Performance Modeling of AODV, DSDV, DSR & TORA Routing Protocols Using NS-2 & NS3

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Abstract **A Network in which nodes communicate without any centralized control as well as infrastructure can be considered as Mobile Ad-hoc Network (MANET.).Data is exchanged in multi hops via wireless channels .For smooth exchange of Communication we need routing protocols for effective and timely delivery of message. Ad hoc routing protocols have several performance metrics to compare. AODV, DSDV, DSR, TORA built on performance metrics like Throughput, End to End Delay, Normalized Route Load, Packet Delivery Ratio, Energy Efficiency with different number of nodes, fidelity, distance etc. We have compared routing protocols basing on the metrics and the performance is analyzed and graphs have been generated on Network Simulator (NS-2,NS-3).**

Keywords: AODV, DSDV, DSR, Packet Delivery Ratio(PDR), MANET

1. Introduction

Mobile ad-hoc network are networks where nodes communicate wirelessly with each other without any existing infrastructure. Wireless networks can be classified in two types: network with infrastructure and network without infrastructure (ad hoc) networks.

Network with infrastructure consists fixed and wired gateways. A mobile node communicates with a bridge in the network (called base station) within its communication radius. When it goes out of range of one base station, it connects with new base station and starts communicating through it. This is called handoff. In this approach the base stations are fixed .In contrast to infrastructure based networks, in ad hoc networks all nodes are mobile and can be connected dynamically in an arbitrary manner. All nodes of these networks behave as routers and take part in discovery and maintenance of routes to other nodes in the network. More formally, an ad hoc network is a collection of wireless nodes that can be rapidly deployed as a multi-hop packet radio network without the aid of any established infrastructure or centralized administration and without any user-initiated configuration actions. They have the advantage of rapid deployment, robustness, flexibility and inherent support for mobility. Routing protocols for Mobile ad hoc networks can be classified into two main categories: Proactive or table Driven routing protocols and on-demand routing protocols.

This flexibility of self-configuring and self-administration makes it lucrative for various applications in military operations, wireless mesh networks; wireless sensor networks etc. Due to the wireless nature of Mobile Ad hoc network, the routing protocol is a very important issue to make it more efficient and reliable.

This paper aims to provide a step by step comparative analysis of 4 popular routing protocols: AODV, DSDV,DSR and TORA.

The rest of the paper is organized as follows: Section 2 presents an overview of the Wireless routing protocol that is analyzed and compared. Section 3 gives a brief description of the Simulation parameters, assumptions hold and description of the step by step comparing methodology used in the paper. Section 4 provides the simulation results and discusses it. Finally the conclusion is provided in section 5.

2. Wireless Routing Protocols

Routing protocols in MANET's can be done in many ways, but most of these are done depending on routing strategy and network structure[1, 3]. According to the routing strategy the routing protocols can be categorized as Table-driven and source initiated, while depending on the network structure these are classified as flat routing, hierarchical routing and geographic position assisted routing [1]. Both the Table-driven and source initiated protocols come under the Flat routing see [fig 5.1].

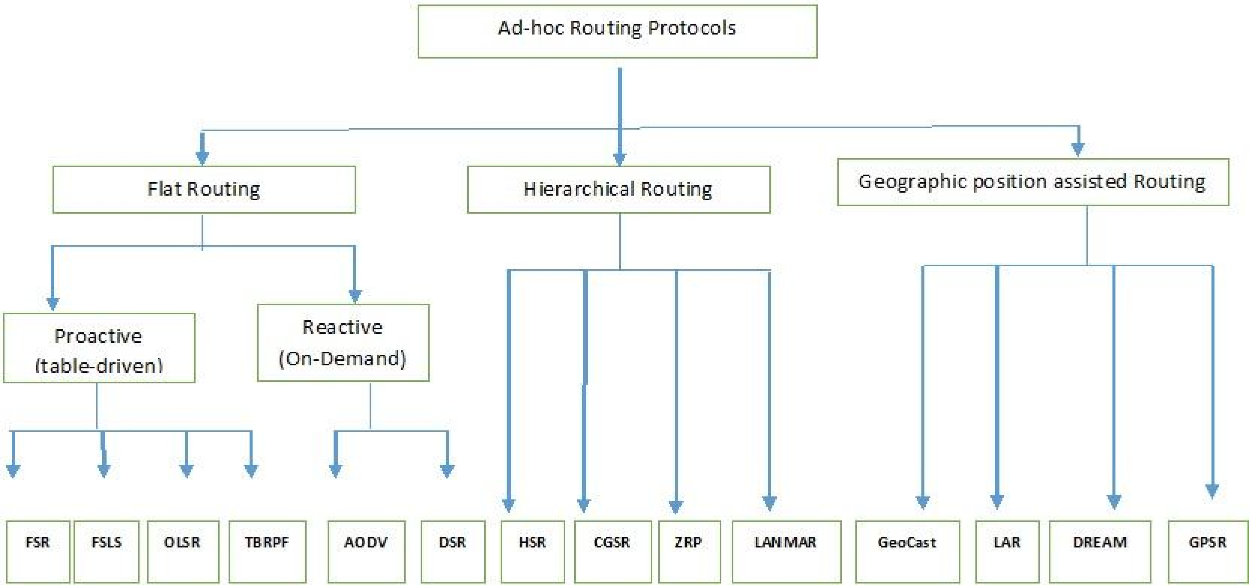

Figure 5.1: Classification of Routing Protocols In Mobile Ad-hoc Networks[1].

2 Table-Driven routing protocols (Proactive)

These protocols are also called as proactive protocols since they maintain the routing information even before it is needed [2]. Each and every node in the network maintains routing information to every other node in the network. Routes information is generally kept in the routing tables and is periodically updated as the network topology changes. Many of these routing protocols come from the link-state routing [1]. There exist some differences between the protocols that come under this category depending on the routing information being updated in each routing table. Furthermore, these routing protocols maintain different number of tables. The proactive protocols are not suitable for larger networks, as they need to maintain node entries for each and every node in the routing table of every node. This causes more overhead in the routing table leading to consumption of more bandwidth.

2.1 Destination-Sequenced Distance Vector routing (DSDV)

The DSDV protocol is a proactive routing protocol, A protocol modified from Bellman-Ford routing algorithm [4]. This protocol has a sequence number as an attribute to the routing table, with the support of this table the packets are forwarded to other nodes in the network.

Protocol Overview

For the packet transmission a routing table is maintained at each node. This is helpful in connectivity with other stations. The table will have list of all destinations, no of hops required to reach that destination. The entry is identified with a sequence number. Each station transmits and updates its routing table to maintain consistency. The routing information is either broadcasted or multicasted.

The DSDV protocol requires that this routing information is disclosed regularly and periodically. As the entries in the table may change dynamically, the advertisement about the nodes is done frequently, so that in a network a node can locate its neighbours. To ensure shortest number of hops for a route to the destination the above method is applied.

The broadcasted data by a node will have its new sequence number and the new route information like the

The Destination address

The number of hops required to reach the destination

The new sequence number stamped by the destination

The routing table contain hardware address along with network address of the transmitting node. The Latest sequence number is preferred for forwarding decisions. As the receiving node receives the route information it increments the metric and broadcasts, So that the hop is too added to reach its destination. As soon as the mobile host receives new information it is dis-emanated as rapidly as possible to the neighboring nodes. The mobile node links are prone to break, so at such times the reachability is marked as “Infinity” saying that there is no hop up to the destination through this node and sequence number is updated. Normal sequence numbers are even numbered and broken link sequence numbers are odd numbered.

The DSDV protocol uses two types full dump and incremental dump for information broadcasting .Full dump will broadcast all routing information against incremental dump which will broadcast the changed routing information. This is done in Network protocol data units(NPDU), multiple NPDU’s are used for full dump and one NPDU for incremental dump. Basing on the largest sequence number, The node will update its routing information . If a new node enters into a network the self-disclosure will make the other nodes to update their routing information with a new node entry. The frequent movement by the hosts make host to transmit their routing tables more frequently which leads to continuous burst of new route transmission upon receiving new sequence number from that destination

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2.2. Ad hoc On-Demand Distance Vector Routing (AODV)

AODV is classified under Distance Vector Routing protocols (DV). In this every node knows about its neighbors and the cost to reach them. A node maintains its routing table to store all nodes, their distance along with the next hop to those nodes. As like DSDV , unreachability is set to “Infinity”. Every node discloses entire routing table to its neighbours so that they can check if there is a useful route to another node using this neighbours as next hop. This protocol has a little delay. To overcome overhead of traffic, Routes are established when there is a need. AODV supports Uni, Multi and Broadcasts. The “Infinity” & loop are solved using sequence numbers and registrations of costs. Every hop counts to one. Along with sequence number, Time- To- Live is taken as added column for every entry. It even has routing flags, interface list of precursors and for outdated routes last hop count is stored.

Unicast Routing

Here the routing is controlled using 3- messages RREQ(Route Request), RREP(Route Reply) and RERR(Route Error).RREQ packet is sent when a node wants to send a packet to know the route [5].RREP includes identifying destination IP address and Sequence number, Source IP address, sequence number as well as a hop count initialized with Zero. If a node receives the RREQ it sets up a server route up to the sender. If the node does not know a route to the destination, it rebroadcasts the RREQ by incrementing the hop count by one. If it knows route RREP is Unicasted to the sender. When a node receives a RREP it compares its routing table or the sequence number higher than it's or lower than its sequence number. If both of them are not true it discards the packet, otherwise it updates her routing table.

In mobile networks link failures are very common. If a node realizes that no other node is reachable it broadcasts a RERR containing list of unreachable nodes their IP addresses and sequence numbers. Every node who receives this list compare the next hops are within the list and update their tables accordingly. If it has some more unreachable nodes its broadcasts its own RERR containing this information .RERR is valid only for neighbours. "Hello" messages are exchanged if the routers are not hearing anything for a long time.

Multicast Routing

AODV has an integrated multicast routing the table contains IPaddress , Sequence number, next hop, hop count and lifetime. RREQ is used to join the group and reply is given using RREP. A requester can receive multiple RREP from which it can choose a shortest distance to the group. Multicast activation message is sent to the chosen tree node. If a node did not receive RREP it presumes no multicast tree for this group and it becomes a group leader. The RREP contains IP of the group leader. The group leader broadcasts a "Hello" messages periodically and increments each time the sequence number of the group. If a node in a group tree does not receive any group "Hello" messages or other group messages it has to repair the group tree with RREQ to ensure that RREP from a node in its own subtree is chosen. If group member leaves a group, he can prune that branch with a MACT and the flag prune set. It has to continue as a tree member if he is not a leaf.

2.3. Dynamic Source Routing (DSR)

The caching of the route is maintained at every node. The list of intermediate nodes will have the details of a node if it is in the cache and sender will transmit it to the next hop along the path. The intermediate nodes will examine the header and forward it to the next node , If no route is found, it is maintained in the buffer until it obtains the route using route discovery process.

Route Discovery and Maintenance [6]-[7]

To find a route to the destination, source broadcast route request packets within its radio range. The route record contains all the nodes visited in the route along with address of the source and destination when a route request is received it does the following. If its own address matches with the destination address then it is considered as reached destination. The route record contains the entire path the request has travelled from the source. This route is transferred back to the source using route reply packet. If node has not received the request and it has a route, it creates a route from its cache and sends it to the source. Such replies are called intermediate node replies. If it does not have a route to the destination, creates one route reply packet with the route from its cache and sends it back to source. If it does not have a route it adds its own address to the route along with incrementing of hop count, rebroadcasts the request. When source receives the reply adds the received route and delivers any pending data packets. If link is broken a route error packet is generated. Thus this packet is unicasted back to the source, erasing all the addresses in the link that contain the broken link.

2.4. Temporally ordered routing algorithm (TORA)

TORA is known as adaptive routing protocol for multi- hop networks. As it is a distributed algorithm the router has to maintain knowledge about their neighbor like other distance vector algorithms this protocol maintains status on a predestination basis. The routing is a combination of reactive and proactive where the source may begin operations in reactive or proactive mode. The routes to gateways and servers may be consistently or frequently required and TORA supports multiple path routing. The Communication overhead with adapting to network topology changes[8] can be minimized by TORA. The idea behind keeping multiple paths is that to discover a new route when network topology changes when all the local routes fall in cache. The route metrics followed by routers use the concept of height associated with a destination like water flows in pipes routes with higher heights may forward packets to lower heights, the paths to forward packets are associated with corresponding destinations so routers have different heights and links to different destinations .Basing on the flow heights are called as upstream or downstream. If the link is lower stream will be upstream and vice versa. An upstream link for a router implies that data flow to destinations can only come into this route via link. A downstream link for a router means data flow leave this router to the neighbouring router via this link.TORA may not always support the shortest path because of their height assignment. TORA is a complex algorithm. It has four operations which are

1. Creating routes
2. Maintain routes
3. Erasing routes
4. Optimizing routes

   Creating route operations is responsible for proper heights, creating directed links reaching to the destination

   Route maintenance is for changes in network topologies .Erasing routes is for setting heights to NULL and changing to undirected links.

   To adjust the height of the routing and to improve routing optimization is done. The different types of packets are Query (QRY),Update(UPD),Clear(CLR)and optimization(OPT)[10]

3. Simulation and Analysis method

The simulations were performed using Network Simulator (NS-2,NS-3), which are popularly used for ad hoc networking community. The routing protocols were compared based on the following 6 performance metrics:

1. Throughput
2. Packet Delivery Ratio(PDR)
3. Normalized Route Load(NRL)
4. Energy Efficiency
5. End-to-End Delay
6. Average End –to-End Delay

3.1. Major assumptions:

Random waypoint mobility scenario creates random mobility scene every time it is executed. Thus in order to compare a protocol with itself, we have to use the same mobility scenario for each variation. But using Random waypoint model, it is not possible .Thus, in order to minimize the randomness for each variation, 3,5,10,20,30,40,50 mobility scenario is generated . This process is undertaken for each variation making it less random.

Parameters	**Value on NS2**
Studied Protocols	DSDV,AODV,DSR and TORA

Simulation time	150 seconds
Simulation area	900 X 700 m
Node Movement Model	Random Waypoint Model
Speed	2 m/s – 10 m/s
Traffic Type	FTP
Node pause time	No Pause time
Packet Size	1040 bytes
Bandwidth	2 Mb/s
Packet Rate	2 Mb/s
No of Nodes	3, 5,10, 20, 30, 40, 50
No of Source Destination	1
Connection	TCP
Propagation	Two ray ground

3.2. Simulation Method

In this section we have discussed the simulation setup for performance evaluation of these protocols. The network simulator (NS2,NS3) are used.Graphs are generated using GNUPlot in NS3.

A) Simulation Setup[9]
In this scenario we have taken the nodes as follows.
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Parameters	Value
No Of Nodes	3,5,10,20,30,40,50
Maximum Speed	10 m/s
Minimum Speed	2 m/s
Simulation time	150 s

4. Simulation results

4.1. Comparison based on Packet Delivery Ratio (PDR), End to End Delay and Routing Load keeping the Pause time constant and varying Speed.

Table 4.1 Throughput

Nodes/Routing Protocol	3	5	10	20	30	40	50
DSDV	341.31	340.97	341.12	601.27	601.22	594.99	597.73
AODV	604.70	532.48	615.68	543.81	536.71	513.78	652.67
DSR	527.46	509.81	523.23	587.09	580.62	563.57	585.80
TORA	0.0000	509.81	523.23	587.09	580.62	563.57	585.80

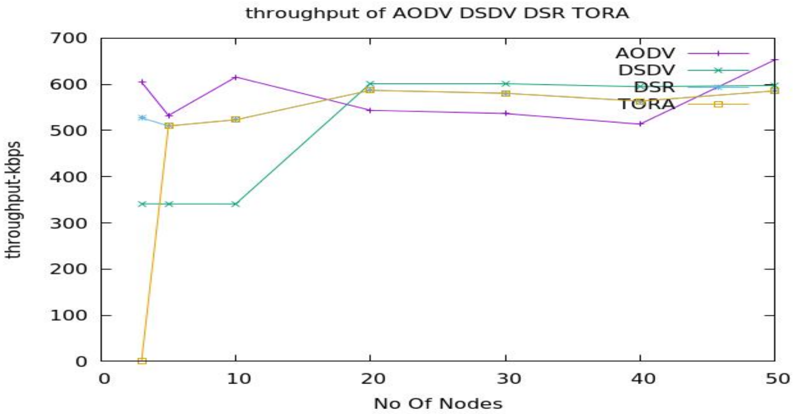


Figure 4.1 Throughput

Table 4.2 Packet Delivery Ratio(PDR)

Nodes/Routing Protocol	3	5	10	20	30	40	50
DSDV	0.9972	0.9964	0.9977	0.9984	0.9983	0.9968	0.9991
AODV	0.9971	0.9964	0.9958	0.9984	0.9985	0.9978	0.9984
DSR	0.9983	0.9986	0.9986	0.9984	0.9985	0.9979	0.9986
TORA	0.0000	0.9889	0.9789	0.9690	0.9590	0.9956	0.9968

Figure 4.2 Packet Delivery Ratio(PDR)

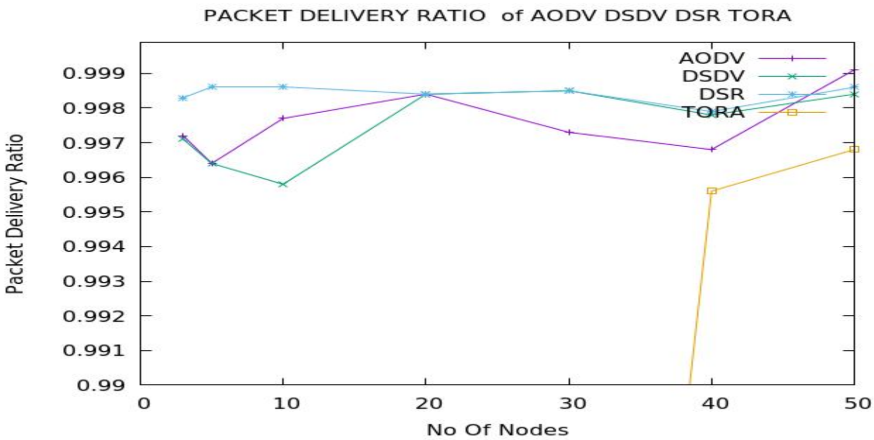


Table 4.3 Normalized Route Load(NRL)

Nodes/Routing Protocol	3	5	10	20	30	40	50
DSDV	0.005	0.010	0.014	0.006	0.009	0.017	0.029
AODV	0.008	0.014	0.030	0.038	0.061	0.089	0.116
DSR	0.004	0.007	0.010	0.005	0.008	0.040	0.005
TORA	0.000	0.010	0.014	0.009	0.012	0.044	0.008

Figure 4.3 Normalized Route Load(NRL)

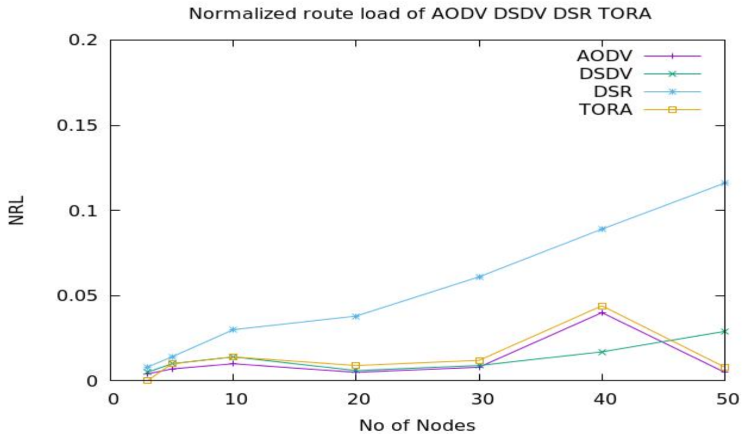


Table 4.4 Energy Efficency

Nodes/Routing Protocol	3	5	10	20	30	40	50
DSDV	89.6667	35.8	17.9	8.15	5.43333	3.475	3.58
AODV	59.6667	35.8	17.9	9	6	4.5	3.58
DSR	89.6667	53.8	26.6	13.05	8.4	6.325	5.06
TORA	30	54.2	27.1	13.09	8.7	6.330	5.10

Figure 4.4 Energy Efficency

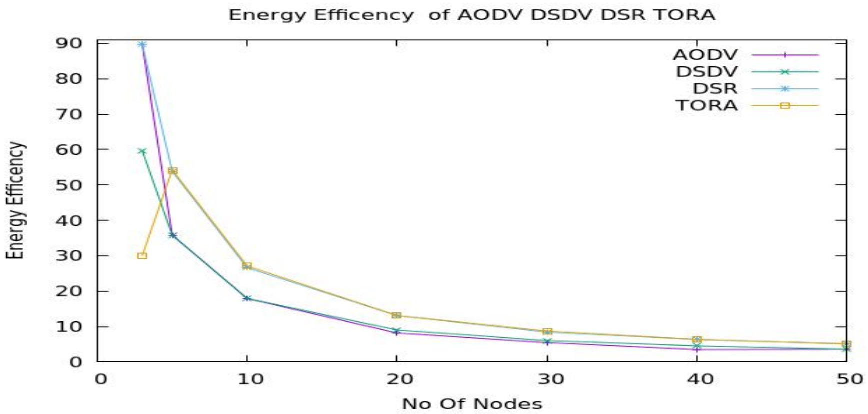


Table 4.5 End To End Delay

Nodes/Routing Protocol	3	5	10	20	30	40	50
DSDV	120.884	122.52	121.207	65.1606	65.2428	58.015	66.2139
AODV	69.5507	66.78	77.3073	61.19	66.3333	69.1676	60.5066
DSR	80.1126	103.591	96.602	51.3933	67.1732	58.6115	73.1535
TORA	0.0000	103.601	96.612	51.3941	67.1740	58.6120	73.1543

Figure 4.5 End To End Delay

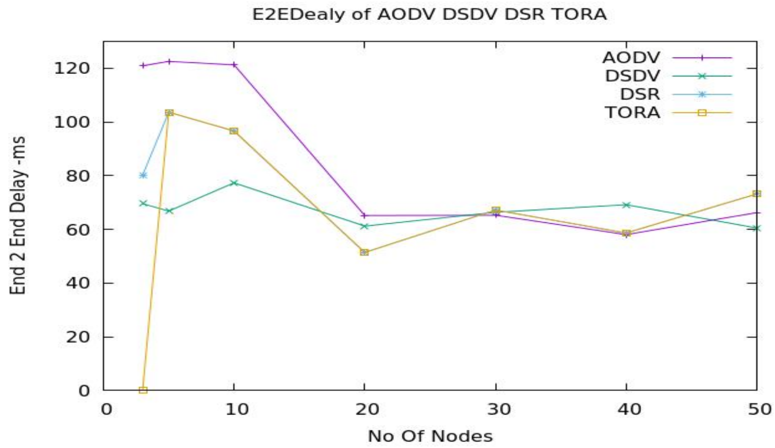
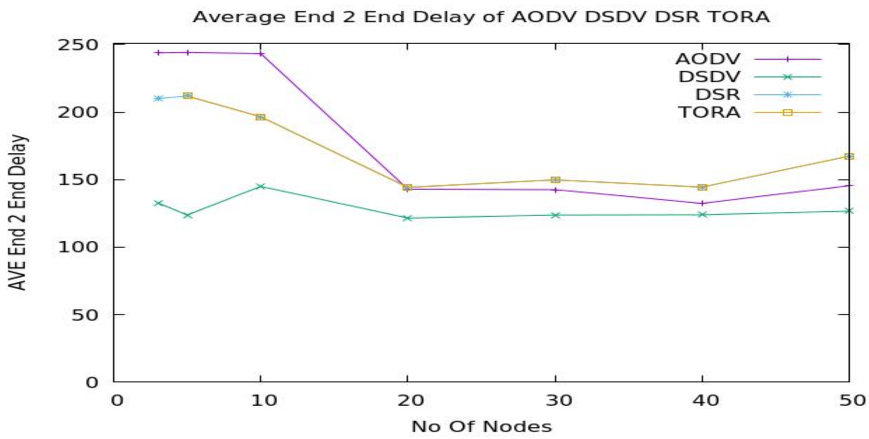


Table 4.6 AVERAGE END-TO-END DELAY

Nodes/Routing Protocol	3	5	10	20	30	40	50
DSDV	243.816	244.147	243.276	142.954	142.558	132.39	145.47
AODV	132.846	123.783	144.939	121.577	123.785	123.955	126.626
DSR	210.015	211.879	196.487	144.304	149.752	144.395	167.399
TORA	0.0000	211.888	196.495	144.309	149.760	144.403	167.408

Figure 4.6 AVERAGE END-TO-END DELAY



5. CONCLUSION

This paper analyses the performance of different source initiated routing protocol for wireless ad-hoc network. These routing protocols are compared with parameters throughput, packet delivery ratio and average end to end delay. All the parameters are calculated with no pause time and number of nodes are varied within a maximum area as specified. Simulation results shows AODV performs better than other protocols in terms throughput and packet delivery ration. DSR performs better than the rest in NRL.Energy Efficiency, End-to-End delay , Average End-to-End is proportionately equal for all protocols. This paper does the realistic comparison of Four routing protocols DSDV, AODV, DSR and TORA The significant observation is, simulation results agree with expected results based on theoretical analysis.

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