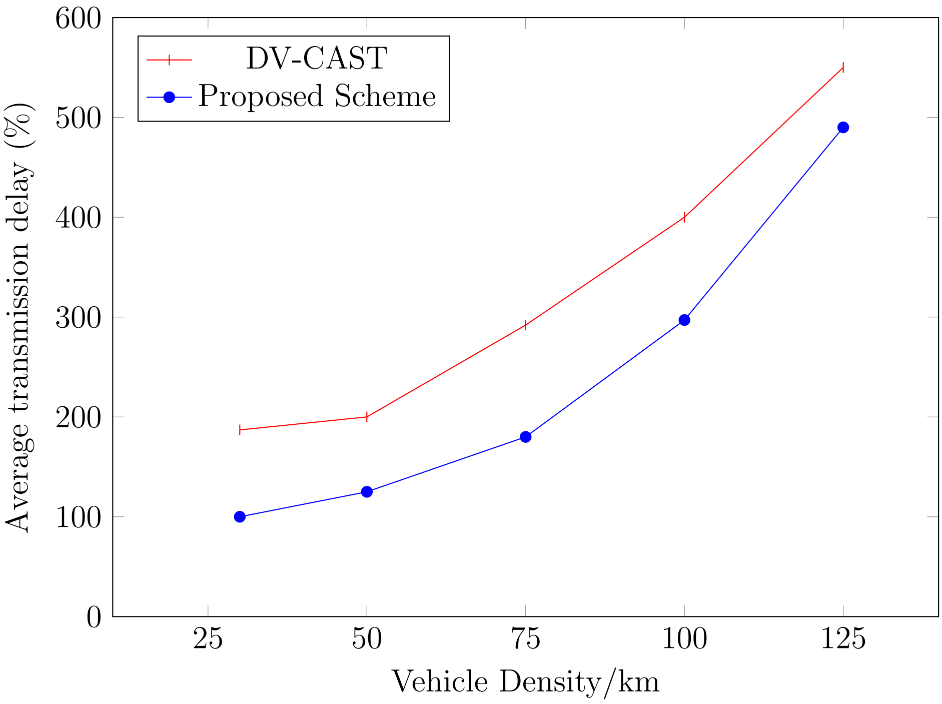

Figure 5.8: Average transmission delay vs Vehicle density.

less as compared to CPB, so due to churn behavior packet delivery ratio effects as speed increases. Packet delivery ratio effect with acceleration because due to frequent change in topology results in churn behavior decrease packet delivery ration . Proposed technique perform well in low speed while performance start declining as velocity increases because in high velocity cross road connection establishment for emergency messages delivery in such short duration is not possible thats why packet delivery ratio decreases with velocity.

This Fig. 5.13 shows the comparison among proposed and flooding scheme. Which shows the relation of velocity with packet delivery ratio. Flooding performance decreases with the increase in velocity while the performance of packet delivery ratio in decreases slightly as compared to flooding. As speed increases in flooding due to lack of clustering topology changes and mobility are dominant factors which plays crucial role in performance degradation. In proposed scheme due to clustering high mobility and frequent topology changes are in control which results to improve overall performance of system.

This Fig. 5.14 shows the comparison among proposed and DV-CAST scheme. Which shows the relation of velocity with packet delivery ratio.

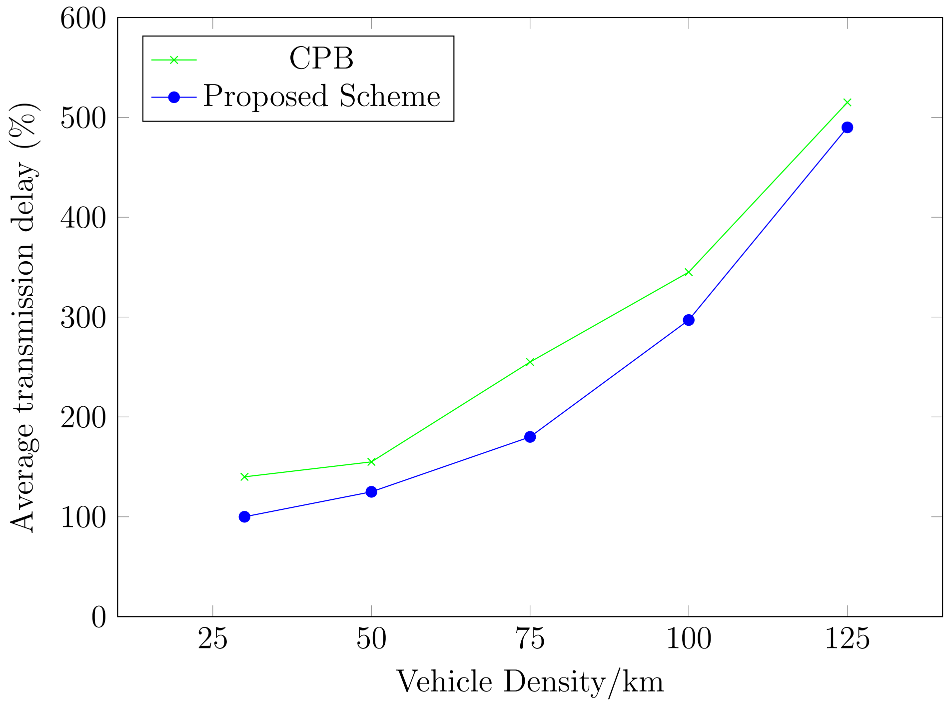

Figure 5.9: Average transmission delay vs Vehicle density.

DV-CAST performance decreases with the increase in velocity while the performance of packet delivery ratio in decreases slightly as compared to DV-CAST. As speed increases in DV-CAST due to lack of clustering topology changes and mobility are dominant factors which plays crucial role in performance degradation. In proposed scheme due to clustering high mobility and frequent topology changes are in control which results to improve overall performance of system.

Fig. 5.15 represent the relation among velocity on packet delivery ratio. Comparison between proposed and CPB scheme shows proposed scheme perform slightly better. As the velocity of vehicles increases they need to communicate faster to successful transmission but due to computational overhead involve in messages dissemination leads to performance degradation. Initially proposed scheme perform better at low speed because vehicles possess more time in low mobility.

Fig. 5.16 shows the relation of node density with average transmission delay occur in case of emergency messages transmission. Proposed scheme perform well as the number of nodes increases so cross road message delivery is easy in dense network while on the other hand CPB did not consider the cross communication so emergency message take more time to deliver to

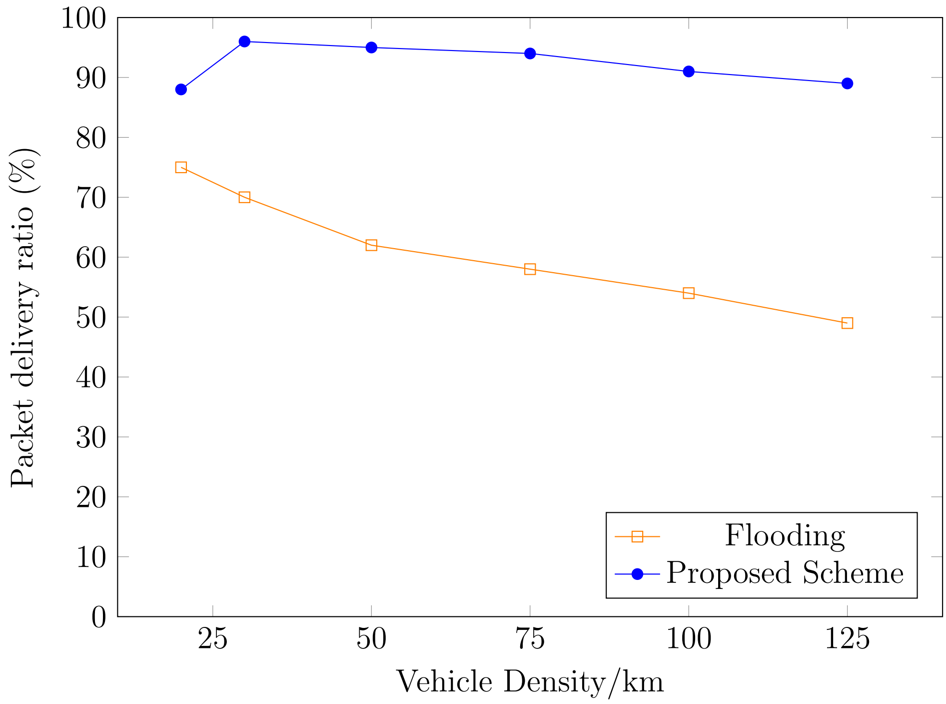

Figure 5.10: packet delivery ratio vs Vehicle density.

other vehicles on that particular route.

As the node density increases delay for emergency message in proposed technique decrease as compared to CPB. Emergency messages need to send as soon as accident happen so that other vehicles can change route in order to avoid traffic jam so in CPB delay incur due to probabilistic forwarding.

Fig. 5.17 shows the proposed scheme performance at different beacon interval rate. Average transmission delay varies at different rates against change in vehicle density as shown. Fig. 5.18 represent the behaviour of proposed protocol at different beacon intervals. performance of packet delivery ratio against node density variations.

Fig. 5.19 shows the performance of proposed scheme at different beacon interval rate. The result of packet delivery ratio against velocity.

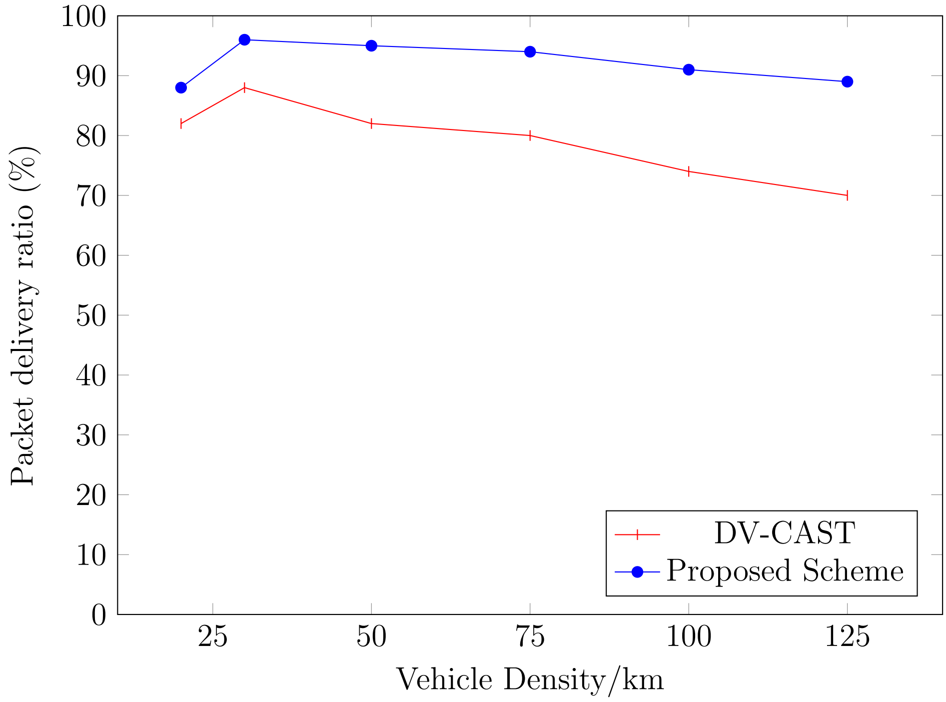

Figure 5.11: packet delivery ratio vs Vehicle density.

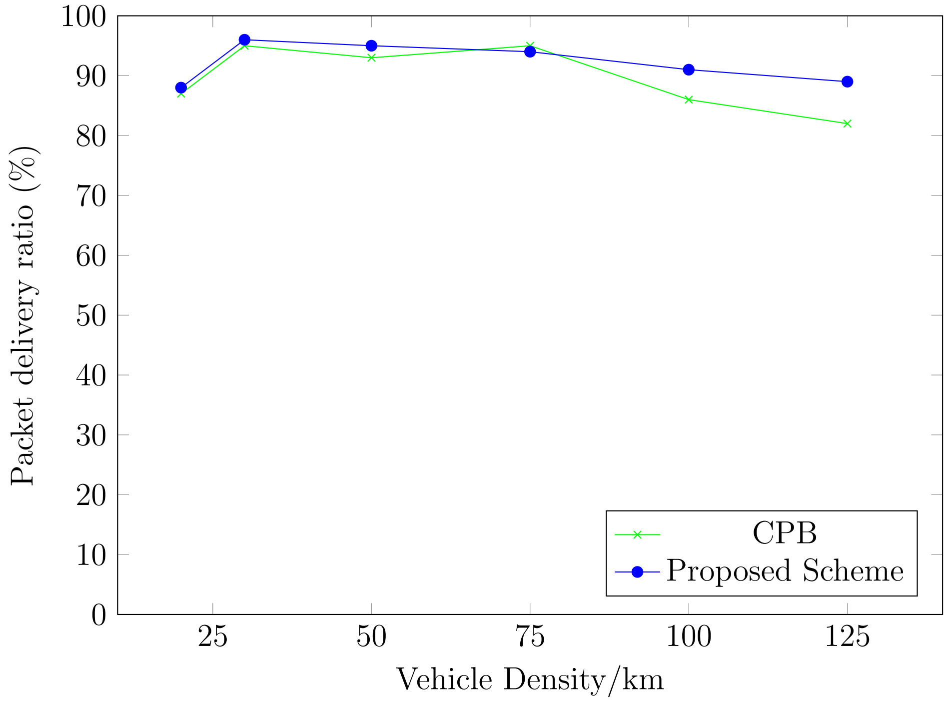

Figure 5.12: packet delivery ratio vs Vehicle density.

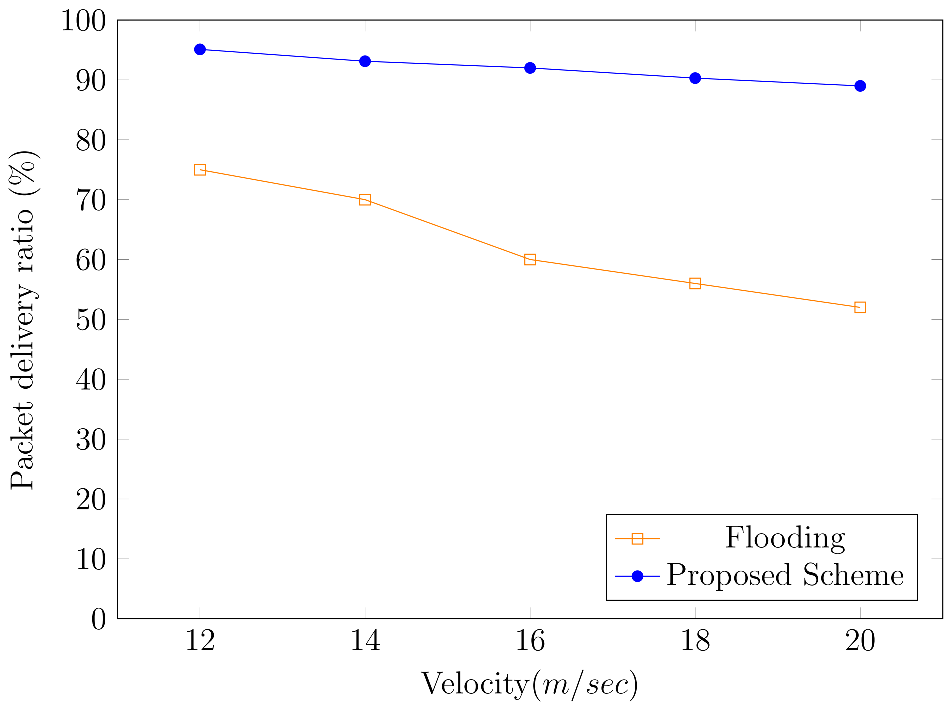

Figure 5.13: packet delivery ratio vs Velocity.

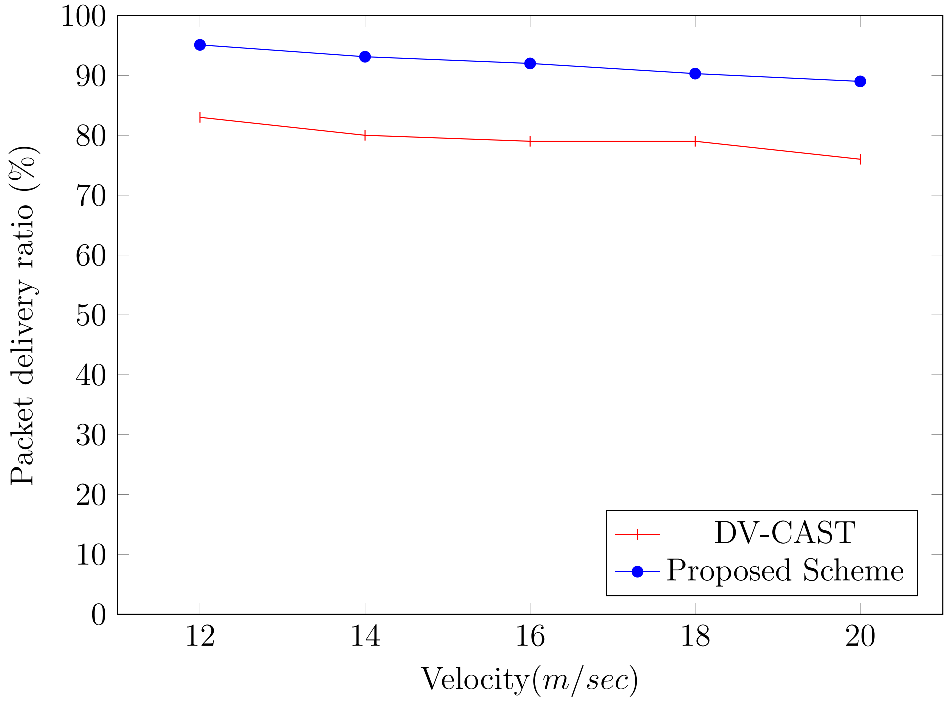

Figure 5.14: packet delivery ratio vs Velocity.

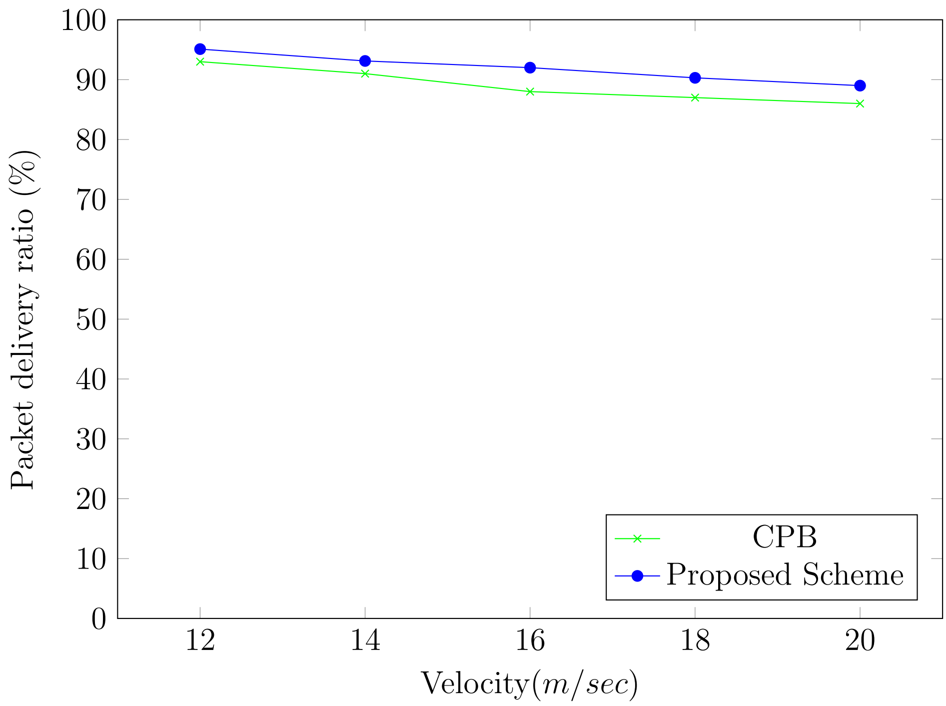

Figure 5.15: packet delivery ratio vs Velocity.

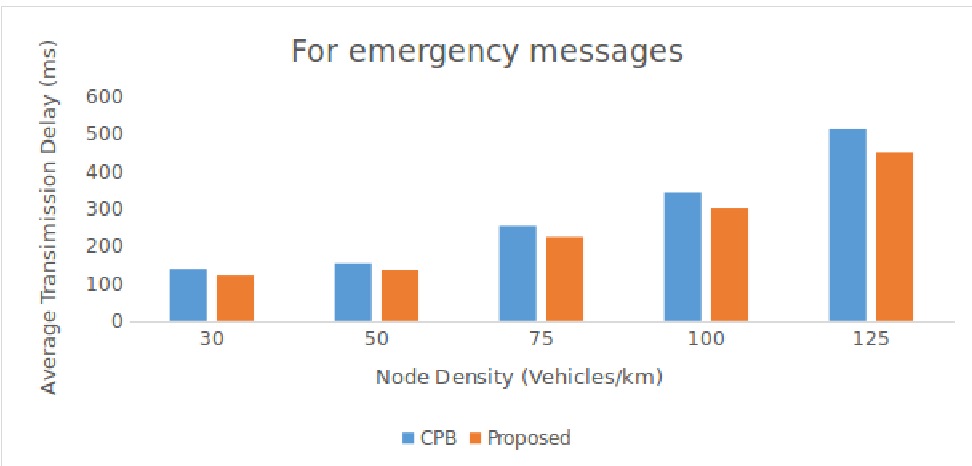

Figure 5.16: Emergency message delay vs Node density.

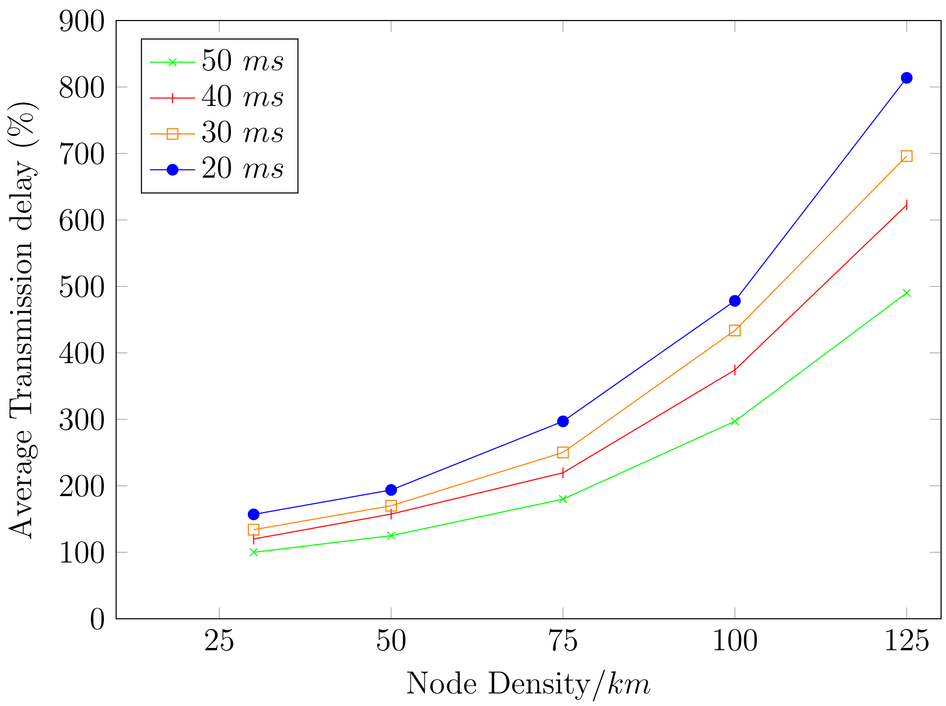

Figure 5.17: Average transmission delay Vs Node density at different beacon intervals

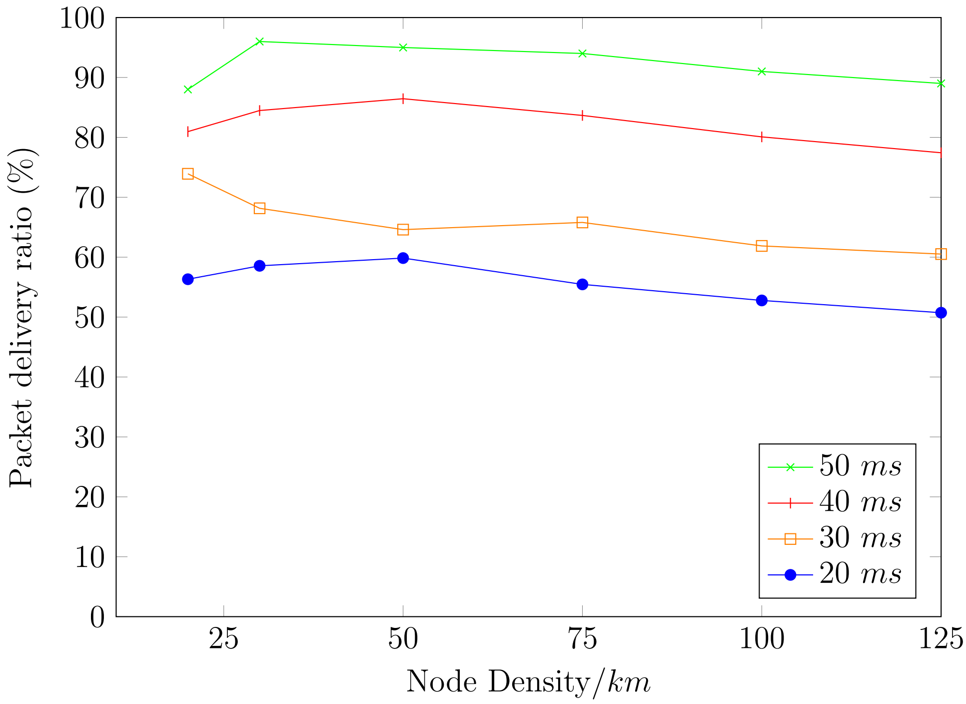

Figure 5.18: Packet delivery ratio Vs node density/km at different beacon intervals

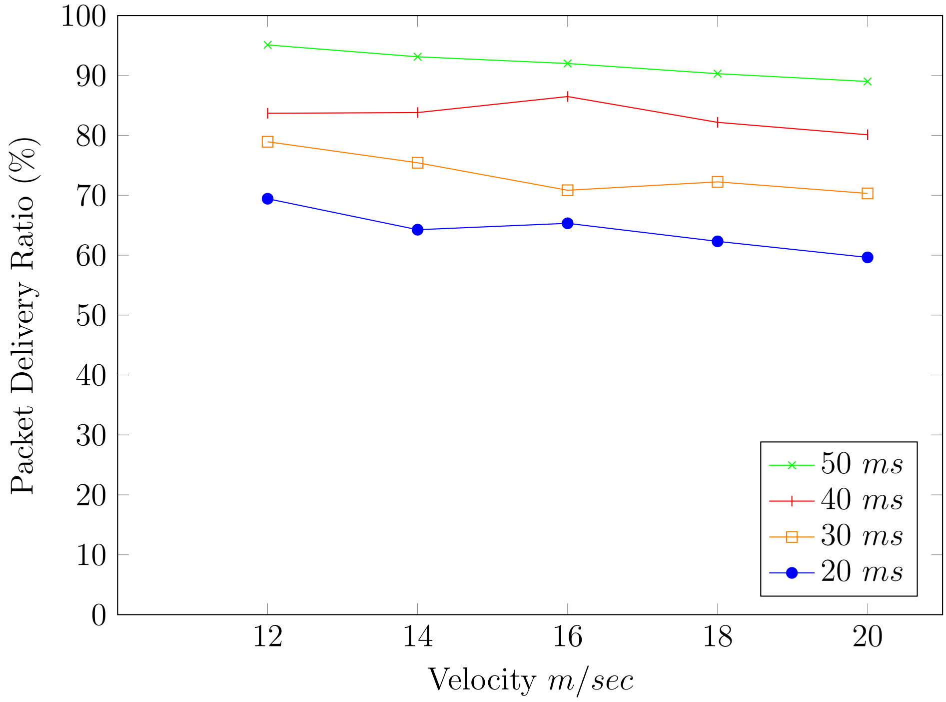

Figure 5.19: Packet delivery ratio Vs Velocity m/sec at different beacon intervals

Chapter 6

Conclusion & Future Work

Lastly, this chapter concludes the presented research work. In which, 6.1 presents the conclusion of this research work. Section 6.2 covers the future directions and some other research challenges that need to be addressed.

6.1 Conclusion

In this work we propose a novel emergency message dissemination scheme. In VANET its challenging to disseminate data due to high mobility and changing topology. So clustering is used to enhance the life time of connection and used interest compatibility for cluster head election to make cluster more stable which helps to reduce the packet loss. As emergency message need to disseminate with minimum and to large number of vehicle we use cross road communication so vehicles traveling in opposite direction spread message fast to those vehicle have same route but away from accident location. Proposed scheme shows better results for both normal and emergency data dissemination.

6.2 Future Work

Connection time need to enhance among vehicle moving opposite direction at high speed. Proposed technique works fine at low speed and high density. There is still need to improve data dissemination in sparse environment where transmission range limit the information coverage, But by using cloud or 5g services information coverage can be enhanced.

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Installation guide

Installation of OMNeT++, SUMO and VEINS

This section provides step by step installation process of OMNeT++, SUMO and VEINS to run a basic simulation in Ubuntu 16.04.

Setting up environment for Smooth installation of omnet++ 5.1.1

First of all check python version , omnet run smoothly with python2.7 instead of 3.x, type "python" in terminal to check version Ubuntu comes installed with python2.7
Secondly, install java if not installed already with this command:
sudo apt-get install openjdk-8-jdk
download omnet++ 5.1.1 archive from internet and extract it in **home/<user>/directory**
Link to download omnet++ 5.1.1

"https://www.omnetpp.org/component/jdownloads/category/32-release-older-versions?Itemid=-1"
After extracting OMNeT, enter into OMNeT directory by terminal by typing **"cd omnetpp-5.1.1"** assuming that you are already in the user directory in terminal.
type pwd and copy directory now type the following command to set paths
gedit ~/.bashrc
A file will open ,now we have to set path : (write this code with your respective directory and add /bin at the end)

export PATH=$PATH:/home/ubuntu/omnetpp-5.1.1/bin

export OMNET_DIR=/home/ubuntu/omnetpp-5.1.1
(after writing to the file , save it and close it)
after saving, type following command in terminal:

source ~/.bashrc

now type the following command to install the necessary libraries for OMNeT , without these packages **./configure** command would give error.

sudo apt-get install build-essential gcc g++ bison flex perl tcl-dev tk-dev libxml2-dev zlib1g-dev default-jre doxygen graphviz libwebkitgtk-1.0-0 qt4-qmake libqt4-dev libqt4-opengl-dev openscenegraph libopenscenegraph-dev openscenegraph-plugin-osgearth osgearth osgearth-data libosgearth-dev openmpi-bin libopenmpi-dev nemiver qt5-default

then type the following command in terminal, if everything goes well, after configuration "good" will be show after execution

./configure

then type the following command, this will take some time so be patient.

Type **"make"**

after **"make"** command is completed, type following to run OMNeT++ 5.1.1

omnetpp

After typing **"omnetpp"**, OMNeT++ will be opened.

INET Installation

after running omnetpp , install INET framework , if it doesn't show up by default then go to **"help"** menu and click on **"install simulation models"** and install INET framework after installing INET framework, run **"build all"** from **"project"** menu

Installing Sumo and its packages

after building all, download the following packages from
"http://sumo.dlr.de/wiki/Contributed/SUMOPy#Linux"
with the help of **"sudo apt-get install <package>"**
python-numpy
python-wxgtk2.8
python-opengl
python-imaging
python-matplotlib
python-mpltoolkits.basemap
as mentioned on the site above , downloading **python-wxgtk2.8** on ubuntu 16.04 may give error if so then use the following commands for installing it.

sudo add-apt-repository ppa:nilarimogard/webupd8
sudo apt-get update
sudo apt-get install python-wxgtk2.8
this will install **python-wxgtk2.8**
after this we will install **sumo** using the terminal command that is:
sudo apt-get install sumo
this will install sumo

Importing Veins and Running Example

next step is to import veins 4.6 in omnetpp project
first of all download veins 4.6 from **"http://veins.car2x.org/download/"**
and extract it to the same folder/directory where **omnetpp** is extracted
after extracting veins 4.6 , we need to import it in **omnetpp** , click on **"file"** then click **"import"**, after that select **"general"** and then **"existing projects into workspace"** and click next.
select root directory by clicking on browse button and add vein 4.6 folder and click finish.
now we need to build all project once again by clicking **project→ build all**.
after building open new terminal and drag **"sumo_launchd.py"** to the terminal,it will write the path to that file itself, then add **"-vv -c"**.
now search for **"sumo-gui"** in **"computer"** folder and drag it into the terminal ,now your command would look something like this.
"/home/sarmad/veins-veins-4.6/sumo-launchd.py' -vv -c '/usr/bin/sumo-gui"
press enter to execute the above command.
after running the above command , it will say **"Logging to /tmp/sumo-launchd.log Listening on port 9999"** now go into omnetpp and right click on **omnetpp.ini** which lies inside the **veins→examples→veins→omnetpp.ini** and **"run as"→"omnet++ simulation"** Thats it.