IMPACT OF HIGH MOBILITY AND RAPID CHANGE IN NUMBER OF MOBILE NODES ON THE PERFORMANCE OF MANET PROTOCOLS

Thesis submitted in partial fulfillment of the requirements for the award of degree of

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CERTIFICATE

I hereby certify that the work which is being presented in the thesis entitled, "*Impact of High Mobility and Rapid Change in Number of Mobile Nodes on the Performance of MANET Protocols*", in partial fulfillment of the requirements for the award of degree of Master of Engineering in *Computer Science and Engineering* submitted in Computer Science and Engineering Department of Thapar University, Patiala, is an authentic record of my own work carried out under the supervision of *Vinod K 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.

(Shivender Taneja)

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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ABSTRACT

A mobile ad hoc network (MANET) is a collection of mobile nodes that are dynamically and arbitrarily located in such a manner that the interconnections between nodes are capable of changing on a continual basis. In order to facilitate communication within the network, a routing protocol is used to discover routes between nodes. The primary goal of such an ad-hoc network routing protocol is correct and efficient route establishment between a pair of nodes so that messages may be delivered in a timely manner. In such networks, nodes are able to move and synchronize with their neighbors.

Due to mobility, connections in the network can change dynamically and nodes can be added and removed at any time. One of the issues in MANET is resource management which includes routing and for routing there are particular routing protocols that gives better performance when checked with certain parameters.

Many routing protocols for Mobile ad-hoc network have been proposed. Among them, DSDV is a representative table-driven protocol, while AODV and DSR are two representative on-demand protocols.

In this thesis, we have analyzed the performance of above cited three routing protocols by varying the number of connections, varying the pause time and high changes in mobility. The performance matrix includes PDR (Packet Delivery Ratio), Throughput, Average End to End Delay and Packet Dropped. As per our findings the differences in the protocol mechanics lead to significant performance differentials for these protocols.

The performance differentials are analyzed using varying simulation time. These simulations are carried out using the ns-2 network simulator. The results presented in this work illustrate the importance in carefully evaluating and implementing routing protocols in an ad hoc environment.

Keywords: Ad-hoc, AODV, DSDV, DSR, MANNET, PDR, Throughput, End to End Delay.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1: INTRODUCTION

1.1 WIRED VS WIRELESS NETWORKS

The network that uses wires is known as a wired network. Initially the networks were mostly wired networks. When there is a use of wire in a network, definitely it also requires network adapters, routers, hubs, switches if there are more than two computers in a network. The installation of a wired network has been a big issue because the Ethernet cable should be connected to each and every computer that makes a network. Definitely this kind of connection takes time, in fact more time than expected, because when we connect wires with computers we have to take care of lot of things like wire should not come under the feet, it should be under ground or it should be under the carpet if computers are in more than one room. However in new homes nowadays, the wiring is being done in such a way that it will look like as it is a wireless connection, greatly simplifying the process of cables. Similarly the wiring of a wired network depends on lot of things like what kind of devices are being used in a wired network, whether the network is using external modem or is it internal, the type of internet connection and many other issues. As we know making a wired network is not an easy task, but still there are many other tasks that are more difficult than making a wired network, but we are not going to discuss these tasks here. In configuring the wired network, the hardware implementation is a main task [20].

Wireless communication has an enormous use these days and is still becoming popular from times immemorial. This is because of the latest technological demands nowadays arising from laptops, wireless devices such as wireless local area networks (LANs), etc. Because of its fast growing popularity day by day, it has led wireless communication data rates higher and it has made its prices cheaper, that is why wireless communication is growing so fast. Wireless communication can work between hosts by two different methods; one method is to allow the existing network carry data and voice, and second method is to make ad-hoc network so that hosts can communicate with each other [19].

Three types of mobile wireless networks exist:

- infrastructure-networks,
- ad-hoc networks and
- hybrid networks.

An infrastructure-network consists of a group of mobile nodes with some bridges. These bridges called base stations connect the wireless network to the wired network. Communication takes place between two or more nodes by first searching for the nearest base station and information flow takes place between the nodes with the base stations as a bridge between them.

In ad-hoc networks, there are no centralized base stations, fixed routers and central administration. All nodes move randomly and are capable of discovering and maintaining the routes between them. Each node acts as a router and communicates to other for a short interval of time like: emergency searches, quickly sharable information like meetings etc[6].

1.2 MANNETs

A Mobile Ad-Hoc network is a cooperative engagement of a collection of wireless mobile nodes. Mobile ad-hoc network hold the promise of the future, with the capability to establish networks at anytime, anywhere. Mobile ad hoc networks (MANETs) are collections of mobile nodes, dynamically forming a temporary network without pre-existing network infrastructure or centralized administration[8]. Nowadays a lot of research efforts focus on Mobile Ad-hoc networks. Since some receiving nodes may be out of the direct range of a sending node, intermediate nodes have to act as routers to forward the data to the receiving nodes.

Ad-hoc routing protocols have been developed to provide the route discovery and maintenance mechanisms for each mobile node in the network to communicate with all other nodes of the network. In this paper, we focus on analyzing the performance of three types of routing protocols Ad-hoc On demand Distance Vector (AODV), Dynamic Source Routing which are reactive routing protocol and, Destination-Sequenced Distance Vector (DSDV) which is a proactive link-state routing protocol. All of these protocols have been gaining great attention within the scientific community.

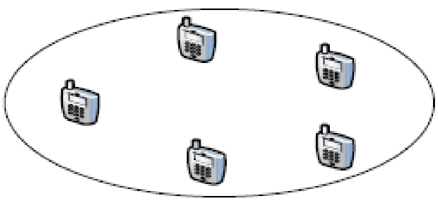

Figure 1.1: Infrastructure less network [4]

A number of characteristics of MANETs are identified:

- A network of hosts, connected by wireless links.
- Network established without a pre-existing infrastructure.
- Routes between nodes may potentially contain multiple hops
- Bandwidth-constrained, variable capacity links.
- Energy-constrained Operation.
- Physical Security.
- Dynamic network topology.
- Frequent routing updates.

Disadvantages of MANETs:

- Limited resources and physical security.
- Limited wireless transmission range.
- Intrinsic mutual trust vulnerable to attacks.
- Lack of authorization facilities.
- Volatile network topology makes it hard to detect malicious nodes.
- Security protocols for wired networks cannot work for ad hoc networks.

Applications of MANETs:

- Cooperative and mobile data exchange in case of industrial and commercial applications
- MANETs combined with satellite-based information delivery, provides an extremely flexible method for establishing communications for fire/safety/rescue operations.
- MANETs can also be used by students to participate in an interactive lecture using their laptops computers.

2.1 ROUTING

Routing is the act of moving information from a source to a destination in an internet work. At least one intermediate node within the internetwork is encountered during the transfer of information. Basically two activities are involved in this concept: determining optimal routing paths and transferring the packets through an internet work.

The transferring of packets through an internetwork is called as packet switching which is straight forward, and the path determination could be very complex.

Routing protocols use several metrics as a standard measurement to calculate the best path for routing the packets to its destination that could be number of hops, which are used by the routing algorithm to determine the optimal path for the packet to its destination. The process of path determination is that, routing algorithms find out and maintain routing tables, which contain the total route information for the packet. The information of route varies from one routing algorithm to another. The routing tables are filled with entries in the routing table are ip-address prefix and the next hop. Destination/next hop associations of routing table tell the router that a particular destination can be reached optimally by sending the packet to a router representing the -next hop. on its way to the final destination and ip-address prefix specifies a set of destinations for which the routing entry is valid.

Routing is mainly classified into static routing and dynamic routing. Static routing refers to the routing strategy being stated manually or statically, in the router.

Static routing maintains a routing table usually written by a networks administrator. The routing table doesn‘t depend on the state of the network status, i.e., whether the destination is active or not [3].

Dynamic routing refers to the routing strategy that is being learnt by an interior or exterior routing protocol. This routing primarily depends on the state of the network i.e., the routing table is affected by the activeness of the destination.

2.2 AD-HOC ROUTING PROTOCOL

2.2.1 Definition

A routing protocol is a protocol that specifies how routers communicate with each other, disseminating information that enables them to select routes between any two nodes on a computer network, the choice of the route being done by routing algorithms. Each router has a priori knowledge only of networks attached to it directly. A routing protocol shares this information first among immediate neighbors, and then throughout the network. This way, routers gain knowledge of the topology of the network[1].

The Mobile ad-hoc routing protocols can be divided into two categories:

Table-driven routing protocols: In table driven routing protocols, consistent and up-to-date routing information to all nodes is maintained at each node. These protocols require each node to store their routing information and when there is a change in network topology updating has to be made throughout the network [8].

On-Demand routing protocols: In On-Demand routing protocols, the routes are created as and when required. This type of protocols finds a route on demand by flooding the network with Route Request packets. When a source wants to send to a destination, it invokes the route discovery mechanisms to find the path to the destination[8].

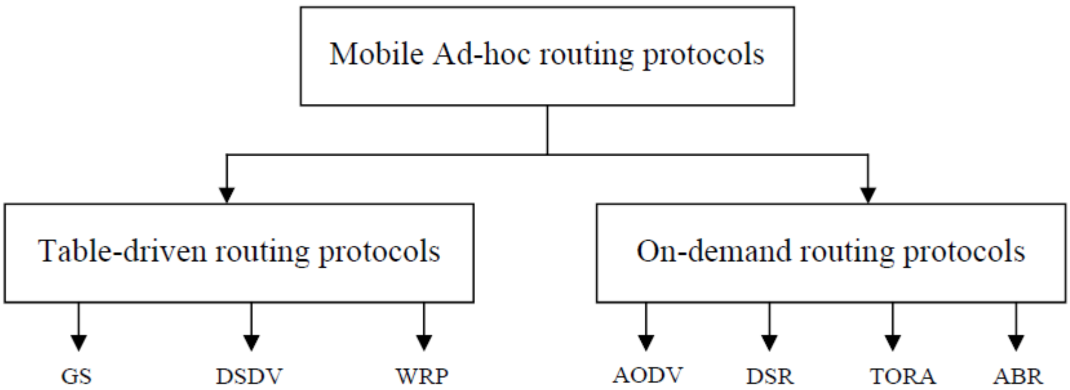

Figure 2.1: Mobile Ad-hoc routing protocols

In recent years, a variety of new routing protocols targeted specifically at this environment have been developed. List containing most of the ad hoc protocols found on the internet. The protocols are sorted based on the type of routing they use. The classic pro-active type updates the routing tables on a regular basis compared to the reactive where they only are updated when requested. The reactive type is very popular in ad hoc networks since they adapt fast which is a key feature. Then there is the hierarchical type which usually combines two or more strategies to create several routing-layers. Routing based on geographical information have also been used but usually requires extra equipment compared to the other protocols. Last of the unicast-protocols are the power-aware that optimize usage of the power stored in the nodes and last there are two sections with multicast protocols.

2.2.2 Properties of Ad-Hoc Routing protocols

The properties that are desirable in Ad-Hoc Routing protocols are [21]:

i). Distributed operation: The protocol should be distributed. It should not be dependent on a centralized controlling node. This is the case even for stationary networks. The dissimilarity is that the nodes in an ad-hoc network can enter or leave the network very easily and because of mobility the network can be partitioned.

ii). Loop free: To improve the overall performance, the routing protocol should assurance that the routes supplied are loop free. This avoids any misuse of bandwidth or CPU consumption.

iii). Demand based operation: To minimize the control overhead in the network and thus not misuse the network resources the protocol should be reactive. This means that the protocol should react only when needed and should not periodically broadcast control information.

iv). Unidirectional link support: The radio environment can cause the formation of unidirectional links. Utilization of these links and not only the bi-directional links improves the routing protocol performance.

v). Security: The radio environment is especially vulnerable to impersonation attacks so to ensure the wanted behavior of the routing protocol we need some sort of security measures. Authentication and encryption is the way to go and problem here lies within distributing the keys among the nodes in the ad-hoc network.

vi). Power conservation: The nodes in the ad-hoc network can be laptops and thin clients such as PDA‘s that are limited in battery power and therefore uses some standby mode to save the power. It is therefore very important that the routing protocol has support for these sleep modes.

vii). Multiple routes: To reduce the number of reactions to topological changes and congestion multiple routes can be used. If one route becomes invalid, it is possible that another stored route could still be valid and thus saving the routing protocol from initiating another route discovery procedure.

viii). Quality of Service Support: Some sort of Quality of service is necessary to incorporate into the routing protocol. This helps to find what these networks will be used for. It could be for instance real time traffic support.

2.3 CLASSIFICATION OF ROUTING PROTOCOLS

The routing protocols can be divided as flat-routing, hierarchical routing and geographic position assisted routing on network structure.

2.3.1 Proactive(Table-Driven) Routing Protocols

In this routing protocol, each node is allocated more than one table containing the latest information about the routes in the network with respective costs of the routes between two nodes. Since, there are many table-driven routing protocols; routing information-updation, the number of tables related to each protocol differs them in one or other way. The protocols work good only when the network is small, as the increased number of nodes will cause more overhead of updation of information inside a table related to each node with more bandwidth consumption. An example of this protocol is Destination Sequenced Distance Vector (DSDV)

2.3.2 Reactive (On-Demand) Protocols

As the name suggests, there is no procedure of maintaining and updating tables according to latest route topology. Whenever a communication is desired, route discovery by flooding the route request packets throughout the network is done leading to connection establishment and further sending and receiving of packets within the network. Examples of On-demand routing protocol are Dynamic Source Routing (DSR), Ad-hoc On-demand Distance Vector Routing (AODV)

2.3.3 Flat Routing Protocols

Flat routing protocols distribute information as needed to any router that can be reached or receive information. No effort is made to organize the network or its traffic, only to discover the best route hop by hop to a destination by any path. Think of this as all routers sitting on a flat geometric plane. Routing Information Protocol (RIP) is an example of a flat routing protocol.

These protocols are further subdivided into Reactive routing-protocol (on-demand), Proactive routing protocol (table-driven) and Hybrid-protocols. Proactive routing is mostly based on LS (link-state) while on-demand routing is based on DV (distance-vector).

2.3.4 Hybrid Routing Protocols

The different types of delays and overheads suffered by reactive and proactive protocols are recovered in a hybrid network. Whenever the network is small, proactive routing is used and reactive routing is used for larger networks making it a hybrid network. The protocol is suitable for highly versatile networks, characterized by a large range of nodal mobility and large network diameters. An example of it is ZRP (Zone Routing Protocol)

2.3.5 Hierarchical Routing Protocols

Heirarchical routing protocols often group routers together by function into a hierarchy. A heirarchical protocol allows an administrator to make best use of his fast powerful routers as backbone routers, and the slower, lower powered routers may be used for access purposes. In this way, the access routers form the first tier of the hierarchy, and the backbone routers form the second tier. Hierarchichal protocols make an effort to keep local traffic local, that is, they will not forward traffic to the backbone if it is not necessary to reach a destination. Some hierarchical protocols also perform route aggregation to reduce the number of routes advertised (only summary routes are advertised).

A Hierarchical-network is used when the size of network inside a MANET[8] increases tremendously. Some examples of the protocol are Hierarchical State Routing (HSR), Zone Routing Protocol (ZRP), Cluster-head Gateway Switch Routing Protocol (CGSR), Land-Mark

Ad-Hoc Routing Protocol (LANMAR)

2.3.6 Geographical Routing Protocols

Two approaches to geographic mobile ad- hoc networks are i.e. Actual geographic coordinates (as obtained through GPS – the Global Positioning System) and Reference points in some fixed coordinate system. For the effective location based routing, the routing updates must be done faster in compare of the network mobility rate as the node positions changes quickly in the network. Some of its examples are: Geo-Cast (Geographic Addressing and Routing), DREAM (Distance Routing Effect Algorithm for Mobility), GPSR (Greedy Perimeter Stateless Routing).

Table 2.1: Comparison of Proactive and Reactive routing protocols

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

2.4 DESTINATION SEQUENCED DISTANCE VECTOR ROUTING

DSDV is a table driven algorithm based on the classical Bellman Ford routing mechanism. Every mobile node in the network maintains a routing table in which all the possible destinations within the network and the number of hops to each destination are recorded. Each entry is marked with a sequence number assigned by the destination node. The sequence number enables the mobile nodes to distinguish stale routes from new ones, thereby avoiding the formation of routing loops. Routing table updates the periodically transmitted throughout the network in order to maintain table consistency. To help alleviate the potentially large amount of network traffic that such updates can generate, route updates can employ two possible types of packets. The first is known as a “full dump”. This type of packet carries all available routing information and can require multiple network protocol data units (NPDUs). During periods of occasional movement, these packets are transmitted infrequently. The mobile nodes maintain an additional table where they store the data sent in the incremental routing information packets. New route broadcast contain the address of the destination, the number of hops to reach the destination, the sequence number of the information received regarding the destination, as well as the new sequence number unique to the broadcast. The route labeled with the most recent sequence number is always used. In the event that two updates have the same sequence number, the route with the smaller metric is used in order to optimize the path[2].

2.5 DYNAMIC SOURCE ROUTING (DSR) PROTOCOL

DSR protocol is an on-demand routing protocol that is based on the concept of source routing. Mobile nodes are required to maintain route caches that contain the source routes of which the mobile is aware. Entries in the route cache are continually updated as new routes are learned. The protocol consists of two major phases: route discovery and route maintenance. When a mobile node has a packet to send to some destination, it first consults its route cache to determine whether it already has a route to the destination. If it has an unexpired route to the destination, it will use this route to send the packet. On the other hand, if the node does not have such a route, it initiates route discovery by broadcasting a route request packet. This route request contains the address of the destination, along with the source node's address and a unique identification number. Each node receiving the packet checks whether it knows of a route to the destination. If it does not, it adds its own address to the route record of the packet and then forwards the packet along its outgoing links. To limit the number of route requests propagated on the outgoing links of a node, a mobile only forwards the route request if the mobile has not yet seen the request and if the mobile's address does not already appear in the route record. A route reply is generated when the route request reaches either the destination itself, or an intermediate node, which contains in its route cache an unexpired route to the destination. By the time the packet reaches either the destination or such an intermediate node, it contains a route record yielding the sequence of hops taken [2].

2.6 AD-HOC ON-DEMAND DISTANCE VECTOR (AODV) ROUTING PROTOCOL

AODV is a routing protocol builds on the DSDV algorithm. AODV is an improvement on DSDV because it typically minimizes the number of required broadcasts by creating routes on an on-demand basis, as opposed to maintaining a complete list of routes as in the DSDV algorithm. AODV is a pure on-demand route acquisition system, as nodes that are not on a selected path do not maintain routing information or participate in routing table exchanges. When a source node desires to send a message to some destination node and does not already have a valid route to that destination, it initiates a path discovery process to locate the other node. It broadcasts a route request(RREQ) packet to its neighbors, which then forward the request to their neighbors, and son on, until either the destination or an intermediate node with a "fresh enough" route to the destination is located. Each node maintains its own sequence number, as well as a broadcast ID [2].

2.7 TEMPORALLY ORDERED ROUTING ALGORITHM (TORA)

The Temporally Ordered Routing Algorithm (TORA) is a source-initiated on-demand routing protocol and Invented by Vincent Park and M.Scott Corson from University of Maryland.. It is a highly adaptive, proficient and scalable distributed routing algorithm based on the concept of link reversal [12]**.** TORA is proposed for highly dynamic mobile, multihop wireless networks [11]. It searches multiple routes from a source node to a destination node. The principal feature of TORA is that the control messages are localized to a very small set of nodes near the occurrence of a topological change. To achieve this, the nodes retain routing information about adjacent nodes. The protocol has three essential functions: **-** Route creation, Route maintenance, and Route erasure. Some quintuple are associated with every node [29]-

- Logical time of a link failure
- The unique ID of the node that defined the new reference level
- A reflection indicator bit
- A propagation ordering parameter
- The unique ID of the node

The first three elements jointly stand for the reference level. A new reference level is defined each time a node loses its last downstream link due to a link breakdown. The last two values define a delta with respect to the reference level.

2.8 ASSOCIATIVITY BASED ROUTING (ABR)

The Associativity Based Routing (ABR) protocol is a new approach for routing proposed by C.K. Toh at the Cambridge University in 1996 [22]. ABR defines a new metric for routing known as the degree of association stability. It is free from loops, deadlock, and packet duplicates.

In ABR, a route is chosen based on associativity states of nodes and temporal stability of the links between the nodes [23]. ABR is beacon-based, so that each node generates periodic beacons (hello messages) to indicate its existence to the neighbors. These beacons are used to revise the associativity table of each node. With the temporal stability and the associativity table the nodes are able to classify each neighbor link as stable or unstable. The fundamental objective of ABR is to find longer-lived routes for ad hoc mobile networks. The three phases of ABR are Route discovery, Route reconstruction (RRC) and Route deletion [22].

Stable routes have a higher preference compared to shorter routes. Fewer paths will break which reduces flooding (bandwidth). In ABR a broken link is repaired locally, so the source node would not begin a new path-finding-process when a broken link appears.

Stability information is only used during the route selection process. Sometimes the elected path may be longer than the shortest path, because of the preference given to stable paths, which are not necessary, a disadvantage. In ABR local query broadcasts may result in high delays during the route repair.

2.9 PERFORMANCE BASED WORK

Comparison Performance Analysis of DSDV, AODV and DSR routing protocol in MANET using NS2 proposed in [4] tells us about the mobility, changing connections in the network dynamically and addition and removal of nodes at any time. They also compared the performance of three protocols and generate throughput, end-to-end delay and routing overhead by changing the size and mobility. [5] proposed the performance evaluation of AODV, DSDV and DSR routing protocol in grid environment i.e. distributed, high performance computing and data handling infrastructure, and a comparison between them using the performance metric such as packet delivery fraction, average end-to-end delay and packet loss. [6] proposed a simulation based performance comparison of routing protocol on mobile ad-hoc network (proactive, reactive and hybrid) and detailed simulation based performance of four different quantitative metrics like packet delivery fraction, average end-to-end delay, jitter and throughput. In [7], comparison of the effectiveness of AODV, DSDV and DSR routing protocols in mobile ad-hoc networks and evaluates the performance of ad hoc network routing protocols and the metrics considered were packet delivery fraction, average end to end delay ad number of packets dropped. In [8], comparison of the performance of routing protocols AODV and DSR using the tool ns-2 and were compared in terms of packet loss ratio, end to end delay, with mobile nodes varying number of nodes and speed and concludes that AODV is preferred due to its more efficient use of bandwidth. In [9], comparison of AODV and DSR On-demand routing protocols on the parameters like packet delivery fraction i.e. throughput, average end-to-end delay and normalized routing overhead using ns-2 and the performance analysis is done by varying mobility pattern(pause time and speed) and traffic pattern(sending rate) and concluded that DSR slightly outperformed AODV. In [15], there is the efficiency evaluation and comparison of AODV and DSDV routing protocols in MANETs on the bases of different network scenarios with various node mobility, number of nodes and terrain size and concluded that the increasing number of nodes, terrain size and maximum node speed bring the decrease of the efficiency of routing protocols, AODV performs worse than the DSDV and efficiency of AODV is about 25% of DSDV when the number of nodes is varying and about 60% of DSDV when maximum node speed is varying. In [16], analysis of DSR and DSDV protocols for different mobility models on different scenarios like random wayward mobility, Group mobility, Freeway and Manhattan models. Performance comparison has also been conducted across varying node densities and number of hops. The mobility of the nodes affects the number of average connected paths, which in turn affect the performance of the routing algorithm and concluded that DSR gives better performance for highly mobile networks than DSDV.

CHAPTER 3: PROBLEM STATEMENT

3.1 PROBLEM STATEMENT

The objective is to compare the performance of three routing protocols based on Table Driven and On-Demand behavior namely, Destination Sequenced Distance Vector (DSDV), Ad-hoc On-Demand Distance Vector (AODV) and Dynamic Source Routing (DSR), for wireless ad hoc networks based on the performance, and comparison on the basis of their properties like throughput, packet delivery ratio (PDR), end to end delay and data packet loss with respect to three different scenarios:

- By varying the number of nodes
- By varying the mobility of nodes,
- and lastly by varying pause time.

The general objectives can be outlined as follows:

1) Study of Ad-Hoc Networks.
2) Detailed study of DSDV, AODV and DSR
3) Generate a simulation environment that could be used for simulation of protocols on the basis of different scenarios.
4) Performance metric such as Throughput, End-to-End Delay, Packet Delivery Ratio and Packet Loss of different routing protocols will be compared so as to find the optimal routing algorithm with respect to considered network scenarios.

CHAPTER 4: METHODOLOGY

4.1 METHODOLOGY

There are mainly three techniques for performance evaluation which are analytical modeling, simulation and measurement. In this paper we have chosen simulation for performance evaluation. Simulation had being chosen because it is the most suitable technique to get more details that can be incorporate and less assumption is required compared to analytical modeling. Accuracy, times available for evaluation and cost allocated for the thesis are also another reason why simulation is chose. By using simulation, researchers should be allowed to study a system in well-known conditions, repeatability if necessary in order to understand events.

4.2 COMPUTER NETWORK SIMULATOR TOOLS

There are many simulators such as Network Simulator 2 (NS-2), OPNET Modeler, GloMoSim, OMNeT++ and etc. In this our work we have choose NS2.34. NS (version 2) is an object-oriented, discrete event driven network simulator developed at UC Berkely written in C++ and OTcl. NS-2 is chosen as the simulation tool among the others simulation tools because NS-2 supports networking research and education. Ns-2 is suitable for designing new protocols, comparing different protocols and traffic evaluations.

4.2.1 Network Simulator 2 (NS2)

In our work we choose Network Simulation Tool (NS-2). NS (version 2) is an object-oriented, discrete event driven network simulator developed at UC Berkely written in C++ and OTcl. NS-2 is primarily useful for simulating local and wide area networks. Although NS is fairly easy to use once you get to know the simulator, it is quite difficult for a first time user, because there are few user-friendly manuals. The purpose of our work is to give a new user some basic idea of how the simulator works, how to setup simulation networks, etc., mainly by giving simple examples and brief explanations based on our experiences. NS-2 interprets the simulation scripts written in OTcl. A user has to set the different components (e.g. event scheduler objects, network components libraries and setup module libraries) up in the simulation environment. The user writes his simulation as OTcl script, plumbs the network components together to the complete simulation.

4.3 SIMULATION MODEL

We run the simulation in Network Simulator (NS-2.34) accepts as input a scenario file and a Traffic File (CBRfile) that describes the exact motion of each node and the exact packets originated by each node. The detailed trace file created by each run is stored to disk, and analyzed using a variety of scripts, particularly one called file *.tr that counts the number of packets successfully delivered and Average end to end delay, Average Throughput, as well as additional information about the internal functioning of each scripts executed. This data is further analyzed with AWK file and Microsoft Excel to produce the graphs.

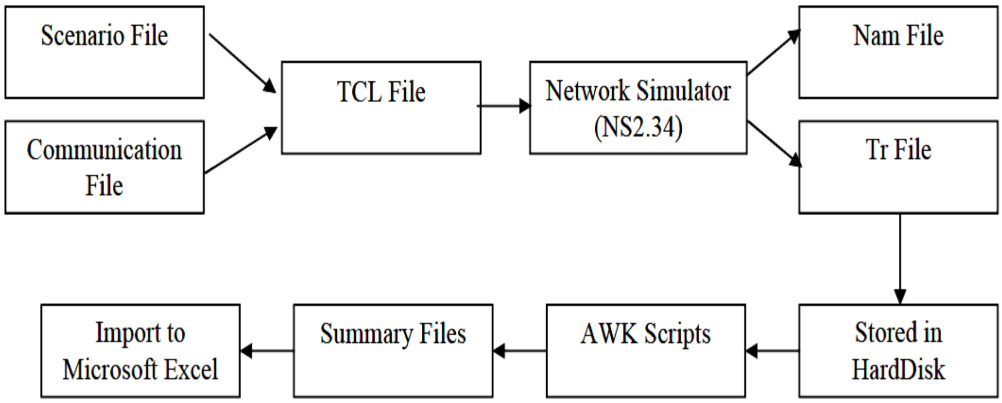

Figure 4.1: Methodology

4.4 PERFORMANCE METRICS

4.4.1 Packet delivery Ratio (PDF) — also know as the ratio of the data packets delivered to the destinations to those generated by the CBR sources. The PDR shows how successful a protocol performs delivering packets from source to destination. The higher for the value give use the better results. This metric characterizes both the completeness and correctness of the routing protocol also reliability of routing protocol by giving its effectiveness[5].

$$Packet\ Delivery\ Ratio\ (\%) : \frac{\sum_{1}^{n} Packet\ \text{Received}}{\sum_{1}^{n} Packet\ Sent} * 100$$

4.4.2 Average end-to-end delay of data packets — There are possible delays caused by buffering during route discovery latency, queuing at the interface queue, retransmission delays at the MAC, and propagation and transfer times. In this paper we use Average end-to-end delay. Average end-to-end delay is an average end-to-end delay of data packets. It also caused by queuing for transmission at the node and buffering data for detouring. Once the time difference between every CBR packet sent and received was recorded, dividing the total time difference over the total number of CBR packets received gave the average end-to-end delay for the received packets. This metric describes the packet delivery time: the lower the end-to-end delay the better the application performance [5].

$$Average\ End\ to\ End\ Delay = \frac{\sum_{1}^{n} (Packet\ Send\ Time - Packet\ \text{Received}\ Time)}{\sum_{1}^{n} Packet\ \text{Received}}$$

4.4.3 Throughput: The throughput is defined as the total amount of data a receiver receives from the sender divided by the time it takes for the receiver to get the last packet [6].

4.4.4 Packet Dropped: The routers might fail to deliver or drop some packets or data if they arrive when their buffer are already full. Some, none, or all the packets or data might be dropped, depending on the state of the network, and it is impossible to determine what will happen in advance [19].

CHAPTER 5: TESTING AND RESULTS

5.1 SIMULATION DESIGN

This section described how to design and implement the comparison between the AODV, DSR and DSDV routing protocol using performance metric such as average end to end delay, packet loss and packet delivery fraction performance metrics. The value of simulation in studies of protocols is that it allows near perfect experimental control: experiments can be designed at will and then rerun while varying an experimental variable and holding all other variables constant. With simulation, it is also possible to test the behavior of networks with more nodes than physical equipment is available for, or networks with equipment that does not even exist yet[5].

The overall goal of this simulation study is to analyze the performance of AODV, DSDV and DSR routing protocols in Mobile Ad-hoc environment. The simulation has been performed using NS2 version 2.34, software that provides scalable simulations of Ad hoc Networks Here the traffic and mobility model is different from the common traffic and mobility model used in. This traffic model is designed for area of mobile nodes and used reasonable mobility/traffic speed in any realistic military scenarios. Traffic sources are TCP packets, the packet rate at the source node is 4 packets/sec. The source destination mobile nodes spread randomly over the network. Only 512 byte data packets are used. In our simulation, we analyze the performance in a network of 100 nodes, 150 node, 200 nodes and 250 nodes that are placed randomly within a 1500m X 1000m and operating over 150 seconds. Here each packet starts its journey from a random source location to a random destination. The simulation is run with different mobility patterns generated for 04 different mobility.

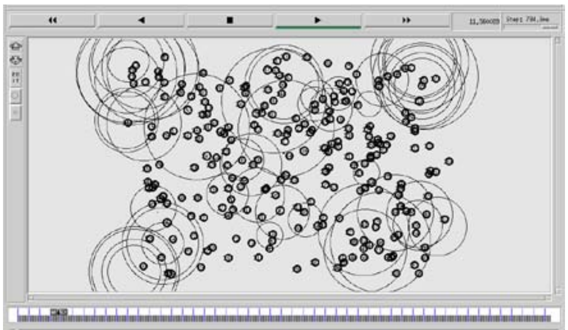

Figure 5.1: Simulation showing packet transfer

5.2 FIRST SCENARIO: VARYING THE NO. OF CONNECTIONS

Table 5.1: Simulation model (varying the no. of Connections)

PARAMETER	VALUE
Routing protocol	AODV, DSDV and DSR
Number of nodes	100,150,200,250
No. of Connections	25, 50, 75, 100
Simulation time	150 sec
Area	1500m X 1000m
Simulation model	TwoRayGround
MAC Type	802.11
Link Layer Type	LL
Interface Type	Queue
Traffic Type	TCP
Packet Size	512 Kb
Queue Length	50
Pause Time	00 sec
Mobility	20 m/s

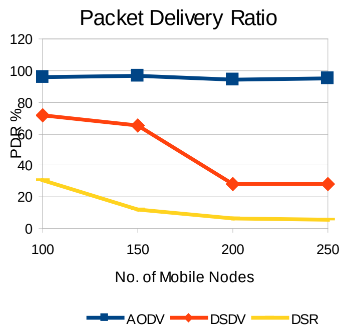

Figure 5.2: PDR (Connections are 25)

Fig: 5.2, when we increase number of nodes from 100 to 250, from all the protocols AODV shows the consistent performance with maximum packet delivery ratio in all the cases, performance of DSR is worst in all the cases of increasing number of nodes.

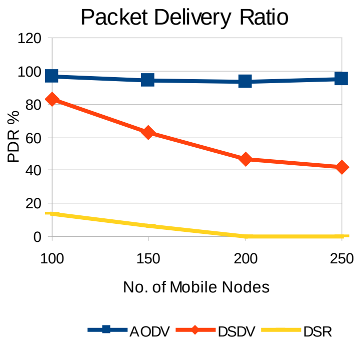

Figure 5.3: PDR (Connections are 50)

Fig: 5.3, when we increase number of nodes from 100 to 250, AODV shows the consistent performance and DSDV shows the better than DSR performance.

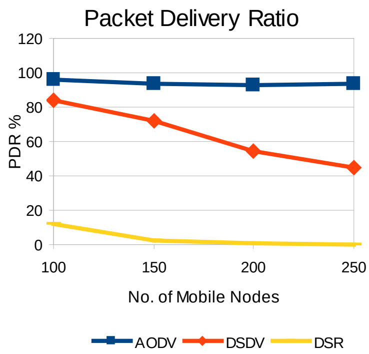

Figure 5.4: PDR (Connections are 75)

Fig: 5.4, AODV shows consistent performance when we increase number of nodes, but packet delivery ratio decreases for DSDV and DSR on increasing number of nodes.

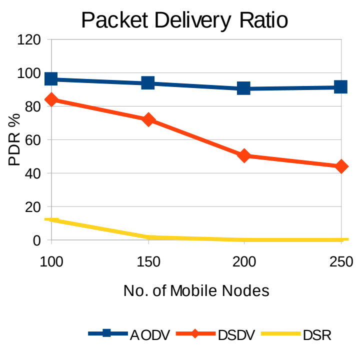

Figure 5.5: PDR (Connections are 100)

Fig: 5.5, AODV shows better performance with consistent packet delivery ratio, where for DSDV it is decreasing when we increase number of nodes

From the above observation we can say that all the four cases favors AODV performance is consistent, while DSDV performance is better than DSR.

Scenario 1: Varying the Connections

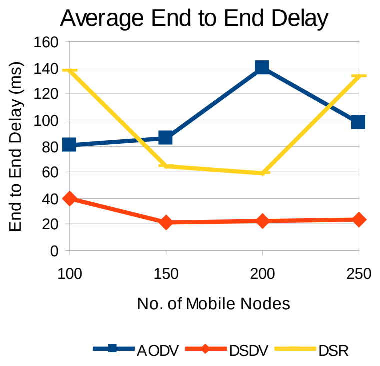

Figure 5.6: E to E delay (Connections are 25)

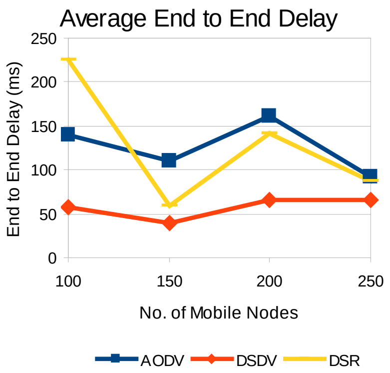

Figure 5.7: E to E delay (Connections are 50)

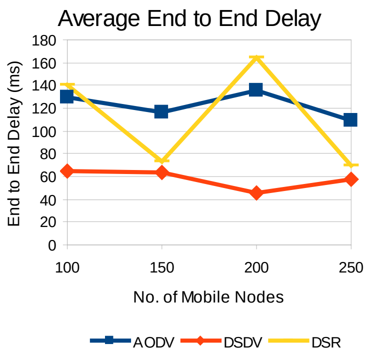

Figure 5.8: E to E delay (Connections are 75)

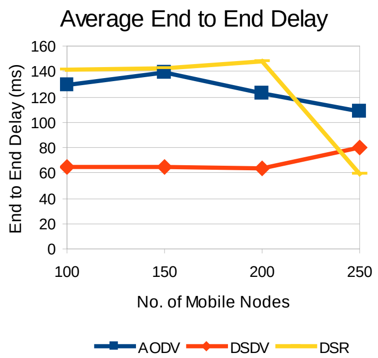

Figure 5.9: E to E delay (Connections are 100)

Fig: 5.6, when we increase number of nodes from 150 to 250, from all the protocols DSDV shows less end-to-end delay. It means DSDV shows better performance.

Fig: 5.7, when we increase number of nodes from 150 to 250, DSR and AODV shows same results with less end-to-end delay. But DSDV is better from both of them.

Fig: 5.8, for up to 150 nodes DSR and DSDV protocols shows almost similar results, but when we increase number of nodes to 200, end-to-end delay increases for DSR but consistent for DSDV. So DSDV shows better results with less end-to-end delay.

Fig: 5.9, when we increase number of nodes from 200 to 250, from all the protocols DSR shows less end-to-end delay. It means DSR shows better performance. While DSDV is better upto 200 nodes.

From the above observation we can say that out of four cases, DSDV shows better result. So we can say that DSDV shows better performance than AODV and DSR.

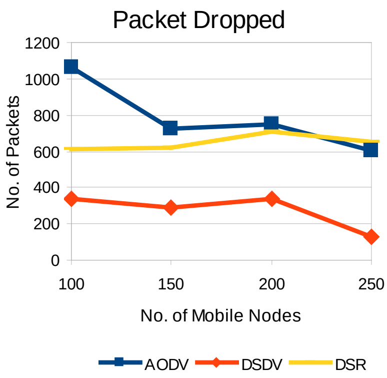

Figure 5.10: Packet Dropped (Connections are 25)

Fig: 5.10, when we increase number of nodes from 200 to 250, from all the protocols DSDV shows the better performance with less packet loss. When number of nodes is 250, then AODV, DSR the protocols shows almost similar packet loss.

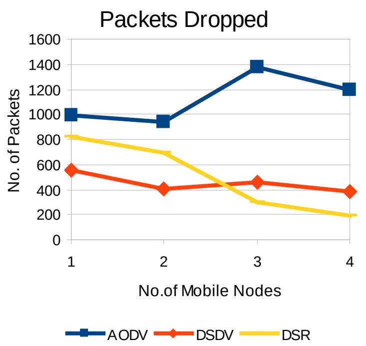

Figure 5.11:Packet Dropped (Connections are 50)

Fig: 5.11, when we increase number of nodes from 150 to 250, the protocols DSDV, DSR shows the similar performance with less packet loss. At 250 nodes, packet loss of DSR and DSDV are almost same, but overall DSDV shows better performance.

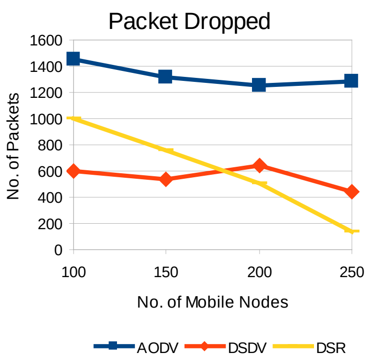

Figure 5.12: Packet Dropped (Connections are 75)

Fig: 5.12, when we increase number of nodes from 100 to 250, from all the protocols DSR shows the better performance with less packet loss as compare to others.

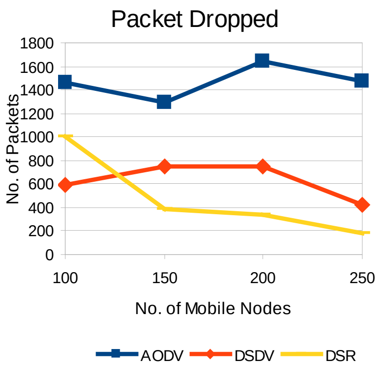

Figure 5.13: Packet Dropped (Connections are 100)

Fig: 5.13, when we increase number of nodes from 150 to 250, from all the protocols DSR shows the better performance with less packet loss as compare to others.

From the above observation we can say that in all the four cases, DSDV, DSR performs almost same with less packet loss.

Scenario 1: Varying the Connections

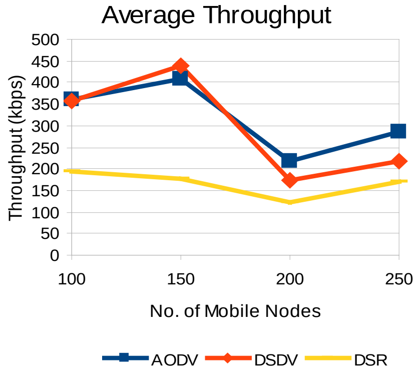

Figure 5.14: Average Throughput (Connections are 25)

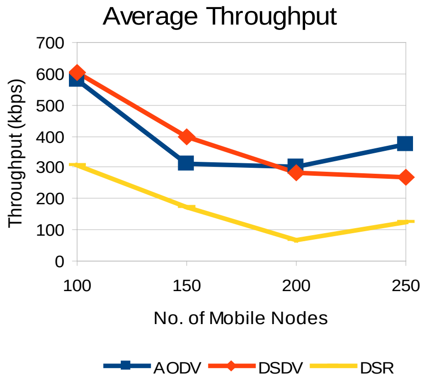

Figure 5.15: Average Throughput (Connections are 50)

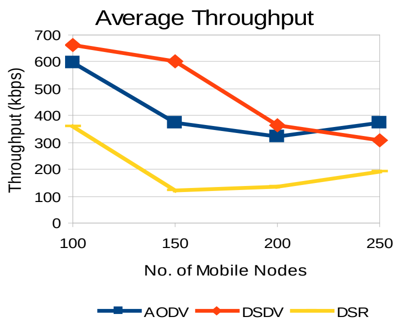

Figure 5.16: Average Throughput (Connections are 75)

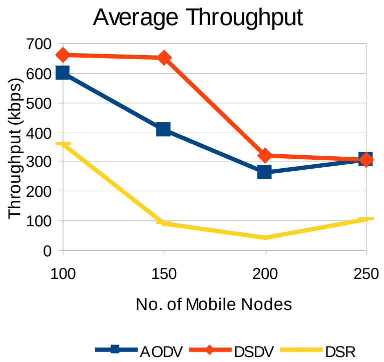

Figure 5.17: Average Throughput (Connections are 100)

Fig: 5.14, for all three protocols, up to 200 nodes, AODV, DSDV shows the same performance but when we increase number of nodes to 250, AODV shows better performance.

Fig: 5.15, for all three protocols, up to 200 nodes, almost similar results are shown in graph but when we increase number of nodes to 250, AODV shows the better performance.

Fig: 5.16, for all three protocols, up to 200 nodes, DSDV performs better but when we increase number of nodes to 250, AODV shows better results.

Fig: 5.17, for all three protocols, up to 200 nodes, AODV performs better but on increasing number of nodes to 250, AODV, DSDV shows same performance.

So from the above observation we can say that DSDV is better for less number of nodes, but if we have large number of nodes then AODV performance is same as DSDV performance.

After analysis of AODV, DSDV and DSR we define some standards for simulation results. HIGH will indicate the best performance, AVG will indicate the average performance and LOW will indicate the lower performance of the protocols.

The standard for PDR values defines below:

HIGH: PDR>80 %

AVG: 60% < PDR <=80%

LOW: PDR<=60%

The standard for average Throughput defines below:

HIGH: Throughput>300 kbps

AVG: 200 kbps>Throughput<=300 kbps

LOW: <=200 kbps

The standard for average E to E delay defines below:

HIGH: E to E < 120 ms

AVG: 120 ms > =E to E < 150 ms

LOW: E to E >=150

The standard for Packet Dropped defines below:

HIGH: PD < 550 nos.

AVG: 550 nos. >= PD < 1050 nos.

LOW: PD >=1050 nos.

Table (3-34) shows the analysis table of the simulation.

Performance comparison of AODV, DSDV and DSR is represented through tables

Table 5.2: PDR (Connections 25)

Packet Delivery Ratio			
Nodes	AODV	DSDV	DSR
100	HIGH	AVG	LOW
150	HIGH	AVG	LOW
200	HIGH	LOW	LOW
250	HIGH	LOW	LOW

Table 5.3: E to E (Connections are 25)

Average End to End Delay			
Nodes	AODV	DSDV	DSR
100	HIGH	LOW	HIGH
150	HIGH	LOW	HIGH
200	AVG	LOW	LOW
250	HIGH	LOW	HIGH

Table 5.4: Packet Dropped (Connections are 25)

Dropped Packets			
Nodes	AODV	DSDV	DSR
100	LOW	HIGH	HIGH
150	AVG	HIGH	HIGH
200	AVG	HIGH	HIGH
250	AVG	HIGH	HIGH

Table 5.5: Throughput (Connections are 25)

Average Throughput			
Nodes	AODV	DSDV	DSR
100	HIGH	HIGH	HIGH
150	HIGH	HIGH	HIGH
200	AVG	HIGH	HIGH
250	HIGH	HIGH	HIGH

Table 5.6: PDR (Connections are 50)

Packet Delivery Ratio			
Nodes	AODV	DSDV	DSR
100	HIGH	HIGH	LOW
150	HIGH	AVG	LOW
200	HIGH	LOW	LOW
250	HIGH	LOW	LOW

Table 5.7: E to E (Connections are 50)

Average End to End Delay			
Nodes	AODV	DSDV	DSR
100	HIGH	LOW	HIGH
150	HIGH	LOW	HIGH
200	LOW	AVG	HIGH
250	HIGH	AVG	HIGH

Table 5.8: Packet Dropped (Connections are 50)

Dropped Packets			
Nodes	AODV	DSDV	DSR
100	AVG	HIGH	HIGH
150	AVG	HIGH	HIGH
200	LOW	HIGH	HIGH
250	LOW	HIGH	HIGH

Table 5.9: Throughput (Connections are 50)

Average Throughput			
Nodes	AODV	DSDV	DSR
100	HIGH	HIGH	HIGH
150	HIGH	HIGH	HIGH
200	HIGH	HIGH	HIGH
250	HIGH	HIGH	HIGH

Table 5.10: PDR (Connections are 75)

Packet Delivery Ratio			
Nodes	AODV	DSDV	DSR
100	HIGH	HIGH	LOW
150	HIGH	AVG	LOW
200	HIGH	LOW	LOW
250	HIGH	LOW	LOW

Table 5.11: E to E (Connections are 75)

Average End to End Delay			
Nodes	AODV	DSDV	DSR
100	HIGH	AVG	HIGH
150	HIGH	AVG	HIGH
200	AVG	LOW	HIGH
250	HIGH	LOW	AVG

Table 5.12: Packet Dropped (Connections are 75)

Dropped Packets			
Nodes	AODV	DSDV	DSR
100	LOW	HIGH	HIGH
150	LOW	HIGH	HIGH
200	LOW	AVG	HIGH
250	LOW	HIGH	HIGH

Table 5.13: Throughput (Connections are 75)

Average Throughput			
Nodes	AODV	DSDV	DSR
100	HIGH	HIGH	HIGH
150	HIGH	HIGH	HIGH
200	HIGH	HIGH	HIGH
250	HIGH	HIGH	HIGH

Table 5.14: PDR (Connections are 100)

Packet Delivery Ratio			
Nodes	AODV	DSDV	DSR
100	HIGH	HIGH	LOW
150	HIGH	AVG	LOW
200	HIGH	LOW	LOW
250	HIGH	LOW	LOW

Table 5.15: E to E (Connections are 100)

Average End to End Delay			
Nodes	AODV	DSDV	DSR
100	HIGH	AVG	HIGH
150	HIGH	AVG	AVG
200	AVG	AVG	HIGH
250	HIGH	HIGH	LOW

Table 5.16: Packet Dropped (Connections are 100)

Dropped Packets			
Nodes	AODV	DSDV	DSR
100	LOW	HIGH	HIGH
150	LOW	AVG	HIGH
200	LOW	AVG	HIGH
250	LOW	HIGH	HIGH

Table 5.17: Throughput (Connections are 100)

Average Throughput			
Nodes	AODV	DSDV	DSR
100	HIGH	HIGH	HIGH
150	HIGH	HIGH	HIGH
200	AVG	HIGH	HIGH
250	HIGH	HIGH	HIGH

5.3 SECOND SCENARIO: VARYING THE MOBILITY

Following parameters have been used in this scenario i.e. number of nodes connecting in the network at a time is varied and thus varying speed of the node with which they are moving in the network, comparison of AODV, DSDV and DSR is represented through graphs.

Table 5.18: Simulation model (varying the Mobility)

PARAMETER	VALUE
Routing protocol	AODV, DSDV and DSR
Number of nodes	100,150,200,250
Number of Connections	100
Simulation time	150 sec
Area	1500m X 1000m
Simulation model	TwoRayGround
MAC Type	802.11
Link Layer Type	LL
Interface Type	Queue
Traffic Type	TCP
Packet Size	512 Kb
Queue Length	50
Pause Time	10 sec
Mobility	25 m/s, 50 m/s, 75 m/s, 100 m/s

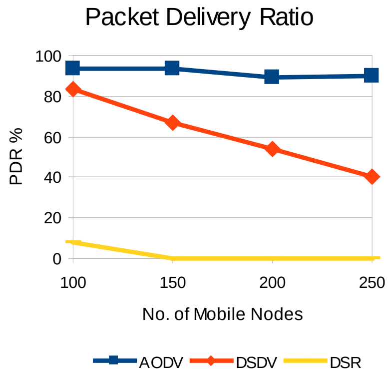

Figure 5.18: PDR (Mobility is 25)

Fig: 5.18, when we increase number of nodes from 100 to 250, from all the protocols AODV shows the consistent performance with maximum packet delivery ratio in all the cases, performance of DSR is worst in all the cases of increasing number of nodes.

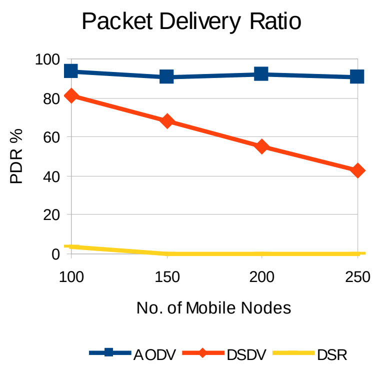

Figure 5.19: PDR (Mobility is 50)

Fig: 5.19, when we increase number of nodes from 100 to 250, AODV shows consistent and better performance, while performance of DSR is worst on increasing number of nodes.

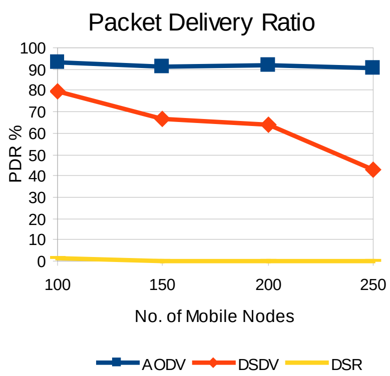

Figure 5.20: PDR (Mobility is 75)

Fig: 5.20, AODV shows consistent performance when we increase number of nodes, but packet delivery ratio decreases for DSDV and DSR on increasing number of nodes.

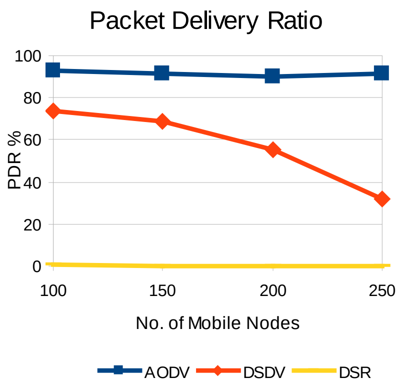

Figure 5.21: PDR (Mobility is 100)

Fig: 5.21, AODV shows better performance with consistent packet delivery ratio, where for DSDV and DSR it is decreasing when we increase number of nodes.

From the above observation we can say that all the four cases favors AODV in terms of packet delivery ratio when we are varying mobility while varying number of nodes.

Scenario 2: Varying the Mobility

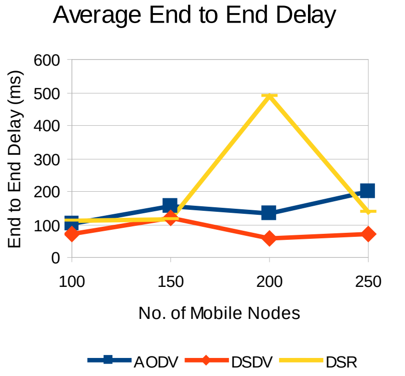

Figure 5.22: E to E Delay (Mobility is 25)

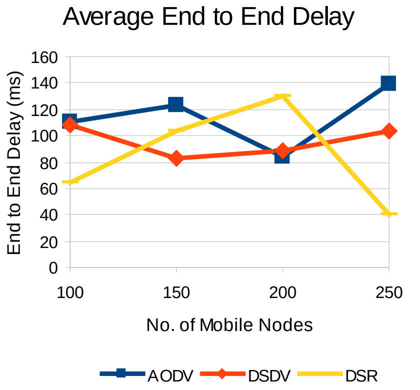

Figure 5.23: E to E Delay (Mobility is 50)

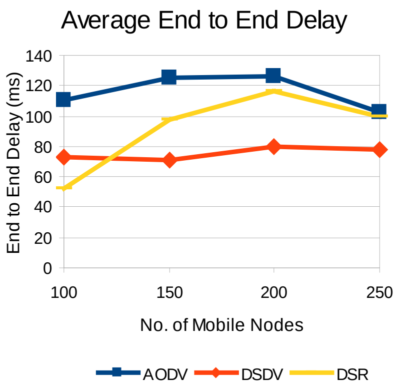

Figure 5.24: E to E Delay (Mobility is 75)

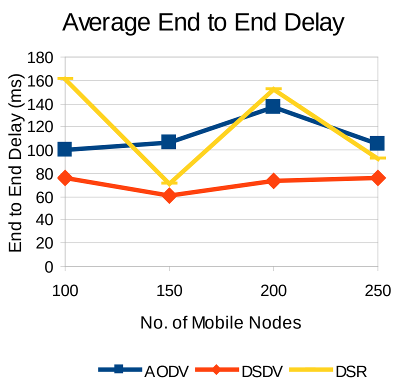

Figure 5.25: E to E Delay (Mobility is 100)

Fig: 5.21, when we increase number of nodes from 100 to 250, from all the protocols DSDV, AODV shows less end-to-end delay. but DSDV shows better performance.

Fig: 5.22, when we increase number of nodes from 100 to 200, DSDV, AODV shows almost similar results, but when we increase number of nodes to 250, DSDV shows results.

Fig: 5.23, from 150 to 250 nodes, delay increases for AODV, DSR protocols, overall DSDV shows the better performance.

Fig: 5.24, when we increase number of nodes from 100 to 250, from all the protocols AODV shows almost consistent and less end-to-end delay, but overall DSDV shows the better performance.

From the above observation we can say that DSDV shows better performance.

Scenario 2: Varying the Mobility

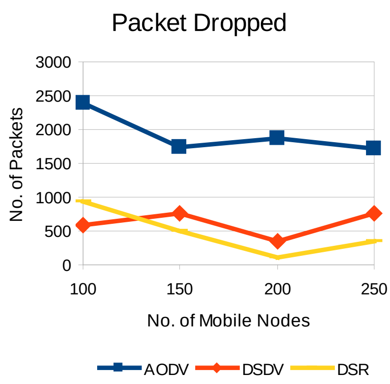

Figure 5.26: Packet Dropped (Mobility is 25)

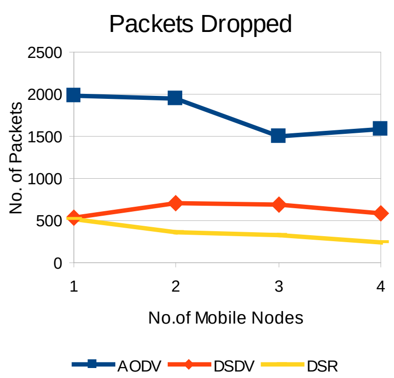

Figure 5.27: Packet Dropped (Mobility is 50)

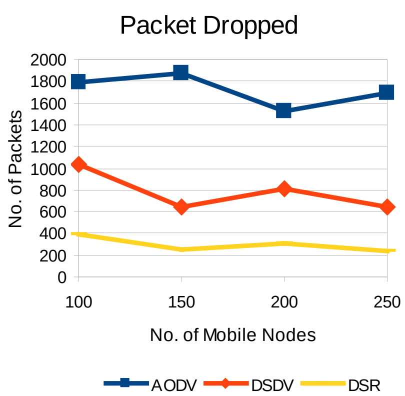

Figure 5.28: Packet Dropped (Mobility is 75)

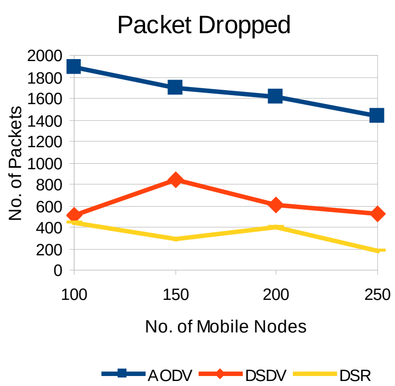

Figure 5.29: Packet Dropped (Mobility is 100)

Fig: 5.26, when we increase number of nodes from 100 to 250, from all the protocols DSDV, DSR shows the better performance with less packet loss.

Fig: 5.27, when we increase number of nodes from 100 to 250, from all the protocols DSDV and DSR shows the better performance with less packet loss, where AODV shows worst performance.

Fig: 5.28, when we increase number of nodes from 100 to 250, from all the protocols DSDV shows the better performance with less packet loss as compare to AODV.

Fig: 5.29, when we increase number of nodes from 100 to 200, from all the protocols DSR shows the better performance with less packet loss as compare to others, but at 250 nodes DSR and DSDV shows almost similar result.

From the above observation we can say that out of four cases, DSDV, DSR shows better performance.

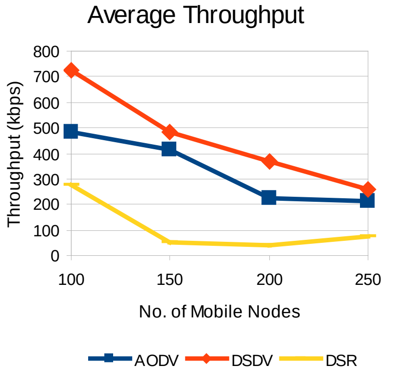

Figure 5.30: Throughput (Mobility is 25)

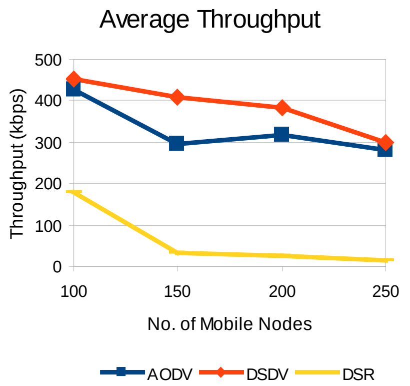

Figure 5.31: Throughput (Mobility is 50)

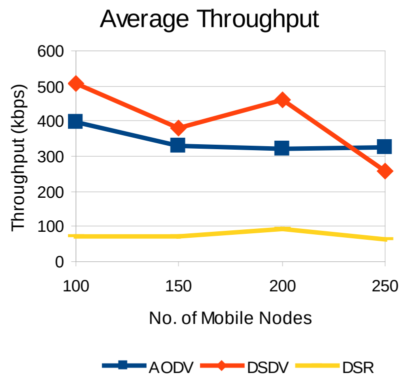

Figure 5.32: Throughput (Mobility is 75)

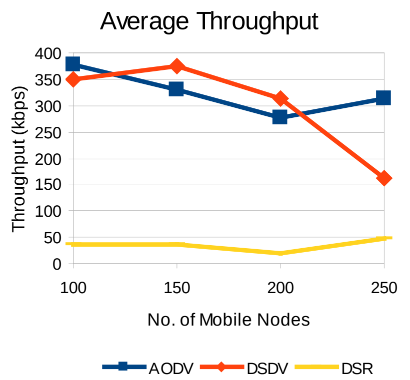

Figure 5.33: Throughput (Mobility is 100)

Fig: 5.30, for all three protocols, up to 200 nodes, DSDV shows the better performance but when we increase number of nodes to 250, AODV and DSDV shows almost similar results.

Fig: 5.31, for all three protocols, when we increase number of nodes from 100 to 250, throughput decreases but DSDV shows better results over AODV and DSR.

Fig: 5.32, for all three protocols, up to 200 nodes, DSDV performs better than AODV and DSR, but when we increase number of nodes to 250, AODV and DSDV shows almost similar results.

Fig: 5.32, for all three protocols, up to 200 nodes, DSDV and AODV shows almost similar results, but when we increase number of nodes from 200 to 250, AODV shows better results.

So from the above observation we can say that out of four cases, DSDV shows better results in three cases.

Performance comparison of AODV, DSDV and DSR is represented through tables

Table 5.19: PDR (Mobility is 25)

Packet Delivery Ratio			
Nodes	AODV	DSDV	DSR
100	HIGH	HIGH	LOW
150	HIGH	AVG	LOW
200	HIGH	LOW	LOW
250	HIGH	LOW	LOW

Table 5.20: E to E (Mobility is 25)

Average End to End Delay			
Nodes	AODV	DSDV	DSR
100	HIGH	HIGH	HIGH
150	LOW	AVG	HIGH
200	AVG	HIGH	LOW
250	LOW	HIGH	AVG

Table 5.21: Packet Dropped (Mobility is 25)

Dropped Packets			
Nodes	AODV	DSDV	DSR
100	LOW	AVG	AVG
150	LOW	AVG	HIGH
200	LOW	HIGH	HIGH
250	LOW	AVG	HIGH

Table 5.22: Throughput (Mobility is 25)

Average Throughput			
Nodes	AODV	DSDV	DSR
100	HIGH	HIGH	AVG
150	HIGH	HIGH	LOW
200	AVG	HIGH	LOW
250	AVG	AVG	LOW

Table 5.23: PDR (Mobility is 50)

Packet Delivery Ratio			
Nodes	AODV	DSDV	DSR
100	HIGH	HIGH	LOW
150	HIGH	AVG	LOW
200	HIGH	LOW	LOW
250	HIGH	LOW	LOW

Table 5.24: E to E (Mobility is 50)

Average End to End Delay			
Nodes	AODV	DSDV	DSR
100	HIGH	HIGH	HIGH
150	AVG	HIGH	HIGH
200	HIGH	HIGH	AVG
250	AVG	HIGH	HIGH

Table 5.25: Packet Dropped (Mobility is 50)

Dropped Packets			
Nodes	AODV	DSDV	DSR
100	LOW	HIGH	HIGH
150	LOW	AVG	HIGH
200	LOW	AVG	HIGH
250	LOW	AVG	HIGH

Table 5.26: Throughput (Mobility is 50)

Average Throughput			
Nodes	AODV	DSDV	DSR
100	HIGH	HIGH	LOW
150	AVG	HIGH	LOW
200	HIGH	HIGH	LOW
250	AVG	HIGH	LOW

Table 5.27: PDR (Mobility is 75)

Packet Delivery Ratio			
Nodes	AODV	DSDV	DSR
100	HIGH	AVG	LOW
150	HIGH	AVG	LOW
200	HIGH	AVG	LOW
250	HIGH	LOW	LOW

Table 5.28: E to E (Mobility is 75)

Average End to End Delay			
Nodes	AODV	DSDV	DSR
100	HIGH	HIGH	HIGH
150	AVG	HIGH	HIGH
200	AVG	HIGH	HIGH
250	HIGH	HIGH	HIGH

Table 5.29: Packet Dropped (Mobility is 75)

Dropped Packets			
Nodes	AODV	DSDV	DSR
100	LOW	AVG	HIGH
150	LOW	AVG	HIGH
200	LOW	AVG	HIGH
250	LOW	AVG	HIGH

Table 5.30: Throughput (Mobility is 75)

Average Throughput			
Nodes	AODV	DSDV	DSR
100	HIGH	HIGH	LOW
150	HIGH	HIGH	LOW
200	HIGH	HIGH	LOW
250	HIGH	AVG	LOW

Table 5.31: PDR (Mobility is 100)

Packet Delivery Ratio			
Nodes	AODV	DSDV	DSR
100	HIGH	AVG	LOW
150	HIGH	AVG	LOW
200	HIGH	LOW	LOW
250	HIGH	LOW	LOW

Table 5.32: E to E (Mobility is 100)

Average End to End Delay			
Nodes	AODV	DSDV	DSR
100	HIGH	HIGH	LOW
150	HIGH	HIGH	HIGH
200	AVG	HIGH	LOW
250	HIGH	HIGH	HIGH

Table 5.33: Packet Dropped (Mobility is 100)

Dropped Packets			
Nodes	AODV	DSDV	DSR
100	LOW	HIGH	HIGH
150	LOW	AVG	HIGH
200	LOW	AVG	HIGH
250	LOW	HIGH	HIGH

Table 5.34: Throughput (Mobility is 100)

Average Throughput			
Nodes	AODV	DSDV	DSR
100	HIGH	HIGH	LOW
150	HIGH	HIGH	LOW
200	AVG	HIGH	LOW
250	HIGH	LOW	LOW

5.4 THIRD SCENARIO: VARYING THE PAUSE TIME

Following parameters have been used in this scenario i.e. number of nodes connecting in the network at a time is varied and thus varying pause time of the network, comparison of AODV, DSDV and DSR is represented through graphs.

Table 5.35: Simulation model (varying the Pause time)

PARAMETER	VALUE
Routing protocol	AODV, DSDV and DSR
Number of nodes	100,150,200,250
Number of Connections	100
Simulation time	150 sec
Area	1500 X 1000
Simulation model	TwoRayGround
MAC Type	802.11
Link Layer Type	LL
Interface Type	Queue
Traffic Type	TCP
Packet Size	512 Kb
Queue Length	50
Mobility	50 m/s
Pause Time	25 sec, 50 sec, 75 sec, 100 sec

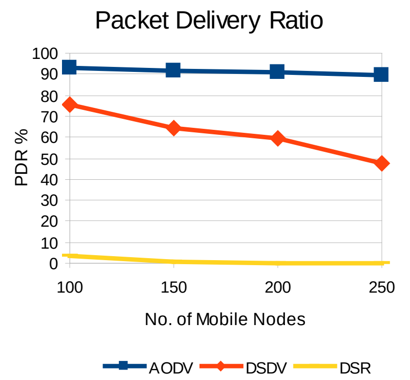

Figure 5.34: PDR (Pause time 25 sec)

Fig: 5.34, when we increase number of nodes from 100 to 250, from all the protocols AODV shows the consistent performance with maximum packet delivery ratio in all the cases while DSR shows worst performance.

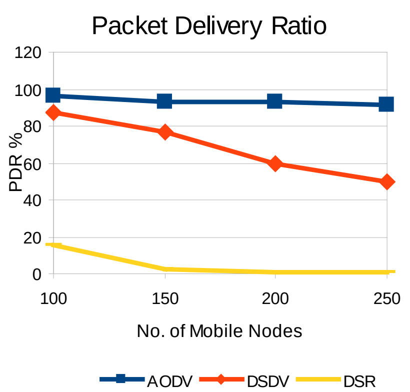

Figure 5.35: PDR (Pause time 50 sec)

Fig: 5.35, upto 150 nodes AODV, DSDV shows the same results, when we increase number of nodes from 100 to 250, AODV shows consistent and better performance, while performance of DSR is worst on increasing number of nodes.

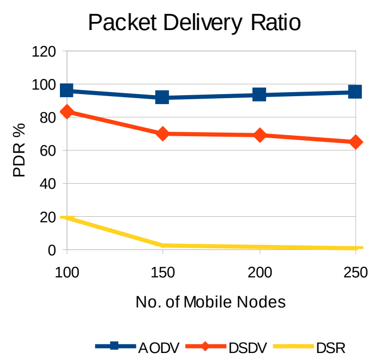

Figure 5.36: PDR (Pause time 75 sec)

Fig: 5.36, AODV shows consistent performance when we increase number of nodes, but packet delivery ratio decreases for DSDV and DSR on increasing number of nodes.

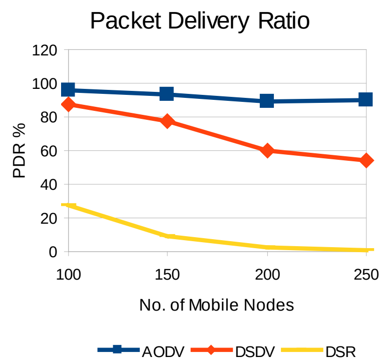

Figure 5.37: PDR (Pause time 100 sec)

Fig: 5.37, AODV shows better performance with consistent packet delivery ratio, where for DSDV and DSR it is decreasing when we increase number of nodes.

From the above observation we can say that all the four cases favors AODV in terms of packet delivery ratio when we are varying pause time.

Scenario 3: Varying the Pause Time

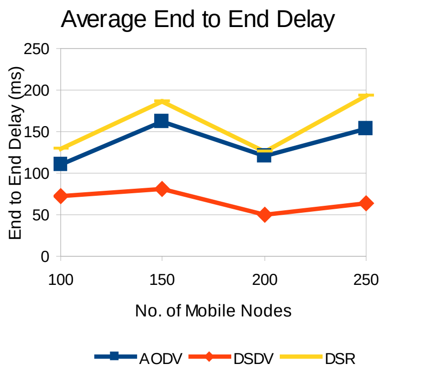

Figure 5.38: E to E Delay (Pause time 25 sec)

Fig: 5.38, when we increase number of nodes from 100 to 250, from all the protocols DSDV shows less end-to-end delay. It means DSDV shows better performance.

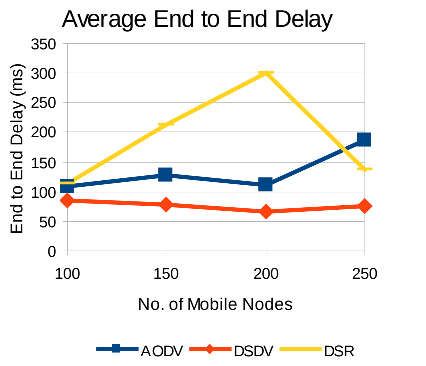

Figure 5.39: E to E Delay(Pause time 50 sec)

Fig: 5.39, when we increase number of nodes from 100 to 200, AODV shows almost consistent and same less end-to-end delay as DSDV, but upto 200 to 250 nodes DSV performs better.

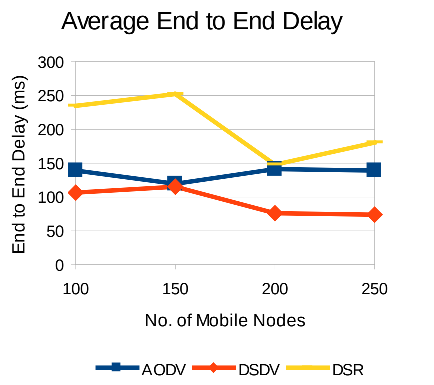

Figure 5.40: E to E Delay(Pause time 75 sec)

Fig: 5.40, when we increase number of nodes from 100 to 250, from all the protocols DSDV shows the better performance with less end-to-end delay.

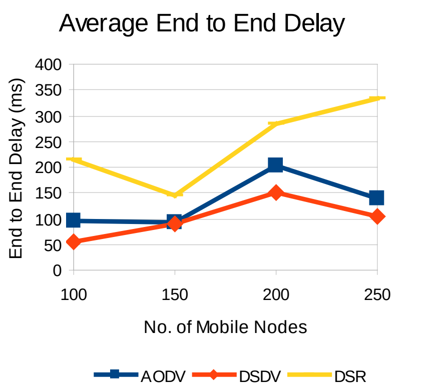

Figure 5.41: E to E Delay(Pause time 100 sec)

Fig: 5.41, when we increase number of nodes from 100 to 250, from all the protocols AODV, DSDV shows the similar performance with less end-to-end delay.

From the above observation we can say that DSDV shows better performance.

Scenario 3: Varying the Pause Time

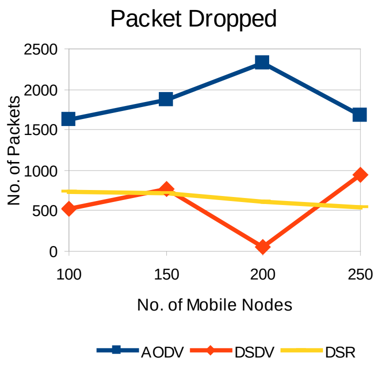

Figure 5.42: Packet Dropped (Pause time 25 sec)

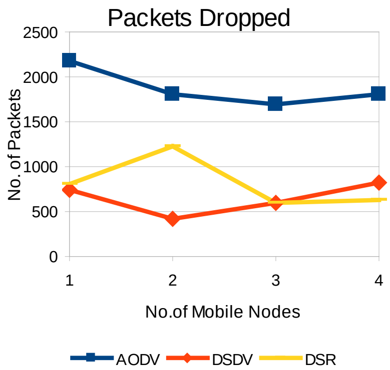

Figure 5.43: Packet Dropped (Pause time 50 sec)

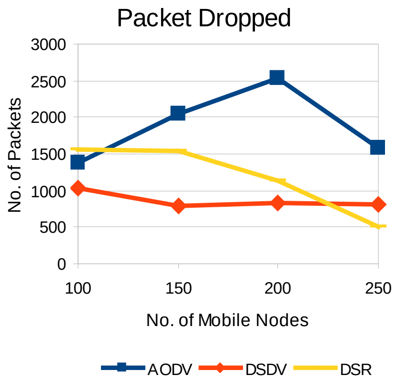

Figure 5.44: Packet Dropped (Pause time 75 sec)

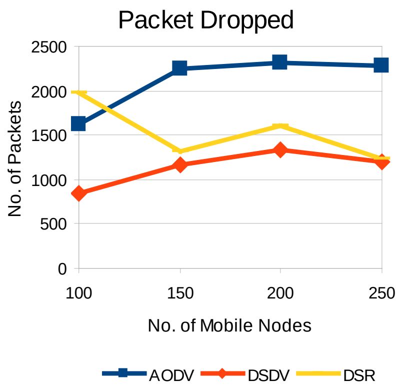

Figure 5.45: Packet Dropped (Pause time 100 sec)

Fig: 5.42, for 200 numbers of nodes, DSDV shows very less no. of packet dropped When increasing number of nodes to 250, DSR and DSDV show almost similar performance and then up to 250 nodes, but overall DSDV shows better performance.

Fig: 5.43, when we increase number of nodes from 100 to 250, from all the protocols DSDV shows the better performance with less packet loss.

Fig: 5.44, when we increase number of nodes from 100 to 250, from all the protocols DSDV shows the better performance with less packet loss as compare to others, but upto 250 nodes DSR and DSDV shows almost similar results.

Fig: 5.45, when we increase number of nodes from 100 to 150, DSDV shows better performance, on increasing number of nodes from 200 to 250, DSR and DSDV shows almost similar results.

From the above observation we can say that in all the four cases, DSDV shows better performance with less packet loss.

Scenario 3: Varying the Pause Time

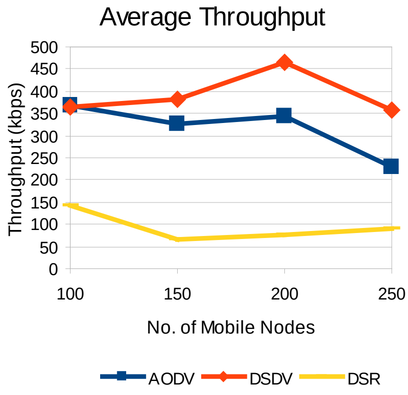

Figure 5.46: Throughput (Pause time 25 sec)

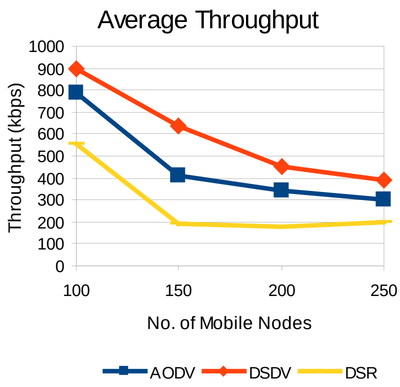

Figure 5.47: Throughput (Pause time 50 sec)

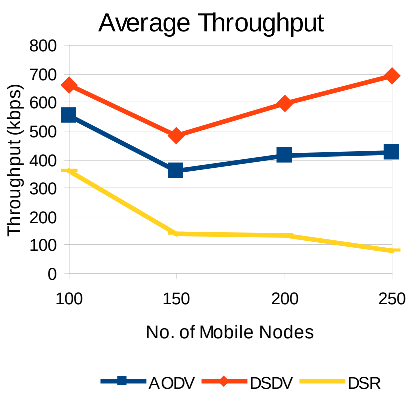

Figure 5.48: Throughput (Pause time 75 sec)

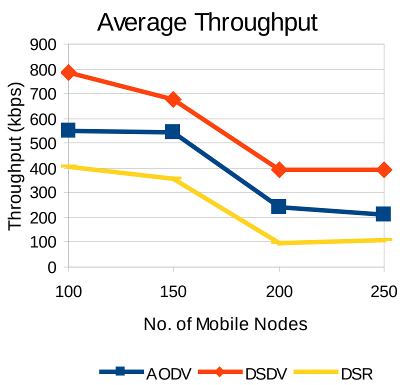

Figure 5.49: Throughput (Pause time 100 sec)

Fig: 5.46, for 150 numbers of nodes, AODV and DSDV shows almost similar results, but when we increase number of nodes to 250, DSDV performs better in all protocols.

Fig: 5.47, for all three protocols, when we increase number of nodes from 100 to 250, Throughput will goes down, but DSDV shows better results.

Fig: 5.48, for all three protocols, at 100 number of nodes throughput is maximum but it decreases at 150 nodes and then DSDV shows better performance.

Fig: 5.49, for 100-250 numbers of nodes DSDV show better results. Throughput decrease as no. of nodes increases. Overall DSDV shows better performance.

So from the above observation we can say that in all the four cases, DSDV shows better performance of throughput when varying pause time while varying number of nodes.

Performance comparison of AODV, DSDV and DSR is represented through tables

Table 5.36: PDR (Pause time 25 sec)

Packet Delivery Ratio			
Nodes	AODV	DSDV	DSR
100	HIGH	AVG	LOW
150	HIGH	AVG	LOW
200	HIGH	LOW	LOW
250	HIGH	LOW	LOW

Table 5.37: E to E (Pause time 25 sec)

Average End to End Delay			
Nodes	AODV	DSDV	DSR
100	HIGH	HIGH	AVG
150	LOW	HIGH	LOW
200	AVG	HIGH	AVG
250	LOW	HIGH	LOW

Table 5.38: Packet Dropped (Pause time 25 sec)

Dropped Packets			
Nodes	AODV	DSDV	DSR
100	LOW	HIGH	AVG
150	LOW	AVG	AVG
200	LOW	HIGH	AVG
250	LOW	AVG	HIGH

Table 5.39: Throughput (Pause time 25 sec)

Average Throughput			
Nodes	AODV	DSDV	DSR
100	HIGH	HIGH	LOW
150	HIGH	HIGH	LOW
200	HIGH	HIGH	LOW
250	AVG	HIGH	LOW

Table 5.40: PDR (Pause time 50 sec)

Packet Delivery Ratio			
Nodes	AODV	DSDV	DSR
100	HIGH	HIGH	LOW
150	HIGH	AVG	LOW
200	HIGH	LOW	LOW
250	HIGH	LOW	LOW

Table 5.41: E to E (Pause time 25 sec)

Average End to End Delay			
Nodes	AODV	DSDV	DSR
100	HIGH	HIGH	HIGH
150	AVG	HIGH	LOW
200	HIGH	HIGH	LOW
250	LOW	HIGH	AVG

Table 5.42: Packet Dropped (Pause time 50 sec)

Dropped Packets			
Nodes	AODV	DSDV	DSR
100	LOW	AVG	AVG
150	LOW	HIGH	LOW
200	LOW	AVG	AVG
250	LOW	AVG	AVG

Table 5.43: Throughput (Pause time 50 sec)

Average Throughput			
Nodes	AODV	DSDV	DSR
100	HIGH	HIGH	HIGH
150	HIGH	HIGH	LOW
200	HIGH	HIGH	LOW
250	HIGH	HIGH	LOW

Table 5.44: PDR (Pause time 75 sec)

Packet Delivery Ratio			
Nodes	AODV	DSDV	DSR
100	HIGH	HIGH	LOW
150	HIGH	AVG	LOW
200	HIGH	AVG	LOW
250	HIGH	AVG	LOW

Table 5.45: E to E (Pause time 75 sec)

Average End to End Delay			
Nodes	AODV	DSDV	DSR
100	AVG	HIGH	LOW
150	AVG	HIGH	LOW
200	AVG	HIGH	AVG
250	AVG	HIGH	LOW

Table 5.46: Packet Dropped (Pause time 75 sec)

Dropped Packets			
Nodes	AODV	DSDV	DSR
100	LOW	AVG	LOW
150	LOW	AVG	LOW
200	LOW	AVG	LOW
250	LOW	AVG	HIGH

Table 5.47: Throughput (Pause time 75 sec)

Average Throughput			
Nodes	AODV	DSDV	DSR
100	HIGH	HIGH	HIGH
150	HIGH	HIGH	LOW
200	HIGH	HIGH	LOW
250	HIGH	HIGH	LOW

Table 5.48: PDR (Pause time 100 sec)

Packet Delivery Ratio			
Nodes	AODV	DSDV	DSR
100	HIGH	HIGH	LOW
150	HIGH	AVG	LOW
200	HIGH	AVG	LOW
250	HIGH	LOW	LOW

Table 5.49: E to E (Pause time 100 sec)

Average End to End Delay			
Nodes	AODV	DSDV	DSR
100	HIGH	HIGH	LOW
150	HIGH	HIGH	AVG
200	LOW	LOW	LOW
250	AVG	HIGH	LOW

Table 5.50: Packet Dropped (Pause time 100 sec)

Dropped Packets			
Nodes	AODV	DSDV	DSR
100	LOW	AVG	LOW
150	LOW	LOW	LOW
200	LOW	LOW	LOW
250	LOW	LOW	LOW

Table 5.51: Throughput (Pause time 100 sec)

Average Throughput			
Nodes	AODV	DSDV	DSR
100	HIGH	HIGH	HIGH
150	HIGH	HIGH	HIGH
200	AVG	HIGH	LOW
250	AVG	HIGH	LOW

5.5 DISCUSSION

From the simulation we found the following results.

5.5.1 Packet delivery ratio

PDR is the ratio between the number of packets originated by the application layer sources and the number of packets received by the sinks at the final destination. It will describe the loss rate that will be seen by the transport protocols, which in turn affects the maximum throughput that the network can support [5, 9].

Figure (5.2-5.8) shows that pause time is 00 seconds (varying the no. of connections) AODV outperforms DSDV and DSR. Figure (5.18-5.21) shows that pause time is 10 seconds (varying the mobility), figure (5.34-5.37) shows mobility 50 m/sec (varying the pause time) environment, AODV outperforms DSDV and DSR in high mobility environment, topology change rapidly and AODV can adapt to the changes quickly since it only maintain one route that is actively used. DSDV deliver less data packet compare to AODV because in rapid change topology it is not as adaptive to route changes in updating its table. DSR does not have mechanism in knowing which route in the cache is stale, data packet is forwarded to broken link.

5.5.2 Average End to End Delay

Average end-to-end delay is an average end-to-end delay of data packets. The delay is affected by high rate of CBR packets as well. The buffers become full much quicker, so the packets have to stay in the buffers a much longer period of time before they are sent.

Figure (5.6-5.9) shows that pause time is 00 seconds, and mobility is 20 m/s (varying the no. of connections), Figure (5.20-5.28) shows that pause time is 10 seconds (varying the mobility), figure (5.38-5.41) shows mobility 50 m/sec (varying the pause time) environment, DSDV performance is better than AODV and DSR. As the mobility rises, the E to E delay is also rises.

5.5.3 Average Throughput

Highest Throughput of a protocols indicate the better performance. Figure (5.14-5.17) shows that pause time is 00 seconds, and mobility is 20 m/s (varying the no. of connections), figure (5-20) shows that pause time is 10 seconds (varying the mobility) environment shows that the throughput of the AODV and DSDV are same in maximum scenario, as the no. of nodes increases the throughput of protocol decreases, as the mobility increases the throughput of protocols is also increase.

Figure (5.46-5.49) shows mobility 50 m/sec (varying the pause time) environment, throughput of protocols decrease when pause time is 25 sec, and 75 sec as the no. of mobile nodes increase. Throughput of protocols increase when pause time is 50 sec, and 100 sec as the no. of mobile nodes are also increase.

5.5.4 Packet Dropped

Packet will drop only at the interface. The reasons of packet dropped are buffer overloaded, etc. In our simulation we find that maximum no. of packets are dropped by the AODV protocols, as comparison to DSDV and DSR. Simulation shows that very less no. of packets are dropped by the DSR protocols.

6.1 CONCLUSION

We have compared three namely, Ad hoc On-Demand Distance Vector Routing (AODV), Destination Sequenced Distance Vector (DSDV) and Dynamic Source Routing (DSR). The simulation of these protocols has been carried out using Ns-2.34 simulator. Mainly three different simulation scenarios are generated and the simulation time 150 sec. Only 512 byte data packets are used. In our simulation, we analyze the performance in a network of 100 nodes, 150 node, 200 nodes and 250 nodes that are placed randomly within a 1500m X 1000m.

We have observed that the Packet Delivery Ration is very high in case of AODV, but it decreases as no. of connections vary, and remain consistent, when no. of connections are fixed. There is no effect on PDR of AODV as varying mobility or varying pause time. DSDV deliver less data packet compare to AODV because in rapid change topology it is not as adaptive to route changes in updating its table. DSR does not have mechanism in knowing which route in the cache is stale, data packet is forwarded to broken link. DSDV performance is good as no. of mobiles are < 150, as no. of mobile nodes increases performance of DSDV decreases.

As far as varying pause time is concerned, DSDV outperforms all other if packet dropped, End to End Delay and throughput are taken as indicator, but overall AODV outperforms DSDV and DSR as in high mobility environment, topology change rapidly and AODV can adapt to the changes quickly since it only maintain one route that is actively used, and its PDR and throughput is high as comparison to DSDV, while taking into account various indicators, DSDV outperforms other two.

6.2 FUTURE SCOPE

For the future work, this area will investigate not only the comparison between AODV, DSDV and DSR routing protocols, but more on the vast areas. Performance of other routing protocol can be evaluated over various mobility models to gain greater insights into the relationship between them. Designing scenarios which depict real world applications more accurately can be designed through in-depth study of the application. Maybe for the future we would be able to focus more on security issue. As we know, routing protocols are prime targets for impersonation attacks.

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ACRONYMS

MANETs	Mobile Ad-hoc Networks
AODV	Ad-hoc On-Demand Vector
DSDV	Destination-Sequenced Distance Vector
DSR	Dynamic Source Routing
OLSR	Optimized Link State Routing
LANs	Local Area Networks
RREQ	Route Request
RRC	Route reconstruction
OPNET	Optimized Network Evaluation Tool
OSI	Open System Interconnection
WLAN	Wireless Local Area Network
RF	Radio Frequency
MWNs	Multi Hop Wireless Networks
HWNs	Hybrid Wireless Networks
WANs	Wireless Ad-hoc Networks
WSNs	Wireless Sensor Networks
IPS	Intrusion Prevention System
MAC	Medium Access Control
TD	Transmission Delay
PD	Propagation Delay
IP	Internet Protocol
TCP	Transmission Control Protocol

BGP	Border Gateway Protocol
IGRP	Interior Gateway Routing Protocol
OSPF	Open Shortest Path First
RIP	Routing Information Protocol
SMRP	Simple Multicast Routing Protocol
ISO	International Standard Organization
ZRP	Zone Routing Protocol
TORA	Temporary Ordered Routing Algorithm
WRP	Wireless Routing Protocol
PDR	Packet Delivery Ratio

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