A FRAMEWORK OF HIGH MOBILITY ROUTING FOR VIDEO TRANSMISSION IN VEHICULAR AD HOC NETWORKS USING RELATIVE SPEED AND DISTANCE

WALID SHAHER MOHAMMED YOUSEF

UNIVERSITI SAINS MALAYSIA

2017

A FRAMEWORK OF HIGH MOBILITY ROUTING FOR VIDEO TRANSMISSION IN VEHICULAR AD HOC NETWORKS USING RELATIVE SPEED AND DISTANCE

by

WALID SHAHER MOHAMMED YOUSEF

Thesis submitted in fulfilment of the requirements
for the degree of
Doctor of Philosophy

May 2017

ACKNOWLEDGMENT

First, all praises and thanks should go to Allah for giving me the health, strength, knowledge and patience to complete this work.

I would like to express my sincere thanks and deepest gratitude to my supervisor, Associate Professor Muhammad Rafie Hj. Mohd Arshad, for his wisdom that assisted me avoid pitfalls throughout this journey and for all his emotional supports. I would like also to thank my field supervisor Dr. Ammar Zahary for his guidance and help throughout the research time. I would like to express my gratitude and thanks to the panel members of the research review.Also, I would like to thank my colleagues in the Research Laboratory for their support and cooperation.I would like to extend my thanks to all academic and non-academic members of the School of Computer Sciences at USM and members of CIT college at university of science and technology especially dean of college Dr. Abdulqader and my friend Redhwan Alnakhlany. I have been blessed with the continuous support from each and every member of my family. I am deeply grateful to my wife,Amira, my brother Dr. Wael, my parents ,Shaher and Jalilah. This thesis is dedicated to them for all their love and prayers.

Walid Shaher

Universiti Sains Malaysia

TABLE OF CONTENTS

CHAPTER 1 – INTRODUCTION

CHAPTER 2 – LITERATURE REVIEW

CHAPTER 3 – THE PROPOSED FRAMEWORK

CHAPTER 4 – IMPLEMENTATION

CHAPTER 5 – RESULTS AND DISCUSSION

CHAPTER 6 – CONCLUSION AND FUTURE WORK

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AI	Artificial Intelligence
ANN	Artificial Neural Networks
AODV	Ad Hoc On-Demand Distance Vector
AOMDV	Ad Hoc On-Demand Multipath Distance Vector
DAPRPA	Defence Advances Research Project Agency
DSDV	Destination-Sequenced Distance Vector
DSRC	Dedicated Short Range Communication
DSR	Dynamic Source Routing
EAPAR	Electronically Steerable Passive Array Radiator
FSR	Fisheye State Routing
GPS	Global Positioning System
GSRP	Global State Routing Protocol
ITS	Intelligent Transportation Systems
LIAITHON	Location-Aware Multipath Video Streaming
LTE	Long-Term Evolution
MANET	Mobile Ad Hoc Network
MDP	Markov Decision Problem

OLSR	Optimized Link State Routing
PRAODV	Prediction-Based AODV
PRNet	Packet Radio Network
PNRS	Persistent Neighbours With Relative Speed
QoS	Quality Of Service
RFID	Radio-Frequency Identification
RREP	Route Reply
RREQ	Route Request
RNVR	Real Neighbours On Vehicle Rewarding
RSU	Road Side Units
SDMR	Spatially Disjoint Multipath Routing
SMR	Split Multipath Routing
SURAD	Survivable Adaptive Radio Networks
TBRPF	Topology Dissemination Based On Reverse-Path Forwarding
TORA	Temporally Ordered Routing Algorithm
VANET	Vehicular Ad Hoc Network
VIRTUS	Video Reactive Tracking-Based Unicast
V2I	Vehicle-To-Infrastructure

V2V	Vehicle-To-Vehicle
WLAN	Wireless Local Area Network
WSN	Wireless Sensor Networks
WRP	Wireless Routing Protocol

SUATU KERANGKA KERJA PENGHALAAN MOBILITI TINGGI UNTUK PENGHANTARAN VIDEO DALAM PANGKALAN KENDERAAN AD HOC MENGGUNAKAN KELAJUAN RELATIF DAN JARAK

ABSTRAK

Penghantaran video adalah satu isu yang kritikal bagi VANET. Masalah utama adalah bagaimana untuk meningkatkan sambungan rangkaian untuk aliran video, menangani kehilangan kerangka, ketaran, kelewatan hujung-ke-hujung dan memaksimumkan pemprosesan. Disamping itu, isu yang paling mencabar berkaitan dengan VANET adalah bagaimana untuk mendapatkan penghalaan yang boleh dipercayai dalam persekitaran mobiliti yang tinggi, dan bagaimana untuk mengoptimumkan overhed penghalaan. Ujikaji rintis telah dilakukan sebelum perlaksanaan model cadangan untuk membuktikan kesan mobiliti dan trafik yang tinggi dalam persekitaran VANET. Kajian perbandingan telah dijalankan menggunakan OPNET bagi tiga protokol penghalaan yang sama dalam VANET, untuk meneliti kesan persekitaran mobiliti dan trafik yang tinggi ke atas prestasi protokol penghalaan. Kajian penyelidikan ini adalah berdasarkan kepada andaian bahawa kelajuan relatif dan jarak memberi kesan kepada topologi dinamik dan capaian rangkaian, terutamanya dalam persekitaran mobiliti yang tinggi, yang merupakan ciri yang penting bagi VANET. Dalam tesis ini, satu kerangka kerja telah dibangunkan menggunakan model matematik untuk mengoptimumkan penghantaran video melalui konsep jiran berterusan untuk kenderaan geganti. Idea di sebalik model cadangan ini adalah untuk meningkatkan capaian VANET dan meminimakan kelewatan hujung-ke-hujung rangkaian dengan menggunakan konsep kelajuan relatif dan julat penghantaran (jarak) jiran kenderaan geganti. Model cadangan ini telah dilaksanakan dan diuji menggunakan MATLAB. Keputusan ujian menunjukkan sebilangan jiran berterusan secara kritikalnya dipengaruhi oleh faktor-faktor kelajuan relatif dan jarak kenderaan dalam julat penghantaran kenderaan geganti. Disamping itu, konsep jiran berterusan yang dikira oleh model matematik yang dicadangkan telah dilaksanakan untuk memenuhi kaedah PNRS, dan diuji menggunakan OPNET dengan pelbagai senario dan penghantaran video yang berlainan. Hasil daripada perlaksanaan cadangan kaedah PNRS ini menunjukkan konsep kelajuan relatif dan jarak ke atas jiran berterusan (iaitu kenderaan geganti yang terdekat) secara kritikal telah meningkatkan lagi prestasi VANET daripada segi kehilangan kerangka, kelewatan hujung-ke-hujung, ketaran dan pemprosesan. Hasil keputusan ini telah dibandingkan dengan senario-senario jiran berterusan yang berlainan berdasarkan kepada faktor-faktor kelajuan relatif dan jarak. Berdasarkan kepada perbandingan ini, hasil keputusan menunjukkan bahawa peningkatan jiran berterusan membawa kepada peningkatan prestasi VANET. Akhir sekali, perbandingan di antara pendekatan PNRS dengan protokol sedia ada membuktikan bahawa pendekatan yang dicadangkan ini telah meningkatkan dan telah mengatasi protokol-protokol lain daripada segi parameter kos, kehilangan kerangka, dan kelewatan hujung-ke-hujung dengan masing-masing 19%, 30%, dan 41%. Oleh itu, keputusan simulasi mengesahkan bahawa PNRS berupaya mempunyai kualiti penghantaran video yang lebih tinggi berbanding dengan protokol sedia ada.

A FRAMEWORK OF HIGH MOBILITY ROUTING FOR VIDEO TRANSMISSION IN VEHICULAR AD HOC NETWORKS USING RELATIVE SPEED AND DISTANCE

ABSTRACT

Video transmission is a critical issue in VANETs. The main problem is how to enhance the network connectivity for video streaming, overcome frame loss, jitter, end-to-end delay, and maximize throughput. Moreover, the other challenging issue in conjunction with VANET is how to carry out reliable routing in the high mobility environment and how to optimize routing overhead. Pilot experiments have been executed before the implementation of the proposed approach to prove the effect of high mobility and traffic over the VANET environment. A comparative study has been conducted using OPNET for three common routing protocols in VANET to examine the effect of high mobility and traffic environment on the performance of routing protocols. This research study is based on the assumption that the relative speed and relative distance affect the dynamic topology and network connectivity, especially in a high mobility environment that is a vital property of VANETs. In this thesis, a framework has been developed using a mathematical model to optimize video transmission by the concept of persistent neighbors for the relay vehicle. The idea behind the proposed model is to improve the VANET connectivity and minimize end-to-end delay of the network using the concept of relative speed and transmission range (distance) of the relay vehicle neighbors. The model has been implemented and examined using MATLAB. The results show that a number of persistent neighbors are critically influenced by the factors of relative speed and distance of vehicles within the transmission range of the relay vehicle. Furthermore, the concept of persistent neighbors that is calculated by the proposed mathematical model has been implemented, to meet PNRS approach, and examined using OPNET for different scenarios and video transmission. The results of the proposed PNRS approach show that the concept of relative speed and distance affects persistent neighbors (i.e. the closest to the relay vehicle) and crucially enhances VANET performance in terms of frame loss, end-to-end delay, jitter, and throughput. The results have been compared to different scenarios of persistent neighbors based on relative speed and distance factors. Based on this comparison, the results reveal that increasing persistent neighbors lead to the enhancement of VANET performance. Finally, the comparison between PNRS approach and the existing protocols proves that the proposed approach has been enhanced and has been outperforming other protocols in terms of cost, frame loss, and end-to-end delay parameters with 19%, 30%, and 41% respectively. Hence, simulation results verify that PNRS can have a higher quality of transmitted video compared to the existing protocols in an acceptable performance.

CHAPTER 1

INTRODUCTION

1.1 Introduction

In recent decades, the field of wireless communication has grown dramatically in both industrial research and commercial applications. Progress in this area has significantly changed the daily life of people around the world (Yu, Gerla and Sanadidi, 2015). Wireless technologies such as Wi-MAX, 802.11/Wi-Fi and Bluetooth (Márquez-Barja, Calafate, Cano and Manzoni, 2011) assist in exchanging information between mobile devices with different ranges of radio broadcasting. Networks that contain mobile devices should consider the lack of infrastructure, which can be used to support wireless connections. Consequently, a new area of portable communications has surfaced to provide self-configuring network infrastructure-less, specifically Mobile Ad Hoc Network (MANET)(Akhtar, Ergen and Ozkasap, 2015; Stojmenovic, 2003). It consists of mobile nodes, which can act as routers, clients, and servers (Stojmenovic, 2003). Due to the current growth of computer and wireless communication technology, the moving vehicles such as motorcycles, cars, and buses communicate with each other without developing any fixed infrastructure Doetzer (2006). These types of networks are called Vehicular ad hoc networks, VANETs.

The research area of VANET has increased rapidly in recent years. Supporting the fast growth of VANETs, standard protocols such as IEEE P1609, IEEE 802.11p and Dedicated Short Range Communication (DSRC) have been designed to adapt to the requirements of VANETs (Kakkasageri and Manvi, 2013). Moreover, several applications have used the intelligent idea in the transportation systems. Typically, VANETs' applications can be divided into three categories: (1) safety, (2) transportation efficiency, and (3) infotainment (Chen, Guha, Kwon, Lee and Hsu, 2011).

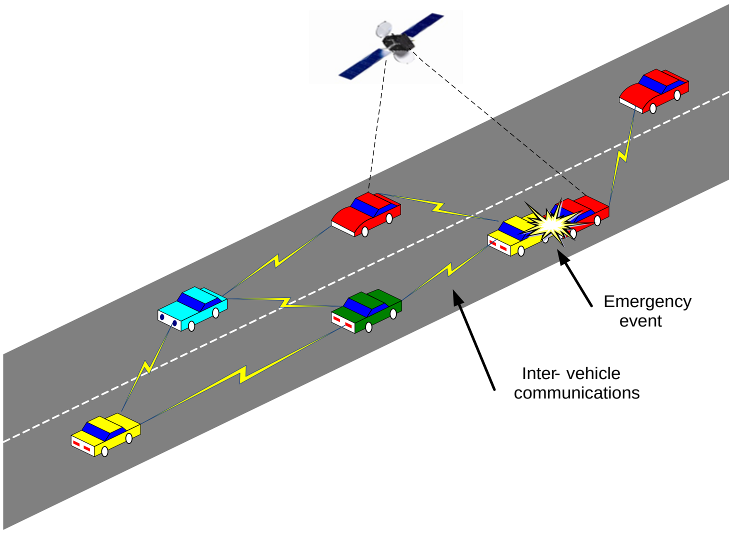

Figure 1.1: Vehicle to vehicle communication in VANET

VANETs have several challenges due to their unique properties such as high dynamic topology and high mobility. For network connectivity, the standards provide VANETs with a sufficient range of communication and bandwidth. Additionally, using vehicle technology as a node to transmit video content, some difficult challenges will occur due to highly dynamic network topology. Moreover, to decrease the end-to-end delay, important methods in VANETs are proposed to improve the network connectivity (Viriyasitavat, Bai and Tonguz, 2011) by gathering the requirements for network efficiency. To emphasize a real contribution to a model is proposed to improve the connectivity of VANET networks. Thus, there is an urgent need for enhancing the connectivity of VANETs in this work by improving the performance of routing protocol used for video transmission over VANET especially delay and jitter.

Recently, VANET has gained much attention, increased primarily by the growth of interest in Intelligent Transportation Systems (ITS). The VANETs' environment, as well as the strict Quality of Service (QoS) requirements represents a challenge on video transmission over VANETs. The most challenging issues in conjunction with VANETs is reliable routing that determines the path of packets traveling over the network (Zeadally, Hunt, Chen, Irwin and Hassan, 2012). Few approaches have considered the route coupling issue that may severely affect the performance of the VANET. Several performance studies (Benslimane, Taleb and Sivaraj, 2011; Gálvez, Ruiz and Skarmeta, 2011; Huang and Fang, 2009; Waharte and Boutaba, 2006; Wang, Lin and Chang, 2004) on path solutions are provided. All these studies have indicated that path scheme will not work or even work adversely for single channel ad hoc network since the interference between paths is very high. To reduce interference (i.e. routing coupling problem) between paths (Gálvez et al., 2011) discover path by taking into account the average weighted distance between paths (Gálvez et al., 2011) using a directional antenna instead of the omni-directional antenna. The protocol can reduce the coupling effect, but it requires the particular kind of directional antennas installed on all the forwarding nodes. Moreover, these works are based on the traditional reactive solution, which is certainly not suitable for highly dynamic scenarios. Additionally, current studies focus on the waiting time as a base for determining the next upcoming hop of the forwarding zone, and this strategy consumes much time and needs broadcasting for all neighbor nodes. However, in this study, the broadcasting and waiting time is minimized by using effective methods for determining of the next hop in the forwarding zone. Furthermore, the proposed framework reduces the computation complexity time as the calculation is subject to the nodes that are only located in the forwarding zone.

Thus, VANETs have recently become a smart field for scholarly research and have also received quite a bit attention from the manufacturing (Benslimane et al., 2011).

Interestingly VANETs are significant technology that supports intelligent transport systems, as well as help to increase in marketing of entertainment applications (Dohler and Li, 2010). By comparing MANETs to VANETs, VANETs have a more dynamic environment, leading high failure rate due to the large number of link break and changes in topology (Dohler and Li, 2010). On the positive side, however, vehicles have unlimited power and computing resources. Including CPU, memory and storage capacity, vehicles are as good as the best options available in the market (Benslimane et al., 2011).

1.2 Problem Statement

The traditional services intended for VANETs need the delivery of multimedia provision or have it as a very useful additional feature. In particular, video streaming abilities over VANETs are vital to the growth of new and appreciated service. A camera installed at an intersection could capture crucial information of an accident to be streamed towards an incoming ambulance and even further to doctors in a hospital, which could decrease significantly the response time in the provision of life-saving health-care. The equivalent camera would correspondingly be able to capture the status of streets, and if this content is transmitted to passengers and drivers, they could better evaluate the traffic circumstances and take informed decisions on their route selection. Police could use cameras connected with vehicles for collecting a local vision of advertisements to be survived or to be used on the follow of fleeing accused. Video streaming could correspondingly be used by on-board game supports to be used as either game-play differences or local business commercial within the game.

However, the high dynamic changes in multi-hop routing is an essential problem for VANETs (Benslimane et al., 2011; Yu et al., 2015). The most challenging issues in conjunction with VANET are dynamic topology and high mobility that affect the network connectivity issue (Gálvez et al., 2011). Thus, the research seeks for extending the connectivity of video streaming to overcome end-to-end delay and delay variation problem. The effect of relative speed should essentially affect the dynamic topology and network connectivity, especially in a high mobility environment, which is an important property of VANETs. To the best of the researcher knowledge and based on current literature, there are a few published studies of research about to addressing the impact of the concept of relative speed along with relative distance within transmission range on network connectivity and routing overhead by decreasing control messages for video transmission in VANETs.

In addition, the number of neighbors that is involved in route discovery and video transmission process in a VANET should necessarily affect the performance of the network and network connectivity. As neighbors are defined later in this thesis, there are persistent and non-persistent neighbors. A persistent neighbor vehicle is the one that has longer connectivity within the transmission range of the relay vehicle because its relative speed and distance are close to the relay vehicle. On the contrary, a non-persistent neighbor has larger relative speed and distance that can minimize its connectivity and take it shortly out of the coverage area of the relay vehicle. Persistent neighbors' concept substantially affects network connectivity and end-to-end delay;

however, there are a few studies of research about this concept in the previous studies.

1.3 Research Questions

The research questions are as follows:

1. How to enhance routing protocol for video transmission in VANET?
2. How to minimize transmission failure and solve the problem of network connectivity by enhancing routing overhead, jitter, throughput and end-to-end delay?
3. What is the level of the research model work efficiency in the high mobility environment?

1.4 Research Motivation

To the best of the researcher knowledge, many of research studies have evaluated the performance of video streaming approaches over VANETs. Thus, there is a need for more systematic comparisons and performance evaluation studies to analyze the functionality of video dissemination protocols. A few research studies have addressed the impact of relative speed and distance on the VANET connectivity and routing for video transmission. Additionally, the concept number of neighbors that are involved in route discovery and video transmission process in a VANET should necessarily affect network performance. The real neighbor concept should essentially affect network connectivity and routing protocols performance; however, there are a few studies of this concept in the previous research. Therefore, the research model is significant because it tries to minimize the gap in the research concerning this concept. It seeks to address the effect of persistent neighbors on the routing protocols performance in high mobility and dynamic topology environment of VANETs in terms of end-to-end delay, jitter, routing overhead and throughput.

1.5 Research Objectives

The main objectives of this research are as follows:

1. To develop an analytical method for maximizing network connectivity by improving routing protocol performance using relative speed and distance.
2. To reduce the transmission failure in the zone by improving routing protocol performance by a mathematical model for persistent neighbors.
3. To examine video transmission in VANET using the proposed approach and make a comparison with another routing protocol.

1.6 Research Contributions

The main contributions of this thesis are:

1. A mathematical model that improves the forwarding issue for relay vehicle in VANET has been developed for video streaming based on persistent neighbors.
2. The researcher proposed a Persistent Neighbors with the Relative Speed (PNRS) approach, which provides good quality for video transmission.
3. Simulation results verifies that PNRS can have a higher quality of transmitted video comparing to the existing protocols in an acceptable performance.

1.7 Research Methodology

The researcher follows a set of methodological steps to achieve the research objectives.

1. Doing a thorough literature review related to the research topic and determining the previous research gaps and shortcomings.
2. Validating the effect of mobility and traffic on routing protocols in VANET. Implementing and executing the simulation using OPNET to compare three basic routing protocols in VANETs namely: DSR, AODV and OLSR. Their performance has examined in terms of routing overhead, end-to-end delay, network load, and throughput.
3. Designing the proposed analytical model in a scientific way and then implementing it using MATLAB. Determining and addressing the most compelling factors from the results.
4. Selecting the most appropriate protocol for the scenarios and performance metrics undertaken, based on the results of validation, and implementing the proposed approach.
5. Performing simulation using OPNET for a high mobility environment of VANETs using a new approach protocol with performance in terms of routing overhead, end-to-end delay, jitter, and throughput for video transmission with different scenarios of execution.
6. Conducting simulation comparisons between the proposed approach and existing schemes.

1.8 Thesis Outline

This thesis consists of the following six chapters:

CHAPTER ONE: presents the problem statement, questions, objectives, motivation, contributions, and methodology of this study. It also discusses the need for improving the efficiency of video streaming transmission in VANET.

CHAPTER TWO: provides a background study and literature review related to the research problem and the possible approaches to overcome it. It critically examines the existing real-time solution that uses methods to improve the video streaming in VANET. Furthermore, it comprehensively discusses the efficiency of the QoS metrics to evaluate the current approaches. It also addresses the need for detecting possible technique that solves the challenge of giving the critical section review.

CHAPTER THREE: explains the proposed framework, routing protocols comparison of high mobility and traffic environment. It also illustrates the validation of mobility effect and designs the new proposed approach based on the idea of the research framework.

CHAPTER FOUR: presents the design and implementation of the work. It contains the proposed solution description, experiments, and simulation environment, trajectory configuration and performance metrics of the simulations.

CHAPTER FIVE: reports the experiments and their results. It also presents a comparative analysis to evaluate the results of the proposed model. In addition, it presents the results analysis and comparisons with existing work.

CHAPTER SIX: concludes this thesis by reviewing the research goals and objectives. The chapter also offers suggestions for future work.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter summarizes most of the relevant background concepts in VANET and the existing works related to the presenting solutions. Some of these studies provide background information and significant challenges. Other studies (Li and Boukerche, 2015; Rezende, Ramos, Pazzi, Boukerche, Frery and Loureiro, 2012), however, undertake related problems such as extending the network connectivity for video streaming and overcome routing traffic received, jitter, end-to-end delay and maximized throughput (Wang, Rezende, Ramos, Pazzi, Boukerche and Loureiro, 2012). This research is done because of lack of studies that have been done directly implicated video streaming in VANETs. This chapter is divided into four parts: Wireless Ad Hoc Network, Intelligent Vehicular Ad Hoc Networks, video streaming in VANETs and routing protocols for transmission in vehicular ad hoc networks. For each division, the motivations of the study as well as a challenge are first described, and then the associated protocols are briefly presented.

2.2 Wireless Ad Hoc Network

The survivable adaptive radio networks (SURAD) program (Freebersyser and Leiner, 2001) related to the history of wireless ad hoc networks with the Defense Advances Research Project Agency (DAPRPA), Packet Radio Network (PRNet). The significant role played by the ad hoc networks was noticed in military applications and many other related research efforts. Due to availability of viable communication equipment and portable computers, industrial and commercial applications for wireless ad hoc networks have become evident in the recent years. Computing capability and information access was also provided to users of mobile ubiquitous by wireless network disregarding their locations. Wireless ad hoc network is independent of previously existing infrastructure, and it is categorized by type. In this type of network, node participation in routing is by data extension to other nodes and based on the network connectivity, the node forwarding the data is always determined. It is a set of networks where all devices are free to move and associating equally with other ad hoc network devices within range. The system is a set of standards with IEEE 802.11 operational mode capable of implementing wireless local area network (WLAN) and it consists of wireless sensor networks (WSN), mobile ad hoc networks MANET and Vehicular Ad Hoc Networks VANET.

2.2.1 Wireless Sensor networks

Wireless Sensor network (WSN) is a collection of spread sensors nodes developed and motivated by military applications to cover a certain range of a geographical area like battlefield surveillance. The application is now used in several physical phenomena like in the study of meteorological parameters such as temperature, humidity, motion, pressure, sound, etc. in a simplest way within the user's comprehension. It consists of a transducer and an embedded processor. The former is used to sense a given physical quantity with a high precision and the later use for processing small memory storage unit and transceiver for transmitting or receiving data locally. The actual size of a network is depended on each particular application and deployment

(Zhao and Guibas, 2004). Wireless sensor networks can be smaller as having two node networks or as large as having million networks.

Being easy to deploy an independent to the availability of power supply, in many applications the source of power to the nodes is battery, which is non-replaceable. Since the node in wireless sensor networks operates only before the depletion of the battery, the most important goal is the conservation of energy. However, the ability of this network to initialize communication with other nodes within range by creating a network to relay information and from the gateway node when the file is deployed makes it attractive. Aggregation of data and its subsequent forwarding from the sensors to the sink is the primary operation in a sensor network.

2.2.2 Mobile Ad Hoc Networks

In the past few years, MANETs have received much attention from the research community. Consequently, significant technical advances have risen for this network. Recently, these multi-hop networks have been envisioned as an important type of next-generation network access, which the demand for multimedia services is increased by end users (Perkins, 2008).

The Quality of Service (QoS) provision is necessary for these multimedia services. Individual features of MANETs, such as mobility, dynamic topologies, energy constrained, limited bandwidth and lack of centralized infrastructure, create the QoS provision a challenging goal over these networks. Therefore, the main significant issues in MANETs are self-configuration and system adaptation. In addition, since the QoS provided by a network does not depend on any single network layer but on the coordinated efforts from all layers, it is advisable to develop dynamic solutions based on cross-layer approaches able to take into account different technical specifications of the protocol stack. The main characteristics faced in a MANETs are:

Dynamic Topologies: The network topology may change accidentally at irregular times due to the free random movement of nodes with diverse speeds. MANET network can accept dynamic movement, movement patterns, and propagation conditions.

Energy Constrained Operation: In an ad hoc network, nodes are fed by limited batteries, so energy consumption is an important issue to be considered. For these nodes, the most important system design optimization criteria may be energy conservation.

Limited Bandwidth: Wireless link continues to have significantly lower capacity than infrastructure networks. In addition, the realized throughput of wireless communications after accounting for the effects of multiple accesses, fading, noise and interference conditions, etc., are often much less than maximum transmission rate of radio.

Security Threats: Mobile wireless networks are usually more tendencies to physical security threats than fixed cable networks. The increased risk of eavesdropping, spoofing and minimize denial of service attacks should be carefully considered.

2.2.3 Vehicular Ad Hoc Networks

VANETs have been an important research issue (Liu, Bi and Yang, 2009) within research communities and industry. All vehicles built with VANETs (Lin, Lu, Zhang, Zhu, Ho and Shen, 2008) will be prepared with the capability to use DSRC (Kenney, 2011), making inter vehicles communicate with each other and with RSUs in the near upcoming years (Parno and Perrig, 2005). The invention of VANETs will greatly assist in traffic management and safety (Barba, Mateos, Soto, Mezher and Igartua, 2012). In an instance, authorities and medical assistance can be notified of the accurate location and severity of the accident effectively on time using the message broadcasting device in the VANETs (Buchenscheit, Schaub, Kargl and Weber, 2009; Yang and Lo, 2010). Furthermore, other vehicles close to the accident can be notified to prevent traffic jam. In addition; social amenities such as online videos and games can be accessed through VANETs, making passengers feel entertained while on a long journey (Costa-Montenegro, Quinoy-Garcia, Gonzalez-Castano and Gil-Castineira, 2012). Moreover, VANETs help drivers to find parking easier by the application of smart parking, and it is environmental friendly as well. Therefore, the services rendered by VANETs for both drivers, transportation authorities, and the society cannot be overemphasized, as it offers safe and enjoyable driving experience for drivers. Also, it provides an avenue for efficient traffic management for transportation authorities as well as improving the environment by reducing pollution. This is why shows VANETs as gaining increasing attention from both research communities and industries and regarded invention as promising future transportation solutions (Losilla, García-Sánchez, García-Sánchez and García-Haro, 2012). In the next section, a special case of VANET is described as Intelligent Vehicular Ad Hoc Networks (InVANET).

2.3 Intelligent Vehicular Ad Hoc Networks

The envisioned InVANET or intelligent transportation systems (ITS) are based on vehicular communication capabilities. Inter-vehicular communication vehicle-to-vehicle (V2V) and via roadside access point's (vehicle-to-roadside, V2R) or Road Side Units (RSUs) are enabled. As timely information is being provided to drivers, the process is expected to contribute to safer and more efficient roads by making travel more convenient. As V2R provides better service sparse networks and long-distance communication, while V2V enables direct communication for small to medium distances and at locations where roadside access points are not available, the integration of the two is beneficial. Figure 2.1 illustrates the most important equipment for intelligent VANET.

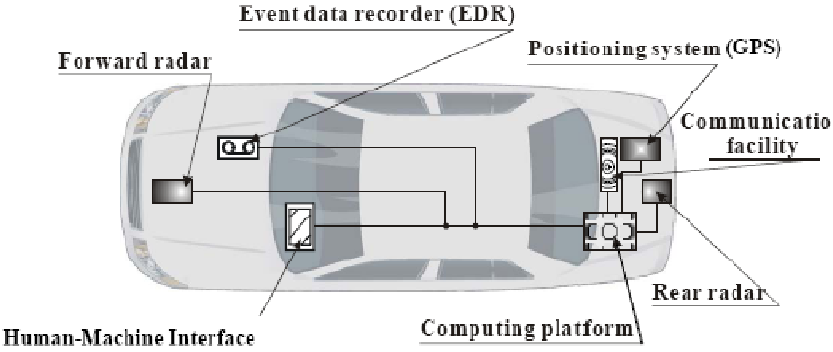

Figure 2.1: Model for InVANET

2.3.1 InVANET Background

Vehicular networks can provide a wide variety of services. Therefore, they attract more attention than other kinds of networks. In VANETs, to provide an extensive list of application collection, including transit safety, crash avoidance, driver assistance, internet access and multimedia, communication between vehicles and possibly with a roadside infrastructure is taken place (Boukerche, Oliveira, Nakamura and Loureiro, 2008). An assumption of the knowledge of the real time position of nodes in this network is made by most protocols, algorithms, and applications. Sensors and On Board Units (OBU) installed in the car as well as Road Side Units (RSU) are incorporated in these networks. The data which is obtained from the sensors on vehicles can be viewed to the driver, sent to the RSU or transmitted to other vehicles based on its nature and significance. This data distributed to the vehicles by the RSU comprising data collected from road sensors, weather centers, and traffic control centers and beside that provides commercial services.

VANET network represents a significant step towards intelligent transportation system. Examples of ITS applications which offer some services are presented in the following paragraphs.

2.3.1(a) Safety

In order to enhance safety in dangerous or sudden driving circumstances, a warning message will be transmitted from a vehicle to its neighborhood. This message is to inform concerning some incidents such as car collision or road surface conditions, so that traffic accident's rate is reduced, and traffic flow control is improved.

2.3.1(b) Resource efficiency

Pertaining to improve traffic fluency by the utilization of data, such as enhanced route guidance or parking spot locator services, remarkable efficiency results are achieved and can be seen in less congestion and lower fuel consumption. This also will, consequently, minimize the environmental and economic impact.

2.3.1(c) Infotainment and Advanced Driver Assistance Services(ADAS)

This is primarily about offering multimedia and Internet connectivity facility to the passengers. These multimedia contents are either downloaded directly from vehicles, or content interchange is taking place between them. There is a great possibility of V2V connectivity, and this basically can be attributed to the persistent evolution of the automotive market and the growing requirements for the car safety. Many issues should be examined, which can be related to architecture, routing, security, performance or QoS. It is essential to impose great concern for interoperability assurance through the standardization of protocols and interfaces, so that the communication between various kinds of vehicles is permitted. Figure 2.2 shows the models of ITS application system.

However, VANETs are structured in an ad-hoc manner; they are quite different from traditional MANETs in terms of network architecture, mobility pattern, an energy constraint, and application scenarios. It has been proved in the literature that is directly applied approaches designed for MANETs, does not lead to efficient performance. It is fundamental provide new approaches, particularly designed for VANETs to succeed in vehicular environment. Examples of the main challenges of communication through VANETs are pointed as many opportunities to develop a broad range

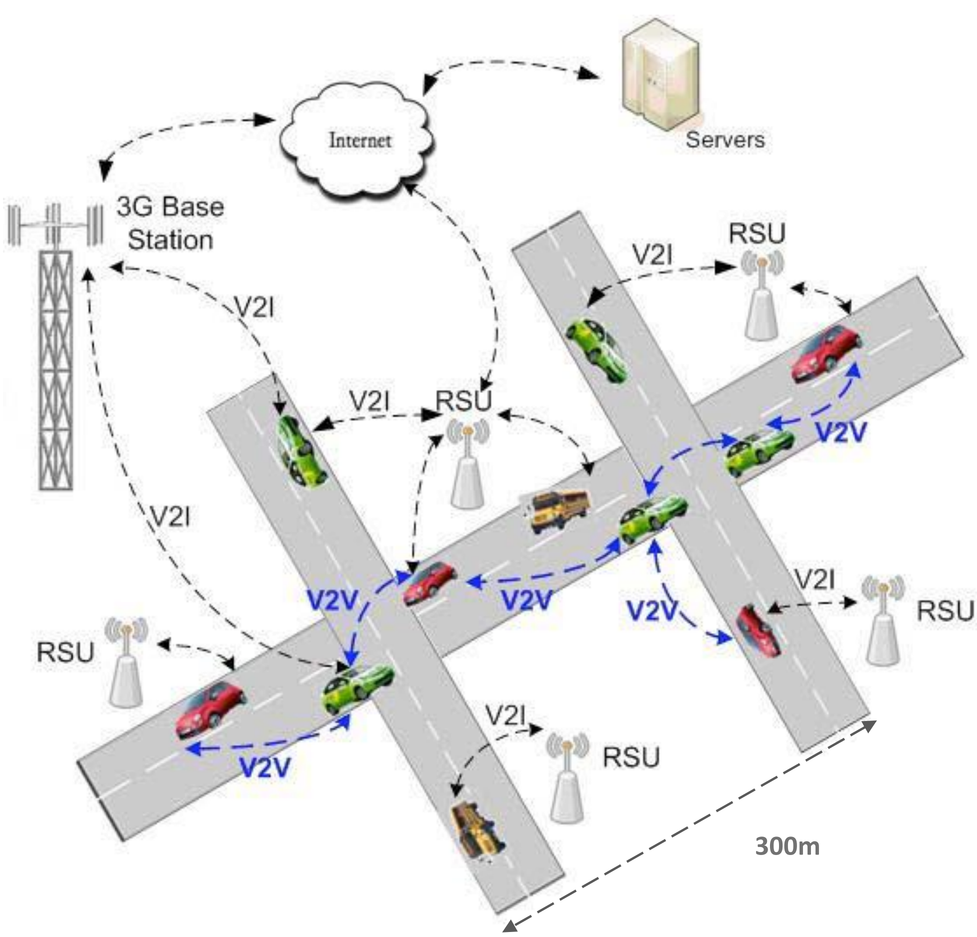

Figure 2.2: ITS application system model

of exceptional services through the utilization of VANETs. These services cover different aspects from offering entertaining applications, such as video conferencing, to improving safety conditions by using automatic braking or promoting the emergency reaction.

2.3.2 VANET Characteristics

VANETs are like to MANETs due to both assist ad hoc interactions among mobile nodes in dynamic network scenarios. However, explored studies and fulfillments executed in the field of MANETs cannot be immediately applied in the case of vehicular networks due to these latter has individual characteristics and specificities (Chaurasia, Tomar, Verma and Tomar, 2012; Spaho, Ikeda, Barolli, Xhafa, Younas and Takizawa, 2013). The following five subsections are describing several features that differentiate VANET networks.

2.3.2(a) Mobility model and network allocation

The main characteristics of VANETs are high node mobility, controlled node's movements, obstacles massive deployment fields and a large number of nodes, which all add to the communication constraints. The environments in ad hoc networks are frequently open spaces. In VANETs, the topology is dynamic although it is not completely random due to the distribution of moving vehicles is mostly over streets and highways as shown in Figure 2.3. In fact, the mobility of vehicles is slightly limited by predefined roads, the direction and some lanes (Behrisch, Bieker, Erdmann and Krajzewicz, 2011).

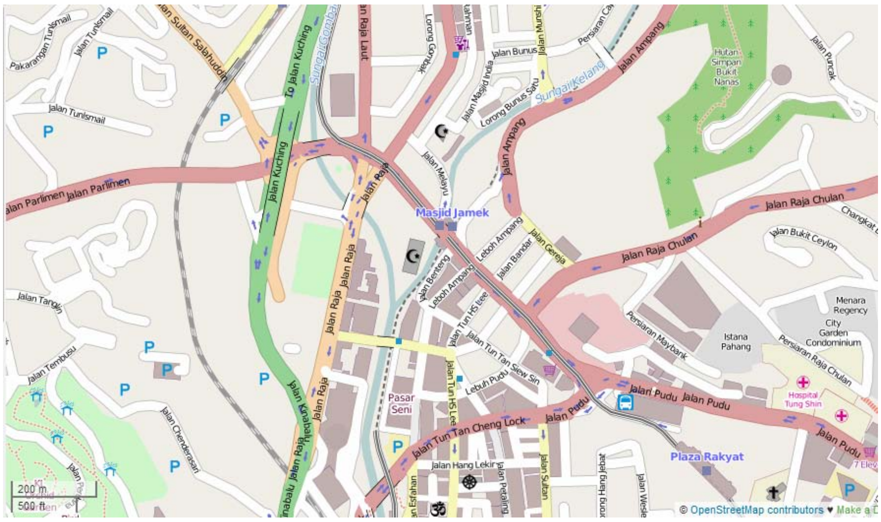

Figure 2.3: Road networks by Open Street Map

2.3.2(b) Network Topology and Density

VANETs have high mobility due to the incredible movement of vehicles, different ad hoc networks. Indeed, the node is capable of connecting and leave the network in a very short time, which makes often change the topology. Additionally, the scaling issues to be included in the solution, due to the network can be very large. Moreover, network density in VANETs can differ as of a very dense network in case of urban mobility to a sparse node distribution as a rural case, in a highly late-night hour. If the connectivity among vehicles is certain in the first case, it becomes a rare experience for the latter case Viriyasitavat, Tonguz and Bai (2009); Yousefi, Altman, El-Azouzi and Fathy (2008). Consequently, VANET protocols have to address these density disparities constrains to achieve well.

2.3.2(c) Security

The main difficult problem in VANETs is security of data and privacy. In fact, for data transmission used in VANETs is very exposed due to the information that the attacks can be played without the need for physical access to the network infrastructure. Consequently, it is necessary to design VANETs as robust as possible and secure them against attacks (Mershad and Artail, 2013; Zeadally et al., 2012).

2.3.2(d) Scalability

VANETs have the promising to produce extremely huge scale, particularly in urban areas where intersections and multi-lane roads are common. Therefore, VANET protocols, mainly those based on a dissemination method, have to face the large number of possible wireless collisions and interferences among nodes through transmissions