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Research Article

Performance Analysis of Simulated Unicasting Routing Protocols in Ad Hoc Network

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Abstract

Mobile Ad hoc Network (MANET) is a collection of mobile nodes that are arbitrarily located so that the interconnections between nodes are dynamically changing. In MANET mobile nodes forms a temporary network without the use of any existing network infrastructure or centralized administration. A routing protocol is used to find routes between mobile nodes to facilitate communication within the network. The main goal of such an ad hoc network routing protocol is to establish correct and efficient route between a pair of mobile nodes so that messages delivered within the active route timeout interval. Route should be discovered and maintained with a minimum of overhead and bandwidth consumption. This paper presents performance evaluation of five different routing protocols i.e. Ad hoc On-Demand Distance Vector (AODV), dynamic state routing (DSR), Fisheye State Routing (FSR), landmark Routing Protocol(LANMAR), and Zone Routing Protocol (ZRP) in variable speed and simulation time. We have used random waypoint mobility model to design the network and performed simulations by using QualNet version 5.0 Simulator from Scalable Networks. Performance of AODV,DSR, FSR, LANMAR, and ZRP is evaluated based on Average end-to-end delay, Packet delivery ratio, Throughput and Average Jitter.

Keywords: *MANET, AODV, DSR, FSR, LANMAR, ZRP, QualNet version 5.0.*

1. Introduction

Mobile Ad Hoc Networks are the self-organizing and self-configuring wireless networks which do not rely on a fixed infrastructure and has the capability of rapid deployment in response to application needs. Nodes of these networks function as routers which discover and maintain routes to other nodes in the network. The Ad hoc network applications include military applications, casual conferences, meeting, virtual classrooms, emergency search-and-rescue operations, disaster relief operation, automated battlefield and operations in environments where construction of infrastructure is difficult or expensive. In MANET, due to lack of centralized entity and mobile nature of nodes, network topology changes frequently and unpredictably. Hence the routing protocols for ad hoc wireless networks have to adapt quickly to the frequent and unpredictable changes of topology (K. Maurya Ashish *et al*, 2010) . There are many routing protocols available for Ad-hoc networks as AODV, CGSR, DSDV, DSR, DYMO, FSR, GSR, OLSR, STAR, TORA, WRP and ZRP etc. In this paper we have used five routing protocols: AODV, DSR, FSR, LANMAR and ZRP and evaluated the performance of these five routing protocol as a function of speed and simulation time.

1.1 Ad hoc On Demand Distance Vector (AODV)

The Ad hoc On Demand Distance Vector (AODV) (P. Bobade Nilesh *et al*, 2010) routing algorithm is a reactive routing protocol designed for ad hoc mobile networks. It builds routes between nodes only as desired by source nodes for transmitting data packets; therefore, it is also known as source initiated routing protocol. It avoids the counting-to-infinity problem by using sequence numbers on route updates such that ensuring the freshness of routes (Gupta Manjeet *et al*, 2012). AODV basically involves two processes, one is route discovery and other is route maintenance. It discovers routes by route request (RREQ) and route reply (RREP) messages and route maintenance is done by HELLO messages and route error (RERR) messages. Each node maintains a route table in which next hop routing information for destination nodes is stored. When a source node wants to know the route to a destination for which it does not already have a route, source node initiates route discovery and broadcasts a route request (RREQ) message across the network. Each node updates the information regarding source node after receiving this RREQ message. When a node re-broadcasts a route request, it sets up a reverse path pointing towards the source node in the route tables (AODV assumes that the links are symmetric and bi-directional). The RREQ message contains source node's IP address, destination

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node's IP address, current sequence number and broadcast ID, it also contains the last known (most recent) sequence number for the destination of which the source node is aware. A route is created to the source node when RREQ message is received at each intermediate node. If the receiving node is not the destination node and does not have a current route to the destination, it re-broadcast this RREQ message. A node receiving the RREQ may send a route reply (RREP) if it is either the destination or if it has a route to the destination with corresponding sequence number greater than or equal to that contained in the RREQ. In this case, it unicast a RREP back to the source in a hop-by-hop fashion. Each node records the route request's source IP address and broadcast ID. If any node receives already processed RREQ, nodes discard the RREQ and do not forward it. Intermediate nodes that forward the RREP, also record the next hop to destination. Forward links to the destination are setup when RREP travels along the reverse path to the source. The source node records the route to the destination and can begin forward data messages to the destination node when it receives the RREP. Here the sending of data messages to the destination node is delayed due to route discovery process. If the source node later receives a RREP containing a greater sequence number or contains the same sequence number with a smaller hop-count, it may update its routing information for that destination node and begin using the better route. As long as the route remains active, it will continue to be maintained. A route is active if there are data packets periodically travelling from the source node to the destination node along that path. To know about active neighbours each neighbouring nodes periodically exchange HELLO messages. When a link break occurs while the route is active, all active neighbours are informed and link failures are propagated by means of route error (RERR) messages to the source node, which also update destination sequence numbers. After receiving the RERR message, the source node invalidates the route and can reinitiate route discovery, if desired.

1.2 Dynamic Source Routing (DSR)

The Dynamic Source Routing protocol is composed of two main mechanisms to allow the discovery and maintenance of source routes in the ad hoc networks (Garg Upasana *et al*, 2012).

Route Discovery: - It is the mechanism by which a source node wishing to send a packet to a destination node, obtains a source route to the destination. Route Discovery is used only when the source node attempts to send a packet to a destination and does not already know a route to that destination.

Route Maintenance: - It is the mechanism by which a node wishing to send a packet to a destination is able to detect, while using a source route to the destination, if the network topology has changed. If this is the case then it must no longer use this route to the destination because a link along the route broken. Route Maintenance for this route is used only when the source node is actually sending packets to the destination. A routing entry in DSR contains all the intermediate nodes of the route rather than just the next hop information maintained in DSDV and AODV. A source puts the entire routing path in the data packet, and the packet is sent through the intermediate nodes specified in the path. If the source does not have a routing path to the destination, then it performs a route discovery by flooding the network with a route request (RREQ) packet. Any node that has a path to the destination in question can reply to the RREQ packet by sending a route reply (RREP) packet. The reply is sent using the route recorded in the RREQ packet. To limit the need for route discovery, DSR allows nodes to operate their network interfaces in promiscuous mode and snoop all (including data) packets sent by their neighbors. Since complete paths are indicated in data packets, snooping can be very helpful in keeping the paths in the route cache updated (Gupta Vishal *et al*, 2012).

To further reduce the cost of route discovery, the RREQs are initially broadcasted to neighbors only (zero-ring search), and then to the entire network if no reply is received. Another optimization feasible with DSR is the gratuitous route replies; when a node overhears a packet containing its address in the unused portion of the path in the packet header; it sends the shorter path information to the source of the packet (Automatic Route Shortening). Another important optimization includes the technique to prevent Route reply Storms because many route replies may be initiated simultaneously a delay time proportional to the hop's distance can be used in order to give higher priority to near nodes.

(N. Thakare *et al*, 2010) In addition, a method called Packet Salvaging is often used in DSR. When an intermediate node forwarding a packet detects through Route Maintenance that the next hop along the route for that packet is broken, if the node has another route to the packet's destination it uses it to send the packet rather than discard it. An interesting and a bit different approach of DSR is:

To summarize we provide the basic characteristics of the Dynamic Source Routing (DSR):

- Uses source routing.
- Provides loop-free routes.
- Supports unidirectional links and asymmetric routes.
- With the optimizations available, it is a good choice for an ad hoc network.

1.3 Fisheye

Fisheye State Routing (FSR) is a link state type protocol that maintains a topology map at each node. FSR differs from the standard link state algorithm in the following:-

- Having only neighboring nodes exchange the link state information.
- Utilizing only time-triggered, not event-triggered link state exchanges.
- Using different exchange intervals for nearby versus far away nodes.

Fisheye technique proposed by Kleinrock and Stevens to reduce the size of information required to represent graphical data. The eye of a fish captures with high detail the pixels near the focal point. The detail decreases as the distance from the focal point increases. In routing, the fisheye approach translates to maintaining accurate distance and path quality information about the immediate neighborhood of a node, with progressively less detail as the distance increases. (K. Maurya Ashish *et al*, 2010) Fisheye State Routing Algorithm (FSR) is a proactive or table driven routing algorithm which has been developed by Wireless Adaptive Mobility Laboratory, University of California, Los Angeles. FSR is based on the traditional link state routing algorithm. Each and every node collects the information about the topology of the network from the neighbouring nodes and calculates the routing table. It then disseminates the information locally to the neighbouring nodes. The FSR differs from the traditional link state routing algorithm in the way it disseminates the information across the neighboring nodes. It reduces the overhead associated with updating routes by introducing the notion of multi-level fish eye scope. The frequency of exchanging the routing information with neighbours depends on the distance between the source and the destination. From the link state entries, the node calculates the optimal shortest routes to other nodes. FSR is simple, scalable and efficient in mobile ad hoc network.

1.4 Landmark ad hoc routing protocol (LANMAR)

LANMAR is an efficient routing protocol in a flat ad hoc wireless network. LANMAR assumes that the large-scale ad hoc network is grouped into logical subnets in which the members have a commonality of interests and are likely to move as a group LANMAR uses the notion of landmarks to keep track of such logical subnets. It uses an approach similar to the landmark hierarchical routing proposed in for wired networks. Each logical group has one node serving as landmark. The route to a landmark is propagated throughout the network using a Distance Vector mechanism. Each node periodically exchanges topology information with its immediate neighbors. Updates from each source are sequentially numbered (Chahal Kavita *et al*, 2012). To the update, the source also piggybacks a distance vector of all landmarks. Through this exchange process, the table entries with larger sequence numbers replace the ones with smaller sequence numbers. As a result, each node has detailed topology information about nodes within its Fisheye scope and has a distance and routing vector to all landmarks. The Landmark Ad-hoc Routing Protocol (LANMAR) is designed to dramatically reduce routing table size and routing update overhead in large-scale ad-hoc networks that exhibit group mobility. LANMAR combines the features of Fisheye State Routing (FSR) and landmark routing; this added some features like landmark election to cope with the dynamic and mobile environment .(Khetrapal Ankur *et al*, 2010) Other advantages of LANMAR include the use of landmarks for each logical group in order to reduce routing update overhead, and the exchange of scoped link state with neighbors only. By virtue of land marking, remote groups of nodes are summarized by the corresponding landmarks. As a result, each node still maintains accurate routing information about immediate neighborhood; at the same time it will keep track of the routing directions to the landmarks nodes, and thus, to remote group.

1.5 Zone Routing Protocol.

Zone Routing Protocol or ZRP was the first hybrid routing protocol with both a proactive and a reactive routing component (K. Maurya Ashish *et al*, 2010) . ZRP was first introduced by Haas in 1997. ZRP is proposed to reduce the control overhead of proactive routing protocols and decrease the latency caused by routing discover in reactive routing protocols. ZRP defines a zone around each node consisting of its k-neighborhood (e. g. k=3). In ZRP, the distance and a node, all nodes within-hop distance from node belongs to the routing zone of node . ZRP is formed by two sub-protocols, a proactive routing protocol: Intra-zone Routing Protocol (IARP), is used inside routing zones and a reactive routing protocol: Inter-zone Routing Protocol (IERP), is used between routing zones, respectively (P. Manickam *et al*¸2011). A route to a destination within the local zone can be established from the proactively cached routing table of the source by IARP; therefore, if the source and destination is in the same zone, the packet can be delivered immediately. Most of the existing proactive routing algorithms can be used as the IARP for ZRP. For routes beyond the local zone, route discovery happens reactively. The source node sends a route requests to its border nodes, containing its own address, the destination address and a unique sequence number. Border nodes are nodes which are exactly the maximum number of hops to the defined local zone away from the source. The border nodes check their local zone for the destination. If the requested node is not a member of this local zone, the node adds its own address to the route request packet and forwards the packet to its border nodes. If the destination is a member of the local zone of the node, it sends a route reply on the reverse path back to the source. The source node uses the path saved in the route reply packet to send data packets to the destination.

2. Problem Formulation

The overall goal of this simulation study is to evaluate and analyze the performance of unicasting routing protocols of mobile ad hoc network. The protocol performance is to be observed in several network configurations where some parameters evolved in order to measure the impact of these parameters on the protocol. The experiment are to be executive to study the effect of packet delivery ratio, average end to end delay, throughput and jitter in the network. In some ways the effect of node mobility, node placement, speed and simulation time in the network are to be considered.

3. Experimental Setup

Qualnet is a network modelling tool, which is used to model wired and wireless network. It uses simulation and emulation to predict the behaviour and performance of the networks to improve the design, operation and management. Performance matrices used:

3.1 Packet Delivery Ratio

Packet Delivery Ratio is defined as the ratio of total data packets received at the destinations to those generated by the CBR sources. 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 world of MANET, packet delivery ratio has been accepted as a standard measure of throughput
.

3.2 Average end-to-end delay

It is the average time it takes a data packet to reach the destination. 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. This metric is significant in understanding the delay introduced by path discovery.

3.3 Throughput

Throughput is the average rate of successful message delivery over a communication channel. It is defined as the amount of data successfully delivered from the source to the destination in a given period of time. It is the amount of data per time unit that is delivered from one node to another via a communication link. The throughput is measured in bits per second (bit/s or bps).

3.4 Jitter

It is the average amount of variation in the end-to-end packet transit time. Jitter is the variation in the time between packets arriving, caused by network congestion, timing drift, or route changes. It should be less for a routing protocol to perform better. It becomes a matter of concern if it is more than the threshold value, which is different for each type of transmission as data, voice or video.

The simulation environment for the proposed work consists of four models:

a) Network model
b) Channel model
c) Mobility model
d) Traffic model

Table 3.1: Simulation Properties

Area	1500X1500 m^2
Transmission range	500 m
Number of nodes	40
Physical / Mac layer	IEEE 802.11 at 2 Mbps
Mobility model	Random waypoint model with no pause time
Maximum mobility speed	1-20 m/s
Simulation duration	30 s
Pause time	30 s
Packet size	512 bytes
Traffic type	CBR (Constant Bit Rates)
Number of packets	5/second
Number of multicast sources	1,2,5,10,15 nodes
Number of multicast receivers	10,20,30,40,50 nodes
No. of simulations	10

4. Results and Discussion

In graphs the speed and simulation time has been varied and all other parameters are same as listed in above table.

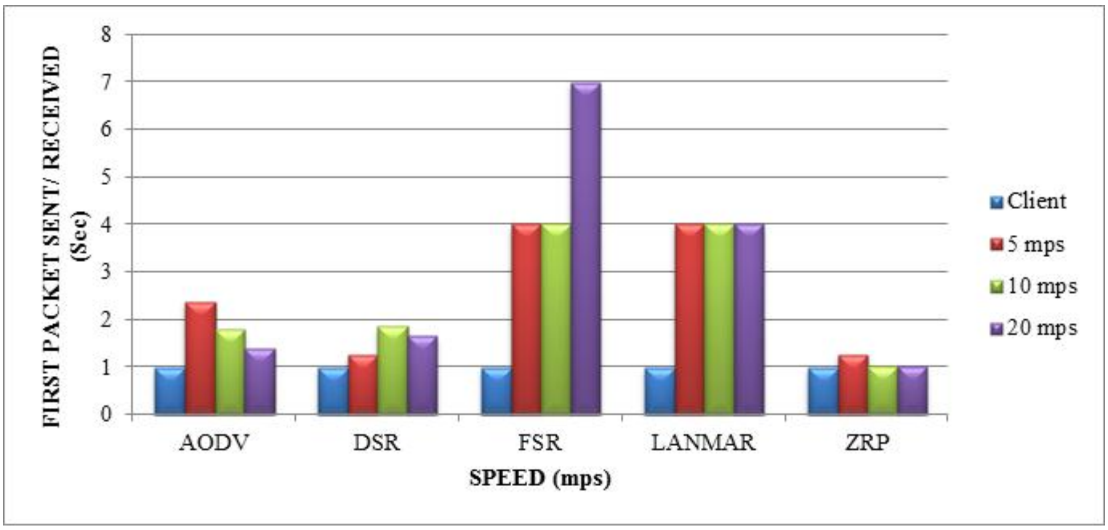

Figure 4.1 – Speed v/s First packet sent/received (Seconds)

All clients sent the first packet at 1 second. The maximum time taken by FSR i.e. 7 seconds in sending first packet in case of speed 20 seconds. On demand protocol i.e AODV and DSR taken minimum time in sending of first packet. The maximum time taken by proactive protocols i.e FSR and LANMAR .the hybrid protocol i.e ZRP taken time in between on demand and proactive protocols.

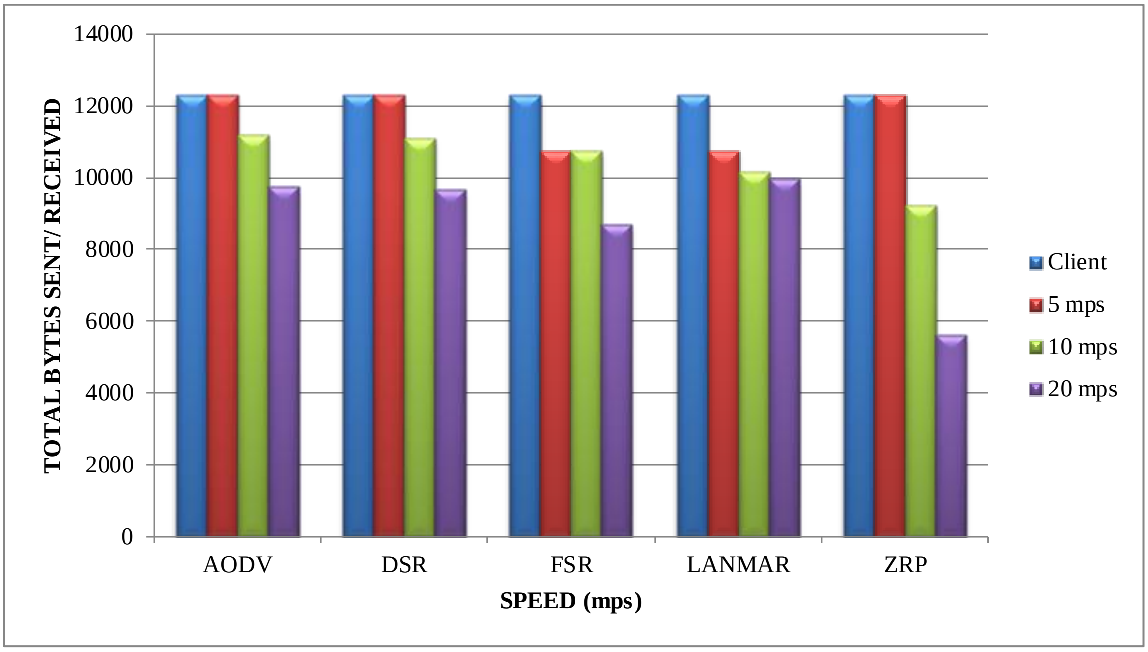

Figure 4.2 – Speed v/s Total bytes sent/received

All clients sent 12288 numbers of total bytes. For AODV, DSR and FSR total no of bytes sent decreases when speed increases i.e. 5 seconds, 10 seconds and 20 seconds. The maximum number of bytes sent by AODV, DSR and ZRP in case of speed 5 seconds. The minimum number of bytes sent by ZRP i.e. 5632 in case of speed 20 seconds.

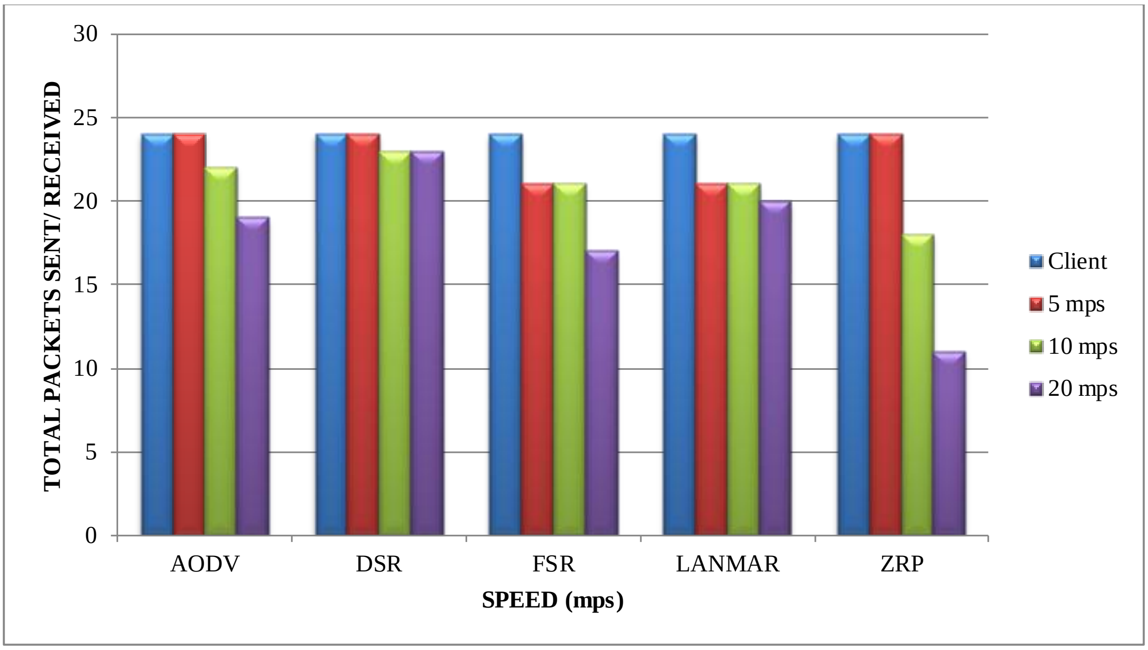

Figure 4.3 – Speed v/s total packets sent/received

All clients sent 24 total numbers of packets. The maximum number of packets i.e. 24 sent by AODV, DSR and ZRP in case of speed 5 seconds. The minimum number of packets sent by ZRP i.e 11 in case of speed 20 seconds.

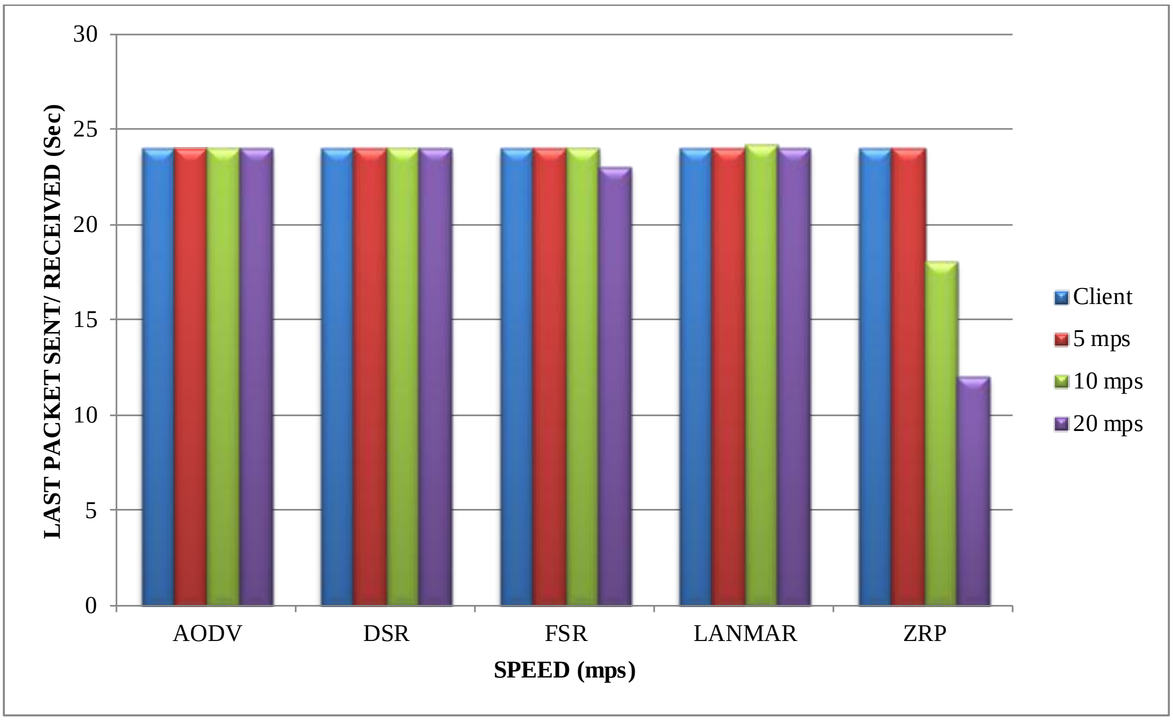

Figure 4.4 – Speed v/s last packet sent/ received

All clients sent last packet at 24 seconds. On demand protocol i.e. AODV and DSR and proactive protocol i.e. FSR and LANMAR sent last packet at same time i.e. 24 seconds in all three cases. The number of packets sent by ZRP decreases when speed increases.

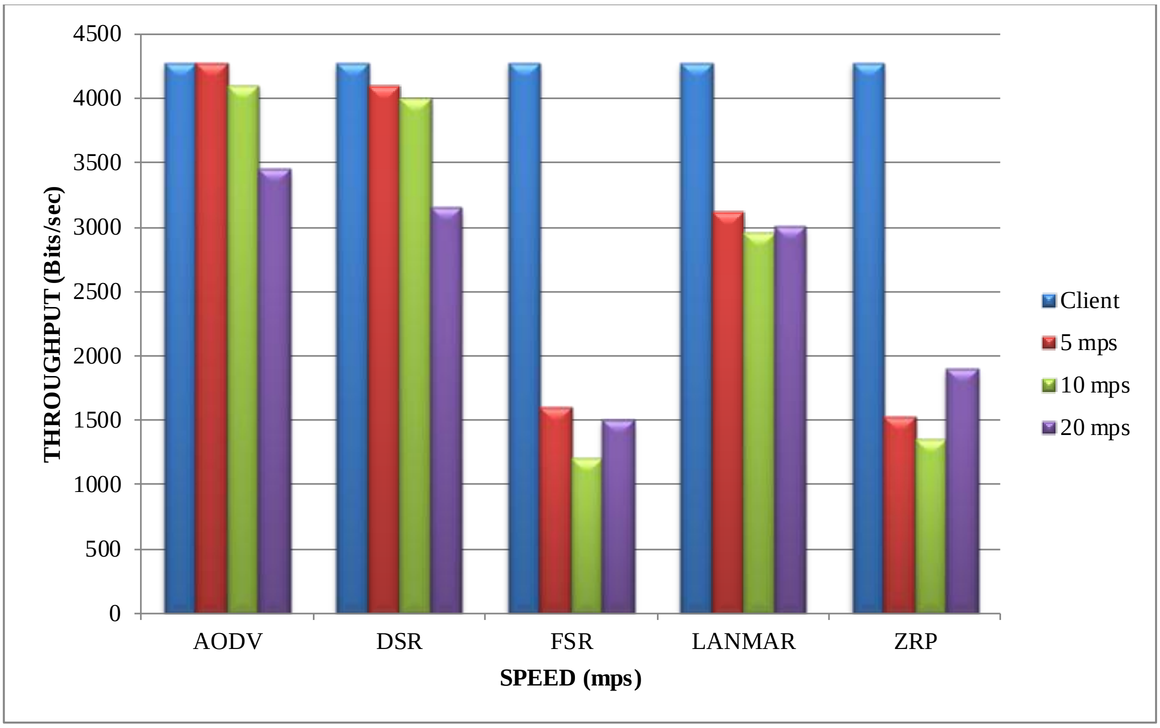

Figure 4.5 – Speed v/s throughput (bits/seconds)

All clients have 4274 bps throughput. The maximum throughput shown by AODV i.e. 4274 bps in case of speed 5 seconds. The throughput of AODV, DSR and LANMAR decreases as speed increases. The minimum throughput taken by ZRP and FSR in all cases.

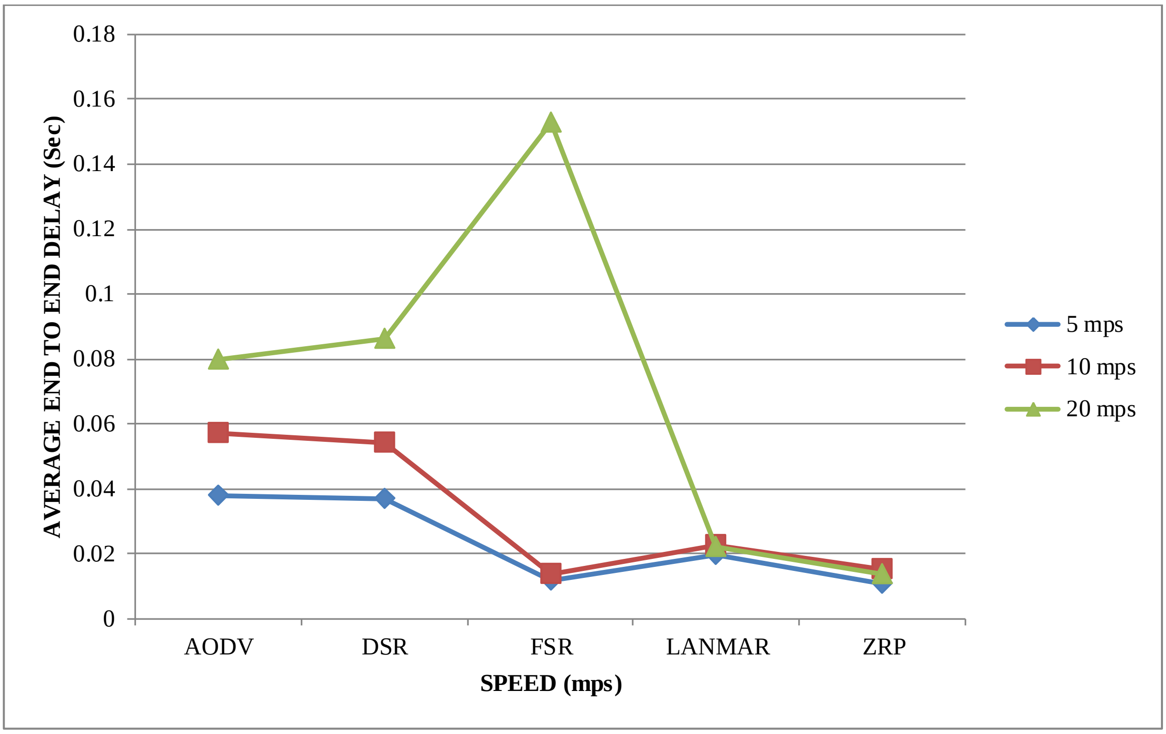

Figure 4.6 – Speed v/s average end to end delay

In AODV and DSR value of average end to end delay increases as speed increases from 5 seconds, 10 seconds then 20 seconds. The maximum delay shown by FSR in case of speed 20 seconds. LANMAR and ZRP had shown almost minimum value of delay in all three cases of speed.

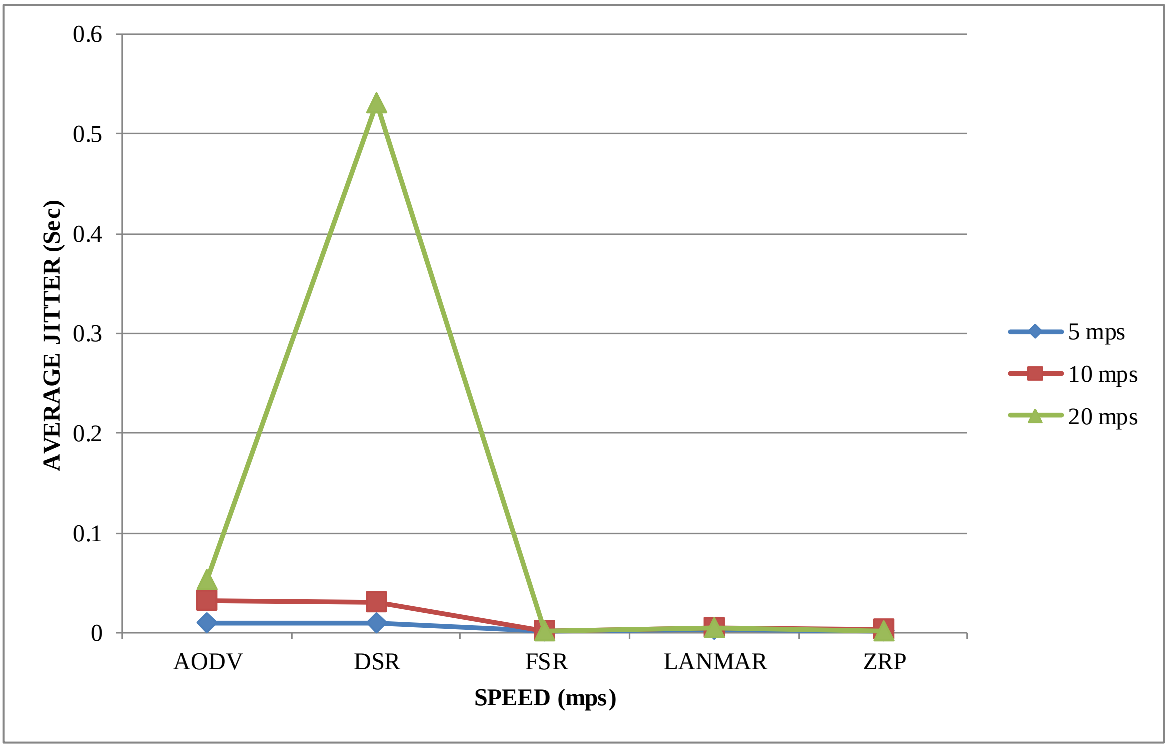

Figure 4.7 – Speed v/s average jitter (seconds)

In AODV value of average jitter increases as speed increases. The maximum value of jitter shown by DSR in case of speed 20 seconds. FSR, LANMAR and ZRP shown equal value of jitter in all three cases of speed.

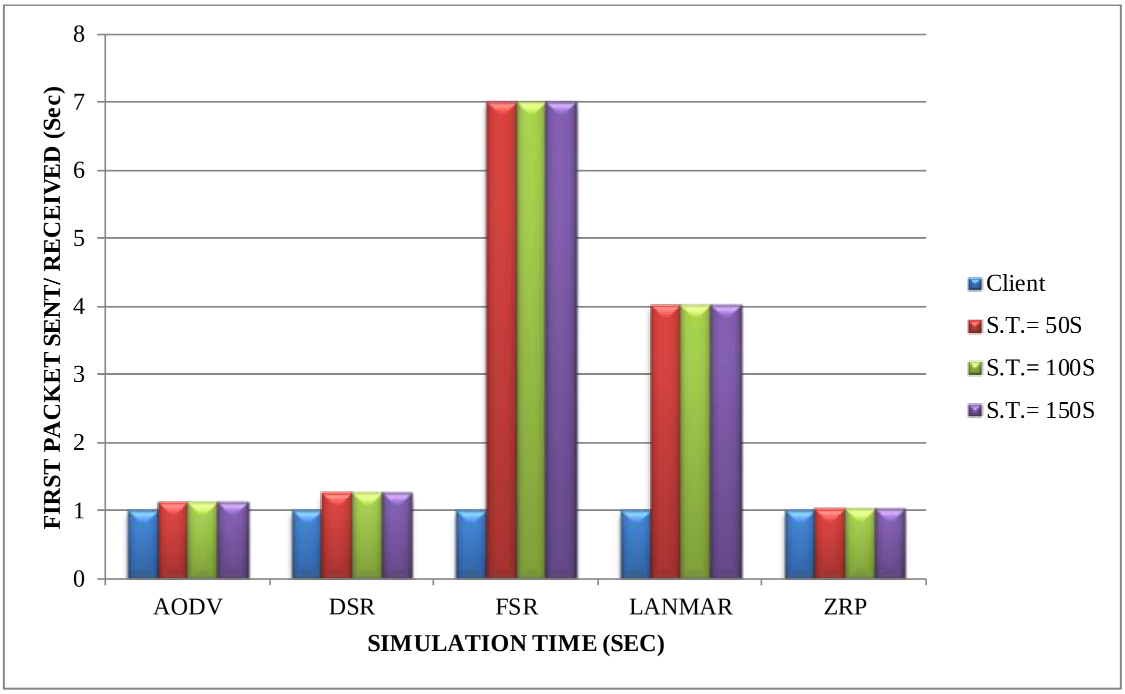

Figure 4.8 Simulation time v/s first packet sent & received

All clients sent the first packet at 1sec. The maximum time in the sending of first packet is taken by FISHEYE in all the three cases. As shown from above figure it is clear that on-demand protocols (AODV, DSR) sent the first packet most early than others. Proactive protocols (FISHEYE, LANMAR) take maximum time in sending of first packet. Hybrid protocol ZRP takes more time than on-demand protocols but lesser time than proactive protocols.

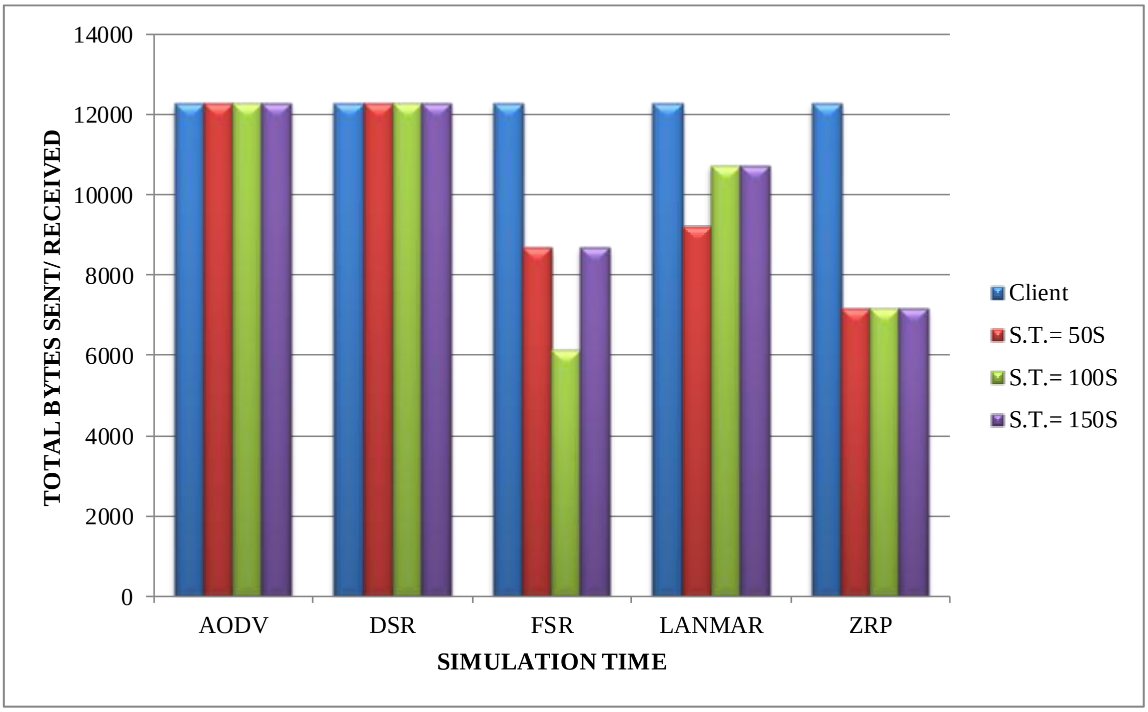

Figure 4.9 Simulation time v/s total bytes sent & received

All clients sent 12288 total numbers of bytes. AODV and DSR sent almost equal no. of bytes in all three cases. ZRP also sent equal no. of bytes in all the three cases i.e.7168. Least bytes are sent by ZRP (hybrid protocol). LANMAR and FSR sent moderate no. of bytes.

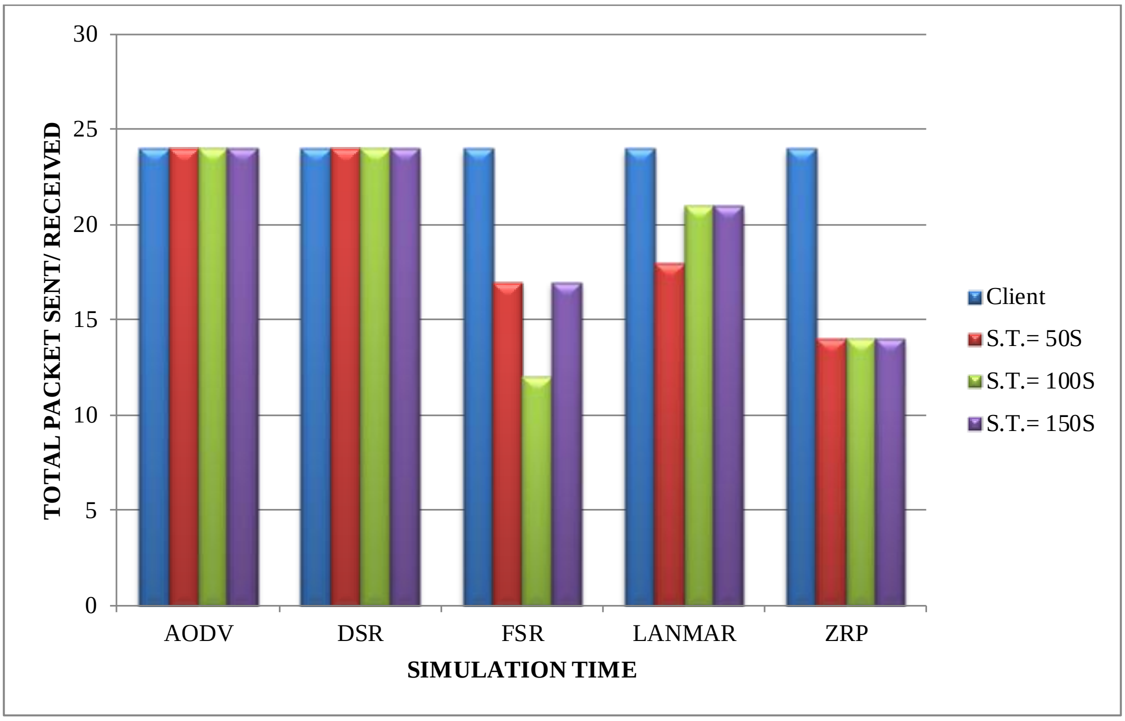

Figure 4.10 Simulation time v/s total packets sent & received

All clients sent 24 total numbers of packets. AODV and DSR almost behaves similarly and sent the maximum no. of packets i.e. 24 in all the cases. Least packets are sent by ZRP (hybrid protocol) in all the cases i.e. 14.

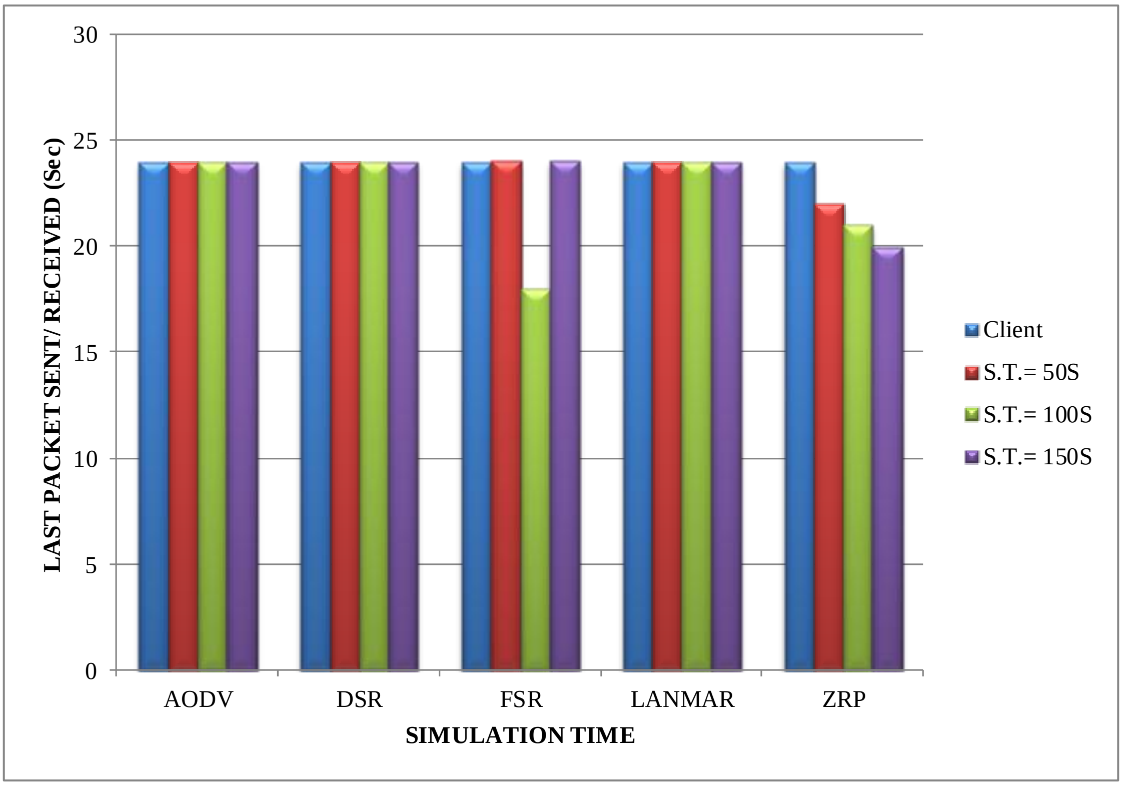

Figure 4.11 Simulation time v/s last packet sent & received

All clients sent the last packet at 24sec. The maximum time in the sending of last packet is taken by AODV, DSR and LANMAR. ZRP takes the least time in sending of last packet.

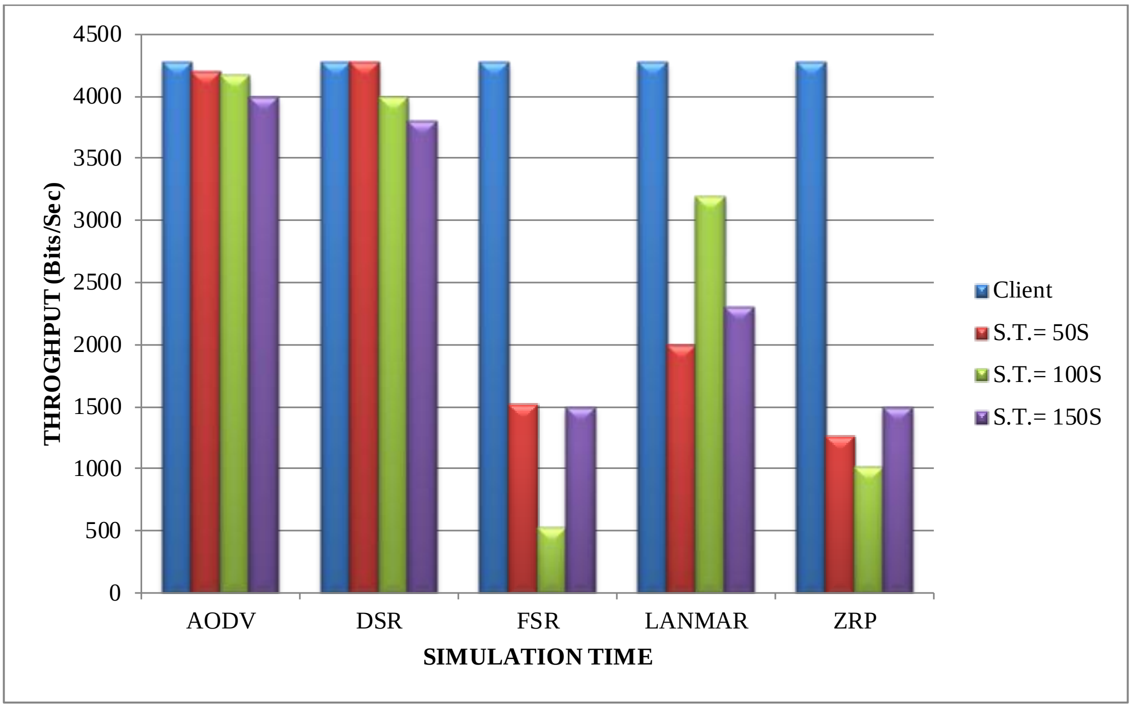

Figure 4.12 Simulation time v/s throughput

All clients have 4274bps throughput. The maximum throughput is shown by AODV and DSR. FISHEYE shows the lesser value of throughput after ZRP whereas LANMAR shows the moderate values of throughput. FSR shows the least value of throughput i.e. 528 bps for simulation time of 100sec.

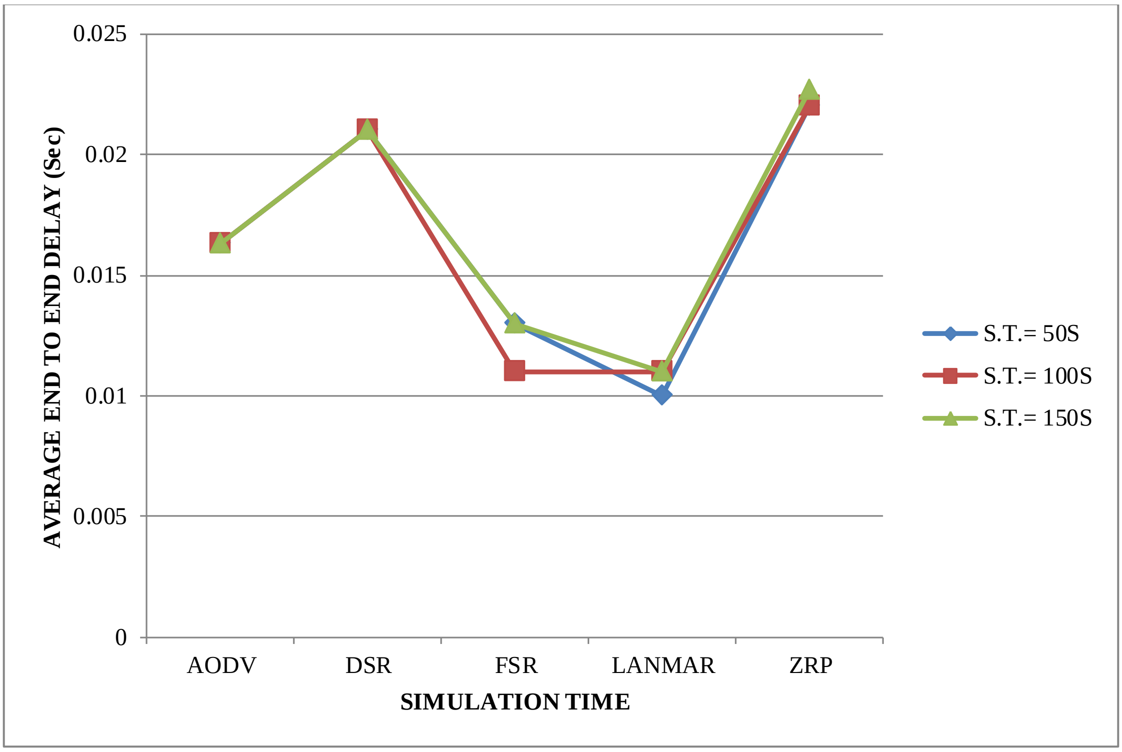

Figure 4.13 –Simulation time v/s average end to end delay (s)

AODV shown equal value of delay i.e. 0.0163 in all three cases. The minimum delay is shown by LANMAR in case of simulation time 50 seconds. The maximum delay shown by ZRP in all three cases. On demand protocols shown maximum delay maximum delay as compared to proactive protocols.

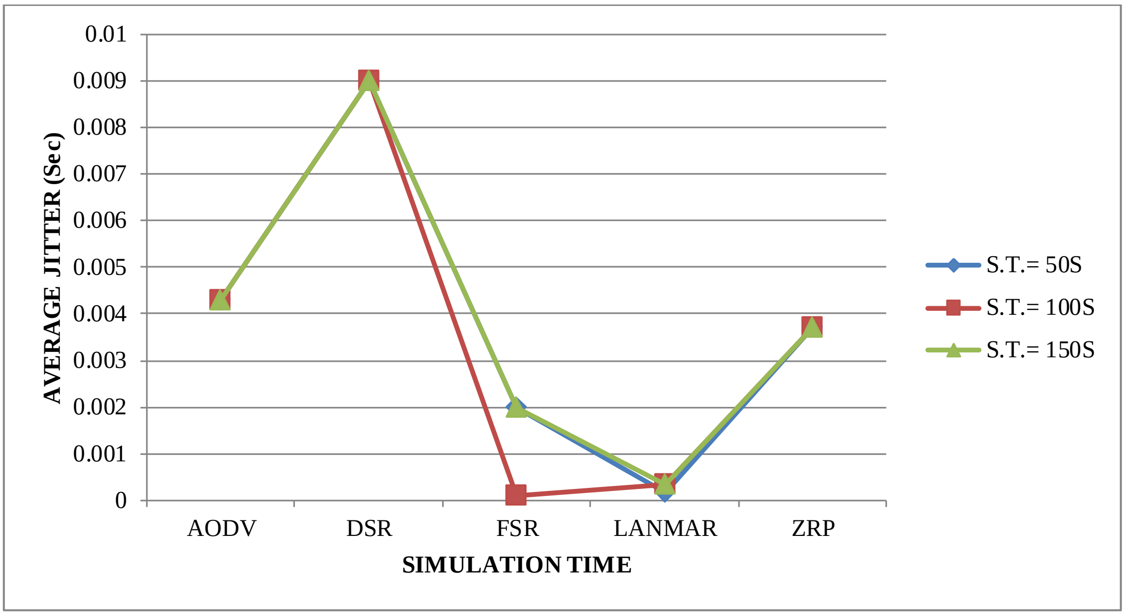

Figure 4.14 Simulation time v/s average jitter

AODV shown equal value of jitter i.e 0.004 in all three cases. LANMAR shows almost equal values of jitter in all the three cases i.e. 0.00035. The maximum value of jitter is shown by DSR when there is a simulation time of 150 sec. The minimum value of jitter is shown by LANMAR. FSR also shows least value of jitter after LANMAR.

Conclusion

In this paper, a performance comparison of AODV,DSR FSR,LANMAR and ZRP routing protocol for mobile Ad-hoc networks is presented as a function of speed and as a function of simulation time. Performance of routing protocol is evaluated with respect to four performance metrics such as average end to end delay, packet delivery ratio, throughput and average jitter. From the above results, it is concluded that in each case the best performance in terms of packet delivery ratio (PDR) and throughput is shown by on demand protocols (AODV and DSR). ZRP shows least values of throughput and PDR in each case. LANMAR shows the least values for average jitter and end-to-end delay. The maximum values of average jitter and ETED is shown by DSR and FISHEYE. AODV and ZRP show moderate values of jitter and delay. In addition, as CBR application increases the total no. of packets sent (PDR) and throughput increases for all the protocols except LANMAR. Regretfully ZRP was not up to the task and it performed poorly throughout all the simulation sequences, hence putting itself out of competition. Hence, the overall best performance is shown by AODV in each case. DSR perform poor in more stressful circumstances.

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