SELECTION OF SUITABLE ROUTING PROTOCOLS FOR COMING GENERATION AD-HOC NETWORK IN TRAFFIC MANAGEMENT

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CERTIFICATE

I hereby certify that the work which is being presented in the thesis entitled, *"Selection of suitable Routing Protocols for coming Generation Ad-Hoc Network in Traffic Management"*, in partial fulfillment of the requirements for the award of degree of Master of Technology in *Computer Science & Application* submitted in Computer Science and Engineering Department of Thapar Institute of Engineering and Technology, Patiala, is an authentic record of my own work carried out under the supervision of *Dr. Vinod Kumar Bhalla* and refers other researcher's work which are duly listed in the reference section.

The matter presented in the thesis has not been submitted for award of any other degree of this or any other University.

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Abhijityaditya Prakash

This is to certify that the above statement made by the candidate is correct and true to the best of my knowledge.

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(Abhijityaditya Prakash)

ABSTRACT

Due to the drastic increase in the number of vehicles over the years, the requirement of traffic management has also increased at the same rate. Even though there is a huge development in VANET and MANET but still there is need of proper traffic management. VANET could give us a large number of benefits and it has been envisioned as the future technology by automotive industries.

There is a requirement of a proper traffic management amongst the vehicles so that they should be able to properly communicate. Vehicles must also provide the information to the roadside units in a timely manner. Communication between the vehicles is processed through routing protocols. There are various types of routing protocols in MANET system and to determine the effective routing protocol is a difficult task. In the current working scenarios routing protocol uses IEEE802.11p standard for transmission of data between the vehicles.C-V2X is the emerging technology and it is more efficient as compared to IEEE802.11p. But as the C-V2X technology is increasing at such pace, soon IEEE 802.11p will be set aside. The main benefit of C-V2X is that the transmission range of vehicles will be just double as of IEEE 802.11p. C-V2X is developed by Qualcomm.C-V2X also uses 5G technology.

There are already many existing routing protocols for the traffic management, careful selection of suitable protocol may yield the best results. So, to narrow down the choices some of the topological based routing protocols are analyzed further i.e. AODV, AOMDV and MDART. All these protocols are studied on the basis of Average End to End Delay, Average Throughput and Packet delivery ratio. Network simulator version 2.34 (NS2) is used to simulate these routing protocols. In this research work, it is concluded that C-V2X, in comparison to IEEE 802.11p standard performs better. The average throughput and packet delivery ratio of AOMDV gives the best output in different traffic scenarios. But in the case of an Average end to end delay, MDART performs better. It is suggested in the findings of thesis work that AOMDV needs design improvements to give better values for Average End to End Delay which is also necessary for the overall performance of traffic management.

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ABBREVIATIONS

AE2ED	Average End To End Delay
AODV	Ad-hoc On-Demand Distance Vector Routing
AOMDV	Ad-Hoc On-Demand Multipath Distance Vector Routing
C-V2X	Cellular-Vehicle to Everything
DART	Dynamic Address Routing Protocol
DSDV	Destination Sequenced Distance Vector
IEEE	Institute of Electrical and Electronics Engineers
ITS	Intelligent Transportation System
MAC	Medium Access Control
MANET	Mobile Ad-Hoc Network
MDART	Multi-Path Dynamic Address Routing
NAM	Network Animator
NS2	Network Simulator 2.35
PDR	Packet Delivery Ratio
RREPs	Route Replies
RREQs	Route Request
RRERs	Route Errors
TCL	Transactional Control Language
V2I	Vehicle to Infrastructure
V2V	Vehicle to Vehicle
V2V2I	Vehicle-to-Vehicle-to-Infrastructure
VANET	Vehicular Ad-Hoc Network

CHAPTER 1

INTRODUCTION

Wireless communication is used to convey the information over the network in Mobile Ad-Hoc Networks (MANET) system. Wireless communication works on IEEE 802.11p standards and it runs on data link layer and physical layer of OSI Model. The nodes or vehicles in MANET act as both routers and host. These nodes forward packet to all the other nodes in the network and it also helps in running user applications. MANET is a key component of Intelligent Transportation System (ITS).ITS has many applications some of which include data sharing, congestion control, traffic management and accidental control. Vehicular Ad-hoc Networks (VANET) is a subclass of MANETs that provides wireless communication services among vehicles and vehicles to roadside infrastructures. The nodes in VANET act both as vehicles and roadside infrastructure. VANET provides efficient Vehicle to Vehicle (V2V) and Vehicle to Infrastructure(V2I) communications. MANETs are categorized into multi-hop routing protocols to transmit structured communications between the vehicles or to different nodes. There are various routing protocols in VANET for data dissemination. Majorly there are two categories of routing protocols that are further divided into subtypes. The two types of routing protocols are Table Driven and On-Demand routing. On-Demand routing protocols are subdivided into various routing protocols namely Ad-Hoc On-Demand Vector Routing (AODV), Dynamic Source Routing (DSR), Temporarily Ordering Routing protocol(TORA),Ad-Hoc On-Demand Multipath Distance Vector routing (AOMDV) and many more. Examples of Table Driven protocol are Destination Sequenced Distance Vector (DSDV) and Optimized Link State Routing (OLSR).

1.1 VANET and MANET

MANET is also called as a wireless ad-hoc network is a connected connection of a wireless device that is used for analyzing traffic flow in the networks. Ad-hoc networks are a multi-hop infrastructure that uses remote networks for communication. Ad- hoc network [3]is easy to setup as it does not require any additional access point. It can be in any trivial or momentary system. In this, each node forwards the packet to another node without any central guidance because here each node behaves like a router to send data and a receiver to get data. The nodes in the ad-hoc network rapidly make a connection whenever the communication is built. Every node in a connection uses radio waves basically it uses IEEE802.11 protocol.

VANET is a subdivision of MANET. It comprises of V2V, V2I and hybrid infrastructure. Vehicle to Vehicle communication is also known as Intelligent Transportation System (ITS).ITS is an important application of VANET. ITS[5] comprises of real-time route discovery, blind crossing, prevention from the collision, control traffic flow, monitoring the traffic flow and many more. VANET also provide internet connectivity to moving the vehicle so that they can send mail, download music, or games for the back seat passenger. IEEE 802.11p and IEEE 1609 WAVE are the basic building block for VANET system.

Vehicle to Vehicle (V2V) transmission provides information exchange platforms for the drivers on the way to distribute the data and cautioning messages about the vehicles in the direction of nearby vehicles. The messages would include car speed, the direction of travel, location, braking and other details.

Vehicle to Infrastructure (V2I) is a useful research field in VANETs. It provides real-time weather update and real-time environmental information to a driver. V2I gives information through a roadside unit that is present besides the road. The roadside unit will have separate server and server will maintain all the details of the vehicles that are passing by. V2I is also termed as “internet of cars” similar to an internet of things or in the broader term we can say “connected car”.

Hybrid Infrastructure is a combination of V2V & V2I communication. In [6] Jeffery Miller introduces a technique same as hybrid infrastructure named as Vehicle-to-Vehicle-to-Infrastructure (V2V2I). In this, he designs a method in which both the communication technique can be used and benefited from it.

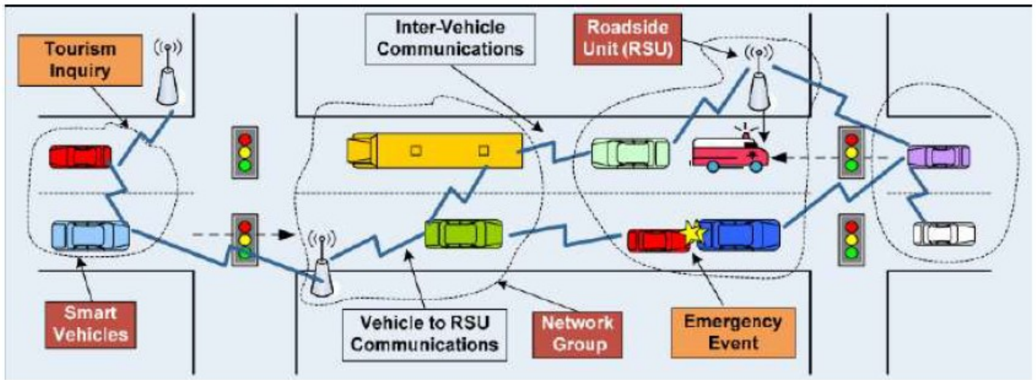


Fig-1.1 Basic Structure of VANET[35]

1.2 Wireless Access Technology in VANET

There are various technologies that are available for VANET implementation. Traffic Management is a must for VANET system. These technologies help in communication between vehicles and other Road Side units. VANET uses a short-range wireless communication system built on IEEE802.11p standard and Wi-Max IEEE 802.16 for management of data.

1.2.1 IEEE 802.11p is a modified and more improvised version of 802.11 standards. In this, they have added Wireless Access in Vehicular Environment (WAVE) so as to make it more flexible and compatible for VANET. The transfer of data between the different vehicle and RSUs is done in licensed ITS band of 5.9 GHz (5.85-5.925GHz).

1.2.2 IEEE802.16 is a merging of various types of wireless standards invented by Institute of Electrical and Electronics Engineers (IEEE). An IEEE 802.16 standard is officially named as WirelessMAN.

1.3 Routing Protocols

VANET provide lots of services to the user like accident alarm, traffic management, auxiliary driving, and communications between other vehicles, internet and so on. So for the proper communications between the vehicles, we need routing protocols. Routing is a key element in a VANET. There are different and vast kind of routing protocols[7] that are routing protocol based on topology, based on the cluster, based on geographical location, based on position and broadcast based. Fig 1.2 defines various routing protocols.

1.3.1 Topology-based routing protocol uses Ad-Hoc Network routing technique and existing link information to forward the data. Topological based routing protocol is additionally isolated into two section i.e. Proactive Routing and Reactive based routing.

1.3.1.1 Proactive routing proto color Table Driven routing protocol, it generally uses shortest path algorithm to frontward the information to source and the destination node. In this next dispatching information is kept in background irrespective of the transmission request. In proactive, there is no route discovery because it only communicates with the neighbors and forwards the packet. Its main disadvantage is that if the link is failed you won't get the information. Some of the examples of Proactive based routing protocol are Topological Broadcast-based on Reverse Path Forwarding (TBRPF), Optimized Link State Routing (OLSR) and Destination Sequenced Distance Vector (DSDV).

1.3.1.2 Reactive based routing protocol is otherwise called as the proper ad-hoc based routing protocol, it transmits packets when the information is asked for. It keeps up the routes that are as of now being used, so there are fewer burdens on the network. Examples of Reactive routing protocols are Dynamic Supply Routing (DSR),Ad-hoc On-Demand Distance Vector Routing (AODV) and Temporary Ordered Routing Protocol (TORA).

1.3.2 Position based routing protocol, in this routing protocol, it utilizes geographic situating data to choose the next following node. There is no global or central way from the source vehicle to destination vehicle. In position-based neighboring node assumes a critical part in forwarding the messages. As neighboring nodes become the beacon to the next available node in a particular time period. It has mainly three services i.e. beaconing, location service and forwarding. Position based routing protocol requires global positioning system (GPS). This protocol helps when the vehicles are moving on a highway quickly and the road has very less obstruction. Examples of position based are Greedy perimeter routing (GPRS) and Distance Routing Effect Algorithm for Mobility (DREAM).

1.3.3 Cluster Based Routing Protocol, in this different vehicle with same attributes, come together and form a group and a cluster head for that group. The characteristics are on the basis of velocity, direction, battery and so on. It has an adaptability of expansive systems. This technique is generally helpful in desert type areas. The example for cluster-based protocols is Clustering for Open Inter-vehicular communication Network (COIN).

1.3.4 Geo Cast routing protocol focuses on dispatching the packets to a group of nodes in particular geographical location. This uses Zone of Relevance (ZOR) for sending the information from source node to destination node. Here the message is generally sent through flooding technique to all the nodes to overcome the problem of network congestion and message overhead. It is a reliable technique in highly dynamic topology. Its disadvantage is that there is a packet transmission delay due to network disconnection.

1.3.5 Broadcast based routing protocol, in this routing protocol packet is broadcasted to all over the network in its broadcast domain. This technique is generally used for sharing the info with all the vehicles in the network. The info can be related to emergency services, weather, road conditions, traffic news, advertisement and announcement.

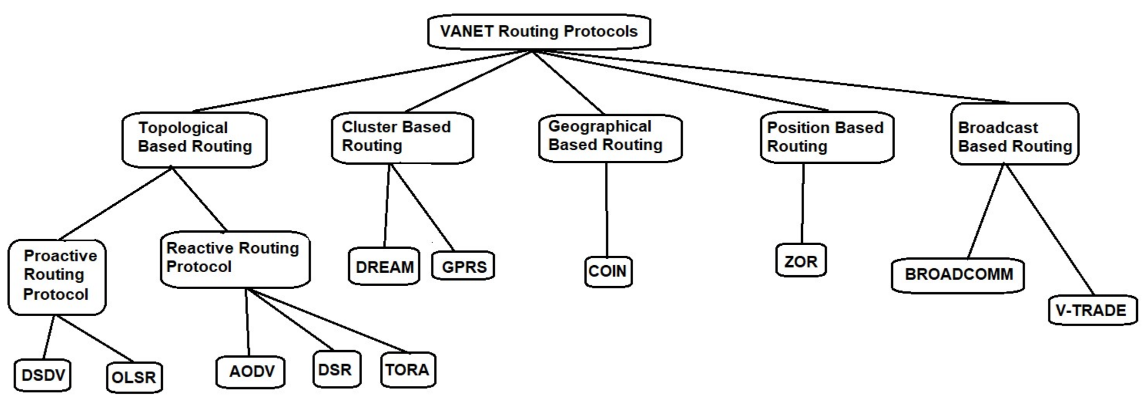


Fig 1.2 Various VANET Routing Protocol

1.4 Challenges in VANET

Despite the fact that VANET is a type of MANET, its conduct and qualities are essentially unique. A vast portion of the VANET inquire so many difficulties that must be routed to accomplish successful vehicular communication, some of them are discussed below.

1.4.1 Examination Of Wireless Communication Technologies: Some remote access advancements and models have been introduced, prescribed and examined for use in VANET by numerous analysts.

- *Cellular technology:* - Cellular technology referred to as 2G, 2.5G, 3G and 4G. In the coming years 5G is also arriving. In some of the countries, 5G is implemented. The 2G and 2.5G elevation give dependable security and vast transmission range. In the present scenario, 3G and 4G technologies are captivating over high-speed transmission and greater bandwidth. In various part of the world different countries have signed various ventures that are now utilizing this cellular network like USA, Europe and Japan. Due to elevated latency rate and narrow bandwidth, it is achievable that in the coming future VANET will get more benefits from Cellular Technology.
- *IEEE 802.11p standards:* IEEE802.11 is supposed to support the wireless connection in VANET system. There are two variations in IEEE802.11 i.e. ASTM and IEEE802.11p. This air interface convention is an effort going on by IEEE operational assembly that would give between Inter-Vehicle Communication (IVC) and vehicle-to-roadside communication. Vehicle running pace from 200 to 300km/h ranging distance of 1000m. IEEE802.11p standard, it's range may vary depending on the speed of a vehicle. Because of significant generation volumes, the evaluated estimated outlay of IEEE 802.11p is anticipated to be moderately small. Thus, this early innovation likewise called WAVE have fairly suitable for VANETs.

1.4.2 Broadcasting of Messages: The VANET require communication, assembling and handling of huge chunks of data packets. One of the attractive elective arrangements for vehicle systems administration system is message broadcasting. Therefore, the various broadcasting technique has been used by many researchers. These methods incorporate confined and unlimited transmission capacity advanced administration arrangements and additionally satellite telecom arrangement which has effectively effected on information administrations.

1.4.3 VANETs Routing Protocols: Many researchers have discussed the appropriateness of MANET steering conventions in VANETs and additionally a few other research studies. Due to oppositely, the regular system dividing (discontinuous system availability) because of greatly powerful topology and elevated versatility in VANET make MANET conventions unsatisfactory for vehicular correspondences. Additionally, the suppositions in MANET directing that conclusion to-end arrange network can be built up constantly, and that transitional hubs amongst source and goal can simply be found can't hold in VANET. Thus, the previously mentioned presumptions don't grasp in VANET, the convey and forward loom was proposed in for VANETs whereby a moving vehicle persistently convey an information bundle until the point when it is sent to another vehicle nearer to the goal without any immediate course.

1.4.4 Power Adjustment and Control: Power management is not an issue in VANET, but it is in the case LTE network and incoming 5G technology. Anyway, power management in term of communication is a testing problem that has to be settled. Through proper routing and management, this problem can be resolved.

1.4.5 Security, Privacy, Anonymity and Liability: Major Problems in VANET system is security, so before designing any VANET architecture we have to think about the security of the system. Several threats are available in VANET like fake messages, traffic disrupting and privacy invasion. The proper structure has to be designed for VANET, as security is an important aspect of VANET architecture. The major challenge is how to develop a proper security solution for VANET architecture. For security reasons, SeVeCOM [9] has provided an architecture for this.

1.4.6 Accident Severity: Accumulation of data accessible when an accident happens, which is caught by sensors introduced locally, available to the nearby vehicles and in the seriousness of the accident. The information gathered is organized in a bundle and sent to a remote-Control Unit with the help of Vehicle to vehicle and Vehicle to infrastructure remote correspondence.

CHAPTER 2

BACKGROUND

2.1Ad-Hoc Routing Protocols

Ad-Hoc Routing protocol is a method in VANET system to transfer the information or messages to other vehicles or to the roadside unit. In Ad-hoc networks, nodes decide where to send the information in the computing device in a mobile ad-hoc network. In this connection is established when there is need to send the data, otherwise they don't communicate. Means that if some node is asking for information that only the node will pass the information. Each node gets the information of its neighbor node and keeps the information to itself, and when someone asks for details than it forwards it to that direction. Topological based routing is a type of Ad-Hoc Routing protocol. Hierarchical type of routing also comes under Ad-Hoc Routing. AODV, AMODV and MDART all are the various categories of Ad-hoc Routing Protocol.

2.2 AODV

This is the very first effective type of routing protocol Ad-hoc On-demand Distance Vector (AODV) routing protocol. This routing protocol communicates the information when they are asked to. AODV routing protocol establishes paths to a destination on the requirement and supports both unicast and multicast. AODV builds routes only when they are asked by the source nodes. There are two packets in AODV that are Request packet and Reply Packet. Request packets broadcast the message to all the other nodes for the information, and when the particular nodes are found then that nodes send the reply packet through unicast to the node that has asked for information. A node that gets the all the messages keeps the route to an entry of the next desired node so that it can send the temporary message to the requesting node. The node that asked for information will forward the request which contains the least number of hops. The entries that are not available in the routing table are recycled after some time. The node will send the error message to the sender's node in the case when the message is not delivered to a destination node.

AODV is a mixture of DSR and DSDV protocol, so it is the better option for routing protocol considering other protocols.

AODV routing protocol is a source initiated routing [4] protocol or On Demand routing protocol. AODV works on route table entry. Destination sequence number is utilized by AODV for route entry. The destination node creates the destination sequence number which is included in any requesting path. Destination sequence number is easy to program and it also ensured the loop freedom. When the destination sequence number has two choices it selects that path or route which has the largest sequence number.

In AODV routing route request packet is broadcasted to all the adjacent nodes and then adjacent nodes further forward the packet till the destination is not received, once destination received the packet and destination sequence number it generates the route reply packet to send data to the source node which is a unicast packet with the destination sequence number. And then source node decides which route to keep after comparing all the destination sequence number.

In AODV there are different message types, namely *Route Requests (RREQs), Route Replies (RREPs), and Route Errors (RERRs)*

- *Route Requests(RREQs)*

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type      |J|R|G|D|U|   Reserved          |   Hop Count   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                            RREQ ID                            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Destination IP Address                     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                  Destination Sequence Number                  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Originator IP Address                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                  Originator Sequence Number                   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Fig 2.1 Route Request (RREQs)

- *Route Replies (RREPs)*

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type      |R|A|    Reserved     |Prefix Sz|   Hop Count   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     Destination IP address                    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                  Destination Sequence Number                  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Originator IP address                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                           Lifetime                            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Fig 2.2 Route Replies (RREPs)

- *Route Errors (RERRs)*

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type      |N|          Reserved           |   DestCount   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|            Unreachable Destination IP Address (1)             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         Unreachable Destination Sequence Number (1)           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-|
|  Additional Unreachable Destination IP Addresses (if needed)  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Additional Unreachable Destination Sequence Numbers (if needed)|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Fig 2.3 Route Errors (RERRs)

In AODV Source broadcast the message with the help of flooding technique to all the nodes in the form of Route Request (RREQ) packet. Flooding is done when the source is needed for the route for the destination. When the destination accepts the data it transmits the information through Route Reply packet (RREP) and uses unicast method to send back the information.

Fig 2.4 and 2.5 shows how the message broadcasted and unicasted in Route Request packet (RREQ) and Route Reply (RREP) packet respectively.

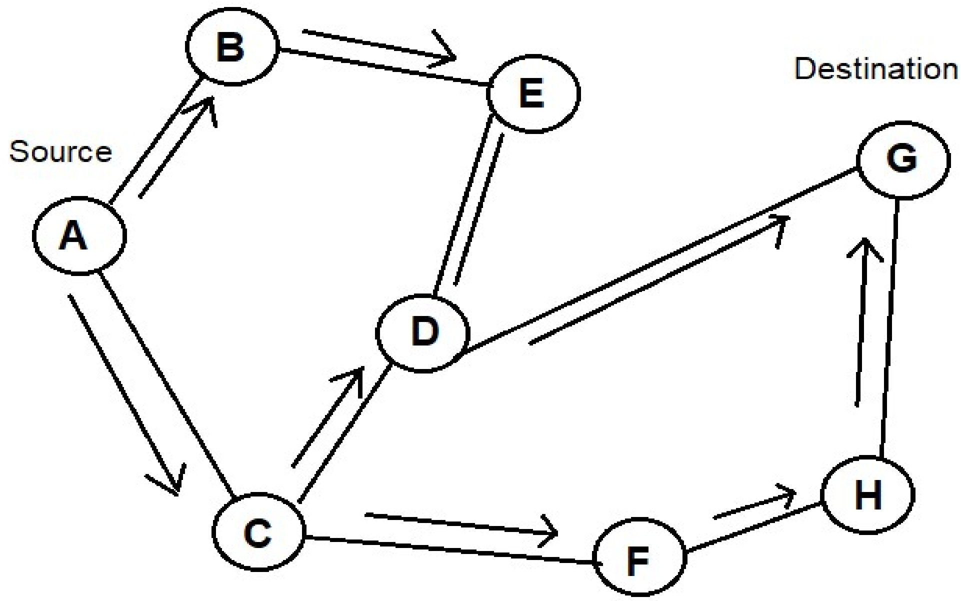


Fig 2.4RREQ Broadcast

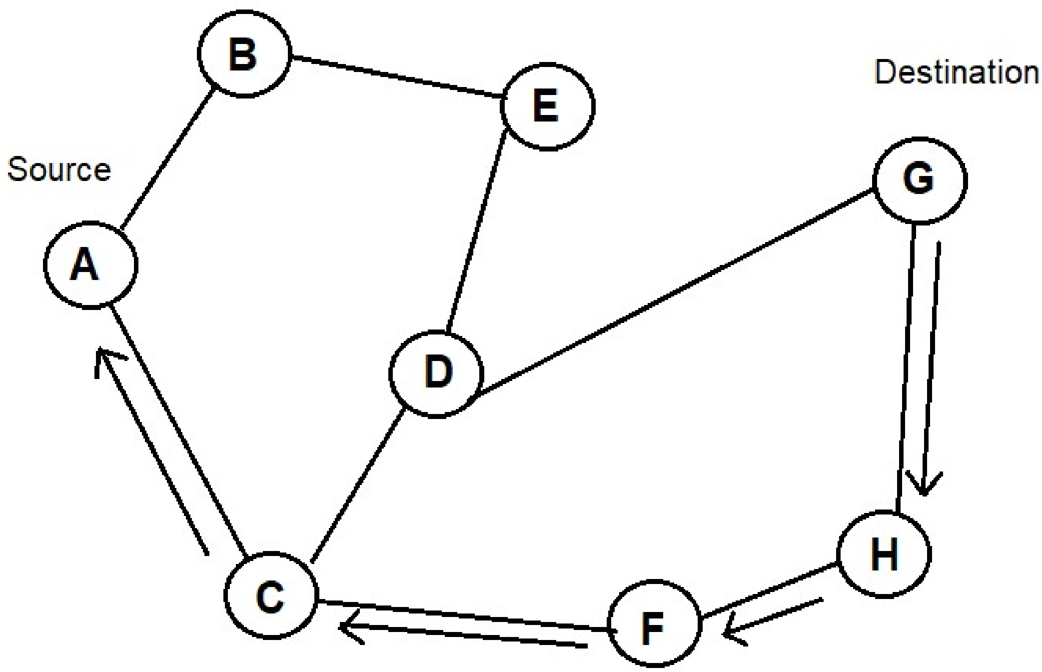


Fig 2.5RREP Forwarded Path

2.3 AOMDV

An Ad-Hoc On-Demand Multipath Vector routing protocol(AOMDV) which is utilized in MANET or in VANET. It is the extension of AODV protocol that is single path routing protocol. This gives the loop-free paths and dislodges alternate path for the transmission. AOMDV performs better than AODV; its packet delivery efficiency is extra and much better as weigh against to AODV [35].

AOMDV works when the source needs to direct the packets to some destination node, the route request packet is generated. Route request packet is broadcasted or flooded to all the nodes in the network and once the node is found then route reply packet is generated from destination node and it is uni-casted toward the source. This part of AOMDV work same as AODV. Here source destination gets all the possible combination to reach the destination node, in case of AODV, it keeps only the effective route other ones get discarded, but here in AOMDV it keeps the entire possible route.

destination	sequence number	hop count	next hop	timeout

Fig 2.6 AODV Route Table Entry

destination	sequence number	advertised hop count	route list			
			next hop1 next hop2 . . .	last hop1 last hop2 . . .	hop count1 hop count2 . . .	timeout1 timeout2 . . .

Fig 2.7AOMDV Route table entry

There is variation in their routing table entry of both protocols see Fig 2.6 and 2.7. Here in AOMDV, you can see that there are multiple route list details. But in AODV it discards the duplicate copy of route. But some of the duplicate copy is useful when there is link failure. But in case of AOMDV, it entertains all the duplicate copy of the node. It reserves all the alternate pathways. But it also keeps the check on is the path loop free.

[35]They have modified the AODV code and they rewrote the algorithm, and increased some set of rules. In case of AOMDV, when an intermediate node receives a reverse path from route request packet, it checks if there are more valid paths are available for a destination. If so then node generates the route reply packet then it sends the details to the source along with the reverse path. There are many scenarios when the intermediate node gets many route requests and it has to reply to a source with all the details.

2.4 MDART

In the latest years, the use of ad hoc network has been increased so much. Most of the research and technology is focused on the small networks and their performance is based on power and their efficiency. Due to which a new multi-hop wireless routing protocol is developed. Most of the protocol is based on different scenarios, like cluster-based protocol is preferable for desert type area, but ad-hoc protocol is used in the city. Most of the routing protocol does not perform equally or efficiently as they are supposed to do.

Recently in the coming years, some of the data is regrouped and sorted using Distributed Hash table (DHT). DHT is used for storing the node location in a network. This gives the idea of physical address based on the connectivity of nodes. DHT routing algorithm is implemented using the topological routing with the address of the node and it keeps the data in its table.

Dynamic Address Routing Protocol (DART) is the example of proactive routing protocol, which is based on a dynamic address of the nodes. A network address is assigned on the basis of node positioning inside the network topology. Using this approach dynamic routing is feasible to implement in a hierarchical way. In this, the node maintains the routing information of the network.

Multipath Dynamic address routing M-DART is basically depended on the DHT based routing protocol and Dynamic Address Routing (DART) protocol. M-DART uses multi path data forwarding strategy on the routing table. It uses hop by hop approach for routing. The core dissimilarity among DART and M-DART is that in M-DART stores each route for siblings, but DART stores only limited routes for siblings. In M-DART as the routing information increases the node does not contain overhead delay by relying on routing information that is provided by DART. There is no need of special routing entry in M-DART, routing update packet is same as DART, refer to fig 2.7.

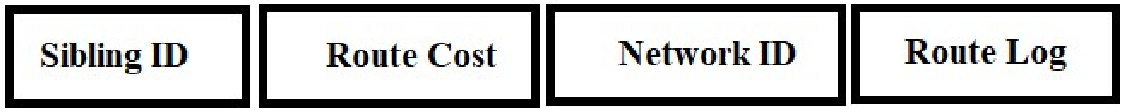


Fig 2.8M-DART and DART routing update Entry

In M-DART packet is forwarded from source to destination with a suitable and most efficient path, but if some node is changed or link is broken than in that case it forwards the packet through a more efficient path that it has discovered. The route in the M-DART is featured by the hierarchical method; it compares the siblings then it keeps the node and route details in an entry.

In [33] they have compared the M-DART to AODV and DSR i.e. reactive protocol and also with DART and DSDV i.e. proactive protocol. They ran the experiment on routing tables, delivery ratio, hop count delivery count, an end to end delay and routing overhead. They did all the comparison using the NS2 simulator.

2.5 C-V2X

Cellular-Vehicle to Everything or C-V2X basically it means every other vehicle connected to every other cellular thing. C-V2X basically offers an alternative solution for IEEE802.11p.C-V2X is an evolving technology that uses a wide range of vehicle connectivity. The vehicle connectivity and safety is a huge market. Safety is the major concern of traffic management. After the development of V2V and V2I technology in VANET system now C-V2X is an emerging technology, where the main concern is to enhance the safety, throughput, reliability, lower the latency and better communication. In this vehicle will also be connected to the pedestrian. C-V2X will play the major role or challenging role in safer autonomous driving.

C-V2X is a developing 3GPP process to enhance the cellular system from 4G to 5G technologies.C-V2X will not only facilitate V2I & V2V but also facilitate Vehicle to Network (V2N). In C-V2X message will broadcast through the server to all the vehicles and vehicles will reply the unicast message back to the server. As V2I and

V2N working area is increased this makes possible application to work faster, like in case of accident we will get to know alert message much faster.

C-V2X is developed by Qualcomm Snapdragon. Qualcomm announced C-V2X 9150 chipset as the first chipset solution for 3GPP R-14 for PC5 based direct communications. One of the major invention that will be highly beneficial for C-V2X is 5G Technology. 5G gives important vision for automation field. It will prove enhanced mobile broadband, mission critical services and another internet of things application.

C-V2X gives two of the complementary transmission modes i.e. PC5 interface and User Interface. Direct communication is based on LTE direct device to design device for the improvement in speed, latency and synchronization. LTE is also used to broadcast the messages from V2X- server to all the vehicles. And vehicles can also reply to the server with a unicast method. LTE is developing Device to Device (D2D) platform communication.

C-V2X possibly solve a major problem related to VANET. It increases and enhances the signal design, enhances transmission structure, more efficient resource allocation and it also helps in the utilization of GPS timing.

Most profitable in C-V2X is the increment in the reaction time and node transmission range, as compared to 802.11p/DSRC. C-V2X transmission range is just doubled as compared to 802.11p range. So because of this driver gets safer driving experience, support high-speed communication and increased environmental situation. C-V2X can properly support even though a car is moving at the speed of 500km/hr.

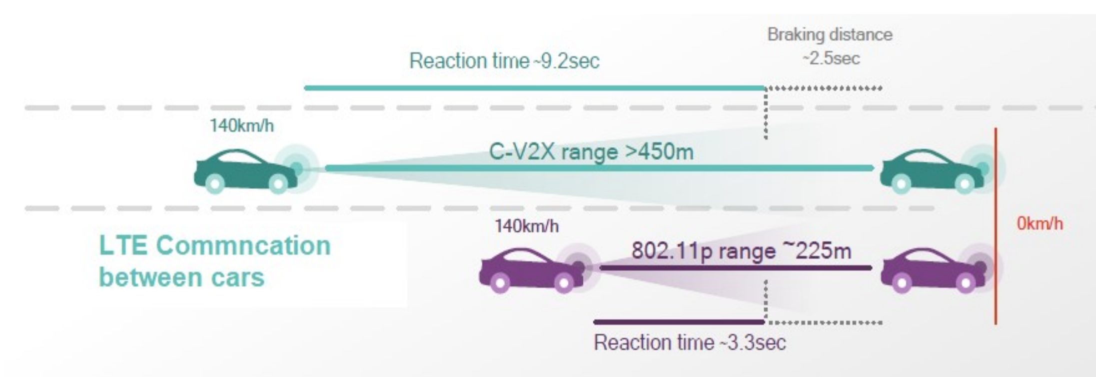


Fig 2.9C-V2X transmission to IEEE 802.11p transmission

2.6 NS2

SIMULATION SOFTWARE

Here we are using Network Simulator 2.35 (NS2) in a LINUX Operating System i.e. Ubuntu14. NS2 is freely available on the internet and anyone can download it.

Network Simulator 2.35

NS is a simulator that helps in networking research. It is used for simulation of all the MANET and VANET related query. It offers extensive hold for TCP connection, multicast protocols, unicast protocols and routing over a wired and wireless connection. And also NS2 has no any graphical user interface and the user has to learn all the language that is related to NS2 i.e. TCL Scripting, C++, Python and many more. Here the programmer has to learn the TCL script for the programming the scenario for and calculating the AWK and other files through trace files.

TCL is a simple open source interpreter type programming language. It provides variables, procedures and control structures as well as many useful features that are found in many languages.TCL works on almost all the advanced systems like Unix, Windows and Mactonish. TCL is comfortable to be used in any application language, script, animated language or different programming language. It is used for rapid prototype and scripting and testing.

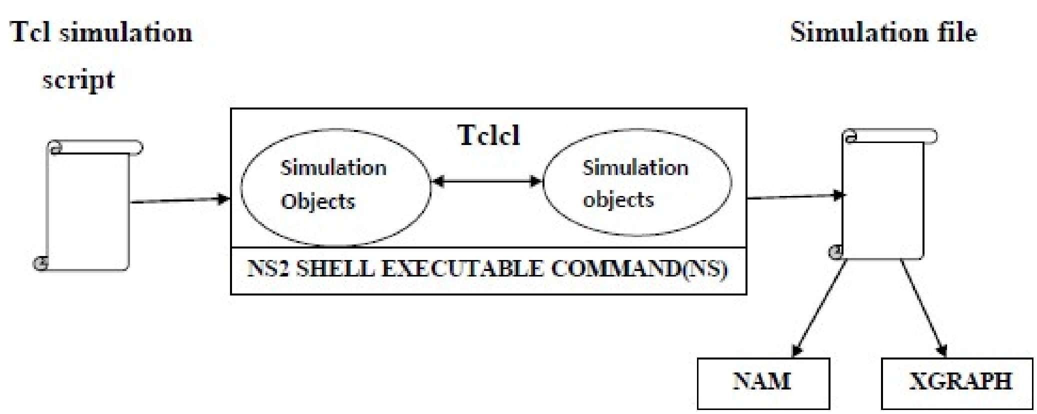


Fig 2.10 Architecture of NS2

This figure 2.10demonstrates the vital structure of NS2. NS2 gives clients apracticable order "ns" which acquires one information, the name of a TCLsimulation scripting document. Most of the time,a simulation is done, with that simulation a trace file is created and with the help of this trace file various graphs are plotted. NS2 have two main contentsi.e. C++ and Object-situated Tool Command Language (OTcl). Here C++ exemplify the inward mechanism i.e., a backend for the simulation and OTcl sets up re-enactment by collecting and rearranging the parts i.e. frontend. C++ and OTcl are associated mutually operating TclCL. In OTcl region, a handle goes about as a frontend which cooperates with clients and other OTcl objects. It also characterizes its own particular strategies and factors to improves the communication.

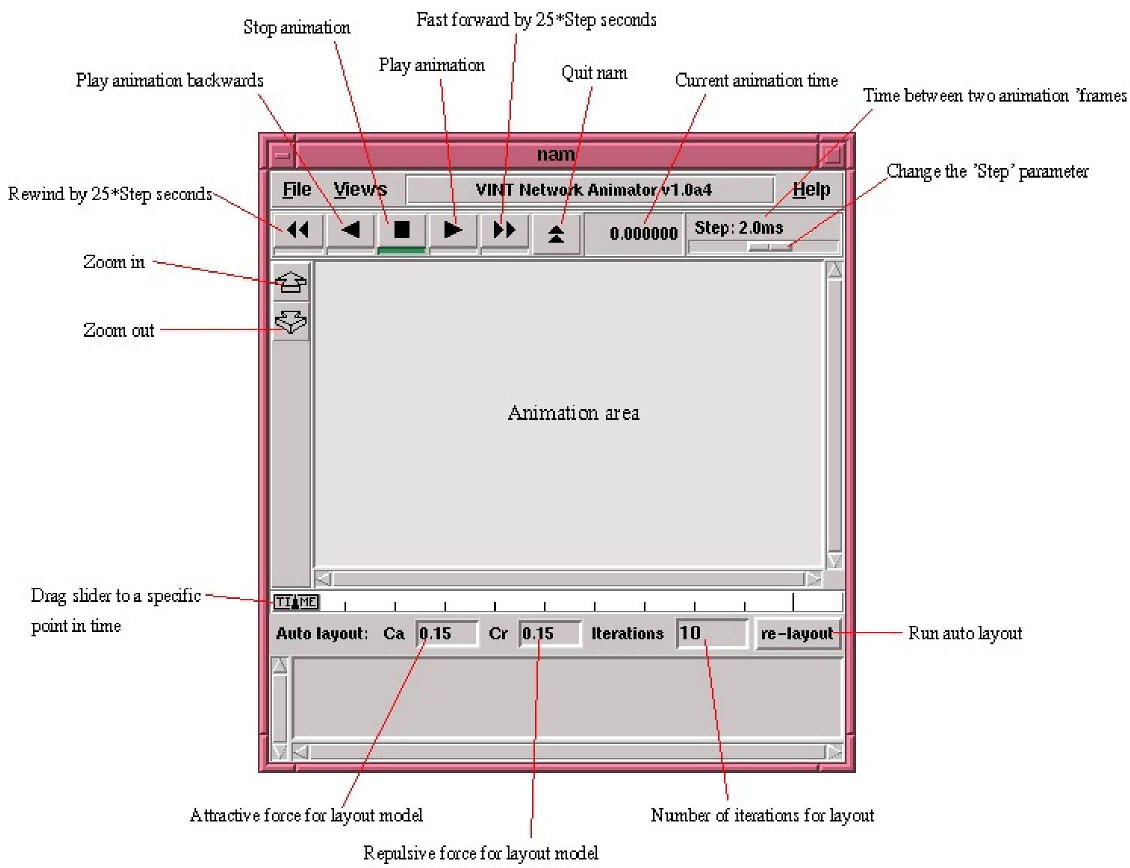


Fig 2.11NAM Window

Fig 2.11 shows the simple NAM file and its terminology. In this all the animation and flow of information can be viewed. Fig 2.12 shows the simple wireless Simulation between source and destination. The data flow is shown in this figure. Fig 2.13 shows another simple simulation of connected nodes or wired nodes.

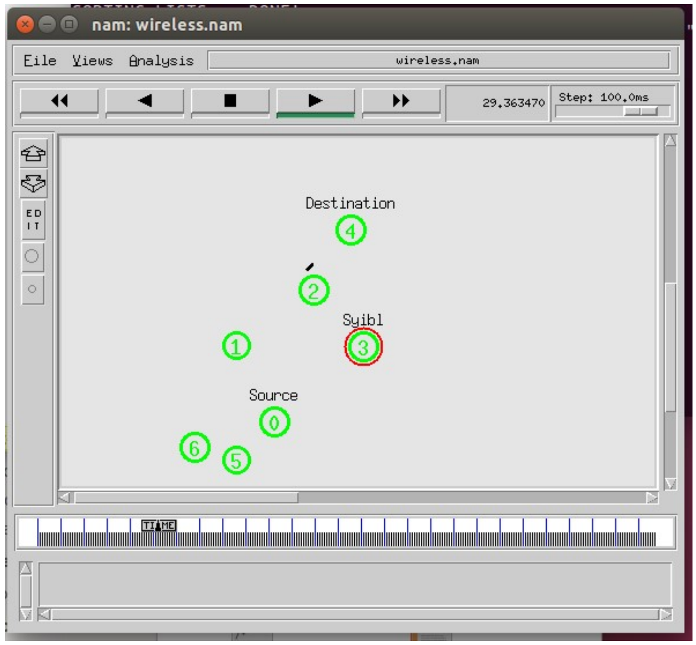


Fig 2.12A simple wireless Simulation between source and destination

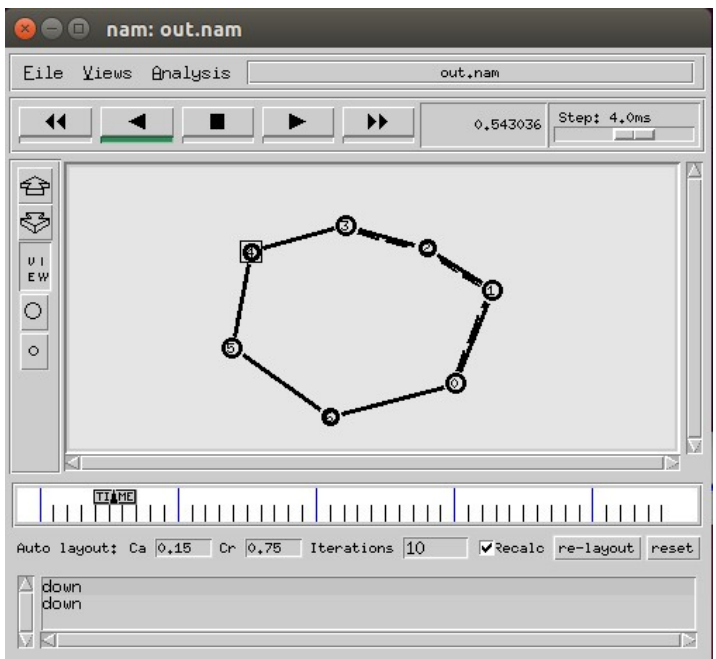


Fig 2.13 Nodes are connected in a circular form

CHAPTER 3

LITERATURE SURVEY

Rendong Bai and Mukesh Singhal et al.[1] defines new routing protocols named as Way point Routing(WPR), in this routing protocol the intermediate node is selected as a waypoint and then the further routes are divided into segments by the waypoint.WPR maintains hierarchy for dynamic routes. In this model source and destination both are considered to be a waypoint. Here desirable benefit is that if the path or route does not reach the destination it does not discard the whole path rather this protocol try to find another path from a discarded waypoint.

Devarajan Jinil Persis, T. Paul Robert et al. [2] in this AODV algorithm is redefined into Ant Colony optimization (ACO), Bee Colony Optimization (BCO) algorithms and Firefly Algorithm(FA) to determine the path in MANET. These all are the biologically inspired algorithm to improve on-demand routing, loop-free routing, stochastic data routing and faster convergence. There are different route request packet and route reply packet for each algorithm.

Jeffrey Miller et al. [6] proposed a new architecture for communication between the vehicles; he combined both V2V & V2I to Vehicle-to-Vehicle-to-Infrastructure (V2V2I). Here the networks are broken into zones,in which one vehicle is chosen as a super vehicle. In this super vehicle will collect all the information and transmit the data to the central server and also it will transmit the data to other super vehicles which are adjacent to it.

D. Helen and D. Arivazhagan et al.[3] have discussed about the advantages, challenges and various application of Ad-Hoc Networks. As Ad-Hoc does not require any central network to forward the information, if nodes get the information it simply forwards the information to an adjacent node. The advantage of Ad-Hoc network is its flexibility, robustness and mobility. Due to all these benefits Ad-Hoc network is an essential part of the future computing networks.

Rakesh Kumar et al.[7] describe comparative studies between various routing protocol in VANET. This paper describes the pros and cons of various routing protocols .The comparison is done on the basis of traffic flow, infrastructure requirement, forwarding method and different scenarios.

Elias C. Eze et al.[10]have discussed about the advancement in VANET and challenges in VANET. They discuss the collision information and traffic dissemination and implies that VANET is an interesting area to work on. There are so many investments are going on in the VANET system by government and private automobiles companies. Different government agencies are working with the car companies along, so as to increase the VANET system. Some companies are Toyota, BMW, Fiat, Nissan, Mercedes and many more.

Srdjan Krco et al.[11] they have proposed an idea for improving the neighbor selection in AODV routing protocol. On the basis of a signal to noise ratio (SNR), they have described the good and the bad neighbors whenever the AODV message is received. In this "hello" message is sent only by the good neighbors. Since just immediate neighbors are storedin the routing table, so all the links are of good quality and there are nice chances that all broadcast and unicast messages are delivered successfully.

Rendong Bai et al.[12] presents a new hierarchical routing technique named as Way Point Routing(WPR) in which intermediate nodes are selected as waypoint and messages are passed through those waypoints. One benefit of this waypoint is that, if the link is broken or discontinued, it does not discard the routes instead from which that particular waypoint it find the other route. This method has many advantages in term end to end delay and routing overhead.

Nadilma C.V. N. Pereira et al.[13] they did the analysis on AODV route discovery mechanism. They investigate the behavior of AODV protocol if one of the links is broken due to a mobility of vehicles. And on the basis of this they take out the throughput, message overhead, end to end delay.

Ahmad Abuashour et al.[14] discuss about the cluster based protocol in VANET. There are many disadvantages of VANET in network instability, which reduces the network efficiency. They have introduced three algorithms i.e. Cluster based lifetime routing (CBLTR), Intersection Dynamic VANET Routing (IDVR) protocol and Control overhead reduction algorithm (CORA). Every algorithm works different, CBLTR focus on increasing throughput. Here Cluster head(CH) is selected on the lifetime among all the vehicle. IDVR focuses on increasing the route stability and average throughput. IDVR select the optimal path or route for the destination. CORA focuses on control overhead on messages.

Nianjun Zhou et al.[15] they present the mathematical simulation using NS2 for reactive routing protocol and calculating the overhead of the nodes. They have studied two models namely Manhattan Grid Model and Poisson Model. Manhattan grid model is for regular node placement and Poisson model is for random node placement. Proved that it is possible to design infinitely scalable reactive routing protocol for different topology available in networks.

Ian D. Chakeres et al.[16] described how to implement the AODV routing protocol. They have discussed the events and possibilities of the ad-hoc on-demand routing protocol. This paper is to tell users how to use the AODV protocol.

Amirhossein Moravejosharieh et al.[17] they do the performance analysis on various routing protocols in vehicular ad hoc network that are AODV, DSR, DSDV and AOMDV. The main idea of their paper was to attain connectivity in vehicles either through V2V or V2I communication. In this, they have examined all these protocols on the base of routing evaluation. Routing performance is calculated through vehicle velocity and vehicle density. In this paper, they have used two different types of routing protocols that are proactive and reactive and concluded that in MANET and VANET if vehicle velocity and vehicle density increases then the potential of both kinds of routing protocols is decreasing.

Yufeng Chen et al.[18] here they have discussed the improved Ad hoc on demand multipath distance vector routing protocol(AOMDV). They collect the real-time data from On-Board Diagnostic (OBD) unit that is installed in vehicles. They have done some changes in AOMDV protocol for cases like fault tolerance and load balancing, and named it as Ad hoc on demand multipath distance vector with speed metric (S-AOMDV). Compared both AOMDV and S-AOMDV, took out the results on the origin of throughput, an end to end delay and message overhead.

Yufeng Chen et al.[19] they developed a cross-layer AOMDV protocol for an efficient vehicle to vehicle communication. they used the retransmission matrix to send the information again, and named the routing algorithm as R-AOMDV. Then compared the AOMDV and R-AOMDV, and proved that R-AOMDV is better.

Sajal Sarkar et al.[20] presents a stable and efficient routing technique based on the node's communication. Here a path is chosen between source and destination based on the nodes quality and it is determined by node's speed, direction and pause time. Mobility factor is generated and based on mobility factor nodes are selected. They performed the experiment on AODV and DSR routing protocol. Using simulation study they have proved by using their method AODV and DSR routing algorithm performs better.

N. Marchang et al.[21] in this they try to present a lightweight trust-based routing algorithm. There approach also helps in finding established dependable routes. This is applied to intrusion detection system to see the trust in other nodes have on each other. There routing protocol takes care of two kinds of attack namely black hole attack and grey hole attack. The author has used the AODV routing protocol to perform the experiment.

Hongkun Li et al.[22] tries to minimize end to end delay in a multiradio multichannel wireless network by selecting the optimum path. They have developed a genetic iterative approach to calculate Multi Radio Achievable Bandwidth (MRAB) for a connection between nodes. The MRAB is then combined with an end to end delay to give a weighted end to end delay. They implement this technique on a well known AODV protocol. Their main motive is to choose a route with a minimum end to end delay and high network throughput. Demonstrations of the experiments are done on NS2.

Cheikh Sarr et al.[23] discuss the IEEE 802.11 based on the ad hoc routing protocol. There is no technique to understand how many resources are available so that it can be used. In a multihop configuration, it becomes even more difficult to analyze. Despite there has been much research has been done but still use of effective bandwidth is still an issue. In this paper, they propose an effective way to use the available bandwidth in IEEE802.11 based ad-hoc network.

Charles E. Perkins et al.[24] this paper defines the difference between popular two routing protocols i.e. AODV and DSR. They did the simulation on the earlier model of NS2. AODV and DSR both initiate routing on-demand basis. DSR utilizes source routing whereas AODV uses table driven routing. They have analyzed many differences in both the routing protocol like DSR is more significant in unicast routing packet which is more expensive in 8021.11 MAC layer. AODV keeps track of recently utilizes path and multiple destinations. Basically, they have described many differences between AODV and DSR.

Mueen Uddin et al.[25] in this author discuss the Mobile Ad-hoc network(MANET) and its energy consumption in a network. Energy consumption is one of the main boundaries or defect of VANETs as nodes or vehicles do not possess permanent power supply, they have to rely on batteries. In this paper, they focus on the energy consumption in MANET by using the fitness function. Fitness function will help in optimizing the energy consumption in MANET. They have applied this fitness function on AOMDV and named it as FF-AOMDV. They have evaluated FF-AOMDV on network simulator. The fitness function is utilized to search the optimal path from source to destination node. FF-AOMDV is compared to AOMDV and Ad-hoc on-demand multipath routing with life maximization (AOMR-LM).

Hamid Menour et al.[26] in this paper they discuss medium access control (MAC) protocols in VANET. To avoid a collision in VANET a proper MAC protocol is needed.only some of the MAC protocol work efficient in VANET as compared to MANET. In this, they summarize the MAC protocols and useful MAC protocol for VANET.

Talipov, Elmurod, et al.[27] they discussed about reverse AODV in VANET for the security purpose. There are so many malicious nodes in VANET and if they enter the system then it will have an adverse effect on communication. So for data security, they have designed a path hoping method for reverse AODV (R-AODV). In reverse AODV source node try to hops on an available path and spilled the data.

Shahabi, Sina, et al.[28] here they discuss the security and performance of the AODV protocol. Security from the malicious node is one of the major concerns. One of the major attacks is black hole attack. Their article suggests a new security or enhanced security in AODV routing algorithm. This algorithm will analyze the data flow and according to the behavior of node, they will detect which node is malicious. All the simulation is done NS2.

Al-khatib et al.[29] they have calculated some of the routing protocols by comparing them.Routing protocols are AODV, DSDV & DSR. They took two type of routing protocols i.e. proactive routing protocol & reactive routing protocol. The whole simulation results are built on throughput, an end to end delay and packet loss. Concluded some of the results and proved that DSDV executes superior to AODV in conditions of finding another route. All protocol gives different output on a different number of nodes, but AODV performs much better. And so on they have proved so many differences.

Manish Bhardwaj et al[30] they have analyzed reactive routing protocol AODV, AOMDV and TORA using various Energy Models. Energy model that they have used are Chandrakasan Energy model, Bansal energy model and Vaddina energy model. They have used these models to calculate the energy overhead on the selected routing protocols.

Satoshi Kurosawa et al.[31] this paper discusses about the black hole attack. They show how to detect black hole attack in AODV routing protocol using dynamic learning technique. They use anomaly detection scheme to find the attack. These simulation results show more effectiveness as compared to a conventional scheme.

Nor Surayati Mohamad Usop[32] here they compare the performance evaluation of different routing algorithm in Grid Environment. The routing algorithm that is compared is AODV, DSDV and DSR. They used the mobile grid environment to compute. Paper describes the best protocol to give the highest performance over a grid environment. They have proved that AODV routing protocol is best among all three protocols.

Marcello Caleffi et al.[33] this paper proposes a multi-path vector ad hoc routing protocol i.e. Multipath Dynamic Address Routing (MDART). The performance of MDART is evaluated through mathematical simulation in various cases. MDART uses distributed hash table in routing protocol.

The problem of packet routing in the Vehicular Ad-hoc Network could be solved by three methods of Ad-hoc routing protocols that are geographic, trajectory-based and opportunistic based forwarding [8]. Theses all the techniques can be joined to carry and forward the VANET routing solution. These solutions will help in the VANET architecture to reduce AE2ED and the routing overhead. In emerging time, simulations or experiments will be more refined and then there will be lot more parameters to overcome the challenges of AE2ED and network overhead.

MK Marina et al.[35] they both have developed an Ad-Hoc on demand multipath distance vector routing protocol (AOMDV), it is the extension of single path distance vector routing protocol i.e. AODV. As the name suggests multi-path means there is a various path from sender's to receiver's node. Considering the AODV protocol, if the message needs to send from sender's to receiver's there is only one path, so if any node moves out from the transmission range or link gets broken, it is not possible that message will be delivered. So to overcome this defect in AODV protocol they came up with the idea of AOMDV. They compared both the AODV and AOMDV protocol in NS2 simulation and proved that AOMDV is more effective protocol.

AmmarZahary et al. [37] here they discuss about the multipath routing in Mobile Ad-Hoc Network. In the proposed paper they gave the organized review for the multipath routing. Theyhave compared two multipath algorithms AOMDV and MRAODV against long-established algorithm DSR and TORA. They simulated all the protocols on NS2. DSR and TORA outperform the AODV protocol. Evaluated the various results on the base of routing overhead, throughput and packet delivery fraction.

Azzedine Boukerche [38] here he has discussed on the evaluated of various routing protocols in MANET. For evaluating, the following routing protocols are selected AODV, CBRP, DSR, DSDV and PAODV (preemptive AODV). Different scenarios, workload, mobility, load and different size of ad hoc network is simulated on NS2. On the basis of simulation he gave the various outputs.

CHAPTER 4

PROBLEM STATEMENT

As we have seen many experiments and implementation of VANET in the previous section, they tell us that traffic management and controlling messages flow between the vehicles is a difficult task. Day by day traffic is increasing on every part of the world, due to which at the same rate accident is also increasing. So to manage a proper traffic management and the proper communication between the vehicles we need a definite solution. To communicate properly between the vehicles we need proper routing algorithm which will send the data or information according to needs. There are so many routing algorithms that transmit the data successfully but those all routing algorithms don't always give the best output. Means still we cannot rely on them. There are several routing protocols like proactive routing protocol, cluster-based, reactive routing protocol and many more. We have discussed these in chapter 1. Out of all these routing protocols reactive routing protocol is more effective.

Reactive routing protocol or Ad-Hoc protocols, they only send the information when they are asked to. Some examples of reactive routing protocol are AODV, AMODV, TORA and many more. So sending the information to another vehicle with the help of these protocols is beneficial. These protocols also do have some cons but they work quite effectively in many scenarios. These all routing protocols use IEEE802.11p for communication between the vehicles. IEEE802.11p does have sufficient range but maximum transmission range is 300m. And it also fails when the vehicle is moving pretty fast, means it sometimes fails to transmit the information at high speed.

C-V2X is the uprising technology that is far better than IEEE 802.11p and is more effective. Its transmission range is just double of IEEE 802.11p and it can cope up with the vehicle moving up to 500km/hr.

So in this dissertation work, it is discussed which reactive routing protocol will be more efficient using C-V2X as a technology for transmission of data.

4.1 Objectives

- To study the behaviour of AODV, AOMDV and MDART routing protocols, by simulating it on NS2 Network simulator.
- To study them for both transmission range as per IEEE 802.11p and for C-V2X i.e. range is 250m and 500m respectively by varying nodes i.e. 10, 20, 30 40 & 50.
- To analyze them on the basis of Average End to End Delay, Average Throughput and Packet Delivery Ratio for selection of a suitable protocol.

CHAPTER 5

IMPLEMENTATION & METHODOLOGY

In this chapter, we are going to talk about the methodology and the implementation of our thesis and the solutions to the referred problem as discussed in the previous section. This chapter describes the implementation on Network Simulator (NS-2.3) for different topological based routing protocol i.e. AODV, AOMDV and MDART. We have used so many scenarios to compare these protocols, on the foundation of throughput, an end to end delivery, and packet delivery ratio.

Table 5.1 Experimental Setups for Simulation

Parameter	Value
Experimental Protocol	AODV, AOMDV, MDART
Number of Nodes	10, 20, 30, 40 & 50
Simulation Time	50s, 100s,150s
Link Layer	Logical Link Layer
Antenna Type	Omni Antenna
Simulation area	320X320
Packet Size	512 bytes
Data Type	CBR
Data Rate	11mbps
MAC protocol	IEEE 802.11p
Simulator	NS 2.34

For VANET simulation many performance metrics have been analyzed. Each parameter shows different behaviour. Here we are going to use some of the parameters to evaluate our experiments. These parameters are Average End to End delay, through put and Packet Delivery ratio. All parameters are vital for evaluation of routing protocols. These parameters will tell us which routing protocol will be better and which will help in traffic management. Like if an average end to end delay is more than the protocol is not efficient. Also in the case of throughput if the throughput value is less, than it is not efficient. If we take a scenario of packet delivery ratio then, if the delivery ratio is less then that protocol is not efficient.

5.1. Delay

Average End to end delay refers to or defined as a time taken by a packet to transmit from source node to destination node. So basically it is period of time taken by message to travel to another end. Packet end to end delay defines how packet moves in the network, how much transmission time it takes, how much propagation time to propagate and processing time to process the data. The end to end delay is evaluated between two synchronous points in a network.

$$d_{end\text{-}end} = N[\, d_{trans} + d_{prop} + d_{proc} + d_{queue}]$$

where

$d_{end\text{-}end}$= end-to-end delay
d_{trans}= transmission delay
d_{prop}= propagation delay
d_{proc}= processing delay
d_{queue}= Queuing delay
N= number of links (Number of routers - 1)

5.2. Throughput

Throughput in data transmission is how much data is transmitted in per unit of time. Here it means how many numbers of packets are delivered to the receiver in a particular unit of time. Throughput measurement unit is bits per second(bps) or megabits per second(mbps). The more throughput is it is more beneficial for the network. A protocol is more effective when throughput is high.

$$\textbf{Throughput} = \frac{\textbf{Number of delivered packets*packet size*8}}{\textbf{Total Time taken}}$$

5.3. Packet Delivery Ratio

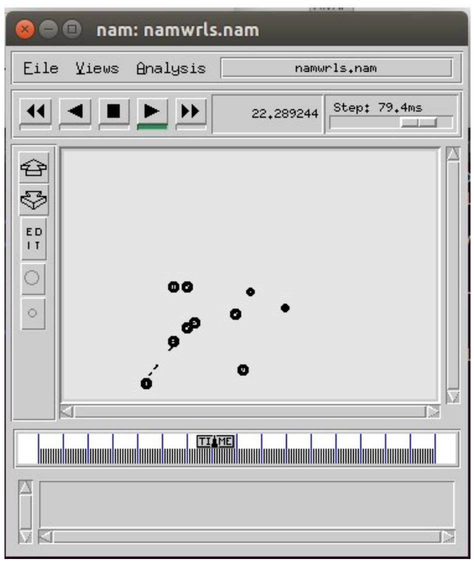
Packet Delivery ratio is one of the important parameters to calculate the network performance. It is described as the proportion between the total data packets received to the total packet sent. Mathematically it can be expressed as,

PDR = Total data packets received / Total data packets sent

5.4. Simulation Details

Implementation of the work is done on the NS2 software, about which we have discussed in Chapter 2. Each time we run the simulation, based on different scenarios, the new window NAM window is created. We have run the simulation *180 times* and each time new window is generated and for each simulation new trace file is generated.

Screenshots of different scenarios



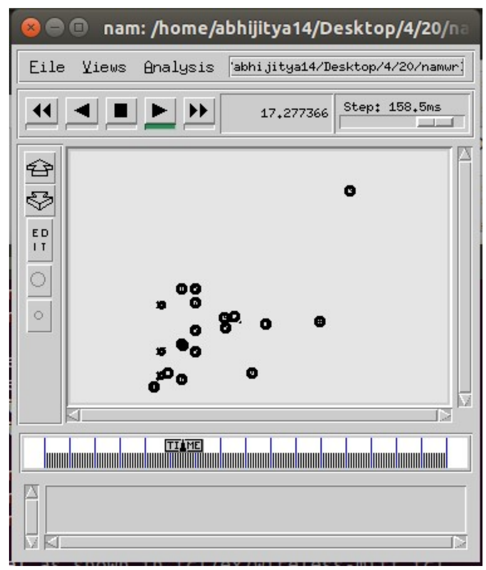


Fig 5.1 For 10 nodes and AODV protocol for protocol
250m

Fig 5.2 For 20 nodes and AODV

for 250m

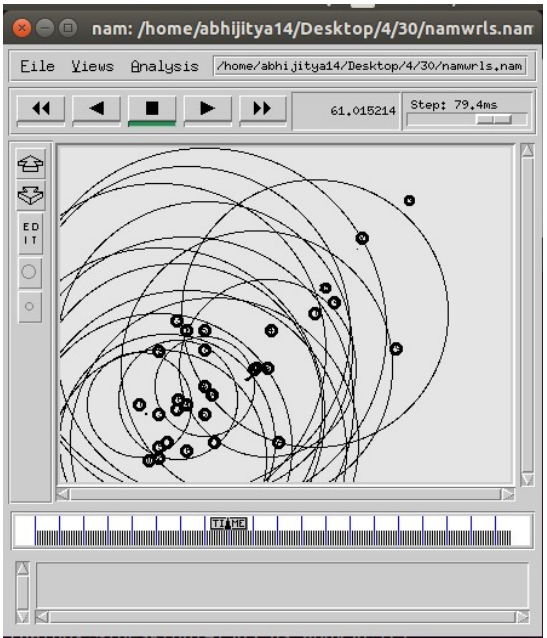


Fig 5.3 For 30 nodes and AODV protocol for 250m

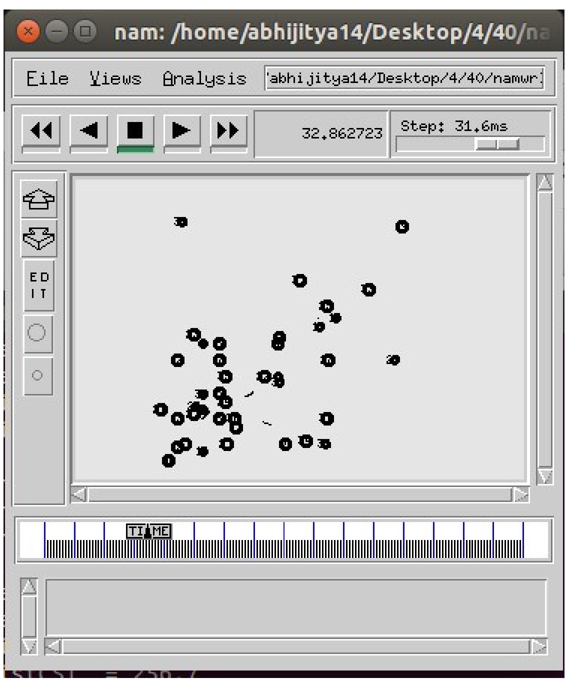


Fig 5.4 For 40 nodes and AODV protocol for 250m

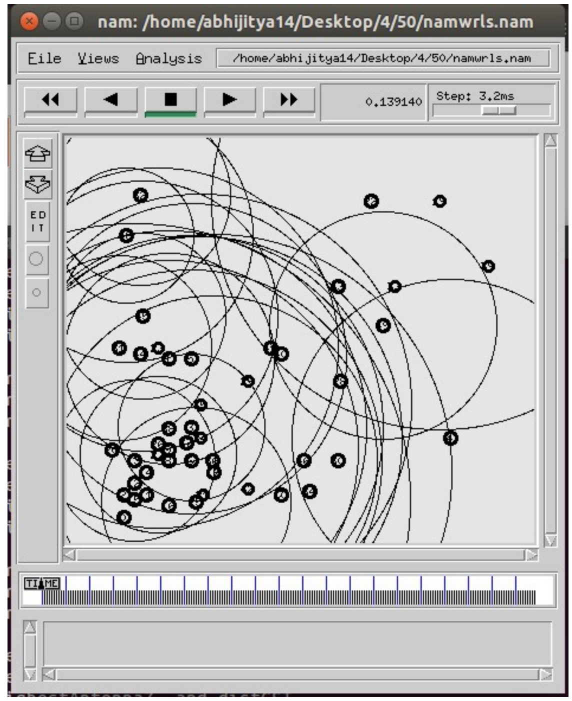


Fig 5.5 For 50nodes and AODV protocol for 250m

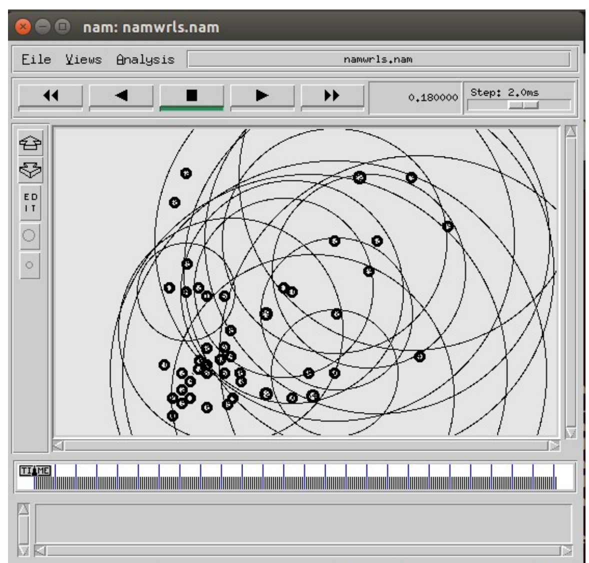
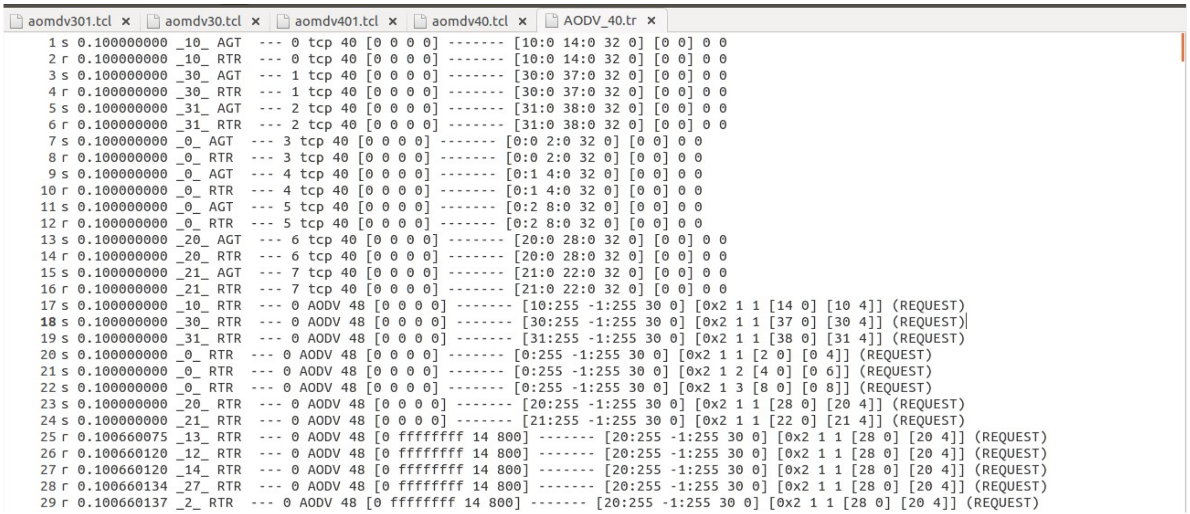
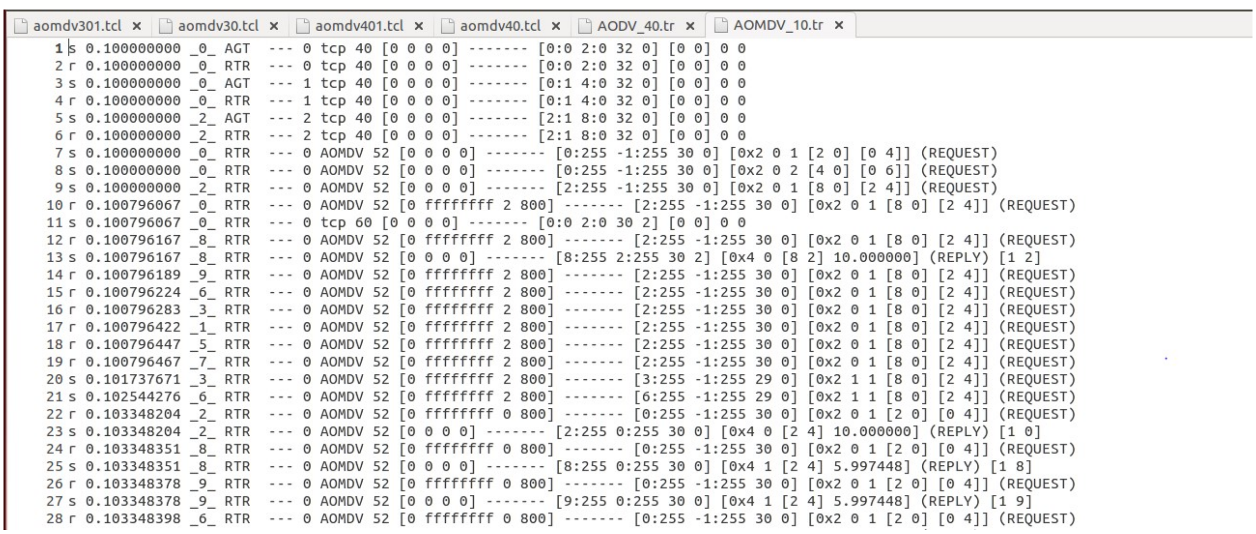


Fig 5.6 For 50nodes and AOMDV protocol for 250m



```
aomdv301.tcl  aomdv30.tcl  aomdv401.tcl  aomdv40.tcl  AODV_40.tr
s 0.100000000 _10_ AGT  --- 0 tcp 40 [0 0 0 0] ------- [10:0 14:0 32 0] [0 0] 0 0
r 0.100000000 _10_ RTR  --- 0 tcp 40 [0 0 0 0] ------- [10:0 14:0 32 0] [0 0] 0 0
s 0.100000000 _30_ AGT  --- 1 tcp 40 [0 0 0 0] ------- [30:0 37:0 32 0] [0 0] 0 0
r 0.100000000 _30_ RTR  --- 1 tcp 40 [0 0 0 0] ------- [30:0 37:0 32 0] [0 0] 0 0
s 0.100000000 _31_ AGT  --- 2 tcp 40 [0 0 0 0] ------- [31:0 38:0 32 0] [0 0] 0 0
r 0.100000000 _31_ RTR  --- 2 tcp 40 [0 0 0 0] ------- [31:0 38:0 32 0] [0 0] 0 0
s 0.100000000 _0_ AGT  --- 3 tcp 40 [0 0 0 0] ------- [0:0 2:0 32 0] [0 0] 0 0
r 0.100000000 _0_ RTR  --- 3 tcp 40 [0 0 0 0] ------- [0:0 2:0 32 0] [0 0] 0 0
s 0.100000000 _0_ AGT  --- 4 tcp 40 [0 0 0 0] ------- [0:1 4:0 32 0] [0 0] 0 0
r 0.100000000 _0_ RTR  --- 4 tcp 40 [0 0 0 0] ------- [0:1 4:0 32 0] [0 0] 0 0
s 0.100000000 _0_ AGT  --- 5 tcp 40 [0 0 0 0] ------- [0:2 8:0 32 0] [0 0] 0 0
r 0.100000000 _0_ RTR  --- 5 tcp 40 [0 0 0 0] ------- [0:2 8:0 32 0] [0 0] 0 0
s 0.100000000 _20_ AGT  --- 6 tcp 40 [0 0 0 0] ------- [20:0 28:0 32 0] [0 0] 0 0
r 0.100000000 _20_ RTR  --- 6 tcp 40 [0 0 0 0] ------- [20:0 28:0 32 0] [0 0] 0 0
s 0.100000000 _21_ AGT  --- 7 tcp 40 [0 0 0 0] ------- [21:0 22:0 32 0] [0 0] 0 0
r 0.100000000 _21_ RTR  --- 7 tcp 40 [0 0 0 0] ------- [21:0 22:0 32 0] [0 0] 0 0
s 0.100000000 _10_ RTR  --- 0 AODV 48 [0 0 0 0] ------- [10:255 -1:255 30 0] [0x2 1 1 [14 0] [10 4]] (REQUEST)
s 0.100000000 _30_ RTR  --- 0 AODV 48 [0 0 0 0] ------- [30:255 -1:255 30 0] [0x2 1 1 [37 0] [30 4]] (REQUEST)
s 0.100000000 _31_ RTR  --- 0 AODV 48 [0 0 0 0] ------- [31:255 -1:255 30 0] [0x2 1 1 [38 0] [31 4]] (REQUEST)
s 0.100000000 _0_ RTR  --- 0 AODV 48 [0 0 0 0] ------- [0:255 -1:255 30 0] [0x2 1 1 [2 0] [0 4]] (REQUEST)
s 0.100000000 _0_ RTR  --- 0 AODV 48 [0 0 0 0] ------- [0:255 -1:255 30 0] [0x2 1 2 [4 0] [0 6]] (REQUEST)
s 0.100000000 _0_ RTR  --- 0 AODV 48 [0 0 0 0] ------- [0:255 -1:255 30 0] [0x2 1 3 [8 0] [0 8]] (REQUEST)
s 0.100000000 _20_ RTR  --- 0 AODV 48 [0 0 0 0] ------- [20:255 -1:255 30 0] [0x2 1 1 [28 0] [20 4]] (REQUEST)
s 0.100000000 _21_ RTR  --- 0 AODV 48 [0 0 0 0] ------- [21:255 -1:255 30 0] [0x2 1 1 [22 0] [21 4]] (REQUEST)
r 0.100660075 _13_ RTR  --- 0 AODV 48 [0 ffffffff 14 800] ------- [20:255 -1:255 30 0] [0x2 1 1 [28 0] [20 4]] (REQUEST)
r 0.100660120 _12_ RTR  --- 0 AODV 48 [0 ffffffff 14 800] ------- [20:255 -1:255 30 0] [0x2 1 1 [28 0] [20 4]] (REQUEST)
r 0.100660120 _14_ RTR  --- 0 AODV 48 [0 ffffffff 14 800] ------- [20:255 -1:255 30 0] [0x2 1 1 [28 0] [20 4]] (REQUEST)
r 0.100660134 _27_ RTR  --- 0 AODV 48 [0 ffffffff 14 800] ------- [20:255 -1:255 30 0] [0x2 1 1 [28 0] [20 4]] (REQUEST)
r 0.100660137 _2_ RTR  --- 0 AODV 48 [0 ffffffff 14 800] ------- [20:255 -1:255 30 0] [0x2 1 1 [28 0] [20 4]] (REQUEST)
```

Fig 5.7 Trace File format for AODV file



```
aomdv301.tcl  aomdv30.tcl  aomdv401.tcl  aomdv40.tcl  AODV_40.tr  AOMDV_10.tr
s 0.100000000 _0_ AGT  --- 0 tcp 40 [0 0 0 0] ------- [0:0 2:0 32 0] [0 0] 0 0
r 0.100000000 _0_ RTR  --- 0 tcp 40 [0 0 0 0] ------- [0:0 2:0 32 0] [0 0] 0 0
s 0.100000000 _0_ AGT  --- 1 tcp 40 [0 0 0 0] ------- [0:1 4:0 32 0] [0 0] 0 0
r 0.100000000 _0_ RTR  --- 1 tcp 40 [0 0 0 0] ------- [0:1 4:0 32 0] [0 0] 0 0
s 0.100000000 _2_ AGT  --- 2 tcp 40 [0 0 0 0] ------- [2:1 8:0 32 0] [0 0] 0 0
r 0.100000000 _2_ RTR  --- 2 tcp 40 [0 0 0 0] ------- [2:1 8:0 32 0] [0 0] 0 0
s 0.100000000 _0_ RTR  --- 0 AOMDV 52 [0 0 0 0] ------- [0:255 -1:255 30 0] [0x2 0 1 [2 0] [0 4]] (REQUEST)
s 0.100000000 _0_ RTR  --- 0 AOMDV 52 [0 0 0 0] ------- [0:255 -1:255 30 0] [0x2 0 2 [4 0] [0 6]] (REQUEST)
s 0.100000000 _2_ RTR  --- 0 AOMDV 52 [0 0 0 0] ------- [2:255 -1:255 30 0] [0x2 0 1 [8 0] [2 4]] (REQUEST)
r 0.100796067 _0_ RTR  --- 0 AOMDV 52 [0 ffffffff 2 800] ------- [2:255 -1:255 30 0] [0x2 0 1 [8 0] [2 4]] (REQUEST)
s 0.100796067 _0_ RTR  --- 0 tcp 60 [0 0 0 0] ------- [0:0 2:0 30 2] [0 0] 0 0
r 0.100796167 _8_ RTR  --- 0 AOMDV 52 [0 ffffffff 2 800] ------- [2:255 -1:255 30 0] [0x2 0 1 [8 0] [2 4]] (REQUEST)
s 0.100796167 _8_ RTR  --- 0 AOMDV 52 [0 0 0 0] ------- [8:255 2:255 30 2] [0x4 0 [8 2] 10.000000] (REPLY) [1 2]
r 0.100796189 _9_ RTR  --- 0 AOMDV 52 [0 ffffffff 2 800] ------- [2:255 -1:255 30 0] [0x2 0 1 [8 0] [2 4]] (REQUEST)
r 0.100796224 _6_ RTR  --- 0 AOMDV 52 [0 ffffffff 2 800] ------- [2:255 -1:255 30 0] [0x2 0 1 [8 0] [2 4]] (REQUEST)
r 0.100796283 _3_ RTR  --- 0 AOMDV 52 [0 ffffffff 2 800] ------- [2:255 -1:255 30 0] [0x2 0 1 [8 0] [2 4]] (REQUEST)
r 0.100796422 _1_ RTR  --- 0 AOMDV 52 [0 ffffffff 2 800] ------- [2:255 -1:255 30 0] [0x2 0 1 [8 0] [2 4]] (REQUEST)
r 0.100796447 _5_ RTR  --- 0 AOMDV 52 [0 ffffffff 2 800] ------- [2:255 -1:255 30 0] [0x2 0 1 [8 0] [2 4]] (REQUEST)
r 0.100796467 _7_ RTR  --- 0 AOMDV 52 [0 ffffffff 2 800] ------- [2:255 -1:255 30 0] [0x2 0 1 [8 0] [2 4]] (REQUEST)
s 0.101737671 _3_ RTR  --- 0 AOMDV 52 [0 ffffffff 2 800] ------- [3:255 -1:255 29 0] [0x2 1 1 [8 0] [2 4]] (REQUEST)
s 0.102544276 _6_ RTR  --- 0 AOMDV 52 [0 ffffffff 2 800] ------- [6:255 -1:255 29 0] [0x2 1 1 [8 0] [2 4]] (REQUEST)
r 0.103348204 _2_ RTR  --- 0 AOMDV 52 [0 ffffffff 0 800] ------- [0:255 -1:255 30 0] [0x2 0 1 [2 0] [0 4]] (REQUEST)
s 0.103348204 _2_ RTR  --- 0 AOMDV 52 [0 0 0 0] ------- [2:255 0:255 30 0] [0x4 0 [2 4] 10.000000] (REPLY) [1 0]
r 0.103348351 _8_ RTR  --- 0 AOMDV 52 [0 ffffffff 0 800] ------- [0:255 -1:255 30 0] [0x2 0 1 [2 0] [0 4]] (REQUEST)
s 0.103348351 _8_ RTR  --- 0 AOMDV 52 [0 0 0 0] ------- [8:255 0:255 30 0] [0x4 1 [2 4] 5.997448] (REPLY) [1 8]
r 0.103348378 _9_ RTR  --- 0 AOMDV 52 [0 ffffffff 0 800] ------- [0:255 -1:255 30 0] [0x2 0 1 [2 0] [0 4]] (REQUEST)
s 0.103348378 _9_ RTR  --- 0 AOMDV 52 [0 0 0 0] ------- [9:255 0:255 30 0] [0x4 1 [2 4] 5.997448] (REPLY) [1 9]
r 0.103348398 _6_ RTR  --- 0 AOMDV 52 [0 ffffffff 0 800] ------- [0:255 -1:255 30 0] [0x2 0 1 [2 0] [0 4]] (REQUEST)
```

Fig 5.8 Trace File format for AOMDV file

Figure 5.7 and 5.8 shows the trace file for AODV & AOMDV respectively. These trace files help us in generating graphs and from these graphs other calculations are also being performed.

CHAPTER 6

RESULTS & ANALYSIS & DISCUSSION

Simulation Environment: -The experiments on different scenarios are performed on Network Simulator 2 version 2.35.

Traffic Model: Constant Bit Rate(CBR)is used to transmit the traffic at a constant rate. The source location and destination location are all over the network. There can be many source and destination in the same network, so they have to make a bonding of each source and a destination node.

We have different scenarios to compare AODV, AOMDV and MDART routing protocol.

First is Transmission range of a Node

1. 250 meter for IEEE802.11p
2. 500 meter in case of C-V2X

Second is number of nodes is in the simulation of the experiment

- 10 nodes
- 20 nodes
- 30 nodes
- 40 nodes
- 50 nodes

6.1.TCP Congestion Window size, data transmission to per unit of time

Here the graph is drawn for AODV, AOMDV and MDART. On the y-axis is the congestion window size and on the x-axis is the time the routing protocol is simulated. There are two different graphs for the different number of nodes. First is for node transmission range to 250m and other for 500m.

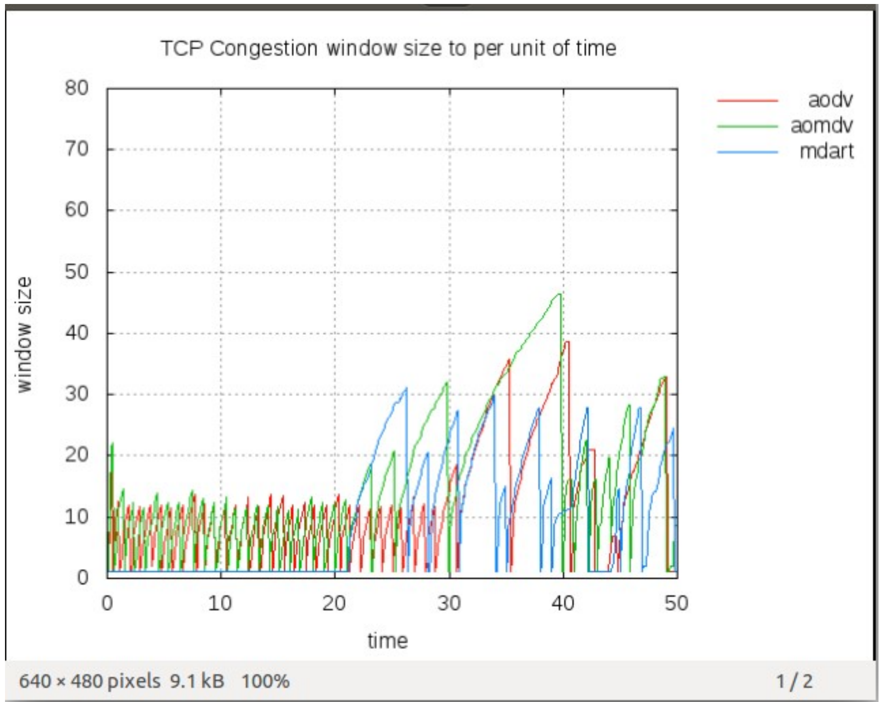


Fig 6.1TCP Congestion window size to per unit of time for 10 nodes with 250m for 50sec simulation

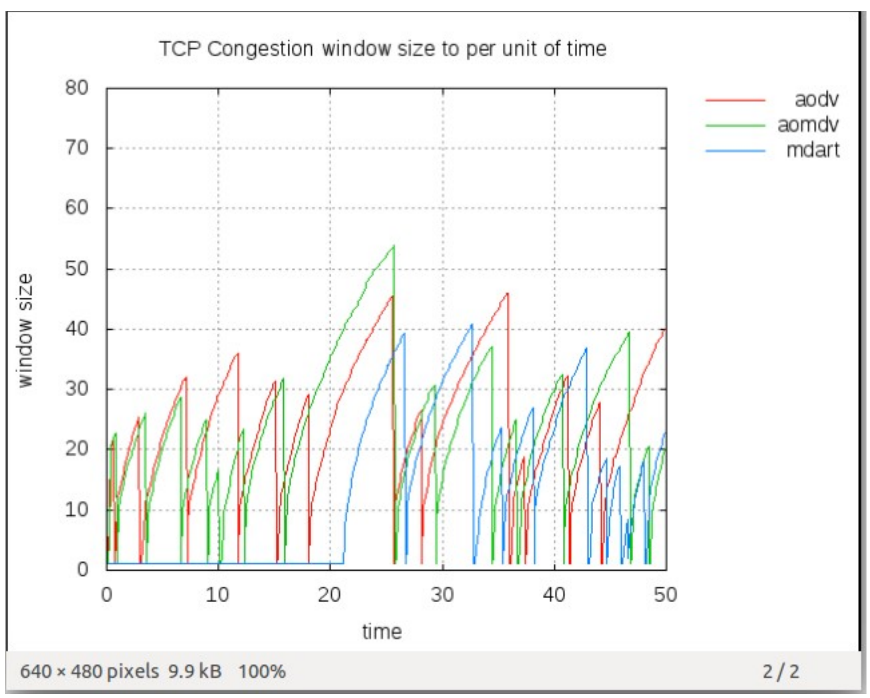


Fig 6.2 TCP Congestion window size to per unit of time for 10 nodes with 500m for 50sec simulation

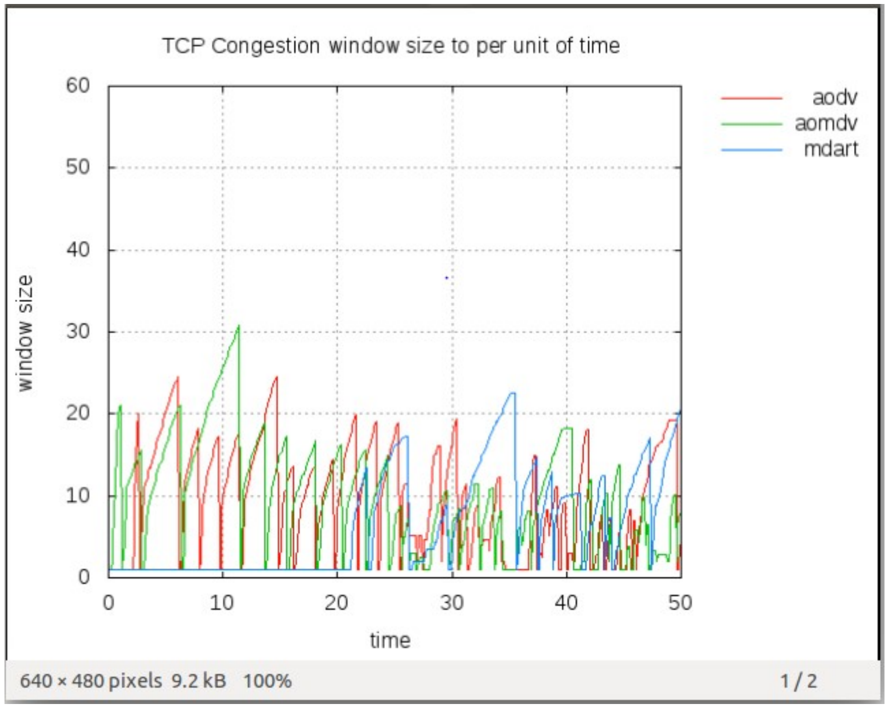


Fig 6.3 TCP Congestion window size to per unit of time for 20 nodes with 250m for 50sec simulation

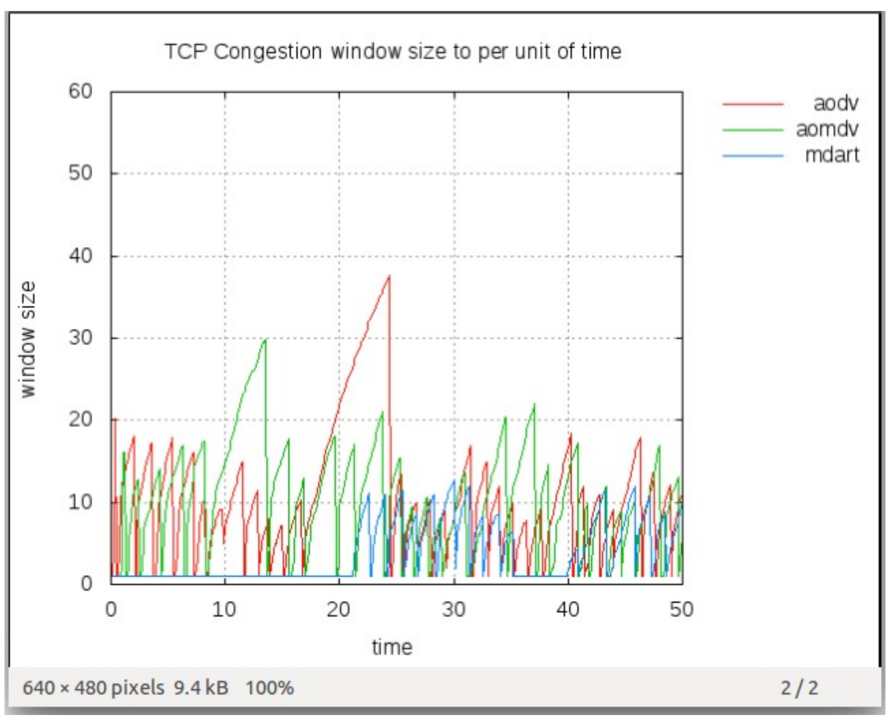


Fig 6.4TCP Congestion window size to per unit of time for 20 nodes with 500m for 50sec simulation

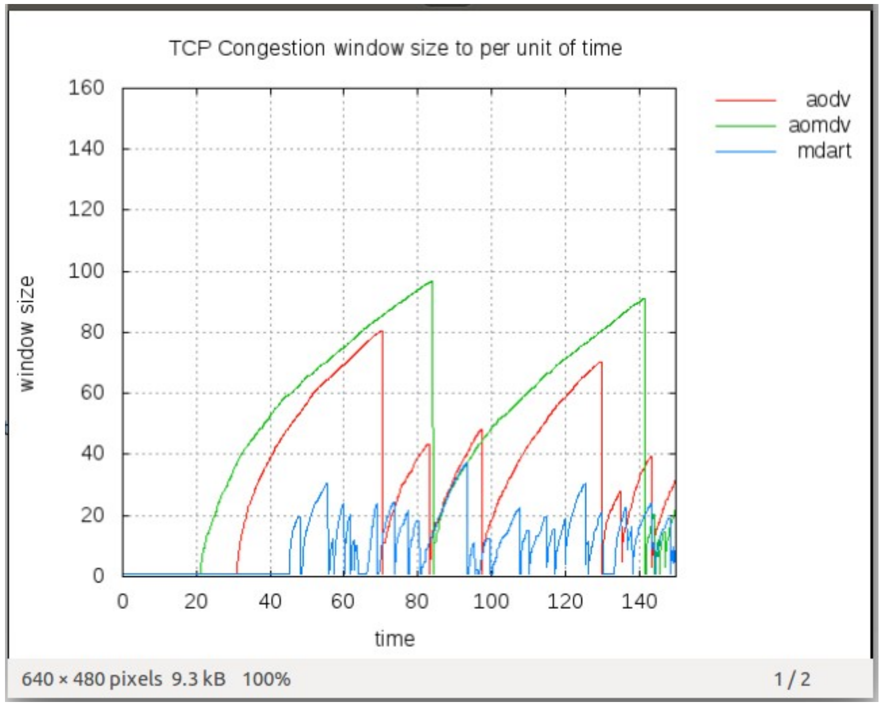


Fig 6.5 TCP Congestion window size to per unit of time for 30 nodes with 250m for 150sec simulation

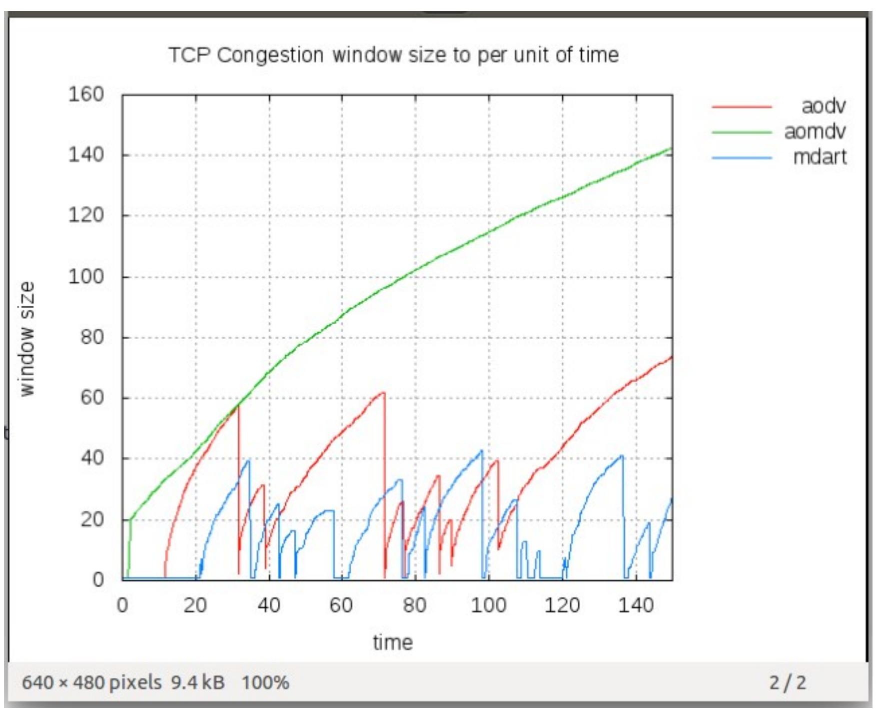


Fig 6.6 TCP Congestion window size to per unit of time for 30 nodes with 500m for 150sec simulation

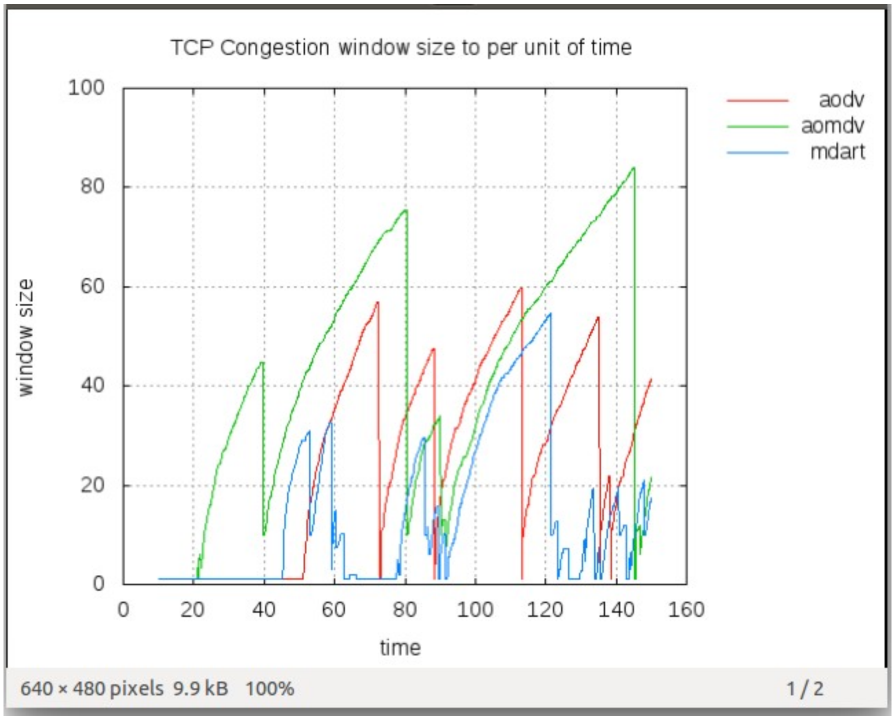


Fig 6.7 TCP Congestion window size to per unit of time for 40 nodes with 250m for 150sec simulation

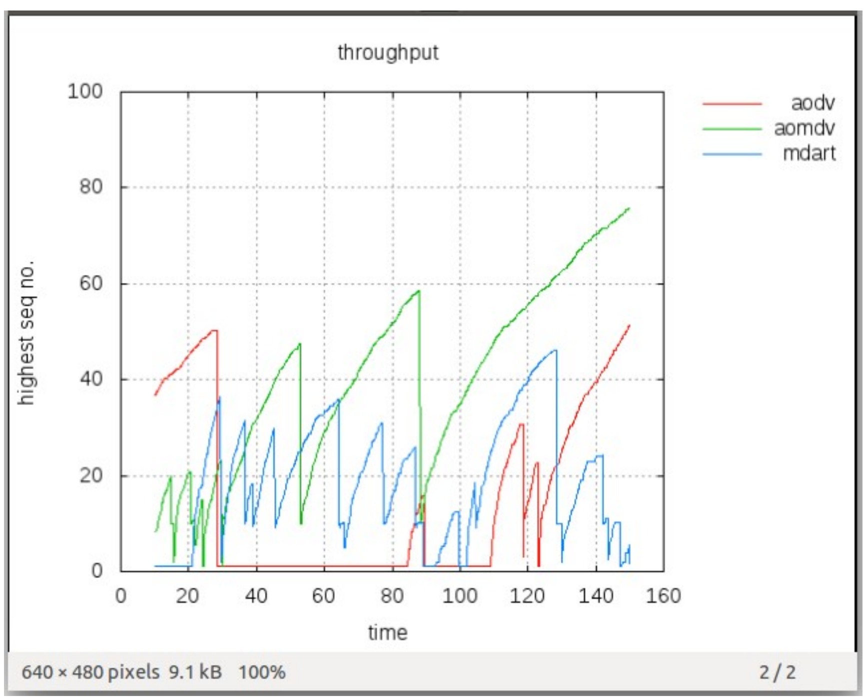


Fig 6.8 TCP Congestion window size to per unit of time for 40 nodes with 500m for 150sec simulation

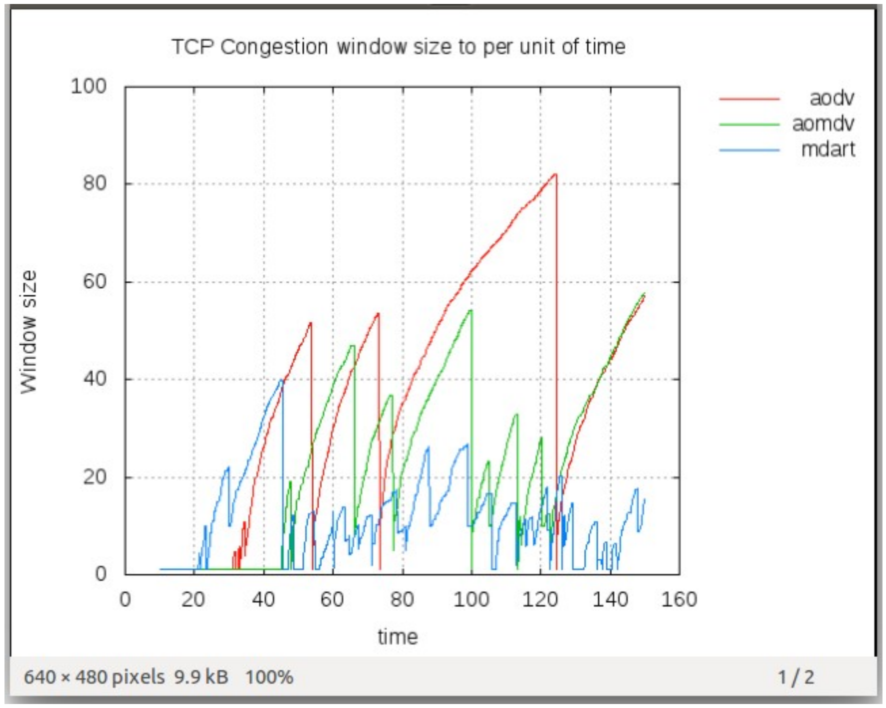


Fig 6.9 TCP Congestion window size to per unit of time for 50 nodes with 250m for 150sec simulation

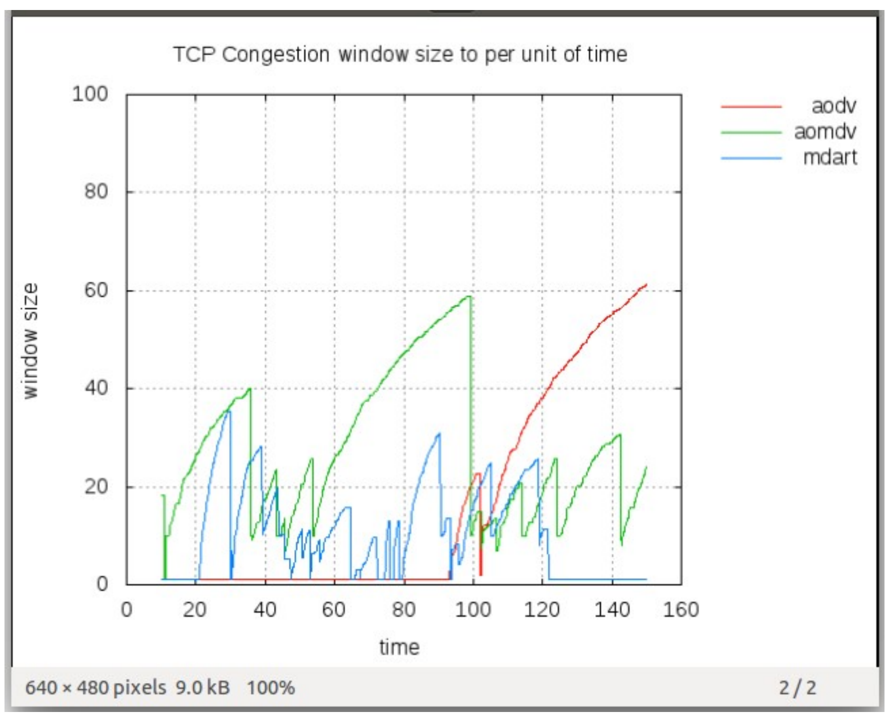


Fig 6.10 TCP Congestion window size to per unit of time for 50 nodes with 500m for 150sec simulation

From all the Fig 6.1 to 6.10 we get to know that TCP Congestion Window size boost up as the number of nodes increases from 10 nodes to 50 nodes. These graphs help us to get to know that if the communication range of a node is increased the data flow rate is better per unit of time. From some of the graph, we get to know that AOMDV performs better than AODV routing protocol. We also see that transmission packet is almost similar for all the protocols in 10 nodes and 20 nodes.

6.2.Average End to End delay against Number of Nodes

AE2ED here defined or refers to an average time taken by the entire node to deliver a packet from sender's location point to receiver's location point. Here the graph is drawn among the AE2ED against the number of nodes. There is a different time of simulation in each case scenario. And we are also considering the different transmission ranges of the node.

Different Simulation time

1. 50 sec
2. 100sec
3. 150 sec

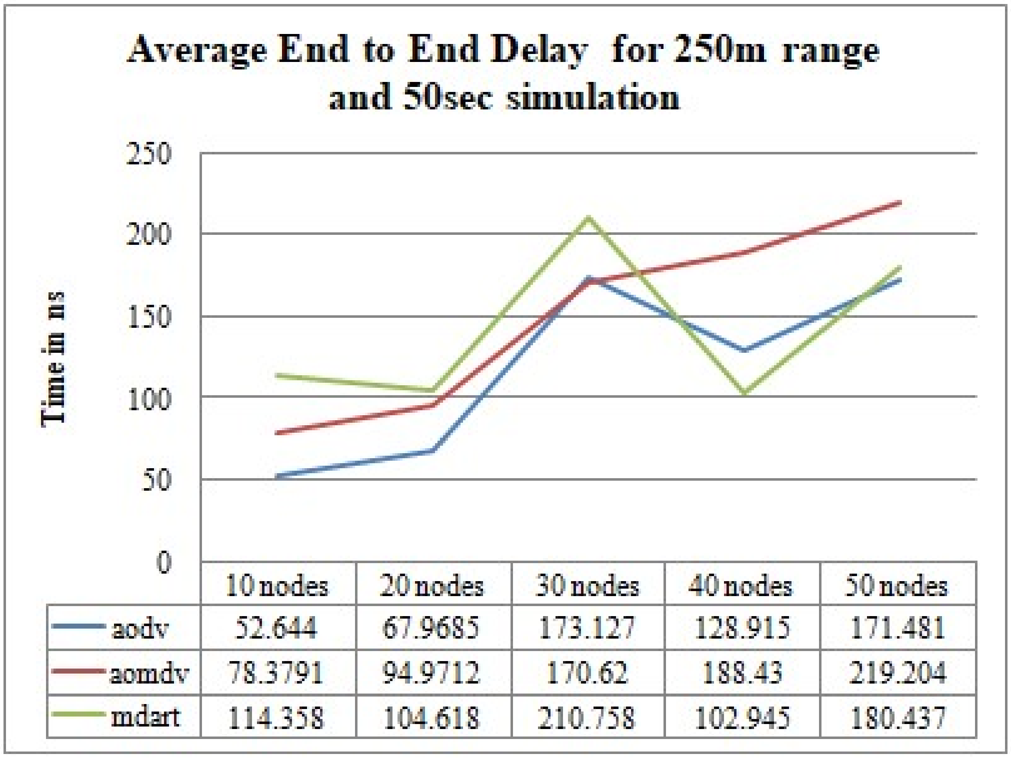


Fig 6.11 AE2ED for 250m range and 50s

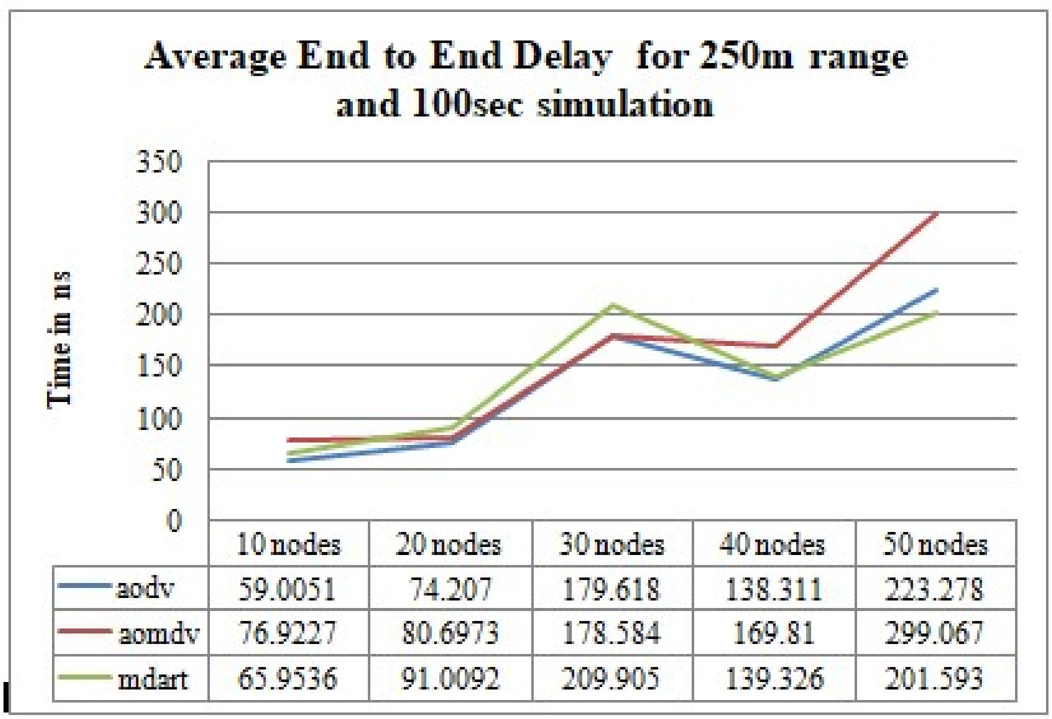
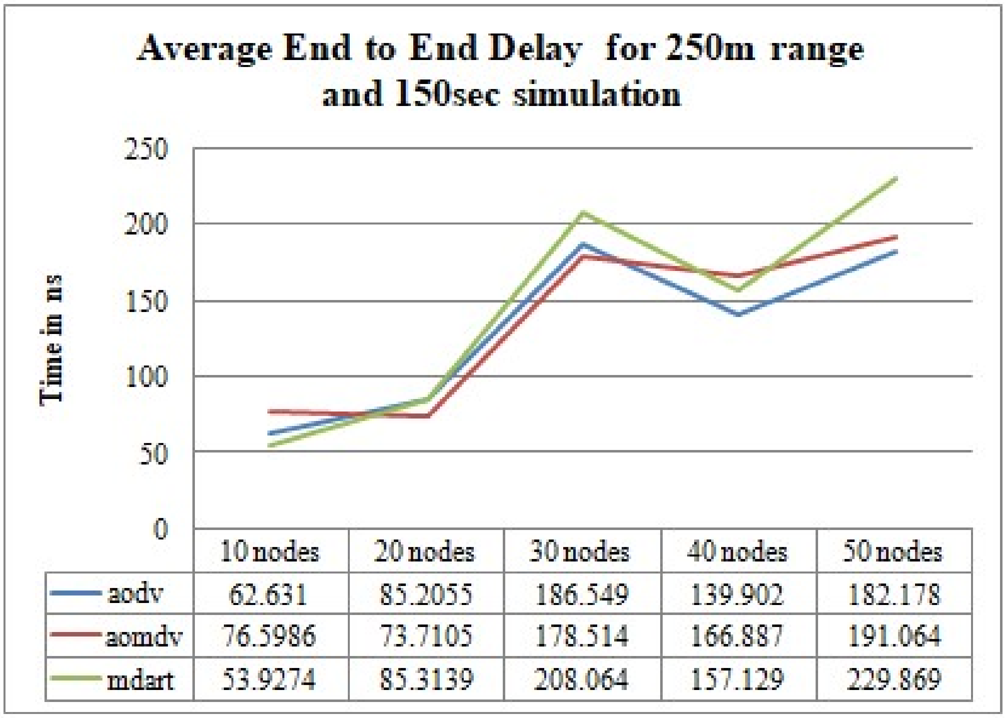
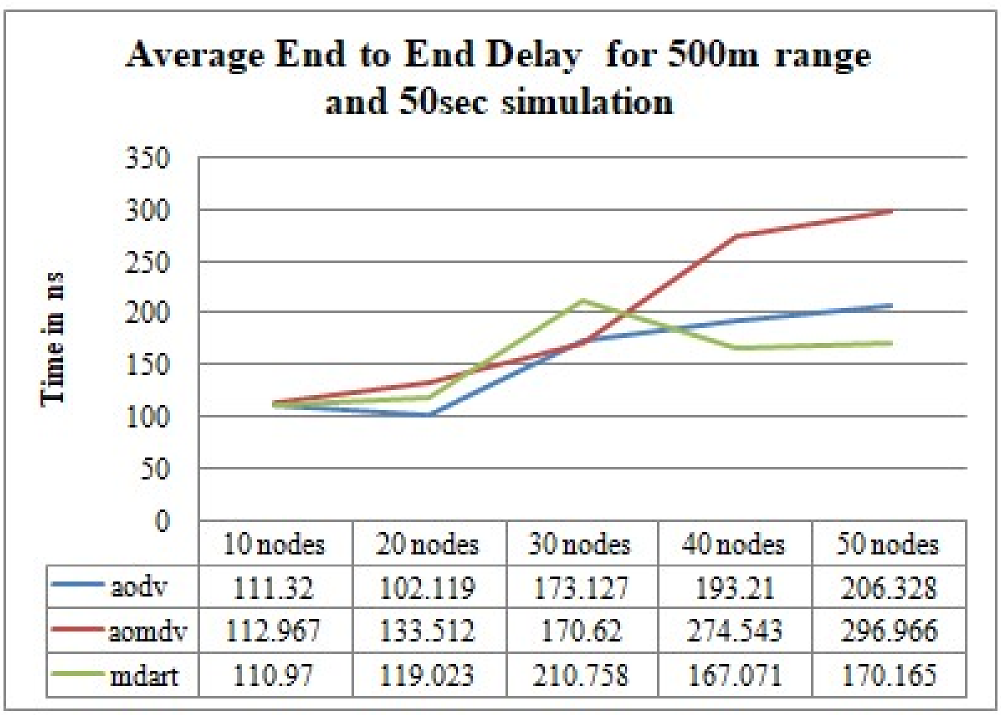


Fig 6.12 AE2ED for 250m range and 100s



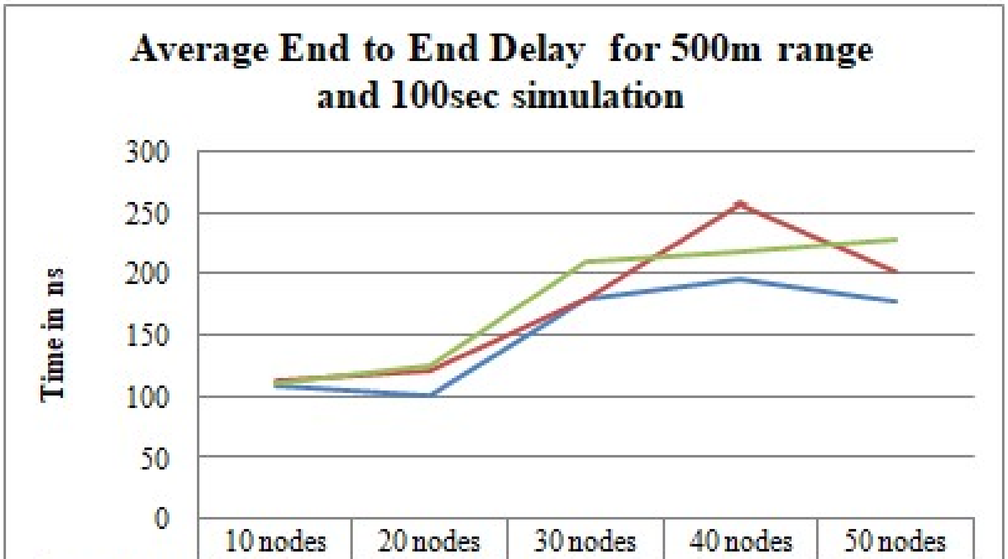
	10 nodes	20 nodes	30 nodes	40 nodes	50 nodes
aodv	62.631	85.2055	186.549	139.902	182.178
aomdv	76.5986	73.7105	178.514	166.887	191.064
mdart	53.9274	85.3139	208.064	157.129	229.869

Fig 6.13 AE2ED for 250m range and 150s



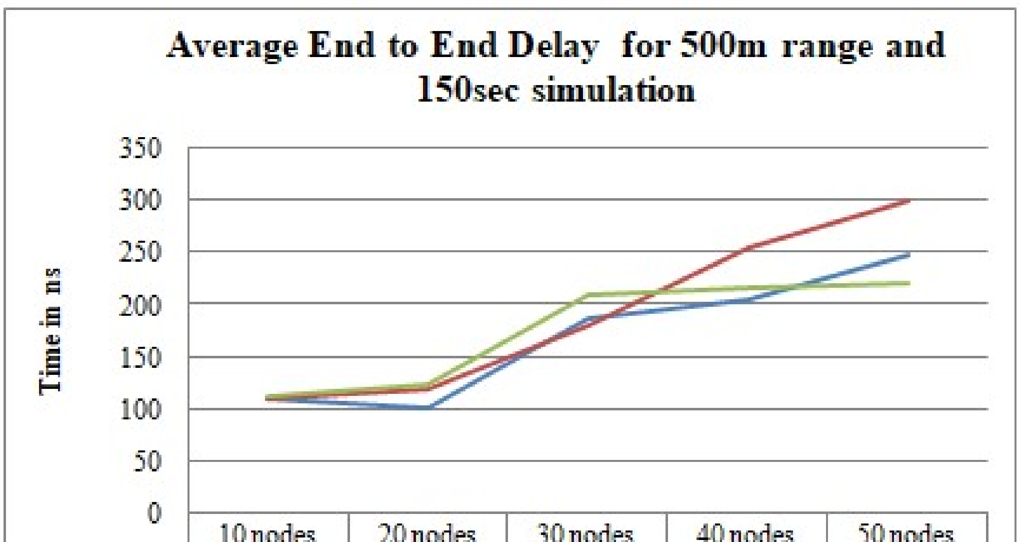
	10 nodes	20 nodes	30 nodes	40 nodes	50 nodes
aodv	111.32	102.119	173.127	193.21	206.328
aomdv	112.967	133.512	170.62	274.543	296.966
mdart	110.97	119.023	210.758	167.071	170.165

Fig 6.14 AE2ED for 500m range and 50s



	10 nodes	20 nodes	30 nodes	40 nodes	50 nodes
aodv	108.951	100.959	179.618	196.462	176.669
aomdv	111.785	121.701	178.584	258.828	200.619
mdart	111.322	125.227	209.905	217.872	226.915

Fig 6.15 AE2ED for 500m range and 100s



	10 nodes	20 nodes	30 nodes	40 nodes	50 nodes
aodv	109.56	100.504	186.549	204.071	246.044
aomdv	110.472	118.404	178.514	253.799	298.108
mdart	111.332	122.561	208.064	215.583	220.209

Fig 6.16 AE2ED for 500m range and 150s

From the graph fig 6.11 to 6.16 it is observed that AE2EDboost up with the increment of a number of nodes. All the graphs increase in a linear fashion. From the graph, we can see that MDART protocol performs better as the no. of nodes increases. AOMDV gives the worst AE2ED. As the transmission range of a node is increased the AE2ED is also increased. So it does not give much of a benefit. When transmission range of MDART is increased, after some time it goes to the saturation point.

6.3. Average End to End delay against Simulation time

Average end to end delay here characterized or referred to as the average time taken by the entire node to deliver a packet from sender's location point to receiver's location point. Here the graph is drawn among the AE2ED to the simulation time of the experiment over various numbers of nodes. Transmission range of a node is also considered.

Graph is drawn between various number of nodes i.e.

1. 10 nodes
2. 20 nodes
3. 30 nodes
4. 40 nodes
5. 50 nodes

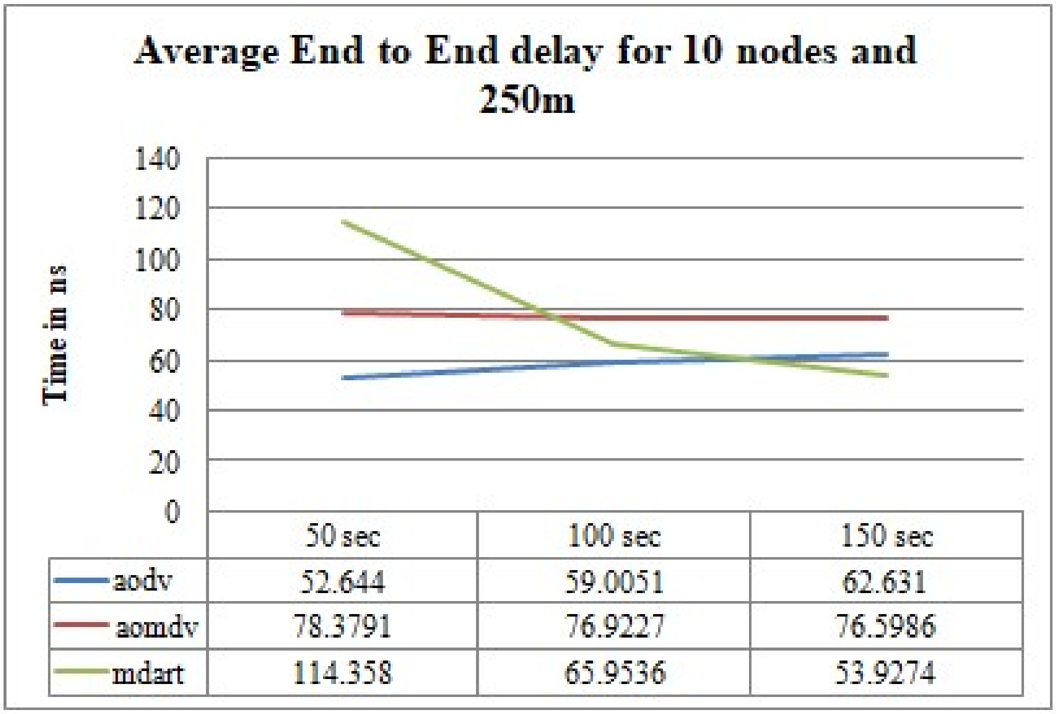


Fig 6.17 AE2ED for 10 nodes and 250m

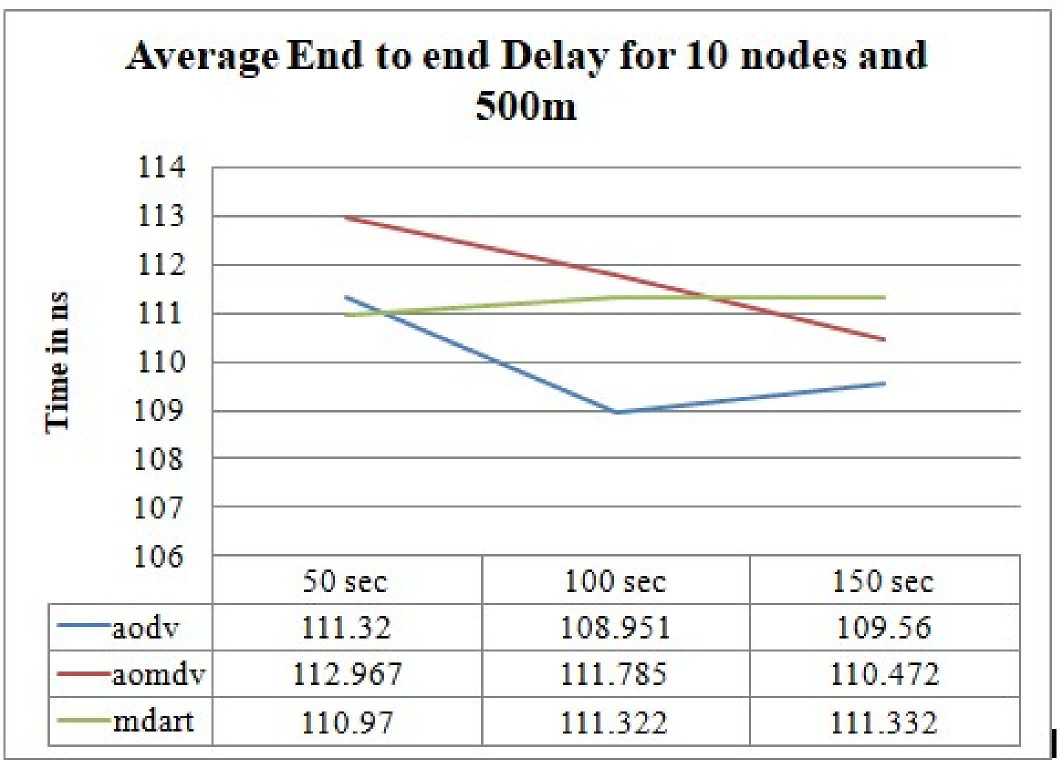


Fig 6.18 AE2ED for 10 nodes and 500m

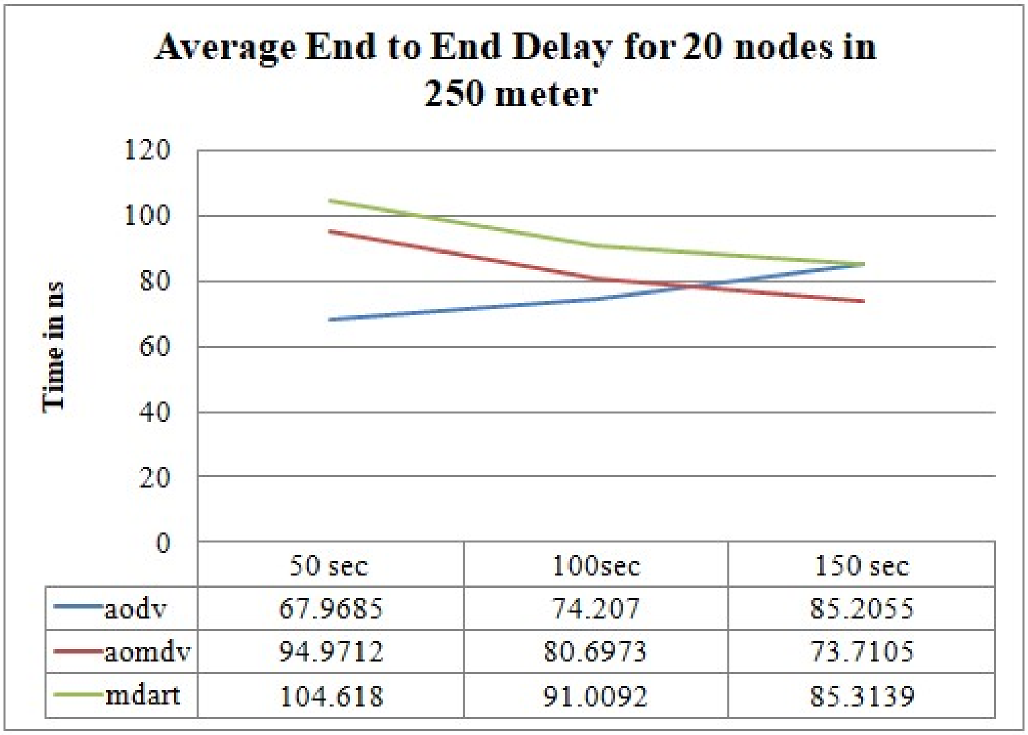


Fig 6.19 AE2ED for 20 nodes and 250m

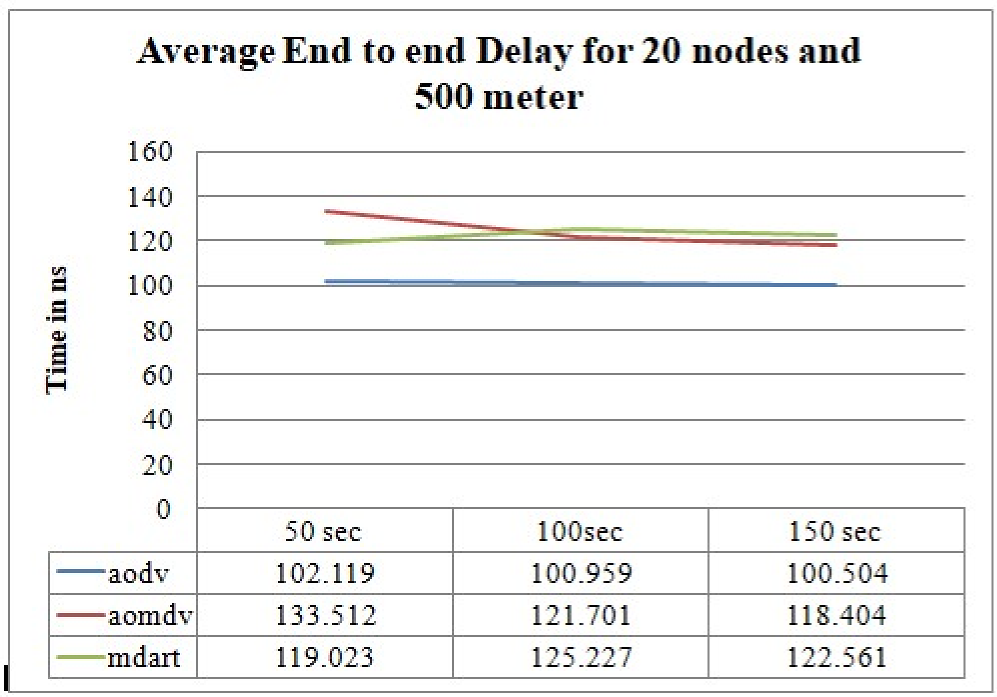


Fig 6.20 AE2ED for 20 nodes and 500m

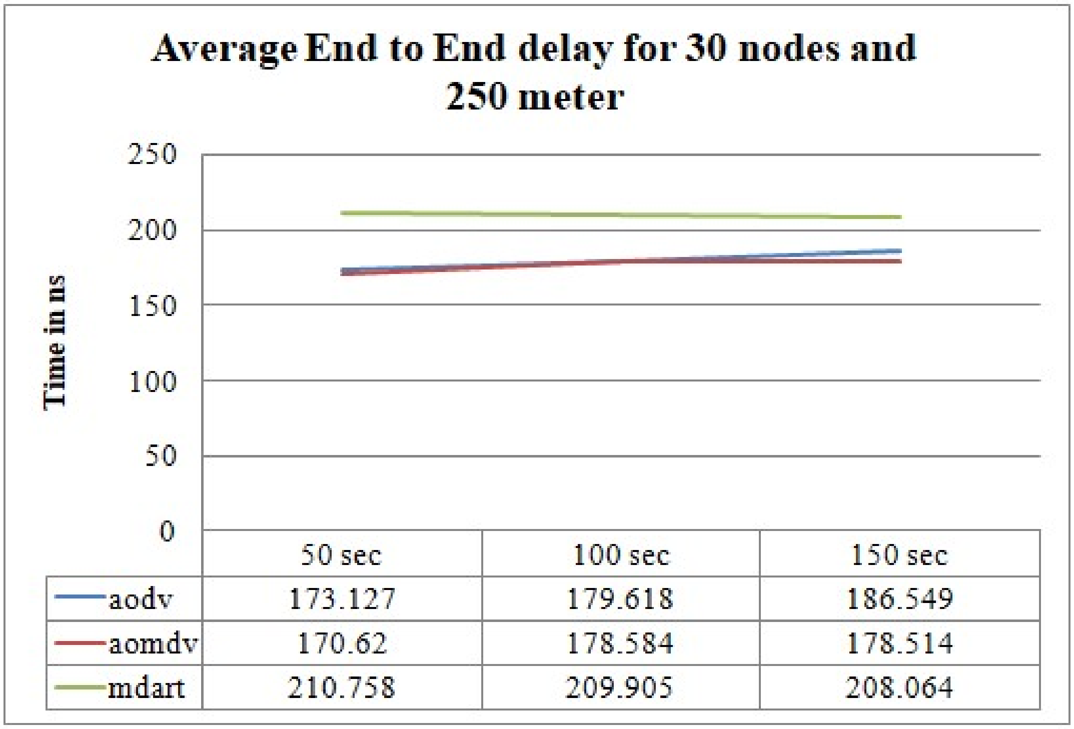


Fig 6.21 AE2ED for 30 nodes and 250m

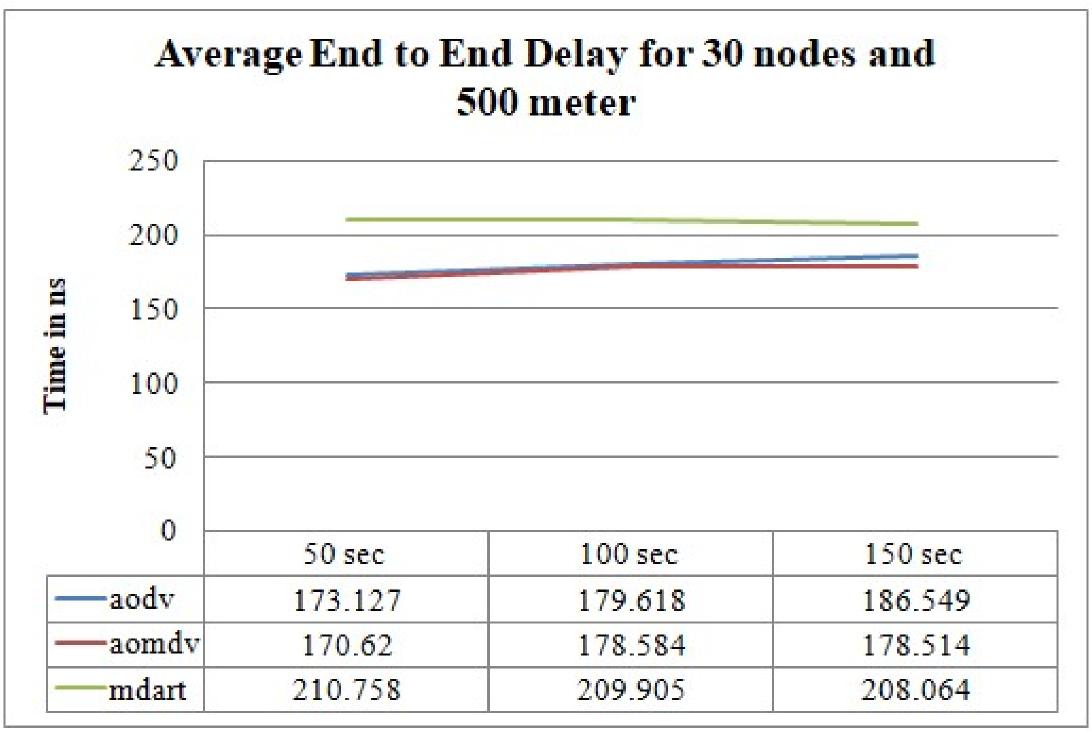


Fig 6.22 AE2ED for 30 nodes and 500m

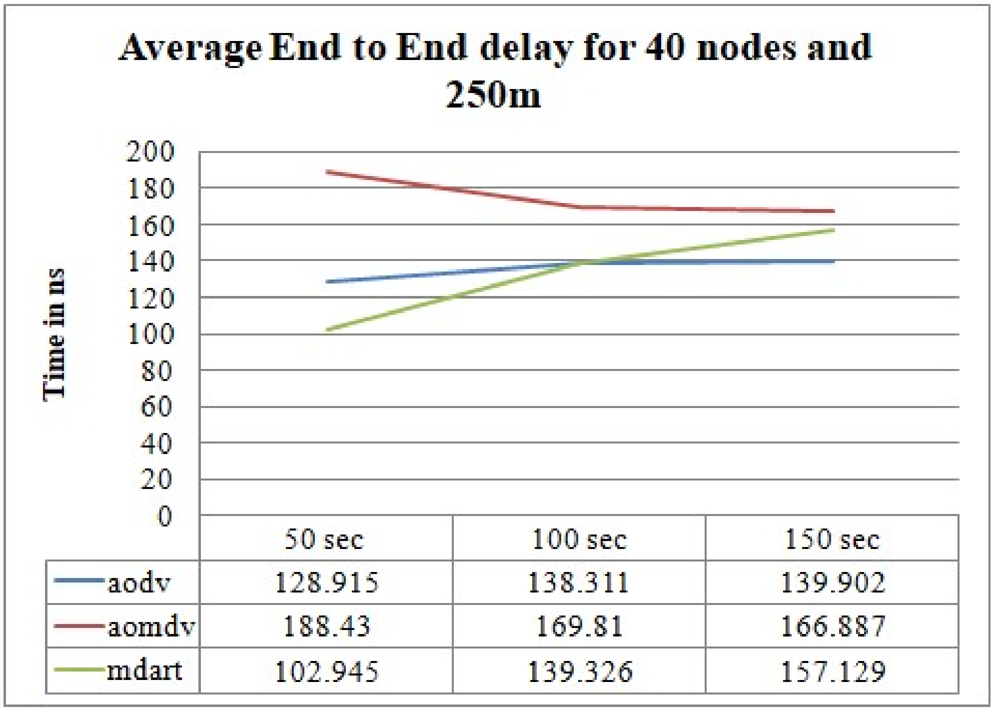


Fig 6.23 AE2ED for 40 nodes and 250m

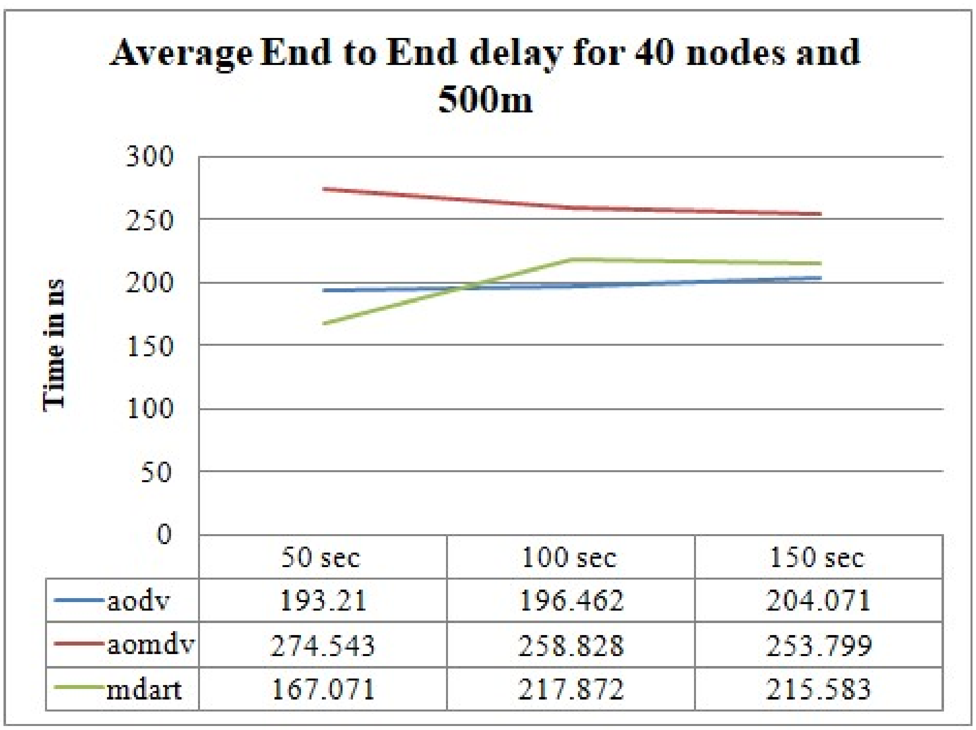


Fig 6.24 AE2ED for 40 nodes and 500m

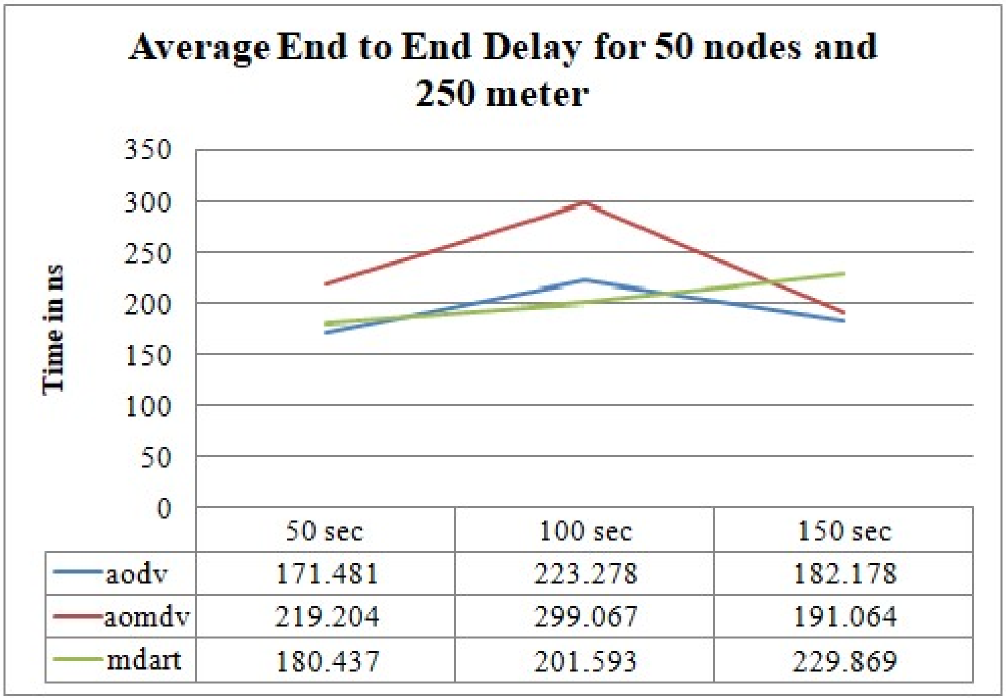


Fig 6.25 AE2ED for 50 nodes and 250m

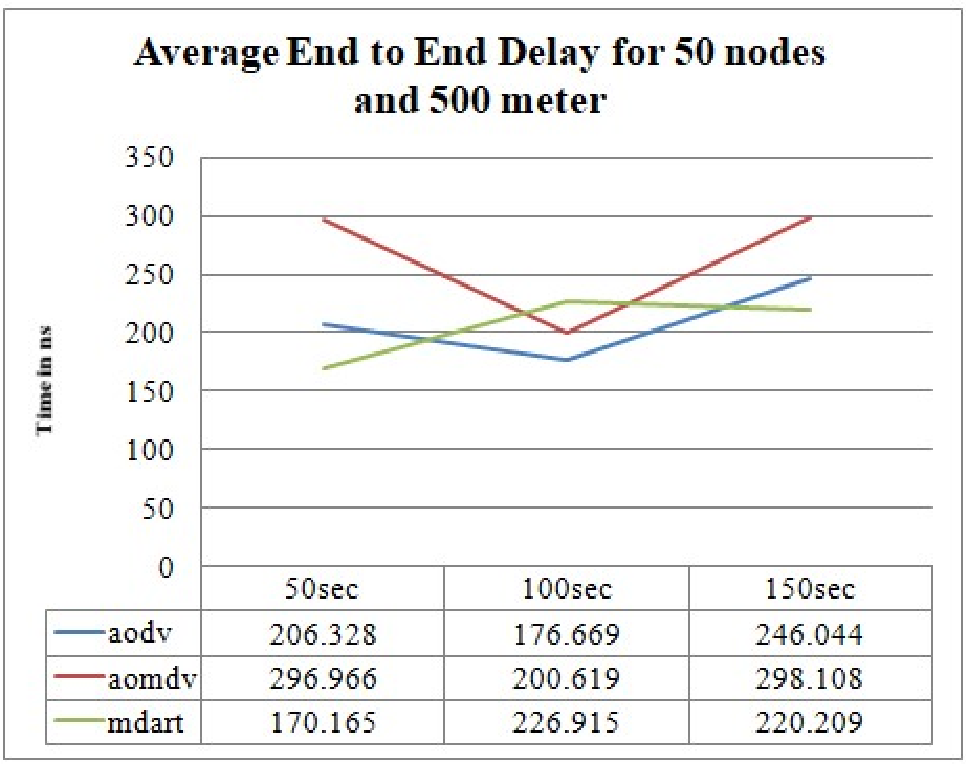


Fig 6.26 AE2ED for 50 nodes and 500m

Here it is observed that AE2ED on the basis of simulation of graph timing. So after comparing graph from fig 6.17 to 6.26, it is recognized that as AE2ED increases the transmission range is also increased. Here MDART protocol performs better in all the scenarios, whether for 10 nodes or for 50 nodes. AE2ED sometimes decreases as the simulation time is increased. AE2ED is increased as the no. of nodes are increased. In some of the cases, the AE2ED remains constant for all the protocols, the change is minor. In most of the cases, AOMDV performs worst.

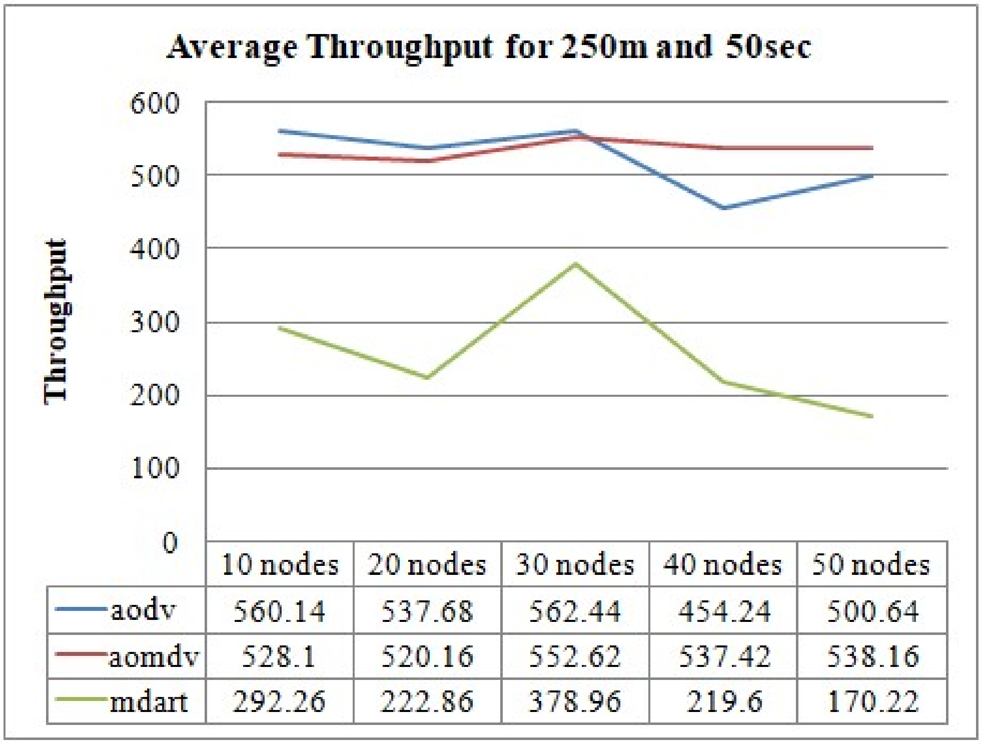
6.4. Average Throughput against Number of nodes

Throughput is termed as the ratio of a number of packets that are delivered to a receiver to per unit of time. Here the graph is drawn between Average throughput and the no. of nodes.

There are 6 different graphs on the basis of node transmission range and simulation time.

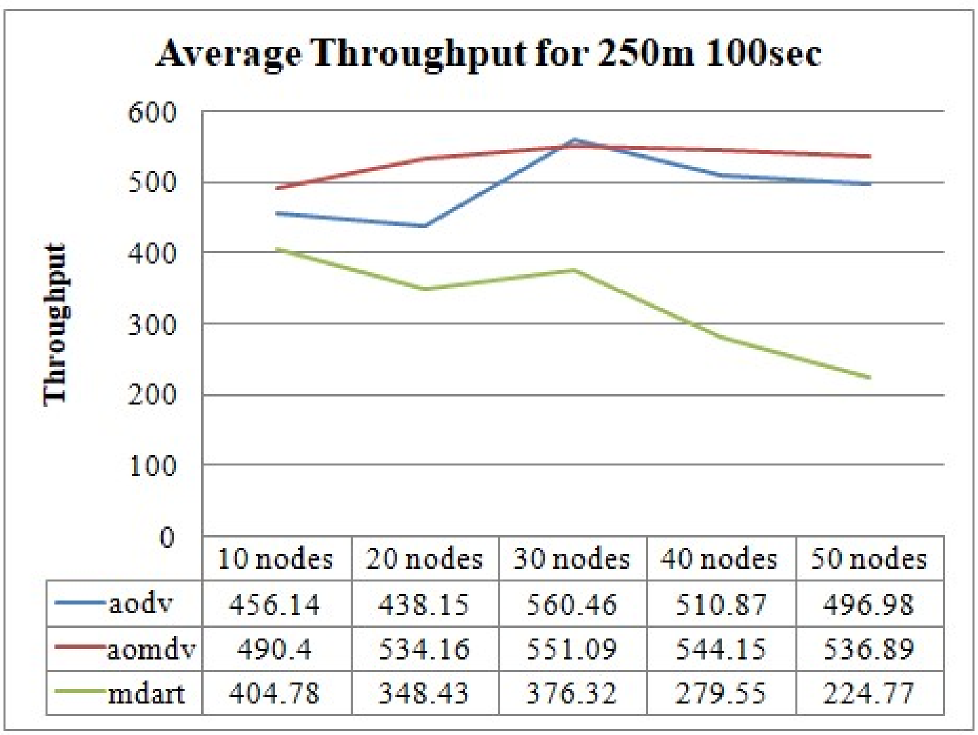
Different simulation time

1. 50 sec
2. 100 sec
3. 150 sec



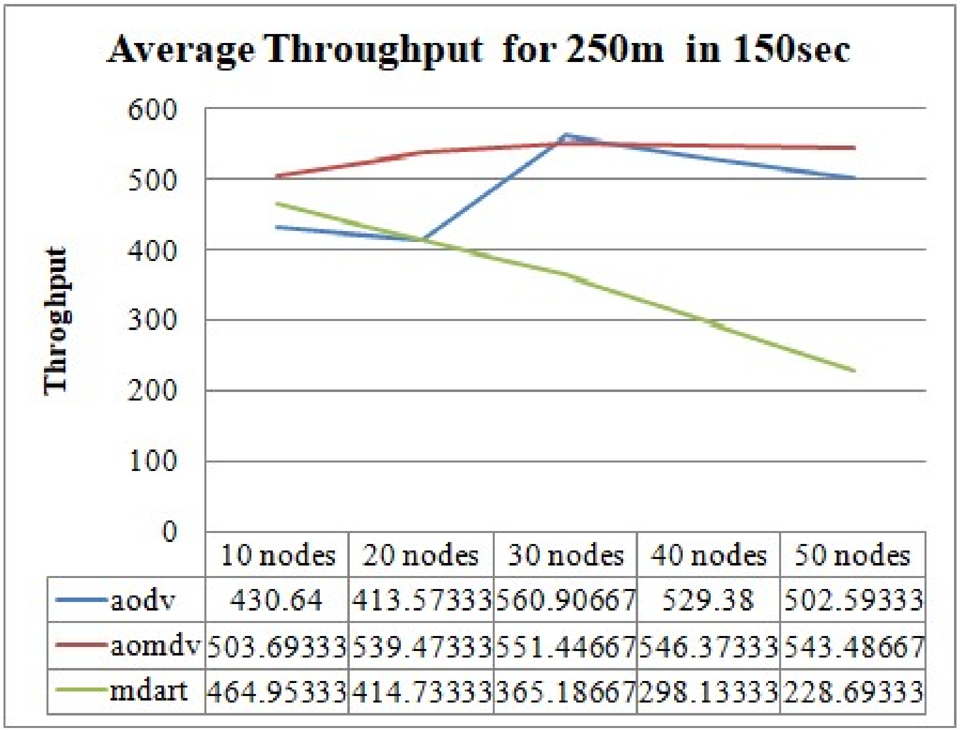
	10 nodes	20 nodes	30 nodes	40 nodes	50 nodes
aodv	560.14	537.68	562.44	454.24	500.64
aomdv	528.1	520.16	552.62	537.42	538.16
mdart	292.26	222.86	378.96	219.6	170.22

Fig 6.27 Average Throughput for 250m and 50s



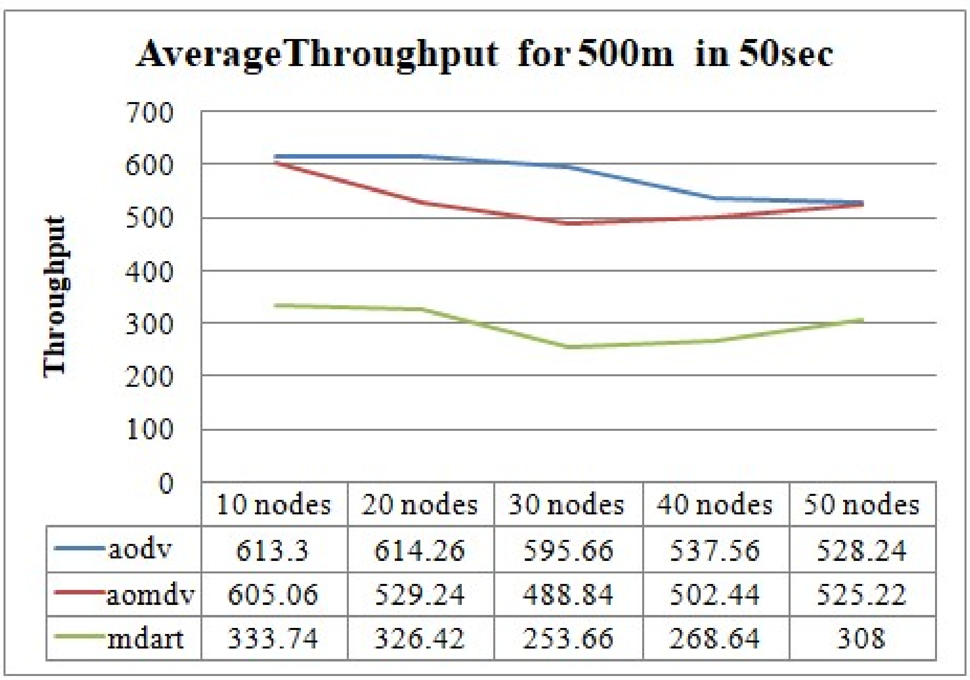
	10 nodes	20 nodes	30 nodes	40 nodes	50 nodes
aodv	456.14	438.15	560.46	510.87	496.98
aomdv	490.4	534.16	551.09	544.15	536.89
mdart	404.78	348.43	376.32	279.55	224.77

Fig 6.28 Average Throughput for 250m and 100s



	10 nodes	20 nodes	30 nodes	40 nodes	50 nodes
aodv	430.64	413.57333	560.90667	529.38	502.59333
aomdv	503.69333	539.47333	551.44667	546.37333	543.48667
mdart	464.95333	414.73333	365.18667	298.13333	228.69333

Fig 6.29 Average Throughput for 250m and 150s



	10 nodes	20 nodes	30 nodes	40 nodes	50 nodes
aodv	613.3	614.26	595.66	537.56	528.24
aomdv	605.06	529.24	488.84	502.44	525.22
mdart	333.74	326.42	253.66	268.64	308

Fig 6.30 Average Throughput for 500m and 50s

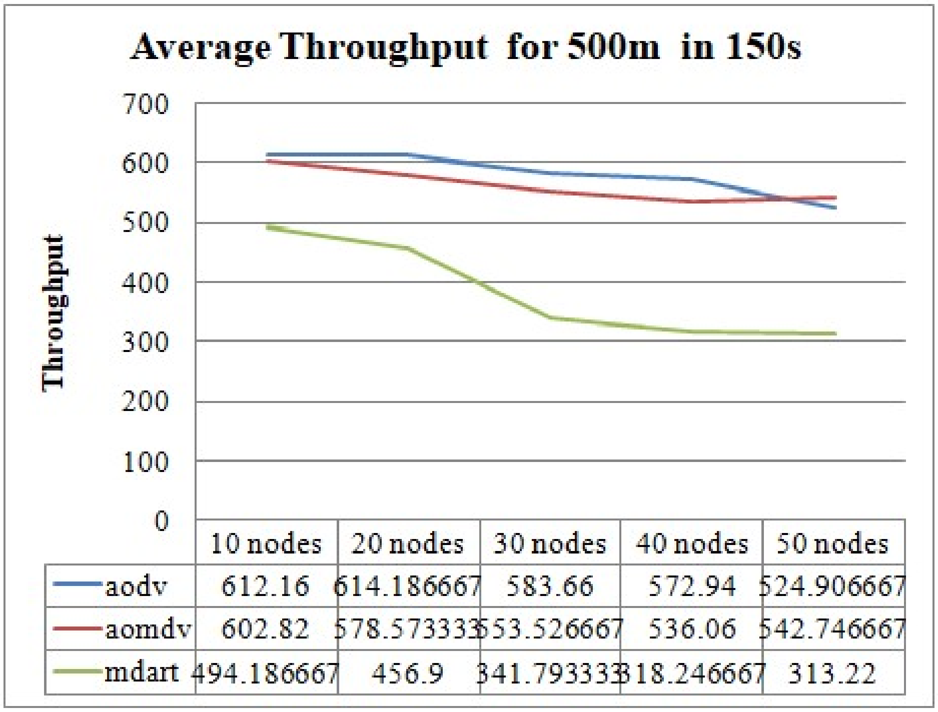


Fig 6.31 Average Throughput for 500m and 150s

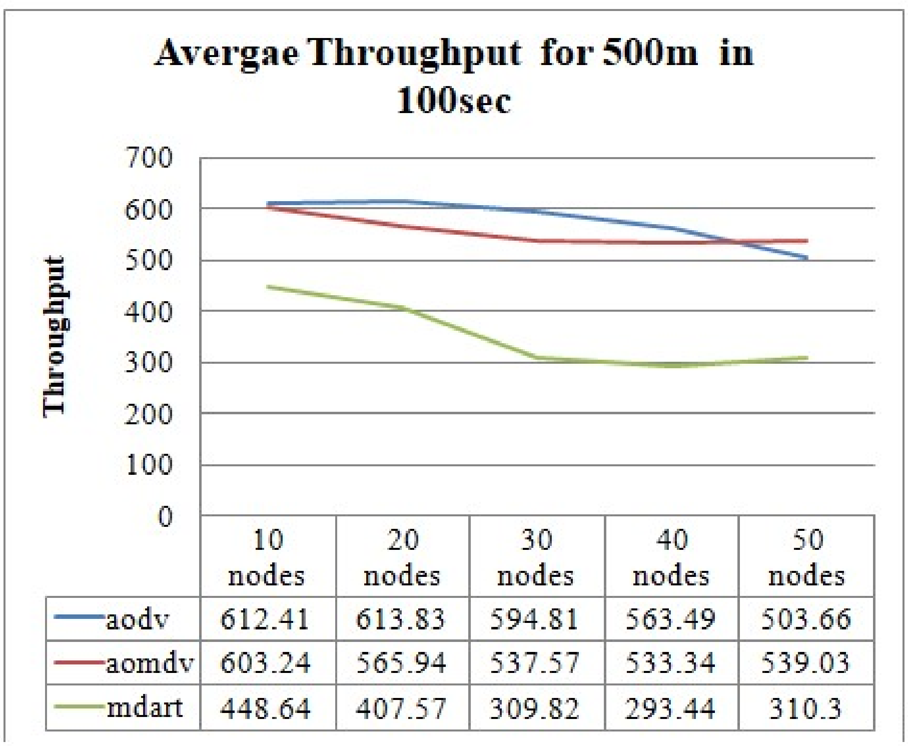


Fig 6.32 Average Throughput for 500m and 100s

From the graph Fig 6.27 to 6.32 average throughputs is compared to a number of nodes. Average Throughput of AODV & AOMDV is more as compared to MDART protocol. And also as the communication range of a node is increased the average throughput of the protocols is also increased. Here AOMDV performs better in the entire scenarios.

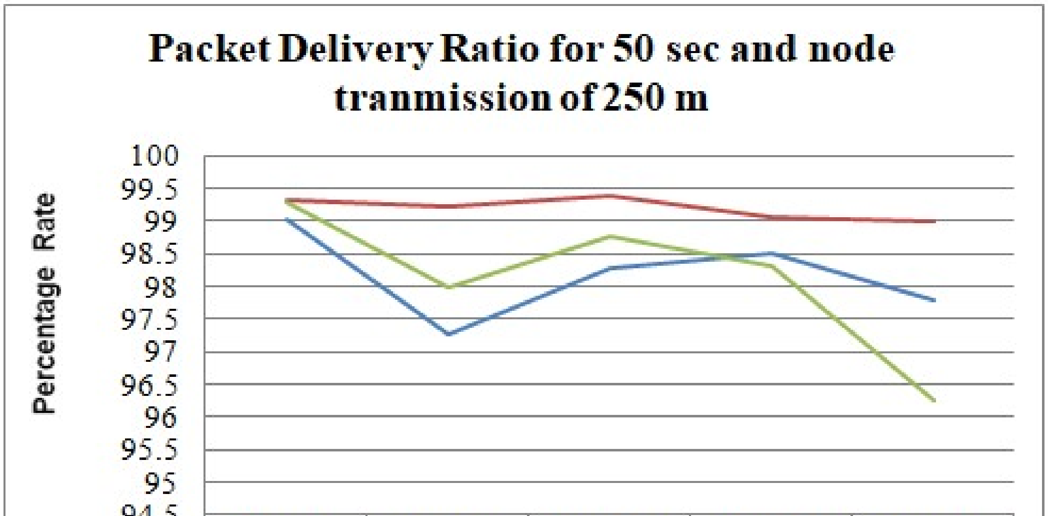
6.5. Packet Delivery Ratio against Number of Nodes

Packet Delivery ratio is the number of the packets received by CBR at the destination to the number of packets sent by the CBR from source. Or in other words ratio of the packet received by destination to those created by source.

The graph is drawn between packet delivery ratio to the number of nodes in a simulation.

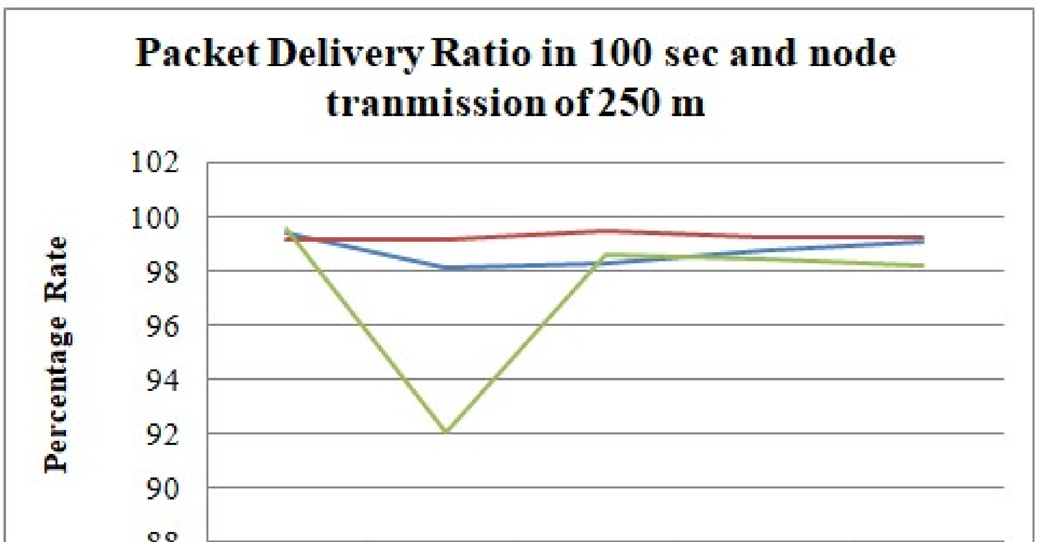
There are 6 different graphs, first on the basis of node transmission range and other on the basis of simulation time. Transmission range of nodes is 250m and 500m. And simulation time is

1. For 50 sec simulation
2. For 100 sec simulation
3. For 150 sec simulation



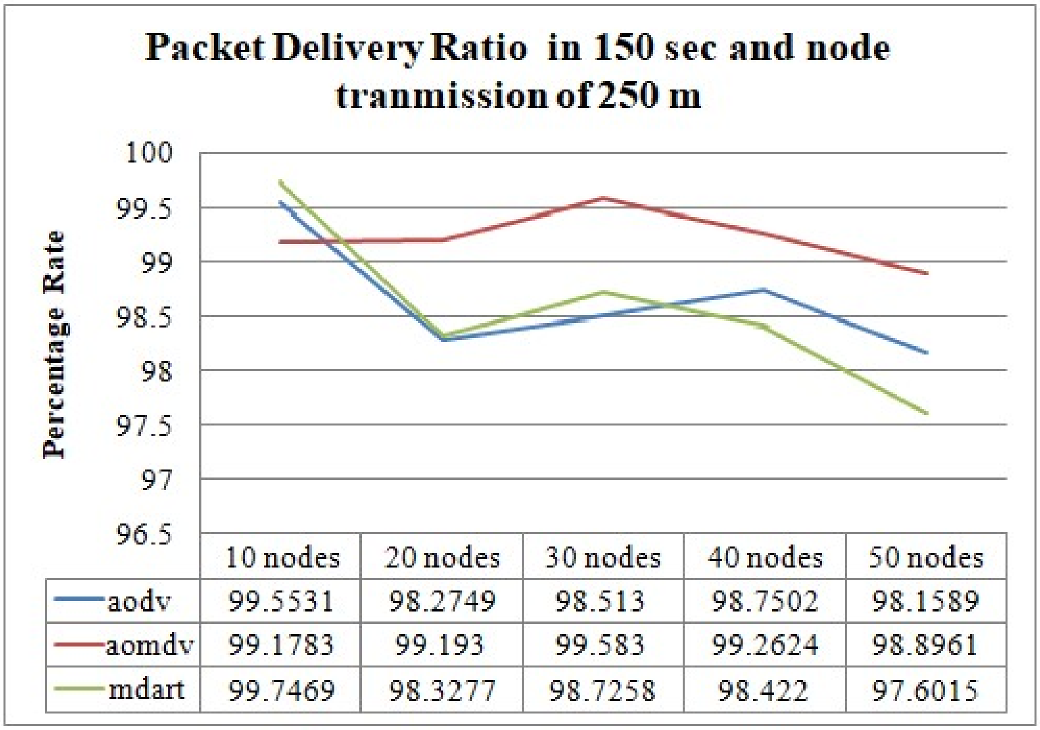
	10 nodes	20 nodes	30 nodes	40 nodes	50 nodes
aodv	99.0241	97.27	98.2703	98.508	97.7889
aomdv	99.3229	99.2412	99.3778	99.0599	98.9986
mdart	99.2933	97.99	98.7853	98.3118	96.2456

Fig 6.33 PDR for the 50s and 250m



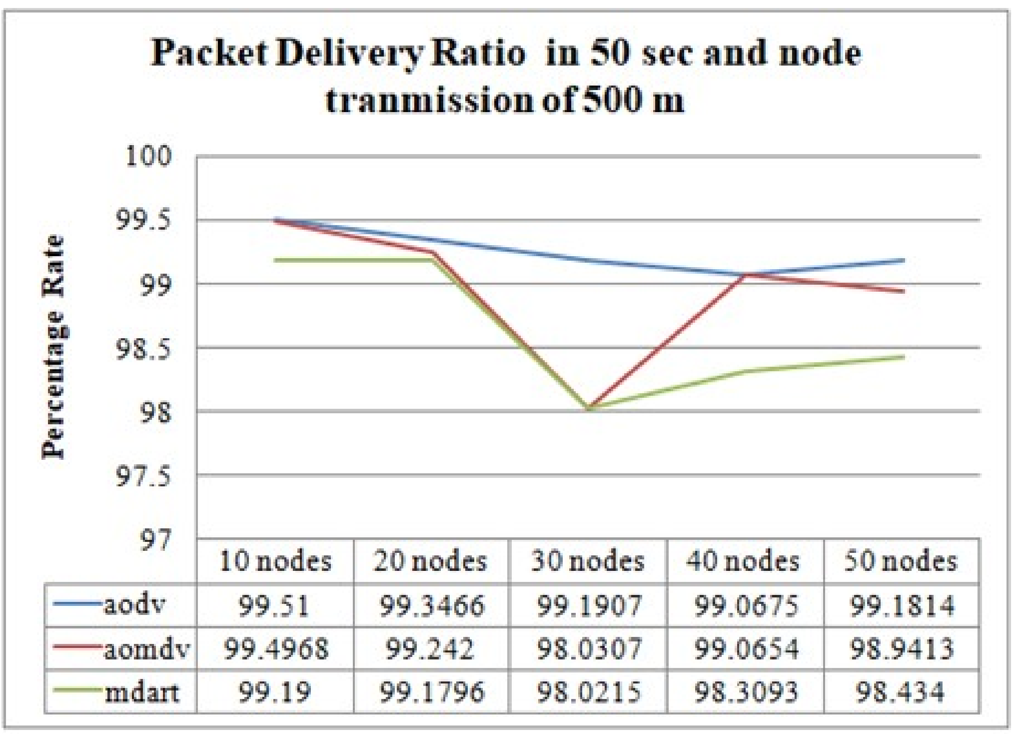
	10 nodes	20 nodes	30 nodes	40 nodes	50 nodes
aodv	99.372	98.086	98.278	98.736	99.054
aomdv	99.138	99.1918	99.4981	99.263	99.2652
mdart	99.5695	92.0416	98.5595	98.4504	98.218

Fig 6.34 PDR for 100s and 250m



	10 nodes	20 nodes	30 nodes	40 nodes	50 nodes
aodv	99.5531	98.2749	98.513	98.7502	98.1589
aomdv	99.1783	99.193	99.583	99.2624	98.8961
mdart	99.7469	98.3277	98.7258	98.422	97.6015

Fig 6.35 PDR for 150s and 250m



	10 nodes	20 nodes	30 nodes	40 nodes	50 nodes
aodv	99.51	99.3466	99.1907	99.0675	99.1814
aomdv	99.4968	99.242	98.0307	99.0654	98.9413
mdart	99.19	99.1796	98.0215	98.3093	98.434

Fig 6.36 PDR for the 50s and 500m

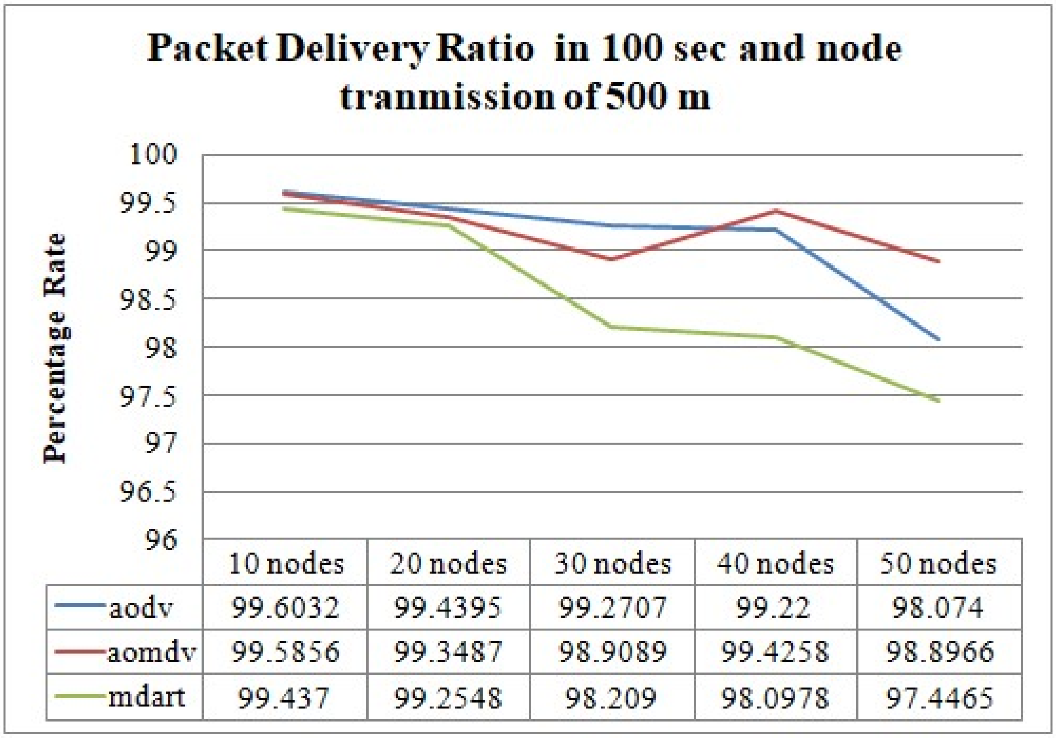


Fig 6.37 PDR for 100s and 500m

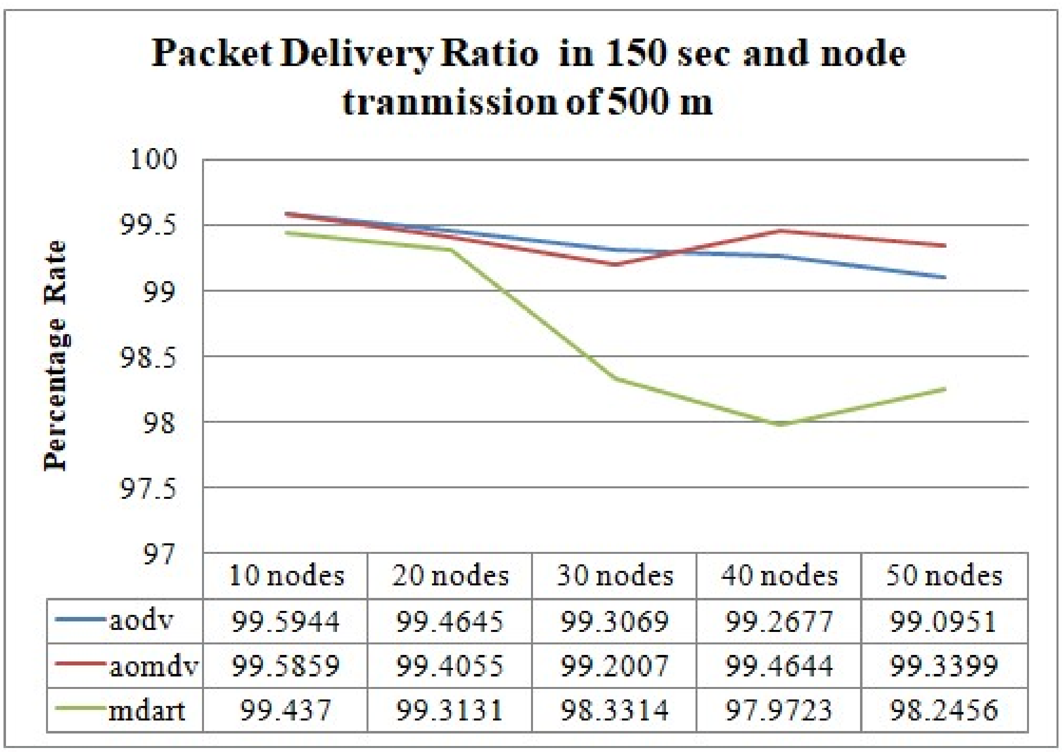


Fig 6.38 PDR for 100s and 500m

From the graphs, Fig 6.33to 6.38 shows that as the number of nodes is increased the PDR is decreased. Increasing the communication range of the nodes, PDR is also increased and gives better efficiency. Comparing to all three protocols i.e. AODV AOMDV and MDART, AOMDV gives the best PDR ratio and MDART gives the worst PDR.

CHAPTER 7

CONCLUSION & FUTURE SCOPE

7.1 Conclusion

Dissertation report is extensively separated into two parts. First part is theoretical knowledge about the problem and also analyzing the possible logical solution to the problem. The second part of this dissertation is related to the simulation studies that have been performed on NS2. In this thesis work first VANET, MANET and different types of routing protocols are studied. Further, the more promising technology called C-V2X is discussed for best results in case of various traffic management scenarios.

The experimental work in this dissertation consists of three protocols i.e. AODV, AOMDV and MDART. All these protocols are examined on the basis of an average end to end delay, average throughput and packet delivery ratio. From this simulation, come to the end of the study that as we increase the transmission range of node the PDR and average throughput is also increased. So C-V2X will be beneficial in terms of throughput and PDR. Also in the scenario of AE2ED increasing the transmission range of a node is not profitable. AOMDV protocol gives the best average throughput and improved PDR but it gives the worst AE2ED. MDART gives the better AE2ED but it gives the worst results in other cases. In the finding of this dissertation work that AOMDV needs the design improvement to give better values in the scenario of AE2ED which is also an important aspect.

7.2 Future Scope

For additional efforts in future, considering the C-V2X technology and utilizing its benefit it is possible to work with a different level of paradigm in various scenarios over more than three protocols. There is one major issue as the VANET is increasing day by day so as the security of the data. Forthcoming year’s security will become the primary concerns for routing algorithm. Various Routing algorithms work in different ways and to select the most efficient routing algorithm is a complicated task but in future, it may be possible to work on all the routing protocols.

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APPENDIX A

PUBLICATIONS

[1]. Abhijityaditya Prakash, Vinod kumar Bhalla, "*Selection of suitable Routing Protocols for coming Generation Ad-Hoc Network in Traffic Management"* Wireless Personal Communications.[Communicated]

APPENDIX B

VIDEO PRESENTATION LINK

https://www.youtube.com/user/abhijitya25

APPENDIX C

PLAGIARISM REPORT

Selection of suitable Routing Protocols for coming Generation Ad-Hoc Network in Traffic Management

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