QOS PROTOCOL FOR VEHICULAR AD HOC NETWORK

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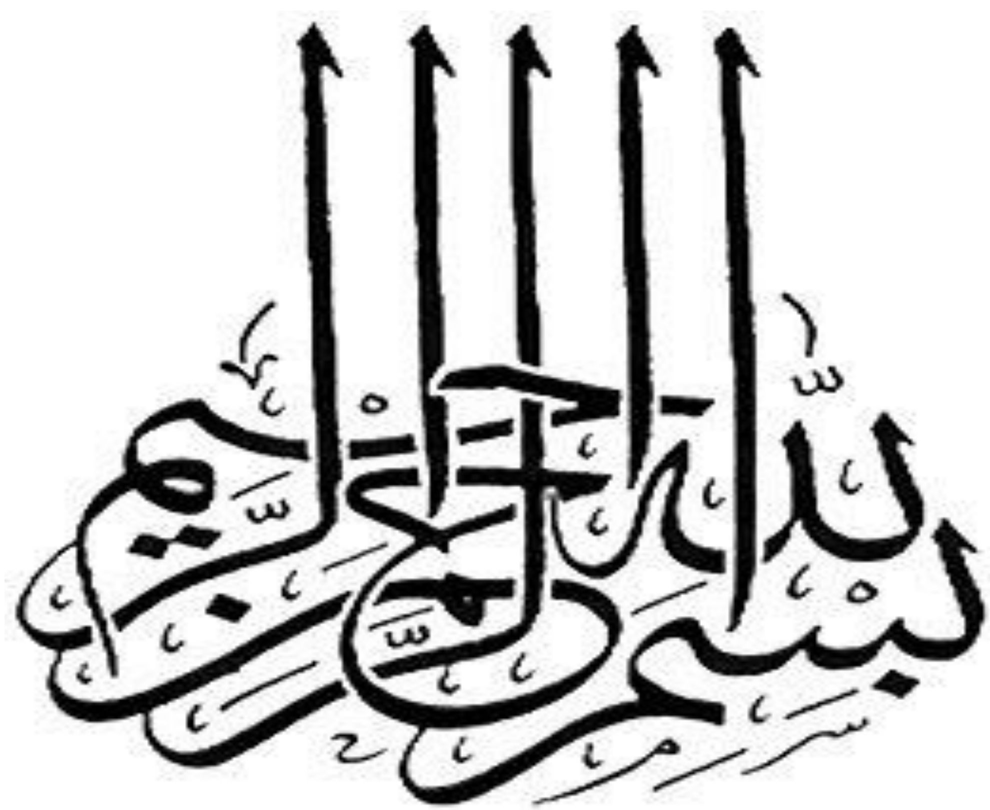
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Copyright Statement

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In the name of ALLAH, The Most Gracious, Merciful and Beneficent. First and foremost all the praise goes to ALLAH **(S.W.T),** The Almighty, and The Creator of the universe, who granted me the grace and strength to complete this work. Peace and blessing of ALLAH be upon His last Prophet Hazrat Muhammad Mustafa **(S.AW.W)**

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ABSTRACT

Vehicular ad hoc network (VANETS) is an emerging field in the area of Ad-Hoc networks. The area is crucial with respect to safety criticality and crowd controlling. VANET is one of the key factors for Intelligent Transportation System (ITS). These networks are challenging and significantly different from other networks in terms of randomness; dynamic architecture and high mobility. Designing data routing protocol for such a diverse and ever changing network is very challenging. The most commonly topology based routing protocol for VANET is Ad-Hoc On-Demand Distance Vector routing protocol (AODV); however the protocol is less optimized and performance degrades as the number of nodes and relative mobility is increased. This thesis emphases on the enhancement of the AODV protocol in order to enrich the performance of basic AODV which is not applicable directly to VANET and enable the protocol to work in scalable mode.

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LIST OF ACRONYMS

Abbreviation	Meaning
VANET	Vehicular adhoc network
MANET	Mobile adhoc network
V2V	Vehicle to Vehicle
V2I	Vehicle to Infrastructure
V2V2I	Vehicle to Vehicle to Infrastructure
AODV	Ad hoc On-Demand Distance Vector
DSRC	Dedicated Short Range Communications
OBU	On Board Unit
RSU	Road Side Unit
AU	Application Unit
TDMA	Time-division Multiple Access
CSMA/CA	Carrier-sense Multiple Access/Collision Avoidance
CDMA	Code Division Multiple Access
RREQ	Route Request
RREP	Route Reply
RERR	Route Error
GPS	Global Positioning System
DSDV	Destination-Sequenced Distance Vector
WAVE	Wireless Access in Vehicular Environments
WiFi	Wireless Fidelity
EDCA	Enhanced Distributed Channel Access

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CHAPTER 1: INTRODUCTION

1.1 Problem Statement

The main problem: Why I select this topic?

- VANETs is a sub branch of MANETs and its protocols are not available as compared to MANETs

- Due to increase number of vehicles day to day.

- For improvement of some important factors that are important in VANETs applications.

- Due to the advancement in automobile industry in modern world.

1.2 Overview

Nowadays, traffic, especially roadside becomes one of the top sources that have direct impact over the social lives of people effecting several important aspects including safety and environmental changes to name a few. According to the data that is provided on world life expectancy, around one million people lose their lives in road accidents. There are several aspects of traffic management; however road safety is one of the significant issues that are a top priority for any government. There exist conventional ways of dealing with the issues which include manning of traffic by police and providing different roadside signs for public awareness; however, these old methodologies seems not to be so effective in the modern fast pace society. Therefore a need has arisen to give the information regarding traffic directly to and from the vehicles themselves. This gives rise to a new paradigm in communication networks by the name of the

Vehicle Adhoc Network (VANETs). This can be done by the trading of the useful information among the vehicles. All the vehicles has the nature of mobility and for that the mobile network should be that much strong that it could self-organized and allow to exchange the information in the absence of any infrastructure. Through the development in microelectronics, it is now possible to incorporate the network and the node into a unity by the wireless connection. VANETs can be used for an extensive range of safety and non-safety applications.

1.3 General Background

Accidents on the roads are the serious and adverse issues around the world. The main reason of the accidents includes the behaviour, road awareness, ability and attitude of the driver on the road. Accidents could be reduced to a great extent by providing the appropriate, precise and reliable info to the driver. Some developed countries have taken an initiative for safe and competent driving conditions. VANETs are the sub branch of MANETs which is an ad hoc network. Research on this topic starts in earlies of 2000 in universities and research labs and now this field is playing an important role in many developed countries and some developing countries are also working in this field.

1.4 Thesis Approach

As far as the study has been carried out there is not much research work has been done in the field of VANETs especially in Pakistan and this is the major reason of working in this area. Due to increase in number of vehicles day by day it is necessary to introduce some applications which can be useful for drivers. The proposed thesis will be a better solution for the optimum routing in the VANETs as compared to the old methods which is achieved by the researchers earlier.

Primarily, discussion on basic AODV will be carried out with some experimental results which will show that the basic AODV is not suitable for VANETs as a direct approach until some alteration will be made in it to get the desired output for some important features of the network.

1.5 Thesis Challenge

The main challenge of proposed work is to optimize the basic AODV routing protocol which floods the entire network with packets for route discovery of the source to destination communication, moreover when the number of vehicles increases in the network it effects the latency, throughput and network life time of the network through its flooding procedure which is the major contest of this thesis .2nd major challenge is to maintain the two hop distance between the source and destination in overall communication.

1.6 Thesis Organization

- The study comprises of the following sections.
- Chapter 2 is comprised of an introduction to MANETs as well as VANETs. It also presents a thorough overview of different protocols of VANETs.
- Chapter 3 consists of the Basic AODV experimental analysis.
- Chapter 4 is based on the enhanced version of the AODV with experimental results of important factors.
- Chapter 5 summarizes the achieved work, future work as well as the recommendations for future directions

CHAPTER 2: LITERATURE REVIEW

Following chapter gives the essence of Mobile Ad Hoc Networks as well as the Vehicular Ad hoc networks with some major differences between the both networks. The chapter also discusses the MAC layer (802.11p) and also some different routing protocols for vehicular ad hoc network.

2.1 Mobile Ad Hoc Network (MANETs)

Arrival of global computing and the designing of innovative, incredible, capable, handy computing gadgets have captured the attention of wireless mobile communication. Wireless mobile communications and networking is an evolving field in which the technology allows the users to avail electronic services at any time, irrespective of their geographical location. The wireless network of are of two types: Infrastructure base and infrastructure less which are also known as ad hoc networks. The network with infrastructure have the networking component (i.e. routers and gateways) through which the nodes are connected which are within the network range. In this nodes are connect to the nearby base station that comes within its communication range. When this node exceeds the coverage area of that base station, it performs the hand off procedure so it can come in the range of new base station. Cellular communication is a classic example for infrastructure based wireless network.

The other type of wireless network is the infrastructure less network and also known as an Ad Hoc network. The phrase ad hoc is the Latin which indicates to perform something for a particular purpose. A mobile ad hoc network is a self configuring type of network of mobile devices which connects them through the wireless medium. It is a P2P, self forming and self restorative type of network. MANETs have the capability to immediately form a mobile node network, combined or segregated into discrete networks while in motion depends on the networking requirement and vigorously handle the leaving or joining of network nodes. The main objective of MANET includes reliability, availability and scalability. The nodes in the network are self-governing processing devices with low capacity that are capable to move freely and due to this factor the topology of the network changes swiftly, randomly and periodically. Each node in a network can be a host or a route which transmits the data to other nodes. Achievement of the communication is extremely relying on the cooperation of the other nodes. Nodes are responsible for vigorously finding out the other nodes themselves for the communication in the wireless range. In MANET nodes are keep on moving which results break in connection as well as restoration frequently. Moreover, maximum number of nodes in network have limited resources in when it comes to battery power as well as on computing ability, so the conventional computing routing protocols are not fit for MANET.

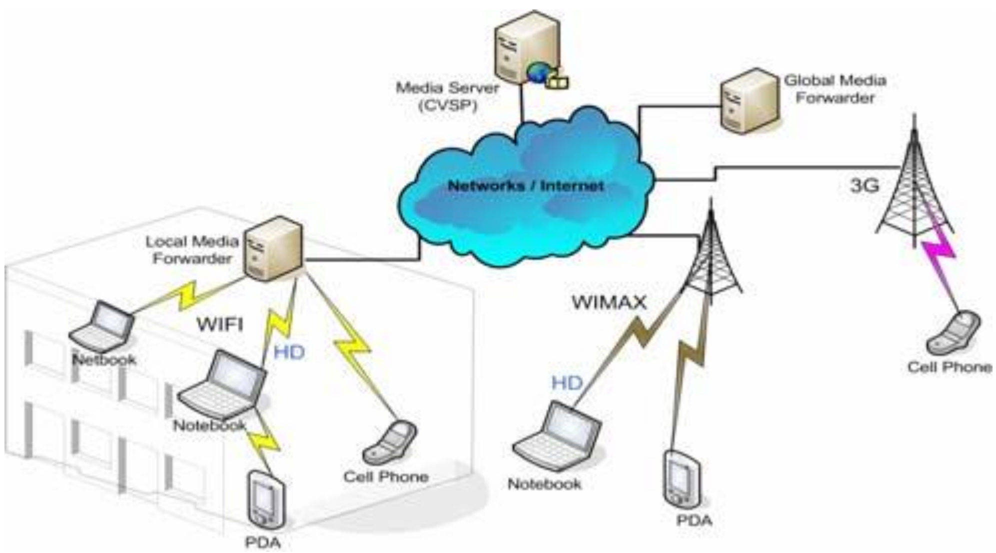


Figure 1: Heterogeneous Mobile Ad hoc Network (MANET)

The devices which are the part of MANET include handheld devices like palmtop, PDA, smartphones, laptop, smart watch, pocket PC or any wireless mobile devices. These devices are normally easy to carry and have batteries in it. Figure 1.1 shows an illustration of a heterogeneous mobile ad hoc network and its communication with different devices.

2.2 Vehicular Ad Hoc Network (VANETs)

Vehicular Ad Hoc Networks (VANETs) have fully-fledged out of the necessity to support the increasing amount of wireless products that can now be used in vehicles [1, 2]. Keyless entry devices, tablets, laptops and smart phones are some of the wireless products. As mobile wireless devices and networks become more and more vital, the demand for Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) communication will be grown day by day [2]. VANETs can be used for an extensive range of safety and non-safety applications, i.e. automatic toll payment, traffic management, enhanced navigation, vehicle safety, location-based services for example, searching the nearest fuel station, restaurant, motels [3] and entertainment as well as information applications for example, giving the internet access to the user.

There are three types on which VANET's works and are briefly described as follow:

Vehicle to Vehicle (V2V): Vehicle to vehicle communications involves a WAN (wireless area network) where vehicles convey their information through messages that what activity they are performing. This information includes many things like their speed, location, their direction, braking, and loss of steadiness. DSRC (dedicated short range communication) technology is is used in V2V communication which is a standard that is set by the organizations like FCC and ISO. The frequency used in this communication is 5.9GHz which is same as the frequency of WiFi but calling it a WiFi network is not appropriate it can be called WiFi like network. The range that is covered by the vehicles in this network is up to 300m. The topology that is used in this network is mesh it means that every node it could be a car or a signal is able to send, receive and captures the signals. V2V network allow the vehicles to communicate to each other without depend on a permanent infrastructure support and can be mostly used for safety, security, and dissemination applications.

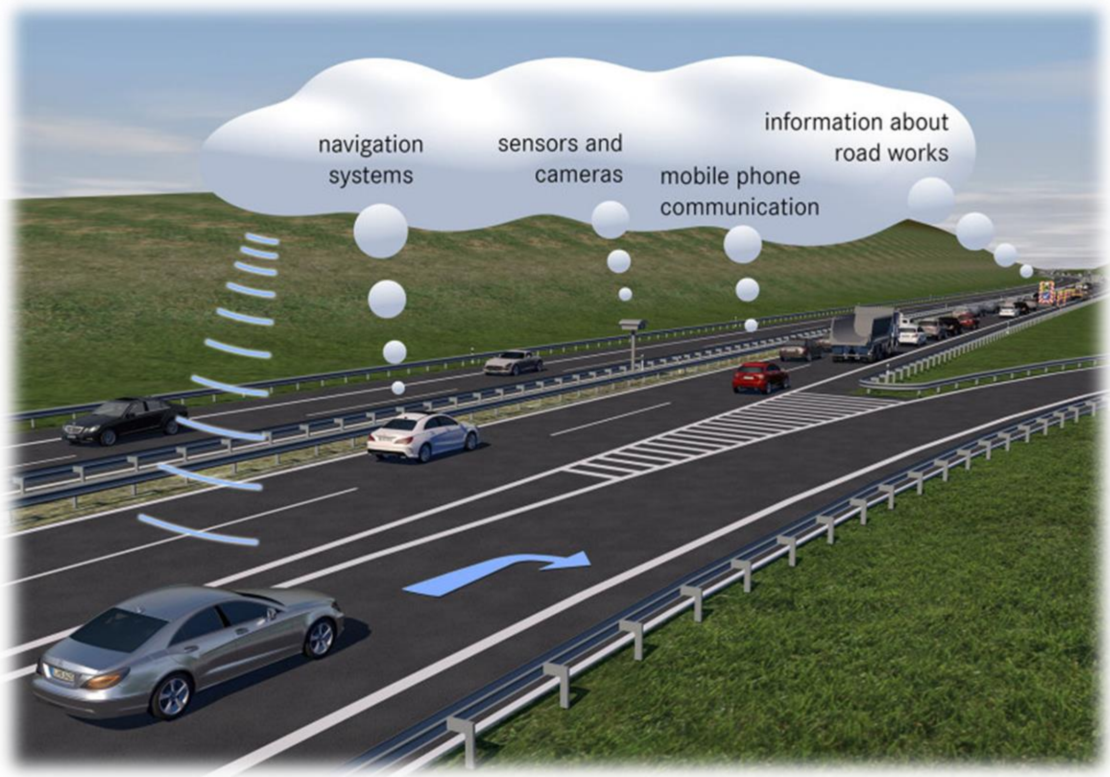


Fig 2: Vehicle to Vehicle Communication

Vehicle to Infrastructure (V2I): Vehicle to Infrastructure communication plays a vital role in the coordination of the vehicles also knowns as OBU (on board unit) and the radio transceivers also known as RSU (road side unit) so that vehicle and the roadside transceiver communicate with each other for safety, security and for traffic management purpose. This network collects the information of local signals and the road conditions and then impose some policies on the group of vehicles which are connected to the network for many useful purpose.

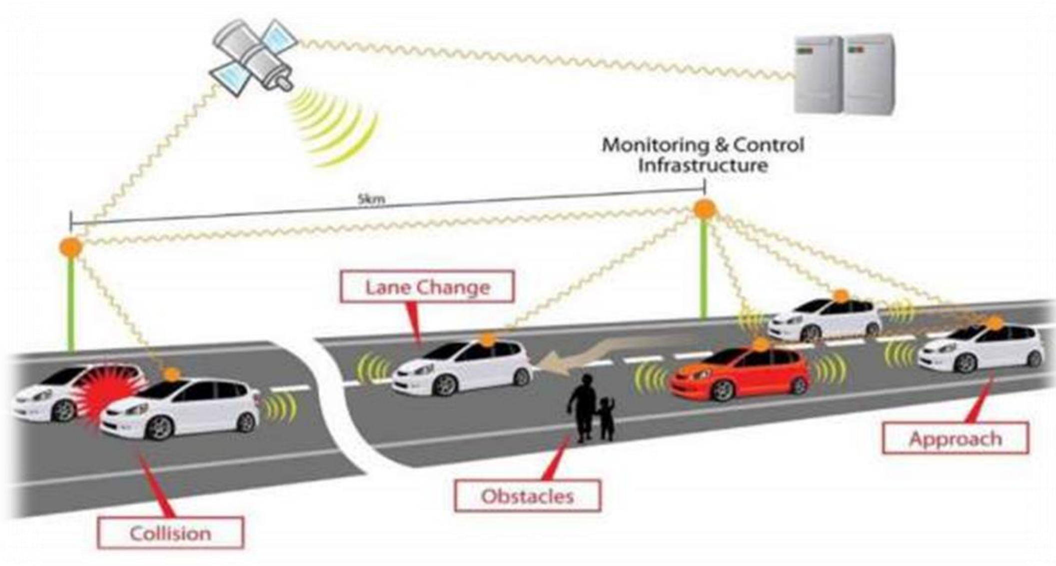


Fig 3: Vehicle to Infrastructure Communication (V2I)

Vehicle to Vehicle to Infrastructure (V2V2I) or Hybrid Architecture: V2V2I or hybrid architecture merge both Vehicle-to-Vehicle and Vehicle-to-Infrastructure. In this type of communication a vehicle can exchange the information with the roadside infrastructure either in a single hop or multi-hop manner, based on the distance, i.e., if it cannot approach the road side unit directly or vice versa. It enables the vehicles to communicate with each other that are distant or allows a long distance internet connection for the vehicles.V2V2I is bit different from other two types of communication that are discussed above.

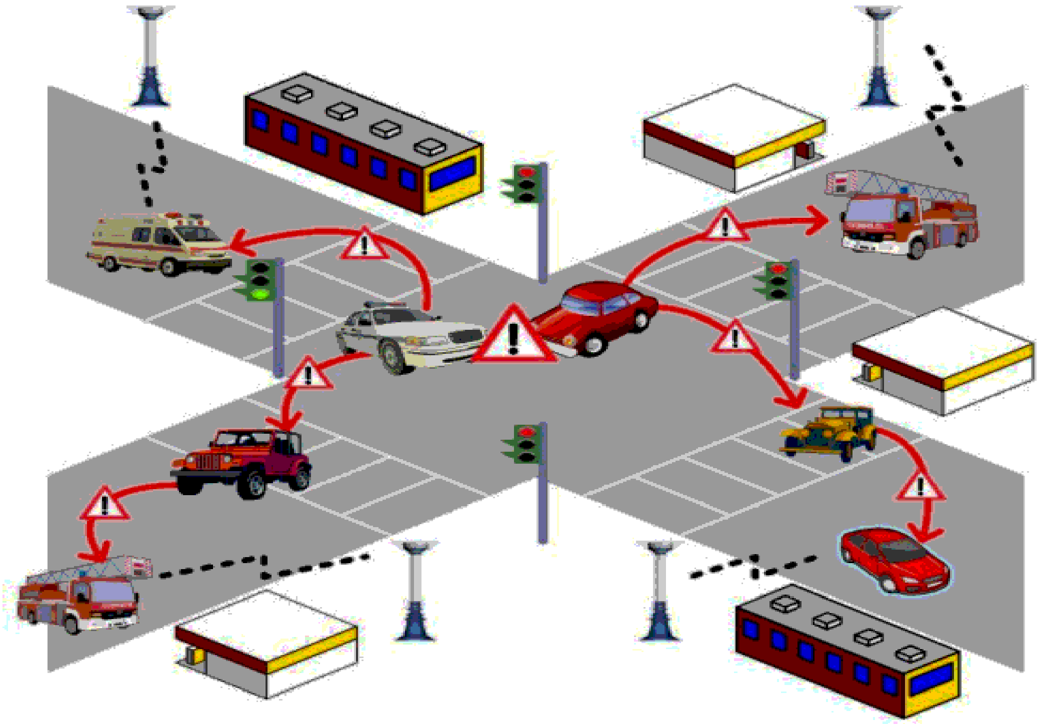


Fig 4: Vehicle to Vehicle to Infrastructure Communication (V2V2I)

2.2.1 Distinguishing features of VANETs

Vanets has become the important research area for the developing countries by increasing their traffic situation day by day. Vanets which belongs to the clan of Manets (Mobile ad hoc networks) has its own distinctive features when it is compared to Manets and some of them are as follows:

1. High Computational Capability: Nodes in the vanets are vehicles and they are provided with sufficient sensors and assets for processing such as global positioning system (GPS), processors and large memory capacity. These resources are the biggest factor for the increasing capabilities of the nodes, which help in resulting the reliable communication by getting the precise information about the vehicle direction, speed and its current position [4-5].

2. Expected Mobility: When it’s come to the mobility the VANETs mobility is very much predictable as compare to the MANETs in which node moves randomly whereas in the VANETs the vehicles (nodes) are usually follow the topology that is defined from the road in which they obey the traffic lights as well as the road signs which results its movements predictable [6, 7, 8, 9].

3. No Energy Problems: Energy is not a big issue in Vanets as compare to Manets because cars continuously provide enough power to on board unit (OBU) by the use of long life battery [5,7,10]

4. Variable Density in Network: This factor only depends on the density of the traffic, it can either be low as in residential traffic or it can be very high in the traffic jam. [9,10]

5. Hefty Networks: The network size in the Vanets varies from small to large such as rural, urban areas, highways or it can be a metropolitan city [9, 10].

6. Immediate Alterations in Network Topology: Vehicles that are travelling on the motorways with the high speeds can change the topology of the network instantaneously and by this the received information can affect the performance of the driver [8, 9, 10].

7. Assurance of Harmless Driving: This thing is only possible when the efficiency of the traffic is improved. The communication -between the nodes is direct through VANETs which allows the pack of applications that needs direct communication among the vehicle over the network. And these applications offer cautioning data to travelers moving along a similar course concerning the criticalness for quick hard breaking or about mishaps, in this manner the driver needs to make a bigger picture of street topology ahead. Moreover, VANETs can likewise enhance voyager fulfillment and enhance movement effectiveness by demonstrating data, for example, shopping malls, service station, climate, restaurants, and hotels [7].

8. Time Critical: It is important that the data in the VANET network should be delivered to the nodes in a particular time so that it will be easy for the node to make a quick decision and make some action rapidly.

2.2.2 Network Challenges

Mobility

As it is obvious that in Ad Hoc Network each node is mobile and it keeps on moving from one place to another within the coverage area, still the mobility is restricted but when it comes to VANETs nodes moves with high mobility and in this type of network vehicles make connection with other vehicles which they never faced before and this connection will not stay long as the vehicles will follow the path in which it is travelling and these vehicles might be not able to face each other again. So it is the very hard problem to secure the mobility challenge [11].

Volatility

The connectivity between the vehicles for the communication can be extremely fugacious and this communication might not happen again as the nodes are travelling throw their coverage area and build up its link with other nodes, these links/connection will be mislaid due to high mobility of the vehicles and they might be move in the opposite direction [11,12]. Lacking of the relative long life context will be found in these networks so the private interaction from the user's device to the hot spot will need long life passwords which seems to be unrealistic for the security of the virtual connection [13].

Verification in terms of Privacy

For the prevention from the different attacks on the network the verification process of the node is very important and to overcome this problem a unique or specific identity can be given to the individual vehicle but this is not the proper solution for most of the users, users which wants to retain their info secure and private [11,12],

Responsibility in terms of Privacy

For legitimate inquiry responsibility will be the good option and this information cannot be repudiated by any user in case of the collision and accidents [11], furthermore it is very important to keep the privacy of the user from others and they are able to keep their personal information (ID, Account Number for toll collection, route etc.) safe from other drivers as well [13].

Scalability

When it comes to the scalability these networks are very big enough and there scalability is increasing day by day due to the increment of the vehicles moreover the other problem rise that this network has not any standards that governs by any authority or firm. The DSRC standards for each country vary from one another and it also varies from vehicle to vehicle [13].

Routing protocol

To create a new protocol that will able to guarantee the delivery of packets in small time frame with low packet drops will be considered as a severe issue for VANETs [14, 15, 16, and 17]

Trifling operative diameter

The small diameter result the weak connection between the nodes during the communication in network, hence it is unfeasible to sustain the topology of the network global for any node. [18]

Fading of signals

Fading occurs due to the obstacles that are placed between the nodes which are exchanging the information. The obstacles can be static like buildings and other moving vehicles. The effect these obstacles fades the signal and try to stop the signals to reach to its desired destination.[15]

Bandwidth Restrictions

In this type of network there is an absence of centralized coordinator which is responsible for the handling of the contention as well as management of bandwidth. Due to the limited range of frequency the channel congestion probability is high when it come to the high density location.

Connectivity

High mobility is the main reason of the frequent disconnectivity in the network and the required duration for exchanging the information would be enhance and to achieve this thing it is necessary to increase the transmission power but it will effect in the degradation in throughput.

2.2.3 Architecture of VANETs

With increasing population vehicles are also increasing rapidly on roads which result the difficulty in the driving and making it more dangerous and challenging day by day. Roads are packed with lots of vehicles, the rules that are speed and safety distance are rarely followed and there is a lack of concentration in travelers while on moving on the road. Following are the main objects present in VANETs architecture.

On Board Unit (OBU)

The first thing that come in VANET architecture is OBU which usually mounted on board of node. It is device that use WAVE technology which is used for the interchanging of information with other units or with road side units (RSUs). The things that every OBU have includes a user interface, for storing and redeem the messages a memory is used and for the processing of all these things a processor is also required, a network sort of interface that uses for creating a link with other OBUs, last but not the least a wireless device for the short communication range which works on 802.11p protocol which is MAC standard for VANETs. A wireless channel is also needed to for the connection between the different OBUs/RSUs and this also works on the IEEE 802.11p standard which is responsible for the interchanging of messages between OBUs/RSUs. The foremost responsibility of an OBU comprises of information security, IP mobility, routing with respect to geography, message transfer with reliability, and congestion control in network. [19]

Application Unit (AU)

AUs are devices equipped inside the vehicle which uses the services supplied by the provider by exploiting OBU capabilities. AU can be a PDA to connect to the Internet or a device dedicated for safety applications. A wired or wireless connection is used to connect the AU to the OBU and may be kept in one physical unit with the OBU. The difference between OBU and the AU is logical.

Road Side Unit (RSU)

The road side unit (RSU) are the devices that use WAVE protocol which are placed in the locations like parking areas, signals, on the road segment or on junctions. RSU is equipped with the device that is dedicated for the short range based communication through the radio technology, and for the aim of communication within the network infrastructure. Different network devices may also be fitted out with RSUs as shown in figures. RSU main operations which are associated with congestion control communication consortium are:

1. The enhancement in the range of the network can be achieve through the redistribution of the messages to different OBUs and relaying messages to RSUs so it can be transmitted to different OBUs.

2. It runs for the safety purpose applications like accident warning, natural disaster warning, and work zone by using communication of V2I which serves as a source of information.

3. The internet connections are provided to OBUs through these units.

2.3 MANETs VS VANETs

The relationship between both the ad hoc networks is that nodes are self-sustaining and are able to handle information by themselves without any infra. VANETs have some distinctive features and it is a subclass of MANETs.

- Quickly Variable Topology

In both the network topology changes swiftly as the nodes are mobilized and cannot stay in a network for long, however, in VANETs the speed of the nodes are comparatively high as compared to MANETs so the network topology in VANETs are frequent and very fast. In VANETs topology can be predictable as the vehicles follow the road path while in MANETs the nodes can be moved anywhere and its topology in not that much predictable.

- Repeated Interruptions

Change in rapid topology causes the frequent interruption in the network. In VANETs the probability of disconnections is very high as compare to MANETs because the connection between vehicles can disconnect very rapidly due to the high speed of the vehicles. The issue of interruptions becomes more inferior if the density of nodes varies.

- Energy Constraint

In VANETs the nodes don’t have any energy restrictions as compare to MANET.

- Production Cost

When it comes to implementing the cost to produce the MANET network is much cheaper than the VANET as both networks have different type of nodes and the manufacturing cost of the equipment varies in both networks.

- Reliability

When it comes to reliability, VANET are much more reliable than the MANET because in MANET the security factor is much lower than the VANET.

Further differences on which both networks differ from each other are mentioned in below table.

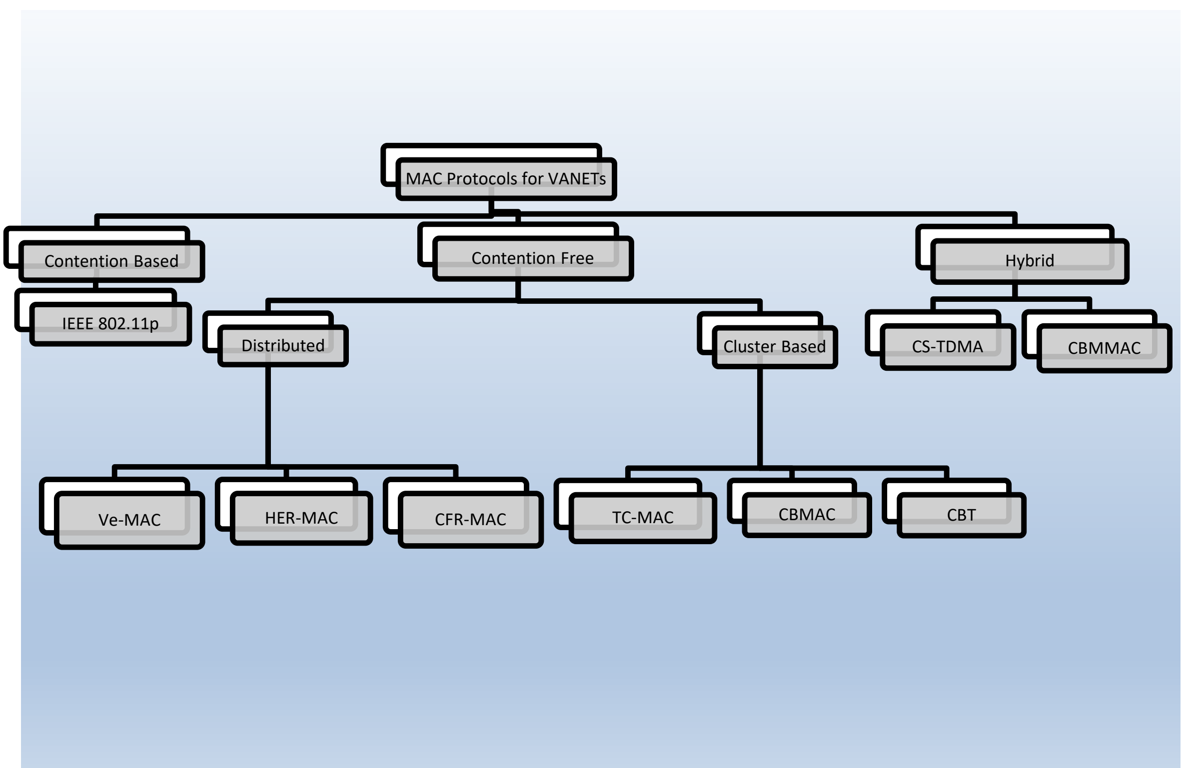
Table 1: Difference Between MANETs and VANETs

S.No	**Parameters**	**MANETs**	**VANETs**
1	Cost of Production	Cheap	Expensive
2	Change in topology	Slow	Frequent and fast
3	Mobility	Low	High
4	Node Density	Sparse	Dense and frequently variable
5	Bandwidth	Hundred Kps	Thousand Kps
6	Range	Upto 100m	Upto 500m
7	Node Lifetime	Depends on power resource	Depends on lifetime of vehicle
8	Multi-hop routing	Available	Weakly available
9	Reliability	Medium	High
10	Moving pattern of nodes	Random	Regular
11	Addressing scheme	Attribute based	Location based
12	Position Acquitsion	Using ultrasonic	Using GPS & RADAR

2.4 MAC Protocols for VANETs

For the improvement of transport system VANETs delivers safety as well as non-safety services to vehicles and to attain this objective vehicle need to communicate where there is no collision and they can efficiently access the channel for communication. Numerous protocols are proposed for vehicular ad hoc network which specifies the accessing of channel by nodes in a different manner. A number of problems are faced during the designing of this protocol like high mobility of vehicles, rapid change in the topology of network, multi-channel separation, neighbouring channel interference and hidden node issue. MAC is categorized into three broad classifications which includes contention based, contention free and hybrid MAC protocols.

Table 2: Types of MAC Protocols



2.4.1 Contention based MAC

These are the protocols that use in wireless communication in which many users are allowed to access the same radio channel deprived of pre-coordination. In IEEE 802.11 the most well known contention-based protocol for VANETs is 802.11p.

- IEEE 802.11p

The base of IEEE 1609WAVE clan of standards is IEEE 802.11p [20]. The medium access control and physical layers are defined by this standard, further wireless access in a vehicular environment stack uses this standard and it is based on CSMA/Collision Avoidance which is defined as the MAC protocol in IEEE 802.11 standard. For accessing of channel Enhanced Distributed Channel Access (EDCA) and Carrier Sense Multiple Access/Collision Avoidance (CSMA/CA) functionality is used by the protocol. For message prioritization, EDCA use Access Category [21]. The priority of these messages are starting from 0 to 3 in which 0 is the lowest priority (AC0) and 3 is the highest priority message (AC3). On the basis of AC, Contention Window and Arbitration Inter-Frame Space accustomed which is mentioned in the table.

Table 3: Contention Window Frame [20-21]

AC	CWmin	CWmax	AIFS	tw
0	aCWmin	aCWmax	9	264µs
1	aCWmin+1/2 - 1	aCWmin	6	152µs
2	aCWmin+1/4 - 1	aCWmin+1/2 - 1	3	72µs

The accessing time of channel is distributed in 100ms of repeating synchronization interval (SI), further these SI are divided into fixed time interval of 50 ms of control channel interval and service channel interval as drawn in figure. By using GPS receiver which is equipped on OBU of individual vehicle all the vehicles are synchronized through coordinated universal time. In CCHI individual vehicle listen or broadcast control or safety message, moreover with SCHI service or nonsafety message are exchanged. If the density of traffic is high, 50ms CCHI is not sufficient for the transmission of safety message through all vehicles [22]. The bandwidth of CCHI is wasted when the density of traffic is less

.

2.4.2 Contention Free based MAC

In contention free protocols, specific plan is followed by the nodes which assures a collision free communication time. These protocols are divided into two broad categories which include distributed based and cluster based MAC Protocols. Further in these two categories there are several protocols which follows the mechanism of collision avoidance and dedicates the time slot to vehicles for accessing the channel so that the transmission can be performed. Protocols which have designed in these categories are VeMAC [23], CFR-MAC [24], HER-MAC [25], TC-MAC [2] and D-CBM [27].

2.4.3 Hybrid MAC Protocol

These protocols are the combination of the contention based as well as contention free MAC protocols. In these protocols mechanism of both the categories are mixed up together so that the vehicles can ass access the channel easily and communicate in a collision free manner. Some hybrid MAC protocol includes CS-TDMA [28,29,31], CBM-MAC [24] and HMM-MAC [30]

TABLE 4: COMPARISON OF MAC PROTOCOL OF VANETS [20-30]

	IEEE 802.11p	VeMAC	HER-MAC	CFR-MAC	TC-MAC	D-CBM	CBT	CS-TDMA	CBMMAC
Based on	CSMA/CA	TDMA	TDMA	TDMA	TDMA	TDMA, CSMA	TDMA	SDMA, TDMA, CSMA	TDMA, CSMA, CDMA
Time synchronization	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Merge collision	Occurred	Occurred	Occurred	Not Occurred	Occurred	Occurred	Occurred	Occurred	Not Occurred
Access collision	Occurred	Not Occurred	Occurred	Not Occurred	Not Occurred	Not Occurred	Occurred	Occurred	Not Occurred
Mobility	Urban/ Highway	Urban/ Highway	Highway	Highway	Highway	Highway	Highway	Highway	Highway
Application	-	Safety	Non-Safety	Safety	Non-Safety	Safety	Safety, Non-Safety	Safety	Safety, Non-Safety
Simulator	Matlab	Matlab	Matlab	-	NS-3	NS-2	NS-2	Matlab	Matlab
Complexity	Low	High	High	High	Medium	Medium	Medium	High	High
Cost	Low	High	Low	High	Low	Low	Low	Low	High

2.5 Routing Protocols for VANETs

Routing protocols in VANETs are categorized on five types which includes Topology based, Cluster based, Position based, Broadcast and Geo-cast base routing protocol. On the basis of applications, these protocols are characterized in mentioned types where they work most appropriate.

2.5.1 Topology Routing Protocol

This type of protocols uses information on the links that are in the network to execute forwarding of packets to the nodes. Further, they are divided into Reactive and Proactive protocols.

i. Reactive Routing

In this type of protocol the route for the node is only open when it is required for a node to communicate. It only retains the routes that are presently in use during routing, which decreases the burden of the network. This protocol is comprised of discovery of a route by flooding the network with route discovery packet for the communication path between nodes and this phase ends when the route from source to destination is found. The well-known reactive routing protocols are AODV, DSR, TORA and PGB.

ii. Proactive Routing

In this type of routing protocol the information about routing for the next hop is kept in the background regardless of communication needs. The benefit of this protocol is that there is no route discovery phase in it as the route for the next hop or destination is saved in the background. But with this advantage the drawback of this protocol is that for real time application it provides low latency. The routing table is created and maintained in the node, so that the next hop is already defined to the packet when it arrives at the node. Moreover the idle paths are also maintained by the protocol during communication which reduces the available bandwidth of the network. Well-known proactive protocols include DSDV, LSR, OLSR and B.A.T.M.A.N.

2.5.2 Cluster Based Routing Protocol

In this type of routing a cluster is formed between the group of nodes and from these nodes, one node becomes the head of cluster which is responsible for the broadcasting of the packets to other cluster heads and the gateway. Scalability can be achieved by using this protocol for large networks, but for highly mobile network overhead and delays is experienced. Virtual infra must be formed in this protocol so that it can provide the scalability in the network. Well know protocols are CBLR, RLSMP, AWCP, CBVANET and COIN.

2.5.3 Position Based Routing

It consist of a class of routing algos. In this geographical positioning property is shared for the selection of the next hop on which the packet has to send, without any prior information of the map to the neighbour which is one hop away, nearby to the destination node. These routing protocols are valuable as there is no requirement to create and maintain the communication path between the source and destination node. This protocol is divided into two categories which includes delay tolerant and position based greedy V2V protocols. Well known protocols include GPCR, CAR, DIR, MOVE, VADD and SADV.

2.5.4 Broadcast Routing Protocol

These types of protocols are commonly used in this network for the purpose of traffic, weather, sharing, road conditions and emergency between the vehicles, also for conveying broadcasts and commercials among the vehicles. Well known protocols includes DV-CAST, V-TRADE, BROADCOMM and UMB.

2.5.5 Geo-Cast Routing Protocol

Its multicast routing, which is based on the location. The purpose of this is to send the packets from source to other nodes which are in the geographical range of the network also known as the zone of relevance. Vehicles that are not in the range of ZOR are unable to get alerts so that the vehicles can avoid unwanted rapid response. In this routing a zone is defined as the forwarding zone and from there the flooding by packets is done to diminish congestion and message overhead of the network which is caused by flooding the packets to the entire network. Unicast routing is performed in the destination zone for the forwarding of the packets. The drawback of this routing is the portioning of the network and hostile neighbours that can cause the difficulty in the packet forwarding. Well known protocols of this routing are IVG, Cached geocast, abiding geocast, DRG, ROVER and DG-CastoR.

CHAPTER 3: THEORETICAL ANALYSIS OF GENERAL AODV ROUTING PROTOCOL FOR VANETs

In this chapter, basic AODV will be discussed. Node movements in VANETs make them different from MANETs and there are many routing protocols in MANETs [32] [33] [34] but these protocols will give poor performance on directly applying to the VANETs due to differences in both networks [35]. In VANETs network topology changes dynamically and also lack in the bandwidth resources so it is not compulsory to sustain the route of each node. This frequent change of topology affects the effective timing of routing and is also reduces the routing rate information. Thus, the protocols that are considered good for VANETs are on-demand routing protocol.

Protocols that come under the umbrella of on-demand follows two process, i.e. Route discovery and maintenance. The route discovery initialization process is starts when the source node which don’t have any routing information in its table needs to form a route to the destination. Routing request packets flooded by the source node on the entire network through broadcasting. On the receiving of route request packet destination node sends a route response packet to the source. This creates a reverse path between the both nodes. The route maintenance process activates when the definite link of the activated path breaks or on the changing of the node. AODV [36] [37] [38], one of the most important routing protocol in MANETs, also need an improvement when applied to the VANETs.

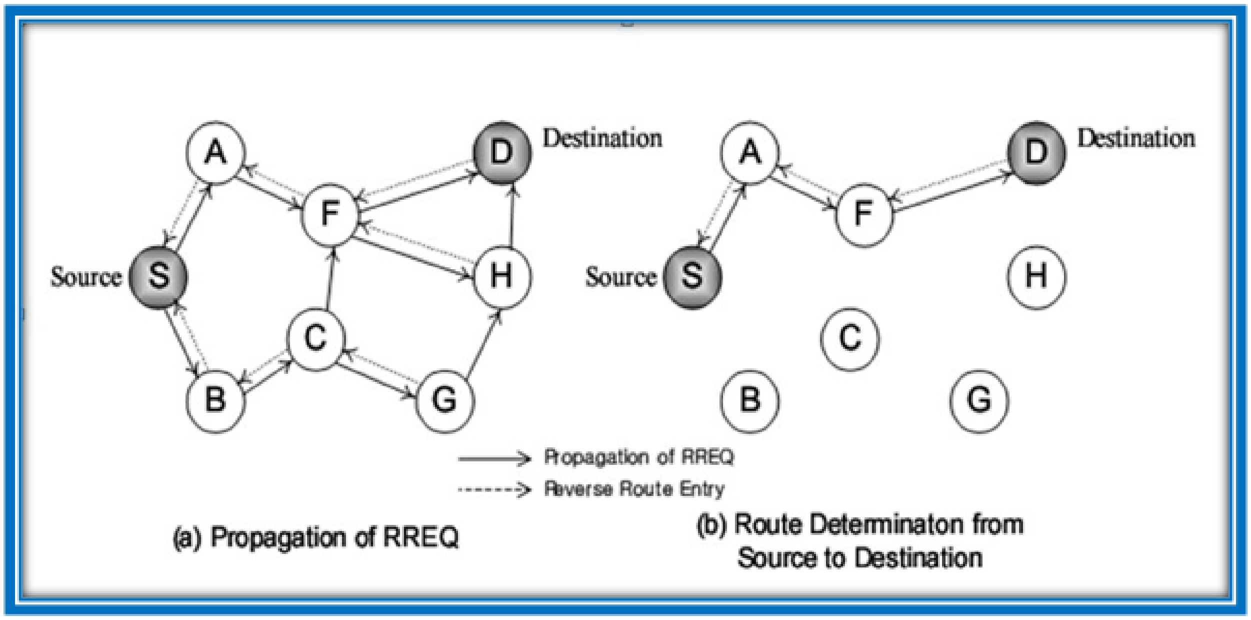


Fig 5: Basic AODV Routing Protocol Mechanism

3.1 Basic AODV

AODV is one of the most popular routing protocol among the ad hoc network and it is a reactive protocol. All the routes doesn't maintain in AODV all the time. When there is a need for transmission route discovery process starts which decreases its overhead. The sequence number is used to make sure the freshness of the routes and is also a loop free topology which makes this protocol unique. This protocol is comprised of three phases: route discovery, data transmission and route maintenance.

3.1.1 Route Discovery

A route discovery phase starts when the source node needs to send information to the destination node having no route to the destination node in its routing table. In this phase a Route Request (RREQ) packet is broadcast from the source node to its neighbour node.

The RREQ packet that received by the neighbours are distributed on three types: receiving node is the destination node, the receiver a proper route to a destination and none of them. In the first two scenarios a Route Reply (RREP) packet is produced by the receiver and the packet is sent back to the node from where the RREQ packet was received and after receiving this RREP packet a link or route is established between the source and the destination. However, in the third case, these RREQ packets are further sent by the receiver to its neighbour until a route cannot be established between the source and destination node and the same process take place.

3.1.2 Data Transmission

After route discovery phase, data transmission phase takes place and the packets starts to transmit by the source node to the destination through the same route that was established earlier. As the nodes are dynamic in the network and keeps on moving so this is the possibility that some of the nodes withdraw themselves from the radio range which results the breakage in link and transmission stops.

3.1.3 Route Maintenance

Route maintenance process takes place in which it tries to repair the same link or to establish a new route to the destination node. In the process the node whose link breaks produces a Route Error (RERR) packet and sends back to the source. On the receiving of this packet source node search in its routing table to look up the old route to the destination. If there is a route, source selects it and again starts the transmission of data. Else the source revives the other route to the destination node and starts its transmission.

3.2 Drawback of Basic AODV

In route discovery RREQ packets are forwarded to the neighbour nodes from the source and is further forwarded to their neighbours, due to this process the entire network is flooded by the RREQ which increases the routing overhead of the network as well as it increase the large amount of consumption in bandwidth. Moreover, more than one route is found by the source node to the destination and a route that have the newest sequence number or having less hops is chosen by the source node. Though the route is not long lasting to complete the transmission specifically in high dynamic VANETs.

3.3 Conclusion

Due to different features of MANETs and VANETs, the MANETs protocol can't be applied directly to the VANETs as it will give the poor performance. As compare to other protocols AODV performs better because of its quick reactiveness capability towards the changing network and establishing the route on demand. In [39], the method proposed by the authors is to add a packet header in the RREQ packet. The results of the simulation illustrate the smaller transmission delay, but there is a trade off in the packet delivery rate. In [40], speed and the position are used as an information for the assessment of the routes lifetime and the selection of the longest lifetime route after the assessment for the delivery of packets. Through this method routes are stable, but in contrast it increases the control overhead. In [41] the mechanism of route discovery is of two types; quick route discovery mechanism and traditional AODV mechanism. This protocol searches for the route through the first mechanism if not found any route than it use the second mechanism for the route discovery. On the traditional one the entire network is flooded by the control packets which increases the overhead of the network.

CHAPTER 4: THEORETICAL AND EXPERIMENTAL ANALYSIS OF EFFICIENT AODV ROUTING PROTOCOL FOR VANETs

This chapter discusses in detail, the designing of enhanced AODV routing protocol. The designing of the protocol generally emphasis on the drawbacks of the general AODV routing protocol, which gives poor results when directly applied to the VANET. This protocol which is designed, must be efficiecnt to achieve the various quality of service result that can be useful for VANET. As in general protocol the network is flooded with the packets which increase the overhead of the network. Research efforts have been made to overcome this issue and to produce better result in various aspect.

The thesis proposed a protocol through which routing of vehicular network could be make better by limiting the packet movement to two hops and by this the network overhead can be reduce to produce efficient results. The software which is used in designing of this protocol is MATLab, GUI based model is used for the illustration of the communication between the nodes.

4.1 Theoretical Ananlysis of Efficient AODV Routing Protocol

Since general AODV is not so profilic for VANETs, therefore it is necessary to tweek in general AODV so that it can be used for VANET as the basic one cannot ne directly applied to VANET and if applied desirable results cannot be achieved through it. Thus, in the proposed work modification in basic AODV has been made by limiting the communication to two hops so that the network overhead could be reduced.

In the proposed work with the help of road side units and by calculating the distance between the source and destination node path distance is calculated and with the help of these parameters throughput, network lifetime and latency is calculated of the whole network. Approach of the work is to set the communication range to maximum number so that the best possible outcomes can obtain and a suitabl block size is set for the communication between the nodes. RSU placed randomly on each execution of the code, throught these RSU communication between the source and destination made easier. In contrast of basic AODV which first discovers the routes by broadcasting the route request packets to the entire network, in the proposed work the route is discovered but not by flooding the entire network through packets but the first path between the source and destination is determined by the help of the RSU in which a source node send a path estabilisihng packet to the nearest RSU and that RSU further sends that packet to the destination with the help of other nodes but keep the path limits to two hops as this thing is the novelity of this approach. Once the link is establish between the source and destination transmission takes place but due to the high mobility this path cann't stay for longer and in this connection the intermediate nodes keep changes to maintain the data transmission between the source and destination and it stops when the transmission between both nodes end.

The packet size which is takento perform the evaluation of the work is 64 bytes and the results are taken on the 4,6,8,10,12 and 14 packets/sec. Latency of the network has been optimized so that the transmission delays can be overcome and the packet loss could be minimized.

4.2 Experimental Ananlysis of Efficient AODV Routing Protocol

The experimental analysis of the proposed work is evaluated on multiple quality of services constraints which includes throughput, latency, total distance in each linked path with 2 hops and network lifetime of the network with varying data rates. Simulation parameters are shown in the below table which evaluates the performance of the efficient AODV routing protocol.

Table 5: Parameters and Values of Simulation

Parameters	Values
Routing Protocol	Efficient AODV
Software	MATLab
Packet Size	64 Bytes
MAC Layer Protocol	802.11p
Simulation Time	1200 sec
Data Rate	4,6,8,10,12,14
Transmission range	180m
No of Nodes	100,120,140,160,180

Figure 6 shows the GUI interface of the simulation through which protocol has been run and figure 7 demonstrates the communication betwwen the source and destination node, though on the right of the GUI the established path between the source and destination is mentioned and on the left side soruce, destination and total number of nodes tabs are mentioned.

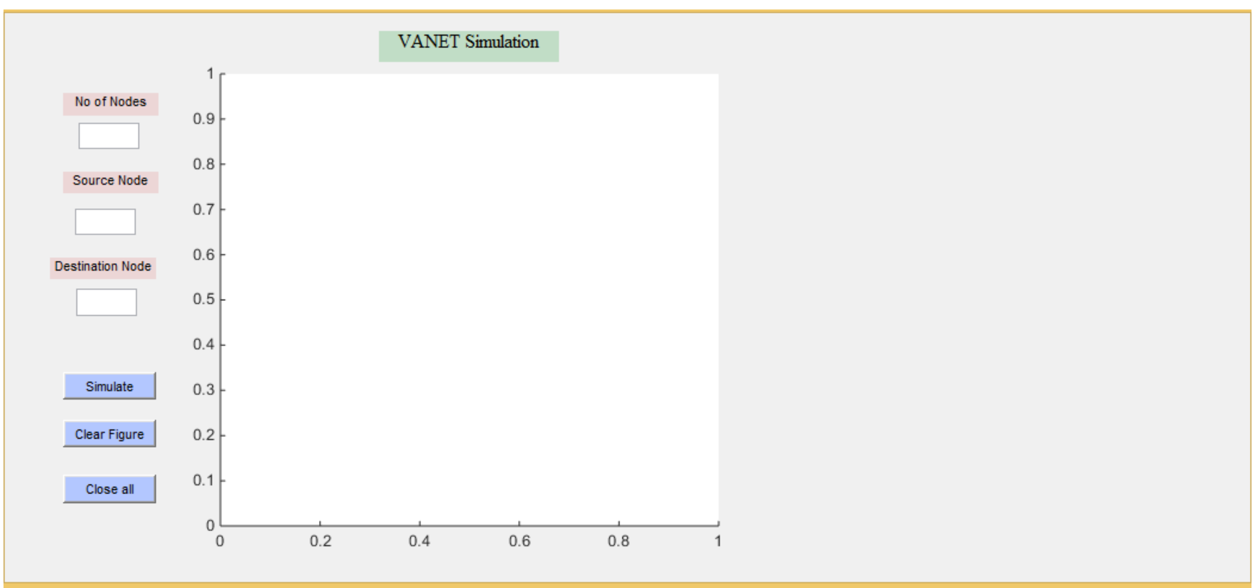


Fig 6: GUI Interface

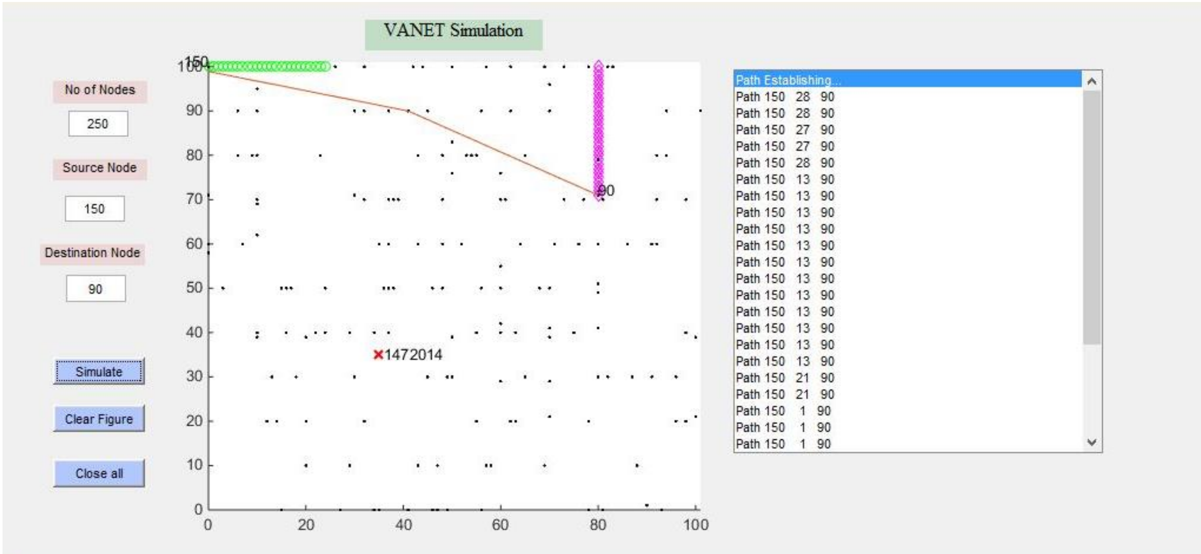


Fig 7: Communication between the Nodes

Results of the protocol are taken on the basis of data rate and by varying the number of nodes in the network.

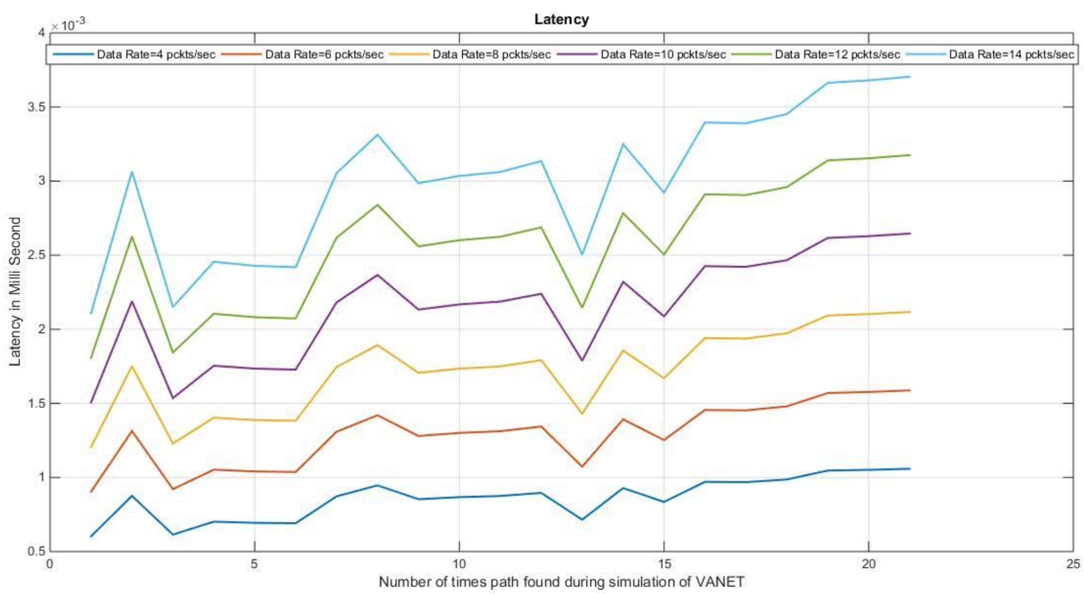


Fig 8: Latency on 100 Nodes

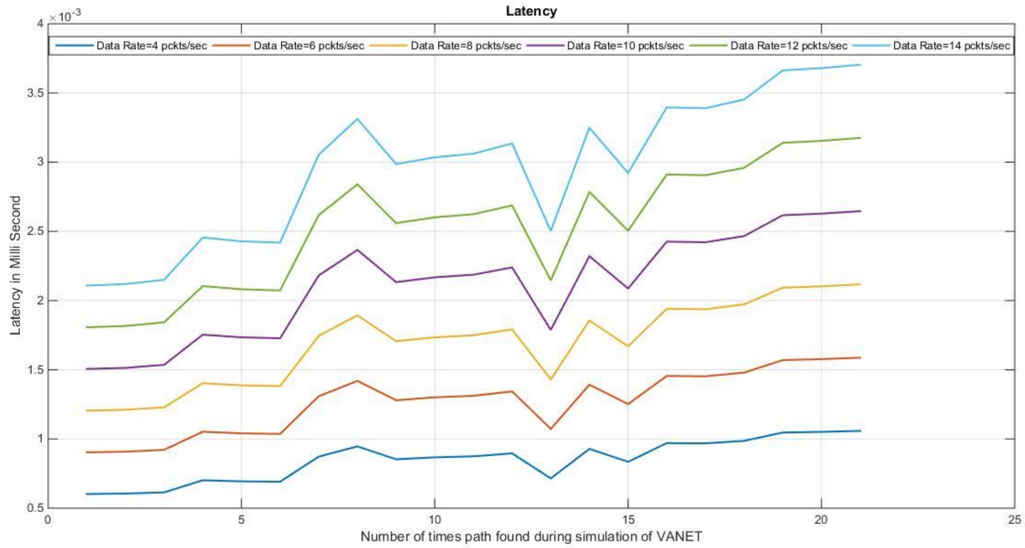


Fig 9: Latency on 120 Nodes

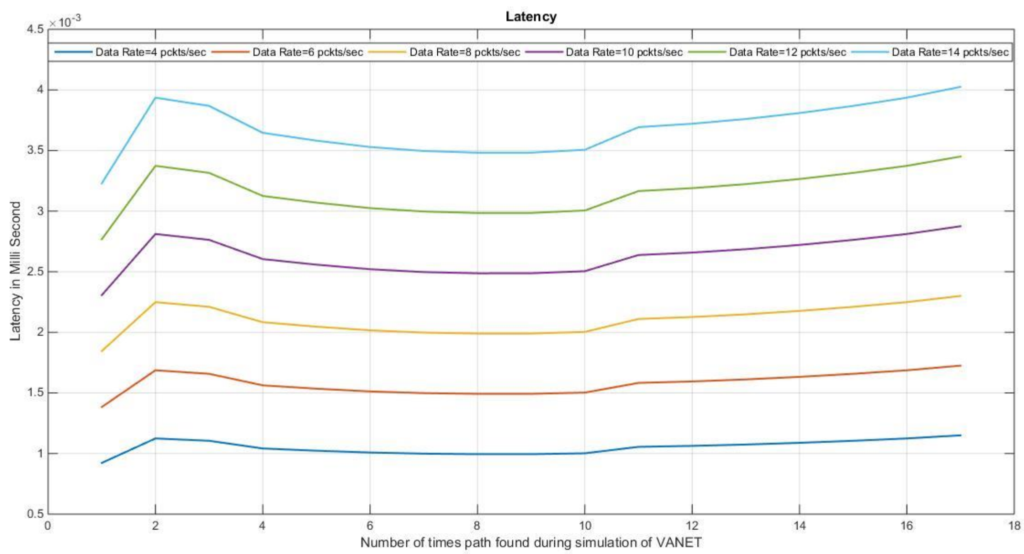


Fig 10: Latency on 140 Nodes

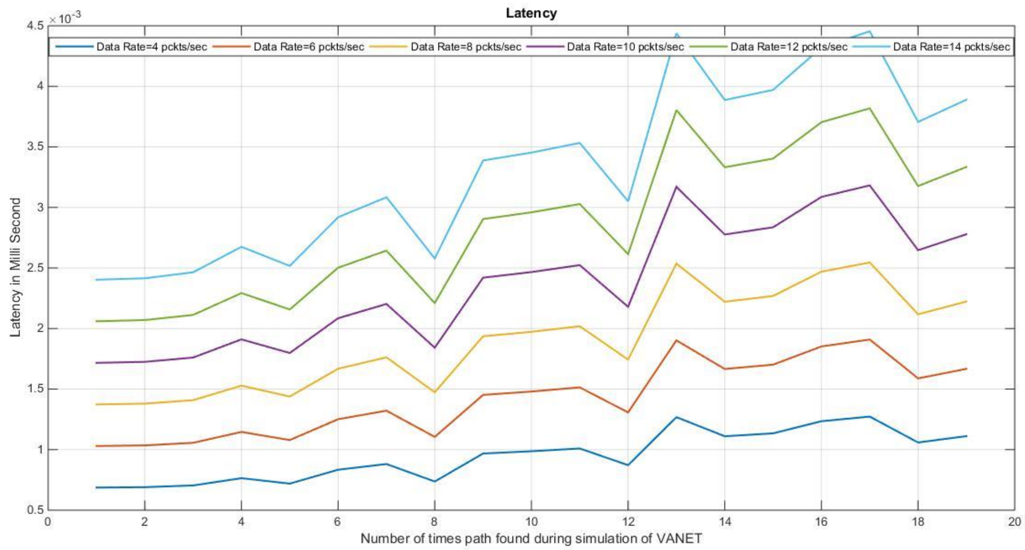


Fig 11: Latency on 160 Nodes

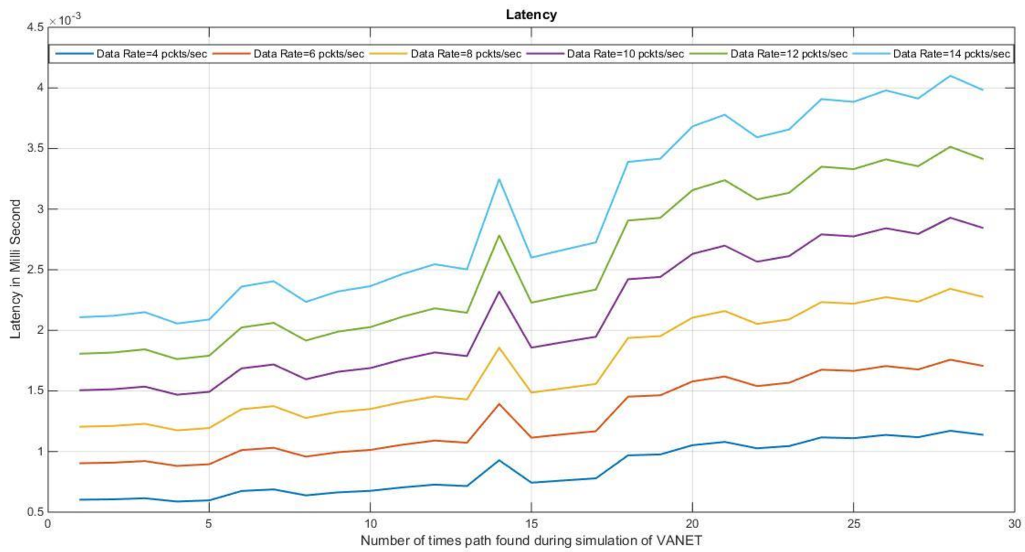


Fig 12: Latency on 180 nodes

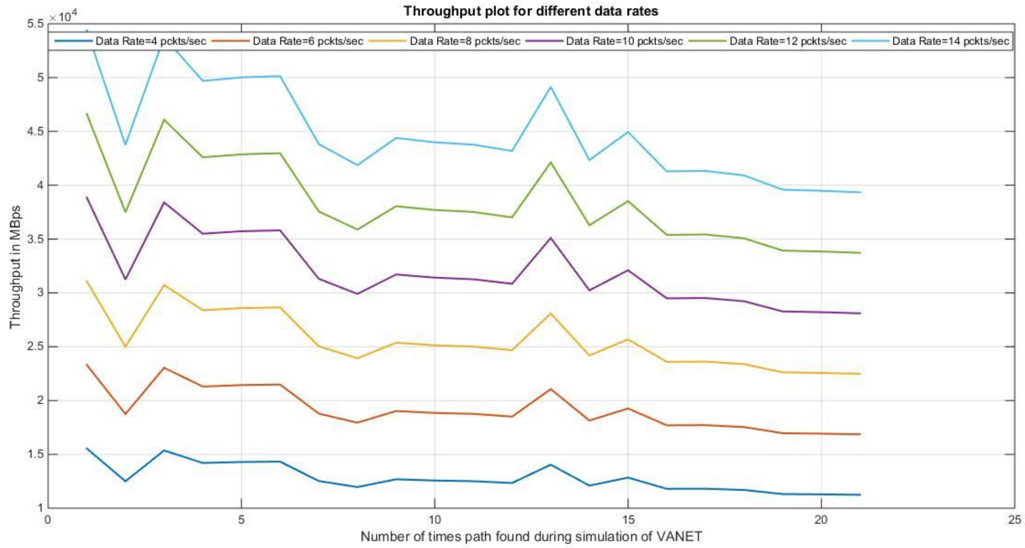


Fig 13: Throughput on 100 Nodes

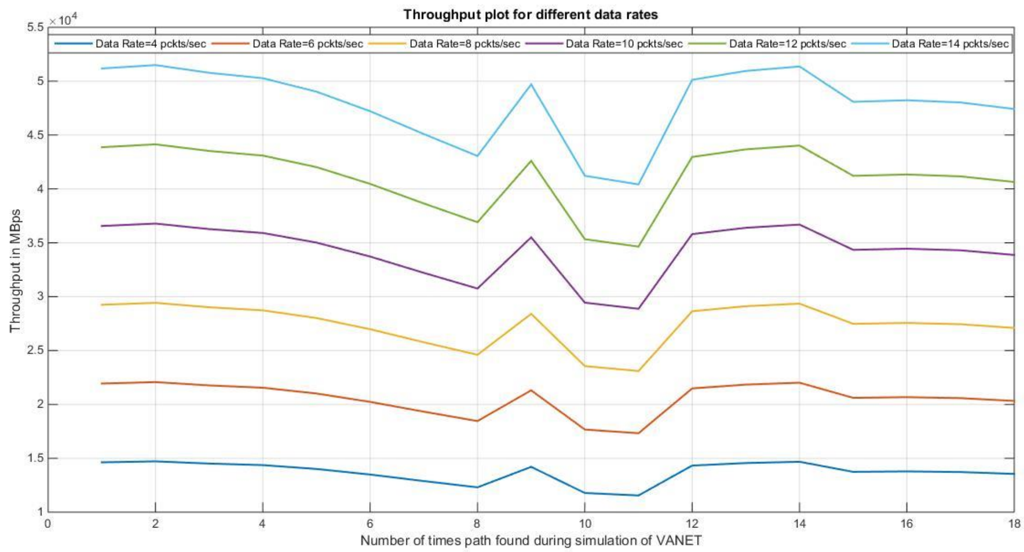


Fig 14: Throughput on 120 Nodes

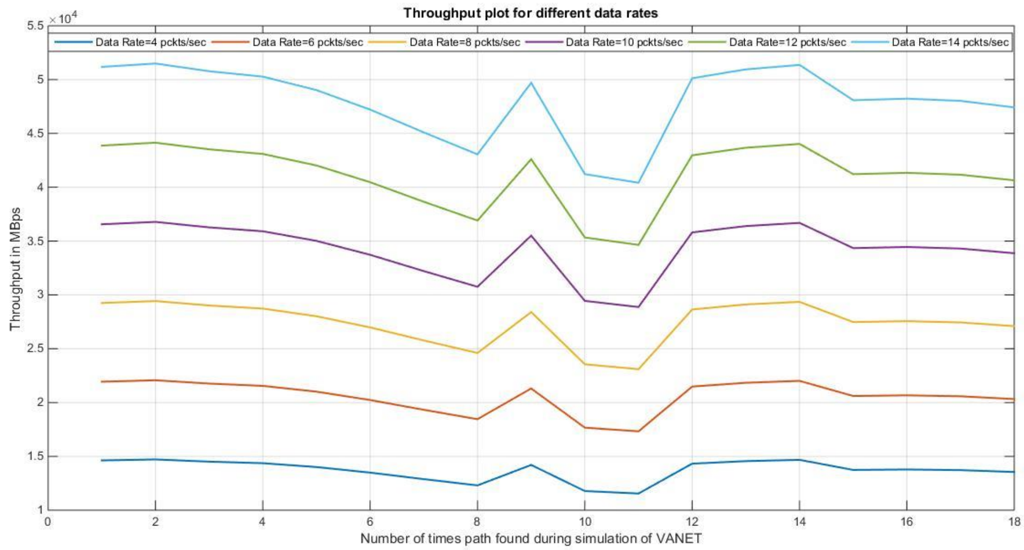


Fig 15: Throughput on 140 Nodes

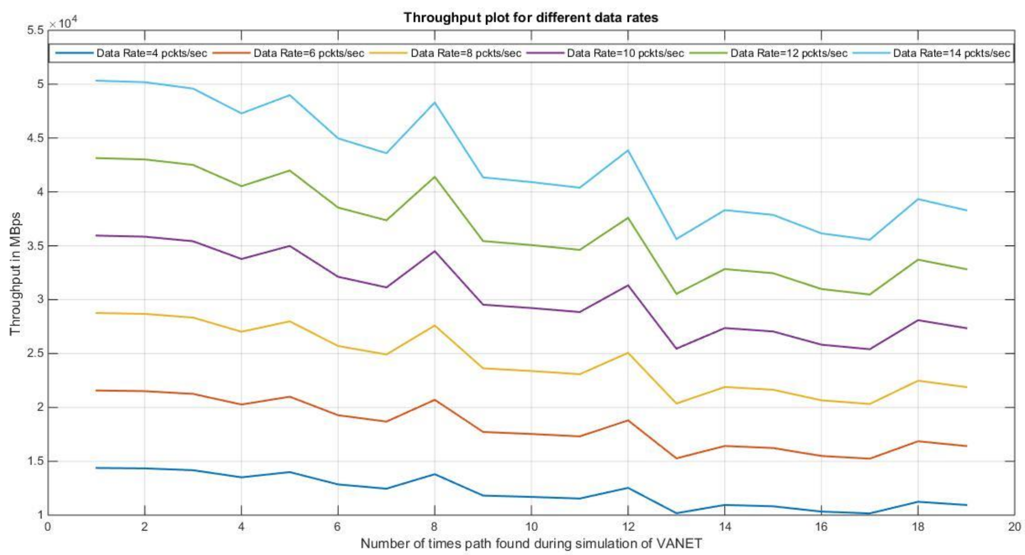


Fig 16: Throughput on 160 Nodes

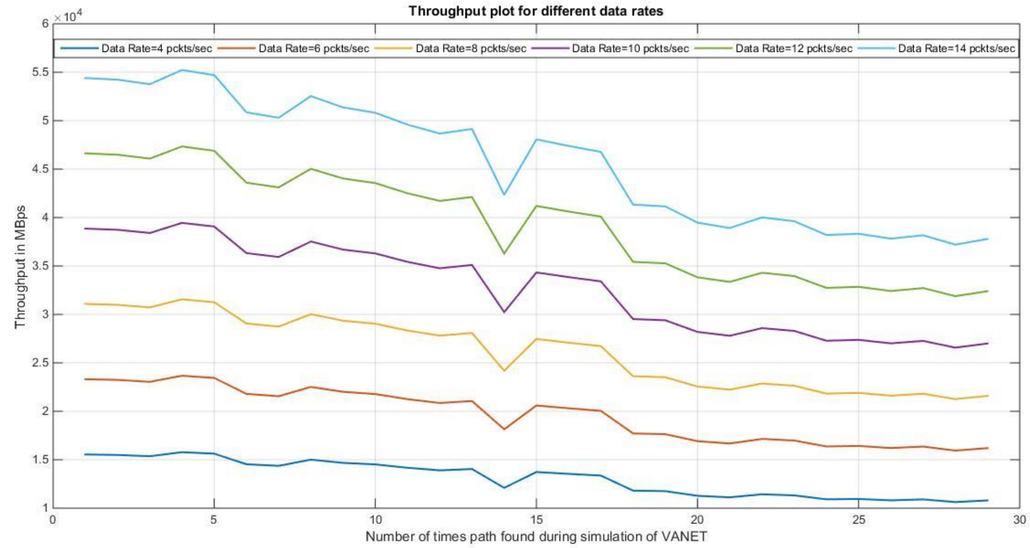


Fig 17: Throughput on 180 Nodes

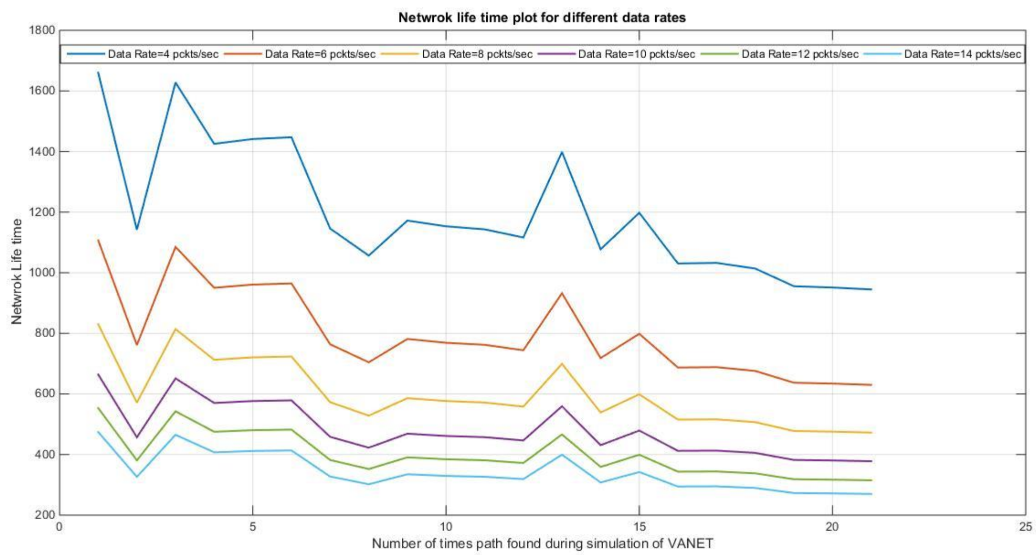


Fig 18: Network Lifetime of 100 Nodes

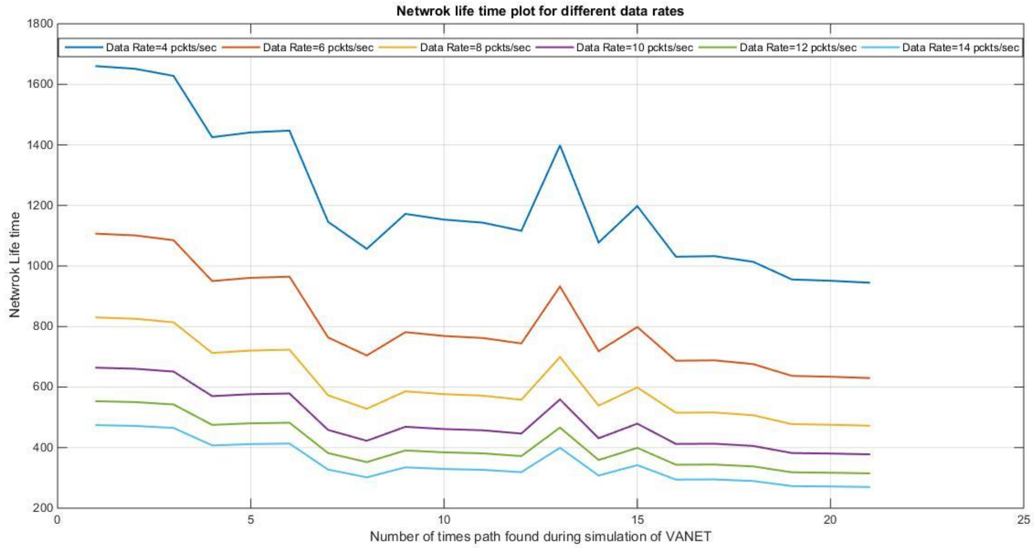


Fig 19: Network Lifetime of 120 Nodes

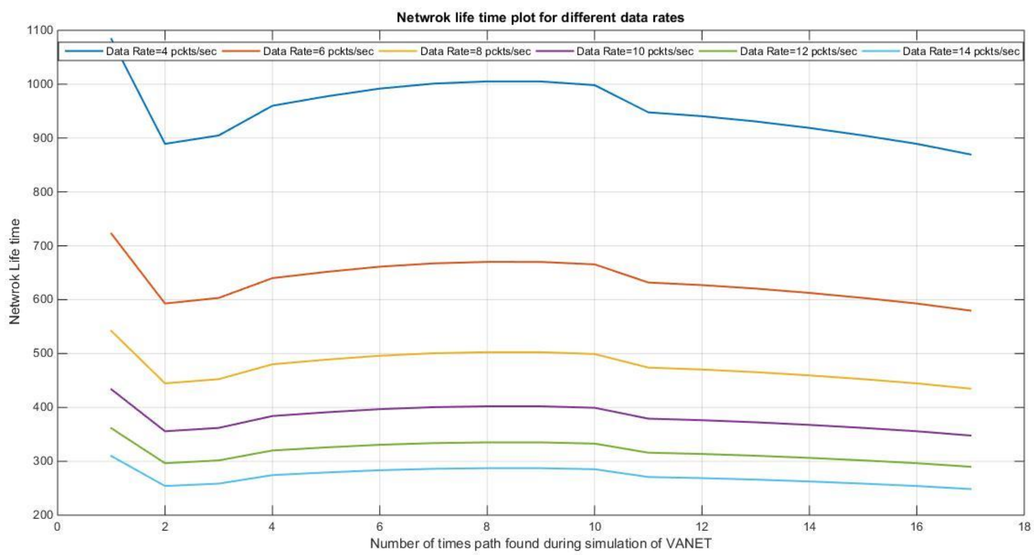


Fig 20: Network Lifetime of 140 Nodes

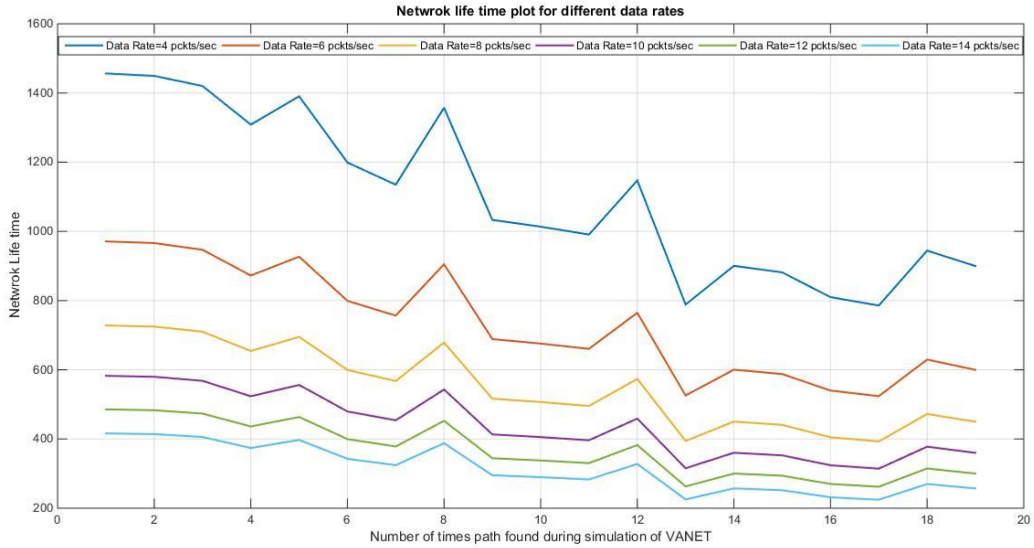


Fig 21: Network Lifetime of 160 Nodes

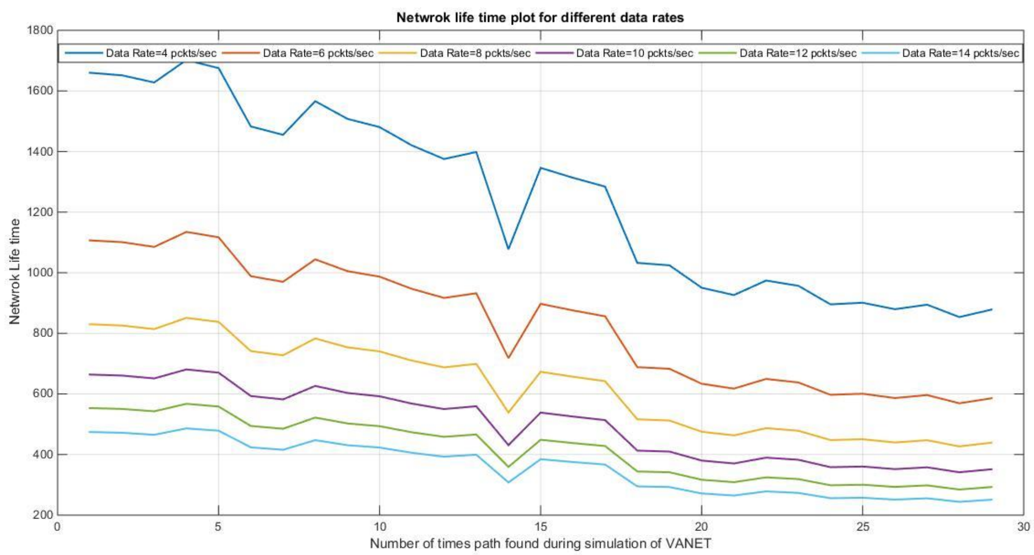


Fig 22: Network Lifetime of 180 Nodes

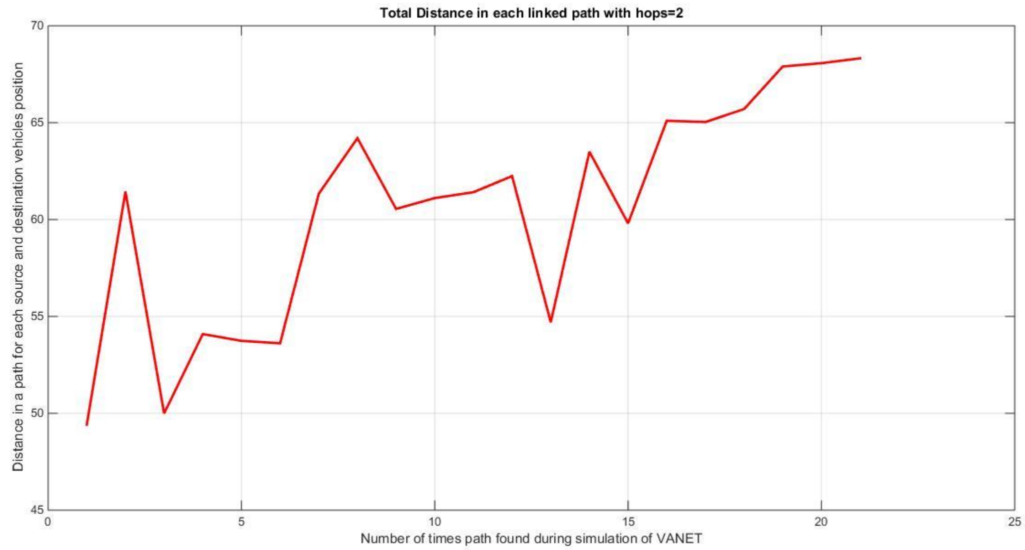


Fig 23: Total Distance covered on 100 Nodes

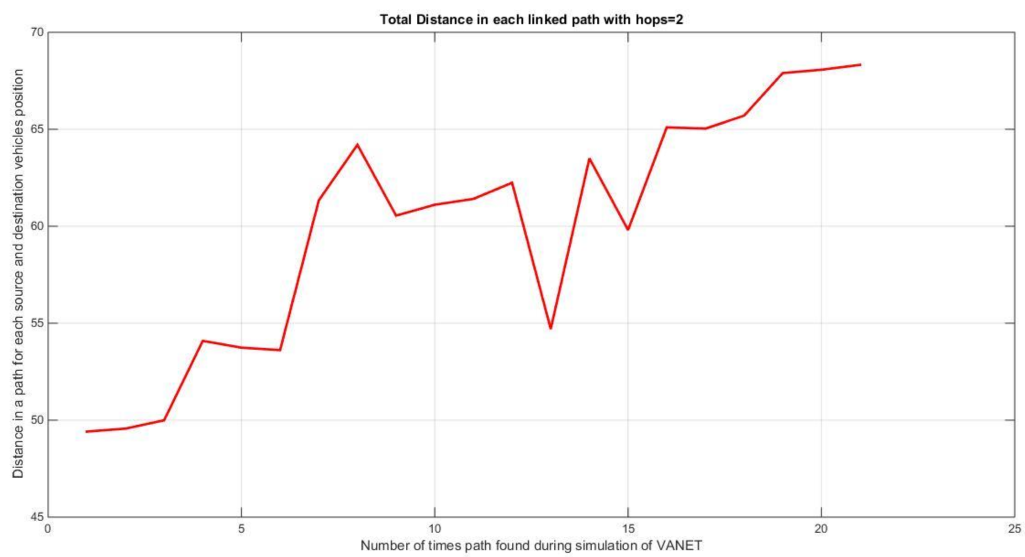


Fig 24: Total Distance covered on 120 Nodes

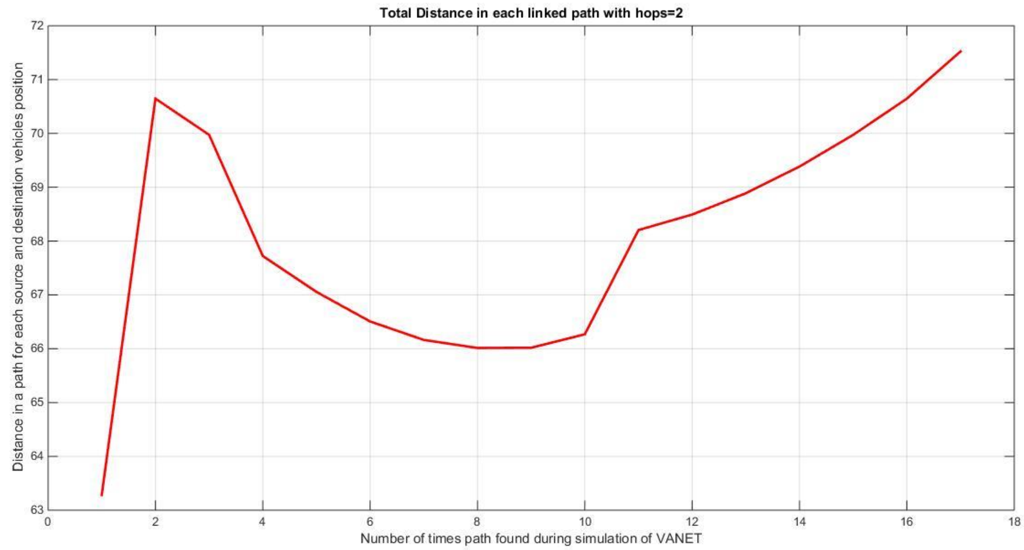


Fig 25: Total Distance covered on 140 Nodes

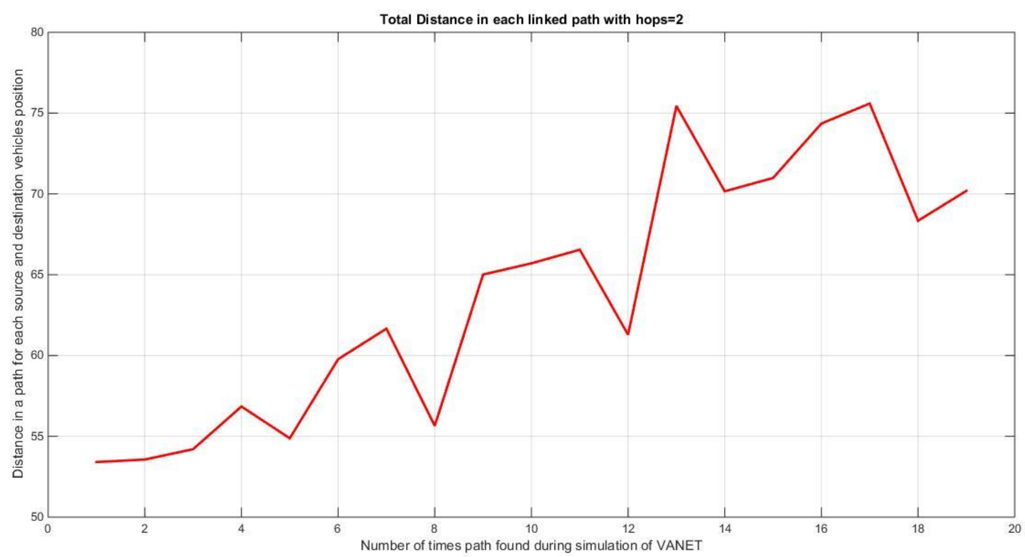


Fig 26: Total Distance covered on 160 Nodes

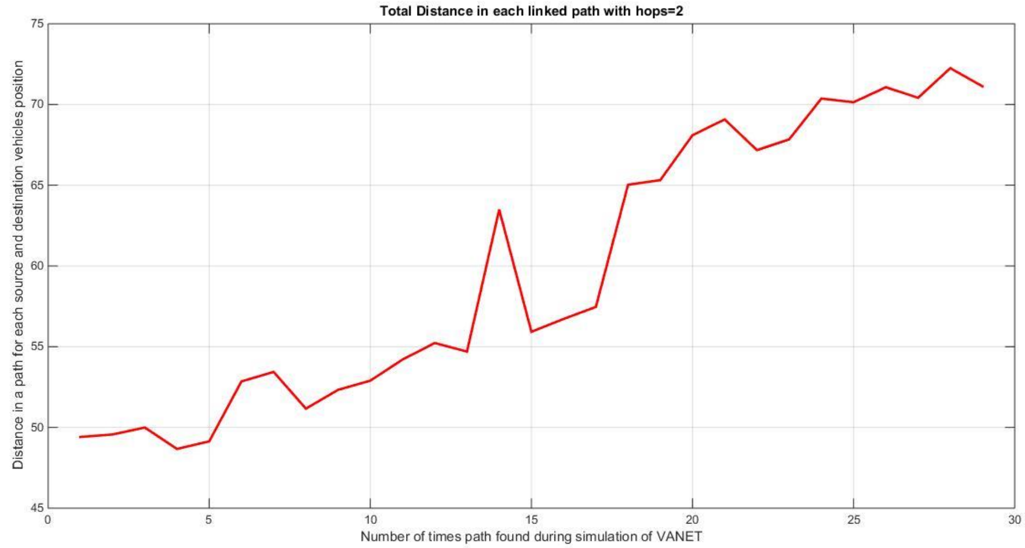


Fig 27: Total Distance covered on 180 Nodes

From the the above results it is clearly shown that the results are changing with increasing the number of nodes in the network, however the stability of the network is not effected affected by the increasing factor of nodes.

CHAPTER 5: CONCLUSION AND FUTURE WORK

5.1 Conclusion

The work that is presented in this research presents an Efficient AODV routing protocol for VANETs which provides the best results over the general AODV when applied to the network, also network will be safe from flooding of the packets in the entire network.From this research, improved results of latency, throughput, network lifetime and total distance is obtained by restricting the communication in minimun hop counts. The results are clearly presented that the enhanced version of AODV is much competent as compare to the basic AODV routing protocol.

5.2 Future Recommendations

The work in this research can help the forthcoming researchers in this field and by taking an innovative approach they can come with better method to get improved results from changing the protocol. For further development of this protocol the factors on which work can be done to obtain more optimized results includes cluster approach and by minimizing the cluster size, by adding the mobility constraints which includes relative speed, movement etc.

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