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ALTINBAŞ UNIVERSITY
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Electrical and Computer Engineering

**PERFORMANCE EVALUATION OF THREE VANET
ROUTING PROTOCOLS IN AL-RAMADY CITY
BASED ON DENSITY**

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Master's Thesis

Supervisor

Prof. Dr. Galip CANSEVER

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The thesis PERFORMANCE EVALUATION OF THREE VANET ROUTING PROTOCOLS IN AL-RAMADY CITY BASED ON DENSITY prepared by ABDALRAHMAN FATIKHAN ATAALLA and submitted on 08/08/2022 has been accepted unanimously for the degree of Master of Science in Electrical and Computer Engineering.

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Abdallahman Fatikhan ATAALLA

Signature

DEDICATION

To my father, my mother, my brothers and my wife, and to everyone who helped and supported me during my academic study, I dedicate the fruit of my efforts.



ABSTRACT

PERFORMANCE EVALUATION OF THREE VANET ROUTING PROTOCOLS IN AL-RAMADY CITY BASED ON DENSITY

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Vehicular ad-hoc network is one of the most popular networks of ad-hoc network considered as subset of mobile ad-hoc network that's designed to improve transportation safety and the drivers comfort so as to reducing the number of traffic accidents by allows vehicles to connect together wirelessly and exchange the information with one another. Many routing protocols are used and evaluated for VANET; these protocols are one of the important challenges of VANET. In this thesis, we will analyse and evaluate the performance of VANET protocols on real world network for apart of Al-Ramady city based on vehicles density. We used various protocols with different scenarios. The routing protocols that tested in the group of reactive like this (AODV and DSR). In addition, the group of proactive like (DSDV). Four performance metrics used to test each protocol like this (PDR, throughput, E2ED, and NRO). The simulators that used in our proposed model are NS-2 and SUMO simulators. In the results, we found the best protocol in term of throughput, PDR and NRO is DSR but in term of E2ED, the best one is DSDV. From the results, we conclude each protocol is suitable for a specific environment.

Keywords: VANET, DSDV, AODV, DSR.



TABLE OF CONTENT

	<u>Pages</u>
ABSTRACT	vi
LIST OF TABLES	xi
LIST OF FIGURES	xii
ABBREVIATIONS	xiv
1. INTRODUCTION	1
1.1 INTRODUCTION	1
1.2 COMMUNICATION TYPES OF VANET.....	2
1.3 PROBLEM STATEMENT.....	3
1.4 OBJECTIVES	4
1.5 SCOPE.....	4
1.6. SIGNIFICANCE.....	5
1.7. THESIS OUTLINE.....	5
2. OVERVIEW	6
2.1. INTRODUCTION	6
2.2. OVERVIEW OF VANET	6
2.2.1. Architecture of VANET.....	7
2.2.2. Characteristics of VANET.....	9
2.2.3. Application of VANET.....	10

2.2.4. Difference between VANET & MANET	13
2.2.5. Challenge of VANET	14
2.3. ROUTING PROTOCOLS	15
2.3.1. Topology Based Routing	16
2.3.2 Position Based. Routing.....	24
2.3.3. Broadcast. Based Routing.....	24
2.3.4. Geo Cast Based Routing	25
2.3.5 Cluster-Based Routing	25
2.3.6. Challenge of Routing Protocols in VANET	26
2.4. SIMULATION TOOLS.....	27
2.4.1 Open Street Map	27
2.4.2 Simulation of Urban Mobility (SUMO)	27
2.4.3 Network Simulator (NS-2).....	28
2.5. RELATED WORK.....	29
3. METHODOLOGY	35
3.1. INTRODUCTION	35
3.2. PROPOSED MODEL.....	35
3.3. SIMULATION PARAMETERS	42
3.4. RUNING NS-2 SIMULATOR	44
3.5. PERFORMANCE METRICS.....	46

3.6. SUMMARY	47
4. RESULTS AND DISCUSSIONS.....	48
4.1 INTRODUCTION	48
4.2. AVERAGE THROUGHPUT	48
4.3. PACKET DELIVERY RATIO (PDR)	50
4.4. AVERAGE END-TO-END DELAY (E2ED).....	52
4.5. NORMALIZED ROUTING OVERHEAD (NRO).....	54
4.6 SUMMARY.....	56
5. CONCLUSION AND FUTURE WORKS.....	58
5.1. CONCLUSION.....	58
5.2. FUTURE WORKS	59
REFERENCES	60

LIST OF TABLES

	<u>Pages</u>
Table 2.1: Comparison between VANET and MANET.....	14
Table 2.2: Comparison between reactive and proactive protocols[29].	23
Table 2.3: Summarizes related work of most VANET routing protocols.	32
Table 2.3: Summarizes related work of most VANET routing protocols. “tables continued” .	33
Table 2.3: Summarizes related work of most VANET routing protocols. “tables continued” .	34
Table 3.1: Commands of simulation.....	42
Table 3.2: Parameter of simulation.....	43
Table 4.1: Average Throughput of AODV, DSR and DSDV.	50
Table 4.2: PDR of AODV, DSR and DSDV.....	52
Table 4.3: Average End-to-End Delay of AODV, DSR and DSDV.....	54
Table 4.4: Normalized routing Overhead of AODV, DSR and DSDV.....	56

LIST OF FIGURES

	<u>Pages</u>
Figure 1.1: VANET [4].	2
Figure 1.2: Type of communication in VANETs [8].	3
Figure 2.1: VANET model	7
Figure 2.2: VANET Architecture	8
Figure 2.3: VANET applications.....	10
Figure 2.4. Routing Classification protocols in VANET.	16
Figure 2.5: Example of DSDV routing table.....	17
Figure 2.6: AODV rout discovery process[26].	20
Figure 2.7: DSR rout discovery process[28].	22
Figure 2.8: Architecture of NS-2 simulator [35]	29
Figure 3.1: Research methodology	36
Figure 3.2: AL-RAMADY city by open street map.	37
Figure 3.3: Commands window and some commands.	38
Figure 3.4: Ramadi.sumo.cfg code.	40
Figure 3.5: Map under SUMO.....	41
Figure 3.6: File output (trace file).	45
Figure 3.7: Network Animatore File (NAM).	45
Figure 4.1: Average throughput VS number of vehicles.	49

Figure 4.2: PDR VS number of vehicles.51

Figure 4.3: Average End-to-End Delay VS number of vehicles.53

Figure 4.4: Normalized routing Overhead VS number of vehicles.55



ABBREVIATIONS

VANET	:	Vehicular Ad-hoc Network
MANET	:	Mobil Ad-hoc Network
NS-2	:	Network Simulator Version two
SUMO	:	Simulation of Urban Mobility
ITS	:	Intelligent Transportation System
RSU	:	Road Side Unit
OBU	:	On Board Unit
V2V	:	Vehicle To Vehicle
V2I	:	Vehicle To Infrastructure
AODV	:	Ad hoc On- Demand Distance Vector
DSR	:	Dynamic Source Routing
DSDV	:	Destination Sequenced Distance Vector protocol
E2ED	:	End To End Delay
PDR	:	Packet Delivery Ratio
NRO	:	Normalized Routing Overhead
RREQ	:	Route Requests
RREPs	:	Route Replies
NAM	:	Network Animator

1. INTRODUCTION

1.1 INTRODUCTION

The world's worrisome growth in both the quantity and speed of cars. Accidents significantly increased as a result of this. In accordance with World Health Organization data, a road accident results in the deaths of about 1.3 million people annually. Additionally, around 50 million of people experience nonfatal injuries, and a large number of them develop disabilities because of their injury. Therefore, the VANET technology enables cars to communicate wirelessly with one another, improving transportation safety and driver comfort in order to decrease the frequency of traffic accidents.[1].

VANET is an abbreviation for the term Vehicular Ad- Hoc Network, which is gaining traction in academia as well as business. It is an important component of the ITS (Intelligent Transportation System), which intends to improve driving safety according inter-vehicle connections with roadside unit [2][3]. The VANET system is supported by the immediate availability of traffic incident information for end users with access to roadside infrastructure and the internet. Ad hoc networks in vehicles may be used as an ITS monitoring and early detection system, delivering an accurate triggering signal for mitigating steps in the early phases of a prospective traffic issue. VANET is a self-organizing network developed for vehicles equipped with communication equipment [4], as shown in Figure 1.1.

The Federal Communications Commission has set aside a specific 75 MHz frequency band for the VANET, known as Dedicated Short-Region Communications (DSRC) in the 5.85 GHz to 5.925 GHz range. In the absence of a central access point, this enables wireless communication between VANET units. As a result, under ITS, each vehicle may act as a transmitter, receiver, and router in order to distribute data. This connection may be accomplished by putting GPS and VANET On-board Units in automobiles and roadside units, which enable communication by constructing a short-range wireless Ad-hoc network. The retrofitted vehicles serve as network nodes, with each node acting as a network router, data destination, and data source. Using a

Device Based on Dedicated Short-Range Communication (DSRC)-based Device, equipped automobiles can communicate over the 5.8 GHz frequency band in the indicated applications [5][6]. DSRC also allows for high-speed communications between automobiles for ITS-based systems, with a range of up to 1000 meters. Warning messages, intersection collision avoidance, and approaching emergency vehicle warning are all potential DSRC-related applications for traffic management and public safety, and this traffic incident information can play a critical role in better driving by making incident information available early [6].

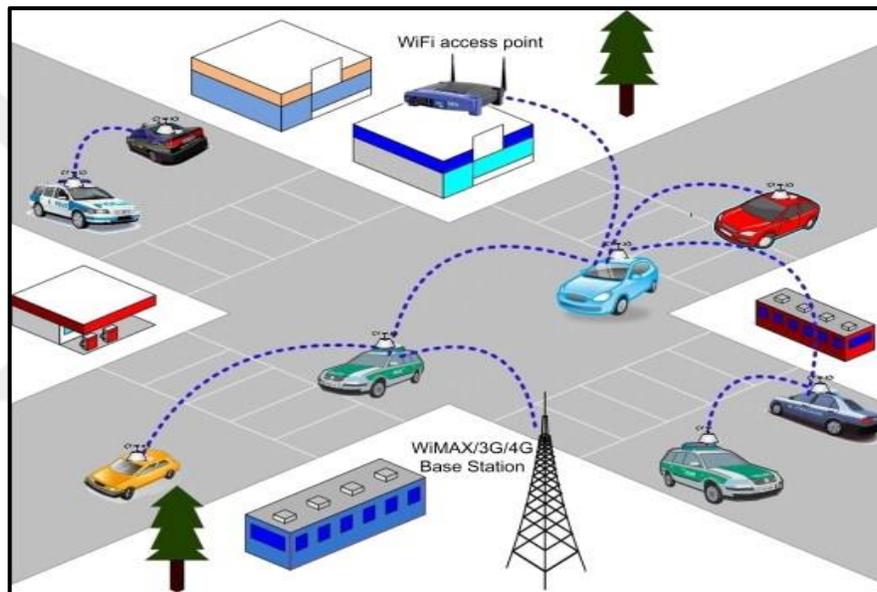


Figure 1.1: VANET [4].

1.2 COMMUNICATION TYPES OF VANET

There are two categories to describing VANET:

- I. Vehicle to vehicle communication (V2V) some features are shared only by vehicles. The domain of this communication, such as vehicle that have same model or vehicles that share the same precise position within the same time interval [7].
- II. Vehicle to infrastructure communication (V2I) warning messages are broadcast from infrastructure to all vehicle on the road via road side unit (RSUs) to improve safety.and traffic

flow. Wherever feasible, their placement, particularly on curves, crossroads, or narrow roadways, should be detected [3].

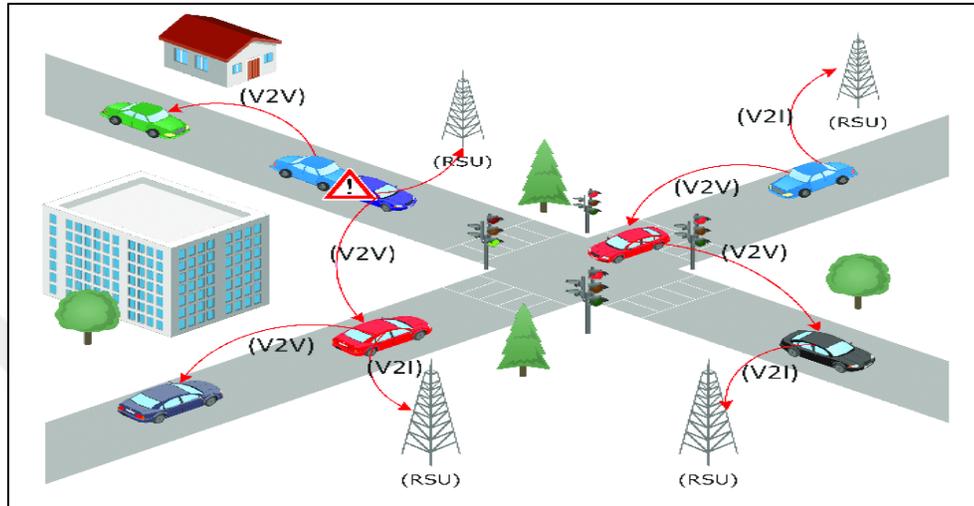


Figure 1.2: Type of communication in VANETs [8].

1.3 PROBLEM STATEMENT

We Present the general problem that tackled the problem of VANETs routing protocols. In this study, the main issue is to compare three protocols also while providing insight into the simulation method furthermore how VANET operates utilizing the tools offered in NS-2. As a result, the reason of choose SUMO simulator is:

- I. It aids in the investigation of numerous study subjects such as a traffic light, algorithm route selection, and vehicular communication simulation.
- II. It is more than simply a traffic simulation; it is a collection of tools and applications that aid in the planning and execution of traffic simulations.

1.4 OBJECTIVES

Many objectives of this thesis but the main objective of it is to evaluate the performance of three routing protocols in VANET. This will be achieved by:

- a. To propose ability to compare between various protocols with different scenarios. The routing protocols that compared in the group of reactive like this (AODV and DSR). Also, the group of proactive like (DSDV). These protocols are based on four performance metric like this (throughput, PDR, E2ED, and normalized routing overhead). In addition, the simulation procedure and how to operate VANET utilizing SUMO under accessible tools in NS-2 are highlighted.
- b. To improve and demonstrate the methodology of VANET simulation using tools that are available by using NS-2 / via using SUMO, because it is more than a traffic simulation, but a collection of tools and applications that aid in the preparation and execution of traffic simulations.
- c. To simulate vehicle ad-hock network (VANET) under real-world traffic (ARAMADY city) in a broad and in-depth evaluation of three routing protocols like these (AODV, DSR, and DSDV) in different scenarios of node density (from 10 to 50).

1.5 SCOPE

This project scope will achieve:

- i. This study focuses to evaluate three routing protocols with different scenarios. The routing protocols that evaluate in the group of reactive like this (AODV and DSR). Also, the group of proactive like (DSDV in five different nodes density scenarios).
- ii. The routing protocols will be evaluated by using four performance metrics like this (throughput, PDR, E2ED, and normalized routing overhead)

1.6. SIGNIFICANCE

The main significance of this thesis is to propose a new approach that used to solve the problem of routing protocols in VANET. This will be achieved by using a different Protocol like, AODV. DSDV and DSR this work takes the main advantage of each protocol them to produce a stable network with high performance.

1.7. THESIS OUTLINE

This project is divided to five chapters distributed as follows:

Chapter1: Presented the overview of VANETs then explain the problem statement, objectives, and scope.

Chapter2: Presented the theoretical part as well as the related work.

Chapter3: introduced the research methodology and the practical procedures to get the results.

Chapter4: This chapter included the simulation setup and discussion the results of project.

Chapter5: Involved the conclusion and future work.

2. OVERVIEW

2.1. INTRODUCTION

This chapter will provide an overview of the background around the thesis. First, it begins with an overview of VANET, including its architecture, characteristics, applications, and routing protocols. Next, it will explain some comparisons between VANET and MANET. Afterward, it will discuss the most likely future challenges that VANET and its routing protocols may face. Finally, talk about simulation tools that used in in proposed model and make a survey about important related work.

2.2. OVERVIEW OF VANET

VANET is a subset of MANET (mobile ad-hoc networks) where vehicle used as nodes. A critical component of VANET is the interconnectivity of access points and automobiles. As dispersed locations and access points were permanently linked to internet, because the vehicles continue to move. V2V and V2I communication are the two terms used to describe the transmission of messages between vehicles and access points [9]. Communication between vehicles is primarily divided into two types: single hop and multi hop. If two vehicles can communicate directly, it is called single-hop communication, and if more vehicles are involved, it is called multi-hop communication. VANET is a specific example of MANET due to varied road constructions and significant vehicle mobility, and because there is no constraint on node density at the network, the unique environment of VANET makes building its routing protocols a difficult process. Routing protocols in VANETs are critical to the success of desired VANET applications [10]. Figure 2.1 show the VANET model.

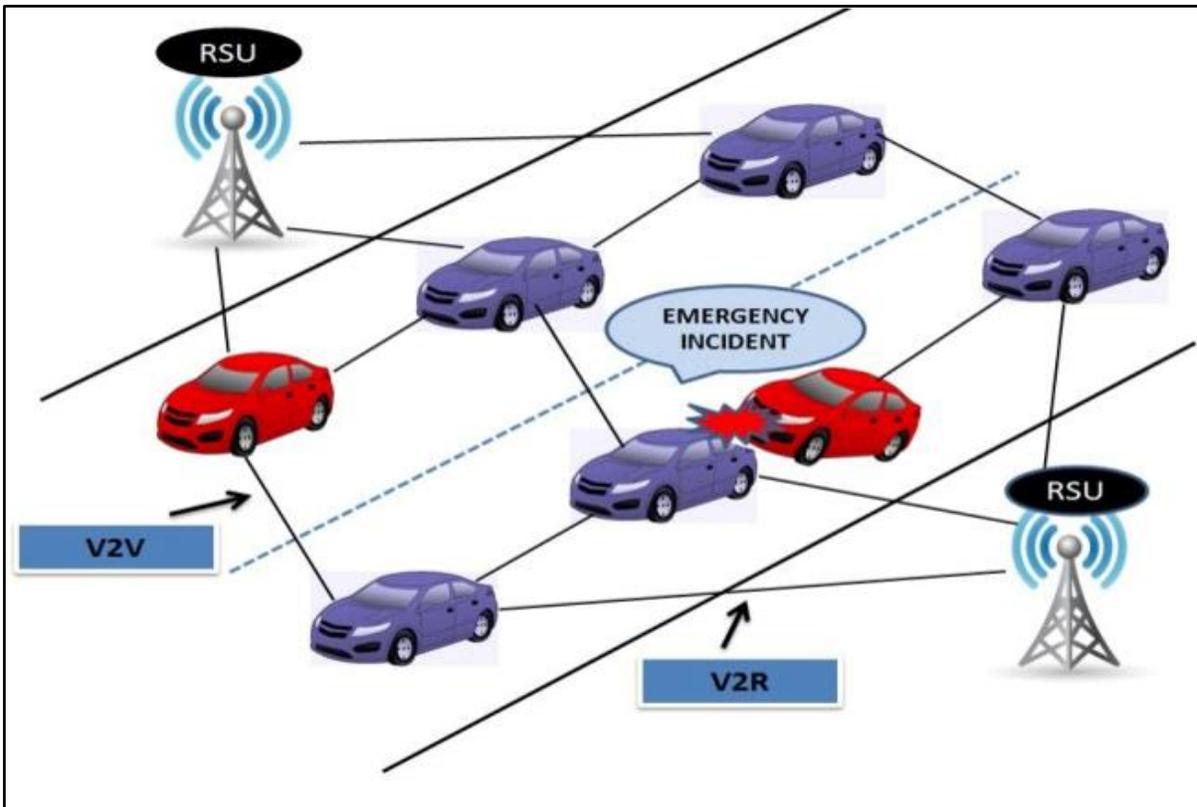


Figure 2.1: VANET model [11].

2.2.1. Architecture of VANET

Communication between automobiles and between vehicles and a Roadside unit may be done using WAVE (RSU). Additionally, this kind of communication enables safety apps to enhance safety of roads and create a more pleasant driving experience for passengers and drivers alike [12].

The phrases "user" and "provider" refer to two distinct people or things. While a user is using the services, a supplier is providing them. RSUs and OBUs may play either a provider or a user role in the network, depending on their specific functions [13]. A system consists of an AU (Application Unit), OBU (On Board Unit), and RSU (Roadside Unit). The figure 2.1, show VANET's architecture.

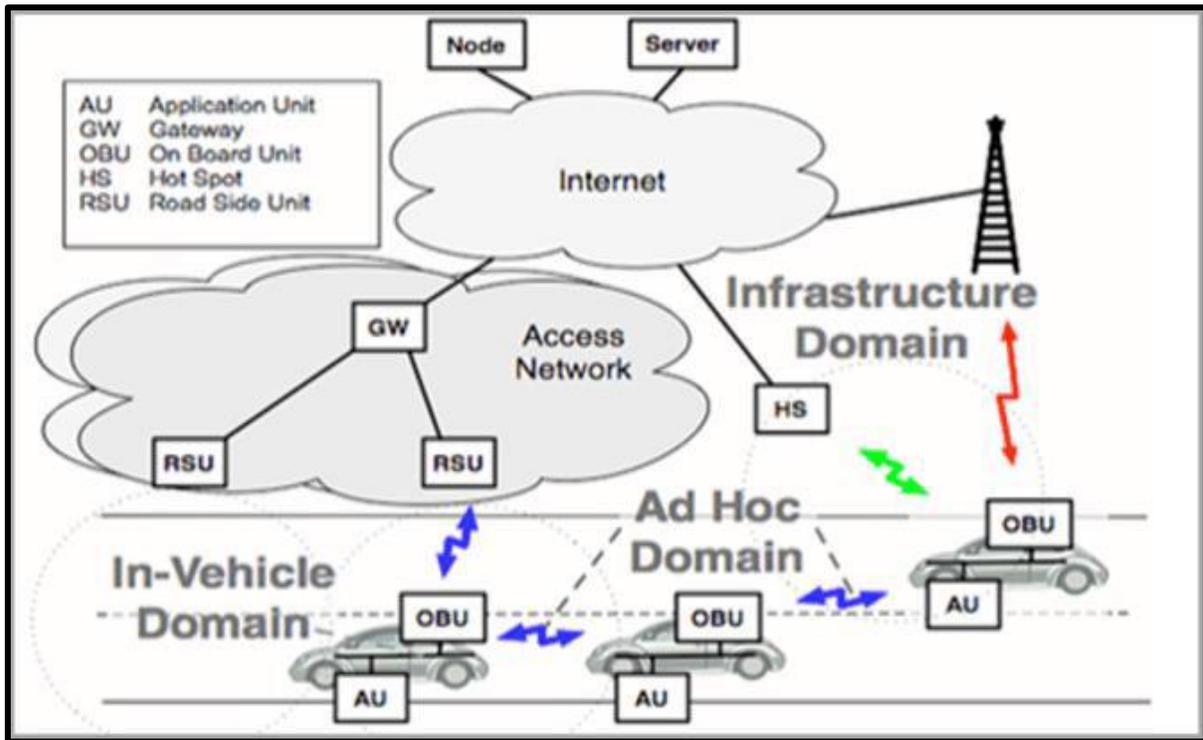


Figure 2.2: VANET Architecture [13].

On Board Unit (OBU): Every vehicle most has OBU to communicate with RSUs or other WAVE devices, OBUs often attached to vehicles. Like a router, the transceiver is linked to an antenna and a CPU [14], [15]. Additionally, it provides other OBUs with information on what it has received. Service programs are the means through which AU is supported. Various wireless communication methods may be used to communicate with all external components [16], [17].

Application Unit (AU): The OBU communicates with the AU through an app that runs on the AU. Additionally, the AU might operate on a standard device, such as a personal digital assistant (PDA), which can access the internet and perform online services. Whether via a wired or wireless connection, OBUs communicate with Application Units It connects OBU to the internet, allowing data to be transferred and received [12][13].

Roadside Unit (RSU): RSUs (radio-frequency identification devices) are often located near junctions and parking lots. Security information may also be utilized to avoid mishaps because of the device's ability to connect to the internet. Information is only accessible to those who have been authorized to do so. The strategies we use include the use of pseudonyms, mix zones, ad hoc anonymity, and quiet times. For instance, they're situated in densely populated areas like parking lots and crossroads [17], [18].

2.2.2. Characteristics of VANET

However, VANET has its own specific property, which may be characterized as being a subset of MANET:

- a. High mobility: There are several variables at play in VANET's environment. During rush hour, the density of traffic increases due to the wide range of speeds being used. Fixed RSUs and mobile vehicles make up the bulk of a VANET. Due of the vehicle's changing speed, communication difficulties emerge at all speeds. In reality, when there is a lot of traffic, automobiles may communicate because it slows or stops the flow of traffic [13][19].
- b. Predictable mobility: Predicting car movements is only possible on roadways. It's simple to find out where you're going using GPS. To quickly ascertain a vehicle's location, just keep an eye on its speed and path on the road.
- c. Topology of Network connectivity: The topology of a system is dynamic, changing all the time as vehicles move about. Changes in the topology of nodes are frequent, as are their connections and separations.
- d. Power resource availability: Because of the powerful batteries in vanet vehicles, the OBU no longer has a power limitation. The construction of a network that does not need energy or processing resources to transmit information from one vehicle to another is completed. For sophisticated computations, they have powerful processors and their own batteries.

- e. Inconsistent network solidity: The amount of traffic in a given area depends on the density of the network. Rural locations have a lower accident rate than either cities or interstates, for obvious reasons:
- f. High computational facility: GPRS, WiFi, Bluetooth, GPS, and other high-tech features are already commonplace in automobiles thanks to recent upgrades by service providers [19]

2.2.3. Application of VANET

A wide range of data and applications are available to drivers and passengers in the VANET environment. The vehicle's onboard electronics incorporate some of the most up-to-date wireless access and sensor technology. The data from the roadside gadget is utilized to ensure everyone's safety and comfort while on the road. It will get data from other vehicles. For the sake of categorizing VANET applications, we will deal with three major headings: safety, traffic efficiency, and leisure and recreation. Figure 3 depicts a taxonomy of VANET applications and the accompanying use cases.

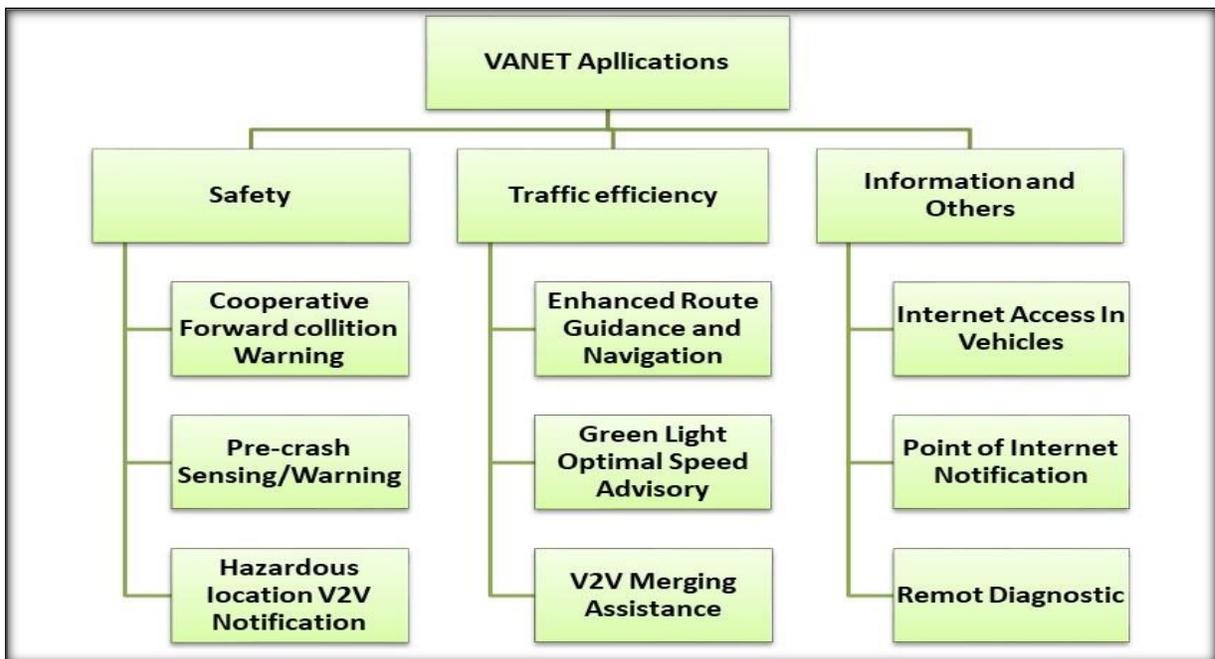


Figure 2.3: VANET applications [19]

Here is a breakdown of the primary use cases for each category.

A. Safety Applications

A primary goal of this apps is to keep motorists safer on the road by alerting them to potentially hazardous conditions before they happen. provides a few use scenarios for safety and the standards that go along with them. We'll go through the most common usage scenarios in the next paragraphs [18].

a. Forward Collision in a Cooperative Environment Warning: the aim of this use to aid drivers in order to prevent rear-end incidents with other cars. Driver distraction or abrupt braking are the most common causes of rear-end crashes. In order to prevent a collision, the vehicles involved exchange location, speed, and direction information.

The vehicle's driver is alerted when a dangerous scenario (such as an inadequate safety distance) is recognized. Sensor / warning prior to crash: Cooperative Forward Collision Warning believes that a collision is imminent and inevitable, unlike this use case. To make greater use of a vehicle's actuators, the participating cars share relevant information with nearby vehicles in an effective manner [3].

b. A Dangerous Place It is the purpose of this use case to notify other cars in the vicinity about potentially hazardous road conditions (such as potholes or bottlenecks) using a vehicle-to-vehicle notification system. That information is used to improve its own safety systems, and it is subsequently shared with other cars in the immediate vicinity. Using V2V connections, the information is then shared with other cars that may be affected. External service providers may also provide RSUs information about potentially hazardous spots on the road, which RSUs then distribute to cars within their communication ranges. Vehicle that has received the data to spread it to others will then use V2V connections.

B. Traffic efficiency applications

The aim of traffic applications is to make transportation networks more efficient by giving drivers and road operators with traffic-related information. Traffic information must be transmitted over the VANET in order to accomplish this purpose. Reduced travel times and lower maintenance costs are both good for road users and road operators, so everyone wins. V-2-V Communication Consortium traffic efficiency instances are outlined below, with a brief explanation of each.

a. In order to better estimate the likelihood of traffic congestion on major highways, the infrastructure owner may gather traffic data from a wide area using this technology. The RSUs will then relay the predicted information to the cars. As a result, drivers will be alerted about present and projected traffic conditions around the area, as well as potential delays and alternate routes to their final destination. As a result, the transportation system as a whole will see an increase in efficiency.

b. In order to help drivers, avoid stopping altogether, the Green Light Optimal Speed Advisory tells them where a signalized junction is and when to switch the light signals, which helps them drive more smoothly and saves time. To avoid having to slow down or stop in order to get to the junction when the traffic light turns green, the vehicle may use this information at the proper moment to compute its ideal speed. This is likely to lead to an increase in traffic and fuel efficiency [19], [20].

C. Infotainment and others

This subcategory includes use cases that have nothing to do with traffic safety or efficiency. Some of these examples offer drivers with frequent amusement or information. Those that are not visible to the driver serve a critical part in increasing the vehicle's performance.

a. Drivers and passengers may use the VANET to connect to the Internet while driving. RSUs serve as internet gateways in this scenario.

b. What's the Deal? By sending out notifications to adjacent automobiles, merchants and advertising agencies may promote special offers and sales to potential customers. Advertisement information such as location, hours of operation, and price is broadcast by an RSU to cars that have been contacted. Each car will filter the received adverts based on the profile and context of the driver before presenting relevant advertisements to the driver [16],[19].

2.2.4. Difference between VANET & MANET

We can see that VANET, and MANET protocols and procedures are comparable in many ways, but this does not mean that the features and behaviour of these two systems are identical. VANET's manufacturing costs are higher than those of MANET, which is the primary difference between the two networks. Because of the rapid speed of automobiles, the VANET has a frequent and fast network architecture, whereas the MANET is sluggish and [21]slow. VANET has a higher bandwidth than MANET. The nodes in MANET, moving at random, whereas in VANET, the nodes move at a regular pace. Here is a comparison between VANET and MANET , as seen in the figure 2.4, [21].

Table 2.1: Comparison between VANET and MANET.

Parameter	VANET	MANET
Production cost	Costly	Inexpensive
Network topology change	Frequent and very fast	Sluggish/Slow
Mobility	High	Low
Density in node	Frequent Variable and Dense	sparse
Bandwidth	Thousand kps	Hundred kps
Range	Up to 600 m	Up to 100 m
Node lifetime	It is depended Vehicle Lifetime	It is Depended on Power Source
Reliability	High	medium
Nodes Moving Pattern	Regular	random

2.2.5. Challenge of VANET

Although VANETs leverage cloud computing to tackle current difficulties, there are still a number of basic issues that must be addressed as the number of intelligent vehicles grows. Based on quick advancement and development predisposition of VANETs, certain important obstacles and needs for future VANETs have been uncovered. Additional developing technologies will be integrated into VANETs in the future, bringing new capabilities to the system [22]. Future VANETs will have to deal with the following significant issues:

- a. Intermittent connectivity: Control and management of vehicle-to-infrastructure network connections is a major problem. The great mobility of vehicle or the great packet loss of

automotive networks should be minimized in order to prevent interruptions in communication.

- b. High mobility and location awareness: Mobile and aware cars are essential for the future of VANET communication. In the event of an emergency, each vehicle should know exactly where the other cars in the network are located.
- c. Heterogeneous vehicle management: There will be a slew of different types of smart automobiles on the road in the future. Another problem of future VANETs is the management of diverse vehicles and their erratic connectivity.
- d. Security: Every user's data content and location is at danger of exposure. Users should be able to determine what information they want to share and what information they want to keep private when their cars communicate with each other in the infrastructure. Local examination of sensitive data rather than uploading it to cloud ensures privacy [23]
- e. Intelligence support for networks: Future VANETs have the difficulty of supporting network intelligence. the clouds on the edge receives and acquires data and does pre-processing of the vehicle in future VANETs before sharing it with other portions of network, such as standard cloud servers [22], [23].

2.3. ROUTING PROTOCOLS

Ad hoc networks, such as VANETs, are distinct from more traditional networks in that they are characterized by more mobility and more rapid topology changes. Routing protocols employed in MANETs are first test in many contexts and then examined for usage in VANETs, where they are not surprising. Vulnerable routing methods do not guarantee that the distribution of identical logical addresses would be refuse in VANET. Thus, we are looking for an alternative solution. As a result, traditional MANET addressing techniques are seldom suitable in a VANET environment. Problems with VANET configuration, number of vehicles, mobility patterns, demographics, Random variation in incoming vehicles, moreover, the main reason is that road size are typically smaller than broadcast coverage; these make the use of inappropriateness of

common ad-hoc protocols. VANET routing protocols may be broken down into five broad categories: Protocols for topology, clustering, position, geocast, and broadcast are examples of this. The figure 2.5 bellow show the routing protocols classification in VANET. [21][24].

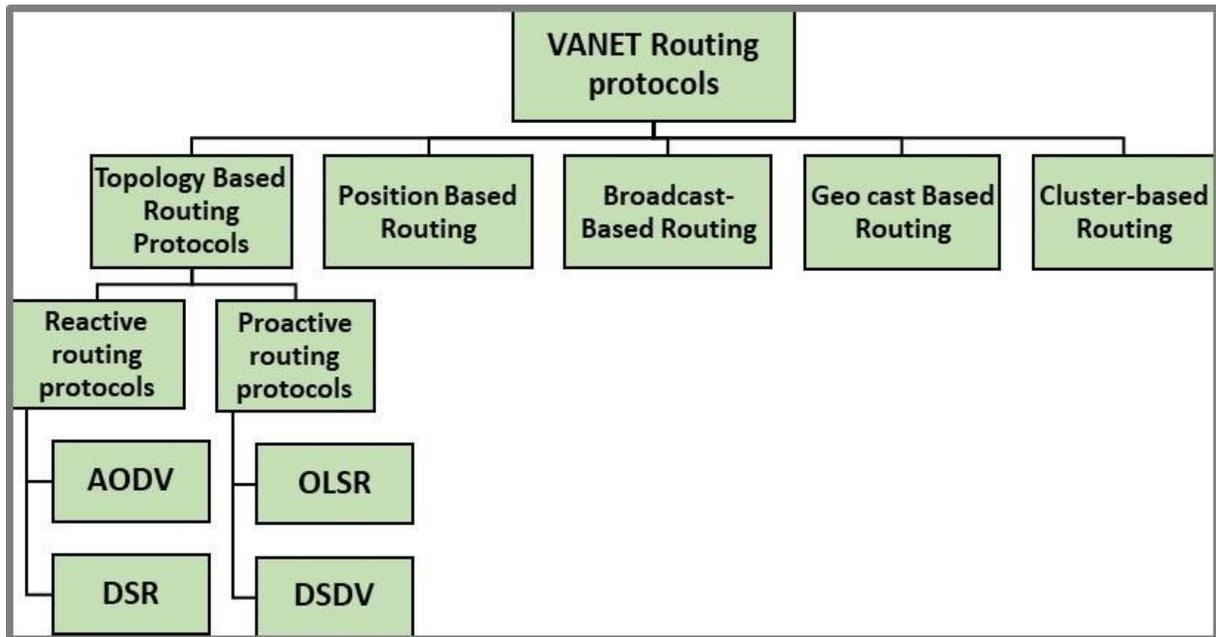


Figure 2.4. Routing Classification protocols in VANET.

2.3.1. Topology Based Routing

Protocols based on topology make advantage of an already-existing connection to transmit data. According to these regulations, there are three main groups.

2.3.1.1 Proactive Routing. Protocols

In this kind of protocols, every node keeps track of its own unique routing table, which contains data that sent to every other node. Examples of preventative measures are DSDV and OLSR. [24].

A. Destination - Sequenced Distance Vector protocol (DSDV)

DSDV Protocol is the most of significant proactive routing technologies first previously designed for MANET. To meet the requirements of a stable environment in MANET, a few changes were made to the traditional Bellman-Ford routing method provided by RIP. The enhancements made to Bellman Ford algorithm eliminate routing table loops. This was accomplished by associating sequence number (originally generated by the node of destination) with each distance vector item to signal its stability and freshness, hence preventing the development of routing loops.

a. Example of DSDV routing table

In order to provide all nodes with a consistent representation of the network structure, routing table changes are frequently broadcast across a stable network; figure 5 depicts the routing table for node N1 in an ad-hoc environment. Accordingly, an enormous volume of network traffic will emerge. To overcome update difficulties, two sorts of packets are specified; the first is a complete dump packet, which carries all available routing information rarely. In contrast, the incremental packet is smaller than the full dump packet and is used to transmit just the information, which has changed since last previous complete dump.

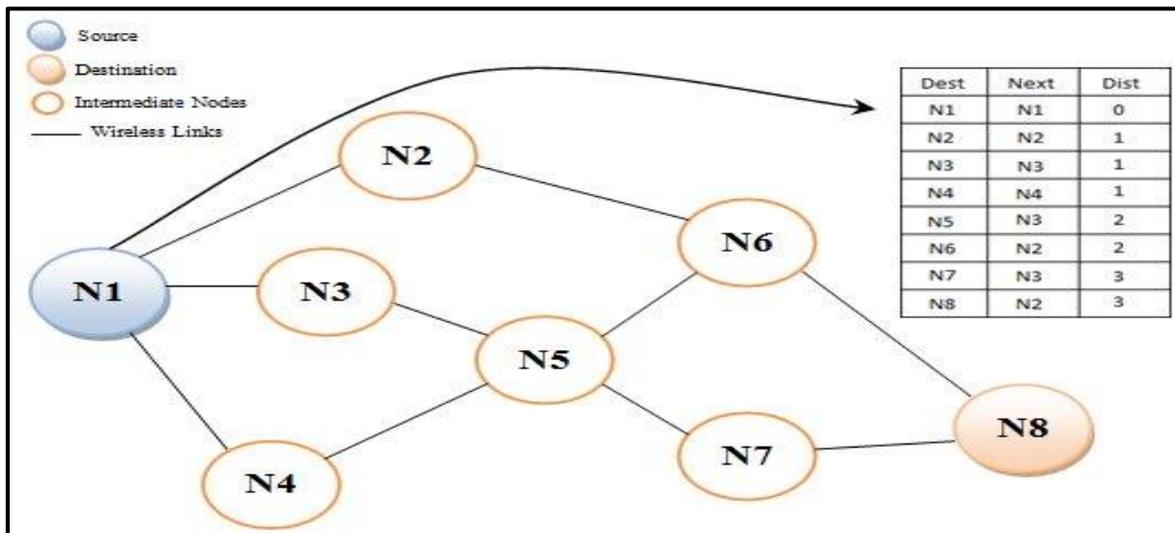


Figure 2.5: Example of DSDV routing table[25].

The primary purpose of DSDV is to maintain track of both outdated and up-to-date information describing the network topology with low influence on network overhead. Consequently, each node has two tables of routing. One is used for data packet forwarding, while periodic routing information packets advertise the other. Accordingly, the first table is in charge of complete dumps while the second table is in charge of incremental packets.

A packet broadcast each time a new route is announced, and it contains the following data for each one: a unique sequence number, an address to the destination, a hops number needed to get there, and so on for each one that is broadcast. Whenever a new sequence number is assigned, all of the network's nodes will take that route. As long as the sequence number is equal, a route that has a lower metric will be utilized since it is the shortest route to the destination. Nodes also keep note of the average amount time that routes to the destination vary until the good metric is obtained, which is known as settling time. It's possible for nodes to cut traffic of network and improve routes by removing broadcasts, which would be sent out if an improved route were to be identified in the near future, thanks to DSDV's management of route freshness[25].

b. Benefits and Limitations of DSDV protocol

The main benefits of DSDV protocol is one of the first accessible protocols. It is well suited for VANET with a limited nodes number. There is no commercial implementation of this method due to the absence of a written specification. DSDV ensures a loop-free route. One of the main limitations DSDV is unsuitable for highly dynamic networks because it needs to regular update for its tables routing, which consumes power of battery and small of bandwidth amount even if the network not active. When the networks topology changes, a new number of sequences is required prior of the network can re-converge.

I. Optimized Link State Routing (OLSR) protocol

This protocol use two messages are, hello and topology control messages. The Hello messages used to gather information of link's state and host's neighbour. Topology control messages are used to disseminate information to nearby nodes. Message control intervals are reduced thanks to the protocol.

2.3.1.2. Reactive routing protocols:

When communication is unavailable, this sort of protocol maintains the routing activity. Route Request packets (RREQ) flood the network to request a route on demand. The most popular of reactive protocols are AODV and DSR.

A. Ad-hoc On- Demand Distance Vector (AODV) protocol:

In this protocol, Route discovery is used to conduct the RREQ and RREP operations whenever the source needs to transmit packets to their intended destination. Routing time intervals may be determined at a cheap cost using this protocol. This protocol seeks to decrease the quantity of transmit messages by determining the routes that on demand rather than retaining update information on the route. With the RREQ, wireless communication is possible to all nodes.

i. Rout discovery process of AODV protocol

a. Route Request (RREQ)

Figure 6 illustrates this. The finding of a route Sending RREQ signals to neighbour to (A, B and C) will help the source node (S) figure out a best way to (D). If the node that receives the "RREQ message" is either an intermediate node or the destination node with "recent enough" information of route to destination, it may react to the node of source with an "RREP message". or rebroadcasting RREQ messages until destination or intermediary node with a "new enough route" is reached in the reverse path. The intermediate node is considered to have "new enough routes" to target node when destination number of sequence in RREQ message is highest than or equal to the number of sequence in destination intermediate node's routing database (with less hop count)[26].

b. Route Reply (RREP)

As described in the preceding paragraph, the target node (D) will send an “RREP message” to all node (S), which will then transfer the message to node (A). After receiving the RREQ message from node (A). Node A then sends the message back to the original sender, node S. Source node S performs AODV receive and reply on the RREP message once it is received. The route entry for destination (D) will be update by this function if any of the provided conditions met. First, if the routing table's destination sequence number is less than or equal to the RREP messages to the number of sequence in destination, or (B). If the routing table sequence number is equal to the RREQ message's number of sequence but with a lesser number of hops, then the second condition is fulfilled. RREP messages with the largest destination sequence number value are chosen if node S gets several RREPs.

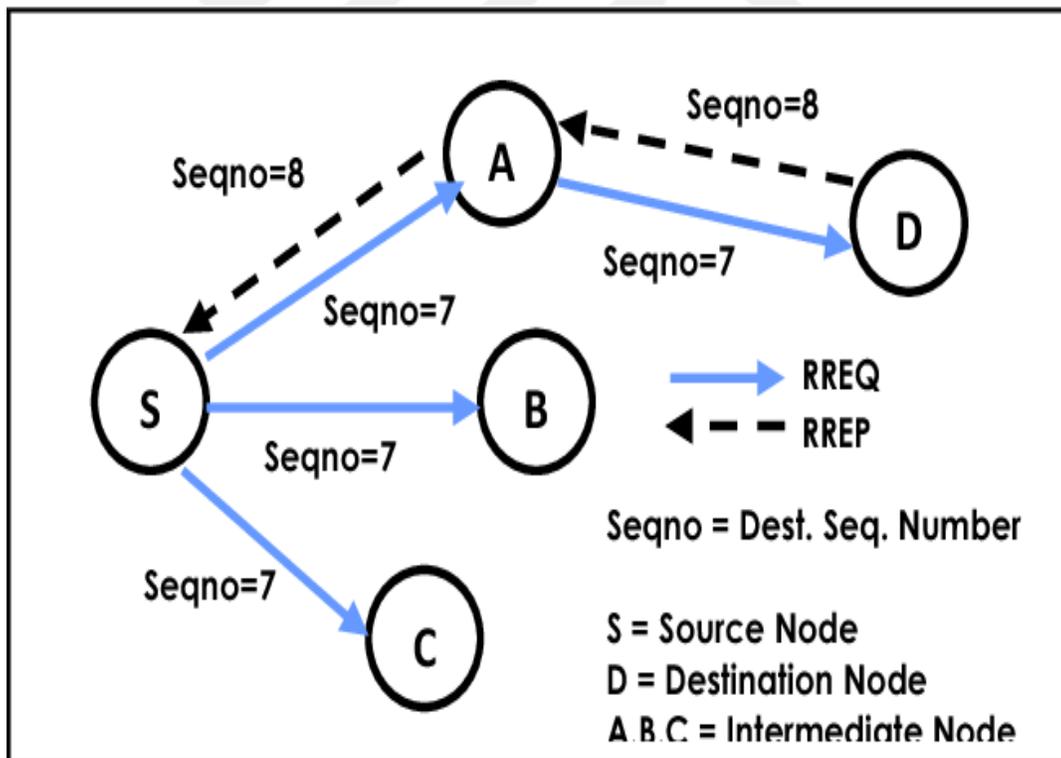


Figure 2.6: AODV route discovery process[26].

ii. Benefits and Limitations of AODV

This protocol's main benefits are that it prioritizes the least congested path above the shortest path and that it allows packets to be sent in both directions even when nodes are constantly changing locations. It also reacts swiftly to changes in topology that impact the routes that are currently in use. Because it does not employ source routing, AODV does not add any extra overhead to data packets. The AODV protocol has a drawback since it demands that all nodes in transmission medium be able to locate each other's transmission. A legitimate route may also have expired, and determining an appropriate expiration period might be challenging. This is because the nodes are mobile and their transmitting speeds might vary considerably and dynamically from node to node. Different network performance measures begin to decrease as the network expands in size. Because it relies on the premise that all nodes work together to construct a path, AODV is subject to a wide range of assaults[26].

B. DSR (Dynamic Source Routing protocol):

DSR is a totally reactive approach. It is a source routing technique, which means that data packets transmitted between nodes carry a list of all the addresses of intermediate nodes via which packets should be routed to their final destination. In DSR, all nodes have a medium storage referred to as routing cache to store the obtained route for any destination node of the network. There are two key aspects of DSR schema. The first schema is the discovery of route and the second schema is route maintenance. During the route discovery process, only two control packets are required for path discovery among any two nodes: RREQ and RREP. During the route maintenance stage, a single control packet known as the Route Error (REER) packet utilized [27].

iii. Rout discovery process of DSR protocol

When the node of source needs to establish a connection with the destination node. It examines its routing cache for a suitable path. If no route is discovered, the route discovery method is launched by broadcasting an RREQ to surrounding nodes. Upon receiving RREQ, if the node in intermediate has a valid path to destination, it transfers the packet of RREP to node that in

source via reverse path of the RREQ packet. If not, it appends its ID to path log field of RREQ header and retransmits the packet of RREQ to surrounding nodes. This procedure is continued until the packet of RREQ reaches its final destination. Due to rebroadcasting broadcasts, RREQ itself may reach to the destination node through many routes. On receipt of the first packet of RREQ, the target node responds by sending a packet of RREP to the node of source, as seen in figure 7. While route selection in DSR is dependent on minimal hop counts, identical RREQ packets arriving at the target node will be rejected if they are identical.

Each intermediate node along the designated route must verify that each sent its successor downstream node has successfully received data packet during the route maintenance phase. Upon detecting a broken connection at any intermediate node, it transmits the message of error route (RERR) to the node of source through the predecessor nodes. On receipt of the packet of RERR, source node starts the process of discovery to establish a new route.

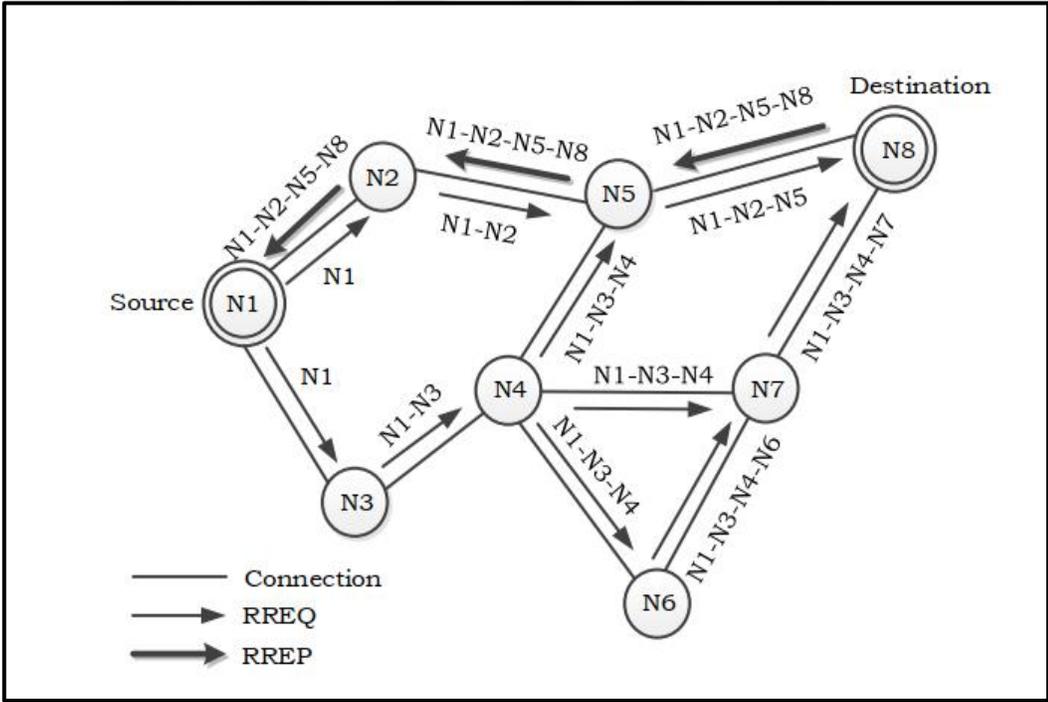


Figure 2.7: DSR route discovery process[28].

iv. Benefits and Limitations of DSR

As the complete route is stored in the packet header, there is not require maintaining a routing table to route a specific data packet, which is one of the protocol's primary advantages. DSR protocol is incapable of scaling to big networks and takes much more processing resources than the majority of other protocols. In order to gain routing information, each node must handle whatever control data it receives, even if not meant for it.

v. Comparison between reactive and proactive protocols

The table 2.1, below show the main Comparison between reactive and proactive routing protocols.

Table 2.2: Comparison between reactive and proactive protocols[29].

Reactive protocols	Proactive protocols
First packet latency is more when compared with table driven routing protocols because route need to be built.	First packet latency is less when compared with on-demand protocols.
No periodic updates. control information is not propagated unless there is change the topology.	Constant propagation of routing information periodically even when topology change does not occur.
Does not incur substantial traffic and power consumption compared to table driven routing protocols.	Incurs substantial traffic and power consumption, which is generally scarce in mobile computers.
A rout is built just if required.	Attempt to maintain consistent, up to date routing information from each node to every other node in the network.
Not available	A rout to every other node in network is always available.

A. Hybrid (both proactive and reactive) routing

Proactive and reactive aspects of routing combined in this sort of protocol. With several nodes, the protocol works best. Hybrid routing aids in improving throughput as the number of nodes grows. Local neighbourhood nodes use the proactive protocol once the global network has been set up using reactive routing.

Hybrid algorithms include the Zone Routing Protocol (ZRP). The routing zone is established by this protocol; however, each node is responsible to keep the network connected. The Nodes in routing zone have instant access to routing information. Comparing ZRP protocol to proactive protocols, it effectively reduces communication overhead. ZRP protocol's route discovery is quicker, and as a result, delays common with DSR reactive routing are reduced [21][24].

2.3.2 Position Based Routing

This kind of routing relies on data from the cars themselves regarding the whereabouts of other vehicles in their vicinity. Geographic routing uses the GPS or other localization methods to determine the precise position of each node. In order to advance a packet to a target, a source utilizes the position of destination to locate next-closest neighbour to the target who is likewise closer to the target than the source is. the most well-known position-based routing protocols is GPSR protocol, incorporates both face routing and greed forwarding into its design [30].

2.3.3. Broadcast Based Routing

When a message must be sent to all vehicles in a VANET, the routing that based on broadcast is the most often used routing mechanism, for example, safety related messages. Messages are sent to neighbouring nodes using flooding, the most basic kind of broadcasting. The overhead of flooding, even if it ensures delivery to all recipients, is considerable, particularly when there are several nodes in the system. As the quantity of communications increases, so does the amount of bandwidth required, which may lead to a decrease in overall performance [26].

2.3.4. Geo Cast Based Routing

It based on multicast routing technology that based on a particular location. The message/packet sent to every node within a certain geographic area known as the Zone of Relevance (ZOR). The message, which may be an accident notice, is normally of minimal importance to nodes, which are far away from accident; therefore, the transmitter does not require to distribute the packets to the nodes outside the ZOR. To reduce the message overhead, a targeted flooding method is implemented inside a certain ZOR [24].

Vehicles in a high-risk region, referred to as a multicast group, would get alerts through the Inter Vehicle Geo cast (IVG) protocol, which suggested in (when an accident happened). To combat network fragmentation, the protocol transmits messages on a regular basis.

2.3.5 Cluster-Based Routing

The neighbouring mobile nodes of a VANET virtually classified in a clustering technique. In the cluster, every node assigned a specific function, such as cluster-head, member or gateway. The average cluster-head work as a regional coordinator, setting up intra-cluster transmission, transfer data, and other similar responsibilities. A node serves as a gateway between clusters by providing inter-cluster connecting. The term "ordinary node" refers to a non-cluster-head node that does not have any inter-cluster links [31].

There are various benefits to routing based on cluster protocols, such as reduced overhead, enhanced throughput and scalability, and greater use in capacity of system because enhanced MAC layer performance.

Due of routing tables must updated after topological changes, clustering minimizes transmission cost at the network layer by reducing their size. Despite the fact that each node only keeps a small portion of the entire routing information of network, clustering is possible to get information of topological by merging the information from current nodes. Due of this, clustering may be explored to construct communication systems that are more scalable and steadier.

VANET has a wide variety of cluster-based algorithms, some of which are described in the following sections. In VANET clustering, there are two types of algorithms to choose from: depending on both location and speed [31][32].

2.3.5.1. Position-based clustering

The nodes' locations are the subject of position-based algorithms. (COIN) uses vehicle dynamics to choose the cluster-head instead of typical approaches that employ node ID or relative mobility. Radio contact between a cluster member and cluster head may last of quite amount of time, when the mobility between them is modest. The COIN protocol is based on the location of the car, which it acquires via GPS [33].

2.3.5.2. Speed-based clustering

Algorithms that route based on vehicle speed are known as speed-based clustering algorithms. There is no need for permanent equipment, like satellite communication or access points, to broadcast messages in the VANET by using the Data Propagation Protocol (PDP) (Little and Agarwal, 2005). There is no need for a global naming function since the algorithm is spread by default. Any kind of traffic situation may benefit from this algorithm. Cost of message exchange is determined by speed, message transmission speed, traffic circumstances, and other factors that are all independent of one other [31]

2.3.6. Challenge of Routing Protocols in VANET

The creation of a dynamic routing of VANET is the most difficult challenge that came with the development and growth of the networks. VANET routing differs from typical MANET routing because of the dynamic and constantly changing topologies of the former. Only a few MANET-specific protocols have been put to the test on VANET. The difficulty, though, is how to minimize the amount of time it takes to transfer data between nodes. Real-time VANET applications may be implemented by overcoming the challenges of MANET protocols. Other potential benefits, such as a reduction in control overheads, must also be considered. The routing protocol should be able to survive the unpredictable and dynamic nature of the vehicular

network architecture, keeping in mind the dynamic features of VANET. In VANET routing, finding and maintaining effective communication pathways in desirable settings is perhaps the most challenging issue [3] [19].

2.4. SIMULATION TOOLS

Because of the VANET's mobility restrictions, accurate predictions of vehicle movement are required for performance assessment. To simulate VANET protocols, a network simulator and mobility models are needed. It is possible to record the protocol's performance under real-world traffic situations by using the mobility model and network simulator.

Using a genuine VANET infrastructure to test and evaluate protocols is complex and costly. Creating traffic and the network environment may be done via simulation. A traffic and network simulator, as well as a few essential VANET simulators, are required for this.

2.4.1 Open Street Map

Volunteers are constructing an open-source map of the globe called Open Street Map, which is being given under an open-content license and is free for anybody to use. The Open Street Map License makes all of the underlying map data and the map pictures available for free (or almost free). With the help of this data, the team hopes to inspire others to do innovative things with it. A Plan of the Area Our map is simple to use. What do you think? Take a peek around and let us know what you think! It has made great strides throughout the years, accomplishing several mapping milestones. Data from Open Street Map has been put to use by individuals, government agencies as well as commercial organizations in several countries and for a wide range of purposes [34]

2.4.2 Simulation of Urban Mobility (SUMO)

This research will use SUMO simulator, which is one of popular tools, which used in the search field for modelling road traffic microscopy. Other options are FARSI and VISSIM. Modelling intermodal traffic networks, involving automobiles on the road and pedestrians, is possible using

SUMO, an open-source microscopic traffic simulation tool. Tools like visualization, route finding, emission calculation, network importing also provided by SUMO. In SUMO, each vehicle or node has its own path and mobility. It has a user-friendly interface and can run on both Linux and Windows. Vehicle types, vehicle counts, right of road regulations, and multi-lane roadways with lane switching rules may specified using SUMO. For example, SUMO used in traffic signal evaluations, route selection and re-routing, traffic forecasts, and vehicle communications simulations.

It allows for the modeling of intermodal traffic networks that include road cars and public transportation. SUMO comes with a slew of helpful tools for discovering routes, visualizing, importing networks, and figuring out emissions, among other things. All of these formats supported by SUMO, including OSM, MATsim, VISSIM, and VISUM. SUMO is written entirely in portable C++ and Python libraries. On top of that, SUMO can run on a wide range of operating systems (such as Microsoft's Windows®, Linux®, or macOS®) and with a choice of network simulators [35].

2.4.3 Network Simulator (NS-2)

The VINT project at the University of California, Berkeley, created the simulator object-oriented Ns-2 as a part of their work on it. The networking research community relies heavily on Ns-2. Simulating TCP and routing protocols via wired and wireless networks (both local and satellite) is facilitated by this tool.

A NS version 2 (NS-2) employs two languages, the main language is C++ and the sub language is (OTCL). The C++ language specify the internal building and process of the simulation's objects, whereas the OTCL specifies the exterior environment for setting the simulation's objects. The design modules the NS-2 has various issues in the distributing code. In order to accommodate any single channel networks, the simulator altered the structure and the two modules, resulting in a physical PHY layer and MAC layer with the CSMA/CA mechanism needed for credible research. Because of the vast size of the Cygwin packages, NS-2's ability to run on

Windows is limited because of the installation of a software application that creates a UNIX-like environment, called Cygwin [30]. Figure 5 depicts the NS-2 simulator's design.

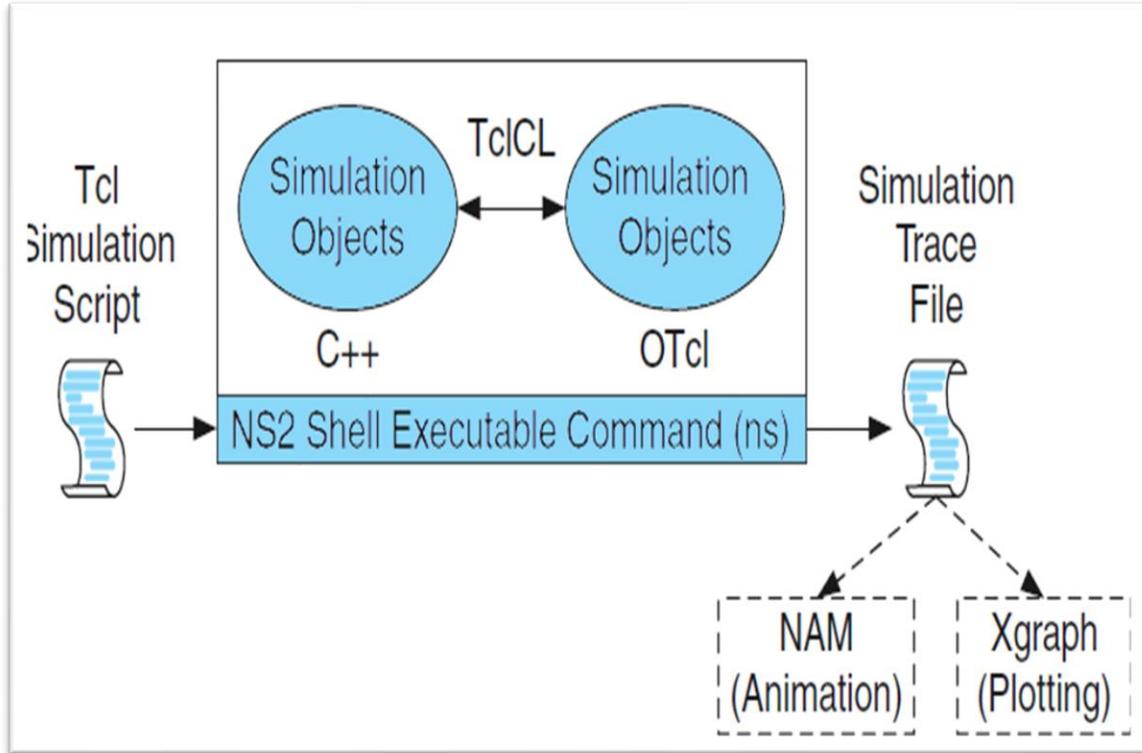


Figure 2.8: Architecture of NS-2 simulator [35]

2.5. RELATED WORK

Even though there are many past studies on the subject, we will just focus on the most relevant ones that have compared and examined topology-based routing protocols for their efficiency and effectiveness. To evaluate these protocols' performance in a VANET setting, the researchers believe that a combination of qualitative comparisons and performance evaluation studies and work is necessary. Several routing protocols for VANETs covered in the paragraph that follows.

In article [36] implemented the Clustering Based Routing Protocol (CBRP) by using VanetMobiSim, NS-2 simulators, then analysed and compared with DSR and AODV protocols

based on vehicles density. The results showed the CBRP is the best protocol in term of packet loss ratio, delay and route costs metric. In [37] the author studied the impact of fading in real world scenario based on three routing protocols like (AODV, DSDV and OLSR) over an intersection scenario with respected to vehicles density. These protocols compared and evaluated by using NS-3 and SUOM simulators. The performance metrics that used are throughput, E2ED and PDR. The results showed the AODV protocol is more robust under fading but not suitable for high density. Another work [38] many routing protocols evaluated and compared; three of them based on topology of network like (AODV, OLSR, DSDV) and other two protocols based on the position of vehicles like (GPCR and GPSR) based on node density. The simulation tools that used in this model are NS-2 and SUMO and the map extracted from real world by using open street map application. The results showed the OLSR protocol is the best protocol in term of throughput and PDR. However, GPCR and GPSR have the best results in term of E2ED and overhead. Also in the work [39] the author analysed and compared between three routing protocols like (AODV, OLSR and DSDV) based on three performance metrics like (PDR, Goodput, Routing Overhead and E2ED). The simulation tools that used in this scenario are NS-3 and BonnMotion. The results showed the OLSR Protocol is the best one.

This work [40] when building a routing path, GPSR chooses a next hop can easily be outside of communication range in greedy transmitting and creates a redundant path in perimeter transmitting. To solve this issue proposed MM-GPSR based on GPSR protocol and compared with original protocol (GPSR) with respect to density and velocity under three performance metric like Packet loss, E2ED, and throughput. The results concluded the MM-GPSR (proposed protocol) better than GPSR. In the work [41] provide a comparison between two VANET routing protocols AODV and GPSR. OMNET++ and SUMO are simulation tools that used in proposed model. Three scenarios implemented like (Density, communication range and velocity) in term of three metrics: PDR, E2ED, and Throughput. The results showed that each protocol suitable for specific scenario. In [42] various protocols of VANET with different real world scenarios tested and evaluated. The routing protocols that compared in the group of reactive like this (AODV). In addition, the group of proactive like (DSDV and OLSR). Under three metrics like (Basic Safety Message, PDR and Average Goodput). The simulation tools

that used in this paper are NS-3 as a network's simulator and SUMO as traffic simulator. The results showed that the AODV good protocol for low-density however, OLSR protocol better than other protocols for highest density.

In article [43] showed the GPSR protocol better than ZRP in term: average throughput, and packet loss, PDR, E2ED when the varying parameter is vehicles density. The simulation implemented with new approach by combining between NS-2 and VanetMobisim simulators. In work [44] provide comparison and evaluation of various protocols like (AODV, DSDV OLSR and DSR) and test the impact of varying of speed and the type of propagation of network in term of Throughput, goodput and receive rate metrics. The simulation tools, which used in this model, are NS-3 and SUMO simulators. The results showed the protocol is the best in the Friis Propagation Model. Whereas AODV, DSDV and DSR are better in Nakagami-m Propagation Model. The work of [45] compared the performance of the famous routing protocols in VANET like (AODV, DSDV, OLSR, GPCR), by combining between to simulators such NS-3 and SUMO based on varying number of nodes. The performance metric that used to evaluate the above protocols are PDR, E2ED, Overhead and Throughput. The results that obtained in these scenarios concluded that the OLSR is the best in term of PDR and throughput. However, the GPSR and GPC in term of overhead and E2E delay. Finally, In [46] used NS-3 and SUMO simulators to analyse the performance of propagation model and three routing protocols in VANET like (AODV, DSDV, OLSR) in realistic scenario. The metrics that used to evaluate the performance of above protocols and propagation models are Throughput, E2ED, routing goodput, PDR and Overhead. The result showed that the results showed the FRIIS and Two-Ray Ground is the best propagation model however, the best routing protocol is OLSR.

Table 2.3: Summarizes related work of most VANET routing protocols.

Reference	simulator	protocols	Based parameter	Performance metric	Advantage
[36]	VanetMo biSim and NS-2	AODV, DSR, CBRP	Density	Packet loss, route costs and delay	CBRP protocol is the best
[37]	ns 3	AODV, DSDV, OLSR		PDR, E2ED and Throughput	AODV protocol is the best
[38]	NS-3 and SUMO	AODV, OLSR, DSDV, GPSR, GPCR	Vehicles density	PDR, E2ED, Routing Overhead, and Throughput	OLSR protocol is the best in term of throughput and PDR however the GPSR and GPCR best other metrics
[39]	ns-3 and BonnMo tion	DSDV, AODV, OLSR	Vehicles density and velocity	PDR, Goodput, Routing Overhead and E2ED	OLSR Protocol is the best one

Table 2.3: Summarizes related work of most VANET routing protocols. “tables continued”

[40]	NS-2 and VanetMo biSim	GPSR and MM-GPSR	Vehicles density and velocity	Packet loss, E2ED, and throughput	The MM-GPSR protocol better than GPSR.
[41]	OMNET+, SUMO	AODV, GPSR	Vehicles density, communication range and velocity	PDR, E2ED, and Throughput	GPSR better than AODV
[42]	NS-3 and SUMO	DSDV, AODV, OLSR	Vehicles density	Safety Message, Goodput and PDR	AODV protocol suitable for low-density however, OLSR protocol good for high-density
[43]	NS-2 and VanetMo bisim	GPSR, ZRP	Vehicles density	throughput, PDR, E2ED, and packet loss	GPSR protocol better than ZRP
[44]	NS-3 and SUMO	OLSR, AODV, DSDV, DSR	propagation model and vehicles speed	Throughput, goodput and receive rate	The results showed the protocol is the best in the Friis Propagation Model. Whereas AODV, DSDV and DSR are better in Nakagami-m Propagation Model

Table 2.3: Summarizes related work of most VANET routing protocols. “tables continued”

[45]	NS-3 and SUMO	AODV, DSDV, OLSR, GPCR	Number of nodes	PDR, E2ED, Overhead and Throughput	OLSR is the best in term of PDR and average throughput. Whereas GPCR and GPSR in term of overhead and E2E delay
[46]	NS-3 and SUMO	AODV, DSDV, OLSR	Time and density	Throughput, E2ED, routing goodput, PDR and Overhead	OLSR has a large throughput, E2ED delay, PDR, and overhead

According to the above studies, researchers primarily focused on comparison rather than simulation and how VANET process works with the tools that available in NS-2, they failed to highlight the significance of SUMO that aids in the achievement of several scientific objectives. They also neglected to show the importance of using SUMO. Instead, it is a collection of tools that aid in the design and execution of traffic simulations, as shown in this dissertation.

3. METHODOLOGY

3.1. INTRODUCTION

In this chapter, we will provide the methodology that implemented. Then explain all steps of the framework. Afterwards, we presented the performance metrics that test to give good results like this (throughput, PDR and E2ED and normalized routing overhead). Finally, we present the summary of this chapter.

3.2. PROPOSED MODEL

The main objective of this methodology is to demonstrate how we carried our proposed model that implemented in this thesis. The goal of thesis to evaluate the performance of VANET protocols for apart of Al-Ramady city. We used various protocols with different scenarios. The routing protocols that tested in the group of reactive like this (AODV and DSR). Also, the group of proactive like (DSDV). The simulator that used in thesis NS-2 has been use for network simulation and SUMO for traffic simulation. In addition, Maps imported from Open Street Map application. Figure 3.1 show the framework of proposed model.

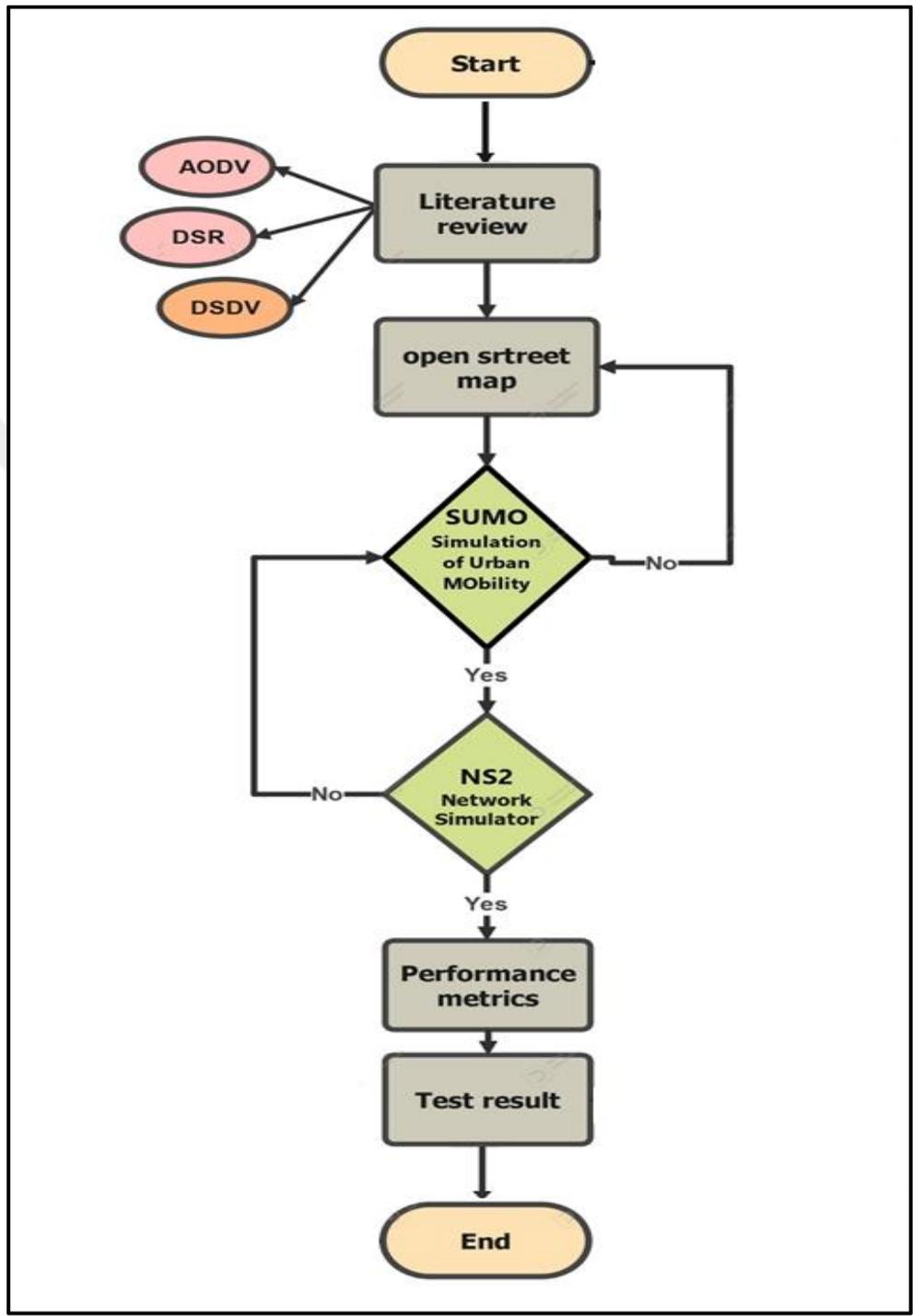


Figure 3.1: Research methodology.

I. Map extraction

The application that used to develop and provides free global geographic data is called OPEN STREET MAP. It generates a file in (osm) form for every location in the globe. We made use of a real-world city map that was taken from Al-Ramady City's Open Street Map. Go to Open Street Map by this link (www.openstreetmap.org) and Click on Export after that Click on manually select and select the area of Al-Ramady city for simulation then when you press export again, a file named (map.osm) downloaded, as shown in figure 3.2.

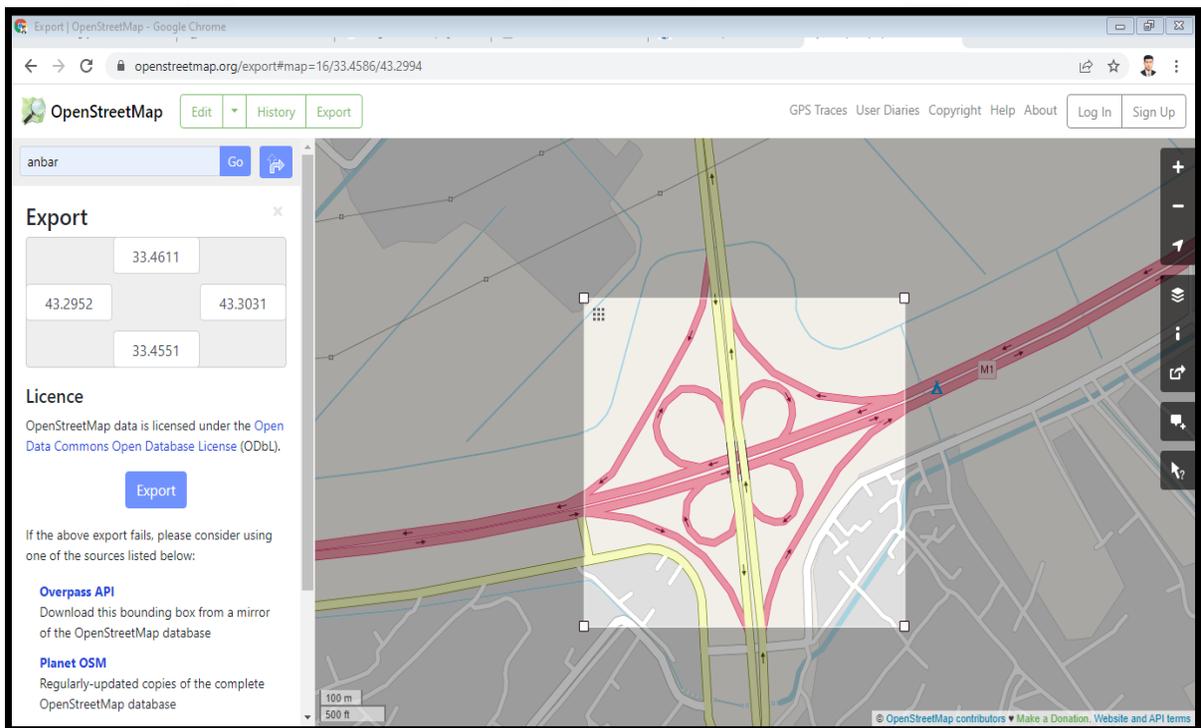


Figure 3.2: AL-RAMADY city by open street map.

II. SUMO simulation model

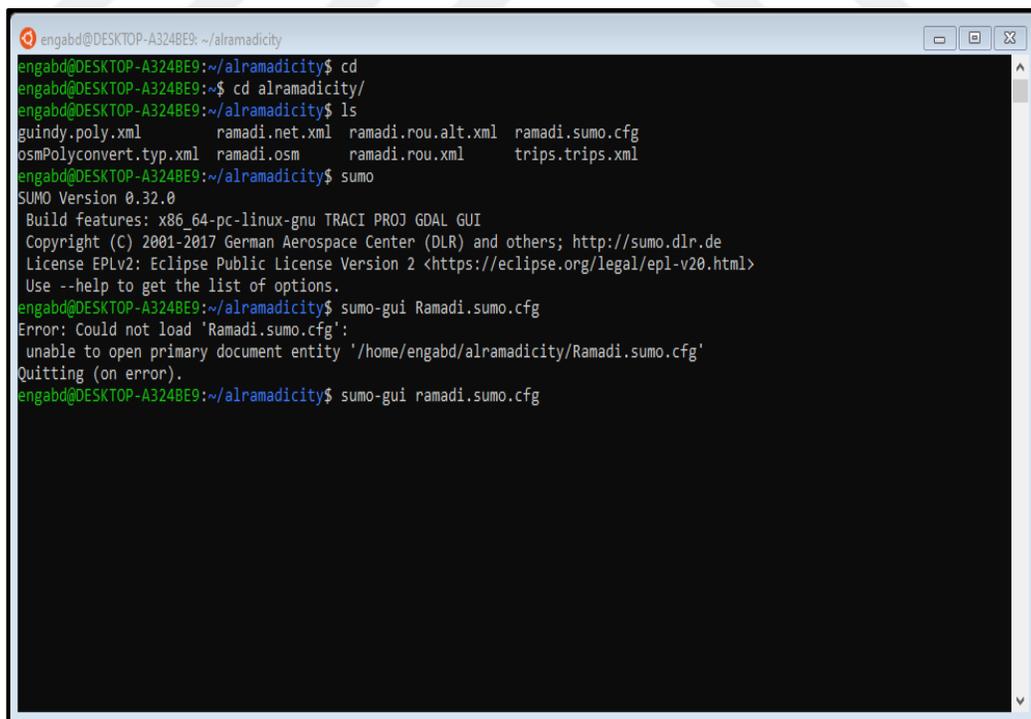
There are a variety of programs to simulate road traffic, such as VISSIM and FARSI, but in this research, we will depend on SUMO version 0.32.0, which is a popular simulator that used for

road traffic among the search community. In addition, it has more good features, which has been explained in detail in the chapter 2.

After extracting the map of the city of Ramadi and saving it in (Ramadi.osm) format. In order to be able to generate traffic. SUMO is capable of converting an osm file to its native xml format. The instructions below describe how to simulate a real traffic network and then transfer it to NS2 to run network simulation.

a. Open commands window

We use Ubuntu version 18.04 in windows 10. Ubuntu is a Linux distribution (or distro). A distribution, in Linux jargon, is a version of the operating system built on the Linux kernel. There are many different Linux distributions available. Many are free and have user communities that provide each other advice and assistance. However, for the ordinary computer user, downloading a free Linux distribution with few support choices might be scary. Figure 3.3 show the commands window and some commands.



```
engabd@DESKTOP-A324BE9: ~/alramadacity
engabd@DESKTOP-A324BE9:~/alramadacity$ cd
engabd@DESKTOP-A324BE9:~$ cd alramadacity/
engabd@DESKTOP-A324BE9:~/alramadacity$ ls
guindy.poly.xml      ramadi.net.xml      ramadi.rou.alt.xml  ramadi.sumo.cfg
osmPolyconvert.typ.xml  ramadi.osm          ramadi.rou.xml      trips.trips.xml
engabd@DESKTOP-A324BE9:~/alramadacity$ sumo
SUMO Version 0.32.0
Build features: x86_64-pc-linux-gnu TRACI PROJ GDAL GUI
Copyright (C) 2001-2017 German Aerospace Center (DLR) and others; http://sumo.dlr.de
License EPLv2: Eclipse Public License Version 2 <https://eclipse.org/legal/epl-v20.html>
Use --help to get the list of options.
engabd@DESKTOP-A324BE9:~/alramadacity$ sumo-gui Ramadi.sumo.cfg
Error: Could not load 'Ramadi.sumo.cfg':
unable to open primary document entity '/home/engabd/alramadacity/Ramadi.sumo.cfg'
Quitting (on error).
engabd@DESKTOP-A324BE9:~/alramadacity$ sumo-gui ramadi.sumo.cfg
```

Figure 3.3: Commands window and some commands.

b. Several files must be prepared before starting the simulation process:

- i. Generate a SUMO network file (*.net.xml)

It depicts the traffic-related portion of a map, including the roads and crossroads where simulated automobiles go straight or diagonally. A SUMO network is, at a crude level, a directed graph. Nodes, often known as junctions in the context of SUMO, depict intersections and the boundaries of roads or streets. To generate it, we must convert the file (Ramadi.osm) to SUMO network file (Ramadi.net.xml). By type the command 1 in table 3.1.

- ii. Generate a (Ramadi.poly.xml) file.

This file imports polygons from various formats and points of interest and transforms them into an SUMO-GUI-viewable description. These programs make up the primary SUMO. To generate it Copy the (osmPolyconvert.typ.xml) file from the (engabd / sumo / data / typemap /) and past it to the folder which we put all the files, that named alramadi city, then typing the command 2 in table 3.1.

- iii. Generate a (Ramadi.rou.xml) file by typing this command 3 in table 3.1.
- iv. Create a (Ramadi.sumo.cfg) file.

A (SUMOCFG) file is a configuration file used by Eclipse SUMO, an open-source traffic simulator. It contains parameters for a traffic simulation in XML format, which includes references to .XML files that contain detailed information about the simulation. SUMOCFG files formerly used them. sumo.cfg file extension. To create a (Ramadi.sumo.cfg) file open a new file and write the code as shown in figure (3.3).

```
<configuration>
  <input>
    <net-file value="
Ramadi.net.xml"/>
    <route-files value="Ramadi.rou.xml"/>
    <additional-files
value="Ramadi.poly.xml"/>
  </input>
  <time>
    <begin value="0"/>
    <end value="100"/>
    <step-length value="0.1"/>
  </time>
</configuration>
```

Figure 3.4: Ramadi.sumo.cfg code.

c. Running sumo-Gui.

sumo-gui is the same software as sumo, but with a graphical user interface. Simulates a predetermined situation. Portable (tested on Linux/Windows); opens a window. Mandatory input: A configuration file for SUMO (see sumo) Sumo-gui produces the same results as sumo.

After completing the required files and placing them in one folder that we named alramadi city. Now, we open (Sumo Gui) by typing this command 4 in table 3.1. After that, the program screen appears as shown in figure 3.5.

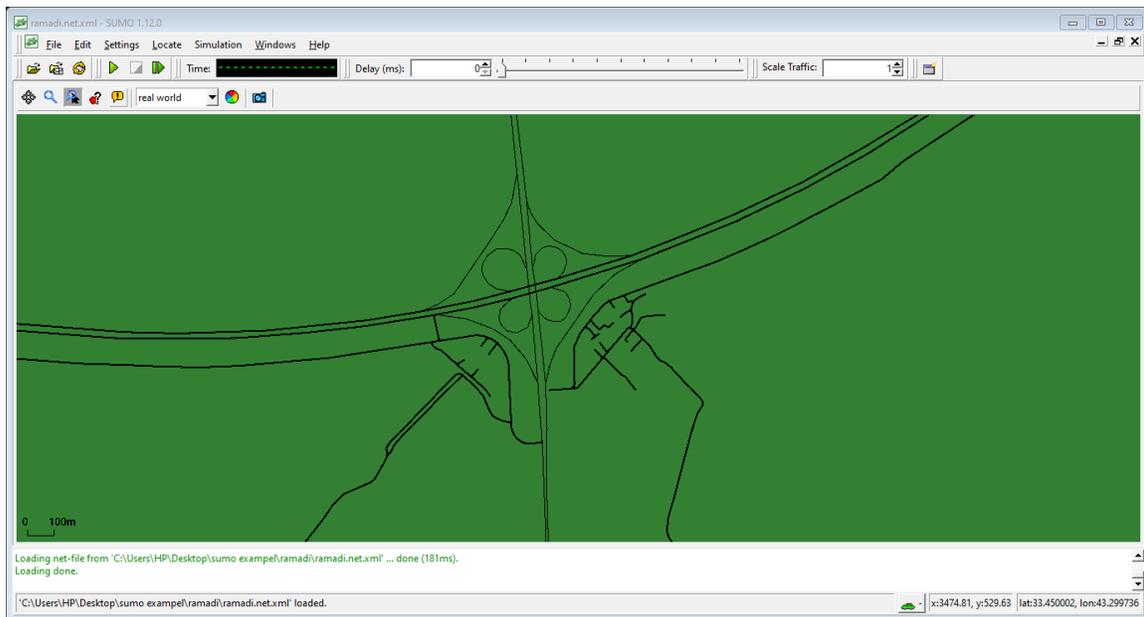


Figure 3.5: Map under SUMO.

d. Exporting to NS2 (generate tcl.file)

After running SUMO Simulation as mentioned in the previous steps. In this stage we will convert from Sumo trace to NS-2 that's mean convert form from (ramadi.sumo.xml) to (ramadi.tcl) form by the following commands:

Firstly, open commands window and then type this command 5 in table 3.1. Secondly, write the command 6 in table 3.1.

After typing the previous commands, three tcl files will be generated, which are (ramadi.tcl, activity.tcl and mobility.tcl). The most important of these files is ramadi.tcl file. The generated ramadi.tcl file have to be modified or changed according to network parameters such as routing protocol, propagation model, Mac layer, physical layer, link layer, number of nods, etc. Which will be explained detail in the next section.

Table 3.1: Commands of simulation.

COM. No.	Commands
1	<pre>netconvert --osm-files Ramadi.osm -o Ramadi.net.xml</pre>
2	<pre>Poly convert-osm files Ramadi.osm-net - file Ramadi.net.xml --type- file osmPolyconvert.typ.xml -o Ramadi.poly.xml Ramadi.net.xml</pre>
3	<pre>python /home/engabd/sumo/tools/randomTrips.py -n Ramadi.net.xml -r Ramadi.rou.xml -e 100 -l</pre>
4	<pre>sumo-gui ramadi.sumo.cfg</pre>
5	<pre>sumo -c ramadi.sumo.cfg --fcd-output ramadi.sumo.xml</pre>
6	<pre>python /home/engabd/sumo 0.32.0/tools/traceExporter.py --fcd-input ramadi.sumo.xml --ns2config-output ramadi.tcl --ns2activity-output activity.tcl --ns2mobility-output mobility.tcl</pre>

3.3. SIMULATION PARAMETERS

The table 3.2 below show the main parameters that used in our proposed model.

Table 3.2: Parameter of simulation.

No.	Parameters	Specification
1	Packet Size	1000
2	Channels type	Wireless Channel
3	Protocols	AODV, DSR and DSDV
4	Transmission Protocol	TCP
5	Number of Nodes	10, 20, 30, 40 and 50
6	Queue Length	100 packets
7	Interface Queue Type	DropTail / PriQueue
8	Radio Propagation Model	Propagation /Two RayGround
9	Time end for simulation	400 second
10	Bandwidth	2Mbps
11	Speed	100 m/s
12	Antenna Model	Omni Antenna
13	Transmission	Two Ray Ground
14	Transmission Rate	64Kb
15	Propagation	Two Ray Ground
16	MAC Type	Mac/802.11

3.4. RUNING NS-2 SIMULATOR

Many simulators can be used to simulate VANET such as ns2, ns3, Omnet++, QualNet, GlomoSim and NetSim. Each researcher has a special scenario and methodology in the research, and each methodology corresponds to a specific simulator to produce the best and most accurate results. In this research, we choose ns2 simulator due of its unique qualities, such as the ability to utilize NS2 as an open-source network simulator and the ability to use it in both Linux and Microsoft Windows operating systems and also easy to combine it with SUMO.

After generate a (ramadi.tcl) file and make a configuration as we mentioned in pervious stage. In this stage run this file to NS-2 simulator by using this command (ns ramadi.tcl). After the simulation completed according to the specified time, as the result two files will generate, Nam and Trace files.

Trace file is a file containing event logs from a simulation operation When the network simulation runs, for example, various events occur, like packet loss and packet acceptance by various vehicles in network. These occurrences recorded in a text file as shown in figure 3.6. The data in this file used to study and evaluate the AODV, DSR, and DSDV protocols utilizing performance metrics.

Network animator (Nam) file consists subset of standard trace file with extension "nam" It includes data for use in tool of the same name to depict packet flow and vehicles movements. Nam file is (TK/Tcl) animation tool for displaying network simulation results and actual packet tracking data for various network visualization scenarios, as shown in figure 3.7.

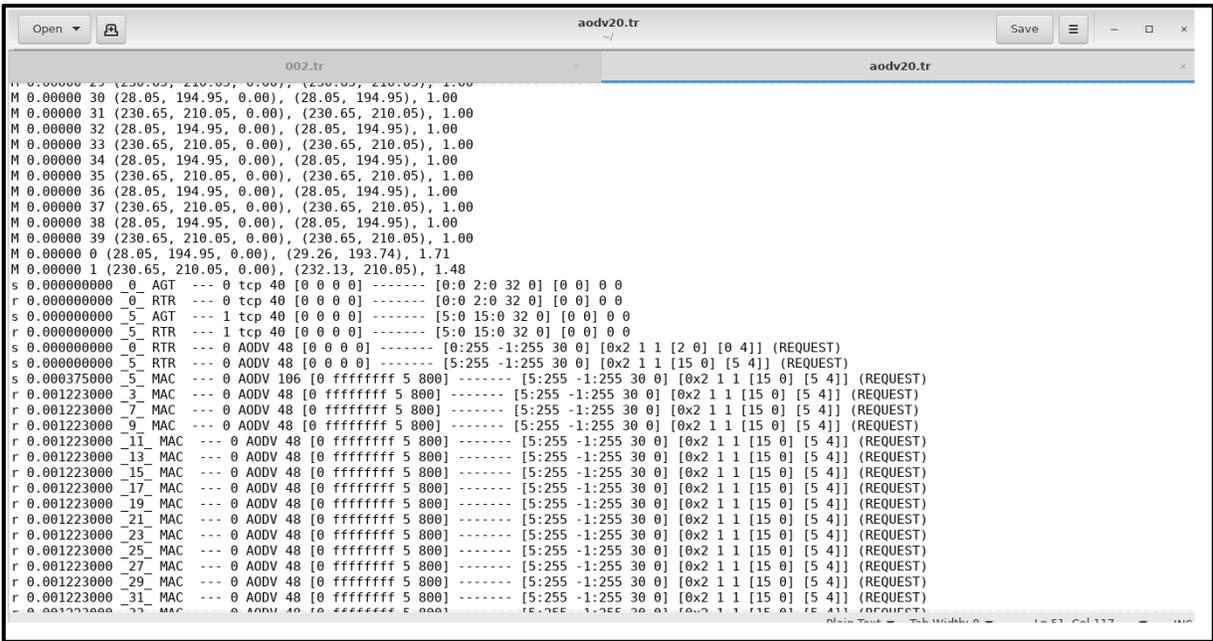


Figure 3.6: File output (trace file).

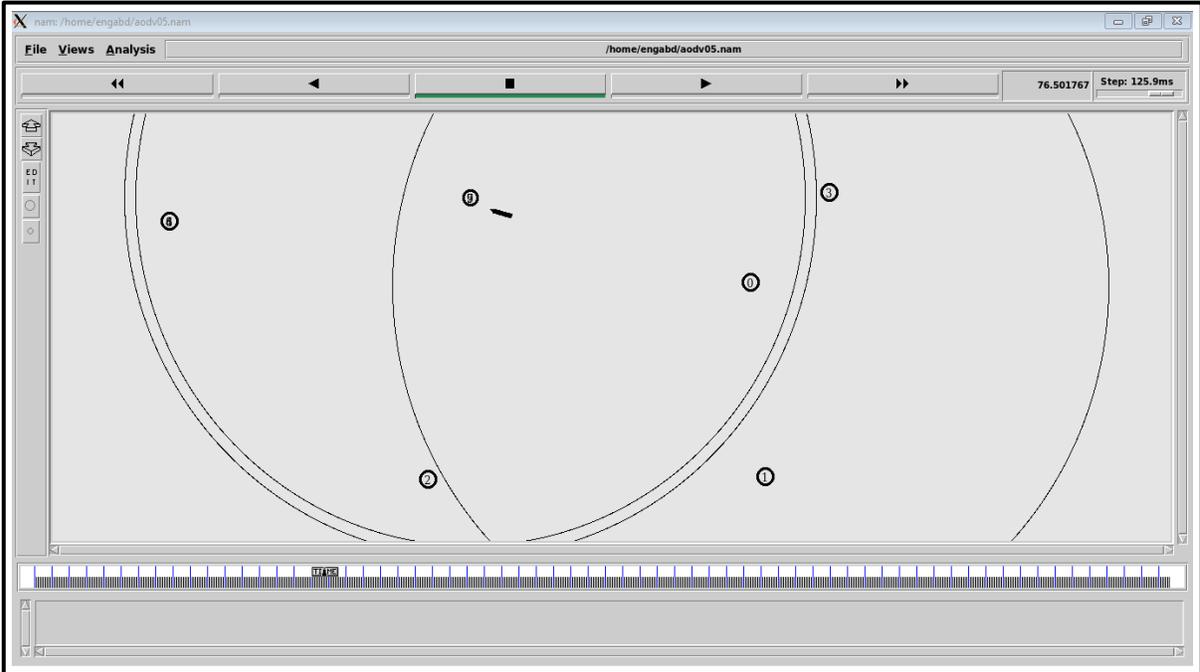


Figure 3.7: Network Animator File (NAM).

3.5. PERFORMANCE METRICS

This research will evaluate the performance of three various VANETs protocols based on four performance metrics, including Throughput, PDR, Normalized Routing Overhead, and E2ED, which explained below:

A. Throughput

The ratio of data reaching a receiver from the transmitter is known as throughput. In other word Throughput is the time it takes form receiver to receive most recent message. Bits or bytes per second (bit/sec or byte /sec) used to measure throughput. The equation (3.1) represents the throughput metric.

$$\text{Throughput} = \frac{\sum \text{Number of received packets}}{\text{Total simulation time}} * \text{Packet size} \quad (3.1)$$

a. Packet Delivery Ratio (PDR)

PDR is the measure of network performance that takes into account both the amount of data packets sent and received in specific network's nodes at their final destination. PDR is determined as in equation (3.2).

$$\text{PDR} = \frac{\sum \text{Number of packet received}}{\sum \text{Number of packet sent}} \quad (3.2)$$

b. Average End-to-End Delay (E2ED)

This performance metric estimates the parcels defer arriving at the goal. At the point when we send a bundle, there are numerous little defer stations through the path from the source to the goal. The all-out deferral is a consequence of the numerous collections of postponement, such

as delay due to temporary storage while finding routes, MAC transmission delay, broadcast, and transmit time. The E2ED is determined as in equation (3.3)

$$\mathbf{E2E} = \frac{\sum \text{End time} - \text{Start time}}{\sum \text{Number of packets sent}} \quad (3.3)$$

c. Normalized Routing Overhead (NRO)

NRO is the ratio of number of routing packets to the total number of data packets received. The Control overhead means the number of routing packets, which are, required in the network for data transmission that is mean the routing overhead equal to number of RTR packets. The Normalized Routing Overhead is determined as in equation (3.4)

$$\mathbf{NRO} = \frac{\text{Number of RTR packets}}{\text{Packets received}} \quad (3.4)$$

3.6. SUMMARY

The proposed model discussed in detail then explain all steps in the framework. We go through each step in great detail. First, show how map extracted by Open Street Map and saved it in (Ramadi.osm) format. Next, explain the simulation of a real traffic network by using SUMO simulator which, be able to generate traffic and to convert the osm file to its native xml file and how it ported to NS-2 by generated a (Ramadi.tcl) file. Then, the generated (ramadi.tcl) file modified or changed according to network parameters. After that, present the performance metric, which used like (Throughput, PDR, normalized routing overhead and E2ED). Finally, running network simulator (NS-2). After the simulation completed according to the specified time, as the result two files will generated, Nam and Trace files. The information in trace file used to analyze the performance of specific protocols, which are AODV, DSR and DSDV by using performance metric. The next chapter will present discussion the results.

4. RESULTS AND DISCUSSIONS

4.1 INTRODUCTION

This chapter introduces and discusses the results, which were obtained through the proposed model that was explained in detail in the previous chapter. In our scenario, three VANET routing protocols have been analysed and compared (AODV, DSDV, and DSR) by using four performance metrics like throughput, PDR, NRO, and E2ED with respect to node density in the network simulation.

4.2. AVERAGE THROUGHPUT

Throughput is the rate of information that is delivered through a specific network. Depending on the results as shown in Table 4.1 and Figure 4.1 that we obtained through the application of the throughput law, it was generally found that the rate of throughput decreases when the number of nodes increases but to different extents from one protocol to another. So, in this case, the second node sends a packet to the third node, the first node cannot send the following packet until the second node has received additional packets.

In low density, when the number of vehicles was (10). We found the average throughput of all protocols very close to each other, but the highest throughput was for the DSR protocol where the average throughput was (595.25kbps), followed by a little less for the AODV protocol where the average throughput was (594.12kbps), while the lowest average throughput was (543.83kbps) for the DSDV protocol.

In high density, when the number of vehicles was (50). We found these protocols are very different from each other in terms of average throughput. Therefore, the highest throughput was for the DSR protocol where the average throughput was (512.32kbps), followed by the AODV protocol where the average throughput was (445.74kbps), while the lowest average throughput was (386.18kbps) for the DSDV protocol.

The usual method of transmission for DSDV is on-demand routing and destination sequenced numbers; however, source routing used by AODV to speed up delivery of packets and boost the overall throughput. Because the DSDV replies to all requests when a message arrives to its destination, will has a greater rate of production. In addition, the target's node only responds to request once, as opposed to the vast majority of other requests being disregarded. Therefore, it enables AODV to outperform DSDV in terms of throughput. As the nodes increase in number, though, although DSR outperform DSDV and AODV in terms of throughput. As shown In Figure 4.1, when number of nodes grows and the number of packets dropped lowers, we will notice more throughput.

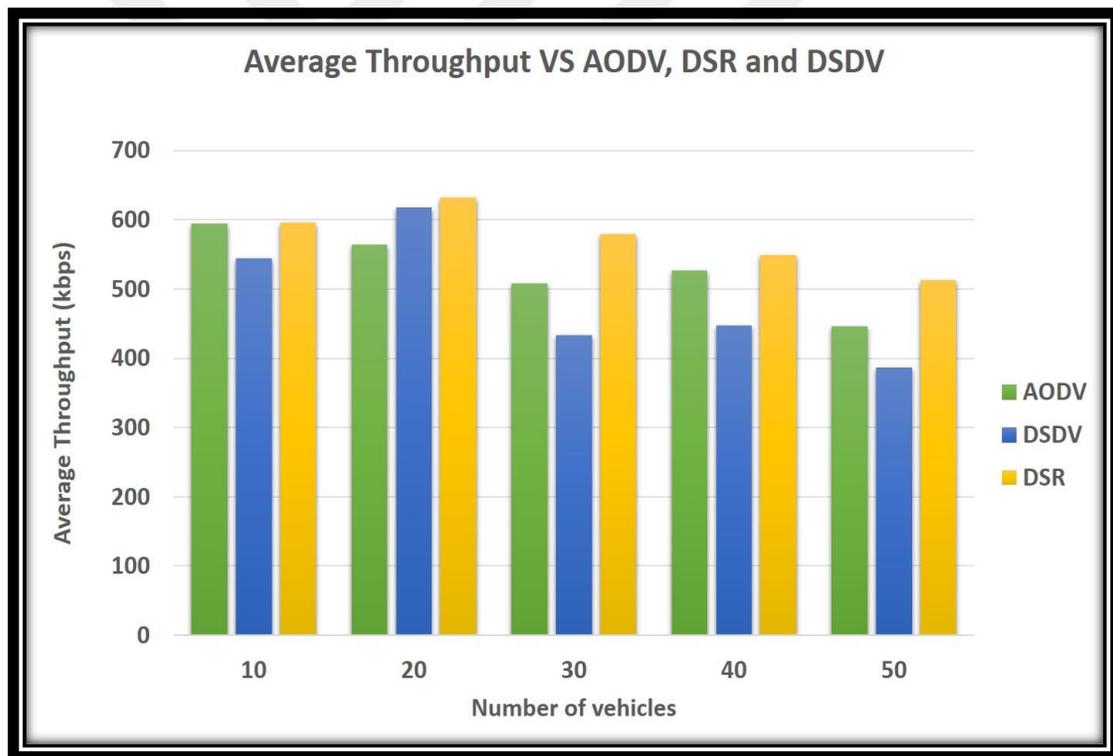


Figure 4.1: Average throughput VS number of vehicles.

Table 4.1: Average Throughput of AODV, DSR and DSDV.

Number of vehicles	AODV protocol	DSDV Protocol	DSR protocol
10	594.12	543.83	595.25
20	563.98	617.49	632.18
30	508.52	432.84	579.88
40	526.61	447.45	548.50
50	445.74	386.18	512.32
Average	527.794	485.558	573.626

4.3. PACKET DELIVERY RATIO (PDR)

PDR define as the percentage of data packets that reach at their intended destinations. The packet delivery ratio measures a protocol's effectiveness in moving packets from one location to another. The greater the value, the more successful the packet delivery. Figure 4.2. Shows the AODV, DSDV and DSR protocols packet transfer ratios with five different node densities. Depend on the results that obtained in table 4.2 and Figure 4.2. We Notice in general when the number of nodes grows, the packet delivery fraction tends to decrease but different from protocol to another.

In low density when the number of nodes is (10). When compare between AODV, DSDV, and DSR protocols. We found the DSR protocol had a better PDR. Where the PDR was (99.68 %), followed by a little less for the DSDV protocol was (99.36%) percentage, while the lowest percentage of packet delivery was (99.17%) percentage for the AODV protocol.

In high density when the number of nodes is (50). We found the DSR protocol had a better PDR whenever the vehicles number changed especially when the nodes of number increases. Where the packet delivery ratio was (99.53%) percentage, followed by a little less for the DSDV protocol with (98.73%) percentage, while the lowest percentage of packet delivery was (98.69%) percentage for the AODV protocol.

The AODV and DSDV are upgrading the route takes a lengthy time due to the path starting on demand. As previously stated, we find that proactive routing protocols give a greater packet delivery ratio than alternative routing protocols. So DSR routing protocol is the best one out of them. We can discover the percentage for all three protocols from the table 4.2 bellow.

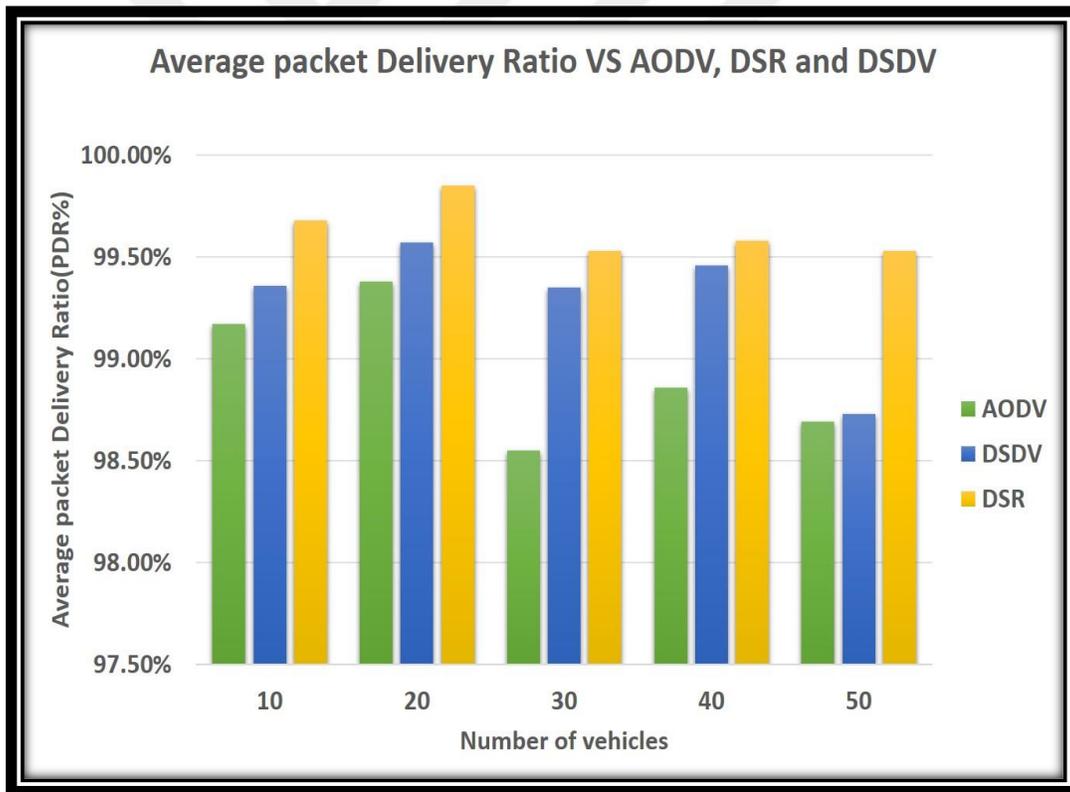


Figure 4.2: PDR VS number of vehicles.

Table 4.2: PDR of AODV, DSR and DSDV.

Number of vehicles	AODV protocol	DSDV Protocol	DSR protocol
10	99.17%	99.36%	99.68%
20	99.38%	99.57%	99.85%
30	98.55%	99.35%	99.53%
40	98.86%	99.46%	99.58%
50	98.69%	98.73%	99.53%
Average	99.17%	99.36%	99.68%

4.4. AVERAGE END-TO-END DELAY (E2ED)

The Average E2ED define as the packet transmission's interruption from the main node to the destination. The total interruption is an accumulation of several small delays in the network. From the definition of E2ED above, we conclude that the lower the value, the greater the performance of the protocol. In millisecond time units, E2EDs for the protocols are stated. Five separate nodes used to measure the E2ED latency. Depend on the results that obtained and show in table 4.3 and Figure 4.3. We Notice generally when number of vehicles grows, the E2ED tends to increase but different from protocol to another.

In low density when the number of vehicles was (10). We found The DSDV protocol outperforms AODV and DSR. This indicates that the DSDV protocol is the best of the three in this E2E scenario because it has fewest values in term of average E2ED, which was (161.106 ms). However, when comparing the two reactive routing protocols, the DSR protocol has a longer E2ED, which was (259.807 ms) than the AODV protocol, which the average E2ED of it was (212.086 ms).

In high density when the number of vehicles was (50), also The DSDV protocol outperforms AODV and DSR. This indicates that the DSDV protocol is the best of the three in this E2E scenario because it has fewest values in all nodes and least average E2ED for all nodes was (183.202 ms). It is based on how these protocols operate that determines Conservative routing methods, such as DSDV, have a higher rate of node growth than responsive routing protocols, and consequently have a longer reaction time from one side to the other. However, when comparing the two reactive routing protocols we found the two protocols very close to each other in term of E2ED, but the AODV protocol has a longer E2ED than the DSR protocol, which was (265.121 ms) and the average E2ED of DSR protocol was (265.121 ms). The reason for this is that the DSR requires a lot of internal processing time when it comes to mapping routes to nearby uninteresting nodes. Another possible reason for the longer AODV latency is the fact that route identification initiated more often with AODV than with DSR. When the number of nodes increases, so the number of intermediary nodes needed to connect the source and destination will increased. Due to the reduced end-to-end latency, DSDV is a better choice in this case. Figure 4.3 shows E2ED vs. vehicles density as indicated.

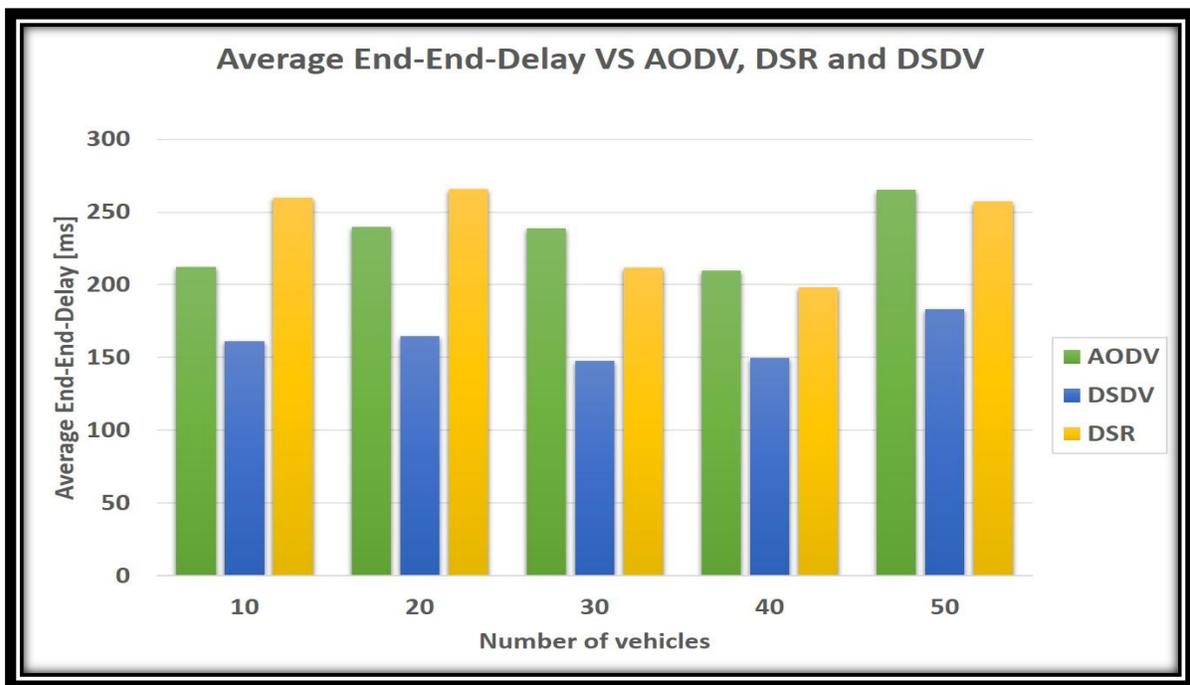


Figure 4.3: Average End-to-End Delay VS number of vehicles.

Table 4.3: Average End-to-End Delay of AODV, DSR and DSDV.

Number of vehicles	AODV protocol	DSDV Protocol	DSR protocol
10	212.086	161.106	259.807
20	239.548	164.54	266.02
30	238.909	147.847	211.915
40	209.818	149.811	198.278
50	265.121	183.202	257.044
Average	233.0964	161.3012	238.6128

4.5. NORMALIZED ROUTING OVERHEAD (NRO)

NRO define as the amount of routing packets transferred per data packet delivered to destination. This parameter used to calculate the routing protocol's overhead during routing operations. Low value overhead implies the protocol generates fewer control packets, freeing up more network resources to send genuine data packets.

Table 4.4 and Fig. 4.4 shows the effect of the vehicles number to normalized routing overhead. We notice when the number of vehicles increases, a little increase in normalized routing overhead for all protocols but different from one to another.

As shown in figure. 4.4. In low density when the number of nodes is (10). We found the AODV protocol higher than DSR and DSDV where the average normalized routing overhead of it was (0.025). Followed by DSR protocol where the normalized routing overhead of DSR was (0.015). By comparing our three protocols AODV, DSDV and DSR, we found the DSDV protocol has least where the normalized routing overhead where the value was (0.014).

In high density when the number of nodes is (50). We found the AODV protocol more impacting by increasing number of nodes than DSR and DSDV where the average normalized routing overhead for all nodes was (0.167). This is because the minimal bandwidth requirement required to maintaining the route from source vehicles to destination vehicles. The average normalized routing overhead of DSDV is (0.148), also impact by increasing number of nodes but less than AODV. By comparing our three protocols AODV, DSDV and DSR, we found the DSR protocol has least average Normalized routing overhead where the value was (0.027) and the fewest impact by increasing number of vehicles.

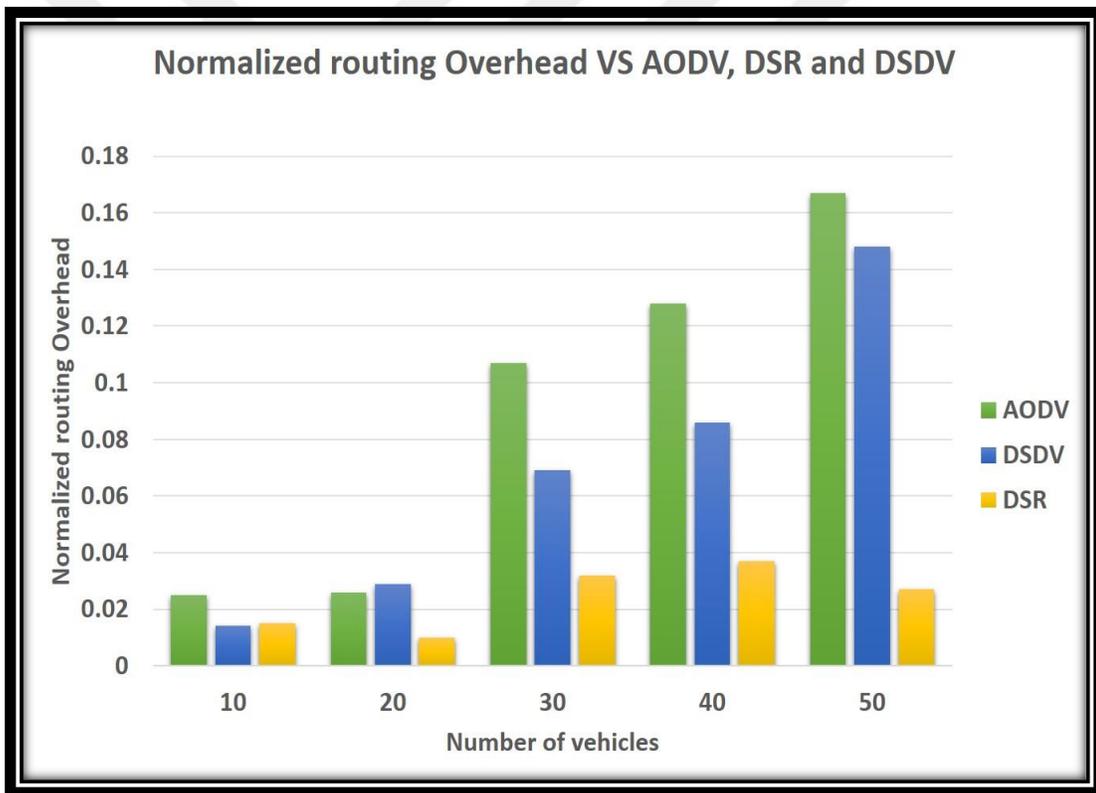


Figure 4.4: Normalized routing Overhead VS number of vehicles.

Table 4.4: Normalized routing Overhead of AODV, DSR and DSDV.

Number of vehicles	AODV protocol	DSDV Protocol	DSR protocol
10	0.025	0.014	0.015
20	0.026	0.029	0.010
30	0.107	0.069	0.032
40	0.128	0.086	0.037
50	0.167	0.148	0.027
Average	0.0906	0.0692	0.0242

4.6 SUMMARY

Through this chapter, we analysed and discussed various routing protocols with different scenarios in term of density. The routing protocols that tested in the group of reactive like this (AODV and DSR). In addition, the group of proactive like (DSDV). We used four performance metrics like this (average throughput, PDR, average E2E delay, and normalized routing overhead). In this chapter, we were able to calculate the performance criteria tests for routing protocols using the density factor. Following our findings, it was determined that, in terms of effectiveness DSR's performance is superior to that of AODV and DSDV in terms of throughput. In term of PDR, we discovered the DSR had a better PDR whenever the node number changed especially when the nodes number increases followed by a little less for the AODV protocol, while the lowest percentage of packet delivery was for the DSDV protocol. In term of E2ED delay we find, in all node counts show that the DSDV protocol outperforms AODV and DSR. This indicates that the DSDV protocol is the best of the three in this E2ED scenario. By

comparing our three protocols AODV, DSDV and DSR, In term of normalize routing overhead we found the fewest protocol affecting by increasing number of nodes and has fewest Normalized routing overhead is DSR protocol. This implies that any approach or protocol will be appropriate in different scenarios, depending on the nature of the labor needed of this protocol to complete a certain task but in most cases, DSR protocol outperforms AODV and DSDV.



5. CONCLUSION AND FUTURE WORKS

5.1. CONCLUSION

This work have provided the performance evaluation of VANET protocols by analysing and comparing three different routing protocols like (DSDV, AODV and DSR) with respect on node density. These protocols tested by using four performance metrics: throughput, E2ED, NRO and PDR. In addition, we highlighting to simulation procedure step-by-step and how to operate the VANET system by using two simulators: SUMO and NS-2. We used an open street map application to download a map of Al-Ramady City.

The findings of our simulation are quite convincing, and thus the following conclusions can be drawn:

- i. In term of average throughput, we found that the highest throughput was for the DSR protocol especially in high density, followed by a little less for the AODV protocol, while the lowest throughput was for the DSDV protocol.
- ii. In term of PDR, we found generally when the number of nodes grows, the packet delivery ratio tends to decrease but different from protocol to another. When AODV, DSDV, and DSR compared, it discovered that the DSR had a better PDR, followed by a little less for the DSDV protocol, while the lowest PDR was for AODV protocol.
- iii. In term of average E2ED, the DSDV protocol outperforms AODV and DSR. This indicates that the DSDV protocol is the best of the three in this E2ED scenario, when comparing other two protocols; the DSR protocol has a longer E2ED than the AODV protocol.
- iv. In term of normalized routing overhead, we notice in general when the vehicles number increases, a little increase in normalized routing overhead for all protocols but different from one to another. the AODV protocol more impacting by increasing number of nodes than DSR and DSDV. The normalized routing overhead of DSDV is affecting by increasing number of nodes but less than AODV. By comparing our three protocols AODV, DSDV and DSR, we found the fewest protocol affecting by increasing number of nodes and has fewest Normalized routing overhead is DSR protocol.

5.2. FUTURE WORKS

In our simulation model, we evaluated and make a comparison between three VANETs routing protocols: AODV, DSVDV, and DSR with respect to nodes density under four-performance metric: average throughput, PDR, E2ED, and NRO.

In future, many research suggestion such as:

- i. In the future, we suggest enhancing the problem of routing protocols by using Meta-heuristics to solve this problem.
- ii. It is good if examine the protocols in high-density environments by increase more number of nodes.
- iii. Evaluate a security issue of AODV, DSDV, and DSR protocols.

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