Available Online at www.ijcsmc.com

International Journal of Computer Science and Mobile Computing

A Monthly Journal of Computer Science and Information Technology

ISSN 2320–088X

IJCSMC, Vol. 3, Issue. 4, April 2014, pg.771 – 779

RESEARCH ARTICLE

A Comparative Analysis of OLSR, DSR and ZRP Routing Protocols in MANETs

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Abstract — A Mobile Ad-Hoc networks (MANETs) is collection of autonomous wireless nodes that are arbitrarily located which move dynamically by changing its network connectivity without the use of any pre-existent infrastructure. The behavior of ad-hoc network is characterized as non-deterministic (interference, multipath, hidden and exposed node problem make wireless channel very difficult to predict). Its routing protocol should not only capable of finding the optimized routes between the source and destination, but should also be adaptive in terms of changing load conditions of the network, changing state of the nodes and changing state of the environment. This paper aims to compare performance of Dynamic Source Routing (DSR), Optimized Link State Routing Protocol (OLSR) and Zone Routing Protocol (ZRP). The performance analysis is based on different network metrics in heterogeneous environment such as Throughput (bits/sec), Delay (sec) and Retransmission attempts (packets) using well known network simulator OPNET 14.5.

Keywords – MANET, ZRP, OLSR, DSR

I. INTRODUCTION

A MANET is a multi hop ad-hoc wireless network and self configuring network of mobile routers connected by wireless links (sometimes called a Mobile Mesh Network) the union of which forms an arbitrary topology. Interest in MANETs is due to the promise of ubiquitous connectivity beyond that currently being provided by the Internet. Firstly, MANETs are easily deployed allowing a plug-and-communicate method of networking. Secondly, MANETs do not need central management so used in military operations where units are moving around the battle field and a central field cannot be used for synchronization [1]. Thirdly, MANETs need no infrastructure, thus reducing the cost of establishing the network so useful in disaster recovery where there is not enough time or resources to install and configure an infrastructure. The growth of technology and the increase in wi-fi capable laptops, mobile phones, MP3 players and other small portable devices has created a genuine reason for the population of MANET [2].

Nodes in MANET are free to travel, and the connection between two nodes is broken when one of them travels out of the transmission range of the other node [3]. In ad-hoc networks, nodes do not start out familiar with the topology of their networks; instead they have to discover it. The basic idea is that each node learns about nodes nearby and static ad-hoc network the positions of a node may not change once it has become a part of the network. E.g.: Rooftop networks. Highly mobile nodes are characterized by limited memory, bandwidth and power and also causing a high rate of change of connectivity within the network. The primary challenge in building a MANET is equipping each device to continuously maintain the information required to properly route the traffic. To overcome this challenge, many protocols of routing in MANET have been presented to the Internet Engineering Task Force (IETF). An ad-hoc routing protocol is a convention, or standard, that controls how nodes decide which way to route packets between computing devices in a network.

This paper evaluates the performance comparison of DSR (Reactive), OLSR (Proactive) and ZRP (Hybrid) protocols under different network conditions. The rest of the paper is organized as follows: Section-2 Routing Protocols; Section-3 Literature Survey; Section-4 Simulation Model and Performance Parameters; Section-5 Critical Analysis and Conclusion. Finally Future Work is presented in Section-6.

II. ROUTING PROTOCOLS

Routing Protocols has been classified as Proactive or Table Driven routing protocol, Reactive or On-demand Routing protocol, Hybrid Routing protocol.

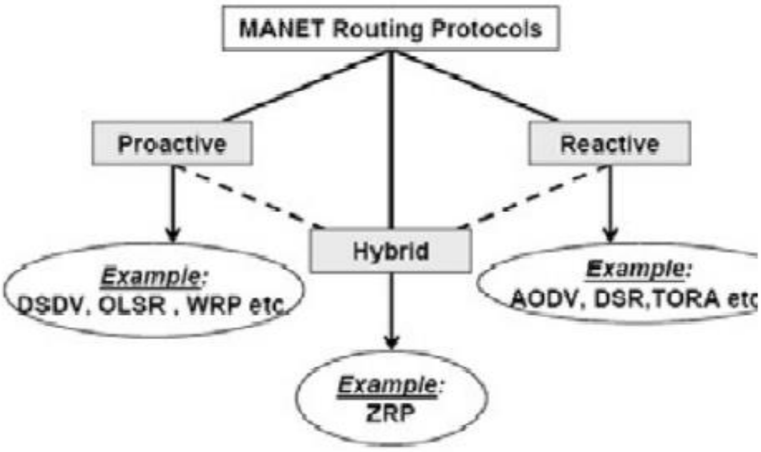

Figure 1. Classification of MANET routing protocols

A. Optimized Link State Routing (OLSR)

The OLSR protocol [4] is a pro-active routing protocol, which builds up a route for data transmission by maintaining a routing table inside every node of the network. The routing table is exchanged by means of Topology Control (TC) packets. OLSR use HELLO message to find one hope neighbors and its two hop neighbors through their responses. The sender can then select its Multipoint Relays (MPR) based on the one hop node which offers best route to the two hop nodes. Reducing the time interval of control messages transmission brings more reactivity to the topological changes [5, 6]. OLSR uses TC messages along with MPR forwarding to disseminate neighbor information throughout the network. The protocol is suitable for high density network and does not allows long delays the transmission of the networks. This protocol does not notify the source immediately after detecting a broken link; source node comes to know that route is broken, when the intermediate node broadcasts its next packets. Each node periodically sends the updated topology throughout the entire network, this increase the protocols bandwidth usage. But the flooding is minimized by MPRs, which are only allowed to forward the topological messages.

B. Dynamic Source Routing (DSR)

The DSR protocol [7] [8] is reactive protocol designed specifically for use in multi-hop wireless ad-hoc networks of mobile nodes. It is on-demand routing protocol composed of two parts: Route Discovery and Route Maintenance [9]. It eliminates the need to periodically flood the network with table update messages which are required in proactive routing protocols. When a node has to send a data a packet to another node, it initiates a route discovery. Route request (RREQ) and route reply (RREP) packets accumulate source route so that once a route is discovered, as in Figure 2(a)[7], the source learns the entire source route and can place that route into subsequent data packets. The source node places the destination IP address, into the RREQ and broadcasts the message to its neighbor’s node. When a node with a route to the destination receives the RREQ, it responds by creating a RREP to the source, as shown in Figure 2(b) [7]. The intermediate routes are maintained in a route cache and are continually updated as new routes are learned (route cache entries need not have lifetimes). In the event of fatal transmission, Route Maintenance Phase is initiated whereby it sends route error (RRER) message to the source node, the erroneous hop will be removed from the node’s route cache, all routes containing the hop are truncated at that point.

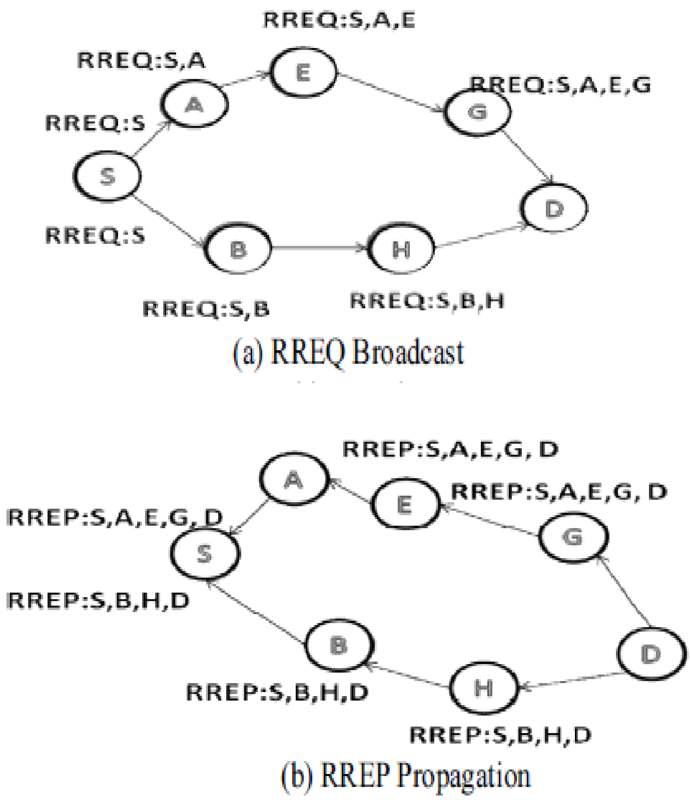

Figure 2. DSR route discovery route

C. Zone Routing Protocol (ZRP)

The Zone Routing Protocol (ZRP) [10] combines the advantage of pro-active discovery within a node's local neighborhood, and using a reactive protocol for communication between these neighborhoods. The local neighborhoods are called zones; each node may be within multiple overlapping zones, and each zone may be of a different size. The “size” is given by a radius of length, where is the number of hops to the perimeter of the zone. By dividing the network into overlapping, variable-size zones, the Zone Routing Protocol consists of several components, which only together provide the full routing benefit to ZRP. Each component works independently of the other and they may use different technologies in order to maximize efficiency in their particular area. Components of ZRP are IARP, IERP and BRP. Figure 3[11] illustrates the different component of ZRP. The Intrazone Routing Protocol (IARP) [12] is used by a node to communicate with the interior nodes of it’s zone and is limited by the zones radius (the number of hops from the node to it's peripheral nodes). The Interzone Routing Protocol (IERP) needs to be able to take advantage of the local topology of a node’s zone provided by the IARP, as well as change the way route discovery is handled: Instead of flooding a route request to all nodes, it should instead use the Bordercast Resolution Protocol (BRP) to only initiate route requests with peripheral nodes. The Bordercast Resolution Protocol (BRP), [13] is to direct the route requests initiated by the global reactive IERP to the peripheral nodes and removing redundant queries and maximizing efficiency. The BRP keeps track of which nodes a query has been delivered to, so that it can prune the bordercast tree (constructed by utilizing the map provided by the local pro-active IARP) of nodes that have already received the query.

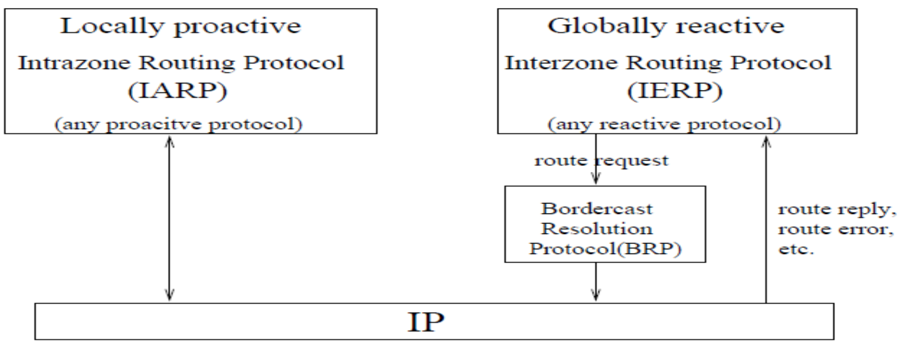

Figure 3. The different component of Zone Routing Protocol

III. LITRATURE REVIEW

Evjola Spaho, et.al [14] investigate the performance of OLSR and AODV protocols in a Vehicular Ad-hoc Networks (VANET) crossroad scenario using Cellular Automation based Vehicular NETwork (CAVNET) and NS3.For performance evaluation they used three metrics: the average Packet Delivery Ratio (PDR), throughput and delay. Their result showed that for high transmission rate, the PDR of AODV is smaller than OLSR; OLSR has better throughput compared with AODV; the delay for both protocols is higher than 1 sec and for small transmission rates, the PDR of both protocols is maximal and the throughput is theoretical, delay for both protocols is small.

Ashish Bagwari, et. al[15] analyzes the performance of reactive routing protocol via increasing number of nodes and observing its effect on Quality of Service (QoS) of Mobile Ad-hoc Network. The reactive protocols that they considering is AODV for this scenario with Multiple Cluster Head Gateway (MCHG). They used following parameters: delay, throughput, traffic sent, traffic received, data dropped and network load using simulation tool OPNET Modeler (Ver. 14.0). They conclude that AODV gives better QoS based on good throughput and acceptable End-End Delay, less data drops. One of notable features of this AODV strategy is that, it reduces our network load which can be responsible for congestion at the time of communication. Therefore, it can be used to extend the network coverage. Priti Garg, et. al[16] compared on-demand and hybrid protocol; temporally routing algorithm (TORA) and Dynamic Source Routing (DSR) and had evaluated their performance with respect to quantitative metrics; average delay, packet delivery ratio and routing load using NS-2 simulator. Their results showed that performance of TORA protocol at mobility variation of nodes has better throughput, packet delivery ratio and routing load than DSR protocol. But average delay of DSR is less compared to TORA. Monika Rajput, et .al[17] compared various reactive protocols such as AODV, DSR, TORA on the basis of their throughput by increasing number of nodes in the network. Their study results that TORA performs better than AODV and DSR when the number of nodes are increased in a network but it is not necessary that TORA perform always better in all the networks, its performance may vary by varying the network. Shaily Mittal, et. al[18] evaluates the performance of AODV, DSR and ZRP is evaluated based on Average end to end delay, TTL based hop count and Packet delivery ratio using QualnetNet Simulator. They concluded AODV shows best results in measuring end to end delay and packet delivery ratio, AODV delivers almost 90 percent of transmitting packets while DSR performs best with minimum number of hops in comparing TTL based hop count. Alwi M Bamhdi, et. al[19] presents some results on the performance of DP-AODV, on the basis of comparisons with the standard protocols Ad-Hoc On Demand Multipath Distance Vector (AOMDV), Ad-Hoc On –Demand Distance Vector (AODV) and Dynamic Source Routing (DSR) and simulation results show that DP-AODV gives better performance than AODV and DSR in all simulations, but AOMDV gives better than others. DP- AODV uses two mechanisms, power control mechanism and hello message mechanism, to dynamically adjust the transmission power, based on node density. The reduction of transmission power effectively decreases interference between nodes, maintaining the connectivity and enhancing the network throughput. Mehdi Barati, et.al[20] discuss performance comparison of DSR and AODV routing protocols with respect to average energy consumption and routing energy consumption using Network Simulator 2(NS2). DSR resulted in the least energy consumption for low density networks and AODV generated higher volume of energy than the DSR in high density networks. They concluded routing protocols used currently in MANET may require some effort to minimize the energy cost of interface in the network. So by considering, the routing overhead of AODV protocol and reducing the number of control packets, energy consumption can be decreased and the lifetime of the network can be increased. Amrita Bose Paul, et. al[21] implemented AODV in NS-3.6 and extensive simulations have been carried out for calculation of Throughput, Packet Delivery Ratio (PDR), and Normalized Routing Overhead (NRO). They conclude that AODV performs better in dense network than in sparse network for client WMNs. Amanpreet Singh, et. al[22] proposed an optimization of the simple AODV route discovery and simulations were performed with the QualNet Network Simulator. They stated that the addition of paging to AODV protocol leads to better route discovery and maintenance, with no packet loss and smaller end-to-end delay and jitter. The control overhead from proactive Regular Paging Update (RPU) and beacon messages can be reduced by offering an adaptive scheme to adjust their intervals. Radityo Anggoro, et. al[23] evaluated performance of AODV and AOMDV with Probabilistic Relay in VANET Environments based on packet delivery ratio, routing overhead, and average delivery delay under variation of vehicle speed. They stated that AODV-PR significantly contributes up to 3-6% improvement in PDR under variation of vehicle speed. Probabilistic relay clearly helps to recover unsuccessful packet transmission through its unipath. AOMDV produces more control packets than AODV due to establishment and maintenance of its multipath. The multipath of AOMDV generates lower RREQ than AODV during our simulation. Rakesh Thakur, et. al[24] had done comparative study of MAODV with unmodified AODV was done using realistic parameters like Packet received, Average end to end delay, Throughput, and energy consumption calculated by varying attributes of Number of Nodes and Pause Time, Implementation and simulations were performed in QualNet 5.0 simulator. The results showed that enhance AODV reduces routing overhead and delay, that method improves security and valid path selection process AODV , and thus enhances the performance of the protocol. Ravinder Ahuja, et.al[25] evaluate the performance of AODV and DSR routing protocol under wormhole attack and compare the performance of these protocol without wormhole attack.

Performance parameters are average end to end delay, Throughput, and Packet delivery ratio (PDR) using Qualnet Simulator 5.0. The results show that performance of routing protocol decreases under the wormhole attack.

IV. SIMULATION MODEL AND PERFORMANCE PARAMETERS

OPNET Modeler is a dynamic discrete event simulator with a user-friendly graphic user interface (GUI), sup-ported by object-oriented and hierarchical modeling, debugging, and analysis. The development language is C. It has grid computing support for distributed simulation. It provides an open interface for integrating external object files, libraries, and other simulators. OPNET Modeler provides a comprehensive development environment with a full set of tools including model design, simulation, data collection, and data analysis and supporting the modeling of communication networks and distributed systems. OPNET Modeler can be used as a platform to develop models of a wide range of systems. These applications include: standard based local area network (LAN) and wide area network (WAN) performance modeling, hierarchical internetwork planning, R&D of protocols and communication network architecture, mobile network, sensor network and satellite network .Other applications include outage, resource sizing and failure recovery. OPNET modeler supports different parameters for the measurement performance evaluation of the MANET network under different routing protocols. These parameters have different behaviors for overall network performance. We evaluate three parameters in our study on overall network performance. These parameters are delay, network load, and throughput.

Statistic	Value
Scenario size	100m×100m
Nodes	50,150
Simulation Time	5 minutes

Table1. Configuration

Delay

The packet end-to-end delay is the delay between the time at which the data packet was originated at the source and the time it reaches the destination, so this is the time that a packet takes to go across the network. This time is expressed in seconds (sec). Delays due to route discovery, queuing and retransmission are included in the delay metric and the data packets that get lost en route are not considered.

Throughput

It is a measure of number of packets in bits/sec successfully delivered over a communication channel. It is the ratio between the numbers of sent packets vs. received packets. It is also the time it takes by receiver to receive the last message [26]. Some factors affect the throughput as; if there are many topology changes in the network, limited energy, unreliable communication between nodes and limited bandwidth available. A high throughput is absolute choice in every network. Throughput can be represented mathematically as in equation given below:

$$\text{Throughput} = \frac{\text{Number of delivered packet*Packet size*8}}{\text{Total duration of simulation}}$$

Retransmission Attempts

Retransmission attempts occurred when delivery of packet is dropped or lost without reaching the destination nodes in network. The increase of retransmission attempts affect directly proportional of the network due to load that is increased on entire network.

V. CRITICAL ANALYSIS AND CONCLUSION

Protocols Parameters	OLSR	DSR	ZRP
Delay (sec)	Average	Maximum	Minimum
Throughput (bits/sec)	Maximum	Minimum	Average
Retransmission Attempts (packets)	Minimum	Average	Maximum

Table 2. Critical Analysis

Therefore, it is concluded that DSR takes more time to search destination with increase in number of nodes. The delay in ZRP is very less as compared to OLSR and DSR. The throughput of OLSR increases with increase in number of nodes. So performance of OLSR is better for dense networks. In case of DSR, initially it takes much time as it has to make multiple entries of routes gathered after route discovery in its routing table. After route discovery its throughput increases uniformly but less than OLSR and ZRP. The maximum retransmission attempts occurred in ZRP and minimum in OLSR.

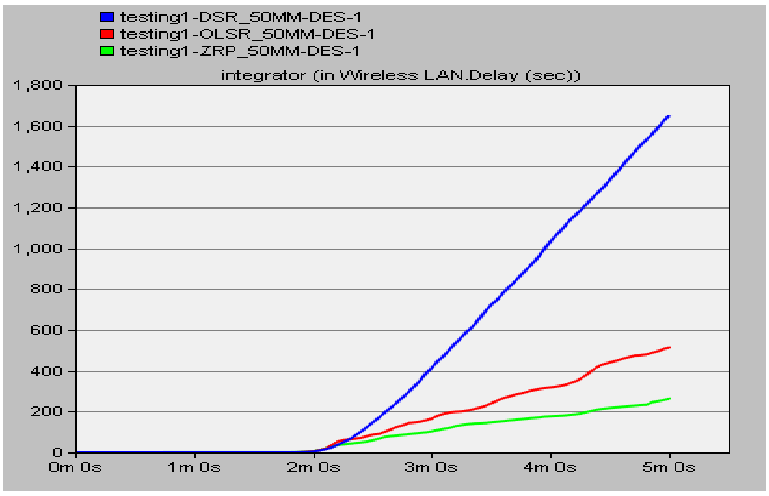

Figure 4: Wireless LAN Delay (nodes=50)

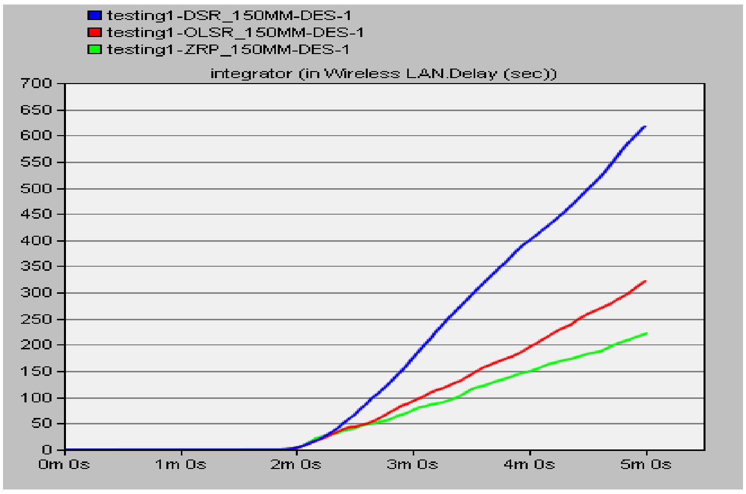

Figure 5: Wireless LAN Delay (nodes=150)

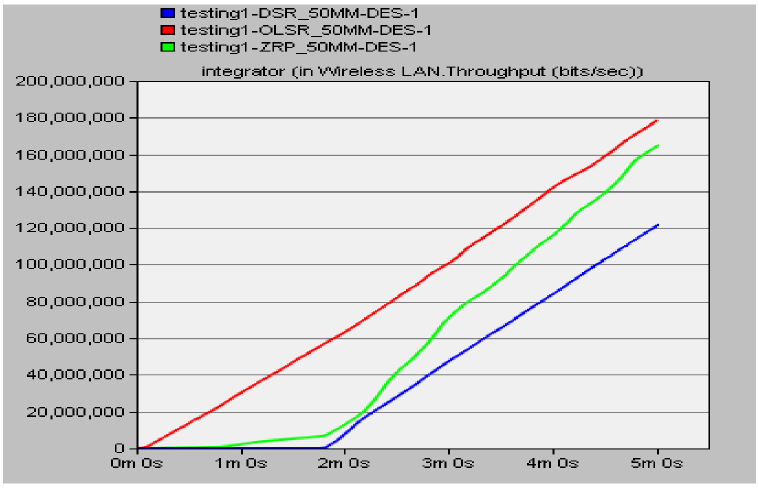

Figure 6: Wireless LAN Throughput (nodes=50)

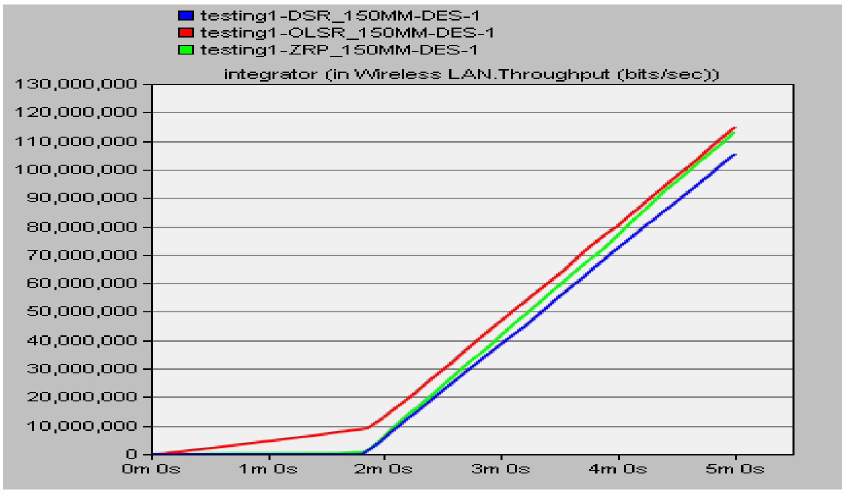

Figure 7: Wireless LAN Throughput (nodes=150)

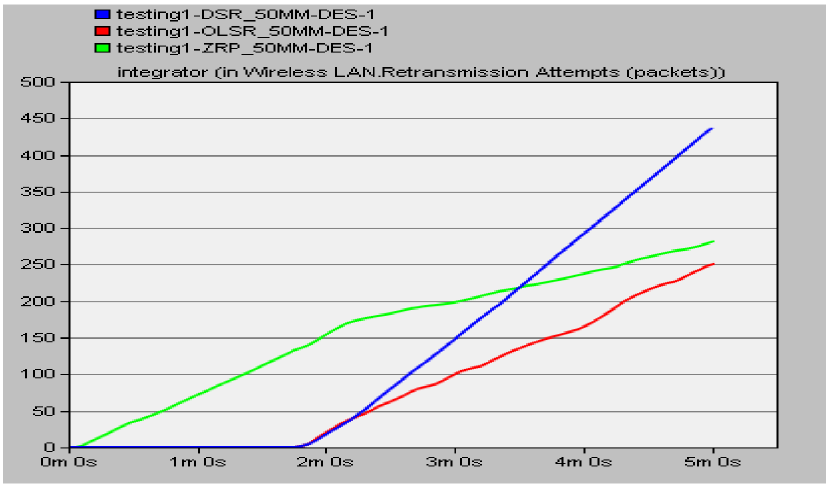

Figure 8:Wireless LAN RetransmissionAttempts(nodes =50)

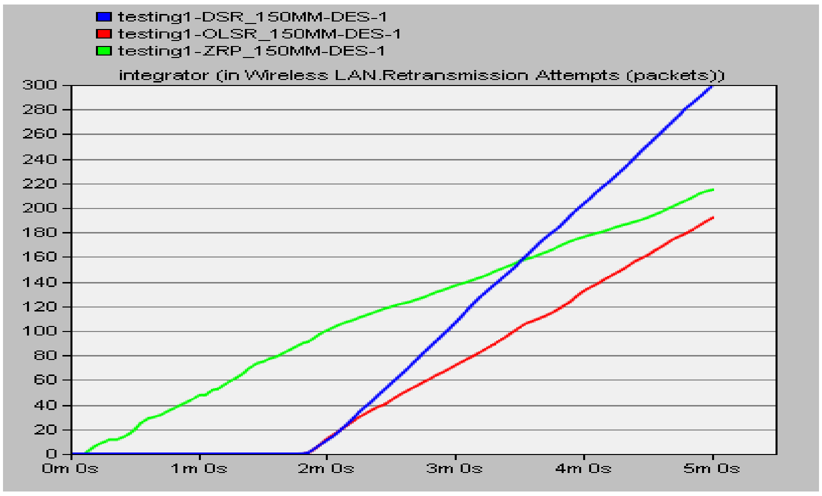

Figure 9:Wireless LAN RetransmissionAttempts(nodes=150)

VI. FUTURE WORK

For the future work, OLSR, DSR and ZRP routing protocols will be compared for WSN which supports mobility of the nodes for both Random Deployment and Quasi Random Deployment. The other performance metric viz., Packet Delivery rate, Network load shall also be taken into consideration. Given the high interest within the area of MANET routing protocols, there are many issues to be researched and resolved before reaching a stage of being commerically or practically viable.

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