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MANET: Simulation Analysis and Performance Evaluation of Routing Protocol Using NS-3

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Abstract: ***Mobile ad hoc network (MANET) is a collection of several wireless devices or mobile users that can communicate among themselves over wireless links in a peer to peer basis and thereby creating a dynamic, arbitrary graph. But some adverse characteristics of MANET like dynamic topology, limited bandwidth, link failure and energy constraints, imposes new demands on routing protocol. This paper aims to study the performance evaluation and comparison of three prominent routing protocols: Destination Sequence Distance Vector (DSDV), Ad-hoc On demand Distance Vector (AODV) and Optimized Link State Routing (OLSR), in a real life scenario. In a given scenario, students investigate the historical site in which number of packets being sends and number of nodes in the network affects the communication reliability. Extensive simulations are made to evaluate the performance of these protocols using various performance differential metrics like packet delivery ratio, total energy consumption and throughput using NS3. In the end it is seen that in most simulation results, proactive routing protocols (DSDV, OLSR) performed significantly better than reactive routing protocols.***

Keywords: MANET, DSR, AODV, TORA, OLSR, DSDV, NS3

I. INTRODUCTION

Evolution of wireless and mobile communication, enables users use their cellular phones to browse the Internet anywhere but these networks require centralized administration with fixed network infrastructure, that also includes set-up and maintenance cost. But, easy availability of mobile nodes enabled with short range wireless interface and computation capability gave the concept of MANET. A Mobile ad hoc Network (MANET) is a network of portable autonomous nodes equipped with wireless interface, communicates over wireless links without centralized administration. These networks can self-configure and maintain the network topology dynamically without the infrastructural support. MANETs have many applications: in tactical networks, emergency services, commercial and civilian environments, home and enterprise networking, education, entertainment, sensor networks, context aware services and coverage extension . Figure 1 shows an ad hoc network with three wireless mobile hosts. Node 1 is not within the range of node 5's wireless transmitter and vice versa. If node 1 and node5 want to exchange packets, they must enlist the services of node 2 And Node 4 to forward the packets for them, since node 2 is within the range overlap between node 1 and node 3.

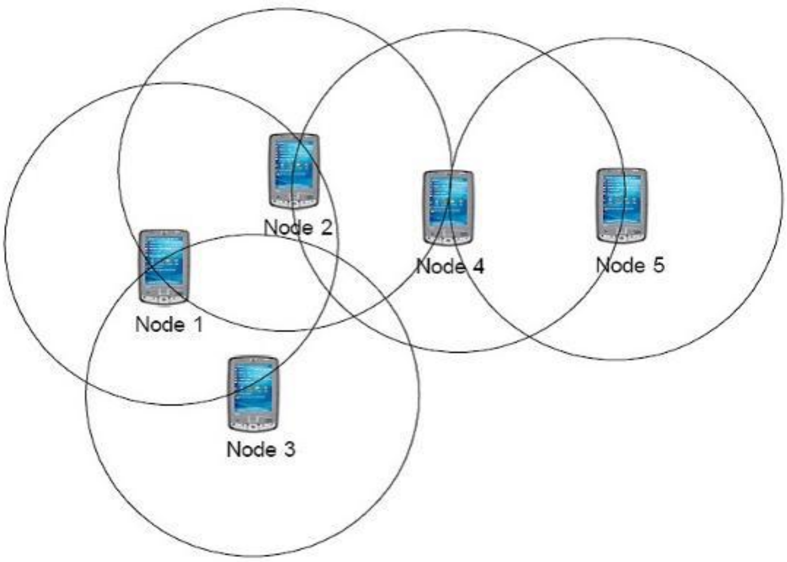

Fig 1: Simple ad-hoc network with three participating nodes

In this paper, in a given scenario, students investigate the historical site in which number of packets being sends and number of nodes in the network affects the communication reliability. Extensive simulations are made using various performance differential metrics like packet delivery ratio, total energy consumption and throughput. For simulations NS3 is being used. In the end it is seen that in most simulation results, proactive routing protocols (DSDV, OLSR) performed significantly better than reactive routing protocols. The rest of the paper is organized as follows. In section 2 literatures survey is presented. In Section 3 brief overview of routing protocols are pointed out. Section 4, describes real world scenario taken into consideration. Simulation results in a given scenario are shown in section 5. Finally, conclusions are drawn in section 6.

II. LITERATURE SURVEY

Routing protocols performance depends on network environment like node density, traffic, mobility, pause time, type of traffic etc. proactive protocols provide excellent performance in terms of packet delivery ratio and end-to-end delays and reactive protocols shows good performance in terms of routing load. In previous paper author concluded that under (constant bit rate) CBR traffic proactive routing protocols is superior than on-demand routing protocols at the cost of higher routing load. AODV is preferred over DSR and DSDV for real time traffic .OLSR behavior changes according to the change in mobility model and traffic type (VBR or CBR) used. Performance is concluded in terms of PDR and Throughput, AODV and DSR perform better than DSDV and in terms of average end-to-end delay, DSDV appears to be the best one. TCP traffic, DSDV performance is better than AODV but at the cost of higher end-to-end delay in both freeway and random waypoint mobility model

The evaluation of how the varying metrics (Number of nodes, Topology size, Packet Rate and Maximum no. of nodes) in different scenarios affect the power consumption in these protocols was discussed. Results concluded that DSR was efficient with most mobility scenarios but at the cost of routing overhead. On the other hand AODV is efficient with some mobility scenarios by eliminating routing overhead of the DSR protocol. It was also shown that DSR resulted better performance with the perspective of energy consumption for low density networks and also for high density networks than AODV. However, AODV was found effective for low loads. They also analyzed that by considering the routing overhead of AODV and reducing the number of control packets, life time of the network can be increased.

III. ROUTING PROTOCOLS

Routing protocols are divided into two categories: Reactive and Proactive. Reactive protocols create and maintain routes when they are needed by the source host. On the other hand, Proactive routing protocols maintains updated lists of destinations and their routes by distributing routing tables periodically throughout the network. In this section, AODV, DSDV and OLSR routing protocols are pointed out.

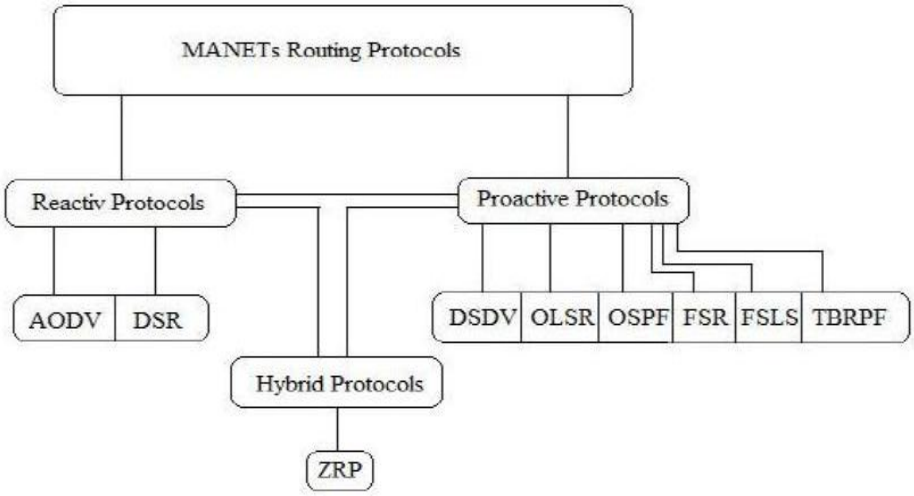

Fig3.1 : Classification of MANET routing protocols

A. Ad hoc on demand distance vector routing protocol

Ad Hoc on-demand Distance vector [9] (AODV) is a very efficient and effective routing protocol. AODV was motivated by the limited bandwidth of the media used for wireless communication. It uses an on-demand approach for finding routes i.e. routes are created and maintained only when they are needed. It borrows, on demand route discovery and route maintenance from DSR and usage of node sequence numbers from DSDV. The major difference between DSR and AODV stems out from the fact that in DSR, data packet carries the total path to be traversed but in AODV, source node and intermediate nodes store the next hop information and a sequence number which is received from the destination indicating the freshness of the received information (A node updates its path information only if the last *DestSeqNum* stored at the node is less than the *DestSeqNum* of the current packet received). Also the information about the active neighbors is received so that when the corresponding route breaks, then the neighbors can be notified.

In an on-demand routing protocol, when a route is not available for the desired destination, source node floods *RouteRequest* (RREQ) packets to its neighbors with the requested destination sequence number. Multiple routes can be obtained from single *RouteRequest*. A *RouteRequest* carries the source identifier (SrcID), the source sequence number

(SrcSeqNum), the destination identifier (DestID), the destination sequence number (DestSeqNum) and the broadcast identifier (BcastID) and the time to live field. When an intermediate node receives a *RouteRequest*, it either prepares a *RouteReply* if it has a valid route to the destination or forwards it to its neighbors. BcastID-SrcID pair discards the duplicate copies received at the nodes. Either destination nodes or intermediate nodes having valid routes are allowed to generate *RouteReply* packets to the source. While forwarding a *RouteRequest*, every intermediate node enters the previous node address and it's BcastID. So, to maintain the active path at the intermediate nodes, a timer is used to delete the entry in case a *RouteReply* is not received before the timer expires. On receiving the *RouteReply* packet, a node stores the information about the previous node from where it receives the packet in order to forward the packet to this next node as the next hop toward the destination. Some of its characteristics are shown in Table 1.

Table 1. AODV Characteristics

Parameters	**Values**
Routing Architecture	Flat
Philosphy	Distributed
Type	Reactive
Broadcasts	Periodically
Route updation	Non-periodic
Multicasting	Yes
Beacon packets	No
Multiple Routes created	No
Utilizes Route Cache/Table Expiration Timers	Yes
Route Maintenance Methodology	Erase route; Notify Source
Routing Metric	Fresh and shortest path

B. Destination Sequenced Distance Vector (DSDV) Routing Protocol:

The Destination Sequenced Distance Vector (DSDV) is one of the first ad hoc wireless networks protocols. It is a table driven routing protocol meaning that at all times, routes to all destinations is readily available at every node. Every node maintains a table listing all the other nodes it has known directly or through some neighbors. To keep an up-to-date view of the network topology, tables are exchanged between the neighbors at regular intervals. Each table entry contains node's IP address, last known sequence number and the hop count to reach that node. Each node uses 2 mechanisms to send out the DSDV updates. They are periodic updates and trigger updates (these are small updates in-between the periodic updates). Single network data packet unit (NDPU) is used during an incremental update meaning that when a node does not observe significant changes in the local topology, where as multiple NPDUs are used during a full dump meaning that when an incremental update requires more than single NPDU or local topology changes significantly. Table updates are initiated by a destination with a new sequence number and based on this sequence number; it may forward or reject the table. DSDV uses triggered route updates during topology change. In highly mobile scenarios, a concept of weighted setting time is considered where an update with change in metric is not advertised to neighbors due to great chance of route fluctuations Some of its characteristics are given in Table 2.

Table 2. DSDV Characteristics

Parameters	**Values**
Routing Architecture	Flat
Loops	No
Multicast capability	No
No of required tables	2
Update transmission	Periodically &as needed
Updates transmission	Neighbors
Utilizes sequence numbers	Yes
Utilizes beacon packets	Yes
Overhead	High
Routing Metric	Shortest Path

C. Optimized Link state routing

Optimized Link State Protocol (OLSR) [16] is a proactive routing protocol i.e. route is always immediately available when needed. OLSR is an optimized version of classical link state protocol which creates large control packet overhead. OLSR uses Multipoint Relays (MPR) to reduce the information exchange overhead in the network as only the MPRs are allowed to broadcast the packet and MPR set of host is kept small. This is the reason why OLSR is used in high dense network. In OLSR, Hello and Topology Control (TC) messages are used as control messages where Hello messages are used for performing the task of link sensing, neighbor detection and MPR signaling and TC messages are used for performing the task of topology declaration (advertisement of link states). Another type of message is Multiple Interface Declaration (MID) messages, performs the task of declaring the presence of multiple interfaces on a node and which is broadcasted throughout the entire network by MPRs. There is also a "Host and Network Association" (HNA) message which provides information about the network and netmask addresses. HNA is considered as a generalized version of the TC message with only difference that the HNA message information is removed only after expiration time while TC message inform about the route cancelling. Some of its characteristics are pointed out in Table 3.

Table 3. OLSR Characteristics

Parameters	**Values**
Routing Architecture	Flat
Number of tables	3(Routing, neighbor and topology table)
Updates Frequency	Periodic
Hello messages	Yes
Characteristic feature	Reduces control overhead using MPR and contention/ 2-hop neighbor knowledge required.

IV. SIMULATION ANALYSIS OF MANET PROTOCOL

In this simulation we check behavior of a network using DSR, AODV, TORA protocols in scenario with 150 node, many network simulators are available to design and simulate networks in many perspectives. NS-2 (Network Simulators-2) and OPNET (Optimized Network Engineering Tools) are the two very well-known

Experimental Setup and Metrics

The ns-3 simulator was used for the experiments. We now describe the traffic pattern, the scenario description and the metrics that were used for the experiments.

Metrics:

The following metrics were used for performance evaluation-

a. **Packet Delivery Ratio ():** It is the ratio between the numbers of packets originated by the application layer and the number of packets received by the sinks at the destination. It describes the loss rate which in turn affects the maximum throughput that the network can support. It represents the reliability of the communication.

$$PDF = \frac{numberOfReceivedPackets}{numberOfSentPackets}$$

This estimate gives us an idea of how successful the protocol is in delivering packets to the application layer. A high value of PDR indicates that most of the packets are being delivered to the higher layers and is a good indicator of the protocol performance.

b. **Throughput:** It is the average rate of successful message delivery over a communication channel. In following figures, average delay is compared between these protocols at 11 Mbps DSSS Rates..

$$NRL = \frac{numberOfRoutingPacketsSent}{numberOfDataPacketsReceived}$$

This metric gives an estimate of how efficient a routing protocol is since the number of routing packets sent per data packet gives an idea of how well the protocol maintains the routing information updated. Higher the NRL, higher the overhead of routing packets and consequently lower the efficiency of the protocol.

c. **Average end to end delay (AED) :** This is defined as the average delay in transmission of a packet between two nodes and is calculated as follows-

$$AED = \frac{\sum_{i=0}^{n}(timePacketReceived_i - timePacketSent_i)}{totalNumberOfPacketsReceived}$$

A higher value of end-to-end delay means that the network is congested and hence the routing protocol doesn't perform well. The upper bound on the values of end-to-end delay is determined by the application. For example multimedia traffic such as audio and video cannot tolerate very high values of end-to-end delay when compared to FTP traffic

Research methodology

Three parameters in the battlefield scenario were varied –Packet delivery ratio , the total number of nodes and average number of nodes in a group and their impact on the three metrics described above were studied. The results are discussed in the next section.

V. RESULTS

i. Packet Delivery Ratio:

It is the ratio between the numbers of packets originated by the application layer and the number of packets received by the sinks at the destination. It describes the loss rate which in turn affects the maximum throughput that the network can support. It represents the reliability of the communication.

In Figure 2 AODV and OLSR outperforms DSDV in every case. OLSR shows best performance when no. of packets is 500 resulting 81.65% PDR. At 100, 150, 200 and 400 packets AODV outperforms OLSR, but in all other cases OLSR shows best results.

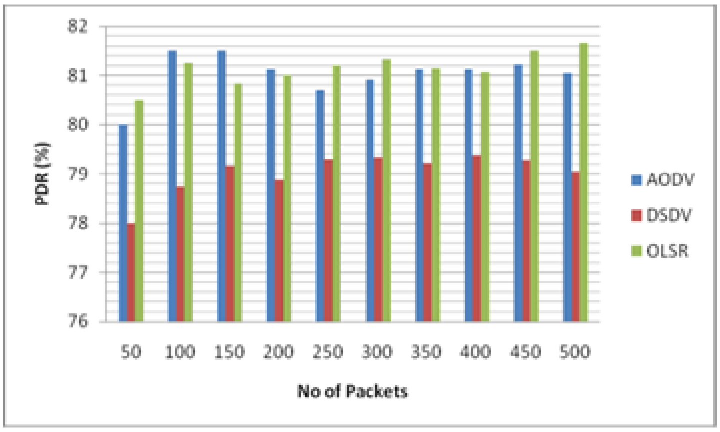

Fig 4.1 : PDR vs. No. of Packets sends when nodes are 5

Figure 3 shows that when no. of nodes is increased to 10 AODV gives worst results. When number of packets is 150, 200, 250, 500, DSDV outperforms OLSR, but at high traffic OLSR performs best from two of them.

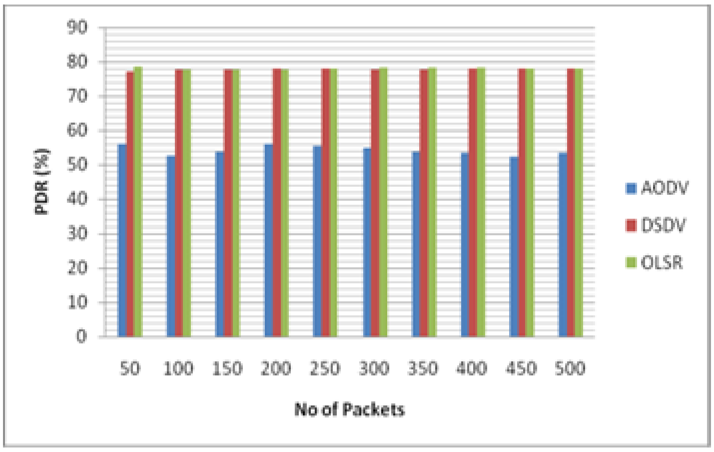

Fig 4.2 : PDR vs. No. of Packets sends when nodes are 10

In Figure 4 AODV shows worst performance. OLSR outperforms DSDV in every case except when number of packets is 50 and 100.

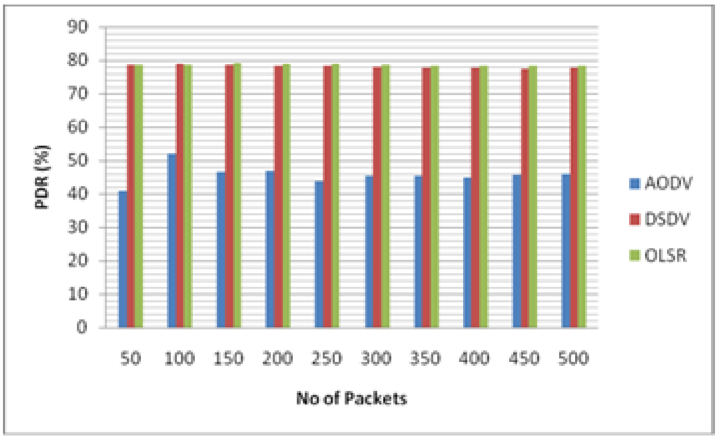

Fig 4.3: PDR vs. No. of Packets sends when nodes are 15

Figure 5 show that DSDV and OLSR outperform AODV in every case. OLSR outperforms DSDV only when number of packets are 50.

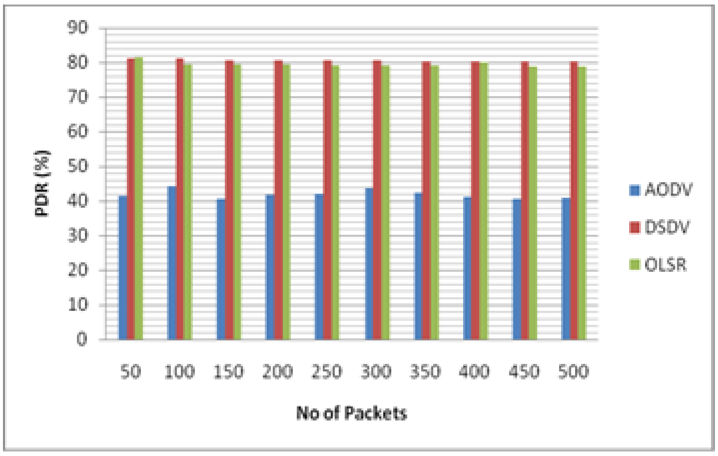

Fig 4.4 : PDR vs. No. of Packets sends when nodes are 20

In Figure 6 it is shown that in every case OLSR outperforms DSDV and AODV.

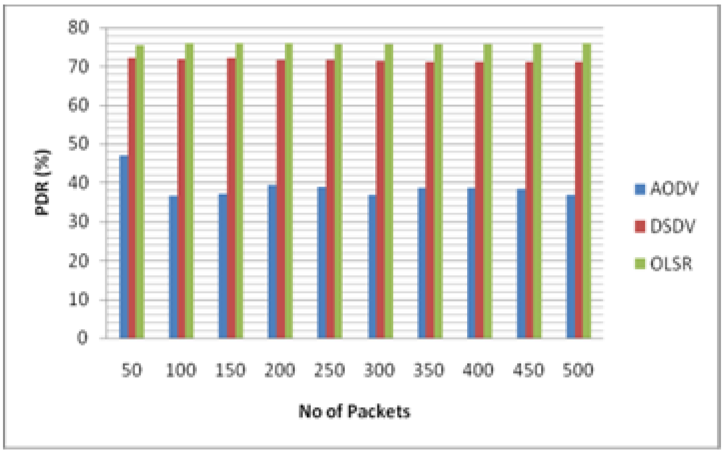

Fig 4.5 : PDR vs. No. of Packets sends when nodes are 25

In Figure 7 OLSR and DSDV outperforms AODV in every case and OLSR performance is better than DSDV.

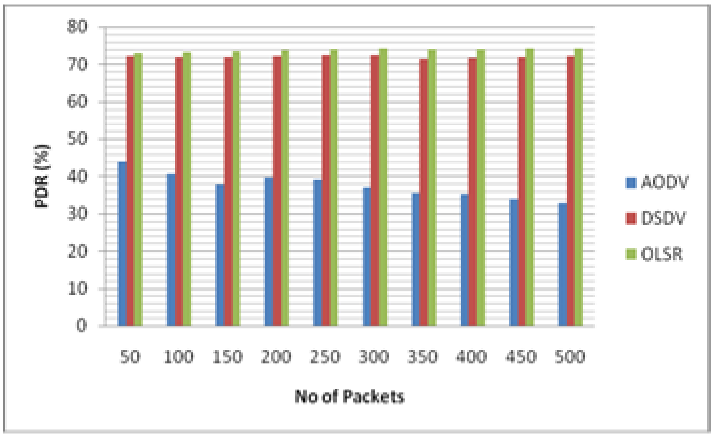

Fig 4.6 : PDR vs. No. of Packets sends when nodes are 30

ii. Effect of varying the Nodes

The effect of varying the Nodes for three metrics are shown in table 4.4 and the corresponding graphs are shown in figures 4.6, 4.7 and 4.8. It can be inferred that as pause time varies, the packet delivery fraction also increases. This is due to the fact that as pause time increases, the relative mobility of the nodes decreases, and hence the congestion also decreases in the network.

Table 4.4: Effect of varying the pause time

No. Of Nodes	Packet Delivery Fraction (%)	Average End-end delay (sec)	Throughput
10	99.91438	0.006738278	0.2570694
15	100	0.006566893	0.3088803

20	100	0.013576984	0.42168674
25	99.95756	0.032688957	0.47558385
30	99.95761	0.010179137	0.49618322

iii. Throughput

It is the average rate of successful message delivery over a communication channel. In following figures, average delay is compared between these protocols at 11 Mbps DSSS Rates.Figure 14 shows that when number of packets is 150, DSDV results more throughput than AODV and OLSR. Otherwise DSDV shows worst performance in every case. AODV outperforms OLSR at 100, 250, 300, 400, and 450 and in all other cases OLSR outperforms AODV

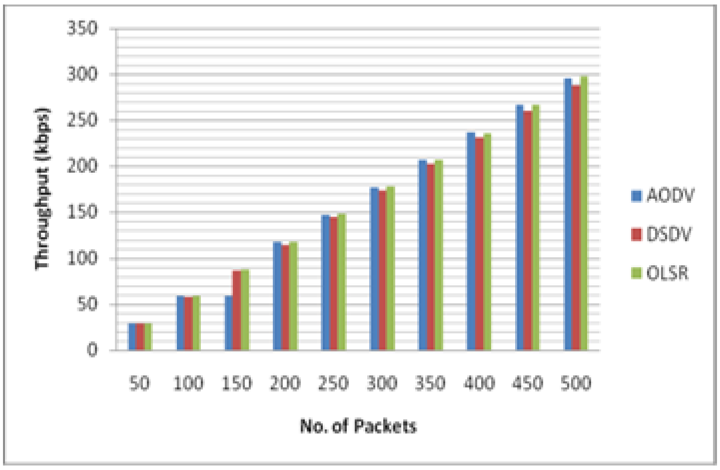

Fig 14: Throughput vs. No. of Packets sends when nodes are 5

Figure 15 shows that when number of packets is 150, 200, 250 and 500 DSDV outperforms OLSR and in all other cases OLSR shows best results.

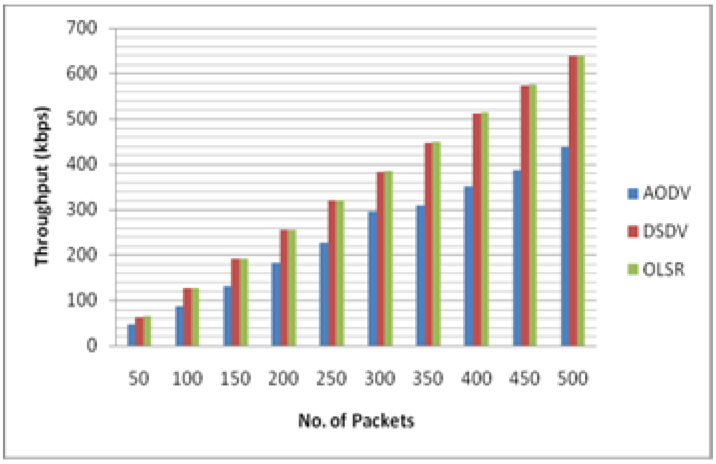

Fig 15: Throughput vs. No. of Packets sends when nodes are 10

Figure 16 show that when number of packets is 50 and 100 DSDV outperforms OLSR.

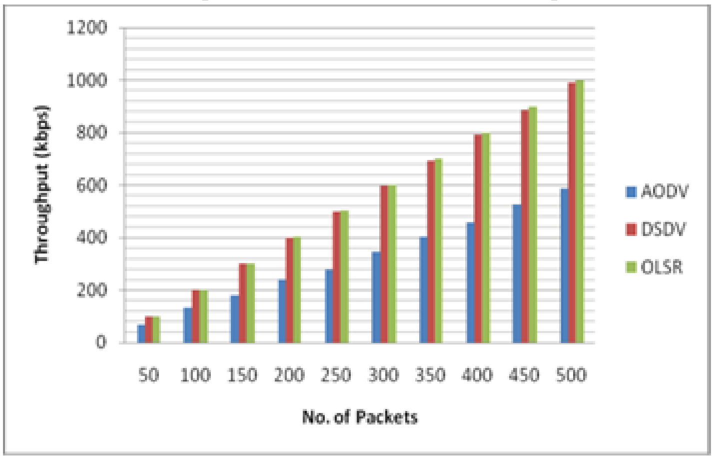

Fig 16: Throughput vs. No. of Packets sends when nodes are 15

In Figure 17 AODV shows worst performance. DSDV outperforms OLSR in every case.

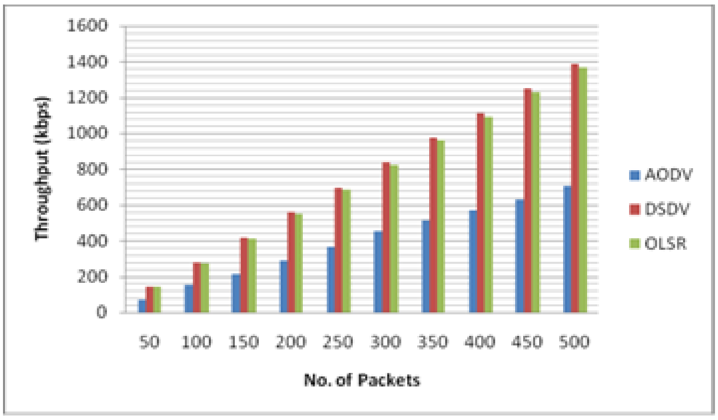

Fig 17: Throughput vs. No. of Packets sends when nodes are 20

In Figure 18 OLSR outperforms DSDV in every case and AODV shows worst performance in all cases.

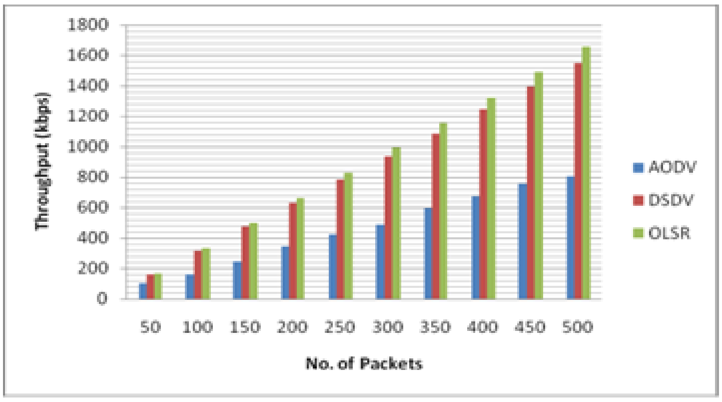

Fig 18: Throughput vs. No. of Packets sends when nodes are 25

Figure 19 shows that OLSR outperforms DSDV in every case and AODV shows worst results in all cases.

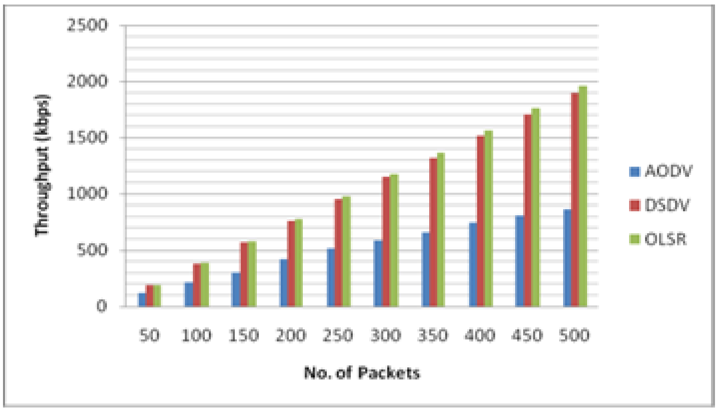

Fig 19: Throughput vs. No. of Packets sends when nodes are 30

VI. CONCLUSION

During the case of PDR, AODV has shown the 81.5% best PDR performance only when, number of nodes is 5 and number of packets is 100 and 150, but in all other cases, the other two protocols always outperform AODV. OLSR has best performance among them with 81.65% best PDR when number of nodes are 5 and number of packets are 500 where as DSDV shows 81.2632% best PDR when number of nodes are 20 and number of packets are 100. So according to this scenario, it is concluded that when traffic is slow then AODV shows best results, when traffic is medium then DSDV shows best results and at high traffic OLSR shows best results.

During the case of total energy consumption, AODV never shows best results and in all other cases DSDV and OLSR outperforms AODV. DSDV and OLSR have quite same performance but OLSR with some better results than DSDV at high traffic.

Further, in case of throughput, AODV shows best results when number of nodes is 5 and number of packets is 200 and 400. OLSR and DSDV have quite same performance but OLSR has 1959.34 kbps the highest throughput where as DSDV has 1900.72 kbps the highest throughput when number of nodes is 30 and number of packets is 500 and these protocols always outperform AODV.

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