Simulation and Comparative Analysis of Single Path and Multipath Routing Protocol for MANET

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Abstract: The basic challenge in MANET is to design robust routing protocol adaptable to frequently changing network topology. On-demand ad hoc routing protocols uses a flooding based route discovery technique to find routes when needed. Since each route discovery incurs high routing overhead and latency, the frequency of such route discoveries must be kept low. On-demand multipath protocols compute multiple paths in a single route discovery to reduce overhead. In this paper, we simulated unipath Ad-hoc On-demand Distance Vector (AODV) routing protocol and On-demand Multi path Distance Vector (AOMDV) routing protocol. AOMDV is efficient when node mobility is high since it provides better statistics for packet delivery and throughput. But if routing overhead is a major concern, then AODV is preferred.

Keywords*-Ad-hoc Networks, AODV, AOMDV, Multipath, MANET*

I. INTRODUCTION

A mobile ad-hoc network consists of mobile nodes moving randomly and communicating with each other in a self organized way for data transmission [1]. The basic issue in routing is efficient delivery of data packets in case of dynamic changing topology and without aid of centralized control. Proactive routing protocols maintain up-to-date routing information of the network topology and changes occurring in network topology are broadcasted through the network but the maintenance of unused paths can occupy a large part of the network bandwidth when topology changes are frequent. In reactive routing protocols, the routes are created on demand reducing the network overhead and load. They also have an inherent limitation of more latency and huge amount of traffic is generated with frequent change in network topology and packets to the destination are lost if any link on established route breaks. Several performance comparisons [2, 3] have shown that on-demand protocols achieve lower routing overhead as compared to proactive protocols. Existing routing protocols like AODV [4], DSDV [5] utilize the single route and dynamic node mobility makes route invalid. This problem can be solved by having multiple paths between source and destination node in a single route discovery. On-demand protocols like DSR [6] and TORA [7] have built-in capability of computing multiple paths but they suffers from other performance problems like stale caches, reply storms [8, 9] and very high overheads [10]. This paper is organized as follows: Section 2 and 3 overviews AODV and AOMDV. Section 4 deals with simulation results and section 5 concludes the paper.

II. AODV

Adhoc on-demand Distance Vector routing protocol [4] uses on-demand route discovery technique to ensure loop free, single path, hop by hop distance vector routing. AODV operates in two sub phases. Route discovery Phase is initiated by a source node not having valid route to a destination node to which it wants to send data. Route maintenance phase for handling dynamic topology in MANET changes as the node moves or when some error persists.

When a node wishes to send data to some destination it floods Route Request (RREQ) messages to all its neighboring nodes. An intermediate node receiving RREQ updates its routing table with reverse route entry to the source node if RREQ is unique. Source id and broadcast id determines uniqueness of a RREQ packet. An intermediate node can further rebroadcasts RREQ to its neighbors or unicasts RREP message back to the source node if it already has unexpired route to that destination in its routing table otherwise destination node replies. In AODV, a node can receive multiple RREP messages for one route discovery message sent but it maintains only one entry per destination in its routing table. An intermediate node always forwards first RREP message received after making entry for forward path towards destination in its routing table and second RREP for a particular RREQ is used for updating table and forwarded only if RREP has higher destination sequence number for the destination or hop count is smaller in case of same destination sequence number otherwise RREPs are suppressed [11]. Higher sequence number ensures fresher route. HELLO messages are exchanged for maintaining neighborhood connectivity.

In Fig 1, source node S initiates route discovery message broadcasting to node A and P. Node I discards duplicate RREQ and furher rebroadcasts RREQ received from A to node B and Q. Destination node D replies to first RREQ received from B and discards duplicate RREQ by Q. So reply is unicasted back to source node and each node maintains single path both in forward and reverse direction. The routing table entry corresponds to fields as shown in Fig 2. AODV uses a timer-based technique to remove stale routes. Each routing entry is associated with a lifetime of a route known as route expiration timeout. This timer is refreshed whenever a route is used.

Destination ID	Sequence Number	Hop count	Lifetime of a route	Next hop

Fig. 2 Routing Table Entry in AODV

Once a route is established between source and destination nodes it is maintained in routing table as long as source needs this route for data transfer and timer does not expires. Whenever a source node moves during active session of data transfer a new route discovery process is initiated and if an intermediate or destination node moves or a link break, RERR message including lists of unreachable destinations along with their sequence numbers is broadcasted back to source node. Each node upon receiving a RERR message from a downstream neighbor and using failed link must invalidate the route and source node re-initiates new route discovery. RERR message is rebroadcasted if at least one destination becomes unreachable.

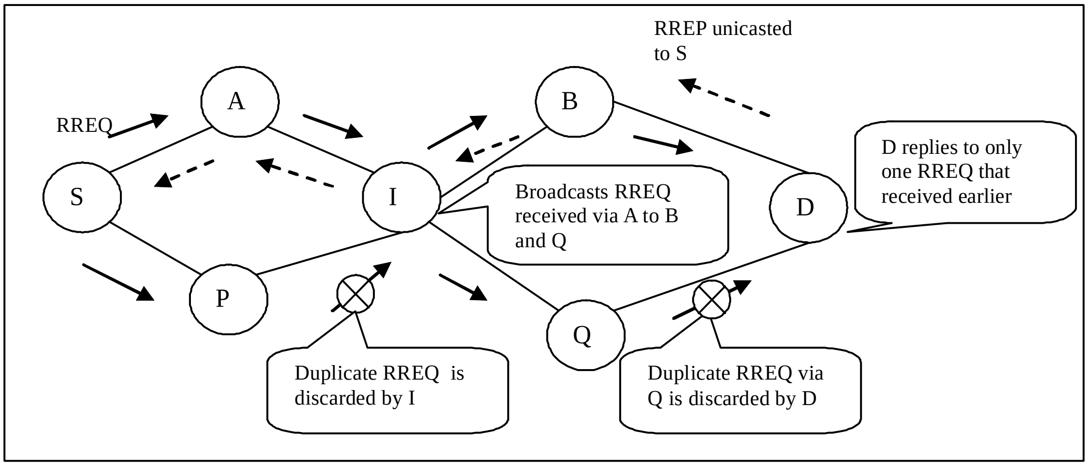

Fig. 1 AODV Route discovery

III. AOMDV

An extension of AODV, AOMDV (Adhoc On Demand Multipath Distance Vector) routing protocol [12] computes multiple loop free and disjoint paths for reducing routing overhead and frequent link failures in case of highly dynamic mobile ad hoc environment. Like AODV, it also initiates route discovery process whenever a node wants to send data but the difference lies in number of routes returned for one RREQ. In AOMDV, multiple reverse paths to the source node are established at intermediate and destination nodes during broadcasting of RREQ. These multiple RREPs traversing through multiple reverse paths results in multiple forward paths to the destination node entered in routing tables of source and intermediate nodes. For each destination, a sequence number, advertised hop count i. e. maximum hop count for all the paths used for sending route advertisement messages for a particular destination and list of next hops along with their corresponding hop count is maintained in routing table as shown in fig.3. Loop freedom is ensured by accepting only those alternate paths to destination having less hop count as compared to advertised hop count for the destination. Node disjoint multiple routes are maintained by applying route update rules which examines duplicate RREQs received from different neighbors of source node without further propagating duplicate RREQs because any two RREQs reaching an intermediate node via distinct neighbors of source node cannot traverse same node. Link disjoint routes are ensured by making destination node reply to RREQs reaching via distinct neighbors and having different first hops.

Destination ID	Sequence Number	Advertised Hop count	Route List			
			Next hop 1	Last hop 1	Hop count 1	Lifetime 1
			Next hop n	Last hop n	Hop count n	Lifetime n

Fig. 3 AOMDV Rouitng Table Entry I

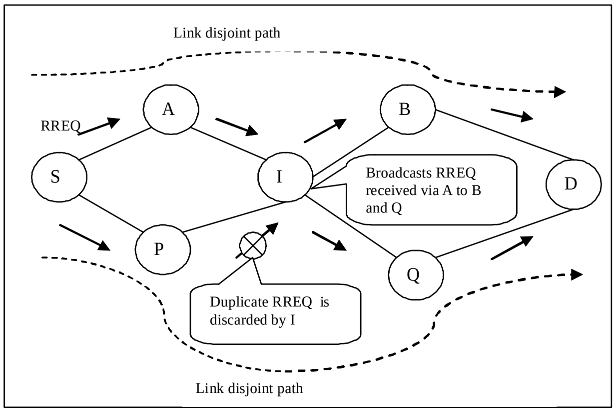

Fig. 4 Link Disjoint Paths in AOMDV

Fig shows link disjoint path computation in AOMDV. RREQ are broadcasted by source node S to A and B. Intermediate Node I receives two copies of same RREQ. It discards duplicate RREQ received from B. Node I further propagated RREQ to B and Q which reaches destination D. I determine that both paths to D via B and Q are link disjoint since X and Y are different neighbors of D. When I advertises these disjoint paths B-D and Q-D to A and P respectively, they also treat these paths as disjoint because last hops B and Q are different. Both are replied by the destination node.

Route maintenance in AOMDV is done using RERR messages. A node generates or forwards a RERR for a destination when the last path to the destination breaks. AOMDV also includes packet salvage mechanism as in DSR that re-forwards the packets forwarded over failed links over alternate paths.

A. Simulation Environment and Results

The simulations were performed on Network Simulator 2. 34 [13] which is a discrete event simulator. Underlying MAC layer protocol used is Distributed Coordination Function of IEEE 802. 11 designed for wireless LANs. Traffic sources used are CBR (Constant Bit Rate) [14] generating source and destination nodes randomly and using UDP (User Datagram Protocol) as an internet protocol. The Random Waypoint Model [15] is used for defining node movement in which each node stops a while for some duration known as pause time before moving to a new location within a simulated area. The simulation parameters used are depicted in Table 1.

Table 1

Different Simulation Parameters

Parameters	**Values**
Routing Protocol	AODV, AOMDV
Simulation Time (sec)	100
Simulation Area	750m X 750m
Simulation Model	TwoRayGround
MAC Type	802. 11
Number of nodes	20
Pause Time (sec)	5
Mobility of nodes (m/s)	5, 10, 20, 30, 50
Packet Size (bytes)	512
Queue Length	50
Data rate	0. 25
Traffic Type	CBR
Link Layer Type	LL
Antenna	Omni Antenna

B. Performance Metrics for Simulation

Performance of a network can be analyzed using analytical modeling, measurement or simulation. In this paper, performance is evaluated using simulation as it provides accurate results and detailed understanding of occurrences of various events.

- Throughput

Throughput signifies data bytes received at the destination nodes in a given period of time [1613].

$$Throughput = \frac{Byte\ received\ X\ 8}{Total\ Simulation\ Times\ X\ 1000} kbps$$

- Packet delivery fraction (PDF)

PDF is the ratio of the data packets delivered successfully to the destination node to those generated by the CBR sources [17].

$$PDF = \frac{Number\ of\ cbr\ packets\ received}{Number\ of\ cbr\ packets\ sent} X\ 100$$

- Normalize Routing Load (NRL)

It is the number of routing packets transmitted per delivery data packets [18].

- Average End-to-end delay

Average End-to-End [19] delay is the average time taken for transmission of data packets from source to corresponding destination. It includes propagation and transfer time of data packets along with other delays like buffering, waiting at the interface queue, retransmission time at the MAC (Medium Access Control). The average end-to-end delay can be calculated by summing the times taken by all received packets divided by their total numbers.

C. Effect of varying speed of nodes on network parameters

Speed of mobile nodes has direct affect on various performance metrics like throughput, NRL, PDF etc. Throughput of a node decreases as speed of a node increases as shown in Fig 5. With low mobility throughput of AODV and AOMDV differs by 7. 75% but as speed increases AOMDV outperforms AODV because of alternate routes available. Decrease in throughput of AODV is 34% and in AOMDV is 17% as speed increases from 5 m/s to 50 m/s.

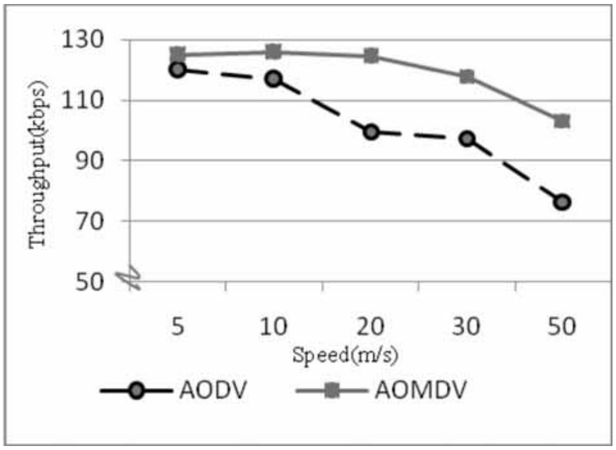

Fig. 5 Throughput vs Speed Graph

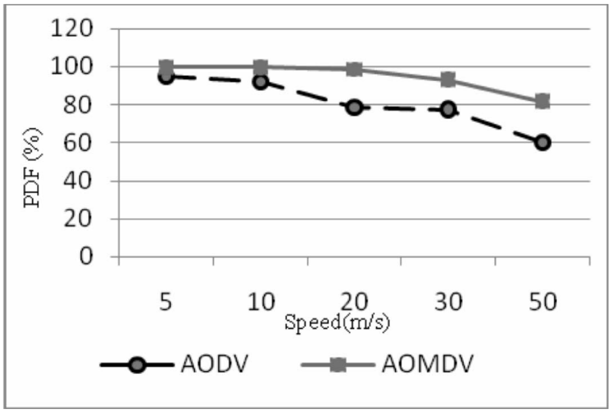

Fig. 6 PDF vs Speed

Fig 6 depicts that AOMDV has better PDF as compared to AODV and PDF for both protocols decreases as speed increases due to congestion in the network. AOMDV being multipath routing protocol ensures better chances of packet delivery through alternate paths if a link fails whereas AODV being unipath drops the data packets if a link fails. With speed upto 10 m/s difference in PDF is less 6%, and it becomes more pronounced 26% at higher speeds i. e. 50 m/s because of frequent link failures occur as mobility of a node increases.

For both AODV and AOMDV NRL increases as speed increases due to frequent link failures as in Fig 7. We can observe that

AOMDV has more routing overhead than AODV approximately 35% more at speed 50 m/s because multiple routes are maintained and more RREPs are exchanged in AOMDV. In AODV as the link breaks packet delivery along that route stops. But AOMDV searches for alternate paths by flooding the network with RREQ packets in case of link failure.

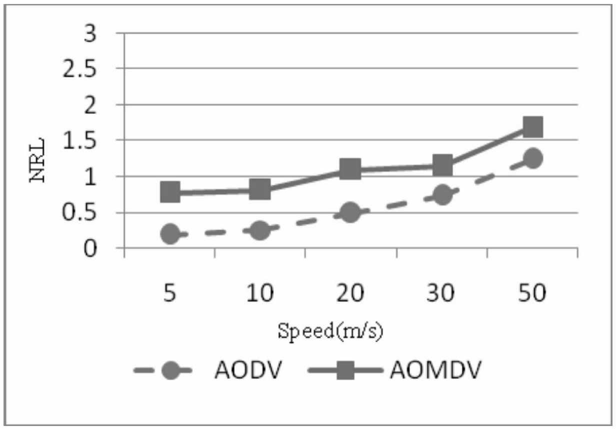

Fig. 7 NRL vs Speed

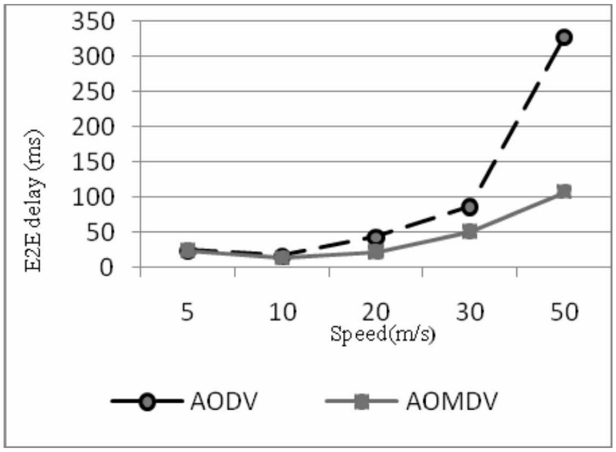

Fig. 8 E2E dealy vs Speed

There is a reduction in the average end-to-end delay with AOMDV as speed increases from 5m/s to 50 m/s as shown in Fig 8. This is because of the availability of alternate routes eliminates route discovery latency is reduced. In AOMDV route failures need not rediscovery of new route always but in case of AODV single path is maintained so it leads to more delay when a route fails. For AODV delay increases from 24 ms to 327 ms with varying speed from 5m/s to 50m/s and for AOMDV from 24. 68 ms to 106 ms.

IV. CONCLUSION AND FUTURE SCOPE

This paper compared the performance of AODV and AOMDV on the basis of packet delivery ratio, routing overhead incurred, average end-to-end delay and throughput. On-demand routing protocols having multipath capability can deal with route failures effectively in mobile ad hoc networks as opposed to single path protocols. We conclude that AOMDV is better than AODV at higher speeds. AOMDV outperforms AODV due to its ability to search and maintain alternate routes to destination nodes when a current link breaks down. Though AOMDV incurs more routing overhead while flooding the network but is much more efficient in terms of throughput and packet delivery fraction. As a future scope AOMDV can be enhanced to compute more disjoint paths and using it for load balancing. It can also be compared to existing multipath protocols and different mobility models.

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