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Relay Node Placement to Improve VANETs Connectivity

A Thesis

Submitted to the Department of Computer Science - College of Computer Science and Information Technology, University of Anbar as a Partial Fulfillment of the Requirements for Master Degree of Science in Computer Science

By

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بسم الله الرحمن الرحيم

(آمَنَ الرَّسُولُ بِمَا أُنْزِلَ إِلَيْهِ مِنْ رَبِّهِ وَالْمُؤْمِنُونَ كُلٌّ آمَنَ
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الآية (**285-286**)

اسم الطالب: كرمل ضياء ابراهيم حميد

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Supervisor's Certification

*I certify that I read this thesis entitled "***Relay Node placement to Improve VANETs Connectivity***" that was done under my supervision at the Department of Computer Science of the University of Anbar, by the student "***Krmeal Deyaa Ibrahem***" and that in my opinion it meets the standard of a thesis for the degree of Master of Science in Computer Science.*

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Abstract

With the tremendous advancement in mobility and network technology, Vehicular ad-hoc Networks (VANETs) have attracted researchers from both academia and industry. Mobile connectivity, traffic congestion, and road safety management consider applications that were created within the network paradigm. In Intelligent Transportation Systems (ITS), the cooperation between vehicles is essential; to improve transportation security, reliability, and management However, it is a challenging task to maintain a well-connected network with unbalanced traffic flow on roads; hence, the performance of network depends on the existence of Road Side Unit (RSU) along the roads.

This thesis investigates the use of normal dynamic vehicles to works as temporary road side unit (RSU). Global Positioning System (GPS) is used to acquire node position information of the network participants. This schema basically depends on normal vehicles with a zero-infrastructure to improves network connectivity, by using each vehicle position and movement direction to decide whether its good candidate to work as relay vehicle or not. The schema providing ubiquitous communications via vehicle-to-vehicle communication. This can be obtained by establish connection between the source vehicle, which is involved in an accident and the selected relay vehicles. The performance of our schema is estimated by two scenarios, the first one is static network connectivity behavior represented by the message reachability and while the second scenario is dynamic network connectivity, we used metrics that capture the variation of the network connectivity with respect to time such as connection duration, re-healing time and receiving time.

In order to evaluate the performance of the proposed schema under different conditions various simulation scenarios have been considered by changing to number of relay vehicles and normal vehicles as well as speeds of relays.

Acknowledgments

All praises to Allah Almighty, who enabled me to complete this work successfully. I would like to express my sincere gratitude to my supervisor ***"Dr. Foad Salem"*** for the continuous support of my research, for his patience, motivation, enthusiasm, and immense knowledge. His guidance helped me in all the time of research and writing of this thesis.

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Dedication

There are a number of people without whom this thesis might not have been written, and to whom I am greatly indebted.

To my mother

A strong and gentle soul who taught me to trust Allah Almighty, believe in hard work and that so much could be done with little

To my father

For earning an honest living for us and for supporting and encouraging me to believe in my self

To My three brothers

My one and only Sister, and

To My Friends

krmeal

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ABBREVEATION

Abbreviation	Description
AP	Access point
DSRC	Dedicated short range communication
DOT	Department of transportation
FMM	Freeway mobility model
Glomosim	Global mobile simulator
GPS	Global positioning system
ITS	Intelligent transportation system
IVC	Inter vehicle communication
MAC	Media access control
MMM	Manhattan mobility model
MOBO_NET	Mobile back bone network
MANET	Mobile ad-hoc network
NS2	Network simulator version 2
OBU	On board unit
OMNET	Objective modular network testable in c++
PVA	Parked vehicle assistance
PHY	Physical layer
RSU	Road side unit
RAV	Responsible autonomous vehicle
TCL	Transaction control language
V2V	Vehicle to vehicle
VANET	Vehicular ad-hoc network
WHO	World health organization
RAV	Responsible autonomous vehicle
PCN	Postcrash notification

Chapter One:

Introduction

Chapter One

Introduction

1.1 Overview

The current development in the wireless networks result in the developing novel technology, which is referred to Vehicular Ad Hoc Networks (VANETs) it combines various network types like wireless LAN (WLAN), cellular technologies, as well as Ad Hoc networks, achieve intelligent Inter-Vehicle Communications (IVCs).The benefits of IVC includes improving traffic management, emergency alerts, road safety, as well as infotainment facilities related to passengers and drivers with increased efficiency the performance of the transportation network[1].

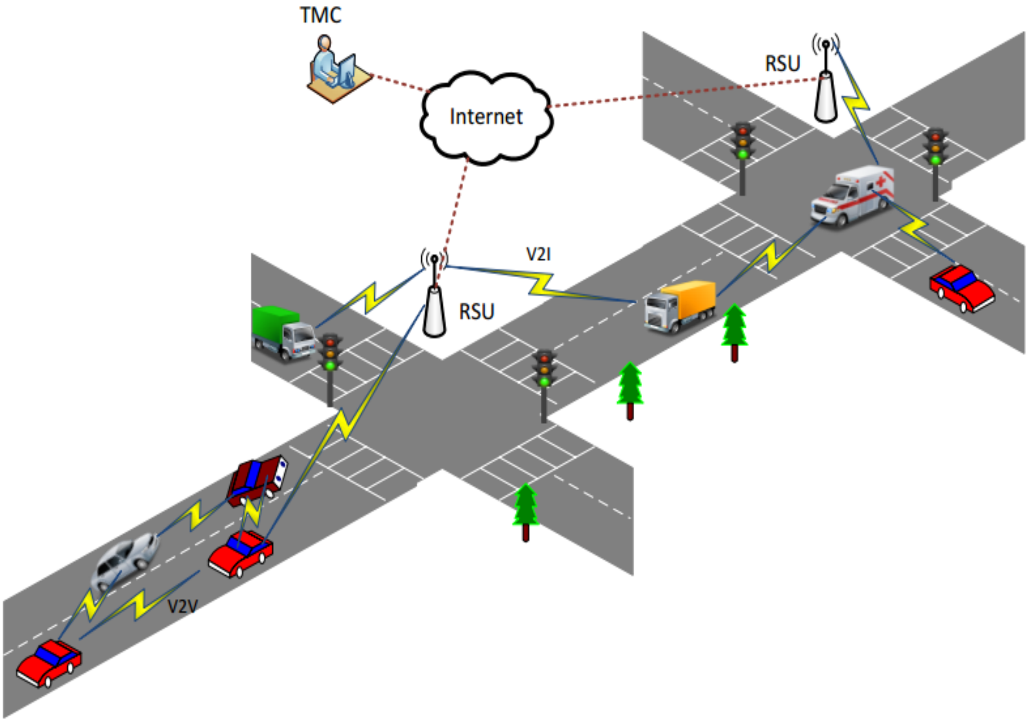


Figure (1.1) Ad-hoc Networks[1]

From 1970s to 1980s, Defense Advanced Research Projects Agency (DARPA) was focusing on developing networks with the use of packet radio for tactical communication in battlefields.

Also, modes in such ad hoc wireless networks were able for self-configuring (or reconfiguring) into networks with no help regarding infrastructures. The increasing demand of wireless communications and the needs of new wireless devices have led to worldwide research activities on autonomous, self-configuring, decentralized, and infrastructure less networks. Networks with such specifications are considered as the base of MANETs. the wireless communications (cell phones) became ubiquitous in the last ten years of 20^{th} century[2].

VANETs considered a distinct type of the MANETs where mobile nodes are specified as vehicles as shown in figure (1.1). The main dissimilarity between MANET and VANET is that VANET nodes are moving in predictable and random way at high speed in comparison to MANETs, resulting in breaking as well as sporadic creation regarding the wireless links. VANET advantages over the conventional ad hoc network is the node (vehicle) has considerable power resource. Generally, the technologies of VANET aim to improve the life safety in the roads via offering traffic information (in real-time) like emergency braking, road condition, vehicle collisions, and so on. The base related to number of applications related to VANET in addition the vehicles are exchanging periodic beacons consists of information related to road status, traffic.

Globally, the road accidents are still considered as unwanted and dangerous problem. Community Attitudes to Road Safety-2009 Survey report indicated that 90% regarding the respondents accepting that the major cause regarding accidents in the road have been “the behavior of driver”. While a less percentage of respondents indicated that “attitude of driving, ability, as well as awareness” additional factors. Dependable, correct, and timely information offered to drivers might be reducing accidents majorly[3].

1.2 Impact of connectivity on safety application

VANET can be considered as a term utilized for describing spontaneous ad hoc networks created over the vehicle that move on roadway. Furthermore, the vehicular networks becomes a high importance to deploy and develop conventional and novel applications.

VANETs have been specified for their elevated mobility, quickly changed topology, as well as one-time, ephemeral interactions. Majorly, MANETs and VANETs have been specified through self-organization and movements of nodes (vehicles in VANETs). Yet, because of the driver's behavior, as well as the high speed, the characteristics of VANETs are majorly dissimilar from MANETs. VANETs have been specified through quick, yet predictable changes in topology, common fragmentations, small effective network diameter, as well as redundancy which is functionally and temporally limited [4].

With regard to communications in VANETs, several problems must be tackled in each one of the traffic states. Clearly, connectivity can be considered optimum in jam state, yet it is very bad at light load correspond to free-flow phase where there is no possibility for transferring the messages to the other vehicles due to the disconnections. VANETs connectivity could be bad in certain roads that might be the result of sparse or even un-balanced traffics[5]. The sparse traffics indicates that a vehicle face extremely difficult to find another one, whereas un-balanced is describing a situation in which vehicles not distributed evenly in the streets because of jams, traffic lights, car-following driving or certain other causes.

Even in the case of high average vehicle density, the un-balanced traffic will be inevitable and sometimes result in disconnections. Connectivity can be considered as a high importance and impacting underlying routings as well as the total applications performance[6]. With regard to the applications of vehicular safety, the consequences regarding message delivery failure in minimum delay as well as the awareness range might lead to deadly accidents [7].

Applications like the safety messaging might be considered as near space applications, in which the vehicles which are considered in close proximity, generally of some meters, exchanging status information for the purpose of increasing the safety awareness. Also, the main goal is enhancing the safety through emergency conditions' alerting. VANETs applications are majorly directed to safety matters. Furthermore, the applications of safety are to monitor surrounding roads, curves of roads, road's surface, approaching vehicles, and so on. The applications related to road safety might be specified in [8]:

- **Real-time traffic:** these applications might be stored at RSU, also might be provided to vehicle wherever and whenever required. This is due to the high importance to solve issues like the traffic jams, avoiding the congestions in addition to the emergency like accidents.
- **Co-operative Message Transfer:** Stopped/Slow Vehicles might be cooperating and exchanging messages for helping other vehicles. Although latency and reliability might be main issues, they might be automating certain things such as emergency braking for avoiding possible accidents. Comparably, another application is the emergency electronic brake-lights.
- **Post-Crash Notifications:** Vehicles involved in accidents might be broadcasting messages related to their positions to the trailing vehicles so that they might be taking in-time decisions in addition to the highway patrols for support.
- **Road Hazard Control Notifications:** A car notify another cars regarding landslides in roads or information related to road feature notifications because of sudden downhills, curves in road, and so on.
- **Cooperative Collision Warnings:** These are alerts regarding two drivers possibly under crash route for the purpose of that they might be mending their way [9].
- **Traffic Vigilances:** Cameras might be connected vie RSU, which might be working as inputs and acting as current tool in the zero or low tolerance campaign against the driving offense[8].

Each one of the safety applications are requiring certain message exchanges between the vehicles. Such massages have been specified into two categories such as beacon and alarm and have various dissemination policies as well as roles in the safety improvements.

Also, the alarm messages are provided through the vehicles for informing the others regarding already occurred events in certain road points such as icy surfaces, car crashes, and so on. While vehicles issuing certain periodic beacon messages and each one of the vehicles sending normal status such as acceleration, position, as well as speed, to neighbors beacon messages have been utilized for inhibiting potential (not already occurred) events such as wrong right/left turnings, forward collisions, lane changing, and so on. It must be indicated that the above-mentioned messages have been corresponding to each other.

Whereas the alarm messages might be having the ability for notifying drivers for already occurred events for the purpose of preventing additional incidents, beacon messages might be preventing from the incidents prior to their occurrence [10].

1.3 Related works

J. Lee et al, in 2010 developed and measured the performances related to roadside unit placements systems, the aim of this paper is to enhance connectivity as well as decreasing disconnection intervals with regard to certain number of the roadside units and transmission ranges. They starts placement approach with initial selections, which each one of the intersections has been candidate. For each circle surrounding the candidate position with the radius equal to the transmission range, the number of vehicle reports inside the circle is counted. the result shows about 72.5 % of connectivity can be achieved when the number of RSU is 1,000 and the transmission range is 300 m, Each 100 m increase of transmission range can improve the connectivity by about 17% [11].

N. Liu et al, in 2011 introduced an idea related to Parked Vehicle Assistances (PVAs), which enable parked vehicle in joining the VANETs as static nodes they investigate network connectivity in PVA through theoretic analysis and realistic survey and simulations. The results proved that even a small proportion of PVA vehicles could overcome sparse or unbalanced traffic, and promote network connectivity greatly [6].

S. Sou et al, in 2011 in this study the authors estimated and quantified the enhancements in the connectivity of VANETs in the case when a few (RSUs) were utilized and for examining routing performances with regard to the broadcast-based safety application in such improved VANET environments. Results show that، even with a small number of RSUs, the performance in terms of the probability of network connectivity, the re-healing delay, the number of re-healing hops, and the message penetration time can be significantly improved [12].

Y. Liang et al, in 2012 proposed a new optimization framework for Roadside Unit (RSU) deployment and configuration. The objective function is to minimize the total cost to deploy and maintain the network of RSU's. the framework also supports the option of specifying selected regions of higher importance such as locations of frequently occurring accidents and incorporating constraints requiring stricter coverage in those areas, results shows that optimization over an area with the size of Cambridge، Massachusetts is completed in under 2 minutes[13].

W. Viriyasitavat et al, in 2012 suggested solutions which can be migrating bad effect of gradual and partial penetrations problem regarding the DSRC technologies. The suggested solution was on the basis of self-organizing network paradigms which draw the inspirations from the biological systems, like the social insect colonies through developing local rules as well as distributed algorithm required for performing such function, it has been indicated that the cars equipped with DSRC might be serving as RSUs[14].

N. Liu et al, in 2013 presented a new RSUs deployment strategy for the VANET's content downloading. Encounters between RSU and vehicles were modeled as time continuous homogeneous Markov chain. Also the deployment algorithm of RSU has been developed on the basis of the algorithm of depth-first traversal with regard to the graph's edges. The results of simulations showing that the suggested deployment algorithm of RSU might be satisfying file downloading service necessities with minimum deployment costs of RSU [15].

J. Barrachina et al, in 2013 suggested Density-based Road Side Unit deployment policy (D-RSU), particularly developed for obtaining effective system with minimum costs for alerting the emergency services when accidents occur. Their method has been on the basis of using RSUs with inverse proportions to vehicle's expected density. The results are showing that D-RSU has the ability for reducing needed number regarding RSUs, in addition to the notifications time for the accidents [16].

C. Sommer et al, in 2014 presented an interesting paper that combined between simulation and experiment in real life to extend the connectivity through using the parked vehicle, and this is done by covering the disconnectivity network problem. The paper assure that the cooperative awareness increased by 40% by using parked vehicles as a relayer [17].

A. Reis et al, in 2015 introduced a methods for parked cars to self-organize and act as a support network to the existing urban vehicular network. Such method enabling the parked cars in creating coverage maps on the basis of received signal strength, also making significant decisions, like in the case when parked cars serving as RSUs. The result shows that even a small number of parked cars can bring considerable improvements to the network, and that our proposed methods for self-organization create support networks of parked cars that can cover the urban area with an optimal numbers of vehicles[18].

D. Ou et al, in 2016 proposed a connectivity-oriented maximum coverage RSU deployment scheme (CMCS). The proposed scheme aims to maximize V2I communication performance in urban areas. The results show that the CMCS is able to cover the majority of vehicles on the roads and increase communication performance with fewer RSUs [19].

M. Fogue et al, in 2018 presented genetic algorithm for roadside unit deployment that applies the genetic algorithm as the ability of automatically offering RSU deployments adequate for certain road map layouts. The study's results of simulation showed that GARSUD has showed the ability of reducing warning notification time (which is considered as the time needed for informing emergency powers that be regarding the dangerous situations of traffic) as well as for improving vehicular communication abilities in various density cases as well as complexity layouts[20].

1.4 Problem statement

VANET composed of mobile nodes essentially suffering from intermittent connections and high delays. By adding supporting infrastructure, connectivity can be improved, including base stations, RSUs, but the cost-performance trade-offs of different designs is poorly understood.

Recently, various methods, schema and algorithms for RSU deployment have been suggested to improve VANET connectivity. But there are several difficulties to determine advantages of using RSU. Because of innovative nature related to the technology of DSRC, general adoptions through market has required so that entire advantages related to technology might be achieved.

1.5 Thesis objective

The aim of this study is to enhance the VANET connectivity in urban environment. To achieve this goal, many factors should be established. VANET without RSU in the road means new challenge appears and to take in to account to achieve this target. This work will consider the urban environment. Relay vehicle as a replacement for RSU connect with source vehicle involved in hazard situation to rebroadcast the safety message in order to expand the informed area and give a strong and reliable connectivity to discover dangerous condition and make decision in time. Four relay nodes were selected to cover the source surrounding environment to achieve better connectivity.

1.6 Thesis contribution

The obstruction in the plans to deploy the RSU on the roads in the urban environment has led to using vehicles as temporary RSU to increase the network connectivity, the dynamic vehicle is the suitable solution to increase connectivity and decrease the additional cost resulting from RSU deployment. The contributions of this thesis are:

1. Using normal moving vehicle as temporary RSU for improve network connectivity and the selection of these vehicles depends on vehicle location, speed and movement direction.
2. Improving network connectivity through increasing the number of vehicles that work as temporary RSU to cover source surrounding area to establish better network connectivity. This approach can be obtained by connecting the source vehicle with relay vehicle when the relay entered in-to the transmission coverage of source

1.7 Thesis outline

The content of this thesis is divided into five chapters:

- ✓ **Chapter Two**: Presents background of VANET network, motivation, Increase VANETs Connectivity Methods, funding problem, vehicles as temporary RSUs, urban and highway environment, VANET mobility model, network simulator (NS-2).
- ✓ **Chapter Three**: Introduces a complete description of the proposed system design in terms of the case study, methodology and algorithm with the tool used
- ✓ **Chapter Four**: Introduces results and evaluation of the proposed system design and the dissection of the obtained results.
- ✓ **Chapter Five**: Gives the thesis conclusions and future work.

Chapter Two:

Theoretical Background

Chapter Two

Theoretical background

2.1 Introduction

Intelligent Vehicular Ad-hoc Networks Vehicles that form Mobile Ad-hoc Network for communication using WiMax IEEE 802.16 and WiFi 802.11. The main aim of designing In VANET's is to avoid vehicle collision so as to keep passengers as safe as possible. This also helps drivers to keep secure distance between the vehicles as well as assisting them at how much speed other vehicles are approaching[21]

VANETs enables the drivers communicating with each other in the range of radio communications. However vehicles are getting out the range, they will be communicating via multi hop networking. In comparison to the mobile vehicles, VANETs are having benefits in no service change, reduced latency, as well as broad coverage. A lot of applications were created in relation to smart cars, for easy environment for the drivers and precise automatic control. Such applications have been majorly based on information exchange, that ensure communications between vehicles[22].

Recently, there are a lot of significant VANET applications. For instance a number of applications are ranging from the dangerous medical services to the comfort activities. VANETs must have the ability for fulfilling all requirements of the constantly changing requirements of users and must be complying with architectures and standards of available technologies [23]. The main aim of using VANETs have been reducing accidents level. This is because the high impact on the safety of passengers and for driving smoothly via drivers in urban area. With the increase in vehicles population, there will be also increase in accidents rate, thus there is necessity for communications between vehicles.

On the basis of statement via World Health Organization (WHO), statistics of Road Traffic Injuries in all nations showing that after the year 2000, road accidents are the main death cause. Thus, there should be more effective traffic systems for the purpose of solving such issue [24] .

With regard to the VANET environment, each vehicle has its structure in device which is called On Board Unit (OBU) /Radio interface. It facilitates their communicating with the other vehicles and RSUs and also enabling short-range wireless ad hoc networks which receives security messages such as unexpected break warning from other vehicles, essential emergency alerts. and non- security message such as comforts & amusement related information [25].

In general, OBUs helps the vehicle to be warned with critical situations, such as accidents, traffic jams, and predicting the movements of the nearby vehicles through the dissemination of traffic associated messages with certain information regarding its current time, speed, deceleration/acceleration, direction, as well as position.

2.2 VANET Characteristics

There are a few comparisons between MANETs and VANETs such as a low and variable bandwidth, infrastructure-less, short range connectivity, and self-organizations, VANETs are characterized by number of characteristics such as highly dynamic topology and reliable channels by which to distinguish them from MANETs. Moreover, most of the MANETs routing protocols cannot be applied in VANETs, as they suffer from poor performance due to high mobility of vehicles VANETs have unique and significant properties impacting designing transportation systems as well as its protocol security. Such properties are specified in the following way [1].

- **Highly Dynamic Topology:** VANET has a highly dynamic environment because of random movement and high speed of vehicles. The topology frequently changes as the links which are between nodes to connect or disconnect, in addition duration time remaining for data packets' exchange was small. Each vehicle might be directly communicating with other in the case when they are having line of sight to each other in radio range. Generally, vehicles' radio domain is approximately 300m.

- **Large number of nodes:** Generally, VANETs considered a technical basis with regard to the envisioned ITS. Thus, it has anticipated that most of vehicles are being equipped with communications abilities like GPS with regard to the vehicular communications in addition to the fixed road-side infrastructure units.

- **Frequent disconnection:** In VANETs, the highly dynamic topology leading to the occurrence of common disconnections between two vehicles in the case of information exchange. Such disconnections commonly happen in highways because of the low density of vehicles. In city scenarios, huge buildings and trees often weaken the network signals, which may lead to a breakdown in communication between vehicles. Vehicles will have the highest probability of changing their directions in urban roads.

- **Huge storage and computational power:** Smart vehicles consist of electronic chips with enough power and storage capacity, so they can store routing information, drivers and vehicles identity confirmation and other information. Vehicles itself providing continuous energy for communication and computing services.

- **Interaction with onboard sensors:** Vehicles can use the onboard sensors like GPS device to provide the information like their location, direction, moving speed of nodes, and other vehicle related information. Such information could be utilized for efficient routing and communication decisions.

- **Communication Environment:** VANETs are divided into two types of environment sparse network (like highways) and dense network (like urban areas) according to the difference of traffic densities. In dense network, there are many objects such as building, trees & other objects that act as obstacles. These obstacles may reduce signal bandwidth and data transfer speed among vehicles and RSUs. In sparse network, all these obstacles are less prone and impact the connection between vehicles.

- **Restricted and Predictable Mobility Patterns:** Dissimilar to MANET's random mobility, the mobility model of VANETs is to maintain connectivity through restricted rules like road maps, speed, traffic flow, and so on, that will be making them predictable as a minimum on short run.

- **Hard Delay Constraints:** a number of VANETs safety applications, emergency messages might be provided with elevated priority and should be delivered to the related nodes (e.g. disasters, accidents) on time. These applications are having elevated requirements with reliability as well as real time. Therefore, end-to-end delay related to single second might be negatively impacting the significance regarding emergency information meaningless.

- **Network connectivity:** In VANETs, we can measure the degree of network connectivity which depends largely on two important factors: wireless links' range as well as portion of nodes. Thus, just a few of nodes on road might be equipped with the wireless interfaces.

2.3 VANET motivation

Everyday around the world, more than 3000 people were killed because of road traffic accidents. Low-income and middle-income countries include about 85% of the deaths and 90% of the annual disability adjusted life years (DALYs) lost because of road traffic accident. Reports show that between 2000 and 2020, deaths from road traffic will decrease by about 30% in high-income countries but increase basically in low-income and middle-income countries. Without convenient action, by 2020, road traffic accident are predicted to be the third leading contributor to the global burden of disease and injury[2].

Generally, drivers are having inadequate information related to the conditions of roads, locations, and speeds of vehicles around them. They are also urged for making certain decisions such as lane changing and breaking with no awareness regarding the nearby environment areas. Communications between the vehicles or between the vehicles as well as the roadside infrastructure might be updating this information rapidly and improving the safety of traffic. For instance, if a vehicle identifies accidents in advance, it is going to be broadcasting warning messages to surrounding vehicles. Furthermore, the vehicles behind them are therefore warned prior to entering accident zone, also it is going to be helping drivers for acting in fast way and choosing alternative routes as well as avoiding traffic congestions [22].

2.4 VANET communication

In the case when vehicles are having the ability of directly communicating with each other as well as with the infrastructure, totally novel paradigm with regard to safety applications of vehicles could be formed. Furthermore, the non-safety applications might be massively enhancing vehicle as well as road effectiveness. There are a lot of issues which might be generate through high speeds of vehicles and high dynamic operating environments.

A number of novel necessities, require novel safety-of-life applications, including novel expectations with regard to the high packet delivery rates as well as the low packet latency. The issue of latency has high importance to the warning messages. Also, there certain other necessities like governmental oversight and customer's acceptance might be providing extremely elevated expectation regarding security and privacy. Communications in the VANET might be achieved directly between the vehicles as one-hop communications, or the vehicles might be retransmitting the messages, thus allowing communication type referred to as multihop communications, which are increasing coverage, robustness of communications, as well as relays at roadside might be also utilized. The roadside infrastructure might be utilized as gateway to internet and, therefore, the context information and data might be obtained, stored, as well as processed [27].

Quick developments in the wireless communication network was made (IVC) as well as (V2I) for composing VANETs. Also, IVC achieve communications between at least two vehicles, while V2I involve information transfer between vehicle as well as fixed entity. Furthermore, the V2I effort has been typically focusing on management services and traffic monitoring. Furthermore, there are other services to establish mobile voice communication links, to enable satellite broadcasts, as well as to support large-scale data downloading that are explored [28].

Cooperative assistance systems are utilized to improving the safety of vehicles through communicating time-critical information to the surrounding vehicles in certain environments, like urban intersections with no traffic signals as well as highway on-ramps. Whereas certain notifications might be informational such as passing assistance and security distance warnings, in the case when used with intelligent vehicle controls, such applications might be actively engaging drivers and vehicles; for instance, through using the emergency braking [2].

Warning functions and information are having the capability of transmitting traffic, vehicles, and roads conditions with vehicles. Beyond safety aspect related to these communications, such category includes applications for improving passenger's entertainment or comfort, like video and live chats, or to enable the online games. Such applications were generally of few stringent latency or delivery requirements, yet they have been typically needing considerably high bandwidth.

2.4.1 Vehicle to Vehicle communication

The Intelligent Transportation System (ITS) can help drivers on the road to react in a hazard situation. ITS provides a solution to alleviate traffic congestion and improves public safety objectives such as collision avoidance. The allocation of 75MHz in the 5.2GHz band for licensed dedicated short range communication (DSRC) delivers high media contents to (V2V) communications [29].

V2V communication avoid costly RSU installations and take advantage of the VANET for the delivery of traffic information, but it should carefully control the additional transmission overhead caused from multi-hop communications by improving bandwidth usage and by possibly involving the lowest number of hops [30]. As shown in figure (2.1) By the V2V communication, the vehicle's driver can receive a warning message from another vehicle when there is any hazard situation or risk of accident portability in the surrounding region to take emergency braking or any reaction to prevent and avoid the accident [31].

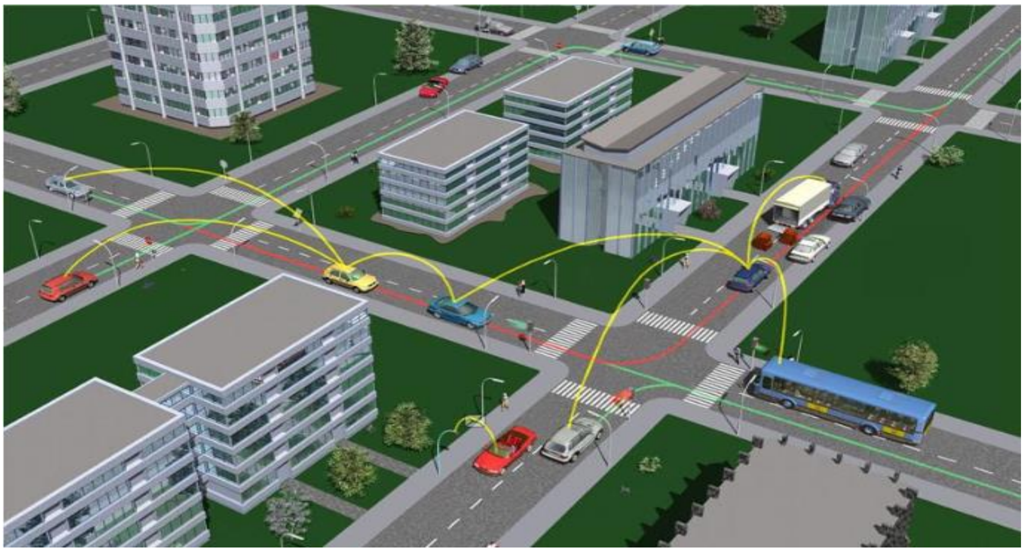


Figure (2.1): Vehicle-to-vehicle communication[32]

Benefits of V2V communication model

There is less costs of installation with removing RSU: The main benefit of such communication models has been reduced installation costs as RSU has been replaced through the On Board Unit (OBU).

Network failure might be decreased: as communications were conducted between vehicles, vehicle's failure will not get result in whole failure of network. In the case when a vehicle getting failure, the procedure regarding that specific vehicle might be conducted through another one.

Effective process of routing could be specified: Since each one of the vehicles in such communication models are acting as router and the effective as well as shortest routes could be selected for delivering data to destination. Effective routing protocols for determining route discovery might be modelled on the basis of nodes' behavior [33].

2.5 Increase VANETs Connectivity Methods

VANETs related to the intelligent transportation systems have used for improving transportation security, management, as well as reliability. The behavior of network might be entirely distinctive in the topological aspects due to vehicular nodes' mobility. Topology might be totally connected in the case when vehicles' flow has been elevated and might be having reduced connectivity or invalid in the case when vehicles' flow has been un-balanced or low [34].

Vehicular network connectivity might be examined from two points of view. The first perspective: instantaneous network topology emerge from the connected multi-hop communications: the data packets have relayed via at least one vehicle which are creating multi-hop paths between destination and source, also all the links related to connected paths existing at transfer time. The second perspective: time-expanded network topology which is characterizing the carry-and-forward communications: the data packets have been relayed via at least one vehicle which is storing and carrying data, and deliver them to destination or to other relay used for meeting the recipients more readily[35].

The vehicles connectivity is a high importance, impacting the forwarding of packets and application performances[36]. non-stop changing in the connectivity because of elevated mobility regarding vehicles, resulting in quick changes in the topology of network[37]. V2V communications has regularly challenging because of elevated vehicles mobility that is not allowing stable connections between them, whereas V2I regularly lead to high installation costs as well as maintenance.

RSUs have specified as backbone regarding the V2I messages as well as connected for providing connectivity to vehicles. It is indicated that the costs regarding single infrastructure unit with regard to the V2I communications might be about $50K USD, that make it difficult to scale for the purpose of covering all roads in geographical area [38].

2.5.1 Autonomous vehicles

Vehicles using sensors as well as real time information, such information might be examined with approaches of machine learning that are routing and controlling vehicles with no intervention from humans. This majorly developed for safety and convenience. A lot of car's manufacturers were focusing on the autonomous vehicles, for instance, BMW start testing in the year 2005[39].

The autonomous vehicles were controlled with the aim to plan vehicles route for minimizing the duration of trips. In such method regarding Responsible Autonomous Vehicles (RAV), it is modified such aim for improving VANETs connectivity. This is going to indicate that autonomous vehicles are going to be modifying routes and speeds from source to the destination which might enhance the total network connectivity[37]. Such method might be improving the VANETs connectivity issue through controlling the autonomous vehicle for bridging gaps between the non-autonomous vehicles as well as creating RAV[40].

Typically, the non-autonomous vehicles are travelling in platoons, therefore, there are gaps between such vehicles. Even through that a lot of routing as well as MAC protocols were provided in past researches which entirely depend on communications in platoon, in RAV, the major aim is to connect such platoons via autonomous vehicles. This might be shown in the Figure (2.2).

Autonomous vehicles might be converting different vehicles platoons into single platoon, therefore improving the connectivity of VANET. This will be introducing an issue regarding the routes that must be autonomous vehicles follow for finding gaps which provide bridges as major add connectivity to overall VANETs.

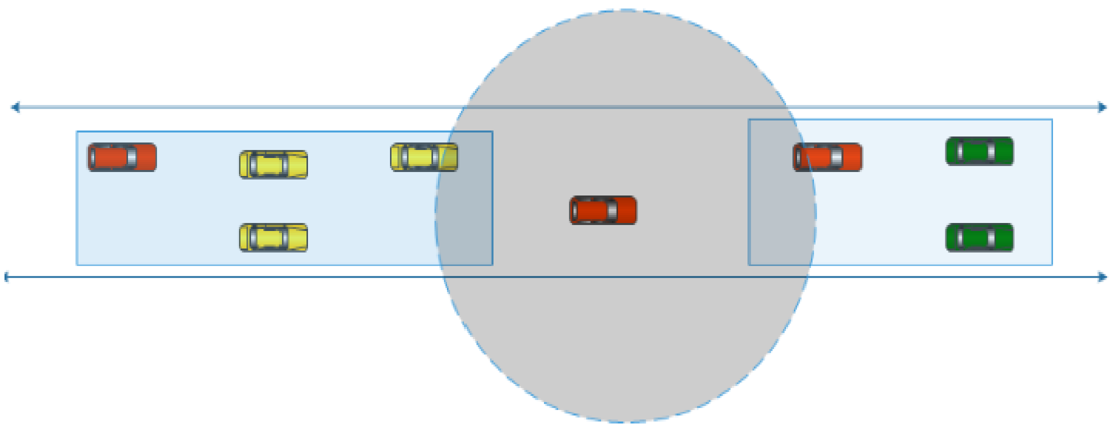


Figure (2.2): Using autonomous vehicle for bridging the gabs between vehicles[41]

In the case when vehicle start the trip with certain destinations, it will be starting with its route through estimating shortest path to destination. Vehicles traversing such route until reaching intersections, it will be having a few options (streets) for selecting from. With regard to RAV, vehicles are making decisions related to the streets which must be selected through game theoretic algorithm for computing utility matrix with regard to all the optional routes, after that picking routes with maximum utility. Due to the fact that other vehicles are nearing same intersections accompanying vehicles, such vehicles might be cooperating with each other. Such cooperation is of high importance for preventing vehicles from taking several routes in simultaneous way as well as wasting the connectivity range of vehicle which might be contributing to overall network connectivity [37].

2.5.2 Automobiles

Automobiles have considered as major utilized means to transport millions of individuals globally. Because of their extensive usage, there is a need to establish communications among them, with the aim to provide entertainment and safety for occupants. The solution has the ability to provide such communications by creating VANETs[42]. The suggested network of communication was focusing on building related to living mobile backbone, totally ad hoc, on the basis of metropolitan buses (MOB-NET), for the purpose of providing infrastructure as well as raising network's connectivity. The main aim of MOB-NET is to provide connectivity over 99% of the time, ensuring end-to-end message deliveries among the majority of applications. The connectivity of network has major quantity, also evaluated through certain aspects such as quantity regarding vehicles which have been circulating in specific environments, circulation's schedule, the way the vehicles have been distributing in lanes, as well as the range related to radio frequency signals. MOB-NET function has been for providing connectivity as well as favoring message exchanges among vehicles in wide regions[43]

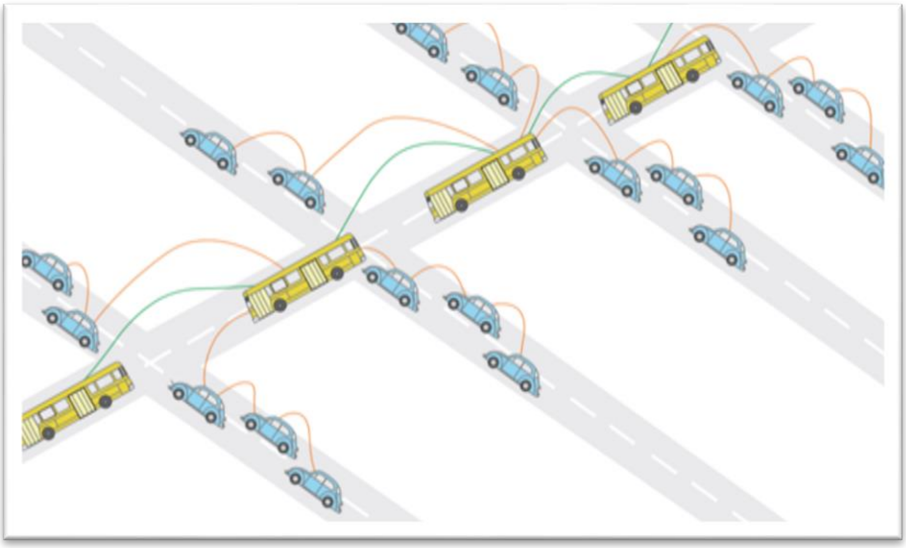


Figure (2.3): Connecting vehicles through automobiles[43]

Buses as shown in figure (2.3) considered to be in a constant movement via all extensions related to express lanes, through such approach being independent and alive of the fixed infrastructure. Such network, along with enabling information exchanges among buses, aim for information exchanges among the vehicles which are separated by a lot of kilometers.

2.5.3 Roadside unit (RSU)

The vehicular networks are using (RSUs) for enhancing communication abilities related to vehicles for the purpose of forwarding the control messages or/and for providing the vehicles with internet access, passengers and drivers [20].

There are a number of VANETs infrastructures recently used that impede VANET's development. The way of deploying VANET infrastructures with low costs for satisfying applications needed network quality of service has a high importance for tackling more developments regarding VANETs. Due to the fact that vehicles are moving in fast way, connection between the RSUs and vehicles are suffering frequent disconnections as well as short periods. Therefore, mobile vehicle might be hardly downloading entire media file from single RSUs. This, VANETs files have been often downloaded with the use of file fragmentations. In the case when mobile vehicles encountering RSUs, it will download piece regarding the needed file, till all pieces related to needed file will be downloaded

RSUs utilized to increase overall coverage related to vehicular network. RSUs are equipped with excellent hardware as shown in figure (2.4) and reduced costs and power constraints in comparison to units utilized in vehicles, they have anticipated for enhancing the performance of network and improving the messages' propagation distance.

Figure (2.4): The Road side unit[44]

RSU network serves as backbone, which allows other WANs or Internet even though that the existence regarding such units might be considerably enhancing communication performances, costs related to using as well as supporting the RSU in the vehicular environments could be extremely high [45]. Based on a study in the U.S. Department of Transportation in the year 2011[46], simplistic RSU is requiring 13,000$ to 15,000$ for each unit capital costs as well as 2400$ for each unit each hear for maintenance and operation.

With the participation of RSU to VANETs, messages could be disseminated in dependent approach with small transmission delay [47]. Automatically, there is desire for installing RSU at places with the high traffic flows.

The deployment scheme of RSUs has been complicated when considering RSU transmission range, installation costs, as well as the ITS Equipment Capability and Compatibility [48].

2.6 RSU Drawbacks

There are several difficulties to determine advantages of using RSU. Because of innovative nature related to the technology of DSRC, general adoptions through market has required so that entire advantages related to technology might be achieved. Also, it must be indicated that these economic justifications are extra difficult in the case when certain roadside infrastructures to display the traffic information like Dynamic Message Sign (DMS) [41]. The continuous cooperation and the coalitions regarding public (city authority, federal agencies, and so on), also private (manufacturers of cars and certain other companies) sectors have been required. Like indicated till recently, such cooperation was unconsummated [49].

Suitable financial investments are considered the main issues in general deployments regarding the roadside infrastructures since investments billions of dollars are needed to install 200*;* 000 – 250*;* 000 RSUs [25]. A lot of RSUs have been required and costly: Communication ranges regarding the DSRC has been restricted to 100-300m that indicate a lot of RSU have been required for establishing comfortable communication in nodes. To implement more RSUs have been very costly. Link disconnections: which is other disadvantage regarding RSU communication models has been the link’s disconnections among nodes. All nodes must be connected with DSRC signal for disseminating messages efficiently among nodes. Due to the fact of mobility patterns related to VANETs nodes have been elevated, nodes are going to be often disconnected from DSRC signal range.

RSU Failure: Message transmissions in nodes has been potential just via RSUs. A case must be considered, in the case when anyone of RSU getting failure whole network is going to be collapsed. All nodes under specific RSUs won’t be under coverages, also such nodes will not get information like warning alert messages, emerging messages from other nodes.

RSUs are going to be slowing down with the multiple service request. With regard to such communication architectures, RSUs acts as servers in the responding back to nodes. Regarding the high density of network topologies, a single RSU receives multiple requests from nodes simultaneously. With regard to such condition, working process that is related to RSU will not be slowing down that is going to degrade communication performances in nodes. With simultaneous multiple requests, RSUs won't be having the ability for responding back to all nodes as well as service requests might be dropped.

Communications are likely via RSUs. Nodes initiate communications with the other nodes via RSU, which will be routing messages to other nodes, also it might be indicated that no two nodes might be directly communicating. All communications might be conducted just via RSUs that might be taking more time for delivering messages among nodes. Therefore, from above-mentioned indications, it might be specified that the communication architecture of RSU has a lot of disadvantages. Efficient communication models might be required for overcoming the disadvantages in RSU communication architectures. Therefore, studies attempting on finding other dependable communication models for VANETs [33].

2.7 Funding Problem

VANETs were created for a lot of applications, like entertainment, transport efficiency, traffic safety warnings, as well as information [50]. Based on certain report, specified Vehicle-to- Infrastructure (V2I) safety applications might be addressing about 2.3 million crashes, which correspond to $202 billion in the costs; the systems of V2I might be addressing 25% regarding all the light-vehicle crashes as well as 14% regarding all the heavy-vehicle crashes[51]. RSUs enabling the drivers not just being informed about surrounding real-time traffic conditions, yet for accessing infotainment services or internet in vehicles [52],[53].

U.S. Department of Transportation (DoT) expected a general deployment regarding RSUs supporting infrastructures with regard to vehicular networks to be occurred in 2008[54].

Such anticipation was not seen by the light due to problems in justifying RSU advantages, no cooperation between private as well as public sectors, yet majorly, no funding with regard to infrastructure that the widespread deployments have estimated for costing billions of dollars[55]. Industry survey in 2012 through Michigan's DoT as well as Center for Automotive Research reiterated that "a major challenge seen by respondents to broad adoptions regarding connected vehicle technologies has been funding with regard to the roadside infrastructures" [56]. The cost to add various types related to infrastructure has been very variable. For instance, install wired base stations which have been connected to Internet might be lowering delays; yet they are requiring expensive power installations as well as wired network connectivity such costs might be 5,000$ for each one of the base stations[57].

Even though that the opportunistic usage regarding open base stations has been free, the finding volunteers permitting access presenting management costs, also might not be providing enough reliability. Furthermore, their usage might be legally difficult.

2.8 Vehicles as Temporary RSUs

2.8.1 Parked vehicles

The vehicular networks require less number of cars being functional and connected. This might not happen because of insufficient radio equipped vehicles or few number of vehicles on road [45]. An approach for avoiding the expenses related to infrastructure deployment has been using vehicles as RSUs [47], also in urban areas cars which have been packed might be leveraged for serving as RSUs[55]. The major idea behind PVA, that allow parked vehicles joining VANETs as static nodes. With the wireless devices as well as rechargeable batteries, parked vehicles might be simply communicating with each other in addition to the counterparts.

Because of the extreme parking in the cities, the parked vehicles have been natural roadside nodes which are specified through specific locations, long-time staying, large numbers, as well as wide distributions. Therefore, the parked vehicles might be serving as static backbone as well as service infrastructures for improving connectivity [6].

With the cars movement, the buildings as well as the obstructions entering and leaving line of sight between them, resulting in detrimental fading as well as shadowing impacts on communication channels. The nodes will be moving far away from each other, also the channel will be disappeared. Parked cars in urban areas were fixed, recognized positions with regard to extended time period and thus, additionally stable communication channels with surrounding RSUs and cars has been likely. The fixed locations has been of high importance to the applications depending on the geo-casting (messages' broadcasting to certain geographic areas), which will make it easy for routing these messages to intended locations[54].

Therefore, there will be an indication that using parked cars might be of high importance to support message exchanges at all times, the majority of cars are considered as parking; of these, the majority are considered as parking on the streets. Such concepts has been supported through recently provided study on utilizing the parked vehicles with regard to the distributed content download[6].

One of the advantages regarding parked cars is their parking positions. Along with streets and sometimes surrounding obstacles, they will be providing certain likelihood to relay beacon messages regarding the driving cars for the purpose of bypassing the obstacles. Such ideas were indicated in the figure (2.5). Conceptually, the parked vehicles representing set regarding dynamic autonomous Stationary Support Units (SSUs), participate in vehicular networks, e.g., for enhancing the safety applications' performance.

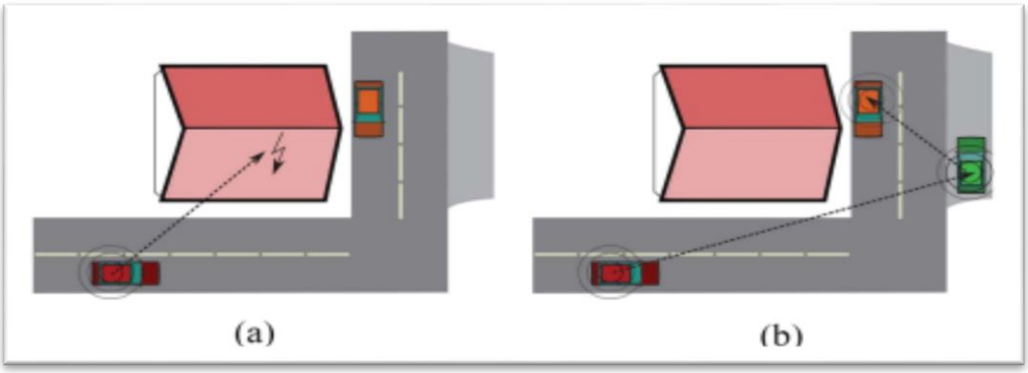


Figure (2.5) Utilization of parked vehicle as relay node[17]

Safety message blocked by an obstacle (b) relaying safety message via parked vehicle

A major advantage in ubiquitous availability related to the parked cars when compared to SSUs and RSUs is going to be majorly join due to these reasons: The availability related to communications through the parked cars might considerably enhance the cooperative awareness and, thus, the vehicular safety.

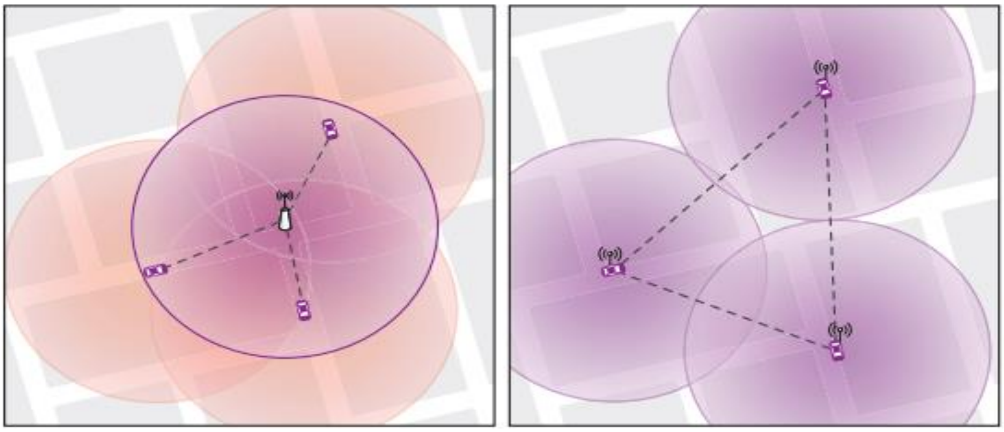
Social network's success as well as crowd sourcing activity showing the will for sharing information for mutual benefits. It must be indicated that technical effect has been reduced, this could be a motive with regard to mandated use, also it must be indicated that the road traffic. Safety might be considerably enhanced with no requirement for deploying unreasonably (because of costs) high number of RSUs. Furthermore, the main benefit of vehicles is to be energy autonomous: as the vehicle is moving, the battery will be recharged continuously. Although using parked cars has some benefits, one-point warrants more investigations:

The parked cars are not considered as energy autonomous (their batteries are not recharging in the case when engine has been off). Using parked vehicles as relay nodes must result in disadvantages for the owners, this is indicated that there are upper limits related to how long the parked cars might be participating in the IVC[17] .

Operation methods for the parked cars:

- Extending the existing fixed RSUs coverage. The parked cars which lie in fixed RSU's range are capable of turning on and establishing themselves as that RSU's relays (Figure 2.6 - a).

- Acting as the stand-alone RSU. In order to broadcast messages of safety and collect safety data, in the case where the parked car is capable of accessing Internet through the on-board cellular radio or any available ways, it can select to be a standalone RSU (Figure 2.6-b).



(a) (b)

Figure (2.6): operating of parked vehicle[55]

(a)As relay node with existing RSU (b) as RSU

2.8.2 Moving vehicle

In [47] a suggestion of using vehicles as temporary roadside unit. This solution has leveraged available vehicles which are equipped with the DSRC for being utilized as temporary RSU. A vehicle might have a small stop and undertake or take on processes of the traditional RSUs- relaying messages for the vehicles nearby and act as a bridge of communication for the vehicles in network. The use of cars as RSU's of improve the reachability of the message and the connectivity of the network, in addition to accelerating DSRC adoption as well as avoiding costs of the deploying of the Road-side Units.

This method has drawn its concepts from the biological self-organizing types of system (like the fish, birds, and ants). Specifically, instead of using an expensive road-side infrastructure (like the RSU) or the high latency of the packet in the Wi-Fi and Cellular networks, the use of DSRC-supplied vehicles has been leveraged for the sake of serving as temporary units of the road-side. According to designed local rules and new algorithm, the DSRC-equipped car can determine independently if or not, it has to play the role of the RSU; and in the case where it has to, it will stop for a limited amount of time and re-broadcast message. That solution might be impractical due to the time of the stopping. The vehicle must stop for various durations according to applications, some of which need more time compared to the others.

Which decreases the mean value of the velocities of the vehicles in the area and there is no guarantee that the vehicle is going to stop at the middle of the way to the work when the temporary roadside unit re-broadcasts safety messages.

2.9 Benefits of using vehicle as Relay node

In early stage of inter vehicle communication technology deployment only a limited amount of all the nodes only is going to be supplied with the on-board devices, thereby, they reduce the possibility of other supplied cars which receive a certain broadcasting through other traffic volumes may be projected for substantially dropping even in the center of the city there is always going to be low density regions of the traffic in the suburban areas and, at the night and throughout the off-peak hours.

The dense utilization of the RSU’s everywhere is not very likely as a result of involved expenses. Combined together, it means that the low densities of the nodes are going to possibly be the normal state for the new systems of the IVC, relay node is not going to be transmitting their own beacons which provide other vehicles with the information on their state and position, but merely retransmit the beacons of the overheard from the moving cars.

Those relays (unlike the RSU) do not require for being rented, pre-deployed, or purchased if a DSRC equipped cars gets to the destination, it may keep serving as relay [17].

2.10 Urban and Highway Environment

High-ways and urban environments have various features, as a result, the routing strategies of the VANET are utilized. In the Urban scenarios, there are several obstacles as a result of the city buildings, vehicle densities, speed is more changeable than highway. As a result, those various properties, urban to high way scenarios have differing strategies of routing [4].

In the comparison with the urban environments, highway contain a number of significant differences of a massive impacts on the concept of the communications, as has been explained by [13], Behaviors in the highway differ from the urban environments in the fundamental points below:

Scenario: In the urban environments, there are corners and junctions with the structures, which affect the propagation of the signal. In the highways, due to the fact that there are no any obstacles, the vehicle is usually capable of forwarding the messages to other vehicles inside the range of the antenna. In spite of this, there were researches showing that the actual vehicles play the role of obstacles in propagating the messages [14].

Pattern of the Mobility: there are many streets, squares, and avenues which are approximated to one another in urban environments. Which is why, drivers have several choices to make. For example, it is capable of turning to another road or going right-ahead. However, in the highways there has been only a small number of the exits and entrances without cross-roads. Which is why, the majority of times, vehicles only have the option of staying on that same road without any sharp turns. From the point of view of the routing perspective, there is a possibility of selecting a variety of choices for forwarding the data in the urban environments, whereas, in the highways, the majority of the cases, same group of the cars can be utilized for information forwarding [15].

Characteristics of the Mobility: The speeds of the cars are low in the villages and the towns, it is typically within the limit of 50km/h, or less, according to the legislations of that country, whereas in the highways, those limits are approximately 120km/h. In the case where speed is greater, the time of the connection to one of the vehicles which travel in the reverse direction or a fixed Access Point (AP) considerably reduces [16].

Characteristics of the Node: The cars have to be provided with a special device of communication, which is embedded or attached to the body, having dedicated interfaces of communications for connecting to other cars or to a specified infrastructure. The device could be interacting with the on-board sensors, which can access the information of the environment, like the location which may be obtained from vehicle's GPS device [17]. However, this device does not include any autonomous system of the power supply, which is why no limitations of the power consumptions are expected.

2.11 VANET Mobility Model

VANET mobility models are typically classified into two types: highway mobility models and urban mobility models. The urban mobility model includes many kinds of models for example: Random Way point Model (RWM), Manhattan Urban Model (MUM) and Rice University Model (RUM).

Typically, there are two lanes in the mobility model of the high way, in which the cars are capable of moving in the two directions respectively. The pattern nodes of mobility within the high way model is high with a few obstacles for preventing the signal transmissions of the DSRCs. As a result of the high nodes' speed in the model, the architecture of the network is going to be frequently changed [33].The Researches in the urban vehicular ad hoc networks has been performed in the three models of mobility that will be listed below:

2.11.1 Free-way Mobility Model (FMM)

Free-way can be defined as a generated-map-based model, which has been specified in[58]. The area of the simulation, which has been denoted with a produced map, has numerous free-ways, every one of the side of which includes numerous lanes, as can be seen in Figure (2.7). None of the urban routes, which is why there have not been any intersections taken under consideration in the model.

At the simulation's start, nodes undergo random placing on lanes, and are moving with the use of the history-based speed values. A distance of security has to be kept between two successive cars in the lane. With the case of distance between two cars is less compared to the specified minimum distance, the 2^{nd} one will decelerate and provide the forward vehicles in moving farther.

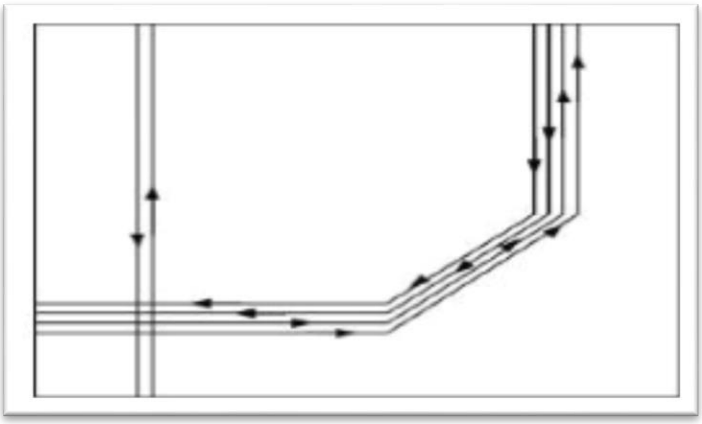


Figure (2.7) The Free-way Mobility Model[59]

Changing lanes is not permitted in the model. The car will move in lane which it is placed inside to the point where it reaches the limit of the area of the simulation, after that, it will again be placed in a random manner in some other location and will repeat this procedure. This case is not realistic for sure.

2.11.2 Manhattan Mobility Model (MMM)

MMM can be defined as a generated-map-based model, it was the first proposed model in [58] for the simulation of the urban environments.

Prior to the start of the simulation, the map which contains horizontal and vertical lanes is produced, as has been illustrated in Figure (2.8). Every one of which will latter include two lanes, which allow movement in the two ways (east/west for horizontal lanes and north/south for vertical lanes). When the simulation begins, the cars are placed in a random manner on roads. After that, they continuously move based on the history -based speed levels (which follow an identical formula to a free-way model).In the case where the vehicle reaches a cross-road, the car will randomly choose an orientation to be followed. Which is, to continue straight-forward, turn right, or turn left. The possibility of every one of the decisions will be specified by authors to 0:5, 0:25, and 0:25 respectively. The distance of security is utilized as well in the MMM, and the nodes are following an identical approach like the model of the model free-way for the sake of keeping this distance.

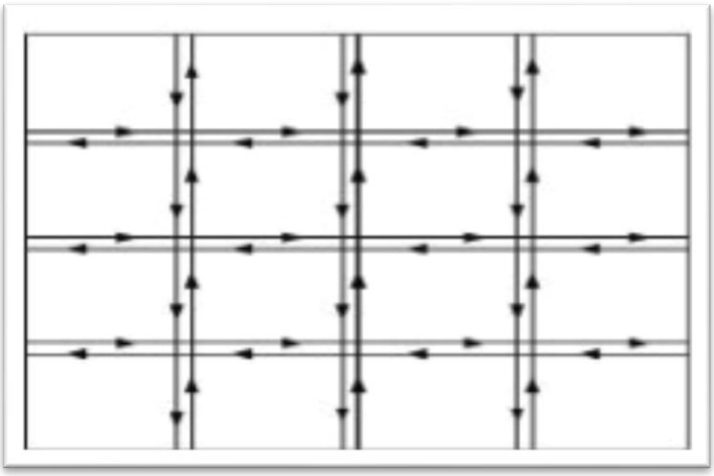


Figure (2.8) Manhattan Mobility Model[59]

However, in contrast to preceding model, the vehicle has the ability of changing the lane at a cross roads. None-the-less, there are no mechanisms of control at those points (i.e. the cross-roads), where the nodes proceed with their movement with no stopping, and that is actually not realistic.

2.11.3 Random-Waypoint Mobility Model

The speed of the node in this model is dispersed in a uniform manner between 9m/s and 16m/s which covers the limits of the speed of the variety of the categories of the roads which are available in the scenarios of the simulation. The pausing period between the successive trips is distributed in a uniform manner in the range of (0sec-10sec.) for the simulation of a short stopping at the destinations. The starting values for the position and the speed of the node will be set based on the approach of the steady-state initializations [18].

2.13 Network Simulator (NS-2)

NS-2 can be defined as an object oriented open source discrete event-driven simulator, which was particularly designed for the researches in the networks of computer communications. Since it was incepted in the year of 1989, NS-2 has constantly gaining interests from academia, government, and industry. Being under continuous investigations and enhancements for several years.

The NS-2 now includes modules for many components of the network like the transport layer protocols, routing, applications, and so on. NS2 became one a very widely utilized network simulator [60]

There are numerous network simulators, such as NS-2, OPNET Modeler, OM-NeT++, GloMoSim. And every one has special characteristics, so, before going to select one of these simulators, there are some important issues to be determined, such as determining the specifications of a simulation model so that the selected simulator must be general-purpose enough to provide the behavior of environment. Indeed, input/output data of the real system must be appropriate with the simulator and the design of experiment. selecting a simulator of the network for the evaluation of the research has been a necessary task for the scholars [61][62].

NS-2 can be applied on many applications, network types, protocols, traffic models, and network elements. All these things in NS-2 are called "simulated objects". Hence, NS-2 has been chosen as the simulation tool for this work due to the fact that it provides an efficient support for the networking researches and education. Furthermore, NS-2 is appropriate for the design of new protocol types, traffic evaluations, and comparison of various protocols [63].

NS-2 is mainly used to research the dynamic nature of the communication network because it is simply an open source, event driven, portable tool of simulation. NS-2 has emerged as a simulator of the network which provides valuable simulations for routing, transport, and multi-cast wireless and over-wired networks. Numerous various versions of the NS-2 were proposed during the past years; the latest one of which is NS2.35. NS-2 support the wireless as well as the wired networks, and it covers numerous protocols and application.

It is also appropriated to design new protocols, comparing various protocols, and for traffic evaluation as well. Hence, we have chosen NS-2 as the simulation tool for this work due to the fact that the NS-2 provides an efficient support for the networking researches and education [64].

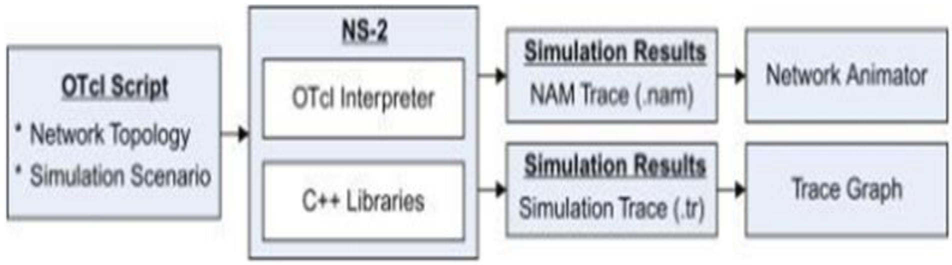


Figure (2.9) The NS2 Basic Architecture[65]

The core of the NS-2 has been written in C++, and it was available for different platforms. However, users have an interaction with the NS-2 through writing the scripts of the Tool command language (TCL). Which must include every command which is required for running the simulation (such as the setup of the topology, the specifications of the wireless parameters). The simulation of the NS-2 creates a trace file for the event as well as an animation trace file that is utilized by included utility NAM for the provision of simulation animations.

The trace file of the event includes packet enqueuer (for the transmissions), packet de-queue (for the forwarding), packet receptions, and packet drops[66]. For every one of the objects in the C++ there is a matching TCL-object, providing the possibility for accessing and modifying the characteristics of the simulation throughout the time of the simulation, as shown figure (2.9).

After completed simulation, almost, the way NS-2 is utilized for presenting the most detailed data about the layers of the network. Therefore, it will provide a massive recording of the trace files all events line by line within network layers. Now, we will explain the reason of using the event driven approach in the NS2, due to the fact that it could actually maintain things which have ever happened in a form of records.

There is a possibility for tracing those records for the evaluation of the efficiency of a special part in this network, like the protocol of the routing, Mac layer load [67].

Chapter Three:
Design of the proposed system

Chapter Three

Proposed System Design

3.1 Introduction

Accidents are one of the major problems that occur every day around the world. The automakers try to prevent or decrease the accident by making development in the vehicles facilities. This task is established by enabling vehicles to discover the possible accident as far as possible by enable (V2V) communication technologies. (ITS) technology has widely used to monitor traffic and to respond quickly to accidents by disseminate safety message services. VANET require a minimum number of vehicle to be well connected and functional, which can fail to achieve due to either small numbers of vehicles on the road or insufficient radio-equipped vehicle as well as the lack in RSU deployment on the roads.

VANET connectivity has considered to be a major challenge due to the vehicles facing a high mobility and obstacles in road which does not allow a suitable connection between vehicles. While RSU result in high cost of installation and maintenance many methods trying to find a suitable replacement by using parked vehicles, autonomous vehicles and RSU distribution methods, but not focusing on normal moving vehicles equipped with DSRC communication technology. Our proposed system aimed to improve VANET connectivity through investigating both static and dynamic relay nodes as temporary RSU.

This chapter also includes a relay node selection mechanism which necessary to determine candidate vehicles to work as a temporary RSU. Based on each node position, direction, speed, relay node has been selected.

3.2 The Case Study and Assumptions

In the VANETs environment each vehicle play a sender, receiver, and router role to forward the messages to nearby vehicles. In the proposed system, Assumes that all vehicles are equipped with on board unit (OBU) that enables vehicles to communicate with each other.

In addition, each vehicle is installed with the Global Positioning System (GPS) which enables the vehicles to announce its location in their environment as shown in figure (3.1). When a vehicle automatic system detects any dangerous situation, a message will generated.

This message will be broadcasted to all neighbor vehicles up to 250m transmission range. There are many applications of the VANETs and each one requires a different solution. For the case study of the research, this thesis adopted a specific problem to find the solution by proposing a practical and cheap explanation for it.

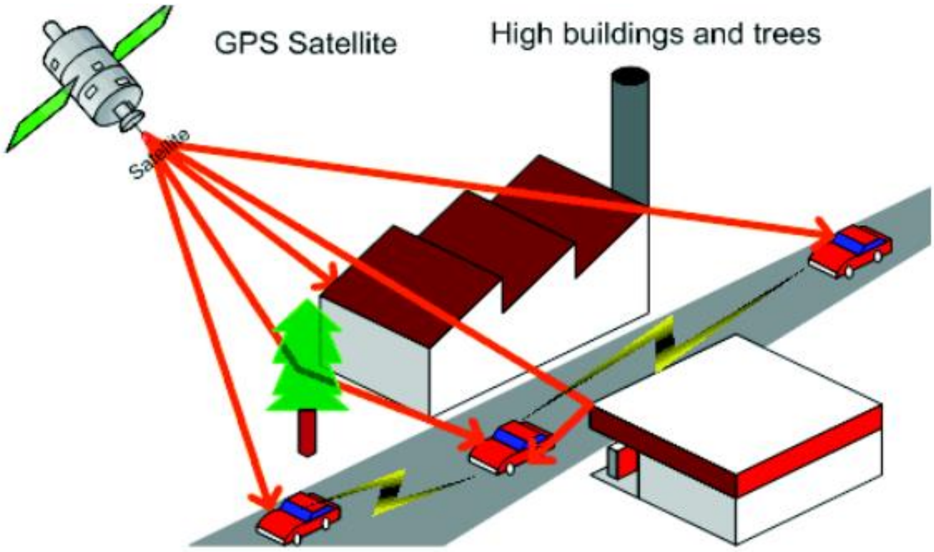


Figure (3.1): The use of satellite (GPS system) for outdoor loculaization

Post-Crash Notification (PCN) considers as a case study where the vehicle with an accident should notify all the neighbor vehicles for congestion avoidance. The target of the PCN system is disseminating the safety message (information about the location of the accident and its time occurring and others) to all vehicles within the source transmission range. This dissemination of the message should be short and does not take long time. The following points describe how the proposed system is implemented:

- This system executes when each relay node is capable to share and disseminate the safety message with the biggest number of neighbors as possible.

- In our scenario, there are two types of vehicles including informed and uninformed vehicles.
- Informed vehicles directly communicate with the source node (accident vehicle) and locate within the coverage area of the source node.
- Uniformed vehicles dependent on the informed vehicles to notify them about the crash accident.
- After source vehicle broadcasted safety massage the received vehicles should make a decision by changing movement direction, taking the first exit in their way, changing lane.
- Vehicle outside coverage area could be informed to make a decision, they might facing the following situation if they enter the accident zone.

  - The road is straight which means no exit are available
  - The vehicle moves too fast to make changing decision
  - The accident zone is already congested

- Based on relay node selection algorithm, vehicles with supreme position and movement direction selected to works as temporary RSU to informed vehicle out of source coverage transmission range, informed vehicle have higher chance to avoid the dangerous zone, with more time to make decision.
- To ensure broader coverage of all accident directions, one relay placement in each direction.
- Guarantees better connectivity and more vehicles in deferent directions are informed about the accident.
- Because of buildings and other obstacles in urban environment, a number of vehicles with no direct line-of-sight with source vehicle will take advantageous of relay vehicle as it will receive safety message by relay rebroadcasting.

3.3 Methodology

In the proposed system, we assumes that normal vehicles are used as temporary RSU. A number of vehicles is selected to work as temporary RSU relaying safety messages to nearby vehicles and acting as a communication bridge for other vehicles in network. With better connectivity, transmission delay and possibility of lost messages, caused by long periods of partitioning, can be reduced.

To achieve a better network connectivity in urban environment, the relay nodes take a crucial role in improving network connectivity by working as rebroadcasting node. This thesis aims to improve network connectivity in vehicular networks avoiding cost associated with RSU deployment and proposed temporary vehicle which play as a relay node.

To determine the feasibility of proposed system, two scenarios were implemented including the first one with "static relay" node and the second one with dynamic relay node. The source node collects mobility metrics, velocity and position location of all the surrounding nodes by using GPS and other on-board sensors parameters. These parameters affect the relay node selection. Afterword, in static relay scenario, it makes a brief stop to play RSU role for rebroadcasting a safety message to nearby vehicles. We assumed the vehicles on the boundary of source transmission range and moving toward the accident point is a relay node, which consider a good candidate for this role. For this scenario relay node efficiency has been investigated through message reachability. On the other hand the second scenario as a dynamic relay node which a normal vehicle works as temporary RSU without needed to be stopped during its trip. When vehicle start broadcast safety message relay node rebroadcast it during its movement to neighbor vehicles in its transmission range.

In order to test the efficiency of the proposed system in selecting the vehicle that is suitable to works as relay node we used Matlab program to build and simulate the normal vehicle behavior, relay node selection depending on its current position from the source vehicle.

3.4 Relay node selection

"Two metrics we should considered". The relay node selection appends the mobility parameters: position and direction mobility metrics to improve the relay selection mechanism. The author in [14] improves the network connectivity by using normal vehicles as relay node to work with the VANETs environment. The approach is dependent on the two parameters direction and position that support static relay in the urban VANETs. This thesis included another important element that optimizes the network connectivity by using dynamic relay node without the need to stop during the trip. As mentioned previously by using GPS in vehicles we can obtain mobility metrics which are used in selecting approach in this thesis.

- Vehicle's position: Source node collects mobility metrics, velocity and position of all the surrounding nodes by using GPS and other on-board sensors in vehicles. The Vehicle position on the boundary of the source transmission range is a good candidate to work as temporary RSU as shown in figure (3.2). Vehicles in this area have both informed and uninformed neighbor. These vehicles have a higher chance to meet with uninformed vehicles than non-boundary ones hence, all vehicles around the non-boundary vehicle is already informed by the source vehicle. The Vehicle position is obtained by using GPS facility in the vehicles.

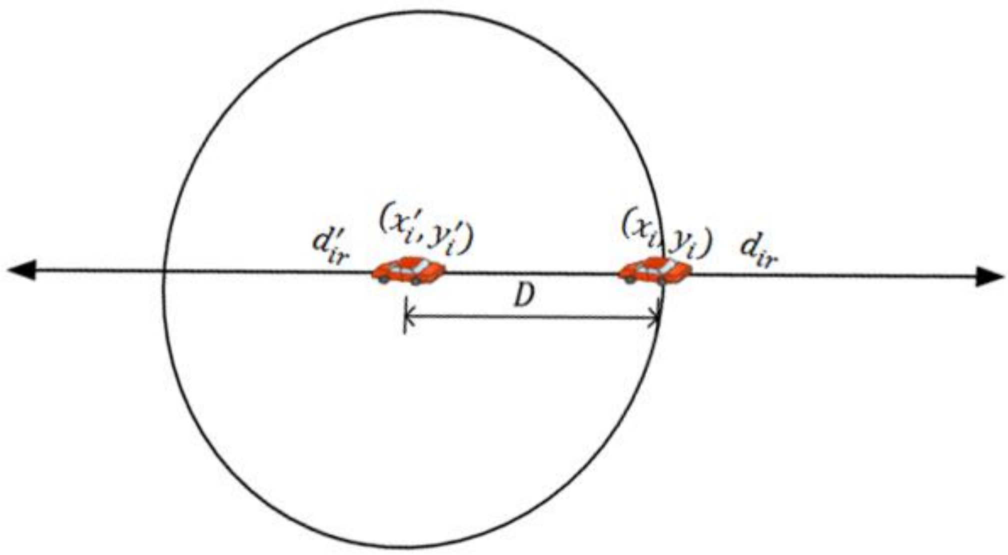


Figure (3.2): Relay node position [68]

A transmission range as a circle of radius D and source vehicle at $(xi - xj)$ as its coordinates, distention vehicle at $(yi - yj)$ consider as shown in Figure (3.1) distance between source and neighbor node D_{ij} that can be calculated as in equation 1 [68]. the farthest vehicle is RSU candidate if its movement direction toward the Region Of Interest (ROI) in static relay scenario and outward ROI in dynamic relay scenario.

$$IVD_{i,j} = \sqrt{\left\{ \left(x_i - x_j\right)^2 + \left(y_i - y_j\right)^2 \right\}} \qquad [68]\ \mathbf{(1)}$$

- Vehicle movement direction: In addition to vehicle position, the movement direction of these vehicles should be taken in account. Working with an urban scenario is more complex and considers as a challenge. The network connectivity is simple in highway scenario where vehicles roaming in two-way directions. To predict the direction of vehicle in two-dimension roads like in urban environment. We calculate the distance between the sender and receiver. The distance decreases when the vehicles are approaching to each other, while in moving away the distance increases. Depending on this idea the distance added to mobility metrics to cover the mobility urban scenario. And this suggestion is developed to take the distance as a main factor to decide which node works as relay node.

3.5 Relay node selection algorithm

When the source vehicle generates a safety message to send, it firstly searches to the vehicles who will temporarily take the role of RSU. Then, it will send the safety message to all neighbor vehicles with rebroadcasting order to the selected relay vehicles.

When selection program start, it will search all directions to select one relay vehicle, based on vehicles coordinates, the position of the vehicles will be identified. Then the program will calculate the distance between the source vehicle and destination vehicles, by using the Euclidian distance equation the distance that will be calculated. The program will search for the vehicle with less distance rather than Radius which represent source transmission range and then choose the farthest one as relay vehicle. This selection process will be repeated four times, one time in each direction of the source vehicle.

Algorithm (1) : Relay Node selection
Input: vehicles (X axis , Y axis), number of nodes ,transmission range
Output: 4 relay nodes

Begin
- Distribute random nodes
- Select the position of center node (x/2 , y/2)
- Get_informations (neighbor)
- Get_ Position (neighbor)
//From GPS get information about the neighbor nodes within a transmission range
- Identify node direction in each side of source node with respect to its coordinate X, Y of_nodes axis
- Calculate Euclidian distance between nodes in this side and source nodes:
• *Ecludain = sqrt((X_of_nodes - xcenternode).^2+ (Y_of_nodes - ycenternode).^2*
- Choose the nodes less than Radius
• *Select_Node=find (distance <radius)*
- Choose farthest node and assume as relay node in this side
• *Index_Ecludain =max (distance (select_node))*
END

3.6 Static relay node

The connectivity of network can be improved by using a single or many vehicles to works as temporary RSU.

The most important service by RSU is to connect vehicles as much as possible through exchanging safety messages and other information about the road. Information is collected by observing the changes in the environments and possible danger situation. This service can be obtain by using normal vehicles in the source transmission range as RSU.

The concept of using vehicle as RSU is proposed for urban environment as an effective alternative which make use of DSRC equipped vehicles as temporary RSUs. The use of vehicle as temporary RSU will improve massage reachability and network connectivity. Broadcast mechanism for safety messages is used in VANET in order to deliver safety massage to all vehicle inside the coverage area to avoid the danger zone. The vehicles which moving toward accident scene should receive a warning. In real scenario there are multiple candidate vehicles that can play a RSU rebroadcasted which they are in the boundary of source transmission range.

The vehicles on the network boundary will be in a position of a great possibility to meet with other uninformed vehicles which are not at the boundary. However, informed and non-boundary vehicles are typically surrounded with other informed vehicles. In addition there are no any additional benefits in having those vehicles play the role of temporary RSUs. The Vehicle movement direction, which they are travelling toward the accident, have to play the role of a temporary RSU. Besides the positions of the vehicle, movement directions of those vehicles have been taken under consideration. The proposed system includes an implemented static relay node scenario to act as temporary RSU. When a vehicle is exposed to an accident and stopped in the road, it starts broadcasting safety message to all nearby vehicles to inform them. The simple safety message communication protocol can be used to send periodic messages from the source. The content of message from the source to other vehicle will contain its present location which is the accident sense so other vehicle can avoided it.

We implemented "one hop" safety-message scenario, which is involved in the V2V communication between the source and relay node. The proposed system assumed that there are number of vehicles acting as relay node, boundary vehicle which is moving toward accident scenes selected by the source node and receive safety message with rebroadcasting order.

Improving connectivity means a wider coverage area and a larger number of received vehicles. To achieve this, one vehicle is chosen in each of the four directions around the source vehicle to work as temporary RSU taking into consideration its location and the distance between it and the source vehicle. Four relay vehicles are selected and each one covers its surrounding area and Guarantee delivery of the safety message to its neighbor vehicles.

Algorithm (2):Selecting RSU Vehicles
Input: All vehicles coordinates
Output: RSU Vehicles

Begin
For all vehicles do
Get coordinates of all vehicles
Check **if** the direction toward or in boundary of zone center
IF the direction of vehicle toward zone center **then**
a) Calculates the distance between the vehicle and the zone center
b) Select vehicle that located on the boundary of zone center and should stop a specific time
Else the direction outward zone center **then**
Select another vehicle moving toward zone center
a) Calculates the distance between the vehicle and the zone center using equation 1.
b) Select another vehicle which located on zone boundary and has an angle β =90^o with respect to first selected one for stopping.
RSU Vehicle has been Identified and Selected
End

3.7 Dynamic relay node

Static relay node faces many challenges including the dangers of stopping vehicle in the road, delay in vehicles traffic, and difficulty in persuading drivers to stop for amount of time. Therefore, we approach the VANET connectivity problem by using dynamic vehicles to bridge the gaps between source and destinations vehicles. To achieve better connectivity, we proposed a utilization in order to enhance network connectivity without needing to stop the vehicle during their trip. Dynamic vehicles are selected to work as temporary RSU, while the source vehicles collect mobility metrics, location, and velocity of all neighbor vehicle by using GPS in the vehicle. As mentioned before relay node selection depends on vehicle position from the source, farthest vehicle from the source within 250m source transmission range selected as relay node. In our proposed system the source vehicle collect mobility metrics and used this information to select one relay node in each direction around it. The selection based on node position and movement direction. With four relay nodes, we insure that all directions is covered and the number of vehicles received the message are increased. In other word, increasing the number of informed vehicle guarantees a better network connectivity. The vehicle on the boundary of the source coverage moves way out the ROI is good candidate for this role. The source vehicle sends a periodic safety message using simple safety message communication protocol. Normal moving vehicles received the message directly from the source, moving relay node received the message with rebroadcasting order.

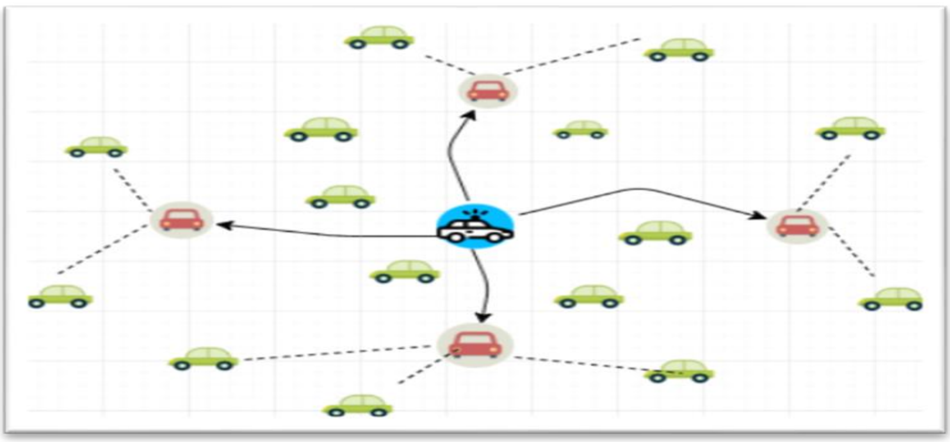


Fig (3.3): Network with four dynamic relay node

For wider coverage and more informed vehicle in the road, the relay node will rebroadcast the safety message during its movement through way out of the accident sense. When relay node becomes out of the ROI its stop working as RSU and source vehicle has to select another vehicle for this role.

Algorithm (3):Selecting RSU Vehicles
Input: All vehicles coordinates , vehicle speed
Output: Identify RSU Vehicles

Begin
Step1:
For all vehicles do
Get coordinates of all vehicles
Check **if** the direction outward or in boundary of zone center
IF the direction of vehicle outward zone center **then**
a) Calculates the distance between the vehicle and the zone center
b) Select vehicle that located on the boundary of zone center
end
Else the direction toward zone center **then**
Select another vehicle moving outward zone center
a) Calculates the distance between the vehicle and the zone center using equation 1
b) Select another vehicle which located on zone boundary and has an angle β =90^{o} with respect to first selected one
RSU Vehicle has been Identified and **Selected**
Step2:
If vehicle out of range **then**
Go to step 1
End

Chapter Four:

Results and

Discussions

Chapter Four

The Results and Discussions

4.1 Introduction

This chapter presents the performance evaluation through the execution of our scenario in order to examine the efficiency of using relay node as temporary RSU. In term of the effects of different node numbers and node velocities. This chapter also includes an explanation of the usage of some important tools required for relay nodes simulation and evaluation. This includes the Network simulator (NS2) based simulation environment and Matlab. One relay node will be compared with different number of relay up to four relay nodes. To prove the enhancement of reachability in different scenarios. Different scenarios will be considered by the diversity of the velocities, number of relays and the number of normal vehicles.

Each measured scenario will also be evaluated by other metrics such as connection duration, re-healing time and receiving time is also measured to evaluate each scenario to ensure there is no negative impact on these metrics that may be effected by increasing the velocity or number of relay vehicles.

4.2 Performance evaluation of relay node selection algorithm

We demonstrate the relay node selection using Matlab as simulator. The main aim is to evaluate the efficiency of proposed system in term of selecting four normal nodes to works as relay node based on each node position and movement direction. The scenario, were implemented in the simulation, are a network with one static node in red color as the source node in the top center of the network and 250 dynamic node in black color. As shown in Figure (4.1) the simulation area is 1000x1000 with 250m as transmission range. The objective of this scenario is to test the capability of the source node to select four relay nodes, each one in different direction. In our work, we only consider v2v communication between the source node and distention nodes. After the simulation begin four node in green color are selected as relay node with 90 angle between them with respect to the source node.

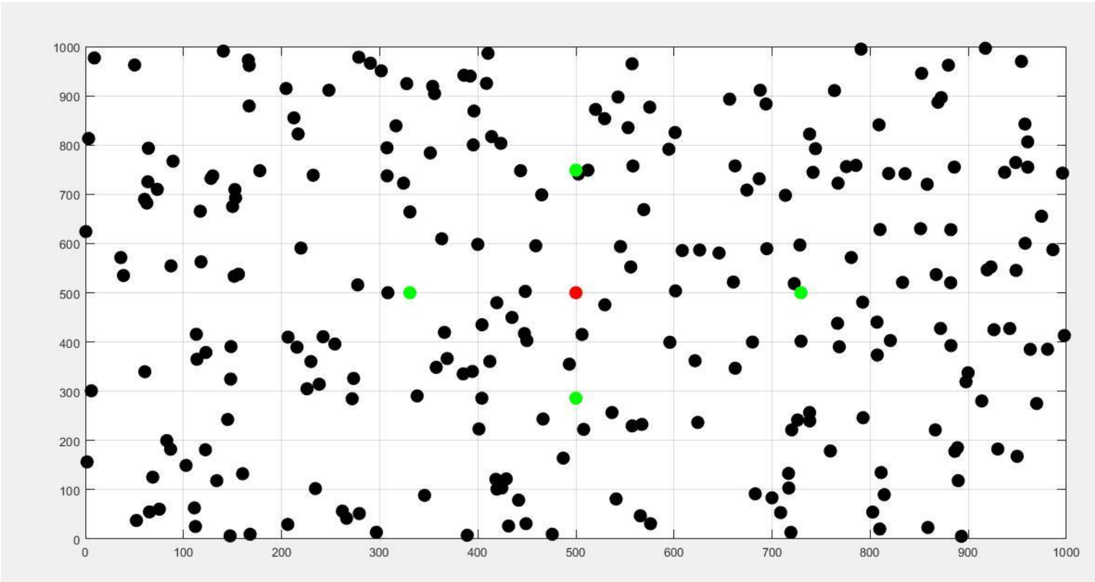


Figure (4.1): The source node with four selected relay node

4.3 Simulation Environment

In this work we implement the system schema in the simulation environment which was used under the Linux (Ubuntu 14.04) operating system. We used the simulator tool NS2 (version 2.35).The mobility model, which is used in this network, the urban mobility model which mathematically constrains the movement in down town area.

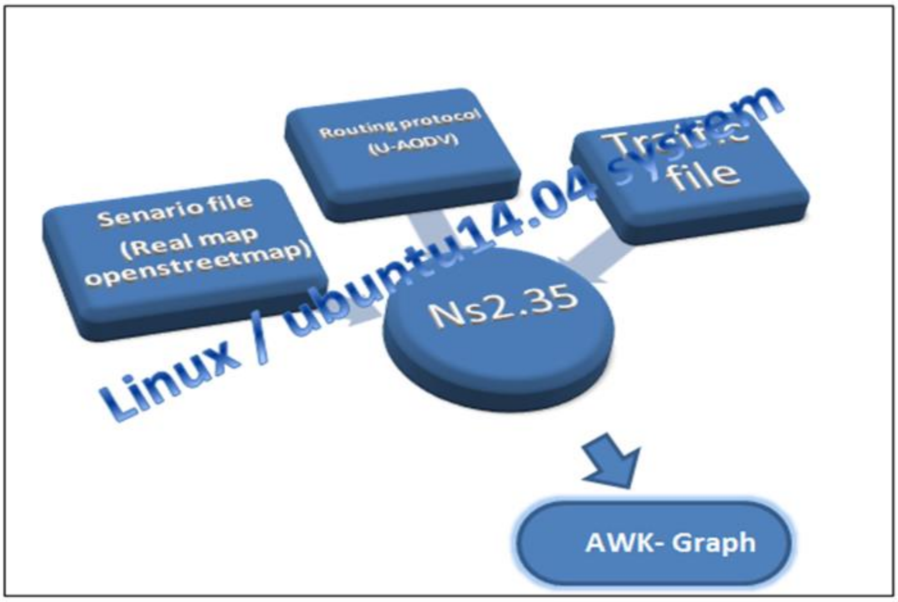


Figure (4.2): The Ns2 environment[69]

The process operates by exchanging the safety message with relay vehicle in order to rebroadcast it to the neighbor vehicles moving toward scene of accident in the road. The network consist two type of nodes: static nodes and dynamic nodes. The dynamic nodes were divided into normal and relay node. We chose (1, 2, 3, 4) vehicles from normal vehicle as relay vehicle. The static vehicle is one vehicle in the top-center of network represent the source vehicle which has been involved in the accident. The simulation scenario based on random motion in order to emulate urban environment.

Table (4.1): The parameter used in our system.

Parameters	Simulation Value
Simulation Environment	Ubuntu 14.04
Simulator	NS-2.35
Simulation Time	300 Seconds
Antenna Model	Omni directional antenna
Transmission Range	250 m
MAC Type	IEEE 802.11p
Interface Queue Type	Drop tail
Network interface type	Wireless Phy
Radio Propagation Model	Two Ray Ground
Simulation Area(Topologies)	1000 X1000 m
Packet size	1500KByte
No. Relay nodes	1, 2, 3, 4
For Varying Vehicle Density	
No. of vehicles	20, 40, 60, 80, 100
Mobility of Vehicles	Random real time urban topology velocity
Relay Vehicle velocity	10, 20, 30, 40, 50 km/h

4.4 Performance Evaluation and Results

4.4.1 Scenario 1:

In our proposed static system we assumed

- One vehicle in the top-center of the network which experiences an accident
- We increase the relay node as (1, 2, 3, 4) and estimate the effect of this increment on network connectivity. The estimation being via message reachability. Normal vehicle moving randomly in 1km *1km urban topology environment.
- To maintain a constant vehicle density in the network, a new vehicle is immediately added to the network once a vehicle exits. We assume that this new vehicle is uninformed.
- Any two vehicles can directly communicate if they are within the corresponding transmission ranges. In addition, we assume accurate "GPS" information in our simulations, a vehicle has perfect knowledge of positions of itself and all of its one-hop neighbors.
- When a vehicle experiences an accident its begin to broadcast safety message, the message received by all neighbors vehicle in the region, but only the relay ones will make brief stop and rebroadcast the message to all vehicle in its transmission range. The message contains the accident location.

4.4.1.1 Message reachability

In this metric we calculate the average number of the vehicles which were received the message through dividing the number of received vehicle on the total number of vehicles. The fundamental goal in this thesis is to achieve a better network connectivity, and successfully examined in new designed relay vehicle system with different number of relays.

Figure (4.3) shows the impact of increasing number of relay nodes. Obliviously from figure (4.3) the four relay nodes perform better than three relay nodes for all times of simulation, as well as three relay nodes perform better than one and two relays. Using four relay nodes enhancing message reachability from 40 vehicles to 147 vehicles.

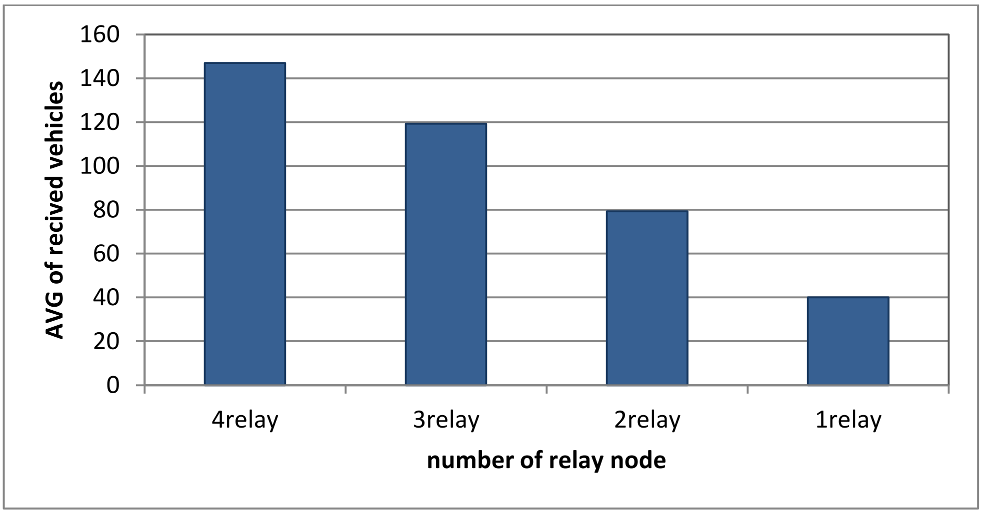


Figure (4.3): Impact change on number of relay vehicles respect to reachability

4.4.2 Scenario 2:

In the proposed dynamic system we assumed

- One vehicle in the top-center of the network which exposed to an accident.
- Different number of dynamic relay nodes were utilized and we increase these nodes such as (1, 2, 3, 4) and estimate the effect of this increment in the connectivity of the network.
- Different relay nodes velocity were implemented such as (10, 20, 40, 50) and estimate the effect of this increment in the connectivity of the network.

- Number of normal vehicle moving randomly in 1km *1km urban topology environment. We increase these node such as (20, 40, 60, 80, 100) with nodes and estimate the effect of this increment in the connectivity of the network. The estimation being via connection duration, re-healing time and receiving time.

4.4.2.1 Connection Duration

Within the first scenario, we test connection duration between relay node and destination nodes when we change the number of normal vehicles from (20, 40, 60, 80, 100) measure the impact of network density in the road on the performance of relay vehicle. In the second scenario, we test link duration by changing the relay vehicle velocity from (10, 20, 30, 40, 50 km\h) to measure the efficiency of relay vehicle velocity on the road on the performance of relay vehicle. We have one source node in the center of the road and four relay nodes.

4.4.2.1.A Average connection duration verses network density

The simulation result in figure (4.4) shows that when for extremely low network density (20 vehicle), the vehicles are usually disconnected; therefore, the number of connection periods is small. As the network density increases to 60 vehicles, the network begins to be connected. As well as the number of relay node increased the connection duration improved this is because more relay node means more vehicle connected in the network. The connection between two vehicles last for longer time. These results shows that unless the vehicle density is above a certain number (60-80 vehicle in this case).

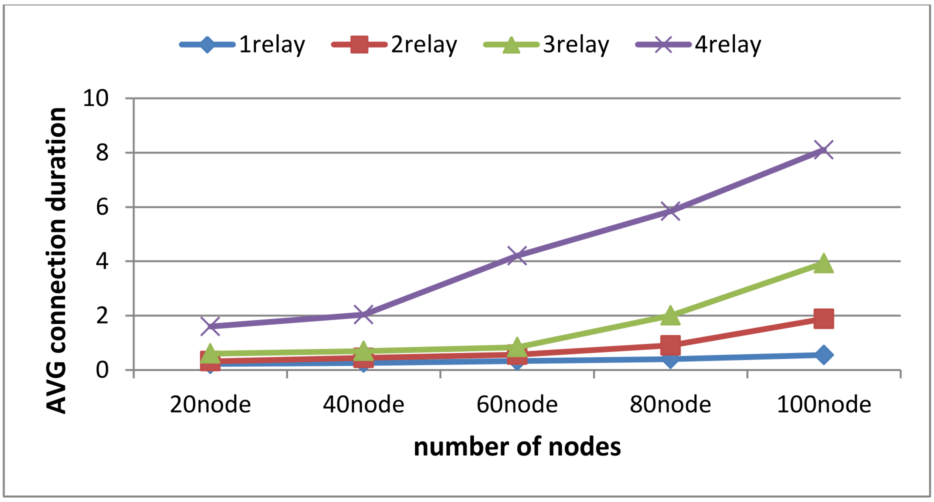


Figure (4.4): Impact change on number of vehicles respect to connection duration

4.4.2.1.B Average connection duration verses relay vehicles velocity

Simulation results for the effect of relay node velocity varying on connection duration is shown in figure (4.5). The performance of relay node with regard of connection duration is improved as the velocity of relay increases. The proposed system keeps its efficiency as increased the number of relay nodes. It is clear that increasing relay node velocity does not decrease connection duration as we can see in figure (4.5).

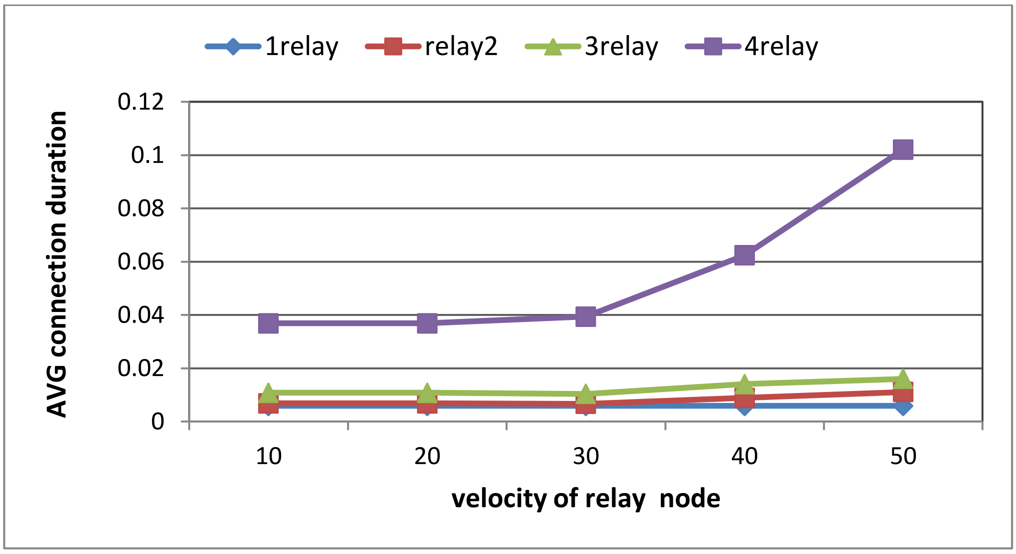


Figure (4.5): Impact change on velocity of relay vehicles respect to connection duration

4.4.2.2 Re-healing Time

Time period between two connection established between pair of vehicles that is called re-healing time. At the first scenario we test re-healing time between relay node and destination nodes when we change the number of normal vehicles from (20, 40, 60, 80, 100) measure the impact of network density in the road on the performance of relay vehicle. In the second scenario, we test the healing time by changing the relay vehicle velocity from (10, 20, 30, 40, 50 km/h) to measure the efficiency of relay vehicle velocity on the road on the performance of relay vehicle. We have one source node in the center of the road and 4 relay nodes.

4.4.2.2.A Effect of network density on re-healing time

We tested the re-healing time by measuring the time between two connected periods. The result of increasing network density to the re-healing time is showed in Figure (4.6). We see in the graph re-healing time in one relay node significantly drops as the density increases. In one relay the re-healing time is the largest because the number of relay is low this will decrease network connectivity and increase time between every two connection. This is essentially due to the fact that when network density increases, there are a higher number of potential connected vehicles. Thus, once a sender and a receiver in such a network are disconnected, these two vehicles take very small amount of time to re-heal and become connected again. When network density and number of relay nodes increase from 20 to 100 and from 1 to 4, network connectivity improved which decrease re-healing time.

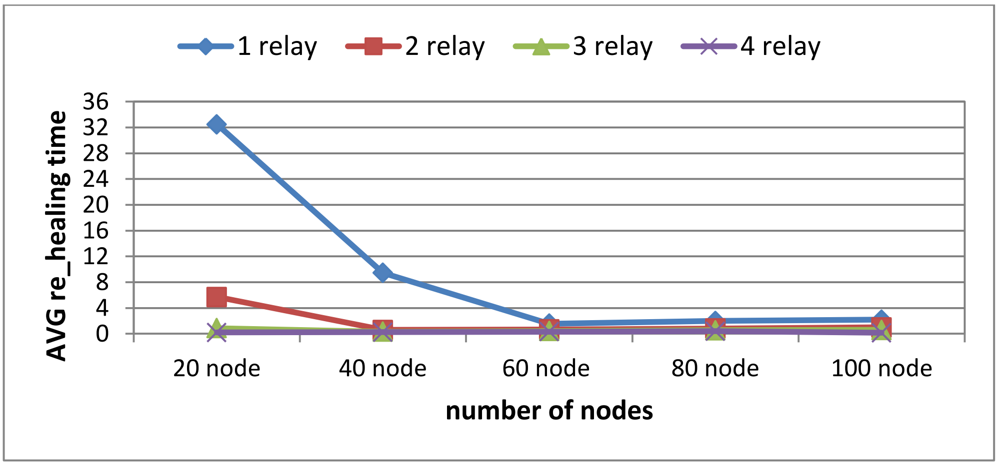


Figure (4.6): Impact change on number of vehicles respect to re-healing time

4.4.2.2.B Effect of relay vehicle velocity on re-healing time

The speed of vehicles and the re-healing time increased in parallel with one and two relay node in the network when relay speed increases over (30km/h in this case), Figure (4.7) shows that increasing relay velocity has no effect in the four and three relay node scenario while there is a negative impact in one and two relay node case.

Increasing relay velocity with disconnected network decrease the chance to find destination node which make re-healing time increased.

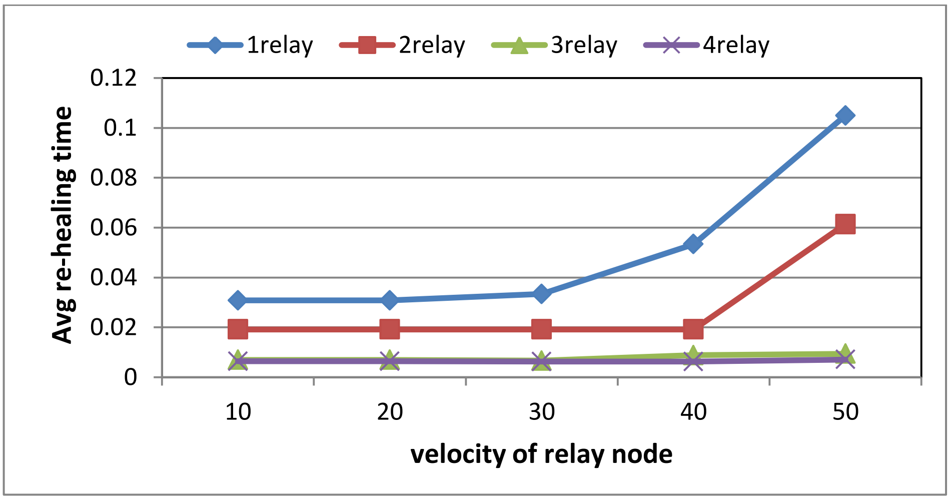


Figure (4.7): Impact change on velocity of relay vehicles respect to re-healing time

4.4.2.3 Receiving Time

Receiving time represents the average of set of all receiving time. This metric shows the efficiency of using relay node in avoiding latency. One of the essential goals of this thesis is to enhance network connectivity through decrease time at which message received. Improving receiving time decrease latency enhance the overall network performance.

4.4.2.3.A Effect of network density on receiving time

From the figure (4.8), it is clear the performance of relay node with regrading receiving time in high density is better. Relay node keeps its efficiency as increased the size of the network as shown in table (4.2). With one relay node receiving time is high, this is because it is hard to find destination node in disconnected network. The receiving time keeps lowering as relay node number increased, As well as network density. Four relay nodes has the lowest average of receiving time than other number of relays.

Table (4.2): Comparison of Vehicle's density and receiving time

Node no	1relay	2relay	3relay	4relay
20	36.6	8.7	3.4	2.8
40	12.6	3.2	2.9	2.8
60	4.3	3.3	3.0	2.9
80	4.7	3.4	3.1	2.9
100	4.9	3.6	3.9	3.0

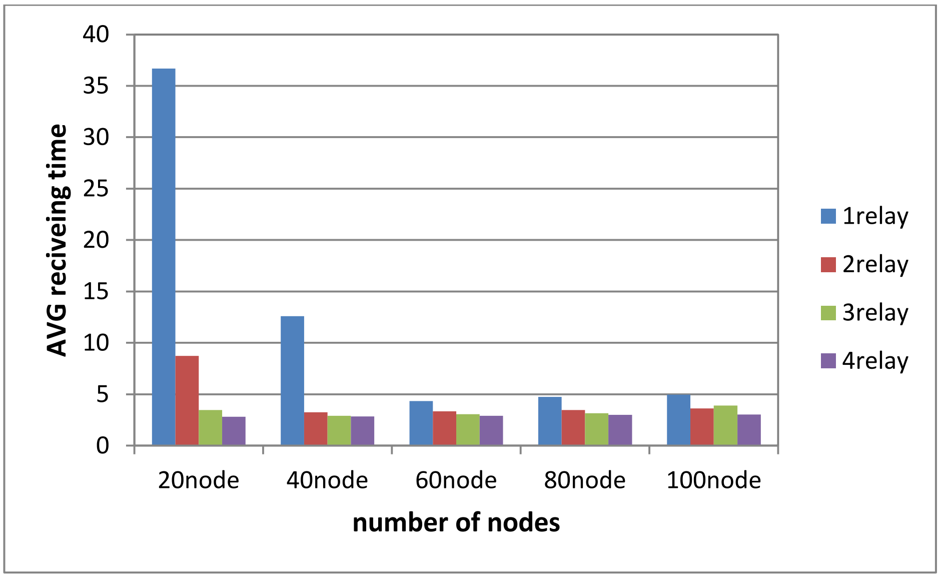


Figure (4.8) Effect of Network Size on receiving time

4.4.2.3.B Effect of velocity on receiving time

Figure (4.9) shows that increasing velocity has no negative effect on receiving time with disconnected network scenario. For one relay network, is highly prone to link breakages and take longer time to connect when the network topology becomes more dynamic and sparse as shown in table (4.3). Network with four relay nodes responds better to the changes of the network topology and keeps a lower rate of receiving time, we can see the average receiving time decrease as the velocity of relay number increases.

Table (4.3): comparative of Vehicle's velocity and receiving time

Relay speed km\h	1relay	2relay	3relay	4relay
10	3.7	3.1	2.9	2.8
20	3.7	3.1	2.9	2.8
30	3.7	3.1	2.9	2.8
40	3.7	3.1	2.9	2.8
50 km\h	3.7	3.1	2.9	2.8

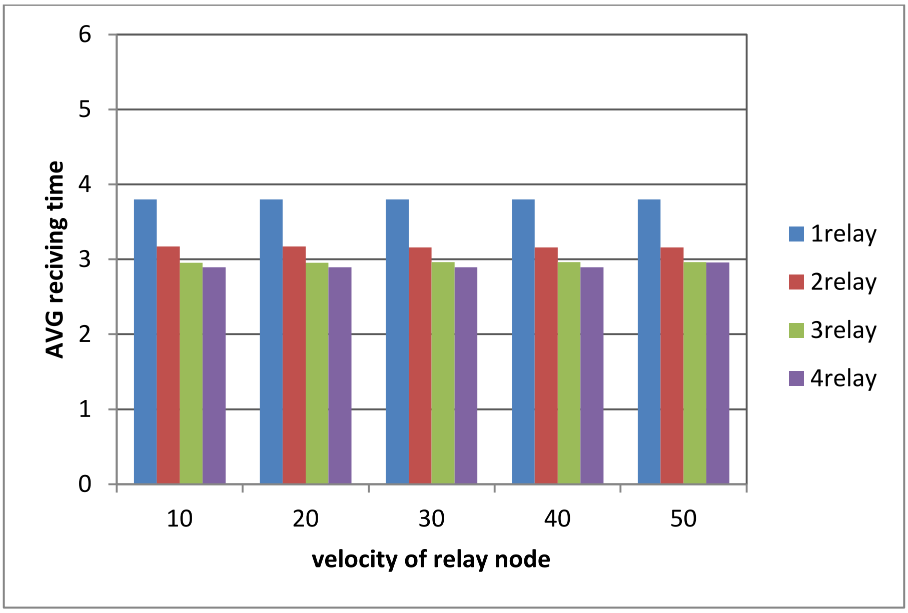


Figure (4.9): Effect of relay velocity on receiving time

4.5 The discussion

This section discusses the simulation and its analysis result to give a brief visualization of the proposed system schema. The first scenario implemented with four static relay nodes notice an enhancement on message reachability. The number of received vehicle is increased from 40 to 147 vehicles. The use of static relay vehicle is a practical solution in urban environment that have more complexity than highway.

By using dynamic relay nodes to get better performance, we increased number of node and changed the number of relay with respect, connection duration and re-healing time, then increased relay node velocity in the second scenario of dynamic relay node. When we increased the number of vehicles with four relay node the result of connection duration improved from (1.59 to 8.1). In the other side when we change relay node velocity we get connection duration in range (0.03 to 0.1) in four relay node and (0.0108 to 0.016) when we compare with the above result we conclude that connection duration in four relay have the better performance and its more effected with network density.

For the re-healing time, we can notice one relay node most effected with the increase of node number. Four relay node is showing small improvement from (0.2 to 0.1) the reason is in well-connected network re-heling is decrease. In the other hand when we increase relay node velocity it has very small impact on four relay node. While negative impact on one relay node can be seen as a result for disconnected network, distention node is hardly fond. The receiving time can be shown in Figure (4.8) and Figure (4.9). Receiving time decrease whenever the number of node increase as well as the relay node velocity. The reason of this decrement is when network considered well connected the time at which message received decreases.

When we compared our results with the paper published by W, Viriyasitavat et al [14] the paper discussed the effect of using normal vehicle as a replacement to RSU in the urban environment, the study used only one relay node in a random direction. The main drawback of this studying is the limited area covered by relay node, which is only one direction of the accident site. In addition the study used only one relay node which could reach a small number of vehicles.

In this study we used static relay node which is adopted by our studying and proved that by only increasing the number of relay node the network connectivity increased and more vehicles reaches the safety message. In another side, our studying adopts dynamic relay node scenario which is improved the overall dynamic network connectivity.

Chapter five: Conclusions and Future Work

Chapter Five
Conclusions and Future Works

5.1 conclusions

In this thesis, we have studied connectivity in Vehicular ad-hoc Network. Focusing on the use of relay vehicles as replacement for road side unit (RSU) in order to evaluate network performance with V2V technology by broadcasting safety messages. The aim of this study was to propose system for minimizing the cost of RSU installation and maintenance and to maximizing the network connectivity through the use of relay vehicles in the network. We estimated network connectivity with number of critical issue such as connection duration, re-healing time and receiving time between normal vehicles and relay one.

The most important conclusions of this thesis are:

1. According to the results, using more than one relay vehicle performs well over the use of one relay vehicle where the average of receiving vehicles was much better.
2. Using four static relay nodes presented a high performance in term of message reachability as shown in figure (4.3) the number of vehicles that received the safety messages are increased every time the number of static relay increased.
3. We proposed an enhancement by using dynamic relay vehicle to work as RSU in VANET. The proposed schema combines the advantages of using moving vehicles with the benefit of low cost.
4. The proposed system can provide better network connectivity without needing to make the vehicle stop in the road which help to decreases roads congestions and delay.
5. We estimated the network connectivity with number of critical issues such as connection duration, re-healing time, receiving time between relay node and destination node.

5.2 Future work

1. There is still room to improve VANET connectivity through implementation With more relay node, increased simulation area and testing on larger network density it will expand the size of the covered area.
2. Analysis of the urban obstacles such as building, trees and basic urban infrastructure which cause congestion in the wireless channel which result in disconnection.
3. There are other parameters of interest as well, such as, link duration, number of connected period. There is a need to test our proposed system with these parameters.

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الخــلاصــة

مع التقدم الهائل في تكنولوجيا التنقل والشبكات ، اجتذبت الشبكات المخصصة للسيارات (VANETs) باحثين من الأوساط الأكاديمية والصناعية. تراعي الاتصالات المتنقلة وازدحام المرور وإدارة السلامة على الطرق التطبيقات التي تم إنشاؤها ضمن نموذج الشبكة. في أنظمة النقل الذكية (ITS) ، يعد التعاون بين المركبات أمرًا ضروريًا ؛ لتحسين أمن النقل وموثوقيته وإدارته. ومع ذلك ، فإن الحفاظ على شبكة متصلة جيدًا مع تدفق غير متوازن لحركة المرور على الطرق مهمة صعبة ؛ ومن ثم ، فإن أداء الشبكة يعتمد على وجود وحدة جانب الطريق (RSU) على طول الطرق.

تبحث هذه الدراسة في استخدام المركبات الديناميكية العادية للعمل كوحدة مؤقتة على جانب الطريق (RSU). يستخدم نظام تحديد المواقع العالمي (GPS) للحصول على معلومات موقع العقدة من المشاركين في الشبكة. يعتمد هذا المخطط بشكل أساسي على المركبات العادية ذات البنية التحتية الصفرية لتحسين اتصال الشبكة ، وذلك باستخدام موضع كل مركبة واتجاه حركة لتحديد ما إذا كان مرشحها الجيد للعمل كمركبة ترحيل أم لا. المخطط الذي يوفر اتصالات في كل مكان عبر الاتصال من مركبة إلى مركبة. يمكن الحصول على ذلك عن طريق إنشاء اتصال بين السيارة المصدر ، والتي تشارك في حادث ومركبات الترحيل المحددة. يتم تقدير أداء مخططنا من خلال سيناريوهين ، الأول هو سلوك اتصال الشبكة الثابت الذي يمثله قابلية الوصول للرسالة ، وبينما يكون السيناريو الثاني هو اتصال الشبكة الديناميكي ، فقد استخدمنا المقاييس التي تلتقط تباين اتصال الشبكة فيما يتعلق الوقت مثل مدة الاتصال ووقت إعادة الشفاء ووقت الاستلام.

من أجل تقييم أداء المخطط المقترح في ظل ظروف مختلفة ، تم النظر في سيناريوهات المحاكاة المختلفة من خلال التغيير إلى عدد مركبات الترحيل والمركبات العادية وكذلك سرعات المرحلات.

جمهورية العراق

وزارة التعليم العالي والبحث العلمي

جامعة الانبار

كلية علوم الحاسوب وتكنلوجيا المعلومات

قسم علوم الحاسبات

استخدام عقدة الابدال لتحسين ارتباط شبكات VANET

رسالة مقدمة الى قسم علوم الحاسبات – كلية علوم الحاسوب وتكنولوجيا المعلومات – جامعة الانبار وهي جزء من متطلبات نيل شهادة الماجستير في علوم الحاسبات

تقدمت بها

كرمل ضياء ابراهيم حميد

بأشراف

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