Study on Performance Analysis of MANET Routing Protocols using NS3

A thesis submitted in fulfillment of the requirements for the bachelor of science in Information & Communication Engineering

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CHAPTER 1: INTRODUCTION

A Mobile Ad-hoc Network (MANET) [1], sometimes called a mobile mesh network, is a self-configuring network of mobile devices connected by wireless links. In other words, a MANET is a collection of communication nodes that wish to communicate with each other. [2] Ad-hoc networks require no centralized administration or fixed network infrastructure such as base stations or access points and can be quickly and inexpensively setup as needed. A MANET is an autonomous group of mobile users that communicate over reasonably slow wireless links. The network topology vary rapidly and unpredictably over time because the nodes are mobile. MANET is kind of wireless Ad -hoc network, is a self-configuring network of mobile routers connected by wireless links the union of which forms an arbitrary topology. The earlier MANETs are called “Packet radio networks” and were sponsored by DARPA in the earlier 1970’s. [2] There are several ad hoc routing protocols that propose solutions for routing within a mobile ad hoc network. This paper compares common reactive and proactive routing protocols such as Ad hoc on-demand distance vector (AODV), Dynamic Source Routing (DSR), Optimized Link State Routing (OLSR) and Destination-Sequenced Distance-Vector (DSDV) by using a simulation platform to evaluate the performances.

1.2 Aim and Objectives

This project is aimed to find out performance analysis of MANET Routing Protocols using ns-3. It is expected to fulfill the following objectives:

- To do a brief study on the MANET routing protocols
- To implement the AODV, OLSR, DSDV and DSR routing protocols using ns-3 (Network Simulator)
- To examine and quantify the effects of various factors
- To evaluate the performance of the routing protocols

1.3 Thesis Structure

This paper is mainly divided into five chapters. Chapter 1 introduces the topic of MANET along with the problem statement. Chapter 2 presents the background of our work and the related work with few examples. Chapter 3 is about the simulation model and the performance metrics. Furthermore, Chapter 4 is about the result analysis of the four routing protocols. Finally our conclusions are presented in chapter 5, along with the future work.

CHAPTER 2: BACKGROUND AND LITERATURE REVIEW

In this chapter a brief description about the key features of the AODV, DSR, OLSR and DSR protocols and the mode of operation for each MANET routing protocol that are given. The basic differences in these routing protocols is the routing strategy based classification- reactive and proactive protocols. Here, the AODV and DSR are the reactive protocols and DSDV and OLSR are the link-state proactive protocols.

2.1 MANET Protocols

Mobile Ad hoc networks or MANETs are the category of wireless networks which do not require any fixed infrastructure or base stations. They can be easily deployed in places where it is difficult to setup any wired infrastructure. As shown in Figure.1.1, there are no base stations and every node must co-operate in forwarding packets in the network.

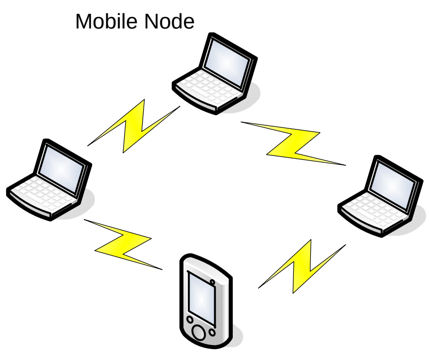


Figure 1.1: A Mobile ad hoc

Thus, each node acts as a router which makes routing complex when compared to Wireless LANs, where the central access point acts as the router between the nodes. [3]

Each device in the MANET can move without any obstacle in any direction and often change links on other devices. Each must have a router because it must follow the traffic to make a connection with its intended use. The main challenge in forming a MANET is to make each device to maintain the information necessary to correctly track traffic. These networks can be self-managed or connected to a wider Internet.

2.1.1 DSDV

The Destination Sequenced Distance Vector protocol is based on the Bellman Ford algorithm. It is a proactive table-driven protocol. This means that every node in the network has routing entries to all the nodes in the network. The tables are updated periodically or when there is a significant change in the network topology. This means that there is always a route to any destination in the network if the topology is not changing very much. To prevent routing loops due to these updates, the updates have sequence numbers that are incremented by two, meaning that it always has to be an even number. The route with the highest sequence number is the freshest route and it is the one that is used. Entries that have not been updated for a while are considered stale and thus deleted. However, if there are two entries with the same sequence number, the one with the better metric is used; DSDV uses hop count as its cost metric. If a node wants to alert the other nodes of an invalid route it sends an update with an odd sequence number and they know to delete that route from their table. DSDV uses settling time to dampen route fluctuations [9]. The periodic updates in the DSDV mode of operation is a considerable disadvantage since it consumes much of the already limited battery power of the MANET nodes, however if the topology is not changing, it can be very efficient since a route to any destination will always be present when needed.

2.1.2 DSR

The Dynamic Source Routing (DSR) protocol can be a simple and robust routing protocol specifically designed for mobile node multi-heap wireless ad-hoc networks. The Dynamic Source Routing Protocol (DSR) is based on the routing of the supply, which means that each packet is forwarded, and the Nursing Associate must deliver the packet while moving to the destination according to the node list. The DSR protocol has two basic processes: root discovery and root maintenance.

2.1.2.1 Root discovery

Root discovery is only found if the root of the supplying node is attempting to send a node's packet and is not yet found in the path. To start route discovery, the provided node sends a "root request" with a single ID as a local broadcast packet. If some intermediate node accepts this root request, it first determines if the root has been requested. Cancels a packet if the node has already seen the root request. Otherwise, it checks the route cache to see if the packet has a route to its destination. The route inventor routes the cache route by providing a "root reply" and providing a replica of the root record collected from the root request. Otherwise, the request is routed until the root request is sent. [4]

2.1.2.2 Route Maintenance

The DSR protocol uses the root maintenance process and works from the packet to the destination. However, once the feeder's contact link is changed to its destination, a star-shaped change is detected. This causes a communication failure between the provided node and the target node. In this state, the DSR protocol looks for other types of observed routes to send information using the route method. If Route Maintenance does not detect other well-known routes for communication, it calls Route Discovery to find the new route at the destination. [4]

2.1.3 AODV

AODV (Ad hoc on-demand distance vector routing) is the source drive type routing protocol. Ad Hoc On-Demand Distance Vector (AODV) is Reactive or on Demand. It uses bidirectional links. Route discovery cycle used for route finding. It maintains active routes. Sequence numbers used for loop prevention and as route freshness criteria. Provides unicast and multicast communication. When the source node sends the message of the destination node without routing, it sends the first RREQ. When a neighboring node source receives a RREQ to a node and a node of the target node, you can see that it is as like as the destination node's address. When this is done, the RREP source is sent to the node. Otherwise, the router examines the routing of the table, arrives at the target node, and then either sends the RREQ to the source node or sends an RREQ. The AODV protocol allows routing nodes to be maintained through the normal broadcast of Hello messages. If the link is broken, an ERROR message is sent to the node and the broken record is deleted or the routing is restored.

The AODV protocol generates routing between two nodes in the network based on root discovery and root maintenance. Root requires a process and broadcasts an RREQ message to the target node in flood form. In the root reply process, the target node prefers the first arriving RREP and sends a RREP message. It is easy to break the path with strong motion of the node during routing which can corrupt the RREP packet. During maintaining the routine, the broken node removes the error packet, and when the broadcast of the RERR packet occurs, the source node sends a message to the request to delay the next packet. The RREP sent from the downstream node to cancel the loopback due to the new trip can be canceled due to local recovery, reducing routing recoverability. Also, despite the routing maintenance process, the node is mobile, which means that it cannot repair or repair the network in a timely manner, which reduces network control information and increases routing delays, thus affecting the efficiency of the network.

2.1.4 OLSR

Optimized Link State Routing (OLSR) is an active routing protocol in MANET. With this protocol, the required path is available due to the active property. Periodically, messages are exchanged to find the underlying mechanism of this protocol. OLSR is called pure link state protocol optimization because it reduces the size of control packets and this control reduces traffic. This protocol also does not generate additional traffic in response to additional failures or failures. All node networks store all destination paths. As a result, it can be applied when large subsets of nodes are communicating with each other or when nodes change over time. The protocol is particularly well-suited for large and dense networks as more optimizations are made. OLSR operates in a fully distributed fashion, depending on the central entity. After sending these messages in a timely manner, reliable transmission of the control messages is not required. This protocol selects multipoint relay (MPR) to reduce the flow of network control messages. [5]

Sender node each node, node n, say, one of its neighbor nodes, wants to select a node set between the network sets. The set can accept the selected node again.

Upon receiving packets from node n, they have a link to node n, 2 hop neighbor nodes. These protocols, Hello and Topology Control (TC) messages, contain two types of control messages that identify the neighbors and continuously generate information about the terrain information.

2.3 Literature Review

Mobile Ad-hoc network (MANET) [6], [7] consists of a collection of self-configuring mobile wireless nodes which can communicate with each other without having any particular infrastructure. That means MANETs does not have any centralized controlling structure. So that they are free to move randomly and independently having the capability to change their links frequently according to the demand of the network. As MANET does not have any centralized administration and have multi hop process, routing process in this network is very much complex. Routing protocols generally uses different algorithms to determine best route between sources to destination for packet delivery [9], [10].Routing tables containing the all route related information are initialized and maintained over the time. The information contained in the routing table varies in accordance with the routing algorithms followed. Routes are selected from these routing tables. In realistic routing protocol implementation, [9], path-loss, quality of the wireless link, fading types, power consumption, change in topology, interference from multiple users etc. cannot be ignored. In most of the performance evaluation [11], [12], of AODV, DSR the widely used routing protocols which have been carried out for ideal (error-less) environments. But in actual sense it is hard to get such an ideal environment. Many researchers have evaluated routing protocols for mobile Ad-hoc network through simulation. The network simulators such as NS2 [13], Qualnet [14], GloMoSim [15], Opnet modeler [16] etc. have been used for performance analysis. The detailed simulation scenarios, performance metrics, environments etc. are discussed in the following subsection. Wang Lin-Zhu & et.al [17] have compared the performance of DSR & AODV protocol by using ns2 simulator. They have compared the performance of these protocols for variable node densities and mobility. Similarly, researchers in [18] have also compared the performance of AODV, DSDV & DSR through ns2 simulator. R. Singh & et.al [19] have evaluated the performance of DSR & DSDV through ns2 simulator. Others researchers in have also considered the performance of the routing protocols. However, S.Kanungo & et.al have considered the fading effect in performance comparison but those are for the MAC protocols and not for the routing protocols. Hence, supporting Quality of Service (QoS), the four protocols, DSR, AODV, OLSR and DSDV are compared with respect to mobility levels, node densities, and network area for two performance metrics-Average Throughput and Packet Delivery Ratio.

CHAPTER 3: SIMULATION METHODOLOGY AND PERFORMANCE METRICS

3.1 Simulation Modeling

Simulators generate output which are as close as possible to real time implementations. Before implementing a complex network, it is necessary to analyze the behavior pattern and evaluate performance before implementing it in today's real application. Several network simulators are available, whose output depicts as close as possible to real time implementation. The simulator NS3 (version 3.27) [19] fall is used to conduct the performance analysis. There are several models available in NS3 simulator. Random Waypoint Mobility model is considered, it is a node mobility model for dynamic network topologies.

3.2 Simulation Environment

The simulation results bring out some important characteristic differences between the routing protocols. The presence of high mobility implies frequent link failures and each routing protocol reacts differently during link failures. The different basic working mechanism of these protocols leads to the differences in the performance. Since our experiments is based on network layer characteristics so changes in routing strategy is only observed where as other characteristics like antenna gain, transmit power, ground propagation model and receiver sensitivity as physical layer characteristics, MAC 802.11 as wireless Ethernet for data link layer characteristics, UDP as transport layer characteristics and CBR as application layer characteristics remain fixed.

3.2.1 Traffic Model

Continuous bit rate (CBR) traffic sources are used having UDP connection. The source-destination pairs are spread randomly over the network. Only 64-byte data packets are used. The number of source-destination pairs and the packet sending rate in each pair is varied to change the offered load in the network.

3.2.2 Mobility Model

The mobility model uses the random waypoint model in a rectangular field. Initially the field configurations used is: 300 m × 1500 m field with 50 nodes. Here, each packet starts its journey from a random location to a random destination with a randomly chosen speed (uniformly distributed between 0 –20 m/s). Once the destination is reached, another random destination is targeted after a pause. The pause time, which affects the relative speeds of the mobiles, is varied. Mobility models were created for the simulations using 50 nodes, with pause times of 0, 2, 4, 6, 8, 10, 20 seconds, maximum speed of 20 m/s, simulation time of 200 secs. Identical mobility and traffic scenarios are used across protocols to gather fair results. To overcome the effect of randomness in the output we have taken the averages of the results to get their realistic values. The goal of our simulation is to evaluate the performance differences of these two reactive and two pro-active routing protocols. We have varied mobility and the number of sources to measure their performance. Simulations are carried out by varying the number of traffic sources from 25 to 50. The pause time is varied from 0 sec (high mobility) to 30 sec (low mobility). The simulation results reveal some important characteristic differences between the routing protocols.

3.3 Simulation Methods and Parameters

The goal of our experiments is to examine and quantify the effects of various factors and their interactions on the overall performance of ad hoc networks. Each run of the simulator accepts as input a scenario file that describes the exact motion of each node using Random Waypoint mobility model. In all our experiments we considered six-seven sample points of a particular factor and verified for four different protocols i.e. AODV, DSR, OLSR and DSDV. The parameters in our simulation are reported in Table 1.

3.4 Performance Metrics

The performance metrics helps to characterize the network that is substantially affected by the routing algorithm to achieve the required Quality of Service (QoS). In this work, the following metrics are considered.

Throughput: Average Throughput is defined as the average number of packets successfully obtained their destinations per unit time. This parameter is calculated as the number of bits delivered per second.

$$Throughput = \frac{(Number\ of\ \ packets\ delivered \times\ Packet\ size)}{Total\ duration\ of\ simulation}$$

Packet Delivery Ratio (PDR): Packet Delivery Ratio (PDR) is the ratio between the number of packets transmitted by a traffic source and the number of packets received by a traffic sink. It represents the maximum throughput that the network can achieve

$$PDR = \frac{Packets\ Received}{Packets\ Sent} \times 100$$

Simulation Parameters	**Value**	**Simulation Parameters**	**Value**
Network Type	Mobile	Simulation Area(sq. m)	450000, 540000, 630000, 720000, 810000, 900000
Connection Pattern	Random		
Packet size	64 bytes	Number of Nodes	25, 30, 35, 40, 45, 50
Duration	200s	Pause Time(s)	0, 5, 10, 15, 20, 25, 30
Connection Type	CBR/UDP	Mobility Speed(m/s)	2, 4, 6, 8, 10, 20

Table 3.1: Simulation Parameters for MANETs

CHAPTER 4: RESULT ANALYSIS

4.1 Simulation Results and Performance Evaluation

Simulators generate output which are as close as possible to real time implementations. Before implementing a complex network, it is necessary to analyze the behavior pattern and evaluate performance before implementing it in today's real application. Several network simulators are available, whose output depicts as close as possible to real time implementation. The simulator NS3 (version 3.27) [19] fall is used to conduct the performance analysis. There are several models available in NS3 simulator. Random Waypoint Mobility model is considered, it is a node mobility model for dynamic network topologies.

4.2 Result Analysis

The performance analysis is carried out with parameters -number of nodes, pause time, network area, and mobility speed while keeping other parameters constant. Four protocols i.e. AODV, DSR, OLSR and DSDV are considered for the comparison purpose on the above performance. Performance factors such as Network Load analysis, Mobility analysis and Network Size analysis are considered while evaluating.

4.2.1 Network Load Analysis

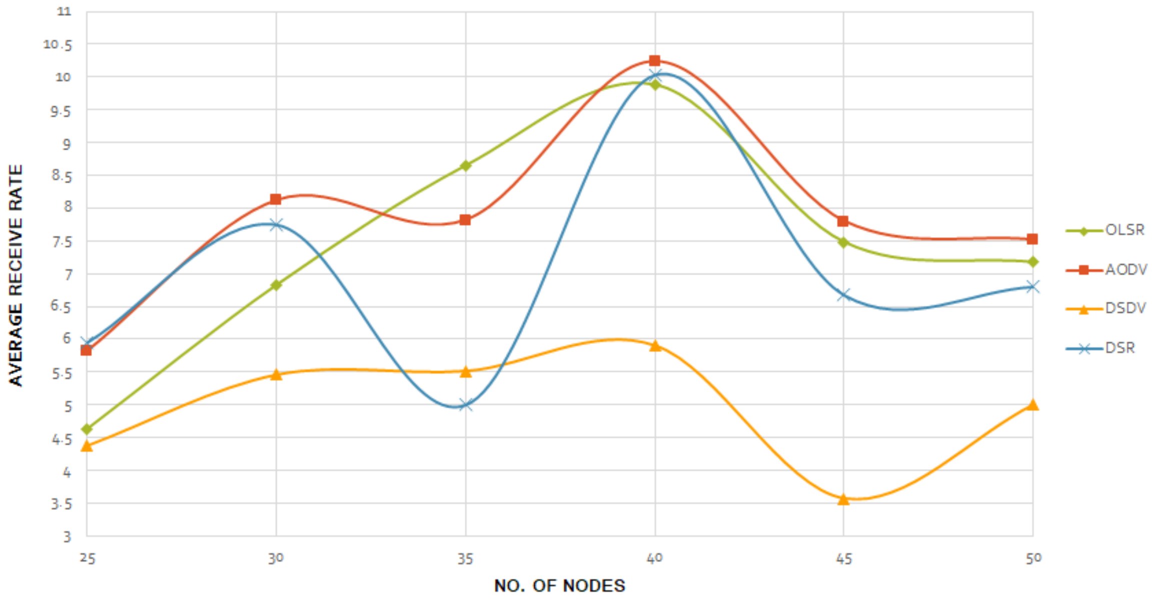
In this analysis the number of nodes varied from 25 to 50 with an increment of 5 nodes whereas the pause time, network size and simulation duration are fixed at 0s, 300X1500 sq. m. and 200s respectively. In simulation, 5 random scenarios are generated by 5 simulation runs for each sample point of a particular protocol and the average value is used to plot the performance of a network by varying the number of nodes. The performance plots i.e. Number of nodes vs PDR, and Number of nodes vs Throughput is shown in Fig 4.1(a) and 4.1(b) respectively. DSR has a very slow rate of change in comparison to other protocols considered in this work. From Fig 4.1(a) it is observed that the AODV outperforms the OLSR and DSR whereas it is very closer with AODV in terms of throughput by increasing the nodes. DSDV has lowest throughput in comparison with all the other three protocols considered.

4.2.2 Network Size Analysis

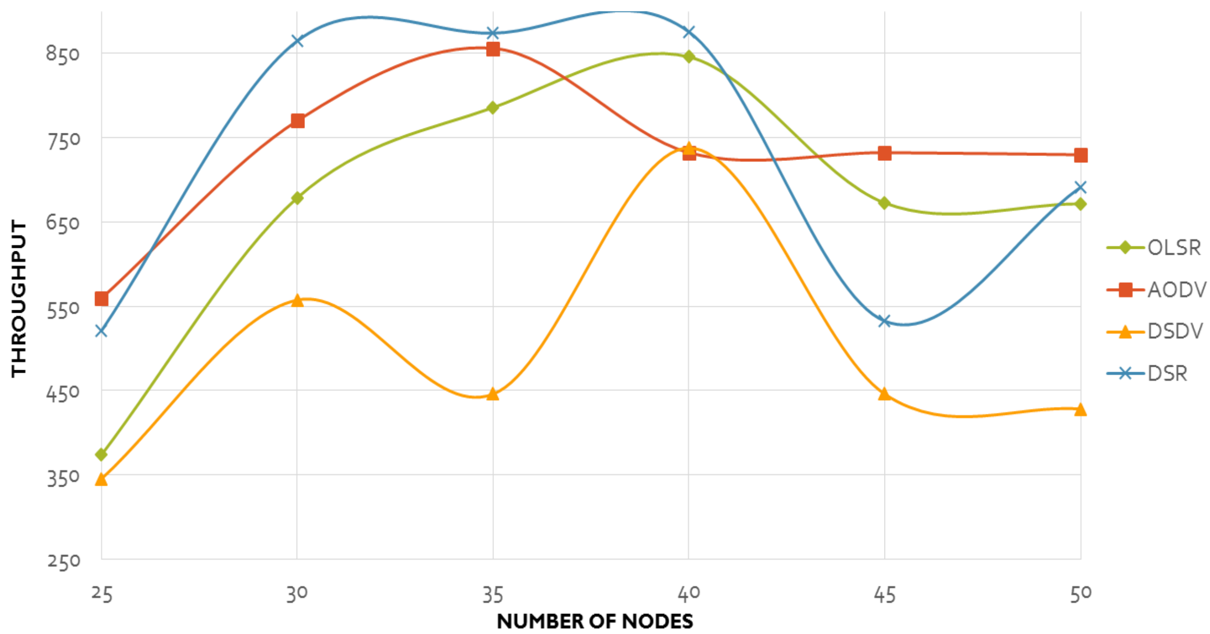
In network size analysis, network area is varied as 300x1500sq. m., 300x1800 sq. m., 400x1575 sq. m., 400x1800 sq. m., 500x1620 sq. m. and 500x1800 sq. m. keeping the number of nodes fixed at 50. From Fig 4.2(a) performance plot varying PDR is observed. DSR performs better compared to other protocols i.e. AODV, DSDV and OLSR protocols. The PDR of AODV and OLSR is almost same. Again, the PDR performance of OLSR is better than DSDV but poor than other two protocols after 400x400 sq. m. network size. From Fig 4.2(b) it is observed that the throughput fluctuates for all protocols as network size is increased gradually. It is maximum for DSR and minimum for DSDV.

4.2.3 Mobility Analysis

In this analysis we assumed that each node has different velocity and direction. In simulation we considered the following pause times: 0s, 5s, 10s, 15s, 20s, 25s and 30s. The maximum speed which is an important factor is also considered, taking values around 0~20 m/s and the total number of nodes is fixed at 50 for each scenario of different pause time keeping all other parameters fixed. The performances factors-PDR and Throughput are measured by varying the pause time which is reported in Fig 4.3(a) and 4.3(b), also the node speed varied as shown in Fig 4.4(a) and 4.4(b) respectively. Similarly, the OLSR has highest PDR and throughput which is reported in Fig 4.3(a) and 4.3(b). From Fig 4.4(b) it is observed that the throughput is lowest for the DSDV. AODV has the moderate throughput which is in between DSR and DSDV. As shown in Fig 4.4(a) and 4.4(b), it can be seen that as speed increases performance of all the routing protocols decreased drastically.

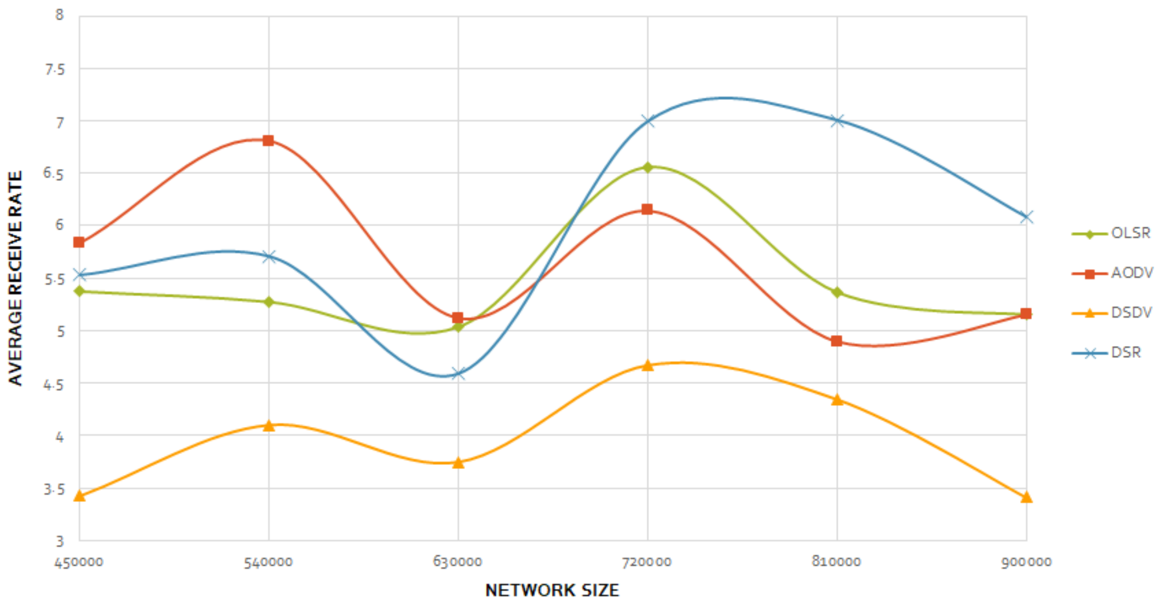


(a)

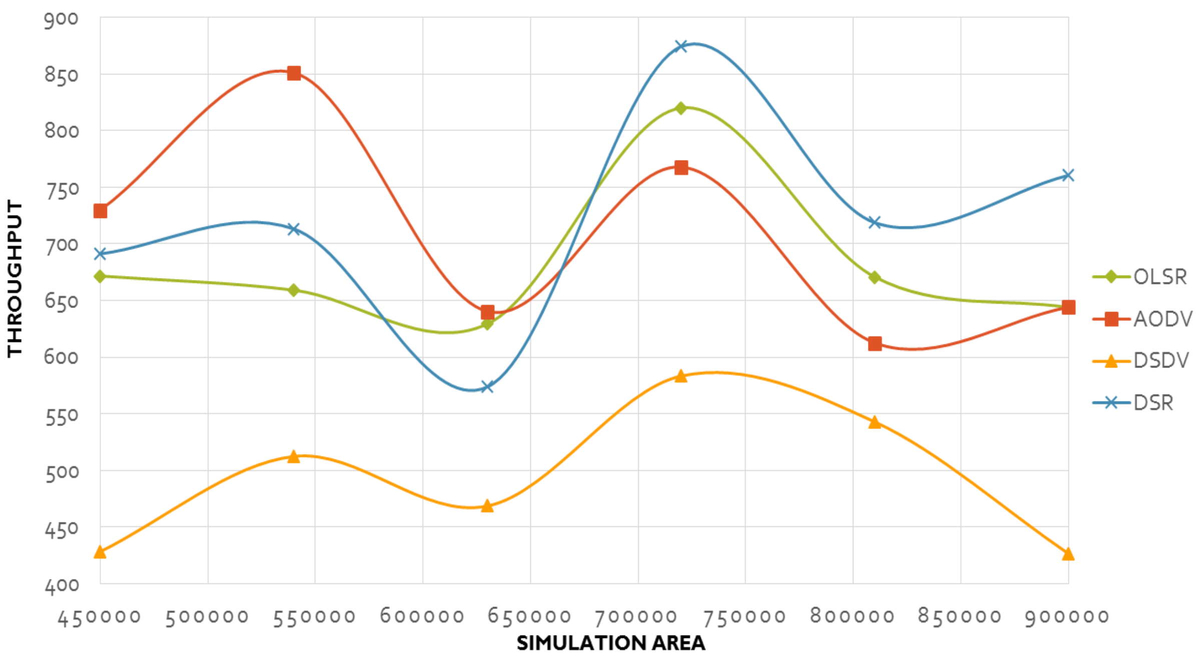


(b)

Figure 4.1: (a) PDR and (b) Throughput performance evaluation varying the number of nodes

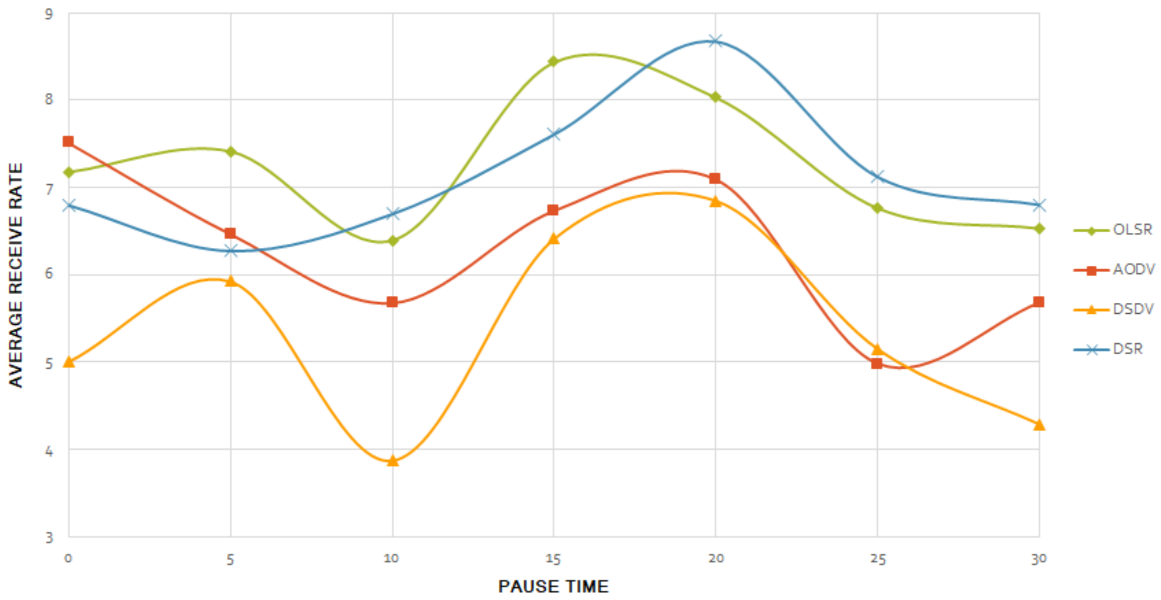


(a)

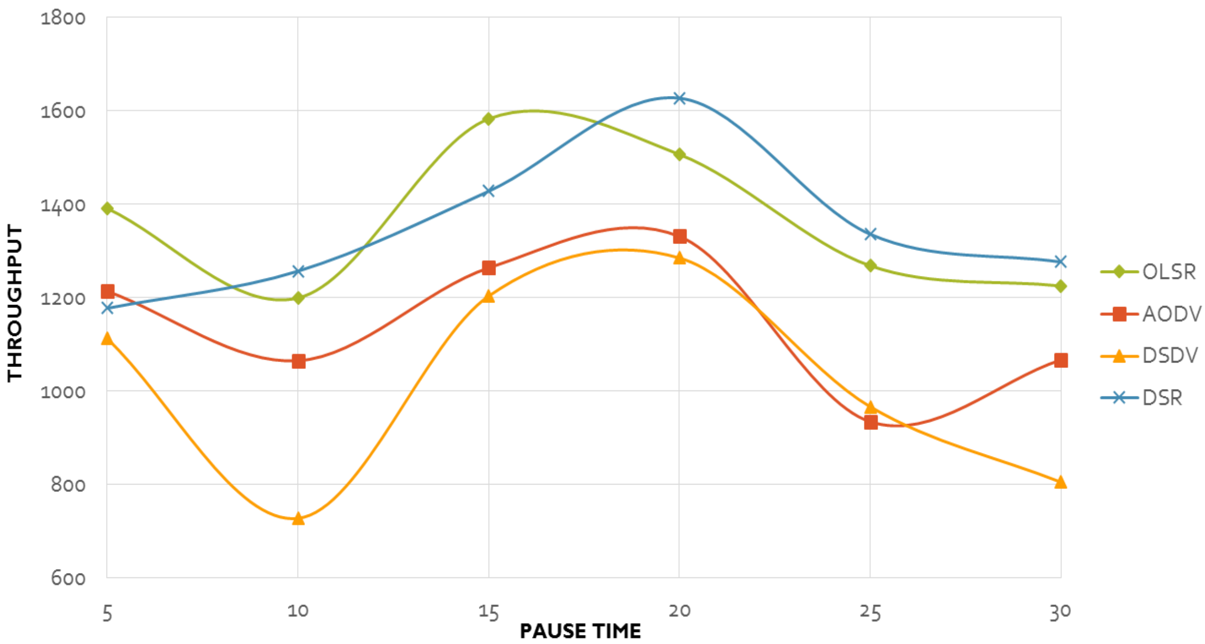


(b)

Figure 4.2: (a) PDR and (b) Throughput performance evaluation varying the network size

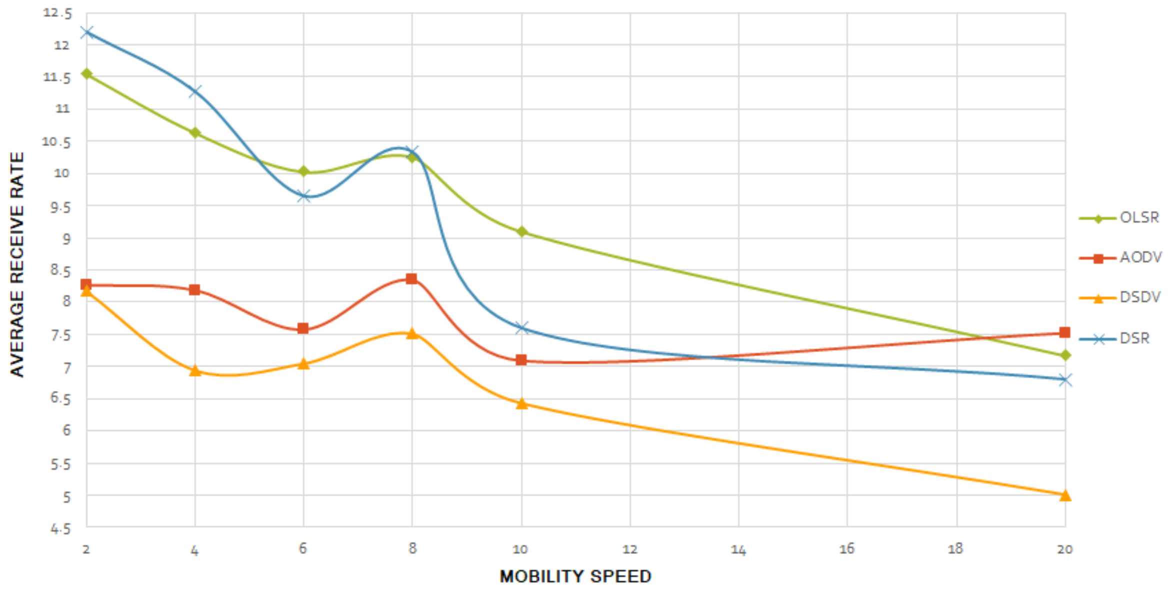


(a)



(b)

Figure 4.3: (a) PDR and (b) Throughput performance evaluation varying the pause time



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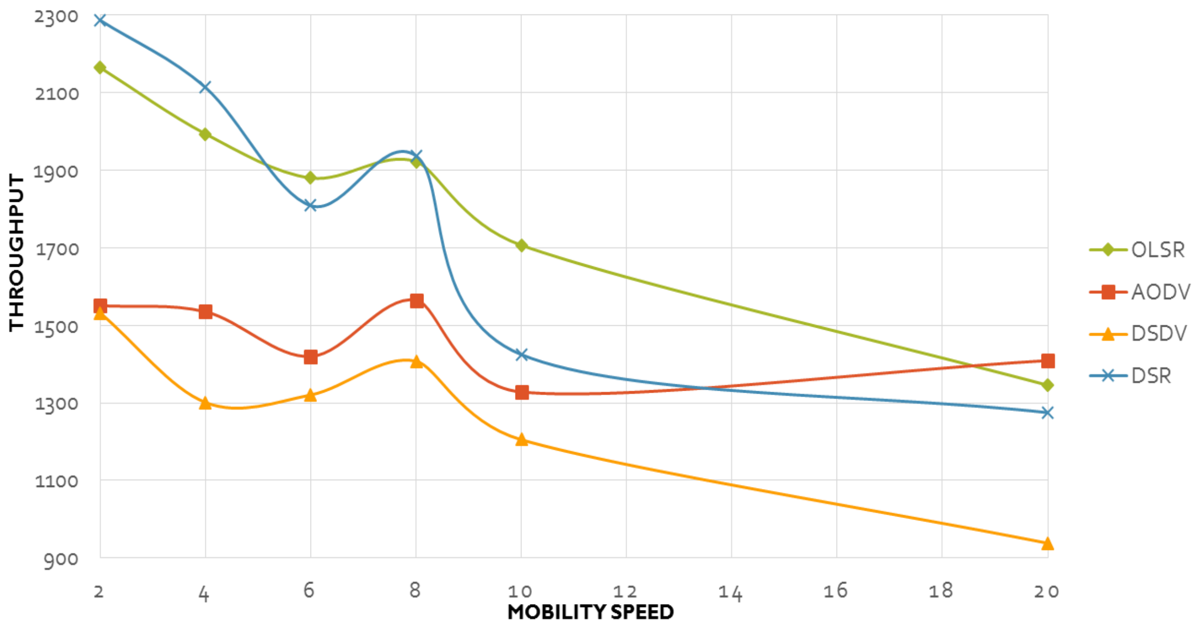

(b)

Figure 4.4: (a) PDR and (b) Throughput performance evaluation varying the node speed

Chapter 5: Conclusion and Future Work

In this paper, the performance of the four routing protocols is evaluated. The routing protocols have been compared on the basis of QoS metrics (PDR, throughput). The performance measures- PDR and throughput with different number of nodes, different speed of nodes and different size of network is simulated and from the results we conclude that DSR shows better performance than the other routing protocols, in case of network size analysis it results in highest value of PDR. In case of load analysis AODV outperformed the other protocols. In this analysis, DSR shows high variation in performance. The On-demand protocols, AODV and DSR perform better than the table-driven DSDV protocol. Whereas in mobility analysis OLSR had the highest PDR and throughput, making it the better option among the four routing protocols. DSDV being one of early algorithms is not good as throughput is very low compared to AODV and DSR protocols. Our focus in the future work is to extend the set of the experiments for extensive complex simulations considering other simulations parameters (propagation models, MAC protocols, etc.) in order to gain a more in-depth performance analysis of the ad hoc routing protocols.

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