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Research paper

behavioral assessment of metrics in manet routing protocols under realistic environments

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Abstract

A Network in which nodes communicate without any centralized control or infrastructure can be considered as Mobile Ad-hoc Network (MANET.).Data is exchanged in multi hops via wireless channels .For the smooth exchange of information, we need routing protocols for effective and timely delivery of the message. Ad hoc routing protocols AODV, DSDV, DSR, TORA have several metrics like Throughput, End to End Delay Normalized Route Load, Packet Delivery Ratio, Energy Efficiency, the number of nodes, fidelity, distance, etc., to Asses. We have compared routing protocols basing on these 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

A network where there will be no pre-established infrastructure, still the node(s) exchange and communicate wirelessly can be considered as a Mobile ad-hoc network[1].These wireless networks are differentiated into two, one with infrastructure and one without infrastructure(ad hoc).With the infrastructure model there exists gateways of fixed and wired variants. In a network, a mobile node exchange information with the base station through a bridge within a boundary called as communication radius [2].When the signal strength within this radius gradually becomes weak or unreachable then it would start its communication with the new base station .This process is called handoff. Here the base station is fixed with the infrastructure less based networks. No such fixed node will be available in ad-hoc mode. In ad-hoc networks all the nodes will be moving randomly in an arbitrary manner. In ad-hoc networks each node can act as a router to maintain the routes and to identify new routes. Here the networks can be formed without any centralized administration and without any prior established infrastructure. Such collection of wireless nodes are deployed as a multi-hop packet radio network. A network of nodes can be deployed rapidly. Robustness, flexibility as well as the support for mobility plays a vital role in such a type of network. There are two variants in this routing protocols, namely Proactive or table driven and on-demand [3].Various applications like military operations, wireless mesh, sensor networks, etc., places like tough terrain make it more suitable to take the advantages of this automatic configuration and administration, Due to the disconnected nature of this type of networks, the routing protocol plays a significant role in making it more efficient and reliable.

In our paper we concentrated on providing a step by step, comparative analysis of the routing protocols: AODV, DSDV, DSR and TORA. The paper presents an overview of the Wireless routing protocol that is analyzed and compared. The other section explain about the parameters used in simulation, the assumptions considered and how the comparison is done. The next section provides the simulation results. We have given the conclusion in the last.

2. Wireless routing protocols

In MANETS, depending on the strategy of routing and structure of the network, a routing is performed in many ways [1], [3].According to the route, the packet takes a particular path which can be classified as table driven and source initiated. Basing on the topology of the network, different types of routings namely flat routing, hierarchical routing and geographic position assisted routing [4]. Flat type of routing is further classified into table-driven and source initiated protocols. [Fig 5.1]

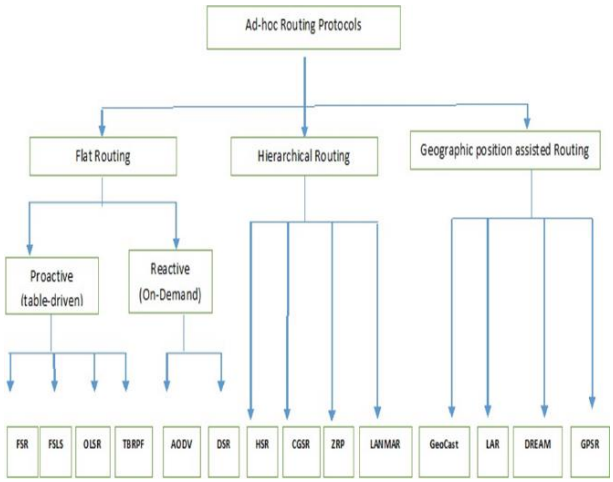


Fig. 5.1: The Organization of Various Protocols in Mobile Ad-Hoc Networks [4].

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Table-Driven routing protocols (Proactive)
The proactive model maintain the information about the routing prior its usage or even before they are needed [5].In a network every node retains the information about the other in the routing tables. Even the dynamic updating of the routes is carried in these routing tables as and when there is a change in topology. Majority of protocols evolved from the link-state routing [4].Updating and sharing of the route information may have slight variations basing on the routing information. These protocols may not be appropriate for huge networks because the node entries are to be maintained at each and every node about every other node resulting in more frequent updates of these tables which consume more bandwidth.

2.1. Destination-sequenced distance vector routing (DSDV)

This is a protocol with a proactive routing in nature, modified from routing algorithm of Bellman-Ford routing [7]. Here the sequence number acts as an attribute to the routing table, with the support of this table, the other nodes receive the packets that are forwarded by the network.
Protocol Overview
For the packet transmission, at each node a routing table is maintained. This would be helpful in connectivity with other stations. The routing table contains the information of all the destinations, total hops necessary to reach the extreme end. The entries are identified with sequence numbers. To preserve uniformity, every station exchanges its updated table. The routing information is either broadcasted or multicast.
This protocol entails about the routing information which is disclosed regularly and periodically, as and when the table entries changes frequently, so that in a network every node will be able identify its neighbours. To have fewer hop count about the route towards the destination, the above method is applied. The updated node details related to the address, MAC Address, hop count, and the latest sequence identification towards the destination node is broadcasted. The Latest sequence number is preferred to take forwarding decisions. As the receiving node receives the route information it updates and forward that information, So that the current hop is added to the path to towards 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 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.
This protocol uses either a full or an incremental dump for information broadcasting. The Full dump will broadcast complete information about routing and the other will broadcast the changed routing information only. 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. When a node enters into a network the node informs all the neighbouring nodes about the update. The neighbouring nodes will modify their routing information with the entry. The dynamic movement of the host updates the routing tables a number of times within no time. Once the latest sequence identification number is updated by the destination a fresh update burst about the route information is communicated to all the nodes.

2.2. Ad hoc on-demand distance vector routing (AODV)

This is classified under Distance Vector Routing protocols (DV). Here a node has knowledge about its neighbors and the cost of reaching that node. A table is maintained to store details like the distance and the next hop towards those nodes. As like DSDV, unreachability is set to "Infinity". Each node discloses the routing information to all the neighbours, which is further used by those neighbouring nodes to find out the availability of a new route through this new node as a next hop. This protocol has a little delay. To overcome the overhead of traffic, Routes are established when there is a need. AODV supports Unicast, Multicast and Broadcast. The "Infinity" &cyclic in nature are solved using sequence numbers and registrations of costs. Every hop counts to one. Along with sequence number, Time- To- Live is taken as an added column for every entry. The details like routing flags, a list of outdated routes, precursors, and last hop count are also maintained.
Unicast Routing
Here routing is controlled using 3- messages like RREQ, RREP and RERR. To get route information of a node a RREQ packet is sent [8]. RREP contains destination, source addresses and Sequence identification number and a hop count which are set to Zero. If a node gets the RREQ it sends a server route to the sender. If it has no information then, it resends the RREQ by adding one to the hop count. A RREP is Unicasted to the sender if it has route information. When a node receive RREP message it compares with routing table to verify whether the current sequence identification number is higher than it's or lower than its sequence identification number. If both of them are not true, it discards the packet, otherwise it updates her routing table.
In mobile networks link failures are frequent. When a node identifies it is not reachable then it broadcasts a RERR message specifying the details of the unreachable nodes, along with details like IP addresses and sequence identification numbers. Every node which receives these details, compares the next hops details 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 details like IPaddress, Sequence identification number, next address, how many hops is required further and a lifetime. RREQ is used to join the group and RREP for a reply. A requester can receive multiple RREP messages and the requester will choose a message which is having least distance to the group. The particular tree node which is selected will be sent the activation message as a multicast. If a node did not receive RREP it presumes no multicast tree for this group and it becomes a group leader. The Route reply contains IP of the group head. The group head sends a message "Hello" as a broadcast message intermittently and increments the sequence number of the group each time. If any one of the node do not receive either the "Hello" messages or other messages from the group, the group tree is reconstructed with RREQ to make sure that it receives the group messages. If a group member leaves the group, he can trim 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)

At every node, the route information is cached. The list of intermediate nodes will have the details of a node if it is in the cache and sender will forward this together with the next address in the path. The in between nodes will verify the details of the header and pass this information to the next node. If no route is found, with the help of route discovery it finds a route, till then this information is maintained in the buffer.
Route Discovery and Maintenance [9]-[10]
To construct the route up to destination source broadcast route request packets within its radio range. The route record contains all the nodes visited in the route along with the source address and the destination address. Once the request is received for the route it does the following, when her address matches with the destination address it is treated as reached destination. The route record contains the entire path the request has travelled from the source.
The source will be intimated about the new route either with the reply packet or the latest route which is created in the cache is sent to the source. These are called intermediate node replies.

If an intermediate node does not have a route through her towards the destination the intermediate node adds her details like the address and no of hops in distance sends this message to the source with a reply packet as a rebroadcasting message. Source adds the received route and delivers any pending data packets when this is received. If there is broken link, a unicast error message packet about the route is prepared and sent back to the source, erasing all the addresses that are contained in the broken link.

2.4. Temporally ordered routing algorithm (TORA)

This algorithm falls under multi-hop adaptive routing. As the algorithm is distributive in nature, the router has to maintain knowledge of the neighbor like other distance vector algorithms this protocol maintains status on a predestination basis. The routing is a combination of reactive and proactive and the source may begin operations in reactive or proactive mode. The routes to servers and gateways are consistently and frequently required. TORA minimizes overhead in communications when the network topology changes [11]. When the topological changes in the network takes place and when all the local routes that are maintained in the cache fails, to identify a new route it maintains multiple paths.

Here height is associated with destination. The metrics used by routers is based on this concept. Like water flow in pipes where the water is first pumped to higher height and from higher height it forwards to lower heights the packets are forwarded as such the packets are associated with corresponding destinations so routers have different heights and links to different destinations .Basing on the flow heights these are called as upstream or downstream. A data flow to destinations can only come into this route via a link is called as an upstream link. A flow of the data go out of this router to the neighbouring router via this link is called as a downstream link.

TORA may not always support the shortest path because of their height assignment. Moreover, TORA is an algorithm which is complex in nature. It has four operations which are

1) Route Creation
2) Routes Maintenance
3) Route Erasing
4) Route Optimization

Route creation phase is accountable for correct heights and creating focused links reaching to the destination. Route maintenance is for changes in network topologies. Route Erasing is for setting heights to NULL and changing to undirected links. In Route Optimization adjusting the height of the routing and to improvement to the routing is done. The different types of packets are Query (QRY), Update (UPD), Clear (CLR) and optimization (OPT) [13]

3. Simulation and analysis method

Network Simulator (NS-2, NS-3) is used for simulating this scenario, the performance metrics that are compared are as follows

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

We have considered Random waypoint mobility model. The same model has to be applied for the individual variations in comparison but it is not possible with the mentioned model to overcome the disorder and to minimize the randomness for each variation. So variation with3, 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
Protocols under study	DSDV,AODV,DSR and TORA
Time for Simulation	150 seconds
Area for Simulation	900 X 700 m
Movement of the model for Nodes	Random Waypoint Model
Speed	2 m/s – 10 m/s
Nature of Traffic	FTP
Pause time for node	No Pause time
Size of Packet	1040 bytes
Bandwidth	2 Mb/s
Packet Rate	2 Mb/s
Node Count	3, 5,10, 20, 30, 40, 50
Number of Source & Destination	1
Type of Connection	TCP
Model for 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 GNU Plot in NS3.

A) Simulation Setup [12]

We have considered the node settings as follows.

Parameters	Value
Node count	3,5,10,20,30,40,50
Maximum Speed	10 m/s
Minimum Speed	2 m/s
Time under simulation	150 s

4. Simulation results

4.1. Comparison based on packet delivery ratio (pdr), end to end delay and routing

Load keeping Pause time constant thereby 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

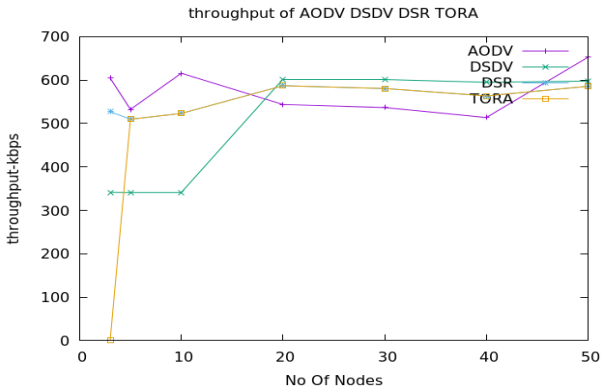


Fig. 4.1: Throughput.

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

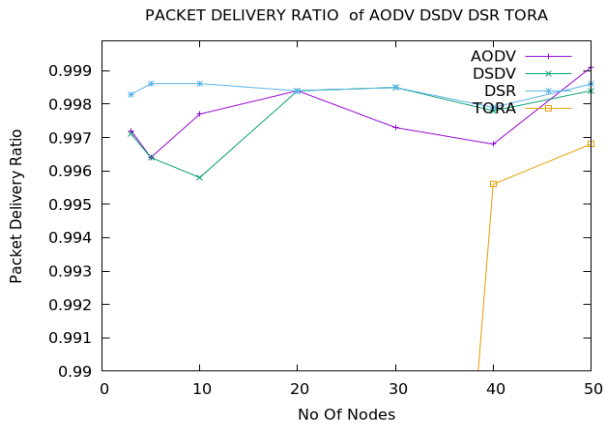


Fig. 4.2: Packet Delivery Ratio (PDR).

Table 4.3: Normalized Route Load (NRL)

Nodes/Routing Proto-col	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

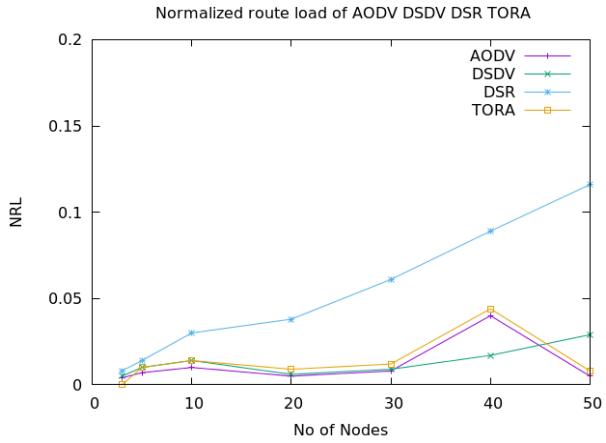


Fig. 4.3: Normalized Route Load (NRL).

Table 4.4: Energy Efficiency

Nodes/Routing Proto-col	3	5	10	20	30	40	50
DSDV	89.667	35.8	17.9	8.15	5.4333	3.475	3.58
AODV	59.667	35.8	17.9	9	6	4.5	3.58
DSR	89.667	53.8	26.6	13.05	8.4	6.33	5.06
TORA	30	54.2	27.1	13.09	8.7	6.33	5.10

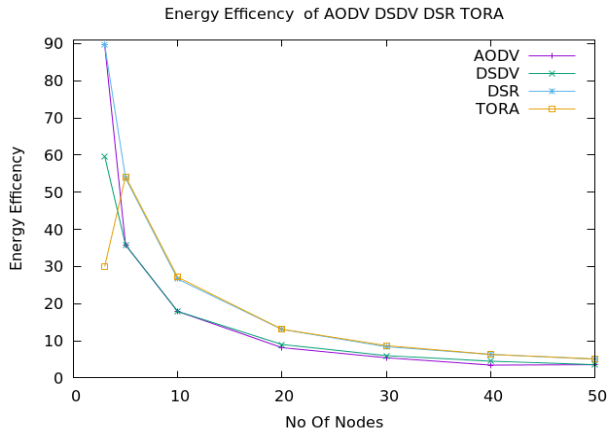


Fig. 4.4: Energy Efficiency.

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

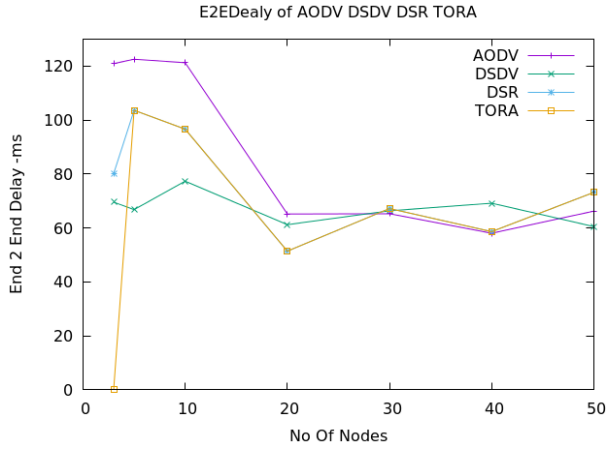


Fig. 4.5: End-To-End Delay.

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

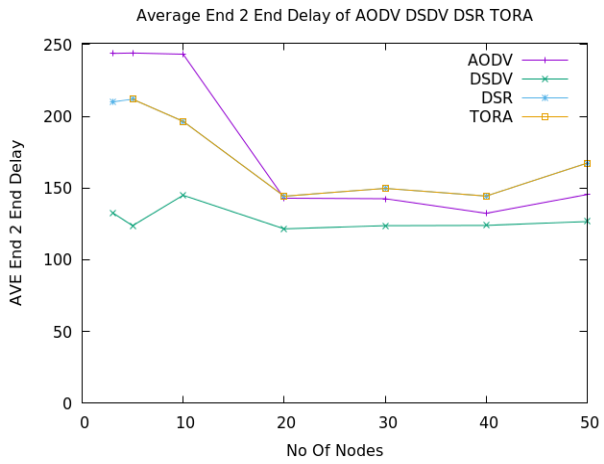


Fig.4.6: Average End-to-End Delay.

5. Conclusion

Here we have considered wireless ad-hoc networks for the analyzation of the routing protocol metrics with different parameters. The considered parameters are estimated with no pause in time and nodes are varied within the specified maximum area. The results projects that AODV performs better in terms of throughput and packet delivery ration. DSR performed better than the rest in NRL. The remaining parameters are proportionately equal for the rest of the protocols. As far as the four protocols are concerned the outcome of the simulation process and the observation of the theoretical analysis are matching with the outcome of the results.

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