A Hybrid Broadcasting Technique Based on Message Priority in VANET

تقنية بث مهجنة بالأعتماد على اولويات الرسائل في الشبكات المخصصة للمركبات

BY

Alaa M. Alsaffar

Supervisor
Dr. Maamoun Ahmed

Master Thesis

Submitted In Partial Fulfillment of the Requirements of the

Master Degree in Computer Science

Faculty of Information Technology

Middle East University

July, 2014

إقرار التفويض

اني علاء محمد حسين الصفار أفوض جامعة الشرق الأوسط بتزويد نسخ من رسالتي للمكتبات او المؤسسات او الهيئات او الافراد عند طلبها.

الأسم : علاء الصفار

التأريخ : ٢٢/٧/٢٠١٤

التوقيع :

Authorization statement

I, Alaa Mohammed Husain Alsaffar, authorize the Middle East University to provide hard copies or electronic copies of my thesis to libraries, institutions or individuals upon their request.

Name: Alaa Alsaffar

Date: 22-7-2014

Signature:

Examination Committee Decision

This is to certify that the thesis entitled "A Hybrid Broadcasting Technique Based on Message Priority in VANET" was successfully defended and approved on July 22, 2014

Examination Committee Members	*Signature*
Dr. Mamoun Ahmed *(Committee Member and Supervisor)* *Assistant Professor* *Vice Dean Faculty of IT and Head of the Department of Computer Science* *Middle East University*	
Dr. Ahmad Kayed *(Chair)* *Associate Professor* *Dean Faculty of IT* *Middle East University*	
(External Examiner) **Dr. Mohammad A. Shkoukani** *Associate Professor* *Computer Science Dept.* *Applied Science Private University*	

Dedication

I dedicate this work to my father, my mother, and my sisters and for my friends and especially for my leader Dr. Maamoun Ahmed for their love, understanding and support; they were the light in my path. Without them, nothing of this would have been possible. Thank you for everything.

Acknowledgement

In the name of Allah the Most Gracious the Most Merciful My guidance cannot comeexcept from Allah, in Him I trust; to Him I repent, and to Him I praise and thanks always go.

I am heartily thankful to my supervisor, Dr. Maamoun Ahmed, whose encouragement, guidance and support from the initial to the final level enabled me to develop an understanding of the subject.

I am grateful of my parents and my family who are always providing help and support throughout the whole years of study. I hope I can give that back to them.

I sincerely acknowledge and express my appreciation to Dr. Hussein Al-bahadili Department of Computer Science Faculty of Information Technology Petra University, Dr. Ahmed Alkayed the dean of the faculty of Computer and Information Sciences for their support, concern and thankful help.

I offer my regards and blessings to all of those who supported me in any respect during the completion of the research.

Finally, I would thank my friends and all people who gave me support and encouragement.

Table of Contents

List of Figure

List of Tables

Abstract

Recently, Vehicular Ad-Hoc Networks (VANET) has grabbed the attention of researchers due to the importance of this type of networks in achieving Intelligent Transport Systems (ITS). VANETs are useful in both safety and non-safety applications where interchanging information between vehicles on the form of vehicle-to-vehicle (V2V) or Interface-to-vehicle (I2V) communication can help in reducing accidents or saving time and effort when searching for the closest fuel station for example.

Since its new birth, the field of VANET has its own problems that need to be addressed by researchers in order for this field to flourish and be commercialized globally. One of the challenges is the broadcasting management. The use broadcasting in VANET is important due to the high mobility of vehicles, the distribution of nodes within the network changes very rapidly and unexpectedly that wireless links initialize and break down frequently and unpredictably.

However, broadcasting should be managed and controlled in a way that prevents damaging problems such as broadcast-storm or increasing number of collisions between broadcasts. The problem that existed in basic flooding technique has been improved using other techniques such as the dynamic broadcasting technique; however, the latter has affected something else, like the delay. Therefore, this research proposes a new technique that tries to combine the best of both techniques. The new proposed Hybrid Broadcasting technique works on a way that takes the importance of messages to be broadcasted into consideration and therefore chooses the mechanism on which it relies to broadcast the messages.

The new technique has shown moderate performance between the two techniques due to the effect of using the basic flooding technique as part of it, which degraded the performance of the hybrid technique with regards to number of collisions, or message delivery ratio. However, in terms of delay, it has shown better performance than the dynamic technique therefore, the new technique has balanced between different metrics such as delay, delivery ratio, message loss, and other metrics in a way that lets the technique adapts in different scenarios easily and dynamically.

الخـلاصـة

في الاونة الاخيرة جلبت الشبكات المخصصة للمركبات انتباه الكثير من الباحثين لأهمية هذا النوع من الشبكات لتحقيق انظمة نقل ذكية. هنالك نوعان من التطبيقات المهمة والمفيدة بين المركبات وهي التطبيقات الامنة والتطبيقات الاقل اهمية وهذه التطبيقات تساعدنا على نقل المعلومات بين المركبات عن طريق الأتصال مابين مركبة ومركبة او مركبة ومحطة جانبية وذلك للتقليل من الحوادث المحتمل حدوثها او للحد من تفاقم الحوادث هذه من الناحية المهمة ولايجاد محطة تزود بالوقود كمثال لتطبيقات الاقل اهمية وتفيدنا هذه التطبيقات في توفير الوقت والجهد ايضا.

ان الشـبكات المخصصـة للمركبـات لـديها مشـاكلها الخاصـة التـي تحتـاج الـى معالجـة مـن قبـل البـاحثين فـي هـذا المجـال لكـي تزدهر عالميـا وتجاريـا. ان احـد هـذه المشـاكل او التحـديات التـي تواجـه البـاحثين فـي الشـبكات المتخصصـة بالمركبـات هـوه نظـام البـث الموجـود فـي هـذا النـوع مـن الشـبكات وان لهـذا النظـام اهميـة عاليـة مـن حيـث ان المركبـات لهـا القـدرة العاليـة علـى التحـرك بصـورة سـريعة وهـذا يـؤثر علـى توزيـع العقد ضمن الشبكه تاثيرا عشوائيا وسريعا والذي يؤدي ايضا الى كسر في عملية الاتصال.

ومع ذلك ينبغي ان تدار عملية البث بصورة جيدة لمنع المشاكل التي قد تحصل وتضر الشبكة مثل مشكلة عاصفة البث او يحدث تزايد في عدد الاصطدامات بين الحزم المبثه داخل الشبكة. وقد تحسنت المشكلة التي كانت موجودة في تقنية الفيضانات الأساسية باستخدام تقنيات أخرى مثل تقنية البث الديناميكية، ولكن هذه التقنية الا وهي تقنية البث الديناميكية تعاني من مشكلة التأخير، لذلك هذا البحث يقترح تقنية جديدة التي تساعد من جعل التقنيتان تعملان بطريقة متوافقة و جمع ماهو افضل بين التقنيات.

التقنية الجديدة المقترحة وهي تقنية البث الهجين والتي تعمل على اخذ اهمية الرسائل المراد بثها وبالتالي يتم اختيار الالية التي سوف تعتمد عليها عملية البث، وقد أظهرت هذه التقنية الجديدة وهي تقنية البث المهجن الأداء المعتدل بين الطريقتين وما هو الدافع من استخدام تقنية الفيضان كجزء منها والتي اثرت عليها من حيث عدد الاصطدامات او نسبة تسليم الرسائل ومع ذلك من حيث التأخير الا انها قدمت اداء افضل من تقنية البث الديناميكي، وان التقنية الجديدة قامت بالموازنه بين كلا التقنيات في مختلف الموازين والمقاييس مثل التأخير، معدل التوصيل، فقدان الرسائل، ومقاييس اخرى بطريقة تسمح للتقنية ان تتكيف مع العديد من السيناريوهات المختلفة بسهولة وشكل حيوي.

List of Abbreviations

Abbreviation	Meaning
VANETs	Vehicular Ad Hoc Networks
MANET	Mobile Ad Hoc Network
OBU	On-Board Unit
OSI	Open Systems Interconnection
WAVE	Wireless Access in Vehicular Environments
LAN	Local area network
WSM	Wireless short message
WSMP	WAVE short message protocol
IPv6	Internet Protocol version 6
TCP	Transmission Control Protocol
UDP	User Datagram Protocol
IETF	Internet Engineering Task Force
V2V	Vehicle-to-vehicle
V2I	Vehicle-to-Infrastructure
EEBL	Emergency electronic brake lights
ETC	Electronic Toll Collection
FCC	The Federal Communications Commission
DSRC	Dedicated Short Range Communication
ITS	Intelligent Transportation Systems
CCH	Control Channel
SCHs	Service Channels
GPS	Global Positioning System
DV-CAST	Distributed Vehicular Broadcast
Hi-CAST	Hybrid intelligent broadcast algorithm
TMDA	Traffic Message Delivery Algorithm
WBSS	WAVE-Basic Service Set
WSAs	WAVE Service Advertisements
CSMA/CA	Carrier Sense Multiple Access/Collision Avoidances

Chapter One

Introduction

1. Chapter One

1.1 Introduction

In the recent years the Vehicular Ad Hoc Networks (VANETs) became the most important class in Mobile Ad Hoc Network (MANET). Basically MANET is dynamic distributed system of wireless mobile nodes in which the nodes can move in any direction, independent of each other.Due to The increasing number of vehicles and their manufacturing evolution has made it necessary to embed smart system in order to ease communication between vehicles to disseminate the information, to improve vehicle, road safety, traffic efficiency, and to ensure the safety to both driver and passenger.

VANET differs from MANET by its highly dynamic topology since MANET and VANET use the same principles such as self-organization, self-management, low bandwidth, and short radio transmission range, but the protocols that are suitable and use for MANET is not suitable or use in VANET without modification(MahajanA. N. et al. 2013), yet the high dynamic VANET requires protocols calibration, and different Quality of Service (QoS) standards to deal with the high mobility of nodes.

Radio interface or On-Board Unit (OBU) must be equipped in vehicles that enable the formation of short-range wireless ad hoc networks. There are many protocols used to broadcast the information ‘packet’ (Zeadally S. et al. 2010). The Roadside Units or Roadside infrastructures (RSUs) are equipped with communication devices and it acts as the static node. RSU is linked to the centralized server located at the transport regulation authority. There are two interfaces in RSU, one for the wireless WAVE stack and the other one for external interfaces like wireline Ethernet that may be used to enable connectivity to the Internet. Also, each OBU may have two interfaces, one for the wireless WAVE stack and the other for sensor-connections and human interaction (R J. K. &A J. E. 2013).

Safety for passengers is considered asthe most important goal to be provided by VANET. Infra-structure or legacy client and server communication are not required to operate in the Ad-Hoc network. Each vehicle equipped with VANET device will be a node in the Ad-Hoc network and can receive and relay others messages through the wireless network. Multimedia and internet connectivity facilities are provided for passengers within the wireless coverage of each car. Automatic payment for parking lots and toll collection are other examples of possibilities inside VANET. The interactions with roadside equipment can likewise be characterized fairly accurately. Most vehicles as well are restricted in their range of motion, for example by being constrained to follow a paved highway (Dalal A. & Menaria S. 2012).

1.2 The Problem Definition

Traffic accidents are one of the daily problems that occur in all over the world; and led to loss life therefore it became a necessity to focus on this subject; of traffic accidents reduction. The evolution of vehicles manufacturing including VANET system became wide spread to provide connectivity between vehicles and the dissemination of emergency messages as well as other messages. In this case it became necessary to reduce collisions occurring between packets during the broadcast and re-broadcast by giving priorities for packets that need to be sent.

1- The problems that occurred as a result of blind broadcasting led to a lot of collisions between the packets that are transmitted to the vehicles. The high proportion of collisions led to a failure in the delivery of the packets and the important information not to be transmitted correctly between all nodes.

2- Existing protocols in broadcasting and re-broadcasting led to the delay of high-priority messages and put them in the same status with the least priority messages and sometimes delaying emergency messages.

1.3 Research Questions:

1. Will a hybridization technique between the flooding and dynamic protocols enhance the broadcasting process in VANET?
2. Does assigning priorities to messages accelerate the process of broadcasting emergency messages?
3. Does the use of the suggested protocols help in the development of VANET?

1.4 Objectives

The main objective of this research is to prioritize messages based on their urgency in order to improve broadcasting in VANET. This research will reduce packets collisions occurring from blind broadcasting. The prioritizing process will lead to designing a hybrid broadcasting technique that should reduce collisions. For example when an accident occurs between vehicles it will cause traffic congestion. In this case messages will be transmitted to inform the vehicles in a certain range of area of the congestion and the message will be set as high priority to be broadcast. If there are other less-important notifications, such as gas station or shopping places; they will be set as less priority.

1.5 Motivation

With an increased number of vehicles and the escalating number of road traffic accidents raised the attention to help in reduction of the losses caused by accidents. There should be a way to help saving people's lives.

Maintaining public and road safety should be focused on. The outcomes of the hybrid broadcasting technique will ensure getting the desired results.

1.6 Proposed work

The proposed work aims to create a hybrid broadcasting technique to manage the broadcasting in VANET by using both broadcasting protocols: flooding & dynamic broadcasting. It also classifies the messages based on their urgency of the message itself as a key to distinguish between using flooding broadcast and dynamic broadcast. The proposed work shown in figure 1.1.

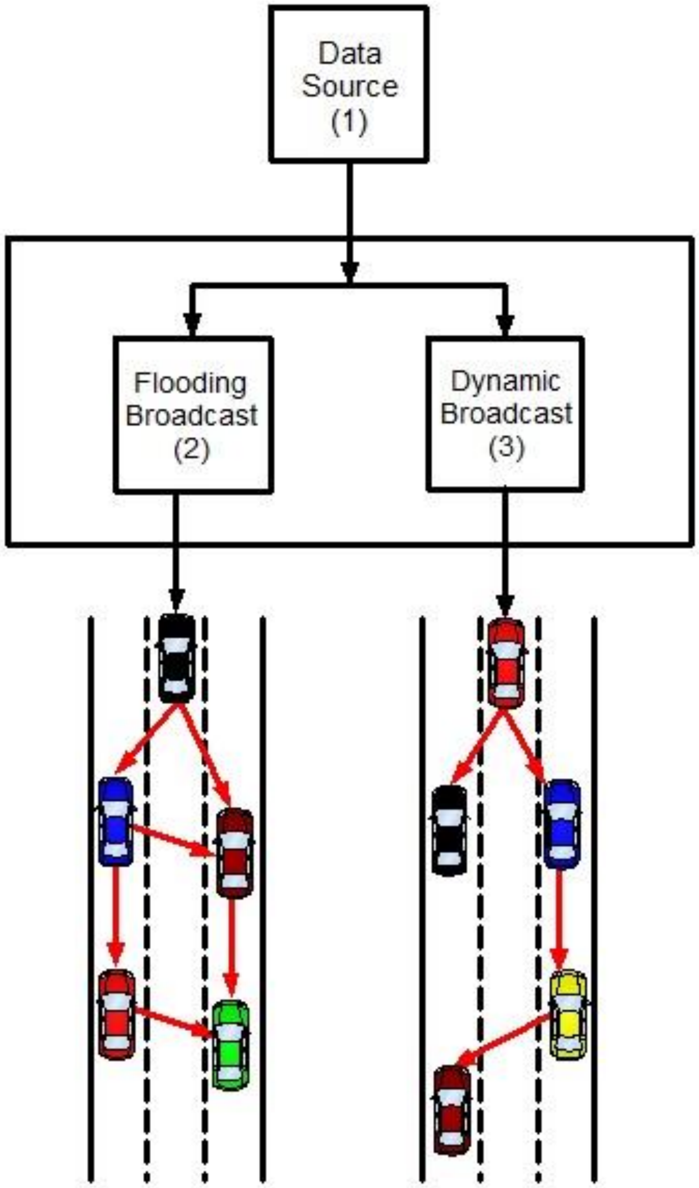

Figure1.1 the Proposed Work

1.6.1 Data Source

It is considered to be a provider for the road situation and information like high priority messages such as road accidents, on the other hand; less priority messages information to be provided; such as the weather and fuel stations.

1.6.2 Flooding Protocol

Blind broadcasting or blind flooding is the simplest broadcasting protocol in VANET. In this protocol; a packet that is received from the adjacent nodes within the same range will be transmitted. After transmission; each node verifies if the packet was sent previously or not, if not sent; the node has to broadcast it, otherwise the node will not broadcast the packet Figure 1.2. This procedure helps ensuring sending packets rapidly and being received by the other node (M.Chitra 2013).

Flooding ensures the full coverage for the entire network. It guarantees broadcasting the packet to every node in the network. This flooding generates many redundant broadcasts. Every node will send copies of the same message (Kumar V. & Bansal M. 2011).

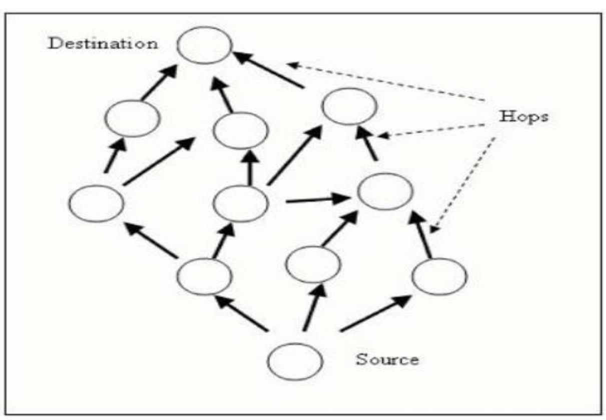

Figure1.1 Flooding Protocol

(Lo Cigno R. A. & Segata M. 2011).

1.6.3 Dynamic Broadcasting

Dynamic calculations for the waiting time must be taken of a vehicle according to the number of neighboring vehicles and distance to source depending on local density and distance that can reduce the number of unnecessary broadcast messages in Vehicular Ad Hoc Network by uses a periodic hello packet beaconing to select the optimal forwarder node under different traffic flow. This technique Intended to evaluate the performance in terms of reachability and reliability, it is requires a GPS inside the vehicle to locate the vehicle position, create a connection between them. The farthest vehicles with a large number of neighbors rebroadcast the packets as quickly as possible but the vehicles with low number of neighbors have to wait according to Equation (1) as shown below that use to calculate the waiting time and receive more duplicate packets. That will help to avoid unnecessary retransmission. This algorithm has been compared with simple flooding and using a random waiting time in terms of collisions account reachability and network overhead (Najafzadeh et al. 2013).

$$Wt = \left(1 - \frac{d_{ij}}{R}\right)^{nn} Wt_{\max}$$

The notation of waiting time formula as follow:
nn: Number of Neighbors in message direction
d_{ij}: The Distance of Vehicle i to vehicle j
R: Transmission Range
$Wt_{\max}$: Maximum Waiting Time

Equation (1) (Najafzadeh et al. 2013)

1.7 VEHICULAR NETWORKS CHALLNGES

There are many challenges facing the VANET As shown in figure 1.3

1.7.1 Mobility

The Ad Hoc Networks it is mean that each node in the network is mobile, and can move from one place to another inside the coverage area, the moving of nodes in Vehicular Ad Hoc Networks in high mobility, vehicles will make connection with another vehicles that maybe never faced before, this connection lasts for few seconds as each vehicle goes in different direction, and these two vehicles may never meet again. (Mehta K. 2012).

1.7.2 Volatility

The connectivity between nodes can be highly ephemeral, these connections will be lost as each car has a high mobility, and maybe will travel in different direction. Vehicular networks lack the relatively long life due to the fast changes in the network topology, so – for example - personal contact of user’s device to a hot spot will require long life password and this will be impractical for securing Vehicular connections (Mehta K. 2012).

1.7.3 Network Scalability

The scale of this network in the world approximately exceedingmillions of nodes, and this number is growing up, another problem will appear when it is known that there is no a global authority control the standards for this network (Mehta K. 2012).

1.7.4 Bootstrap

Only few number of vehicles will be have the equipment required for the OBU, so if we make a communication between vehicles it must have to assume that there is a limited number of vehicles that will receive the communication, in future we must focus on getting the number higher to get a communication between all vehicles (Mehta K. 2012).

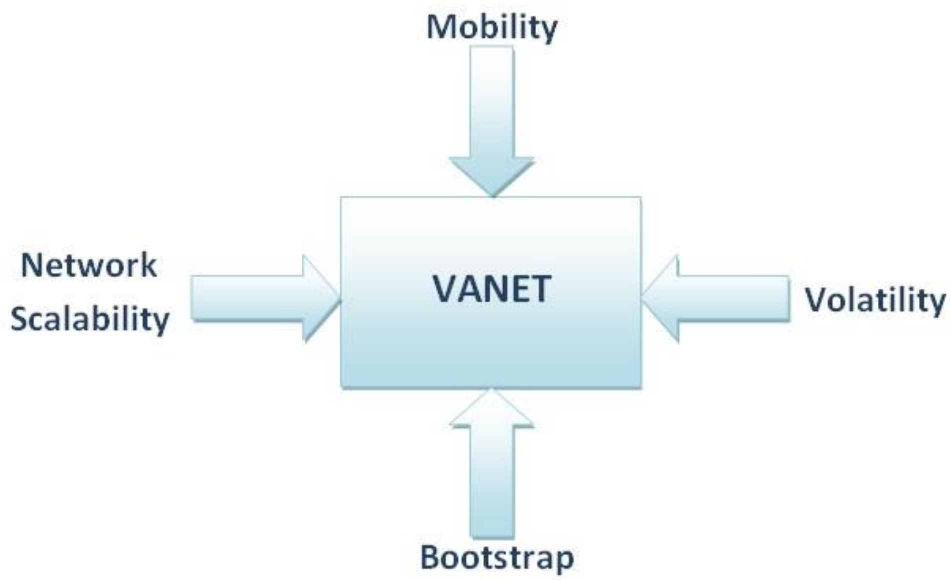

Figure 1.2 VEHICULAR NETWORKS CHALLNGES

1.8 Broadcasting in VANET

Broadcasting in general refers to a method of transferring a message to all nodes simultaneously in the area covered. Broadcasting in VANET received attention of researchers. There is difference between broadcasting in VANET and broadcasting in MANET due to several reasons, such as mobility patterns, network topology, traffic patterns and demographics at different times.

Emergency traffic, weather, road data among vehicles and delivering advertisement and announcements are shared and may be the applications relying on broadcast in VANET. Because of the movement of vehicles at high speeds in VANETs, frequent dynamic changes in topology are exchanged which results in changes in routing information. Assistant traffic condition messages can be disseminated in VANETs to all vehicles within a certain geographical area. Flooding is one of the easy ways to apply a broadcast service in which each vehicle rebroadcast messages to all the nodes surrounding it; except for the one it received from.

Flooding assures that the message will reach all the nodes; which mean vehicles in the network. (Mahajan A. N. et al. 2013). Three important regimes of operation in VANETs should be emphasized there are: the Dense Traffic Regime when the traffic density is above a certain value, Sparse Traffic Regime the traffic density might be so low, and Regular Traffic Regime For both sparse and dense traffic scenarios (Tonguz O. et al. 2008).

There are many broadcasting protocols in VANET as show in figure 1.4that organize the process ofcommunications hence, the data transmission between vehicles.

Broadcasting usually produces collisions that occur during broadcasting of messages; our research aims to help in reducing collisions by prioritizing messages based on their urgency and the designing a hybrid broadcasting technique that combines two broadcasting protocols: flooding anddynamic broadcasting protocols in order to deal with the prioritized messages.

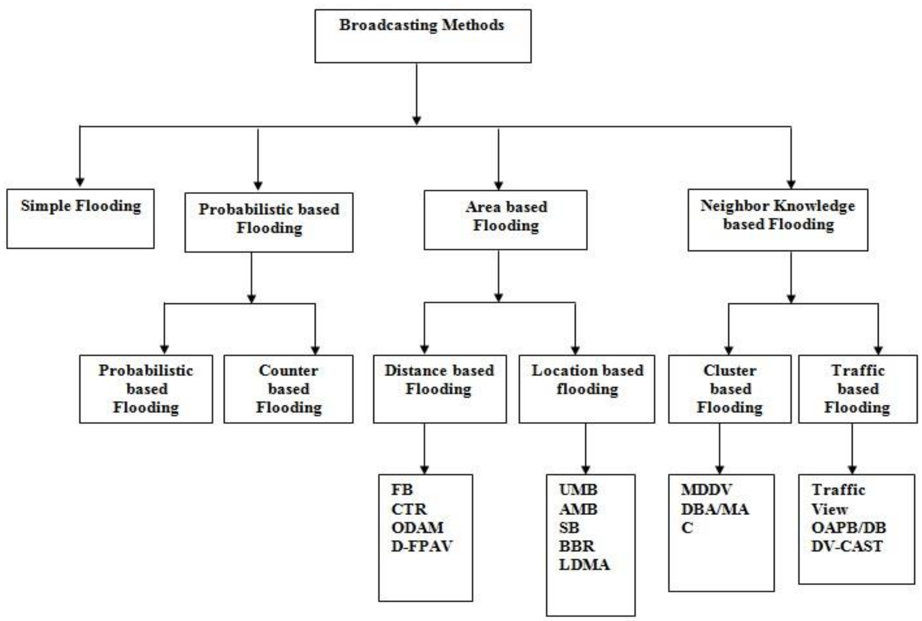

Figure1.3Broadcasting Protocols

(Chitra M. et al. 2013).

1.8.1 Classification of broadcasting protocols

As shown in Figure 1.5, the broadcasting protocols can be classified into two types based on the safety of the applications that related to the network:

1. Reliable Protocols – Collision avoidance – safety applications
2. Dissemination Protocols – Traffic Management– Non-safety applications

The Reliable Protocols also can be classified into three typesFigure 1.5:

1. Rebroadcasting Protocols
2. Selective Acknowledgement Protocols
3. Changing transmission parameters

The dissemination Protocols also can be classified into two typesFigure 1.5:

1. Flooding Protocols
2. Single Relay protocols

The safety related applications in VANET demand time-critical and reliable broadcasting protocol. The reliable routing protocol can deliver the emergency message from the source vehicle to all the vehicles in the entire network with low latency time. The performance of the reliable routing protocol is measured based on the success rate of the message delivery, and time taken for latency in a single broadcast phase. The success rate of the message delivery can be increased by three methods:

1. Rebroadcasting the message
2. Selective Acknowledgement
3. Changing transmission parameters

Retransmitting the same broadcasted message is called as the rebroadcasting policy. Here the challenge is that how the rebroadcasting is to be done and how many times the rebroadcasting should happen (R J. K. & A J. E. 2013).

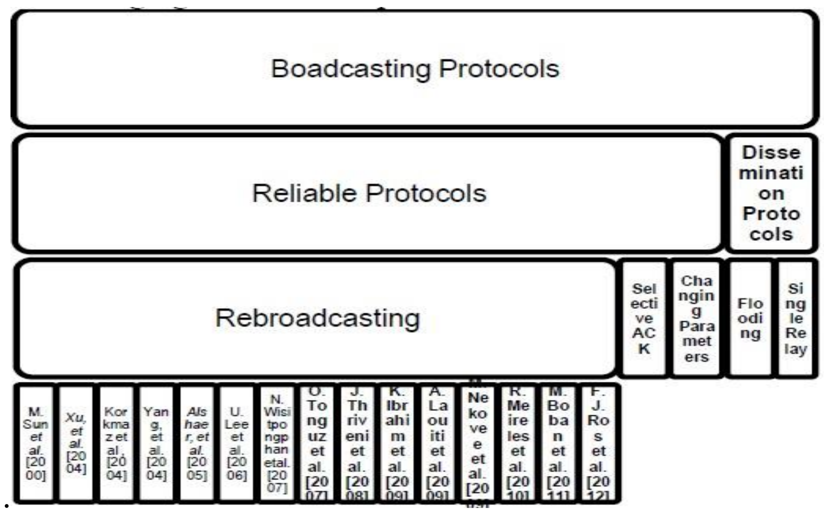

Figure1.4 broadcasting Classification

(R J. K. & A J. E. 2013).

1.9 Message priorities in VANET

Message priorities are used to classify the importance and urgency of each message. In VANET messages are packets of road information sent from a vehicle to another. Priorities should be assigned to these messages. The priorities, are assigned to a message, are based on how urgent it is. Message priorities in VANET differ from one to another two factors should be taken into consideration: delay and reliability. For example, when an accident occurs, messages related to the accident will be transmitted and messages must be transmitted immediately with high reliability and low delay. Therefore, these messages should have a higher priority compared with congestion related messages created during a traffic congestion period (Suthaputchakun C. & Ganz A. 2007).

1.10 IEEE 802.11 AND 802.11P

There are several things that IEEE 802.11 protocol based on it like CSMA/CD and inter-frame spaces, which used in both IEEE 802.11b and 802.11g. These are used by simulation of VANET. The wireless communication standard IEEE 802.11 operates in the centralized mode. IEEE 802.11b data rates can reach 11Mbps, but in exercise it can reach 7.5 Mbps only. IEEE 802.11a uses the 5 GHz frequency, the theoretical maximum throughput is 54 Mbps practically it is only 24Mbps. The IEEE group has developed a new PHY/MAC it is the 802.11 standard, which is designed just for VANET. The Wireless Access in Vehicular Environments (WAVE) suggests the IEEE 802.11p is suitable for the High speed in Vehicular communication. Because of in MANET the nodes move in random and in normal speed but in the VANET the moving of the nodes in a high speed. One of the main functions of IEEE 802.11 standard in VANET Environment is each vehicle checks the transmission medium before transmitting the packets. If the medium is empty for particular duration of time the vehicle can transmit the packet directly. If not it retransmits the packets after some time. The 802.11b is the most popular wireless technology which uses 2.4 GHz band. The requirement of this modification is based on the vehicular safety concepts, communication between V2V and V2I(Ramakrishna B. et al. 2010).

At the MAC layer, WAVE uses CSMA/CA as the basic Medium Access Scheme. The Dedicated Short Range Communication (DSRC) at 5.9 GHz specify band for the ITS communications uses the IEEE 802.11p, which is now called Wireless Access in Vehicular Environments (WAVE). The most important requirements for a MAC protocol for VANET are the low Latency and High reliability. Shown in Figure1.6.

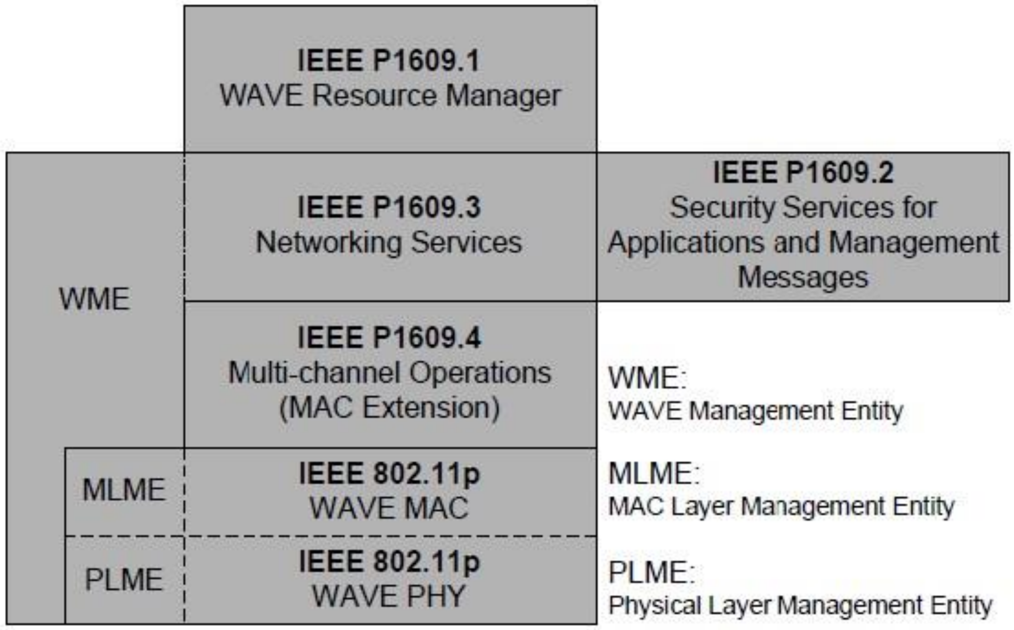

Figure 1.5 IEEE

(Zang Y. et al.).

1.11 Outline of the thesis

This thesis will be included six chapters in the first chapter will give an overview of the VANET as different from MANET and what are the challenges most often, also to identify the IEEE protocol which is compatible with VANET, identify the types of existing applications Safety and Non-Safety applications that deal with VANET, also talk about the importance of broadcast messages and the priorities of messages, Finally explain the problem definition of thesis, motivation and the proposed work. In second chapter will include the previous studies and research. In the third chapter the new hybrid broadcasting technique will be introduced and explained in details. The fourth chapter includes Methodology and Implementation. The fifthchapterresults of simulations will be shown. In sixth Chapter the conclusion and future work.

Chapter two

Background and Literature Review

2. Chapter two

2.1 Literature Review Introduction

There are many methods and techniques used to reduce the packet collisions resulting from blind broadcasting in VANET. This is a summary of some of the techniques that are being developed and used in this area:

Message priority was proposed; which is assigned according to the message urgency to increase the communication reliability also apply a repetitive transmission mechanism that provides reliability differentiation for each priority message and show the adaptation of IEEE 802.11e in VANETs with different message priorities (Suthaputchakun C. & Ganz A. 2007). A complete version of a multi-hop broadcast protocol for VANET was implemented. The difference between broadcasting in VANET and broadcasting in MANET. Explaining the three different regimes that a vehicular broadcast protocol depends on. A proposed model was designed to deal with extreme situations. Distributed Vehicular Broadcast (DV-CAST) protocol integrates the use of various routing solutions(Tonguz O. et al. 2008).

Hybrid intelligent broadcast algorithm was proposed for alert message broadcasting which is called Hi-CAST algorithm aim to deliver the alert message effectively, this algorithm uses delay and probabilistic broadcast protocols together with token protocol. Calculate the Rebroadcasts degree of the alert message according to the fuzzy control rules (Bae H. 2011). A simple and flexible design and new broadcasting protocol for VANET was produced to reduce overhead, increase in the rates of receive the packets, reduce the collision and packet loss in broadcast the message, improvement in the reliability and performance of the network. It was accomplished by how to find the next forwarder node in an efficient way(Mahipal. et al. 2012).

A study and comparison between the three types of regimes in VANET were presented. Dense Traffic Regimes, Sparse Traffic Regimes, and Regular Traffic Regimes. The three performance parameters Reliability, Overhead, and Speed of Data Dissemination were described to define the extreme traffic situation(Singh Y. & Sharma A. 2012). A broadcast protocol improves the rate of receipt of broadcast messages depends on where each unit has the ability to identify network congestion by sequential numbers that are resulting from the number of packets received recently. Based on the percentage that has been received properly in the last few seconds. Thus be able to tell the extent of overcrowding and it improves performance. The contention window can increase the reception rate of broadcast frames when there is normal and moderate network traffic, which is desired in VANET(Awasthi S. & Singh A. 2013).

New broadcast-based message delivery approach termed the Traffic Message Delivery Algorithm (TMDA) was presented; which is based on several broadcast algorithms forwarding, position-based and delay-based and also contains information on traffic, TMDA aim to reduction the effect of the broadcast storms by control the dissemination instead of re-send broadcast messages randomly (Li Y. et al. 2013). A broadcasting type was presented and a number of broadcasting protocols were explained and how they work and how they help to meet the requirements of VANET **(**Tirmare P. & Mule B. 2013). A broadcasting technique for safety a message was presented that dynamically adjusts waiting time of a vehicle dependson the number of neighbor vehicles and distance to source. And evaluate the performance compared with the flooding protocol (Najafzadeh S. et al. 2013). A comparison between number of broadcast protocols and clarify its advantages and disadvantages, explain broadcast storm problem broadcast suppression techniques for broadcasting in VANET to avoid unnecessary loss of information during broadcasting (Chitra M. & Sathya S. 2013).

A new adaptive approach was proposed allowing the increase of efficiency of the warning message dissemination processes; using the urban environment information where the vehicles are moving. It can identify the vehicles which are in the dangerous position and immediately send a warning message to that dangerous position vehicle. This approach makes all the available information used efficiently. The Profile-driven Adaptive Warning Dissemination Scheme (PAWDS) is designed to improve the warning message dissemination process. PAWDS system dynamically modifies some of the key parameters of the propagation process and it cannot detect the vehicles which are in the dangerous position. The proposed system identifies the vehicles which are in the dangerous position and sends warning messages immediately. The vehicles must make use of all the available information efficiently to predict the position of nearby vehicles. (R S. & R G. 2014).

An optimal protocol was presented for the broadcast of safety messages in VANETs. Optimality, in terms of delay and transmission count, is achieved using a broadcast strategy that exploits opposite vehicles. To carry out reliable and efficient broadcast coordination, intelligent periodic rebroadcasts, which effectively adapt our protocol to sparse and dense networks, are proposed. Simulations are conducted and results were presented to show that it has a better performance over existing competing protocols that were previously proposed. An optimal multi-hop broadcast protocol for vehicular safety. Simulations show the optimality of OCast compared to similar solutions. It can ensure robustness and guarantee desirable performance of high message delivery ratio, limited latency and acceptable communication overhead under different traffic dens (Benaidja A. et al 2013).

A topology-transparent broadcast protocol was presented detailing mathematical analysis for obtaining the probability of success and the average delay. It was shown, by analysis and simulations, that the proposed protocol outperforms two existing protocols for vehicular networks with topology-transparent properties and provides reliable broadcast communications for delivering safety messages under load conditions deemed to be common in vehicular environments. In most parts of the simulations, messages with length 200B are issued from each vehicle approximately 5 times per second. Message frequency of approximately 5 messages with length 100B (per second per user) is sufficient for communicating position and other useful information. After adding different overheads, the message length did not exceed 200B assumed in the simulations. With the described load characteristics, it was shown that POC-based broadcast can reliably deliver safety messages with low delay. Furthermore, POC-based broadcast performs noticeably better than random repetition broadcast protocols, namely, SFR and SPR. It was concluded that POC-based broadcast provides good performance in vehicular environments. (Farnoud F. & Valaee S. 2009)

2.2 Background

2.3 The OSI Open Systems Interconnection layer in VANET

OSI Includes five layers as shown in figure 2.1 dividing the entire problem space into multiple layers, with good defined interfaces between layers, promotes scalability, structured design, and technical evolution

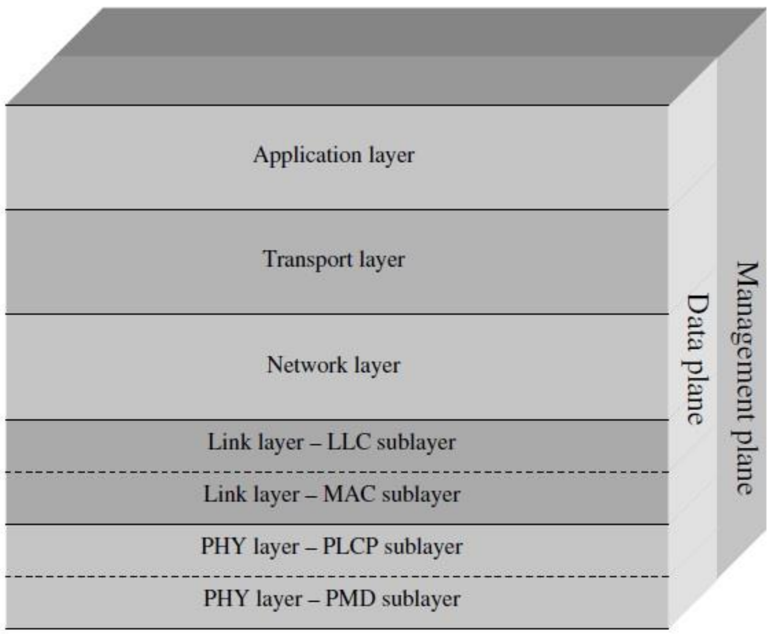

Figure 2.1 The OSI layer in VANET

2.3.1 Physical layer

The PHY protocol for the Dedicated Short Range Communication (DSRC) is following the standardization protocols of the IEEE standards association. The modification of the popular IEEE 802.11 WLAN standards is done to support the DSRC communication. This modification, once done, is referred to as 802.11p wireless access in vehicular environments (WAVE), and will at the end be incorporated into a future release of the baseline 802.11 standards (Hartenstein H. & Laberteaux K. P. 2010).

2.3.2 Link layer

The IEEE 802.11p wave amendment also defines the MAC sub layer of the link layer of the link layer. The LLC sub layer of the link layer will use the existing, stable IEEE 802.2 standard. In a management environment, a MAC extension protocol defines how a device switches among the various DSRC channels allocated by the FCC. A separate IEEE standards working group, called the 1609, is working on developing this protocol, this group has an authority for a set of related standards referred to jointly as the 1609.x. the MAC extension protocol has a specifically designated IEEE 1609.4 multi-channel operation (Hartenstein H. & Laberteaux K. P. 2010).

2.3.3 Network and Transport layers

As in Figure2.2 Safety applications and non-safety operations are supported by different set of protocols. The IEEE 1609.3 Networking Services standard defines a message, the WAVE short message (WSM), and a protocol, the WAVE short message protocol (WSMP), to support network and transport layer functions for DSRC safety applications. The 1609.3 standard also defines a message called the WAVE service advertisement (WSA), which is used to advertise the availability of one or more DSRC services at a given location. A WSA might be used, for example, to advertise a traffic information service offered by an RSU. The IEEE 1609.2 Security Services standard defines the encrypting and authenticating mechanisms for data plane WSMs and management plane WSAs. Non-safety applications can also use WSMP, but in most cases are supported through a conventional Internet stack above layer 2. In particular, network layer services are provided by the Internet Protocol version 6 (IPv6). Transport layer services for non-safety applications utilize the familiar Transmission Control Protocol (TCP) or User Datagram Protocol (UDP). All three of these protocols: IPv6, TCP, and UDP are quite stable, and are defined by the Internet Engineering Task Force (IETF) (Hartenstein H. & Laberteaux K. P. 2010).

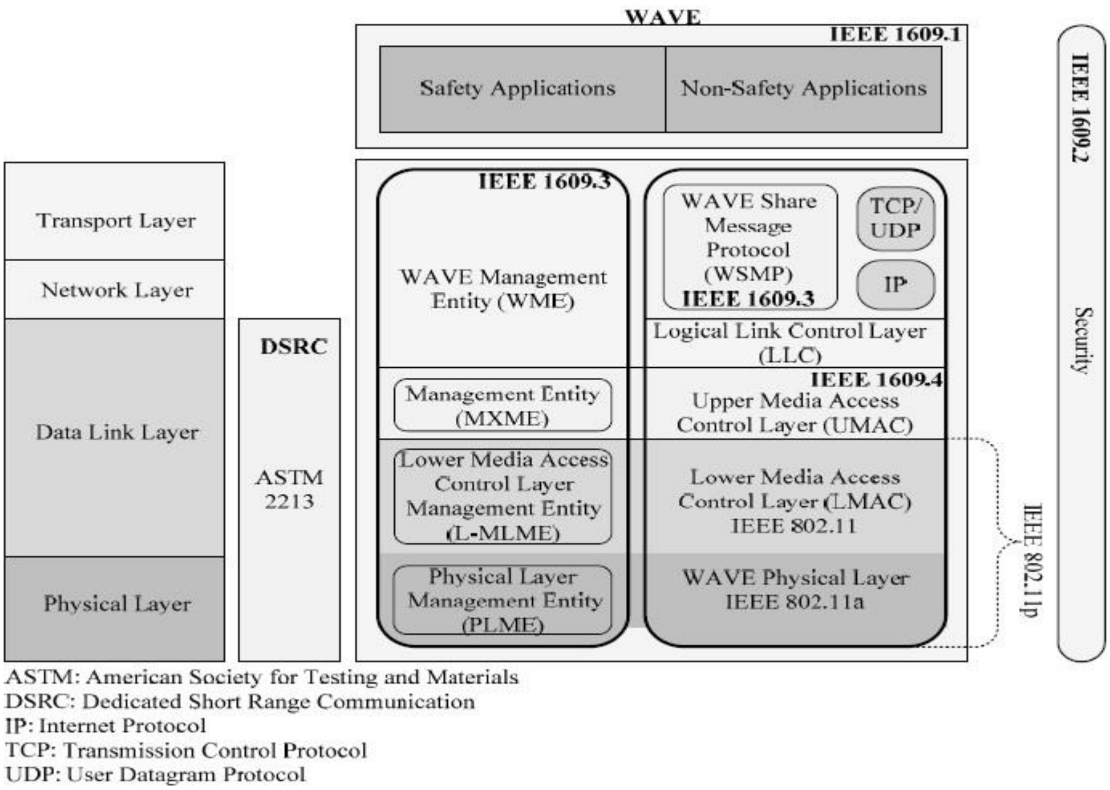

Figure 2.2 WAVE protocol architecture

(Zeadally S. et al. 2010).

2.3.4 Application layer

Application layer protocols have unlimited variations. In particular, most non-safety applications that can run over the Internet can also run over a DSRC communication system (which may have a backhaul link into the Internet). Some of these protocols are covered by some well-established standards. Others will be the subject of future standardization efforts or will be proprietary. Safety applications will likely have both a standard portion and a proprietary portion. The standard portion includes a common message format for conveying the state of a vehicle, an intersection, or other relevant information. The SAE DSRC technical committee is working on developing the J2735 Message Set Dictionary standard in order to define message formats (Hartenstein H. & Laberteaux K. P. 2010).

2.4 VANET Applications

There are over one hundred recommended applications of VANETs. These applications are of two groups it is safety and non-safety applications related. They can be classified into V2V or V2I applications. This is a list of some these applications(Elumalai P. & Murukanantham P.).

(Figures from 2.4 to 2.14: (Taha M. M. I. 2008))

2.4.1 Safety application

Safety applications can play an important role in reducing the number of accidents. More than 50 percent of the accidents can be avoided if the driver is informed with a warning half a second before the moment of accident.

A. Emergency electronic brake lights

The (EEBL) one of the important safety application in VANET. Every vehicle is equipped with brake lights which warn the vehicle that in the back there is an activation of brakes by the front driver. But they suffer of two problems. The first problem is that the brake light gives no quantification it does not tell if the driver is pushing lightly or strongly on the pedal. The second one is visibility in the case of fog it is difficult on the driver to see the brake light of the front vehicle making it difficult to avoid a crash. example, as shown in Figure 2.3,when a large vehicle is between two cars, if the first car breaks suddenly the second one will not see the brake light of the car in front because of large vehicle between them. The EEBL application must broadcast warning messages. These messages should provide information about the braking vehicle, such as speed, acceleration; position (Lo Cigno R. A. & Segata M. 2011).

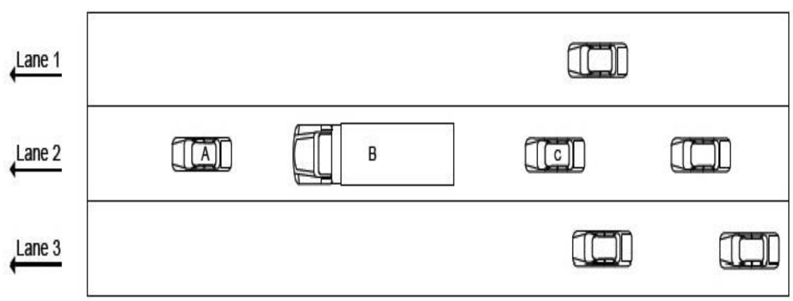

Figure 2.3 the EEBL

(Lo Cigno R. A. & Segata M. 2011).

B. Co-operative Collision Warning

Co-operative collision warning is a V2V safety application, in case of any sudden change in speed of vehicle or driving direction, the vehicle is considered abnormal and broadcasts a warning message to warn all of the vehicles in the back of the probable danger like Figure 2.4.This application requires an efficient broadcasting algorithm with a very small latency.

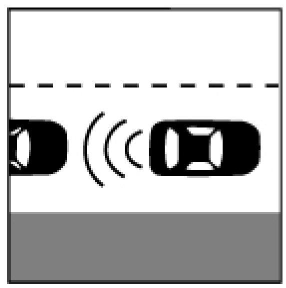

Figure 2.4 The Co-operative Collision Warning

C. Lane Change Warning

Lane-change warning is a V2V safety application in Figure 2.5, a vehicle driver can warn other vehicles of his desire to change his traveling line and to make sure there is an enough space for his vehicle this helps to avoid hit the other vehicle on the other line, this application depends on broadcasting.

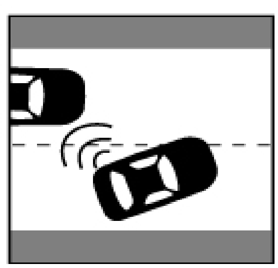

Figure 2.6 The Lane Change Warning

D. Intersection Collision Warning

Intersection collision warning is one of the V2I safety applications. At intersections a centralized node warning there is an approaching vehicle it is possible of accidents and assists them to determining the proper approaching speed as shown in Figure 2.6. This application uses only broadcast messages.

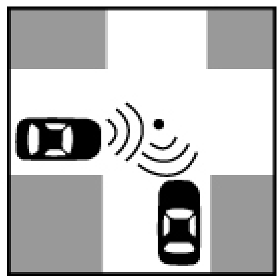

Figure 2.7 the Intersection Collision Warning

E. Approaching Emergency vehicle

Incoming emergency vehicle is a V2V public-safety application, high-speed emergency vehicles (ambulance or police car) Figure 2.7, can warn other vehicles to clear their line. This application depends on broadcasting.

Figure 2.8Approaching Emergency vehicle

F. Rollover Warning

Rollover warning is a V2I safety application. A RSU can alert us that at critical curves ahead by broadcast information about curve angle and road condition, in Figure2.8 approaching vehicles can determine the maximum possible approaching speed before rollover.

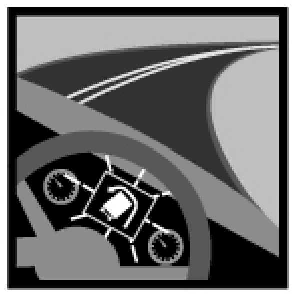

Figure 2.9 the Rollover Warning

G. Work Zone Warning

Work zone warning is a V2I safety application. A RSU can alert the vehicles that at work zones ahead to warn incoming vehicles of the possible danger and warn them to decrease the vehicle speed and change the driving line as shown in Figure 2.9.

Figure 2.10 the Work Zone Warning

2.4.2 Non-safety application or User Application

User applications can provide to the road users some information like entertainment services, advertisements etc. Some applications are related only to user entertainment and cannot be linked to safety applications. The main role of the user applications is to provide the comfort to the passengers (Elumalai P. & Murukanantham P.).

A. Coupling/decoupling

Coupling/decoupling system is a V2V non-safety application that is designed to link multiple buses or trucks and make them like a train to minimize the headway distance and time of the traveling and to decrease crashes like Figure 2.10.

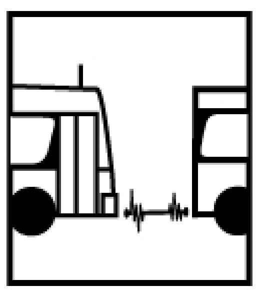

Figure 2.11 the Coupling/decoupling

B.Inter-Vehicle Communications

Inter-vehicle communication is a V2V non-safety application that enables passengers to communicate with each other using instant as shown in Figure 1.11, voice chatting and even video chatting.

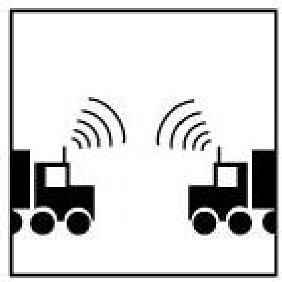

Figure2.12 the Inter-Vehicle Communications

C. Electronic Toll Collection (ETC)

Electronic toll collection is one of the V2I non-safety applications that support the collection of payment using automated systems to increase the operational efficiency. Systems typically consist of OBUs that are chargeable with prepaid smart cards. These OBUs are identified by RSUs located in places allocated to them. ETC was the first widely accepted DSRC application and it is practically implemented in many toll collection sites Figure 2.12.

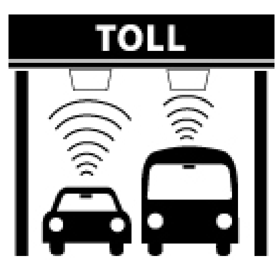

Figure2.13 the Electronic Toll Collection (ETC)

D. Parking Lot Payment

Parking lot payment is one of the V2I non-safety applications that provide benefits to parking operators, simplify payment for customers, and reduce congestion at entrances and exits of parking like Figure 2.13.

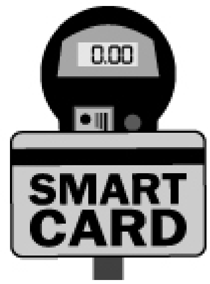

Figure2.14 Parking Lot Payment

E. Traffic Management

The navigation system inside the vehicle is one of the non-safety applications that are designed to reduce driving time and fuel consumption by exchanging real-time information about traffic conditions and road information in the driving route shown in Figure 2.14.

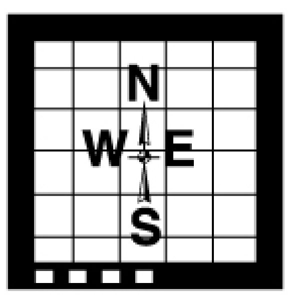

Figure2.15 Traffic Management

2.5 The Federal Communications Commission (FCC)

The Intelligent Transportation Systems (ITS) considered Vehicular Ad Hoc Networks (VANETs) as an important communication infrastructure (Chitra M. et al. 2013). The communication between the vehicles is based on short-range wireless communication for example IEEE 802.11. [1]The Federal Communication Commission (FCC)[2] has allocated 75 MHz in 5.9 GHz band for Dedicated Short Range Communication (DSRC). For vehicles in a Vehicle Network; DSRC was conceived to provide the architecture to allow communication with each other and with infrastructure (Najaonfzadeh S. et al. 2013). One of the seven frequency channels is nominated as the Control Channel (CCH) this channel only used for safety applications and for system management, the other six channels are used for Service Channels (SCHs), mainly for the support of non-safety applications as shown in Figure 2.15.

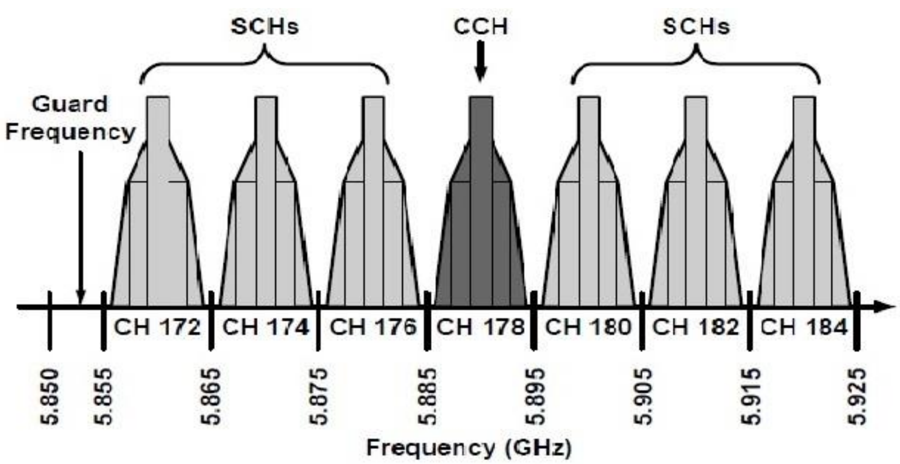

Figure2.16CCH & SCHs

(Zang Y. et al.)

[1] http://standards.ieee.org/getieee802/download/802.11-2012.pdf
[2] http://www.fcc.gov/

Therefore, safety applications are categorized into two types: Periodic (Beacons) and Event-Driven safety messages

2.5.1 Periodic (beacon)

The periodic safety message exchange is preventive in nature, and its objective is to avoid the occurrence of dangerous situations, such as collision avoidance, driver assistance, and cruise control. The periodic safety message may contain information regarding the position, direction, and speed of vehicles (Campolo C. et al. 2011).

2.5.2 Event-driven safety messages.

The event-driven safety message may be generated as a result of a dangerous situation or when an abnormal condition is detected such as road accident. The event-driven safety messages disseminated within a certain area with high priority. The event-driven safety messages require low latency and reliable deliver. Besides event-driven safety-related data there are two types of messages that can be periodically transmitted over CCH: short status messages (beacons) and WBSS (WAVE-Basic Service Set) establishment and advertisement messages (WAVE Service Advertisements, WSAs) WSAs are sent to advertise and the related parameters a WBSS set-up that provides connectivity transport of non-safety services during the SCH interval. (Campolo C. et al. 2011).

Chapter Three

The Proposed Hybrid Broadcasting Technique

3. Chapter three

3.1 Introduction

In this chapter, the new hybrid broadcasting technique will be introduced and explained in details, the algorithm by which we combined both flooding and dynamic broadcasting techniques will be discussed. The advantages and limitations of the algorithm will also be pinpointed in order to leave the space for future researchers to follow and enhance the advantages, and overcome the limitations.

3.2 Why hybrid

Following the literature review in chapter 2, the reader can conclude the following:

A- In the basic flooding technique, the broadcasts can reach up to 100% of the network in most of the times (reachability) in the least delay times, since the flooding requires no calculations prior to starting the broadcasting process. However, flooding technique suffers from redundancy and collisions and leads to broadcast storm problem which is the problem resulted when attempting to send a message to all nodes by forcing them to rebroadcast the message. The advantage of this technique then is the low delay time, which can be utilized in our hybrid broadcasting technique as to be shown later in this chapter.

B- The dynamic flooding technique - on one hand - helped to solve the problems related to broadcast storm, on the other hand, this technique relies on calculating what is known as "waiting time", which was defined in chapter 2. The waiting time calculations add to the total delay which affects the applications that are time-critical.

Therefore, considering the advantage of a technique overcomes the limitations of the other and vice versa. This led to proposing the hybrid broadcasting technique which takes into consideration the importance of the message itself, also known as *access category*, or *priority*

3.3 Message Priority

The WAVE protocol through its physical layer (standardized as IEEE 1609.4) (Chen Q. et al. 2009) Provides what is known as *AccessCategory*(AC)which is eight levels of priorities as defined in the standard IEE4E 802.1D (IEEE Computer Society Sponsored 2004) The eight priority levels and their mapping to traffic classes are as shown in table 3.1 (matter of fact that the levels are 7, the eighth is left for traffic of more importance than background but less importance than best effort)

Number of Queues	Traffic Types							
1	BE (EE, BK VO, CL, VI, NC)							
2	BE (EE, BK)				VO (CL, VI, NC)			
3	BE (EE, BK)				CL (VI)		VO (NC)	
4	BK		BE (EE)		CL (VI)		VO (NC)	
5	BK		BE (EE)		CL	VI	VO (NC)	
6	BK		BE	EE	CL	VI	VO (NC)	
7	BK		BE	EE	CL	VI	VO	NC
8	BK	—	BE	EE	CL	VI	VO	NC
User Priority	1	2	0	3	4	5	6	7

BK = Background
BE = Best Effort
EE = Excellent Effort
CL = Controlled Load

VI = Video (<100 ms latency and jitter)
VO = Voice (<10 ms latency and jitter)
NC = Network Control

Note: in each entry, the boldface type is the traffic type that has driven the allocation of types to classes.

Table3.1Traffic Types and Number of Queues

(Stallings W. 2001)

In order to understand how each user priority is mapped to traffic classes, it is important to clarify the traffic classes (from the most to the least important)

Traffic Class	**Time critical / not**	**Characteristics**
Network Control (7)	Time- Critical	Safety-critical, consisting of traffic needed to maintain and support the network infrastructure, such as routing protocol frames.
Voice (6)	Time- Critical	less than 10 ms delay, such as interactive voice
Video (5)	Time- Critical	Less than 100 ms delay, such as interactive video.
Controlled Load (4)	Not Time-Critical	loss-sensitive, such as streaming multimedia and business-critical traffic
Excellent Effort (3)	Not Time-Critical	loss-sensitive, but of lower priority than controlled load
Best Effort (2)	Not Time-Critical	Not loss-sensitive
Background (0)	Not Time-Critical	This type includes bulk transfers and other activities that are permitted on the network but that should not impact the use of the network by other users and applications

Table 3.2Traffic Type

- The first row in the table 3.1 shows that if there is only one queue, all traffic classes are carried on that queue.
- If there are two queues (second row), 802.1D recommends assigning network control, voice, video, and controlled load to the higher-priority queue, and excellent effort, best effort, and background to the lower-priority queue. The reasoning supplied by the standard is this: To support a variety of services in the presence of bursty best-

effort traffic, it is necessary to segregate time-critical traffic from other traffic. In addition, further traffic that is to receive superior service and that is operating under admission control also needs to be separated from the uncontrolled traffic.

- The allocation of traffic types to queues for the remaining rows of the table 3.1 can be explained similarly (Seaman M. et al 2000).

3.4 The Hybrid Broadcasting Technique

Based on the previous remarks, the hybrid broadcasting technique was proposed to combine the best of each broadcasting technique, the basic flooding for its low delay and the dynamic broadcasting for its high packet delivery ratio (low collisions hence low packet dropping ratio).

The algorithm takes into consideration the message priority as an important factor in determining when each of the mentioned techniques can interrupt. For instance, suppose we have one transmission queue (at the MAC), all traffic types would be treated at the same Quality of Service (QoS) as shown in table 3.1, this QoS belongs to Best Effort (BE) class which means that all traffic types then will be treated equally in terms of delay and latency.

On the other hand, having two queues will split the traffic types into two classes, those from 0-3 will be treated as BE class, yet the rest will be treated with VO (Voice) class which means that they will be treated with better QoS standards; less delay and latency. The more the number of queues the more precise is mapping between the user priority and the traffic class until we reach the 1:1 mapping (for each queue, a traffic class is mapped to one user priority and therefore the traffic class is treated with its own QoS standards: delay, latency, and time-critical versus non-critical).

This is considered the building-block of our proposed technique, that is, to decide whether to rely on flooding to broadcast a message or to use dynamic broadcasting approach.

The flowchart below 3.1 illustrates the process of choosing the best broadcasting technique to cope with the traffic type.

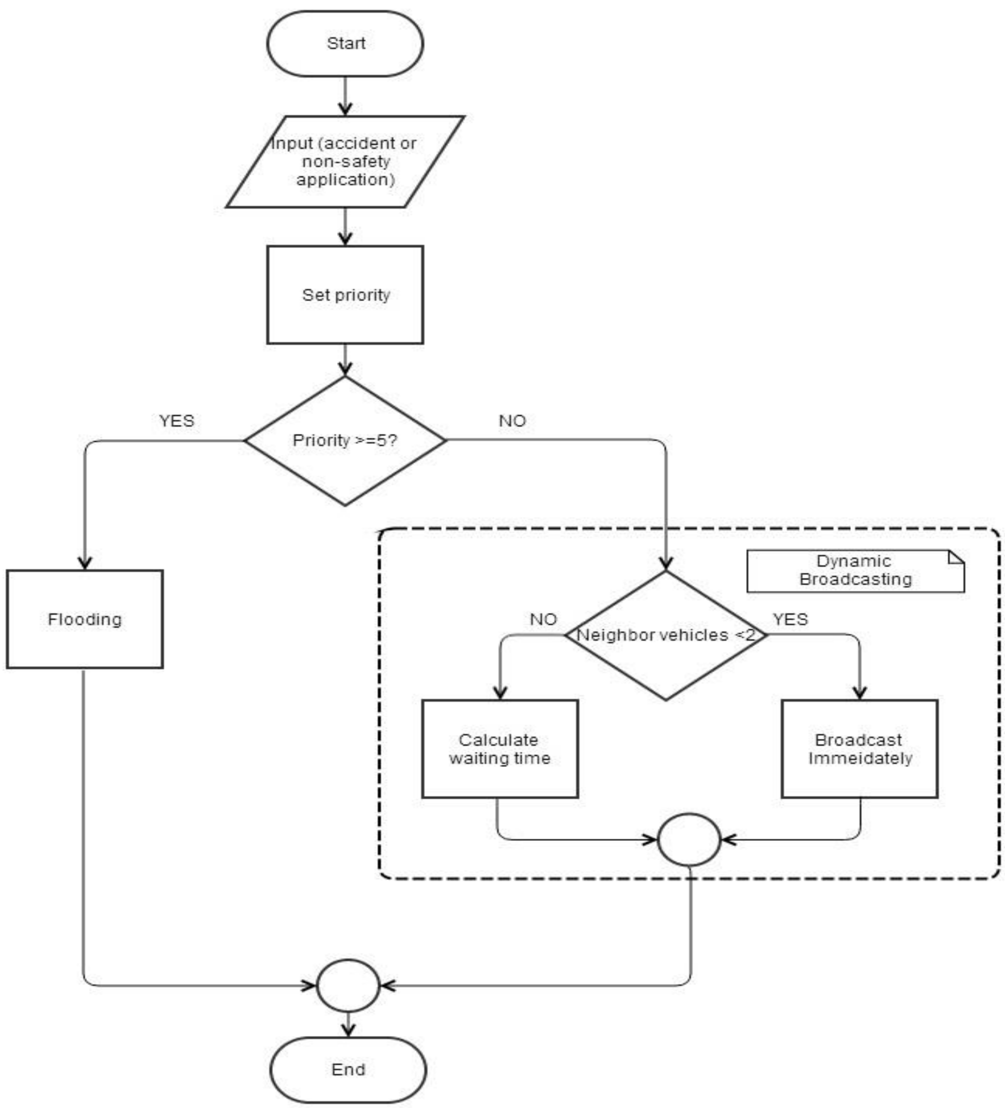

Figure3.17The Proposed technique’s flowchart

For the IEEE 802.1D standards - from which the user priority (also known as Access Category, AC) the WAVE used – number of transmission queues are 8 queues, each one is dedicated for a traffic class, the table 3.2 shows the values where the broadcasting is time-critical and where it is not. Hence, if any message that carries an AC value of 5 and above, it means the message belongs to time-critical class, in which the delay and latency is more important therefore, the algorithm will choose basic flooding technique to broadcast the message as fast as possible. On the other hand, of a message carries an AC value below 5, the time is not a crucial issue, hence it can be broadcast after waiting time determined by the dynamic broadcasting technique and ensuring less collisions.

Chapter Four

Methodology and Implementation

4. Chapter Four

4.1 Introduction

One of the problems in the VANET occur constantly in the broadcasting of packets between vehicles is packet collisions. In this research, studying and collecting the row data extracted from the VANET system will pinpoint the key parameters that can help in analyzing the proposed model to solve packet collisions by using a hybrid protocols technique using both flooding & dynamic broadcasting and to prioritize messages based on their urgency. Messages will be categorized based on their priorities. Designing the proposed model and proposed work which will help in developing a VANET simulation model using OMNET++[3], and the other stages of this work will be the evaluation process by measuring output from the proposed model's simulation and to compare it to the previous models in the same field and generalizing the results of the study to other domains. Linux4 (Ubuntu 12.45) will be the operating system.

4.2 OMNeT++

OMNeT++ is an extensible, modular, component-based C++ simulation library and framework, primarily for building network simulators. "Network" is meant in a broader sense that includes wired and wireless communication networks, on-chip networks, queuing networks, and so on. Domain-specific functionality such as support for sensor networks, wireless ad-hoc networks, Internet protocols, performance modeling, photonic networks, etc., is provided by model frameworks, developed as

3 http://www.omnetpp.org/
4http://www.linux.org.org/
5 http://www.ubuntu.com/

independent projects. OMNeT++ offers an Eclipse-based IDE, a graphical runtime environment, and a host of other tools. There are extensions for real-time simulation, network emulation, alternative programming languages (Java, C#), database integration, SystemC integration, and several other functions.

4.3 SUMO Road Simulator

SUMO is an open source, highly portable, microscopic and continuous road traffic simulation package designed to handle large road networks. It manages vehicles, streets, lanes and routes, obstacles, and many other features that are related to road simulation [6]

4.4 Veins and VACaMobil

Veins[7] is an open source simulation package responsible of mobility management in vehicular network simulations. It is based on two well-established simulators: OMNeT++, an event-based network simulator, and SUMO, a road traffic simulator. It extends these to offer a comprehensive suite of models for IVC simulation. SUMO is connected to OMNET++ through TCP connection manger which provides the information such as, position of the vehicles, routes, congestion and connection between vehicles that are generated by the SUMO simulator and this information is in turn given to the mobility manger (Traci manager within Veins). The veins simulator has the disadvantage of the inability to assign the number of cars statically in the network, it is all generated randomly. Therefore, VACaMobil was used, which is similar to veins with

[6] http://sumo-sim.org/

7 http://veins.car2x.org/

the difference that in the latter, number of cars can be set statically and remains unchanged during the simulation run.

4.5 MiXiM

MiXiM[8] is an OMNeT++ modeling framework created for mobile and fixed wireless networks (wireless sensor networks, body area networks, ad-hoc networks, vehicular networks, etc.). It offers detailed models of radio wave propagation, interference estimation, radio transceiver power consumption and wireless MAC protocols

4.6 Built-In Features

VACaMobil provides the basics of flooding technique, the combination of MiXiM, VACaMobil, and SUMO provides a basic VANET simulation that includes:

- The ability to include custom maps in which the VANET can be deployed. The custom map can be created and ported to SUMO using OpenStreetMap open-source service; the sample map that is included within VACaMobil was used.
- Accident scenario: the number of accidents can be pre-determined and based on that the simulation can take place considering the accidents and how the network will behave accordingly.
- Vehicles mobility on the x-y coordinates: the combination lets the user experience the behavior of the VANET while configuring the mobility of vehicles.
- The ability to measure readings such as CO2 emission, acceleration and speed of vehicles, and many other useful readings.

8 http://mixim.sourceforge.net/

4.7 Evaluation Metrics

In order to evaluate the new proposed approach, certain metrics should be taken into consideration, such as number of broadcasts received at each node (vehicle), message delivery ratio, broadcast delay, and number of collisions. Whenever the term "collisions" is mentioned, it means collisions between messages not collisions between vehicles.

A- Number of collisions is an indicator of how well the broadcasting technique can manage the VANET.

B- The broadcast delay is an indicator of how much time is needed for the broadcasting technique to deliver messages to destinations.

C- Message delivery ratio metric is used to express the compliment measure, which is the message loss. The message loss in this case is an indicator of how much is lost due to different reasons including collisions.

D- Last measure is the number of broadcasts received at each node, which is an indicator of the reachability of the broadcasts and the number of redundant broadcasts being received at each node.

4.8 Implementation of the Hybrid Broadcasting Technique

4.8.1 The Basic Flooding Part

As a built-in feature, the basic flooding technique is adopted within the MiXiM simulator so that it can be ran directly with minimum configuration (number of vehicles, number of accidents, time and duration of accident, etc…).

Running the VACaMobil example found in the latest MiXiM version 2.3 (VACaMobil github branch[9]) with configuring the SUMO mobility simulator for a custom map or the default map is enough to analyze a simple accident-flooding scenario.

[9]https://github.com/GRCDEV/mixim-sommer

4.8.2 The Dynamic Broadcasting Part

Based on (Najafzadeh et al. 2013), two files were created to implement the dynamic approach, (can be found in appendix A) that includes the following:

A- Determining the list of neighbors for each vehicle: To do this, periodic beaconing was used which can store the information needed to calculate the waiting time. Periodic beaconing can store number of neighbors and distance to each neighbor, for vehicles with 1 neighbor, the vehicle will broadcast the message immediately but for those with more than one neighbor, the waiting time can be calculate based on the formula derived in the original paper (Najafzadeh et al. 2013):

$$Wt = (1 - \frac{d_{ij}}{R})^{nn} Wt_{\max}$$

Where:

nn: Number of Neighbors in message direction

d_{ij}: The Distance of Vehicle i to vehicle j

R: Transmission Range

Wt_{max}: Maximum Waiting Time (200 ms based on the original paper)

B- If the density of the VANET is high, the probability of having two or more neighbors for each vehicle increases, therefore vehicles with more number of neighbors rebroadcast the packets as quickly as possible while close vehicles or those with low number of neighbors have to wait and receive more duplicate packets. Thus it will avoid unnecessary retransmission if possible.

Chapter Five

SIMULATION AND RESULTS

5. Chapter Five

5.1 Introduction

Based on the configuration, settings, and measuring criteria, simulations were performed to validate the hybrid broadcasting technique. In this chapter, results of simulations will be shown, presented as graphs and finally explained and analyzed.

5.2 Simulation of VANET with Basic Flooding Technique

Simulation has been performed on a network to study the behavior of basic flooding technique and its pros and cons.

The following table states the parameters used in this scenario and others scenarios throughout this chapter; other changes – if any occurred - on the parameters will be stated explicitly.

Parameter	Value
Maximum Transmission Power	20mW (Default value)
Carrier Frequency	5.9GHz (WAVE's default)
Bitrate	18 MBps
Data Priority	7 (highest priority in order to force flooding)
Simulation Area	10x10 km
Simulation Time	200 seconds
Number of accidents	1
Accident Starting time	30s
Accident Duration	50s
Number of vehicles	100

Table 5.3simulations parameters

5.2.1 Number of collisions

Running the simulation for 200s with one accident per 100 cars shows the following graph which shows the number of collisions per simulation time:

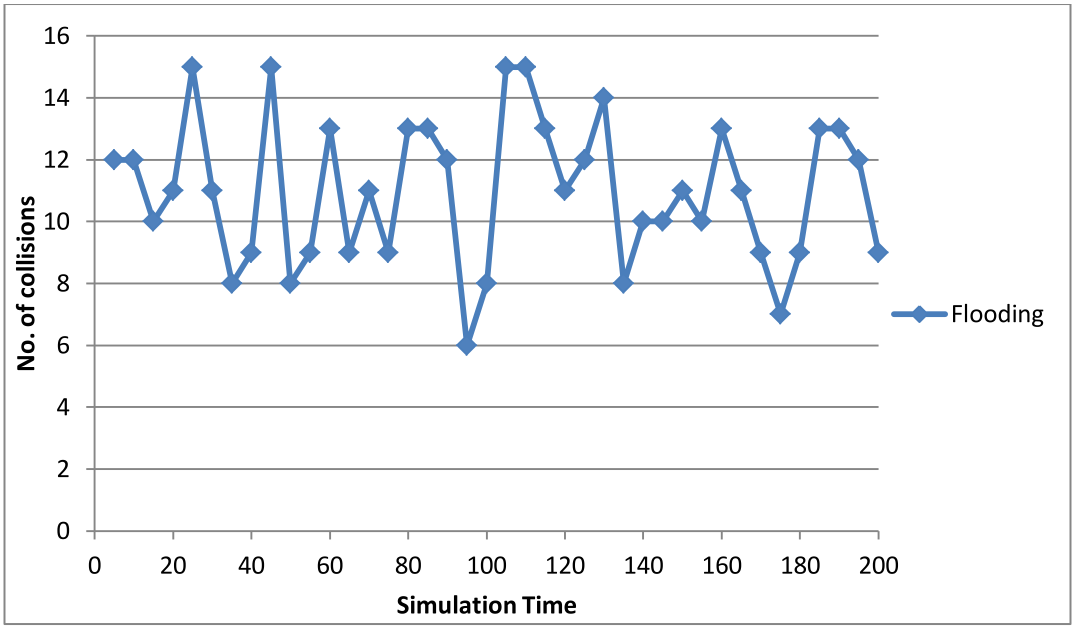

Figure5.18 number of collisions in Flooding Technique.

Figure 5.1 shows that number of collisions car reach up to 15 collisions per second on basic flooding approach, with an average of 10.975 collisions per second.

5.2.2 Broadcast Delay

The other important factor to be investigated is the time delay, the delay is defined as the time required for a message to reach its destination, and in the case of broadcasting, the destination is the nodes of the network, hence the delay is the time required for a message to cover all nodes in the network.

The broadcast delay was measured in terms of network density, as shown in figure 5.2 where the number of cars per square kilometer was increased from 50 to 200 cars (that is 500 to 2000 cars per the whole area of the simulation, 10x10km)

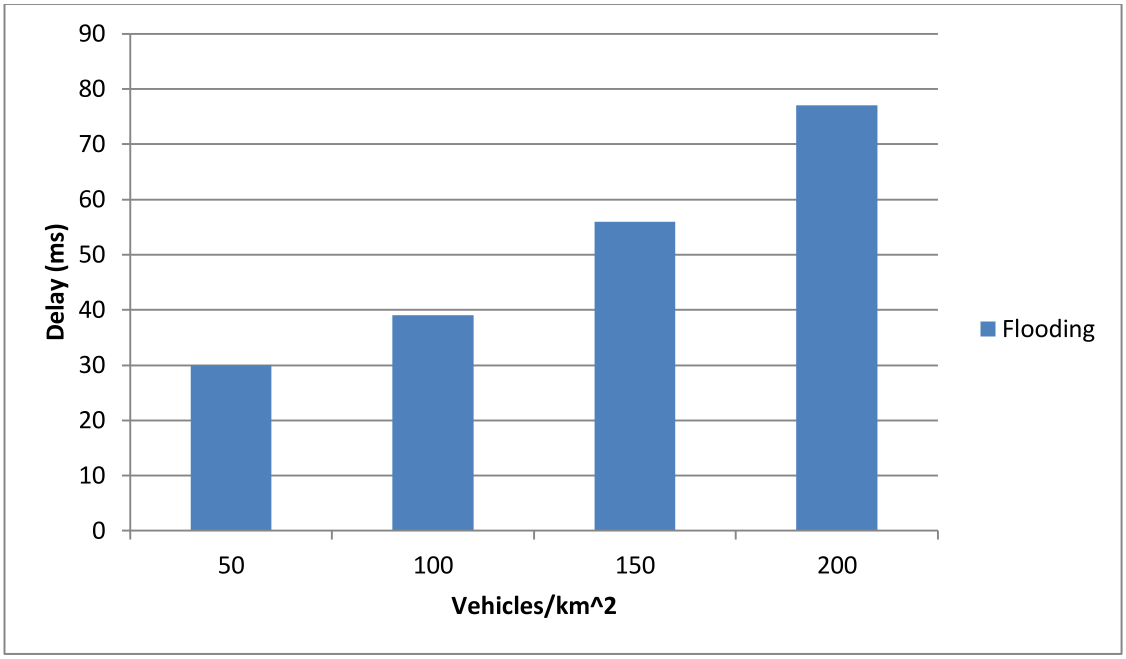

Figure5.19broadcast delay in Flooding Technique

The more the vehicles per square meter the network has, the more collisions occur, the more delay the network shows.

5.2.3 Received Broadcasts

p

5.2.4 Message Delivery Ratio

Message delivery ratio represents the ratio between the numbers of nodes that received the broadcasts successfully to the total number of nodes in the network, by taking the compliment of the ratio, the result of the message loss due to many reasons including the collisions.

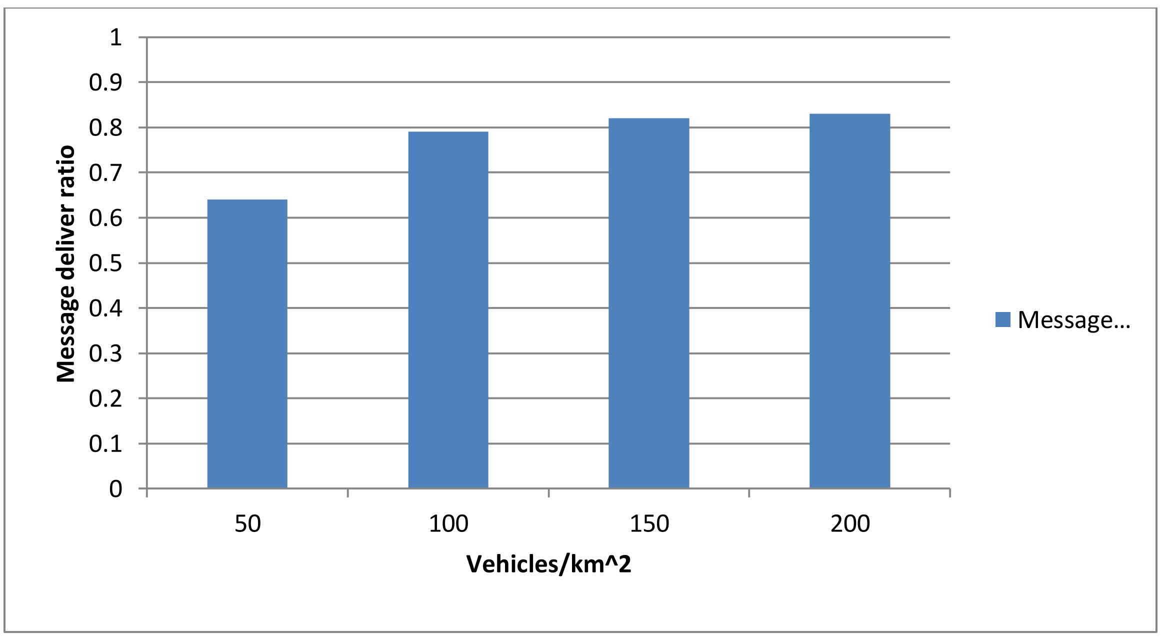

Figure5.20 Message delivery ratio in Flooding Technique

5.3 Dynamic Broadcasting

As explained previously in chapter 1, dynamic broadcasting relies on calculation of waiting time for a node before it broadcasts. Similar to the previous section, simulation has been performed on the dynamic broadcasting technique as follows:

5.3.1 Number of collisions

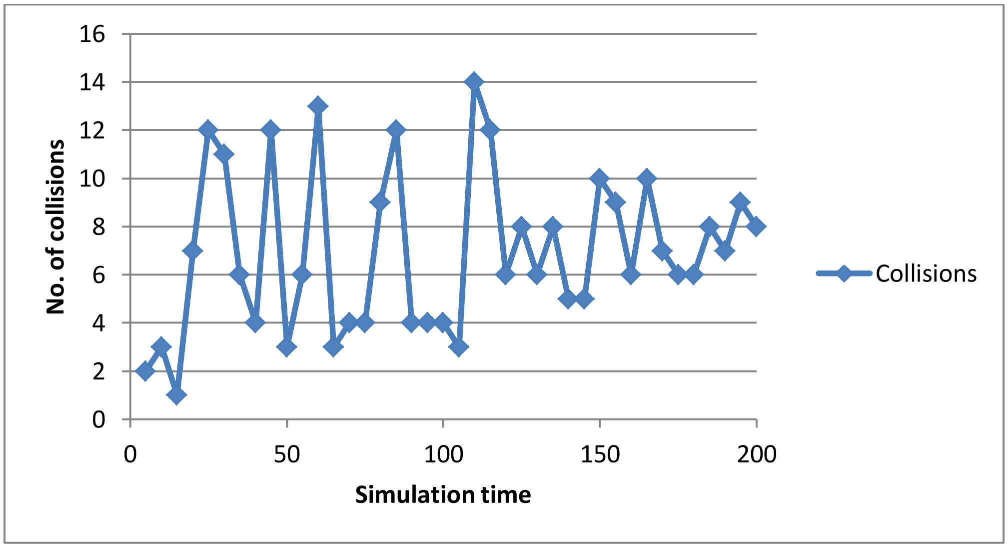

Figure5.21collisions in Dynamic technique

Numbers of collisions have been dropped due to the regulation on broadcasting resulted by applying the dynamic broadcasting algorithm as shown in figure 5.5. The algorithm takes into consideration the waiting time equation shown in chapter 1 and regulates the transmission of broadcasts based on that.

5.3.2 Broadcast Delay

The dynamic broadcasting approach suffers from slight end-to-end delay due to the fact that the algorithm relies on pre-broadcasting calculations and those in turn have the main role in delaying the broadcasting process itself as shown in figure 5.6

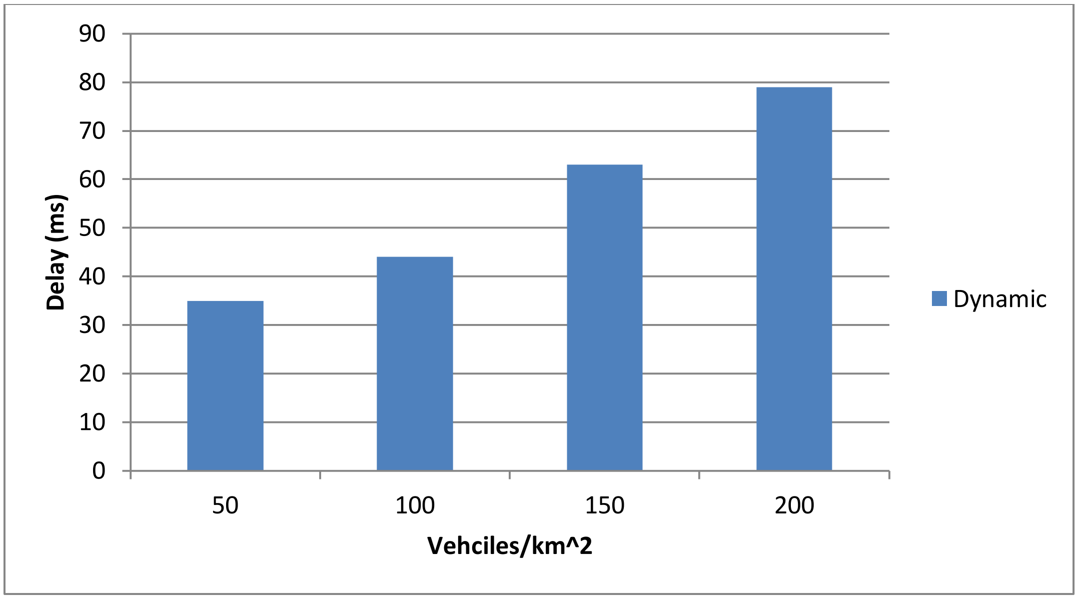

Figure5.22 delay in Dynamic technique

5.3.3 Broadcasts Received

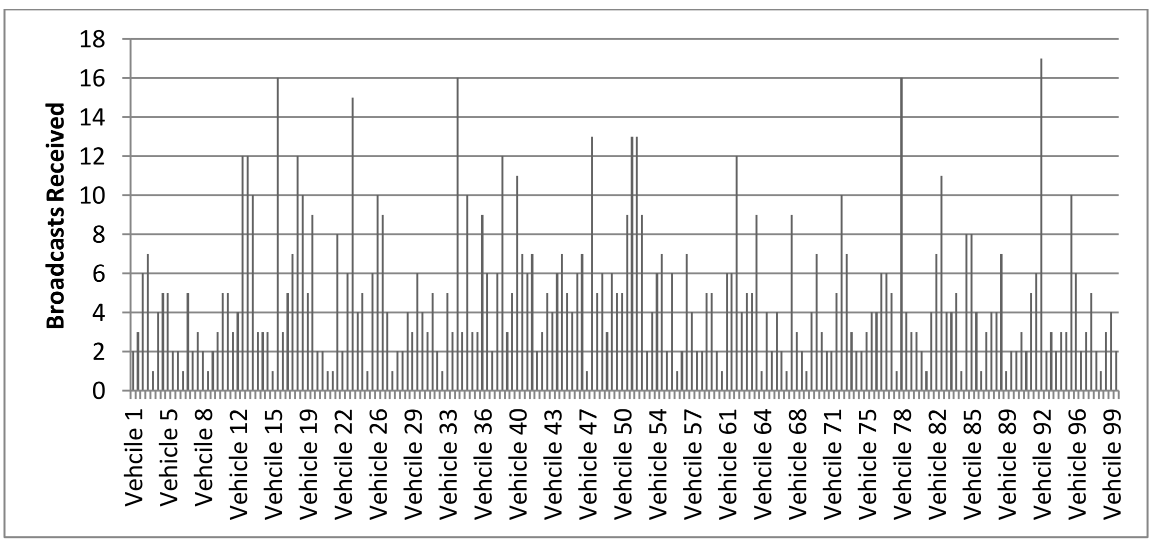

Figure 5.23broadcasts received in Dynamic technique

It is obvious that number of broadcasts received by each vehicle has been decreased due to managing the problem of redundancy as shown in figure 5.7; however, there are still nodes that suffer from the problem nevertheless.

5.3.4 Message delivery ratio

The management of collisions through the use of the dynamic broadcasting algorithm has the effect of reducing the message loss in VANET, it can be shown in figure5.8through complimenting the message delivery ratio which is on average higher that the ratio using basic flooding technique.

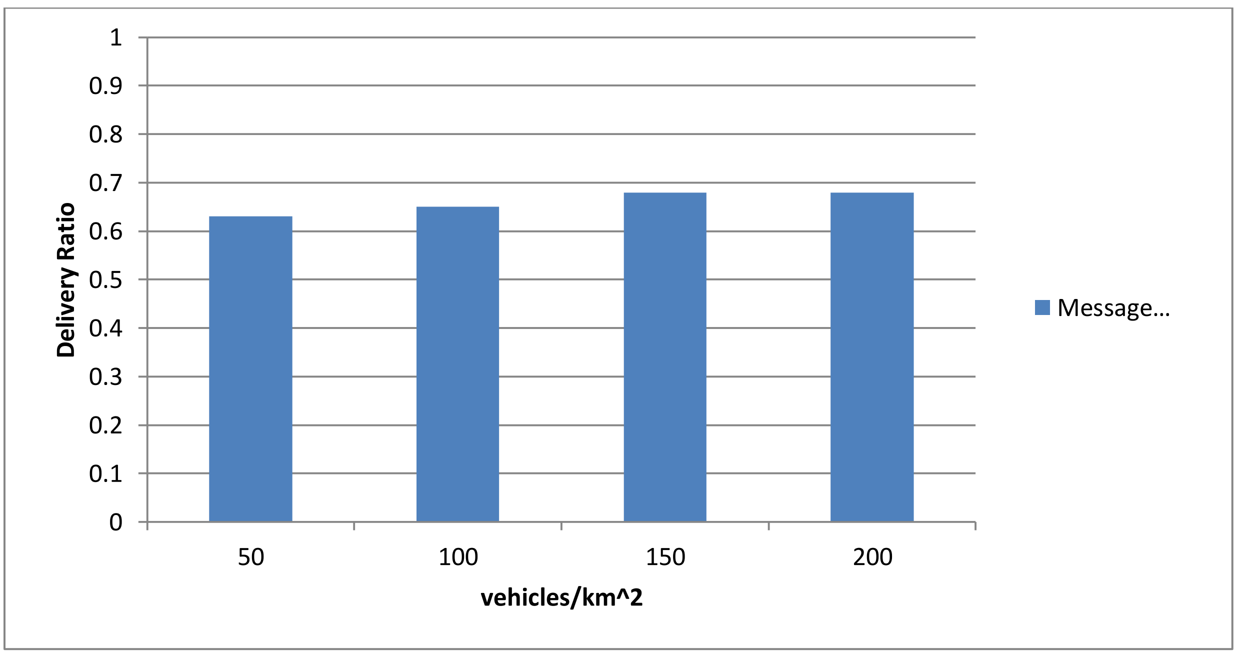

Figure 5.24message delivery in Dynamic technique

5.4 Hybrid Broadcasting Technique

Following the sequence of tests, the hybrid broadcasting technique was tested and compared to both basic flooding and dynamic broadcasting techniques. The flowing subsections are similar to those in the previous sections in the measuring criteria:

5.4.1 Number of Collisions

The hybrid broadcasting technique depends on the fact that for high priority traffic the technique utilizes the basic flooding technique in order to achieve the least delay. On the contrary, it utilizes the dynamic technique in the low priority situations where time is not critical, this allows more delay yet less collisions. Overall, the hybrid technique achieves less average number of collisions than the basic flooding technique but less delay than both techniques.

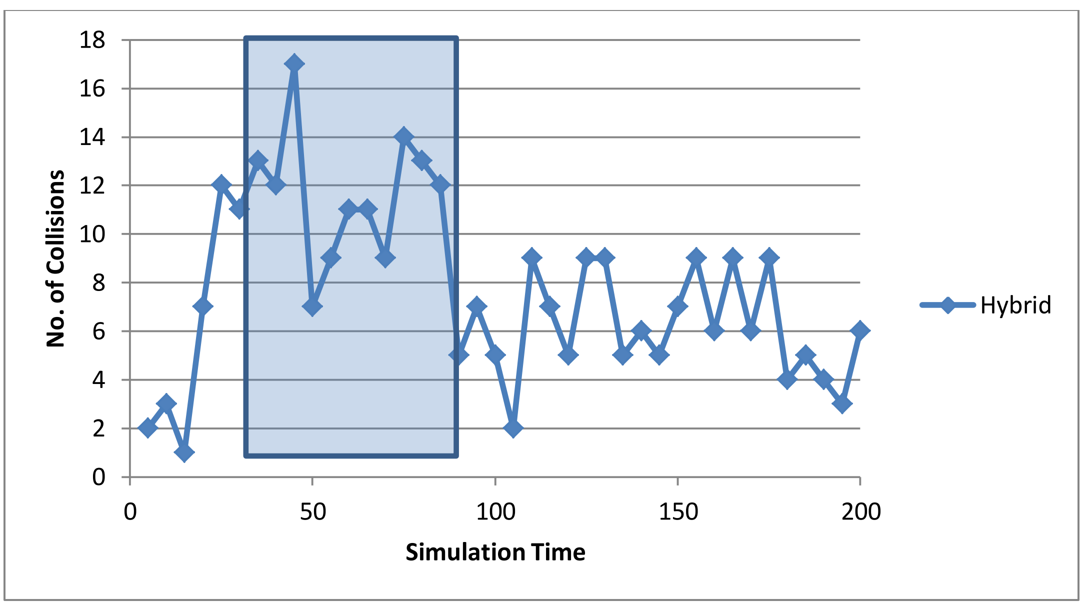

Figure5.25collisions hybrid technique

Note that the highlighted area is the area when the accident happens (starting time=30s, duration =50s). In this highlighted area, the hybrid technique utilized the basic flooding technique in which the number of collisions increased while before and after the area the number of collisions was close to that in the dynamic technique, with an average of 7.65 collisions per simulation second, compared to basic flooding technique where the average number of collisions was 10.975 and 6.925 collisions per simulation second for the dynamic broadcasting approach.

5.4.2 Broadcast Delay

The effect of using the hybrid broadcasting technique is obvious regarding the end-to-end delay. The delay can be similar to situations where dynamic technique is used; however, the delay is decreased when an accident happens by converting to basic flooding technique. By doing so, the total average broadcast delay is reduced as shown in figure 5.10

Therefore, for each of simulation scenarios wherein the density is changed from 50 up to 200 vehicles per square kilometers, the same scenario of the above subsection is repeated, where an accident happens at second 30 and lasts for 50 seconds. In this period, the broadcasts are flooded and hence the delay is decreased, while before and after this period the delay is similar to where the dynamic broadcasting technique is on.

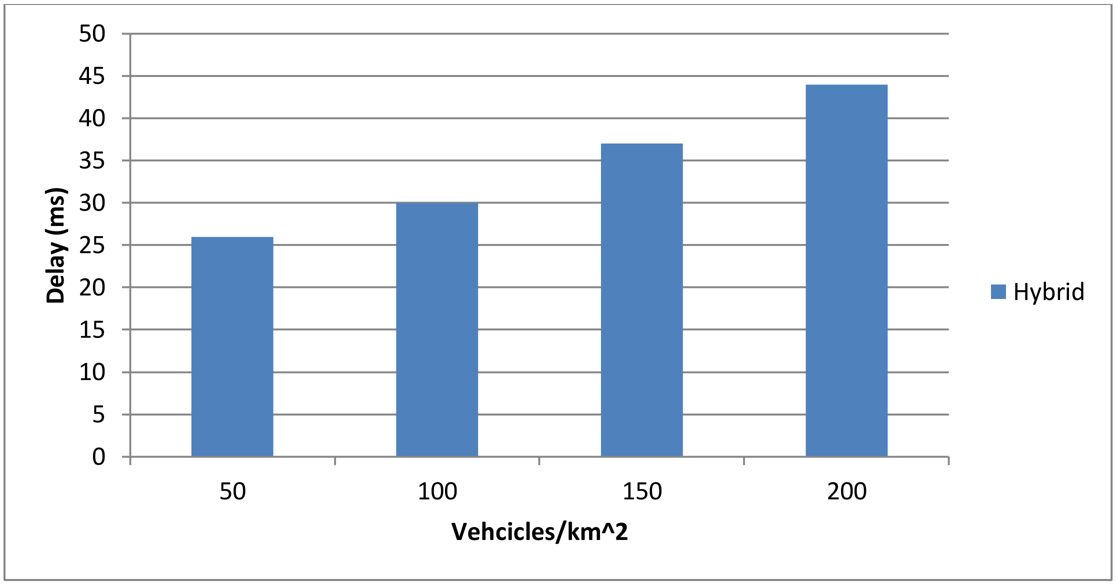

Figure5.26delay in hybrid technique

5.4.3 Number of Broadcasts Received

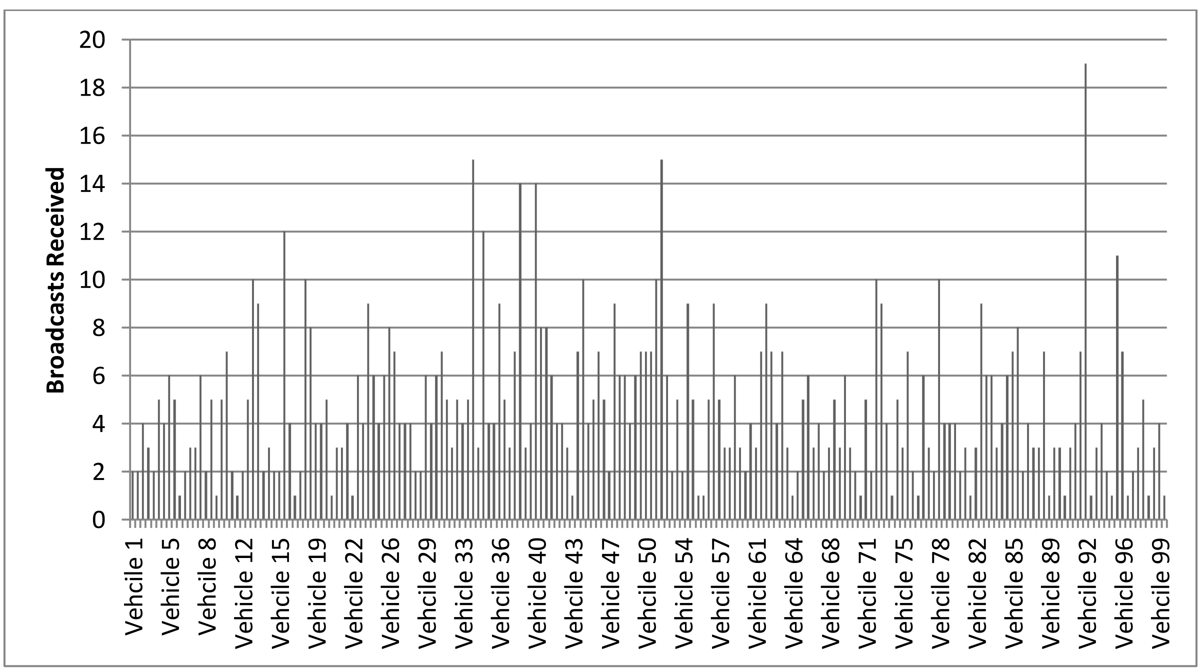

Figure5.27broadcasts received hybrid technique

Similar to the number of broadcasts received when using the dynamic broadcasting approach, the hybrid approach achieved less redundancy that the basic flooding technique yet similar (and sometimes either higher or lower) number to that achieved by the dynamic technique as shown in figure 5.11. In general, the three techniques have achieved 100% reachability of broadcasts with zero vehicles with 0 broadcasts received.

5.4.4 Message Delivery Ratio

Message delivery ratio for the hybrid broadcasting technique lies on the middle between both flooding and dynamic broadcasting technique on average. The reason behind this is that hybrid technique delivers as similar amount of messages as the dynamic technique, except that it behaves worse when an accident happens, where the message loss starts to increase due to collisions.

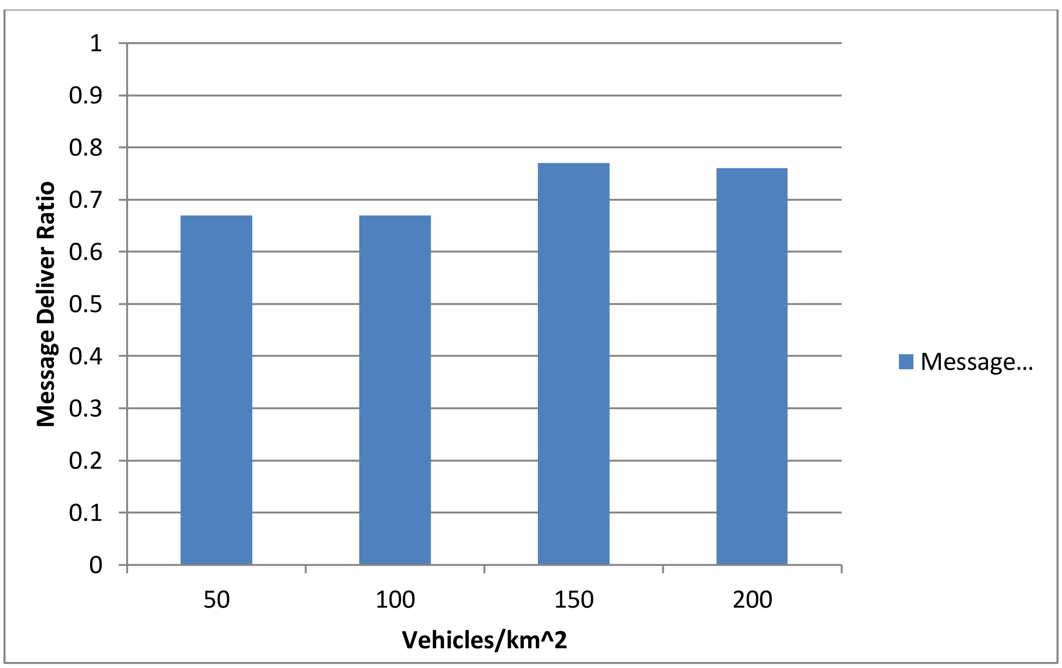

Figure5.28 message delivery ratio in hybrid technique

5.5 Comparing the Three techniques

In this section, the results in the previous sections are combined to show the areas of strength and weakness for each technique, particularly the new hybrid broadcasting technique.

5.5.1 Number of Collisions for the 3 Techniques

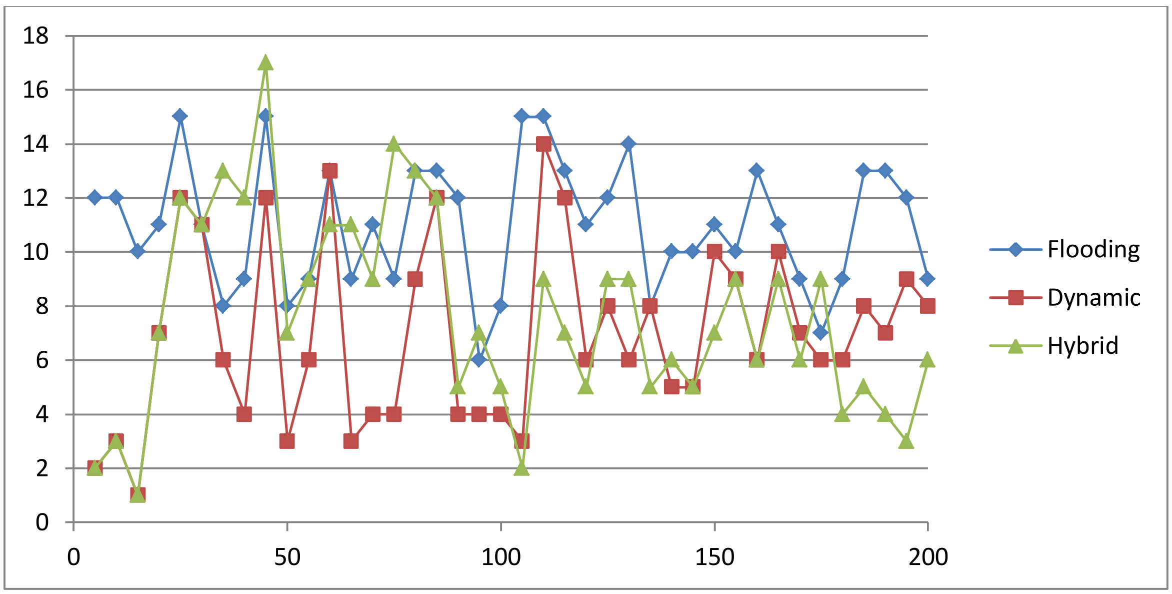

Figure5.29collisions in three techniques

Figure 5.13 shows the area where the hybrid technique performed the worst and the best compared to the other two techniques. It is obvious that in the period of the accident (30s-80s of the simulation time), the hybrid technique shows its worst performance because it basically worked as basic flooding technique, while on the other hand it shows similar performance to the dynamic technique before and after the accident.

5.5.2 Broadcast Delay

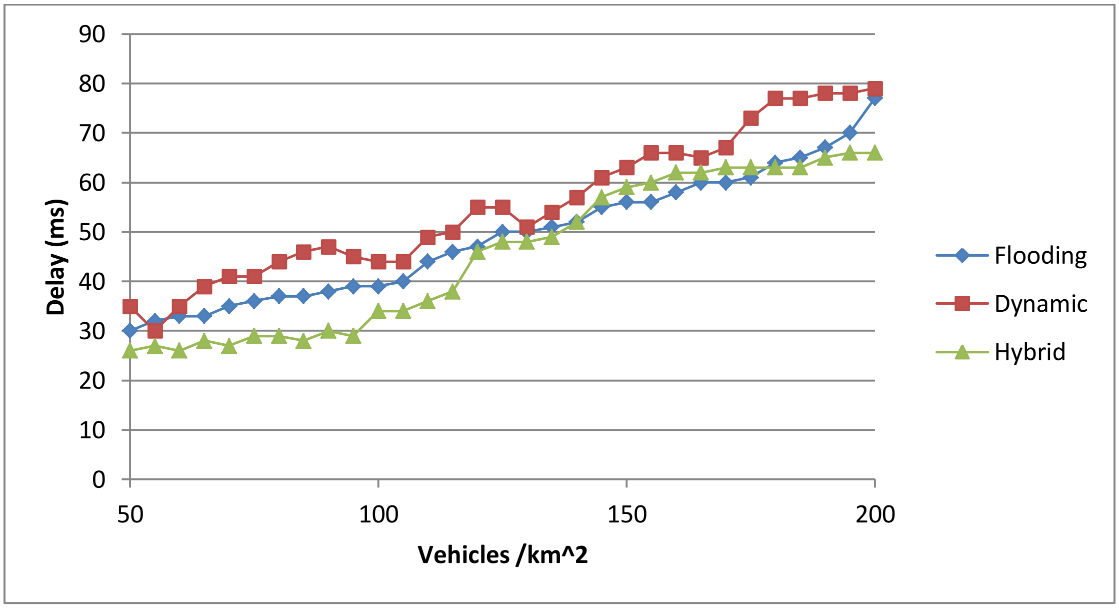

Figure5.30 broadcastdelay in three techniques

As explained before, the hybrid technique utilizes the benefits of both basic flooding and dynamic broadcasting techniques in a way that it benefits from the low delay of basic flooding technique while on the same time, tries to reduce the number of collisions by using the dynamic broadcasting technique in the times where no accidents occur. Figure 5.14 shows that the average broadcast delay for different VANET densities is lower for the hybrid technique than in the case of basic flooding or dynamic techniques. The reason behind this is that for each scenario, the delay is the least when an accident occurs because the flooding technique is being used. However, when no accident occurs, the hybrid technique goes back to the dynamic broadcasting technique increasing the delay values yet keeping it below the flooding and dynamic techniques on average.

5.5.3 Average Broadcasts Received

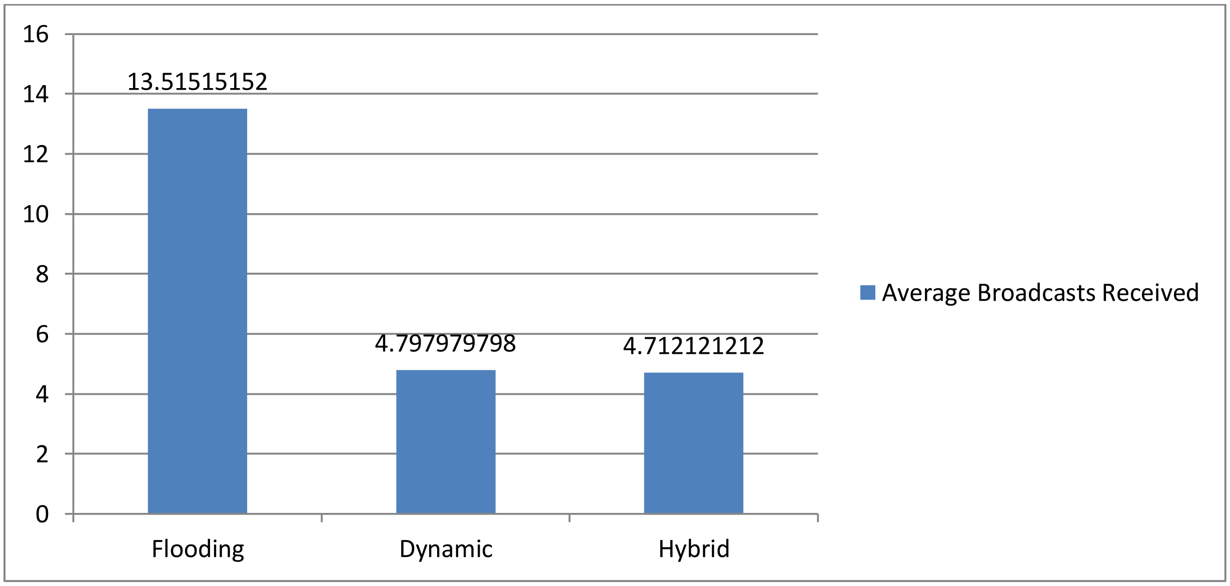

Figure5.31Broadcasts received in three techniques

From the previous sections, it was mentioned that all techniques have 100% reachability therefore there is no reason to compare the reachability; however, taking the average broadcasts received at each vehicle as shown in figure 5.15, it is clear that the flooding technique sends more redundant broadcasts than both the Hybrid and the Dynamic techniques. The Dynamic and Hybrid technique however are very similar because they control the number of broadcasts received using the waiting time formula

5.5.4 Message Delivery Ratio

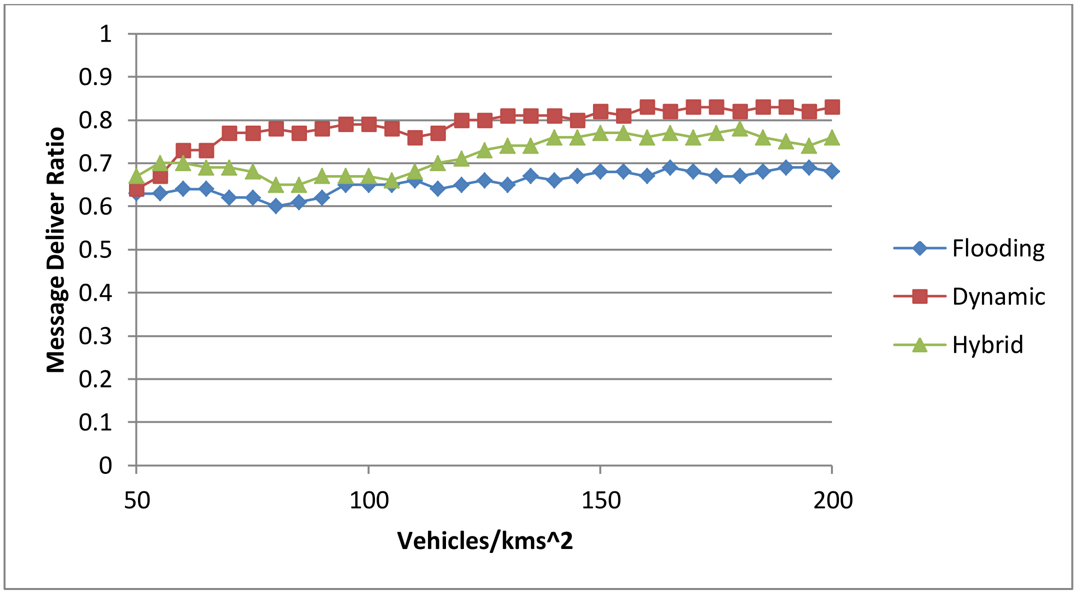

Figure5.32Delivery in three techniques

The message delivery ratio is the reflection of the number of collisions (a compliment to it), hence, as explained before, the number of collisions for the Hybrid technique is less than it in the case of basic flooding yet it is not better than it in the case of the Dynamic technique. So, reflecting that on the message delivery ratio, the Hybrid technique delivers more messages than the flooding technique, yet not better than the Dynamic technique and that is because in the period between 30 and 80 seconds where the Hybrid technique works as basic flooding technique the number of collisions increases and that affects the message delivery ratio directly as shown in figure 5.16.

Chapter Six

CONCLUSIONS AND FUTURE RECOMMENDATIONS

6. Chapter Six

6.1 Conclusion

It was obvious from the simulation results that the proposed hybrid technique has shown promising results in terms of end-to-end delay while keeping the number of collisions, message delivery ratio and number of broadcasts better than the basic flooding technique but no better than the dynamic broadcasting technique. The reason behind this was that when an accident happens, the hybrid technique utilizes the basic flooding technique without any enhancement hence it adopts its drawbacks regarding the metrics mentioned above. On average, number of collisions for the hybrid technique reached 7.65 collisions per simulation second while it was 10.975 for the flooding technique and 6.925 for the dynamic broadcasting technique.

Number of collisions is one of the reasons behind packets loss, and while packets loss was not studied by itself, the message delivery ration was. The message delivery ratio is the compliment of the message loss, and since the basic flooding technique suffers the most from the collisions, it delivers the least amount of messages, therefore it also suffers from message loss. This has been reflected on both dynamic and hybrid techniques on the same way.

The three broadcasting techniques behaved similarly regarding number of broadcasts received at each node, which means all of them have 100% reachability of broadcasts. However, since the basic flooding technique lacks the management of broadcasting and relies on just forwarding the broadcasts with the least amount of control over redundancy, number of broadcasts received at each node was higher than both hybrid and dynamic techniques on average.

Results also showed that the average broadcast delay for different VANET densities is lower for the hybrid technique than in the case of basic flooding or dynamic techniques. The reason behind this is that for each scenario, the delay is the least when an accident occurs because the flooding technique is being used. However, when no accident occurs, the hybrid technique goes back to the dynamic broadcasting technique increasing the delay values yet keeping it below the flooding and dynamic techniques on average.

6.2 Future Work

In order to achieve the desired results from the newly proposed hybrid technique, we should focus on reducing the number of collisions in a way that guarantees the same performance regarding the end-to-end delay. In order to be able to achieve this, when an accident happens and when the hybrid technique turns to basic flooding technique, there should be an improvement on the latter to control the number of collisions with adding the least amount of overhead. That is, we recommend improving the basic flooding technique to reduce the number of collisions and this in turn will be reflected on the performance of the hybrid broadcasting technique.

Upon improving the basic flooding technique, message delivery ratio will be increased automatically as by the number of collisions - which affects the message delivery ratio – will be reduced, and as a result, message loss will also be reduced.

As the field of VANET is still amateur regarding different areas such as security and QoS, the hybrid broadcasting technique will also be studied while focusing on those areas.

APPENDIX A:

Dynamic Broadcasting Technique

```
#include "Dyn.h"

Define_Module(Dyn);

void Dyn::initialize(int stage) {
	BaseWaveApplLayer::initialize(stage);
	receivedBeacons = 0;
	receivedData = 0;
	priority = 0; // Default
}

void Dyn::onBeacon(WaveShortMessage* wsm) {
	receivedBeacons++;

	DBG << "Received beacon priority  " << wsm->getPriority() << " at
" << simTime() << std::endl;
	int senderId = wsm->getSenderAddress();

	if (sendData) {
		t_channel channel = dataOnSch ? type_SCH : type_CCH;
		sendWSM(prepareWSM("data", dataLengthBits, channel,
dataPriority, senderId,2));
	}
}

void Dyn::onData(WaveShortMessage* wsm) {

	int recipientId = wsm->getRecipientAddress();

	if (recipientId == myId) {
		DBG  << "Received data priority  " << wsm->getPriority() <<
" at " << simTime() << std::endl;
		receivedData++;
	}
}

void Dyn::wait(WaveShortMessage* wsm) {

	int recipientId = wsm->getRecipientAddress();

	if (noReceit == 1 ) {
		broadWSM(*wsm); }
	else {
	//get distance and number of neighbors
	for (unsigned int i=0;i<no_nodes;i++)
	{
		gate("out")->getPathEndGate()->getOwnerModule();
		if (e->getDestination() ==  e->getGateway())
		{
	       //1-hop node
			EV << e->getDestance();
				}
```

```
      }
      }
Int wt;
      Wt = (1-(getDestance()/250))*0.2;
      *wsm = wsm(wt);
      broadWSM(*wsm);
      }
}


Dyn::~Dyn() {

}
```

APPENDIX B:

Hybrid Broadcasting Technique

```
#include "Hyb.h"
#include "Dyn.h"

Define_Module(Hyb);

void Hyb::initialize(int stage) {
      BaseWaveApplLayer::initialize(stage);
      receivedBeacons = 0;
      receivedData = 0;
      priority = 0; // Default
}


void Hyb::onBeacon(WaveShortMessage* wsm) {
      receivedBeacons++;

      DBG << "Received beacon priority  " << wsm->getPriority() << " at
" << simTime() << std::endl;
      int senderId = wsm->getSenderAddress();
      int priorityid wsm ->getPriority();

      if (sendData) {
            t_channel channel = dataOnSch ? type_SCH : type_CCH;
            sendWSM(prepareWSM("data", dataLengthBits, channel,
dataPriority, senderId,2));
      }
      else
            {
           If(priorityid<5){broadWSM(*wsm(0));}
           else
                (Dyn->onBeacon(*wsm));
            }
}
```

APPENDIX C:

WAVE Short Message with priorities:

```
cplusplus {{
#include <Coord.h>
}}

classnoncobject Coord;

packet WaveShortMessage {
	//Version of the Wave Short Message
	int wsmVersion = 0;
	//Determine which security mechanism was used
	int securityType = 0;
	//Channel Number on which this packet was sent
	int channelNumber;
	//Data rate with which this packet was sent
	int dataRate = 1;
	//Power Level with which this packet was sent
	int priority;
	//Unique number to identify the service
	int psid = 0;
	//Provider Service Context
	string psc = "Service with some Data";
	//Length of Wave Short Message
	int wsmLength;
	//Data of Wave Short Message
	string wsmData = "Some Data";

	int senderAddress = 0;
	int recipientAddress = -1;
	int serial = 0;
	Coord senderPos;
	simtime_t timestamp = 0;
}
```

References

- Awasthi S., & Singh A. (2013)Enhancement of Broadcasting in Vehicular Ad-hoc Networks (VANET) by Dynamic Adaption of Contention Window Size, *International Journal of Engineering Research & Technology (IJERT)*, Vol. 2 Issue 6.

- Bae I. H. (2011). Design and Evaluation of a Hybrid Intelligent Broadcast Algorithm for Alert Message Dissemination in VANETs. *International Journal of Grid and Distributed Computing,* Vol. 4, No. 4.

- Benaidja A., Moussaoui S., & Naït-Abdesselam F. (2013).An Optimal Broadcast of Warning Messages in Vehicular Ad Hoc Networks. *International Journal of Computer and Information Technology,* Volume 02– Issue 05.

- Chitra M. & Sathya S. S. (2013). EFFICIENT BROADCASTING MECHANISMS FOR DATA DISSEMINATION IN VEHICULAR AD HOC NETWORKS. *International Journal of Mobile Network Communications & Telematics (IJMNCT),* Vol. 3, No.3.

- Campolo C., Vinel A., Molinaro A., & Koucheryavy Y. (2011).Modeling Broadcasting in IEEE 802.11p/WAVE Vehicular Networks. *IEEE COMMUNICATIONS LETTERS,*VOL. 15, NO. 2.

- Chen Q. Jiang, D., &Delgrossi L (2009). IEEE 1609.4 DSRC multi-channel operations and its implications on vehicle safety communications*. Vehicular Networking Conference (VNC), 2009 IEEE.*

- Dalal A. & Menaria S. (2012). A Review on Broadcasting Schemes for Emergency Messages in VANET. *International Journal of Computer Technology & Application,*Vol 3 (6), 2022-2026.

- Elumalai P., Murukanantham P. (2010).*Reliable data dissemination for car safety application in VANET,* (Master's Thesis), Department of Electrical and Information Technology Faculty of Engineering, LTH, Lund University SE-221 00 Lund, Sweden

- Farnoud F. & Valaee S. (2009).Reliable Broadcast of Safety Messages in VehicularAd Hoc Networks. *IEEE Communications Society subject matter experts ©2009 IEEE*

- Hartenstein H.& Laberteaux K. P. (2010). *VANET:Vehicular Applicationsand Inter-Networking Technologies*, (1st Ed.). United Kingdom: Wiley & Sons.

- Kumar V., & Bansal M. (2011) Reliable and Efficient flooding Algorithm for Broadcasting in VANET. *International Journal of Computer Technology and Applications*, Vol 2 (5), 1379-1384.

- Li Y., Papanastasiou S., Akhlaghinia J., & Peytchev E. (2013). TMDA: A Broadcast-Based Message Delivery Algorithm for VANETs. *International Journal on Advances in Telecommunications,* 6(1 and 2), 34-44.

- Lo Cigno R., A., & Segata M. (2011).*Models and performance of VANETbased emergency braking*,(Unpublished master's dissertation), UNIVERSITY OF TRENTO:Italy.

- Mahajan A. N., Saproo D., Khedikar R. (2013).ANALYSIS AND COMPARISON OF VANET ROUTING PROTOCOLS USING IEEE 802.11p AND WAVE. *International Journal of Engineering Research and Applications (IJERA),* Vol. 3, Issue 4, pp.1556-1561.

- Mahipal, Batish S., Kakria A. (2012).Efficient Broadcasting Protocol for Vehicular Ad-Hoc Network. *International Journal of Computer Applications,* Volume 49– No.23.

- Mehta K. (2012).Security Issues and Research of Vehicular Ad-Hoc Networks (VANET). *International Journal of Research in Computer Engineering and Electronics. 1,* Vol : 1 ISSUE :2

- Najafzadeh S., Ithnin N., Razak S. A., & Karimi R. (2013). Dynamic Broadcasting in Vehicular Ad hoc Networks.*International Journal of Computer Theory and Engineering*, Vol. 5, No. 4.

- Ramakrishnan B., Rajesh R. S., & Shaji R. S. (2010). Performance Analysis of 802.11 and 802.11p in Cluster Based Simple Highway Model. *(IJCSIT) International Journal of Computer Science and Information Technologies,* Vol. 1 (5) , 2010, 420-426

- R S. & R G. (2014) Alert Message Dissemination Protocol for VANET to ImproveRoad Safety.*International Journal of Emerging Technology and Advanced Engineering (IJETAE),* Volume 4, Issue 1.

- RJ. K. &AJ. E. (2013) A Survey on Broadcasting Protocols in VANETs.*International Journal of Innovative Technology and Exploring Engineering (IJITEE),*Volume-3, Issue-6.

- Savita, Kaur N. (2013). Headway based Model for Effective Broadcast in Vehicular Ad-Hoc Networks. *International Journal of Computer Applications,* Volume 66– No.13.

- Singh Y., & Sharma E. A. (2012) Study of Broadcasting and Its Performance Parameter in VANET.*International Journal of Soft Computing and Engineering (IJSCE),* Volume-2, Issue-2.

- Suthaputchakun C. & Ganz A. (2007). Priority based inter-vehicle communication in vehicular ad-hoc networks using IEEE 802.11 e.IEEE 65th (pp. 2595-2599)

- Stallings W. (2nd). (2001). High-Speed Networks and Internets: Performance and Quality of Service, 2nd Edition

- Seaman M., Smith A., Crawley E., & Wroclawski J. (2000). Integrated Service Mappings on IEEE 802 Networks. *© The internet society (2000).*

- Tirmare P. & Mule S. B. (2013). A Survey Of Broadcasting Based Routing Protocols For VANETs. *International Journal of Engineering Research & Technology (IJERT).* Vol. 2 Issue 2.

- Tonguz O., Wisitpongphan N., Bai F., Mudalige P., & Sadekar V. (2008). Broadcasting in VANET.*IEEE*, (pp. 7-12).

- Taha M. M. I. (2008).*Broadcasting Protocols in VehicularAd-Hoc Networks (VANETs),* (Unpublished master's dissertation), Department of Electrical EngineeringAssiut University Assiut, EGYPT

- Zeadally S., Hunt R., Chen Y. S., Irwin A., & Hassan A. (2010). Vehicular ad hoc networks (VANETS): status, results, and challenges.*Springer Science+Business Media*, 217-241.

- ZangY., Stibor L., Cheng X., Reumerman H. J., Paruzel A.,& Barroso A.Congestion Control in Wireless Networks for Vehicular Safety Applications.

- IEEE Computer Society Sponsored by the LAN/MAN Standards Committee (2004) 802.1DTM IEEE Standard for Local and metropolitan area networks Media Access Control (MAC) Bridges. *Approved 4 June 2004 American National Standard Institute Approved 9 February 2004 IEEE-SA Standards Board,* USA.