



# COMPREHENSIVE COMPARISON STUDY FOR ROUTING PROTOCOLS IN MOBILE AD-HOC NETWORK USING NS2

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## ABSTRACT

Mobile Ad Hoc Network (MANET) is a collection of wireless mobile nodes dynamically forming a tentative network without the use of any existing network infrastructure or centralized administration. Nodes of these networks function as routers which discovers and maintains the routes to other nodes in the network. 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. In this paper, we compared and evaluated the performance of four routing protocols in MANET: Ad hoc On-demand Distance Vector (AODV), Ad-hoc on-demand multipath distance vector (AOMDV), Destination-Sequenced Distance-Vector routing (DSDV) and Dynamic Source Routing (DSR). Network Simulator version 2.35 (NS2) was used to perform the performance study. The performance of the routing protocols was evaluated based on the routing overhead, average end-to-end delay, packets delivery ratio and packet loss ratio. The simulation results shown that AODV and DSR have better performance than AOMDV and DSDV on varying the network size, whilst DSR, AOMDV and AODV are better than DSDV on varying node velocity.

**Keywords:** MANET, performance, AODV, DSR, AOMDV, DSDV, NS2.

## 1. INTRODUCTION

MANET is a kind of wireless network and a self-configuring network of moving routers associated with the wireless network [1], it can communicate with other nodes through wireless links without any fixed infrastructure support. MANET is used in many applications, such measure ambient conditions in the environment, military, surveillance, seismic detection. The ultimate objective of MANET is to offer the solution that keeps stability between the nodes in the network, despite the movable nodes and limited bandwidth and other resources constraints. According to dynamic nature of Ad-hoc Networks, makes it enormously complicated and challenging mission to obtain accurate knowledge of the network state [2].

Many routing protocols have been devised for MANET and a few of them can be integrated into our study [3]. This paper is aimed to study the comparison of most popular protocols in MANET and it uses in the same environment. The evaluations of performance metrics and compression analysis to four popular ad hoc networks have been discussed.

The rest of article is organized as follows: in Section 2 presents the background and related word. In section 3, we provides a brief of our simulation environment. Section 5 provides the simulation result and discussion and Section 6 presents the research conclusions.

## 2. BACKGROUND AND RELATED WORK

### 2.1 Cataloguing for routing protocols of MANET

Routing protocols are responsible for establishing path and exchange packets between the source and the destination. All nodes of these networks behave as routers, also responsible for maintaining path between two nodes

until the communication gets over. MANET routing protocol can be classified into three kinds:

### 2.2 Proactive routing protocols

Proactive routing protocols are also well-known as table driven routing protocols. Nodes by proactive routing protocols uphold routing table which contains information about each and every node residing on that particular network. The information in the routing table is upgraded over time so that each node in the network has the pure view of the recent structure of the network. The proactive protocols are suitable for fewer numbers of nodes in networks because they necessity to update node entries for each and every node in the routing table of every node, which creates supplementary routing overhead. There are several of advantages and disadvantage such as that routes are obtainable whole the moment they are desirable. However, these protocols are that the control overhead can be considerable in large networks or in networks with rapidly moving nodes and additional control traffic examples protocols for that DSDV and Global State Routing (GSR) [4].

### 2.3 Reactive routing protocols

Reactive routing protocols are also recognized as on-demand routing algorithms. Reactive protocols do not need to constantly preserve a route between all pairs of network nodes, but the route from the source node to the destination node is founded when two nodes want to interconnect with each other. When a source node needs to transmit data packets to the destination node, first it checks its route table to check if it has a route. If it does not find any valid route, it performs a route discovery procedure to find a path to the destination means route discovery becomes on-demand. The route remains valid till the connection is not terminated. The main advantage



of using reactive routing protocols is that it has relative fewer routing overhead as associated to proactive routing protocols. The disadvantage of reactive routing protocol is the overview of route achievement latency, an example of that DSR and AODV [4].

#### 2.4 Hybrid routing protocol

Hybrid routing protocols association features of both reactive and proactive routing protocols, characteristically endeavouring to feat the reduced control traffic overhead from proactive systems and reducing the route detection delays of reactive systems by maintaining routing table Example of Hybrid Routing Protocol Zone Routing Protocol (ZRP).

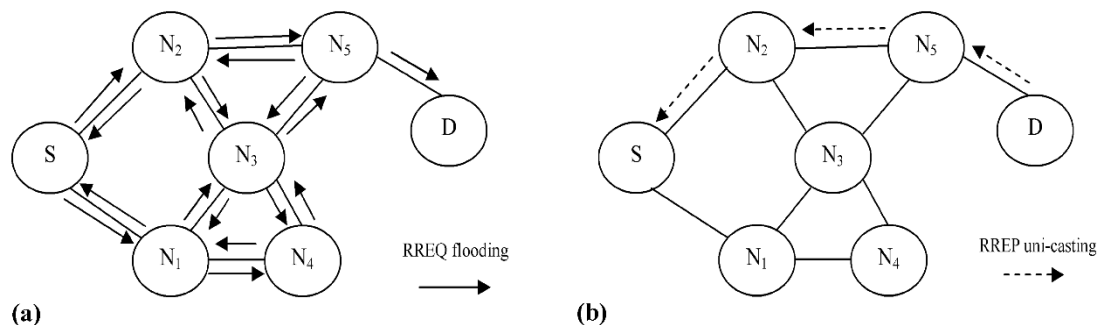
There are many reactive protocols have been proposed in MANET, in this study we will focus on three popular that is related to our research which are: AODV, DSR, AOMDV and DSDV.

#### 2.5 Ad hoc on-demand distance vector (AODV)

AODV or on-demand routing protocol is a reactive routing protocol designed for ad hoc networks up to thousands of nodes. In this, nodes preserve traditional routing tables specifying the next hop to take to reach the destination. All nodes regularly broadcast a 'HELLO' messages to its one-hop neighbors, which makes it possible for them to verify the link operation, or it is detected by a link signalling mechanism after the link is

used. When a link break is detected the end nodes source and destination are informed and it is up to them to find a new path. To reduce the route request broadcast storms the route discovery can be performed using an expanding ring search. When a node needs to send data to another node which the root are not predefined [5]. A source node (S) pledges the root detection phase to regulate a new route whenever a transmission is desirable. It broadcast Route Request (RREQ) to its neighbors. When each node receives the RREQ and has a route to the destination node (D), it updates a reverse route to the source in the routing table. Each neighboring unicasts a route reply packet (RREP) which has an incremented the sequence number to the reverse route it means that nodes reply to RREQ by RREP packet only if they have an active route towards the destination. Figure-1 shows the RREQ and RREP messages flow diagrams. The source node restarts the discovery process to make a new route to the destination if they still require an open route to the destination concerned[2].

AODV has many advantages that effect on data transmission through neighbors to a destination such as accelerate adoption to dynamically link conditions, avoid complications of counting link to infinity. The disadvantages of AODV can be heavy bandwidth consumption due to RREQ messages and unpredictable routing due to ancient sequence numbers.



**Figure-1.** AODV routing protocol. (a) RREQ messages, (b) RREP message [6].

#### 2.6 Dynamic source routing (DSR)

DSR is reactive and non-hierarchical routing protocol. The concept of DSR protocol is based on two techniques like route discovery and route maintenance. Route discovery in which node attempts to discover a route to a destination and route maintenance in which node maintains a route that is being used, these routes are stored in its route-cache. In route cache, multiple routes may be available for the same destination. It uses source routing in which no traditional routing tables are maintained at intermediate nodes, periodic updates and link status messages are required.

Every node has route request table to keep the information about route requests originated or forwarded by that node. It maintenance route cash for insertion, getting and deletion of the route. Generally, it uses three messages as RREQ, RREP and route error (RERR). The

route for a data packet is specified in IPv6 like routing header. The node receives an RREQ and rebroadcasts it unless it is the destination or it has a route to the destination. Such a node replies to the RREQ with a route reply RREP. The RREP routes itself back to the source by traveling backward. If the active linkage on a source route is cracked, the source node is informed using an RERR packet. After this mission complete. The route remove from their caches and packet will be sent through another route if available. The main characteristics of DSR are route cache can further reduce route discovery, a single route discovery may yield many routes to the destination. However, there are many drawbacks associated with DSR represent by packet header size grows with route length due to source routing, a flood of route request may potentially reach all nodes in the network[7].



## 2.7 Ad-hoc on-demand multipath distance vector (AOMDV)

AOMDV protocol is an extension to the AODV protocol for computing multiple loop-free and link disjoint paths. The routing entries for each destination contain a list of the next-hops long with the corresponding hop counts where next hops have the same sequence number and help in keeping the path of a route. For each destination, a node maintains the advertised hop count, which is defined as the maximum hop count for all the paths, which is used for sending route advertisements of the destination.

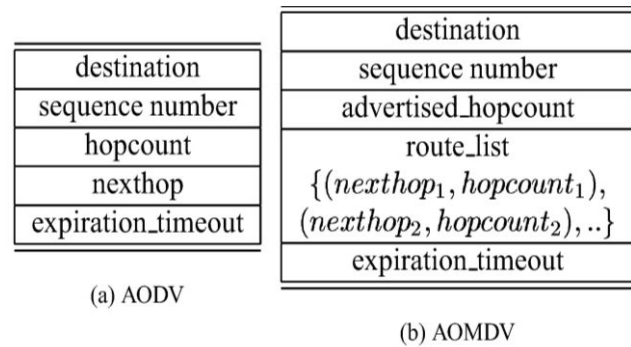
Each duplicate route advertisement received by a node may define an alternate path to the destination. Loop-freedom is assured for a node by accepting all alternating paths to the destination if it has a less hop count as compared to advertised hop count for that destination. As the maximum hop count is used, the advertised hop count does not change for the same sequence number. When a route advertisement is received for a destination with a greater sequence number, the next-hop list and the advertised hop count are reinitialized. AOMDV working on finding node-disjoint or link-disjoint routes. For finding node-disjoint routes, each node does not immediately reject duplicate RREQs and each RREQs arriving via a different neighbor of the source defines a node-disjoint path. This is mainly due to the lack of the broadcast of duplicate RREQs by the node, and any two RREQs arriving at an intermediate node via a different neighbor of the source could not have traversed the same node [8].

## 2.8 Sequenced distance-vector routing (DSDV)

An on-demand routing protocol, AOMDV has its roots in AODV, a popular single-path routing protocol. AOMDV creates a more extensive AODV by discovering, at every route discovery process, a multipath (i.e. several other paths) between the source and the destination. The multipath has a guarantee for being loop-free and link-disjoint.

AOMDV likewise offers two key services: route discovery and route maintenance. Since it greatly depends on the AODV route information, which is already available, AOMDV incurs less overhead than AODV through the discovery of multiple routes. Compared to AODV, AOMDV's only additional overhead are extra RREPs and RERRs intended for multipath discovery and maintenance, plus several extra fields to route control packets (i.e. RREQs, RERRs and RREPs). Adding some fields and changing others modified the structure of the AOMDV's routing table.

Figure-2 presents the routing table entries' structure for AODV and AOMDV. In AOMDV, *advertised\_hopcount* is used instead of the *hopcount* in AODV. A *route\_list* stood as a replacement for *nexthop*; this change essentially defining multiple *nexthops* with respective *hopcounts*. All *nexthops*, however, are still allotted the same destination sequence number. Every time the *sequence number* gets updated, the *advertised\_hopcount* is initialised.



**Figure-2.** Routing table structure for AODV and AOMDV.

AOMDV utilizes three control packets: RREQ, RREP, and RERR. Initially, when a source node is required to transmit data packets to a specific destination, the source node broadcasts an RREQ. Because the RREQs is a flooded network-wide, several copies of the very same RREQ may be received by a node. In the AOMDV, all duplicate copies undergo an examination to determine the potential alternate reverse path. However, of all the resulting set of paths to the source, only the use of those copies, which preserve loop-freedom and disjointedness, get to form the reverse paths.

In the event the intermediate nodes get a reverse path through an RREQ copy, it conducts a check to determine the number of valid forward paths (i.e. one or many) to the destination. If so, an RREP is generated by the node and the request is sent back to the source using the reverse path. For this route discovery, the RREP has a forward path that was not employed in any prior RREPs. The RREQ is not further propagated by the intermediate node. Otherwise, the node would broadcast the RREQ copy again—in case any other copy of this RREQ has not been previously forwarded and this copy has led to the updating or formation of a reverse path.

Like intermediate nodes, the destination likewise forms reverse paths when it receives RREQ copies. As a response to each RREQ copy arriving through a loop-free path towards the source, the destination produces an RREP, despite forming reverse paths that use only RREQ copies arriving through loop-free and disjoint alternate paths towards the source.

An RERR packet is used in AOMDV route maintenance. In the event link breaks, it generates an RERR message, listing lost destinations. The RERR is sent upstream by the node towards the source node. In the case of the existence of previous multiple hops which were using this link, the RERR is broadcast by the node. If there are no previous multiple hops, the request is unicast. Upon getting an RERR, the receiving node initially checks whether the node which sent the RERR is its own next hop towards any of the destination that is listed in the RERR. If the sending node is indeed the recipient node's next hop, the receiving node makes this route table invalid, after which it propagates the RERR back to the source. In this manner, the RERR continues to be forwarded until the source receives the request. Once this happens, it can



initiate the route discovery again if it still requires the said route.

## 2.9 Related work

Several research works have addressed the performance of routing protocols for different applications and scenarios:

Rewa Sharma *et al* (2013), in [9], performed a simulation study and also compared the DSR and DSDV routing protocols by varying the pause time and measured the metrics like packets lost, packet delivery ratio, packet arrival rate, end to end delay. According to use several of the performance metric. On another hand, it is also observed that packet delivery ratio is more consistent in DSR than DSDV with varied pause time. The increase in node mobility reduces the performance of DSDV.

In Hitesh Gupta *et al* 2013, in [10], performed a study on the various congestion control techniques, through node-disjoint multipath routing method based on AOMDV protocol. Uses route discovery method and identify all the available node-disjoint routes using a single flooding of an RREQ message. This study greatly reduces the routing overhead caused by route discovery

and maintenance processes thus increasing the network capacity.

In Ashok Kanthe *et al* (2012), in [11], evaluated the performance of routing protocols; DSR and AODV, in MANET, using network simulator 2.35. The researchers focused on routing table on AODV for one route per destination and number of destination sequence. Also, they studied the performance of AODV and DSR in terms of the location of nodes, speed, the number of connections and traffic between nodes. Their study noted that DSR has better performance than AODV for a number of nodes less 20 nodes. Also, AODV protocol is scalable than DSR.

## 3. SIMULATION ENVIRONMENT

The comparison between AODV, DSR, AOMDV, DSDV routing protocols was conducted using NS2. NS2 written in C++ and OTcl. The overall simulator is described by a Tcl class simulator and deployable on Medium Access Control (MAC) layer model. It provides a set of interfaces for configuring a simulation and for choosing the type of event scheduler used to drive the simulation. Table-1 shows the simulator configuration parameters.

**Table-1.** Simulator parameters.

Parameters	Value	Unit
Simulation time	300	second
Number of nodes	5, 10, 15, 20	node
Traffic control type	CBR	-
Maximum connection	5	-
Routing protocols	AODV, AOMDV,DSDV, DSR	-
Max speed	3,5,7,9	m/s
Network size	760 × 760	m <sup>2</sup>
Packet size	512	byte
Mobility model	Random way point	-
MAC protocol	IEEE 802.11	-

Many of qualitative and quantitative metrics that can be used to compare between reactive and proactive routing protocols. Therefore, the following different quantitative metrics have been considered to make the proportional study of these routing protocols through simulation environment.

### a) Average end-to-end delay (Avg2e delay)

This metric represents the average end-to-end delays experienced by each data packet at each hop on its way from the source node to the destination node[12]. The average e2e delay is computed as follow:

$$avg\ e2e\ delay\ (ms) = \frac{\sum_{i=1}^n (R_i - S_i)}{n} \quad (1)$$

where  $i$  is the packet index for data transmitted over the network and  $n$  is the total number of packets,  $R_i$  is the time

at which a packet with index  $i$  is received, and  $S_i$  is the time at which a packet with a index  $i$  is sent.

### b) Routing overhead (ROH)

The routing overhead ratio metric is the total number of routing packets, which is divided by the overall number of data packets that were delivered [13].

$$Routing\ overhead(\%) = \frac{No\ of\ routing\ packets}{No\ of\ routing\ packets + No\ of\ data\ packets\ sent} * 100 \quad (2)$$

### c) Packet loss ratio (PLR)

PLR is the ratio different between the number of data packets sent and the number of data packets received. It is calculated as follow:





$$PLR (\%) = \frac{(\text{no of packet sent} - \text{no of packet received})}{\text{no of packet sent}} * 100 \quad (3)$$

#### d) Packet delivery ratio (PDR)

PDR is the ratio of data packets delivered to the destination to those generated by the sources. It is calculated as follow:

$$PDR (\%) = \frac{\text{Number of packets received}}{\text{Number of packets sent}} * 100 \quad (4)$$

## 4. SIMULATION RESULT AND DISCUSSIONS

### 4.1 Effect of node speed

Figure-3 showing for all protocols; AODV, DSR, DSDV and AOMDV varying node speed. DSR and AOMDV show significantly lower percentages of delay through changing node speed and AODV protocol exhibit slightly higher delay than AOMDV and DSR. On the other hand, DSDV's delay gradual rise until the end of simulation time. On the other hand, DSR still fluctuates until the end time of simulation.

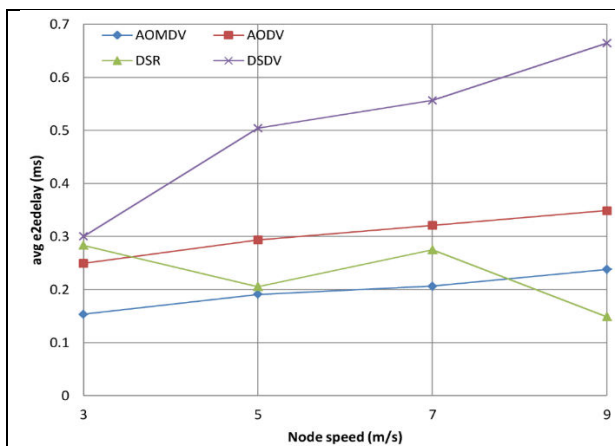


Figure-3. Average end to end delay with respect to the node speed.

Figure-4 showing the PLR for all protocols, we observed there was variation between DSDV with other protocols. We can notice that DSDV behaves wobbling through simulation time. AODV, DSR and AOMDV start with a lower number of packet loss with the slightly difference between them. We can observe that DSR has a better performance than other protocols at same simulation.

In terms of PDR, we observed in figure 5 that AODV, AOMDV and DSR have identical PDR since the protocols have similar routing mechanisms but DSDV presents alteration from other protocols with steep decline delivery packets through increasing of node speed till 7 m/s then gradual raise till the end of simulation time.

In Figure-6, we observed AODV and DSR have better ROH. AOMDV have slightly ROH more than DSR and AODV. On the other hand, ROH of DSDV has a steep decline at 7 m/s. it can be observed that AODV, AOMDV and DSR have better performance than DSDV when changing node speed. Also to the fact that the early RREQ packets are introducing an almost highest percentage of ROH in DSDV.

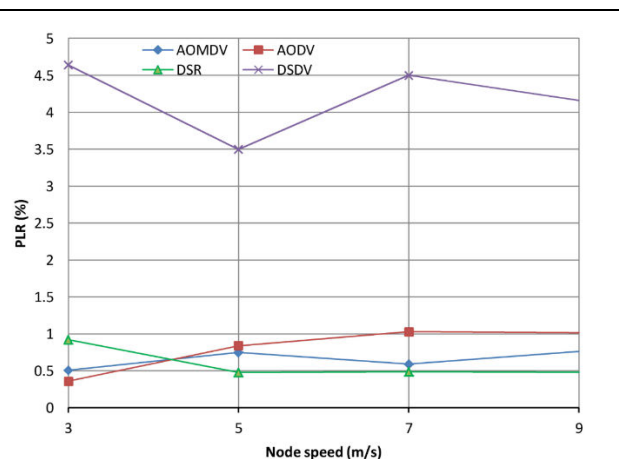


Figure-4. PLR with respect to the node speed.

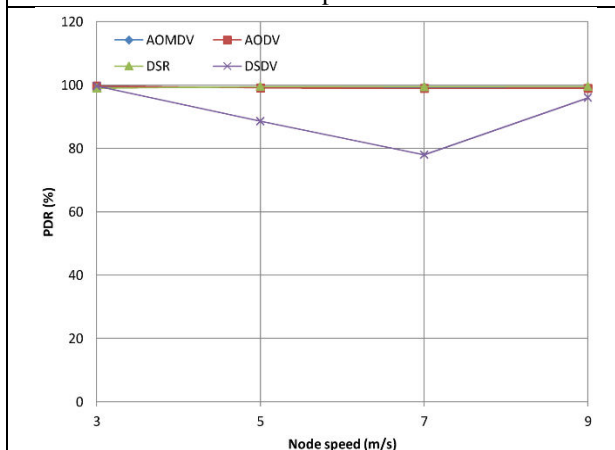


Figure-5. PDR with respect to the node speed.

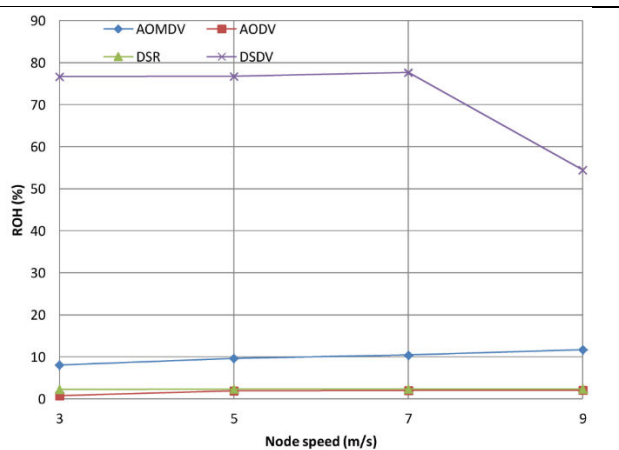


Figure-6. ROH with respect to the node speed.

### 4.2 Effect of number of nodes

In Figure-7, we noticed that AODV has a high percentage of avg e2e delay through a small number of the

node. However, the avg e2e delay of AODV protocol steady decreases when the number of nodes increase. On



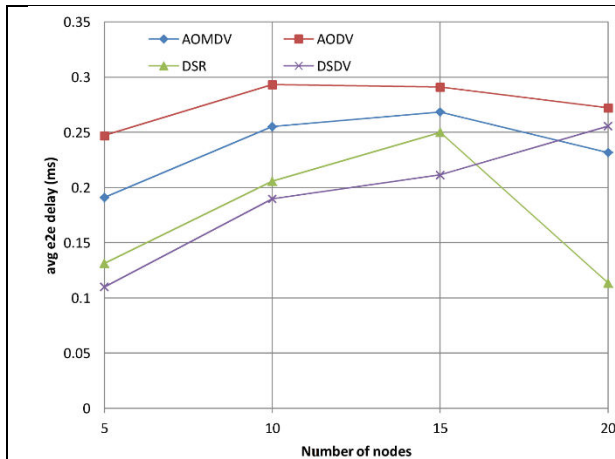
the other hand, DSDV routing protocol lower delay for a small/large number of nodes although slightly gradual rise.

We observed, in Figure-8, that all simulated protocols have less number of packet drops with slightly fluctuate, while DSR has a lower packet dropping than others for a small/large number of nodes and DSDV packet dropping gradually raises with the increment in the number of nodes.

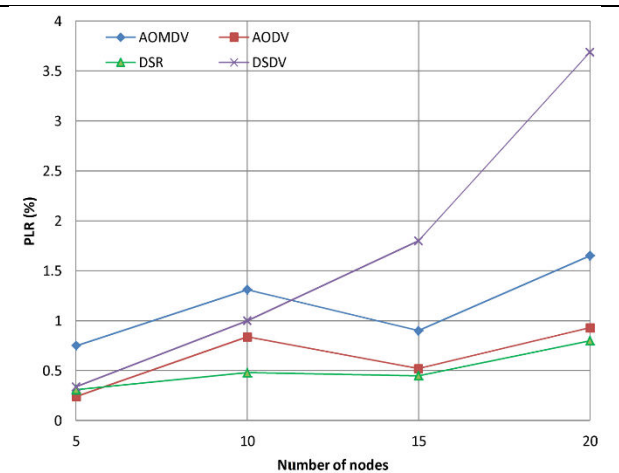
We noticed, in Figure-9, that AOMDV's PDR steady decrease through simulation time for a small and

large number of nodes. AOMDV and AODV slightly waving to end of simulation time. On the other hand, DSR routing protocol shows better PDR for a different number of nodes.

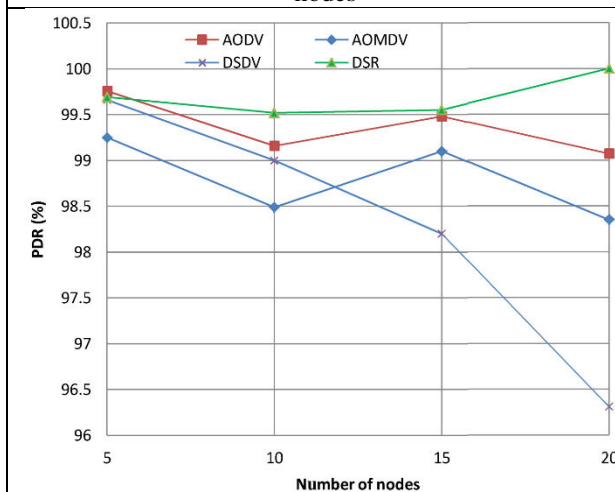
Finally, figure 10 presents a lower ROH of AODV and DSR through simulation time, but AOMDV gradually raises through a small and large number of nodes. On the other hand, DSDV showing a linear trend in terms of ROH with a different number of nodes.



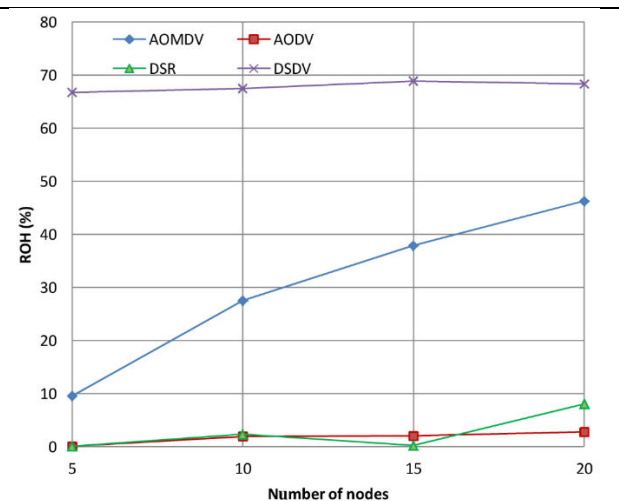
**Figure-7.** Avg e2e delay with respect to the number of nodes



**Figure-8.** PLR with respect to the number of nodes.



**Figure-9.** PDR with respect to the number of nodes



**Figure-10.** ROH with respect to number of nodes

## 5. CONCLUSIONS

This research study evaluates the performance of four routing protocols AODV, AOMDV, DSDV and DSR through NS2. The evaluation of comparison between these protocols based on several of performance metrics average e2e delay, packet loss ratio, packet delivery ratio and routing overhead. The study performed over two network parameters; node speed and number of nodes. In the first scenario for node speed, we concluded DSR routing protocol has better performance than other simulated protocols and provided high performance percentage in packet delivery ratio, packet loss ratio, average e2edelay, while AODV has better performance through routing

overhead. In second the scenario for a number of nodes, DSR and AOMDV behave better performance throughout varying number of nodes while DSDV presents worse performance.

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