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Delay Reduction Technique for Dynamic MANET On-demand Routing Protocol

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ABSTRACT: Mobile Ad-hoc Network (MANET) is a network whose characteristics include absence of any kind of infrastructure, dynamic topology and limited resources. It consists of a set of wireless mobile nodes communicating with each other without any centralized control in order to communicate it requires multi hop routing. Routing in mobile ad-hoc networks is a key issue which decides network performance. Dynamic MANET On-demand Routing (DYMO) is a reactive protocol that suffers by significant delay variation. This paper proposes a Reduced Delay Dynamic MANET On-demand Routing protocol (RD-DYMO) with faster route discovery then established protocol. Additionally in order to reduce delay variation, short path selection mechanism is suggested which select route with minimum number of hop counts. The QualNet simulator is used to compare performances of both protocols. Simulation results are observed for wireless network scenarios with variation of node mobility, pause time, network area and packet sent rate. The results show the end to end delay in mobile scenarios decrease significantly, without much affecting the other QoS parameters. In addition proposed protocol improved packet delivery.

Keywords: MANET, DYMO, Average end-to-end delay, Packet delivery ratio (PDR).

I. INTRODUCTION

The mobile ad hoc network (MANET) is collection of wireless nodes and fully self autonomous system which communicating with each other via wireless channels, has received a great deal of attention because it can be quickly deployed in many scenarios in the absence of any fixed infrastructure [1]. Since many applications require minimum delay and stable end-to-end connections to guarantee quality of service (QoS) without much worrying about energy consumption, e.g. battlefields, disaster relief search and rescue operation.

In disaster relief rescue operation, the rescuers are moving randomly to the specific area. When a rescuer detects a survivor he sends (multicast) a message to the others. So, anyone available will come and help with the rescue operation. These operations require higher PDR and lower latency because not so many packets will have to be retransmitted due to collisions [2]. While the mobility parameters allow for generating different scenarios, their relationship with the actually generated degree of connectivity dynamics is usually not immediate.

The mobile nodes allowed to communicate directly without any other pre-establish infrastructure of centralized management. If there is not any infrastructure, such as base stations or access points, which are required in conventional data network and cellular system, every node, must have router functionality [3]. Therefore, routing issues are popular research interests in MANET and a number of papers have focused on the development of routing protocols [4], [5], and [6].

In Mobile Ad hoc networking delay is an important quality of service parameter where challenging network environments are considered, either because of variations of node speed, packet sent rate and the lack of infrastructure, or because of temporary disconnection and high latency. In these networks the routing protocol is a cornerstone of communication, making end-to-end message transmission over multiple hops possible. In ad hoc networks, the network dynamics requires the routing protocol in order to react on the changing topology or to search for the destination on-demand [7]. DYMO is one of the recent developments in ad hoc routing, which uses a reactive route discovery. When a packet has to be transmitted, the source floods the network with route requests, and the destination node replies using the reverse path. During this process, a route is established, which is then used for the data transmission. This has direct impact on end to end delay. End-to-End packet delay is measured in terms of the time from when the source node generates a data packet to when the destination node receives it [8].

DYMO provide realizable performance for application states but delay varies significantly for different mobile ad-hoc network parameter variation. So our aim is reducing average end to end delay without much affecting other QoS

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parameters. We are introducing RD-DYMO in order to reduce end to end delay. RD-DYMO combines these three mechanisms for reducing end to end delay:

1. It provides fast ad hoc routing for finding the path between source and destination.
2. Select the short hop count path for faster end to end packet delivery
3. Decrease the wait during the back-off in case any transmission fails.

The rest of this paper is organized as follows; In Section II explains DYMO and RD-DYMO. Section III shows Simulation results and analysis. In last, Section IV concludes the paper.

II. DYMO AND RD-DYMO

In this section we will see overview of DYMO routing protocol and then suggest the RD-DYMO routing protocol which is expected to provide route between source and destination with less delay as well less number of hop count for data packet transmission.

A. DYMO overview

The DYMO routing protocol enables reactive, multi-hop routing between participating nodes that wish to communicate. It is a newly proposed protocol currently defined in an IETF Internet-Draft [9]. DYMO is a successor of Ad hoc On-demand Distance Vector (AODV) routing protocol. It is a simplified combination of the AODV and Dynamic Source Routing protocol (DSR) routing protocols. As is the case with all reactive ad hoc routing protocols, DYMO consists of two operations: *route discovery* and *route maintenance.* Route discovery operation finds path between source and destination and route maintenance operation generate error packet for finding another path when active path is broken. Broadcasting is used to flood the network with the route request. If the destination is discovered, a reply message containing the discovered path is sent back. A routing table with information about nodes is maintained by each node.

B. RD-DYMO

Expanding Ring Search (ERS) used by every reactive routing protocol for route discovery operation. RD-DYMO uses the enhanced ERS for faster route discovery while flooding. In original flooding, the route request (RREQ) message is broadcasted to entire network so every neighbour node will receive and process it. The ERS uses time to live (TTL) mechanism for its operation.

TTL or hop limit is a mechanism that limits the lifespan or lifetime of RREQ in a network. The TTL value determines the maximum nodes that the RREQ can go through. In the initial state of the ERS scheme, the TTL value is set to be N. Thus, the message is broadcasted in a ring with radius of N hops. If the route to destination is not found, N is increased by K, and the message is broadcasted again. This step is repeated until the value of TTL is more than a value named as "threshold". In case, hop number crosses the threshold, value of TTL is set to a "limited value" then the RREQ message is broadcasted to entire network.

Fig.1 shows an example for the ERS route discovery in DYMO. We assume that the source node (S) wants to send a message to the destination node (D). In DYMO it has to find the way to D by using the ERS mechanism. Arrow in different colours are indicating development after each broadcast for different TTL values.

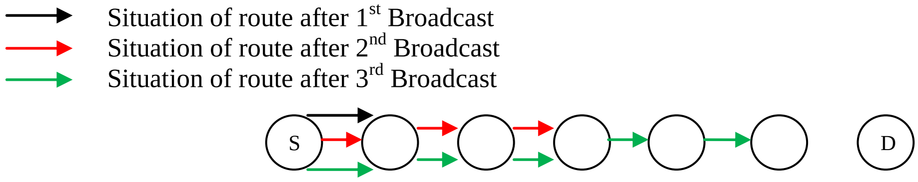

Fig.1: ERS for DYMO

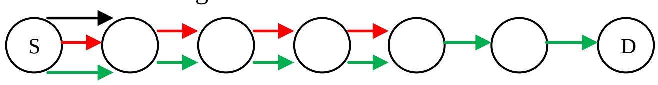

Fig.2: Enhanced ERS for DYMO

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- Initially the node S broadcasts the RREQ message TTL set to be N=1. It means the radius for Ring Search is one-hop. Because the node D is not cover in first attempt of the Ring Search, and there is no nodes in the ring knowing the information about D. Consequently, the route to D is not found.
- Now TTL is increased by increment constant (K = 2). The node S continues broadcasting the RREQ message with radius of ring search of 3. In this case, no way to D is found.
- The source node again increases TTL by 2 and broadcast the RREQ. This time also route to D is not found. DYMO provide 3 retries for RREQ. Finally, TTL is set to a "limited value" and then RREQ message is broadcasted to entire network.

Finally D receives the RREQ message. One's D gets RREQ, It will acknowledge S by sending a RREP message. This reply will sent via same path through RREQ came.

Fig.2 shows the enhanced ERS mechanism for fast route discovery used in proposed protocol. In order to find route in less time, the increment constant is set to 3 (K=3). So ring search covers the more number of nodes in fewer attempts. Now S initiate route discovery with TTL set to be N=1. After broadcast RREQ node wait for RREP for specific value of time called as "wait time". T_C is symbolic represent for wait time. The wait time mechanism uses following two equations in order to calculate wait time.

$$T_c = 1.5 * \text{DYMO NET TRANSVERSAL TIME} \qquad \ldots\ldots (1)$$

$$T_c = 1.5 * \text{PREVIOUS WAIT TIME} \qquad \ldots\ldots (2)$$

Equation (1) is used in proposed protocol to calculate wait time after first time RREQ flooded in network. In a situation of no route found toward D, as indicating by black arrow in Fig.2 within calculated time period, the value for TTL is increases by K and the RREQ is flooded in network. This time wait time is calculated by equation (2) and so for remaining broadcast. Now again there is no way to reach to D, TTL value is increases by K again and wait for RREP. At the third attempt in this example RREQ reached at D. RREP is sent back to S. In this way source node generates a RREQ message every time with incremented TTL value and set $T = t + T_C$. The symbol "t" denotes the real time and T_C is a wait time for that the source node waits before RREQ message rebroadcasting in case no RREP found. If the TTL value is greater than the threshold value, TTL value will be set to limited value and the RREQ message will be broadcasted to entire network.

Short hop count path selection mechanism provides the shortest available path which contributes in faster packet delivery. RD-DYMO utilizes hop count information to reduce the number of nodes participating in packet transmission process by obtains the lowest hop count path to a given destination.

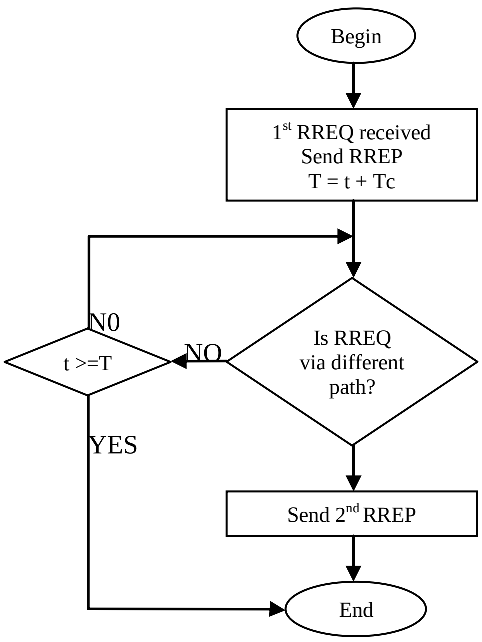

Fig.3: Destination node's algorithm for obtaining another RREP

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In existing protocol one's the first RREQ arrived at destination node, it immediately send back RREP toward source. Target note does not wait for another RREQ which may arrives from different path. In case same RREQ arrives at target node from different path it will be discarded without taking any action. In proposed protocol; after sending back the RREP, target node waits a NODE TRAVERSAL TIME for another RREQ, if target node finds another RREQ via different path instead of discarding; it sends back another RREP towards source. Fig.3 shows destination node's algorithm for obtaining another RREP.

Same waiting mechanism adopted by source node. After getting first RREP source node waits for another RREQ for a NODE TRAVERSAL TIME. In case no RREP it starts forwarding the packet through available route. If another RREP from different path arrive then source extract information from both RREP and obtain number of hop count. The RREQ event handler processes the hop count "hc1" for first RREP and "hc2" for second RREP. At the source these hop values to be compared to select path for transmission with minimum hop in order to reduce end to end delay. Fig.4 illustrate Source node's algorithm for obtaining path with minimum hop.

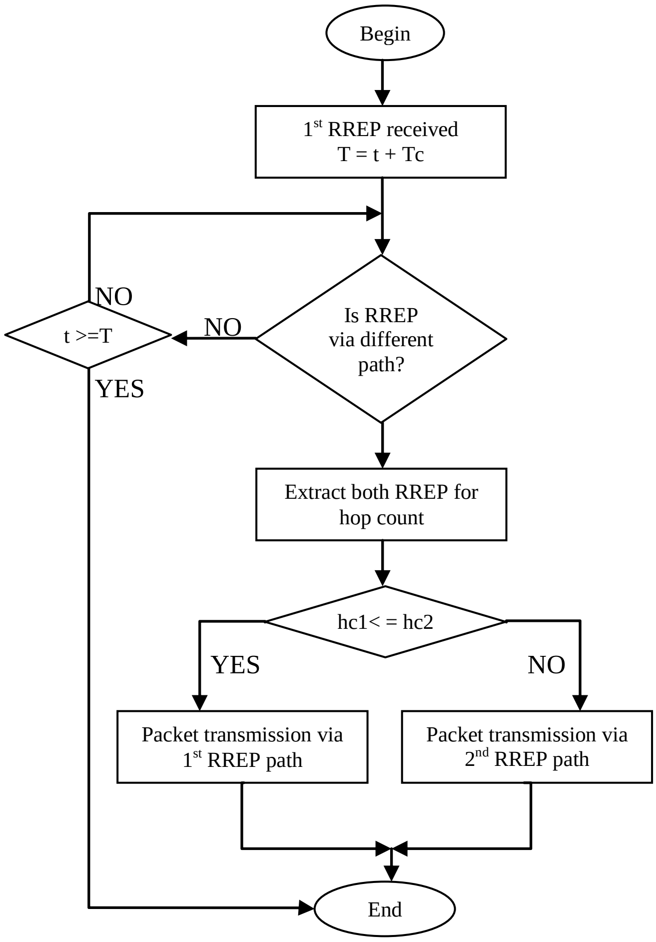

Fig 4: Source node's algorithm for obtaining minimum hop path

III. SIMULATION RESULTS AND EVALUATION

All simulations are run on QualNet Network Simulator. It is a discrete event simulator. This simulator provides a comprehensive environment for designing protocols, creating and animating network scenarios, and analyzing their performance. It is extremely scalable, portable and makes good use of computational resources and models large-scale networks with heavy traffic and mobility, in reasonable simulation times.

Multiple scenarios are examined for protocol's effectiveness in order to reduce end to end delay. The results were based on a simulation setup where a pre-defined number of nodes were placed based on random way point model. We use a linear battery model used for all simulations. The battery is discharged linearly as a function of discharge current load. Traffic is generated using constant bit rate (CBR). The source-destination pairs are chosen randomly over the network.

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The packet size is limited to 512 bytes. Pause time, Simulation area and speed of the mobile node varied to analyse the network performance of DYMO and RD-DYMO. Parameter kept constant while simulations are stated in table I.

TABLE I
PARAMETER SETS FOR SIMULATION

Parameters	**Simulation area**	**Pause time**	**Packet sent rate**
Field size (m^2)	500x500,750x750, 1000x1000, 1250x1250, 1500x1500	1500x1500	1500x1500
Simulation time (s)	300	300	300
Pause time (s)	30	10,20,30,40,50,60,70,80	30
Number of nodes	50	50	50
Speed (m/s)	10	10	10
CBR application	7	7	11
Packet sent rate	1	1	1,2,4,8,16,32
Mac Layer	IEEE 802.11	IEEE 802.11	IEEE 802.11

A. Area variation

Fig.5 shows that with increasing network area delay increases exponentially for DYMO. This is because distance between two nodes goes on increasing with increment in simulation area. For small area network delay is almost same for both protocols. Proposed protocol reduced average end to end delay for network area 1250m x1250m and 1500m x1500m by 30% to 40% with respect to existing protocol. From Fig.6 we observed that higher node density over a given area proves to be better in terms of successful packet delivery. Packet delivery is above 90%.

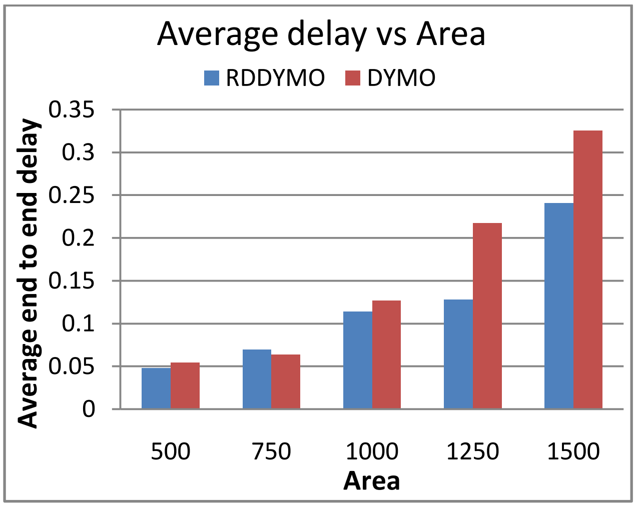

Fig.5: Average end to end delivery Vs area

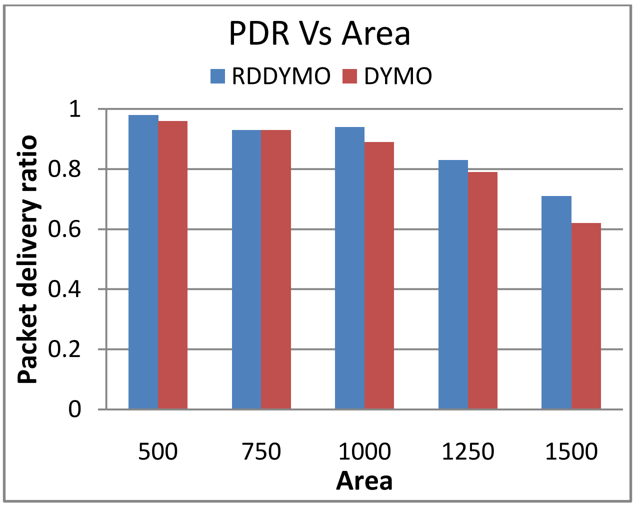

Fig.6: Packet delivery ratio Vs area

Its clear form Table II represents average end to end delay for pause time variations and percent change by which modified protocol reduces delay. Pause time varies from 10 to 80 seconds. RD-DYMO significantly reduces delay for highly dynamic networks. For pause time 30 seconds and 40 seconds delay reduced by less percent. Percent change in delay reduction is moderate when network become static. While RD-DYMO improved other performance parameters, it spends almost same or even less amount of energy.

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TABLE III
AVERAGE END TO END DELAY AND PDR VS. PAUSE TIME

Pause time	Average end to end delay			Packet delivery ratio		
	DYMO	RD-DYMO	% Change	DYMO	RD-DYMO	% Change
10	0.26574	0.18861	-29.02	0.73	0.79	+8.21
20	0.24520	0.17719	-27.73	0.75	0.79	+4.33
30	0.21424	0.20406	-4.74	0.78	0.79	+1.28
40	0.22365	0.20783	-7.07	0.78	0.77	-1.28
50	0.21826	0.18995	-12.96	0.77	0.78	+1.29
60	0.23132	0.19756	-14.59	0.78	0.79	+1.28
70	0.24494	0.21179	-13.53	0.75	0.77	+2.66

B. Packet sent rate

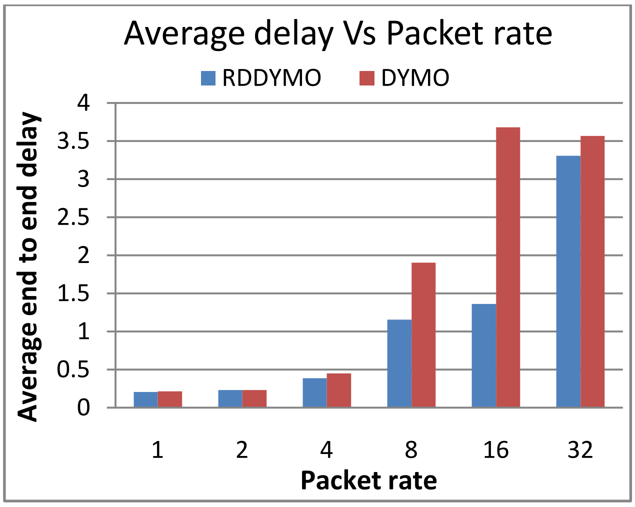

Fig.7: Average end to end delivery Vs packet sent rate

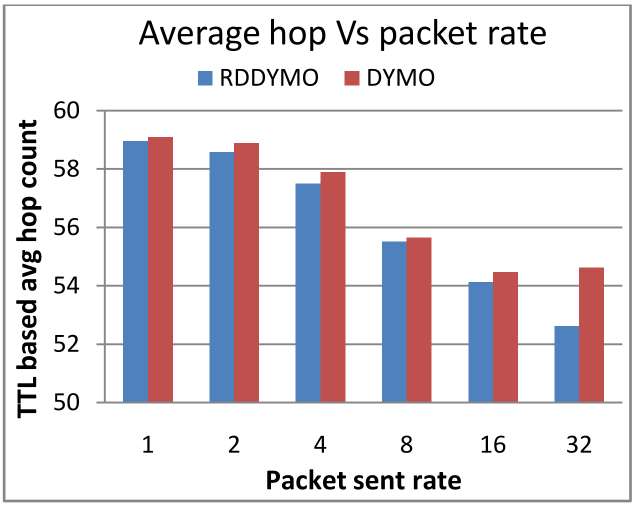

Fig.8: Average hop count Vs packet sent rate

Fig.7 shows effect of traffic load on delay. Clearly delay is very less when data packet sent at low rate. Packet sent rate is taken by 2^N, where N is vary from 0 to 5. Delay for DYMO increases large amount for higher data rate. RD-DYMO reduces 40% to 60% for packet rate 8p/s and 16p/s respectively.

Fig.8 shows that modified protocol successfully reduces the number of intermediate node participated in packet transmission between source and destination. The hop count is gradually decreasing when packet sent rate increase.

IV. CONCLUSION

This paper proposes the RD-DYMO routing protocol for MANETs that effectively reduce the end to end delay during the route discovery using three mechanisms; reducing wait time for RREP, increasing TTL value and selecting path with minimum hop count. It was observed that by using these mechanisms in routing protocol we are able to reduce the end to end delay by 5% to 30%. Revised protocol has successfully reduced delay for dynamic networks also. Hence, RD-DYMO is useful for applications in which nodes are highly mobile. RD-DYMO also improves the packet delivery ratio. There is trade off, while RD-DYMO improve the QoS parameter the total energy consumption is slightly increase but we are successful to keep these variation within 1%. Overall performance by RD-DYMO over DYMO is improved. Thus, RD-DYMO is a good choice as routing protocol for mobile ad-hoc networks for large area networks and low packet sent rate.

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