Performance Evaluation of Reactive, Proactive and Hybrid Routing Protocols Based on Network Size for MANET

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Abstract

Ad hoc network is a collection of wireless mobile nodes where wireless radio interface connects each device in a MANET to move freely, independently and randomly. Routing protocols in mobile ad hoc network helps to communicate source node with destination node by sending and receiving packets. Lots of protocols are developed in this field but it is not easier to decide which one is winner. In this paper, we present investigations on the behavior of five routing protocols AODV (Ad hoc On demand distance vector), DSR (Dynamic Source Routing), DYMO (Dynamic MANET On demand), OLSR (Optimized link state routing) and ZRP (Zone routing protocol) based on IEEE 802.11CSMA/CA MAC protocol are analyzed and compared using QualNet simulator on the basis of performance metrics such as Average Jitter, Total Packets Received, Packet Delivery Ratio, End-to-End Delay, Throughput, Average Queue Length, Average time in Queue, dropped packets due to non availability of routes and Energy consumption in transmit and receive Mode. To test competence and effectiveness of all five protocols under diverse network scenarios costing is done by means varying load by varying CBR data traffic load, changing number of Nodes and mobility. Finally results are scrutinized in from different scenarios to provide qualitative assessment of the applicability of the protocols.

Keywords: MANETs, DSR, DYMO, AODV, OLSR, and ZRP, CBR.

1. INTRODUCTION

A Mobile ad hoc network is characterized as a network containing nodes that are self organizing and not bound to any centralized control like a base station. The mobile nodes with wireless radio interface are connected by wireless links where each device in a MANET is free to move independently and randomly with the capability of changing its links to other devices frequently. Mobile ad-hoc networks or "short live" networks control in the nonexistence of permanent infrastructure. Though, [1], [2], and [3] illustrates performance of the protocols. This paper throws lights on various experimental and analytical comparative results of AODV, DSR, DYMO, OLSR and ZRP obtained by Qualnet simulator for varying network type, Investigated performance of all five routing protocol uses CBR traffic under Random waypoint Mobility Model. The result draws some general conclusion by considering some vital metrics with MAC and physical layer model which can be helpful in research work of researcher for future references.

2. SIMULATION SETUP

In this scenario wireless connection of varying network size (20 nodes, 50 nodes, 100 nodes and 200 nodes) for MANET is used for comparison the performance of routing protocol (AODV, DSR, DYMO, OLSR, ZRP) and over it data traffic of Constant Bit Rate (CBR) is applied between source and destination. The nodes are placed randomly over the region of 700m x 700m. The 2, 5 and 10 CBR applications are applied in their respective network of size 20, 50 ,100 and 200 over different source nodes and destinations nodes [20 nodes-> (9, 12) (10, 2), 50 nodes-> (47, 40, 24, 23, 44) (35, 49, 31, 46, 10), 100 nodes-> (99, 63, 47, 49, 73, 76, 29, 37, 86, 41) (13, 32, 2, 36, 8, 23, 75, 4, 70, 38) and 200 nodes->(107, 8, 32, 189, 9, 191, 75, 163, 176, 63, 20, 42, 180, 65, 51) (174, 3, 86, 4, 16, 85, 195, 190, 64, 17, 175, 41, 10, 118, 1)] to analyze the performance of AODV, DSR, DYMO, OLSR and ZRP routing protocols. The animated simulation of network size 20, 50, 100 and 200 are shown in FIGURE 1, FIGURE 2, FIGURE 3 and FIGURE 4.

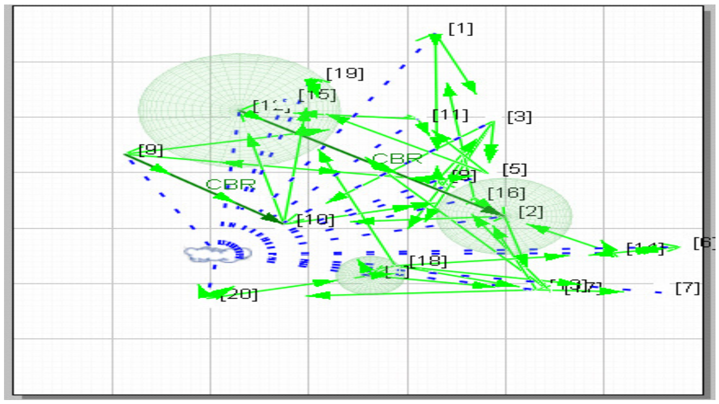

FIGURE 1: Animation view of 20 nodes with 2 CBR(s).

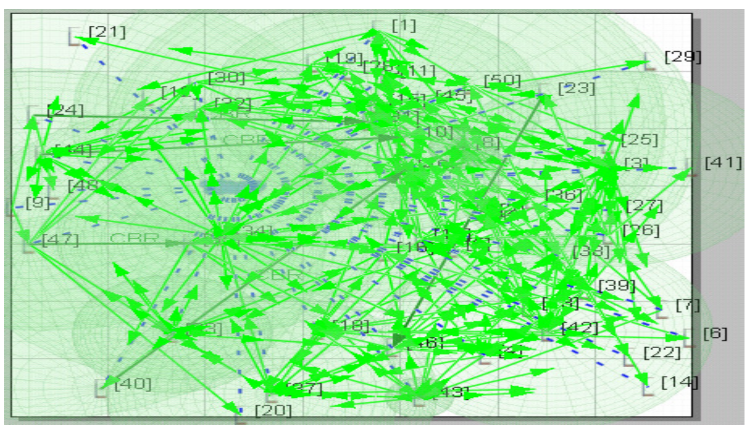

FIGURE 2: Animation view of 50 nodes with 5 CBR(s).

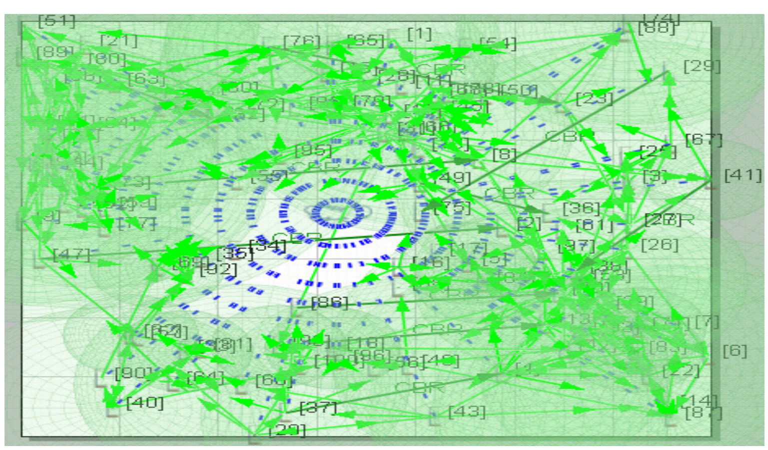

FIGURE 3: Animation view of 100 nodes with 10 CBR(s).

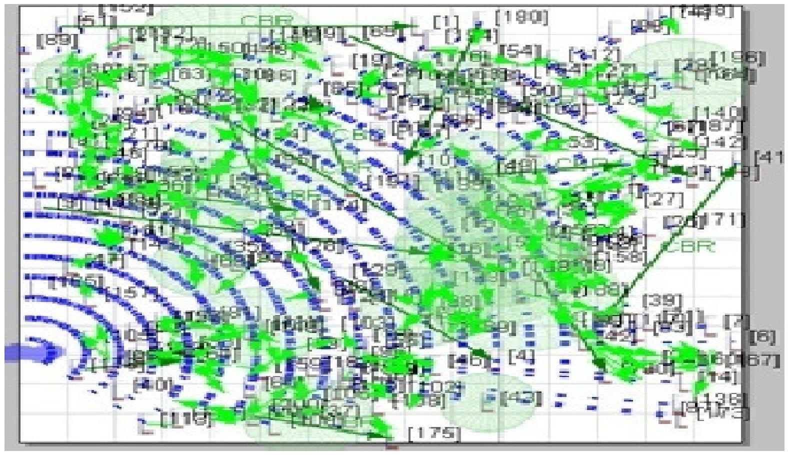

FIGURE 4: Animation view of 200 nodes with 15 CBR(s).

2.1 Performance Analysis: The simulations parameters are shown in Table1.

TABLE 1: Simulation Parameters for varying network where mobility of the nodes kept a constant

Parameters	Values
Simulator	QualNet
Protocols studied	AODV, DSR, DYMO, OLSR & ZRP
Number of nodes	20, 50, 100, 200 nodes
Simulation time	100 s
Simulation area	700*700 sq m
Node movement model	Random waypoint mobility
Traffic types	2, 5 ,10 & 15 CBR sources, respectively
Mobility of nodes	Min speed=1m/s ,Max speed=10m/s,
Rate of packet generation	20 packets/s
Size of packets	1000 bytes

The Qualnet 5.0.2 network simulator [6] is used to analyze the parametric performance of Dynamic Source Routing (DSR) [4, 5], Ad Hoc On-Demand Distance-Vector Protocol (AODV) [8][10], Dynamic MANET On Demand (DYMO) [7], Optimized Link State Routing (OLSR)[11] & Zone Based Routing Protocol (ZRP)[9] routing protocols. The IEEE 802.11[12] for wireless LANs is used as the MAC layer protocol. The performance is analyzed with varying nodes in network keeping traffic load and mobility constant. The results are shown in from FIGURE 5 to FIGURE 13.

3. PERFORMANCE METRICS

3.1 Average Jitter

This metric is calculated by subtracting time at which first packet was transmitted by source from time at which first data packet arrived to destination. This includes all possible delays caused by buffering during route discovery latency, queuing at the interface queue, retransmission delays at the MAC, propagation and transfer times. We can observe that at density of 20 nodes all the four protocols except DSR have small jitter value than at density of 50 nodes. OLSR shows highest jitter and ZRP is next to it for high node density as shown in FIGURE 5. It can be established that by analyzing effect of network size on jitter for all the five protocols, the jitter although small for small network increase as the network size increases.

Jitter is the variation in the time between packets arriving, caused by network congestion, timing drift, or route changes. But at high density network say for 200 nodes since query packets will be flooded throughout the network control overhead increases, it consumes more time to reconfigure the route if link failure occurs. Hence there will be more time variation between arrivals of packets results in more jitter value.

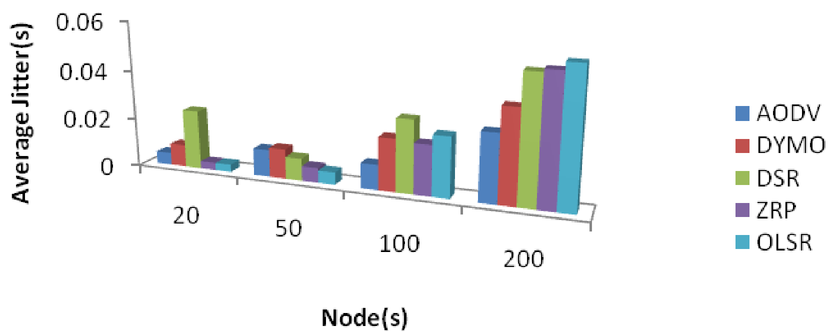

FIGURE 5: Graph [4.6.3.1.1]: IEEE 802.11-CBR Server: Average Jitter(s) for AODV, OLSR, ZRP Comparison-Node (10, 40, 80, 120) Variation Network.

4.6.3.1.2 Packet Delivery Ratio

It specifies the packet loss rate, which limits the maximum throughput of the network. The better the delivery ratio, the more complete and correct is the routing protocol. In the FIGURE 6 we can observe that when network density is less i.e for 20 nodes, numbers of packets delivered are more as compared at denser network of size 200 nodes. DSR has an edge over other protocols in successfully delivering data packets for varying node density. DYMO and AODV are close behind. All the three on demand routing protocols (AODV, DSR and DYMO) are winner in packet delivery statistic. OLSR as traditional wired protocol trail behind on demand protocols. Value for hybrid protocol ZRP is less because as number of nodes increase number of overlapping zones increases thus increases query messages.

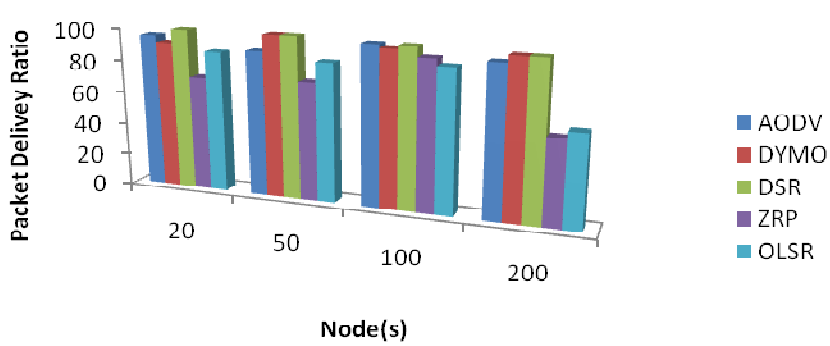

FIGURE 6: Graph [4.6.3.1.2]: IEEE 802.11-CBR Server: Packet Delivery Ratio for AODV, OLSR, ZRP Comparison-Node (10, 40, 80, and 120) Variation Network.

4.6.3.1.3 Average End-to End Delay

Delay metric specifies delays due to route discovery, queuing, propagation and transfer time. After studying the operation of AODV, DYMO, DSR, ZRP and OLSR we can observe that, end to end delay is more in ZRP as compared to others. ZRP operation of route discovery uses additional time as it uses IARP, IERP and BRP leading to more number of control packets. When a destination node is not found in the local zone of the source node it initializes IERP. ZRP takes time for inter communication between IERP and IARP. Each node maintains routing table of their local zone. This adds unnecessary traffic in the network. This causes route acquisition delay. After discovering the route to the destination the data packets are encapsulated by two protocols. Hence it takes more time for data packet to reach to the destination.

Proactive protocol OLSR is next trailed to ZRP creates large end to end delay in dense network as it periodically exchange topology information to maintain end-to-end routes. For node density of 20, 50 and 100 nodes OLSR has least end to end delay as OLSR uses multipoint relays (MPRs), a node's one hop neighbor selected for forwarding packets, to reduce the control traffic overhead.DSR is behind OLSR as it uses source routing in which a data packet carries the complete path to be traversed, like when DSR starts route discovery it broadcasts RREQ packets to its neighbors. When neighbor node receives RREQ packet for particular destination it checks for the route destination in its Route Cache. If route to the destination is found then that intermediate node sends back the gratuitous RREP to the source node. Where this gratuitous RREP includes the source route to the destination. As it takes additional time to set reverse route to source node by intermediate nodes after receiving RREQ packets. Once the route is discovered in DSR entire source route is available at source node.

While in AODV only at intermediate nodes have the information about next hop neighbors along the discovered path. DYMO has least end-to end delay as sequence numbers used in DYMO makes it loop free. These sequence numbers are used by nodes to determine the order of route discovery messages and so avoid propagating stale route information in high density network. For node density of 20 and 100 average end to end delays of DSR and DYMO are higher than AODV, ZRP and OLSR as shown in FIGURE 7.

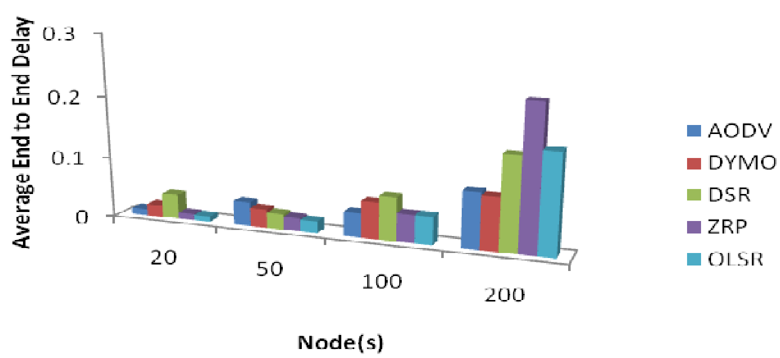

FIGURE 7: Graph [4.6.3.1.3]: IEEE 802.11-CBR Server: Average End to End Delay for AODV, OLSR, ZRP Comparison-Node (10, 40, 80, 120) Variation Network.

4.6.3.1.4 Throughput

Throughput is the average rate of successful data packets received at destination. As the number of the nodes increases in the network, route discovery becomes more complicated, because centralized node routing zones will highly overlap with each other, hence the route request queries will be flooded in to the network, and the intermediate nodes will send same route request queries multiple times, hence the route acquisition delay will have higher percentage as the number of nodes increases.

On demand routing protocols like DSR and DYMO shows good stable results on varying node density. AODV throughput decreases for high density networks. Zone routing protocol results are painful for increase in node density as are compared to AODV, DYMO and DSR. This is as shown in FIGURE 8.

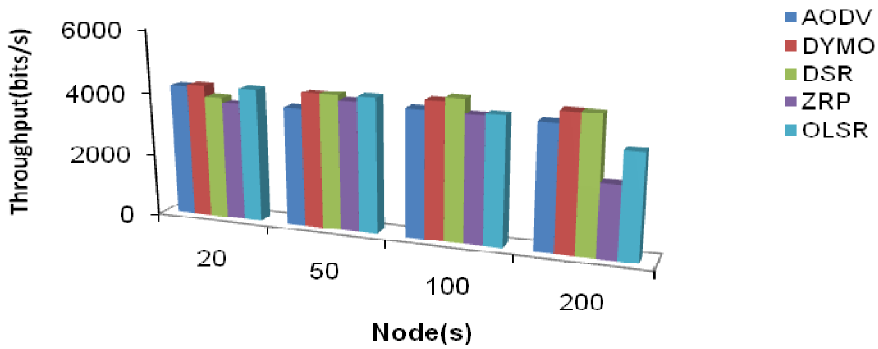

FIGURE 8: Graph [4.6.3.1.4]: IEEE 802.11-CBR Server: Throughput for AODV, OLSR, ZRP Comparison-Node (10, 40, 80, 120) Variation Network.

4.6.3.1.5 Average Queue Length

It is FIFO Queue Size (bytes) in MAC layers. The length of Queue depends on congestion and route discovery. For varying network size AODV builds small queues. DYMO is next following AODV builds queue of small size as shown in FIGURE 9. The lower performance of DSR of different density network is attributed to use of aggressive caching.

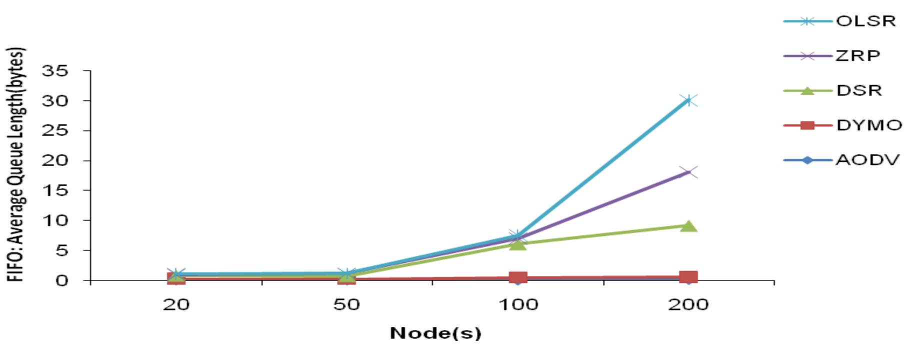

FIGURE 9: Graph [4.6.3.1.5]: IEEE 802.11-FIFO: Average Queue Length(bytes) for AODV, OLSR, ZRP Comparison-Node (10, 40, 80, 120) Variation Network.

Value for hybrid protocol ZRP is high because as number of nodes increase number of overlapping zones increases thus increases query messages. Thus lead to increase in control packets. Also there are chances that these query messages may be forwarded again inward instead of moving towards the destination. This unnecessarily adds build up queue and creates delay in the system. None of the protocol is dramatically worst than OLSR in dense network as OLSR hello messages which may become very large in dense networks since they contain a neighbor list.

4.6.3.1.6 Average Time in Queue

It describes average waiting time of packets to be forwarded or processed. Waiting time for packets in DSR is long as it builds long queue is attributed to use of aggressive caching. Next highest waiting time is for ZRP and OLSR packets as observed for denser networks. In rest of scenario for varying network size AODV, DYMO and ZRP show satisfactory result as shown in FIGURE 10. OLSR processing times of packets are larger in dense network of 200 nodes while negligible for network size of 20, 50 and 100 nodes.

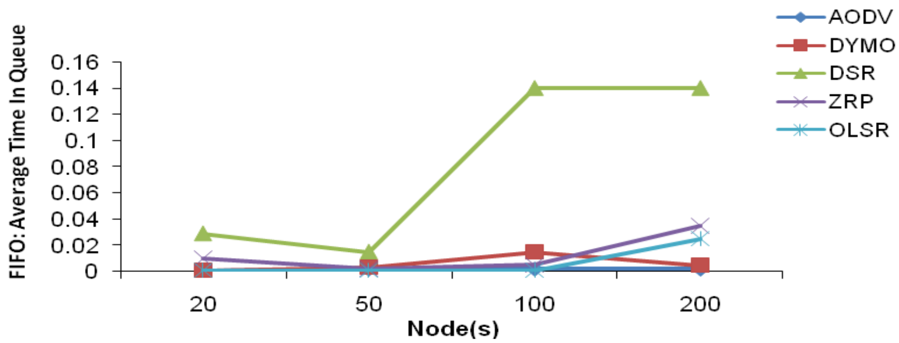

FIGURE 10: Graph [4.6.3.1.6]: IEEE 802.11-FIFO: Average Time in Queue for AODV, OLSR, ZRP Comparison-Node (10, 40, 80, 120) Variation Network.

4.6.3.1.7 Broadcast Received (802.11 DCF)/ Broadcast Packet Received Clearly (802.11 MAC)

IEEE 802.11 MAC describes total number of broadcast received and total number of successful broadcast received from the channel without errors. Values for broadcast received and broadcast received clearly are same as shown in FIGURE 11 and FIGURE 12. It has been observed that large number of broadcast has been received in ZRP and OLSR as both of them make use of proactive approach sends incremental dump to periodically exchange topology information. Broadcast Received clearly in AODV, DSR and DYMO are less due to their reactive nature.

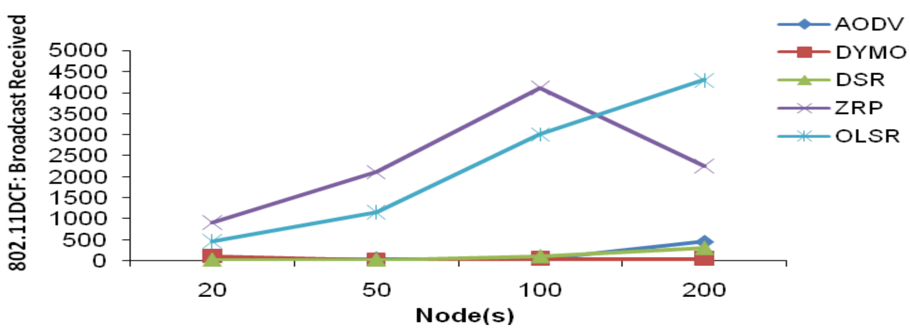

FIGURE 11: Graph [4.6.3.1.7]: 802.11DCF: Broadcast received for AODV, OLSR, ZRP Comparison-Node (10, 40, 80, 120) Variation Network.

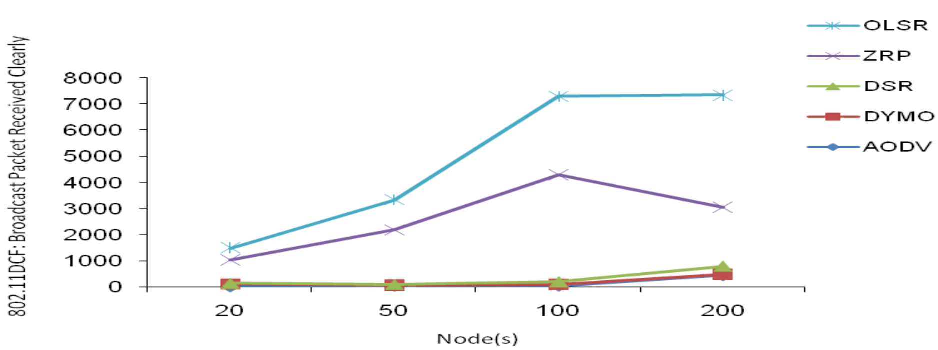

FIGURE 12: Graph [4.6.3.1.8]: 802.11MAC: Broadcast Packet Received Clearly for AODV, OLSR, ZRP Comparison-Node (10, 40, 80, 120) Variation Network.

4.6.3.1.8 Packets from\to Application layer

Small number of packets send from application layer are same for AODV, DYMO, DSR and ZRP for varying network size are shown in FIGURE 13 and FIGURE 14 while bulk of packets are send in OLSR. Same thing has been observed when packets are travelling from transport layer to application layer.

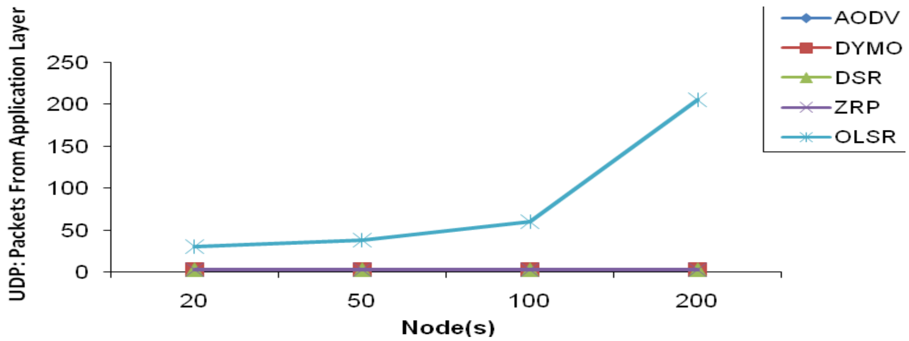

FIGURE 13: Graph [4.6.3.1.9]: UDP: Packets from Application Layer for AODV, OLSR, ZRP Comparison-Node (10, 40, 80, 120) Variation Network.

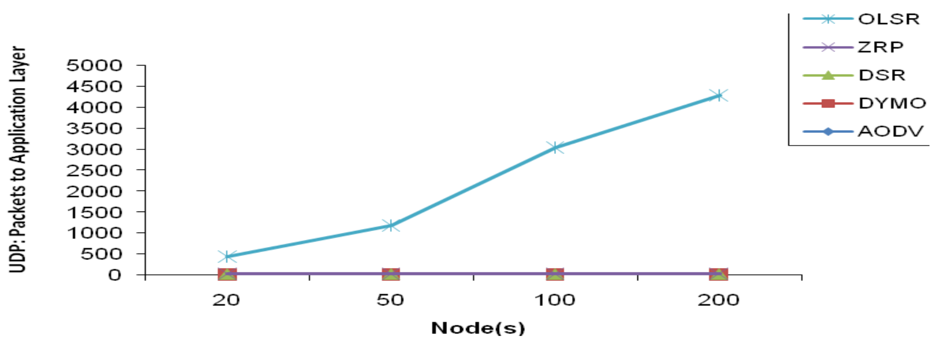

FIGURE 14: Graph [4.6.3.1.10]: UDP: Packets to Application Layer for AODV, OLSR, ZRP Comparison-Node (10, 40, 80, 120) Variation Network.

4. CONCLUSION

For varying network size with constant mobility to analyze the performance of AODV, DSR, DYMO, OLSR and ZRP: The analysis showed on demand routing protocols like DSR and DYMO shows good stable results of throughput on varying node density. AODV throughput decreases for high density networks. DSR has an edge over other protocols in successfully delivering data packets for varying node density. DYMO and AODV are close behind. DSR is better in transmission of packets per unit time and maximum number of packets reached their destination successfully with some delays. Whereas AODV & DYMO having almost same values in all of the performance metrics, they transmit packets with very less delay but transmits less packets to their destination as compare to DSR.

For high node density OLSR shows highest jitter and, ZRP and DSR are next to it. Average Jitter of DSR is high for varying network. End to end delay is more in ZRP as compared to others as ZRP operation of route discovery uses additional time as it uses IARP, IERP and BRP leading to more number of control packets. OLSR is next trailed to ZRP and DSR is behind OLSR as it uses source routing. Waiting time for packets in DSR is long as it builds long queue is attributed to use of aggressive caching which increases with increase in network size. Next highest waiting time is for ZRP and OLSR packets as observed for denser networks.

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