

# Routing Load Analysis over 802.11 DCF of Reactive Routing Protocols DSR and DYMO

Parma Nand, S.C. Sharma

**Abstract**—The Mobile Ad-hoc Network (MANET) is a collection of self-configuring and rapidly deployed mobile nodes (routers) without any central infrastructure. Routing is one of the potential issues. Many routing protocols are reported but it is difficult to decide which one is best in all scenarios. In this paper on demand routing protocols DSR and DYMO based on IEEE 802.11 DCF MAC protocol are examined and characteristic summary of these routing protocols is presented. Their performance is analyzed and compared on performance measuring metrics throughput, dropped packets due to non availability of routes, duplicate RREQ generated for route discovery and normalized routing load by varying CBR data traffic load using QualNet 5.0.2 network simulator.

**Keywords**—Adhoc networks; wireless networks; CBR; routing protocols; route discovery; simulation; performance evaluation; MAC; IEEE 802.11

## I. INTRODUCTION

THE Mobile Ad-hoc Network (MANET) is a collection of self-configuring mobile node without any infrastructure.

The mobile nodes with wireless radio interface are connected by wireless links where each device in a MANET is free to move independently and randomly with capability of changing its links to other devices frequently. It is a multihop process because of the limited transmission range of energy constrained mobile nodes and thus each device in network topology acts as a router [1]. With dynamic nature of network topology the routes changes very fast and frequent and so the efficient routing protocols plays important roles in handling it. They should be capable to ensure the delivery of packets safely to their destinations. MANETs are also capable of handling topology changes and malfunctions in nodes through network reconfigurations. The mobile adhoc networks are very flexible and suitable for several types of applications, as they allow the establishment of temporary communication without any pre installed infrastructure (figure 1). Beside the disaster and military application domain the deployment of mobile ad-hoc networks for multimedia applications is another interesting area. With newly emerging radio technologies, e.g. IEEE 802.11 DCF [3], the realization of multimedia applications over mobile ad-hoc networks becomes more realistic.

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To find a route between the end-points is a major problem in mobile multi hop ad-hoc dynamic networks. The problem is further aggravated because of the nodes mobility. Many different approaches are reported to handle this problem in recent years, but it is very difficult to decide which one is best routing algorithm. It is also reported in the performance analysis of different routing protocols [4,5,6] in literature. Other aspects of ad-hoc networks are also subject to current research, especially the dynamic changing network topology of nodes.

In this paper the characteristic comparison and performance analysis of DYMO and DSR on-demand routing protocol based on IEEE 802.11 DCF is presented. This paper explores the performance with the parameters metrics data throughput, dropped packets due to non availability of routes, duplicate RREQ generated for route discovery and normalized routing load by varying data traffic CBR (Constant Bit Ratio) load over UDP using Qualnet 5.0.2 simulator [2].

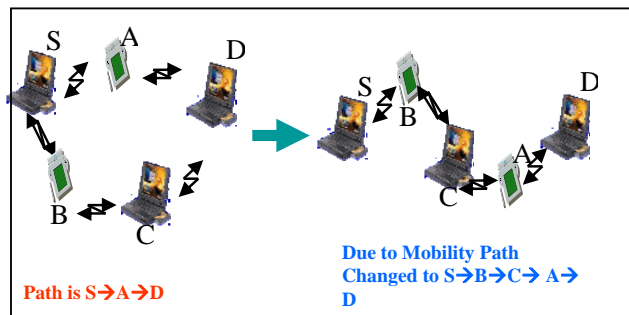


Fig. 1 The dynamic scenario of network topology with mobile nodes

## II. ROUTING PROTOCOLS: CLASSIFICATION IN BRIEF

Routing is the process of finding a path from a source to destination among randomly distributed routers. The broadcasting [7, 8, 9] is inevitable and a common operation in ad-hoc network. It consists of diffusing a message from a source node to all the nodes in the network. Broadcast can be used to diffuse information to the whole network. It is also used for route discovery protocols in ad-hoc networks. The routing protocols are classified as follows on the basis of the way the network information is obtained in these routing protocols.

### A. Proactive (or Table-driven) routing protocol

The proactive protocols maintain routing information about each node in the network. The information is updated throughout the network periodically or when topology

changes. Each node requires to store their routing information.

*For example*

1. Destination sequenced Distance vector routing (DSDV) [10]
2. Source Tree Adaptive Routing (STAR) [11]

#### *B. Reactive or On-demand routing protocol*

The reactive routing protocols look for the routes and are created as and when required. When a source wants to send to a destination, it invokes the route discovery mechanisms to find the path to the destination.

*For example*

1. Ad-Hoc On-demand Distance Vector (AODV) [12]
2. Dynamic Source Routing (DSR) [13, 14]
3. Dynamic MANET On-demand (DYMO) [15]

#### *C. Hybrid Protocols*

These protocols are using the best features of both the on-demand and table driven routing protocols.

*For example*

1. Temporally ordered routing algorithm (TORA) [16]
2. Zone Routing Protocol (ZRP) [17]

These classes of routing protocols are reported but choosing best out of them is very difficult as one may be performing well in one type of scenario the other may work in other type of scenario. In this paper it is observed with the simulation of AODV, DSR and STAR routing protocols. These three protocols are briefly described below. The characteristic summary of these routing protocols is also presented in this paper in table 2.

### III. DYNAMIC SOURCE ROUTING PROTOCOL

The key feature of DSR [13, 14] is the use of source routing. The source (sender) knows the complete hop-by-hop route to the destination. These routes are stored in a route cache. The data packets carry the source route in the packet header. It is an on-demand routing protocol and composed of two parts:

- *Route Discovery*
- *Route Maintenance*

#### *A. Route Discovery*

When a node in the ad hoc network attempts to send a data packet to a destination for which route is not known, it uses a route discovery process to find a route. Route discovery uses simple flooding technique in the network with route request (RREQ) packets. Each node receiving an RREQ rebroadcasts it further, unless it is the destination or it has a route to the destination in its route cache. Such a node replies to the RREQ with a route reply (RREP) packet that is routed back to the original source. RREQ and RREP packets are also source routed. The RREQ builds up the path traversed so far. The RREP routes itself back to the source by traversing this path backward, the route carried back by the RREP packet is cached at the source for future use.

#### *B. Route Maintenance*

The periodic routing updates are sent to all the nodes. If any link on a source route is broken, the source node is notified using a route error (RERR) packet. The source removes any route using this link from its cache. A new route discovery process must be initiated by the source if this route is still needed. Also, any forwarding node caches the source route in a packet it forwards for possible future use. Some of the techniques that are evolved to improve it are:

i) Salvaging: an intermediate node can use an alternate route from its own cache, when a data packet meets failed link on its source route.

ii) Gratuitous route repair: a source node receiving a RERR packet piggybacks the RERR in the following RREQ.

This helps cleaning up the caches of other nodes in the network that may have the failed link in one of the cached source routes.

### IV. DYNAMIC MANET ON-DEMAND (DYMO)

The Dynamic MANET On-demand (DYMO) [15] is a reactive, multihop, unicast routing protocol. The DYMO is a memory concerned routing protocol and stores minimal routing information and so the Control Packets is generated when a node receives the data packet and it doesn't have any valid route information. The basic operations of DYMO are:

- *Route Discovery*
- *Route Maintenance*

#### *A. Route Discovery*

The source router generates Route Request (RREQ) messages and floods them for destination routers for whom it doesn't have route information. Intermediate nodes store a route to the originating router by adding it into its routing table during this dissemination process. The target node after receiving the RREQ responds by sending Route Reply (RREP) message. RREP is sent by unicast technique towards the source. An intermediate node that receives the RREP creates a route to the target and so finally it reaches to originator. Then routes are established between source and destination in both directions.

#### *B. Route Maintenance*

Route maintenance consists of two operations. It avoids expiring good routes and so it updates reverse route lifetime on data reception and forward route lifetime on data transmission. The DYMO nodes monitors link over which traffic is flowing in order to cope up with dynamic network topology. A Route Error (RERR) message is generated when a node receives a data packet for the destination for which route is not known or the route is broken. This RERR notifies other nodes about the link failure. The source node reinitiate route discovery quickly as it receives this RERR. Hello messages are used by all nodes to maintain routes to its neighbor nodes. The sequence numbers are used in DYMO to make it loop

free. These sequence numbers are used by nodes to determine the order of route discovery messages and so avoid propagating stale route information.

The DYMO routing protocol is designed for memory constrained devices in mobile ad hoc networks (MANETs) as it quickly determines route information dynamically.

#### V. SIMULATION SETUP

The Qualnet 5.0.2 [2] network simulator is used for the analysis. The animated simulation is shown in fig. 2. The IEEE 802.11 DCF [3] for wireless is used as the MAC layer protocol. In the scenario UDP (User Datagram Protocol) connection is used and over it data traffic of Constant bit rate (CBR) is applied between source and destination. The 100 nodes are placed uniformly over the region of 1500mx1500m. The mobility model uses the random waypoint model in a rectangular field. The multiple CBR application are applied over 13 different source nodes – 4,53,57,98,100,7,5, 49,10,93,1,92,9) and destinations nodes - 51,91,94,59,60,96, 58,97,100,54,45, 44,38 respectively. The data traffic load is varied as 1,2,4,5 and 10 packets per sec to analyze the performance of AODV, DSR and DYMO routing protocols. The simulations parameters are shown in table I.

Parameter	Value
Area	1500mX1500m
Simulation Time	90,120, 200 sec
Channel Frequency	2.4 Ghz
Data rate	2.Mbps
Path Loss Model	Two Ray Model
Mobility Model	Random-Way Point
Packet size	512 bytes
Physical Layer Radio type	IEEE 802.11b
MAC Protocol	IEEE 802.11 DCF

#### A. Performance Metrics

**Throughput:** Throughput is the average rate of successful data packets received at destination. It is usually measured in bits per second (bit/s or bps), and sometimes in data packets per second.

**Data Packets Dropped for no route:** The data packets are dropped, when route is broken due to mobility or nodes energy is exhausted or congested.

**Duplicate RREQ Packets:** In the route discovery RREQ messages are received by nodes from neighbors more than once because of flooding technique used in it.

**Normalized Routing Load:** It is the number of routing packets per data packets delivered at the destination.

#### VI. RESULT & DISCUSSION

The Qualnet 5.0.2 network simulator [2] is used to analyze the parametric performance of Dynamic Source Routing

(DSR) [13,14] and DYMO [15] routing protocols. The performance is analyzed with different variation of traffic load. In this analysis thirteen different CBR (Constant Bit Rate) traffic applications over the UDP (User Datagram Protocol) connection are generated as described in simulation setup. These are applied on different source to destination nodes. The results are shown in figures from 2 to 5.

**Throughput:** With the varying CBR data traffic the throughput is analyzed. The successful packet delivery in an adhoc network is observed with increasing MAC based CBR traffic load over UDP. It is found that DYMO performs better than DSR. The better performance of DYMO is attributed to its ability to search route quickly as it avoids expiring good route by updating route lifetime appropriately. The performance of DSR is reduced as it doesn't have proper technique to expire stale routes. (Figure 2)

**Packet drops due to no route:** The Packets are dropped when it is not able to find the proper route to deliver the packets or the queue buffer is full. It also happens when the route are broken or congested. It is observed in this analysis that dropped packets are more in case of the DYMO routing protocol because the routes are broken quickly due to mobility of the routers. The DSR uses its cache to find alternative routes to deliver packets. (Figure 3)

**Duplicate RREQ Packets:** In route discovery the simple flooding technique is used and hence the duplicate RREQ messages are received from neighboring node. These duplicate packets are overusing the network channel. The DSR protocol is found to have lesser duplicate RREQ than others because of its salvaging and gratuitous route repair techniques. The DYMO is having more duplicate RREQ as dynamic network causes more routes breaks and hence route discovery. (Figure 4)

**Normalized Routing Load:** The normalized routing load is found to be highest for the DSR protocol as it doesn't have proper techniques to expire stale routes. The DYMO has low as it avoids expiring good routes by updating route lifetime appropriately. (Figure 5)

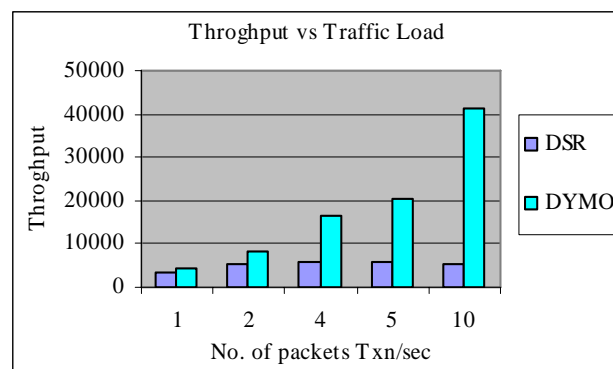


Fig. 2 Throughput Vs Traffic Load

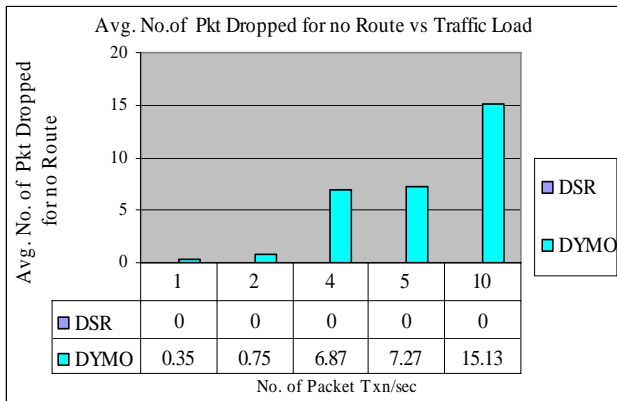


Fig. 3 Avg. no. of Packet dropped for no Route vs Traffic Load

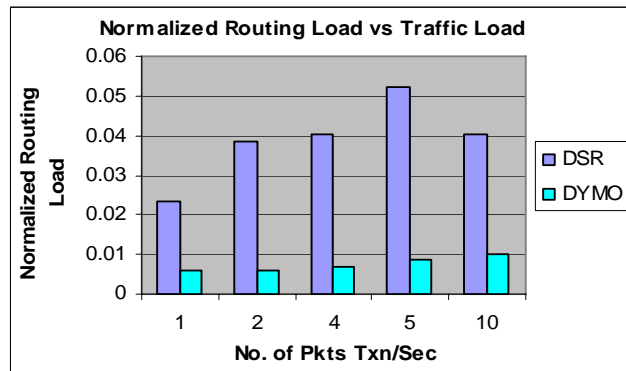


Fig. 5 Normalized Routing Load vs Traffic Load

## VII. CONCLUSION

It is observed the throughput is best in case of the DYMO as it avoids to expire good routes and outperforms both DSR. It also performs better with heavy load. The packet drops are nil in case of DSR because of its alternative route in cache and this also produces less duplicate RREQ packets. The dropped packets due to no routes and error replies are more in case of DYMO as routes breakages are more than DSR due to route dynamics. Hence the reliability of data packets is more with DSR but the normalized load with it more in zeal to find alternative routes.

## REFERENCES

- [1] C.-K. Toh, Ad hoc Mobile Wireless Networks: Protocols and Systems, Prentice Hall PTR, 2002:55-77.
- [2] Qualnet Simulator [www.scalable-networks.com](http://www.scalable-networks.com)
- [3] IEEE, 1997, Wireless LAN Medium Access Control (MAC) and Physical layer (PHY) Specifications, IEEE Std. 802.11.
- [4] N.S. Yadav, and R.P. Yadav, 2007, Performance Comparison and Analysis of Table-Driven and On-Demand Routing Protocols for Mobile Ad-hoc Networks, International Journal of Information Technology, Vol.4, No. 2, pp 101-109.
- [5] A.A. Pirzada, C. McDonald, and A. Datta, 2006, Performance Comparison of Trust-Based Reactive Routing Protocols, IEEE Transactions on Mobile Computing Vol. 5 No.6 pp. 695-710.
- [6] Elizabeth Belding, Royer, Routing approaches in mobile ad hoc networks, in: S. Basagni, M. Conti, S. Giordano, I. Stojmenovic (Eds), Ad Hoc Networking, IEEE Press Wiley, New York, 2003.
- [7] S.Y. Ni, Y.C. Tseng, Y.S. Chen, J.P. Sheu, The broadcast storm problem in a mobile ad hoc network, in: Proceedings of the 1999 Fifth Annual ACM/IEEE International Conference on Mobile Computing and Networking, IEEE Computer Society, New York, pp. 151-162, August 1999.

TABLE II CHARACTERISTIC SUMMARIES OF DSR AND DYMO ROUTING PROTOCOLS		
Protocol	Dynamic Source Routing (DSR) [13,14]	Dynamic MANET on demand (DYMO) routing protocol. (DYMO) [15]
Authors	Josh Broch, David Johnson, and David Maltz	Ian D. Chakeres and Charles E. Perkins
Category	Reactive	Reactive
Metrics	Shortest path, next available	Shortest path
Route Recovery	New route, notify source	Local repair
Route repository	Route cache	Routing table
Broadcasting	Simple	Simple
Multiple paths	Yes	No
Loop freedom maintenance	Source route	sequence numbers
Communication Overhead	High	High
Feature	Completely on demand	Only keeps track of next hop in route

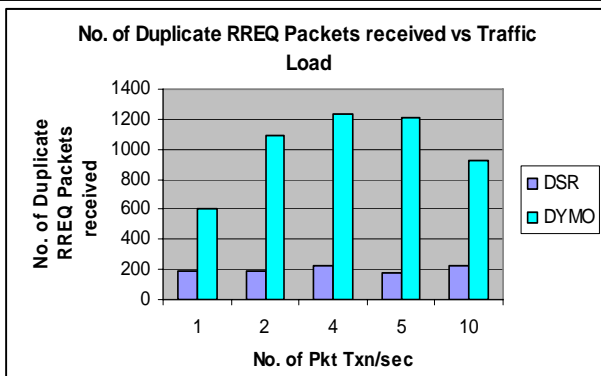


Fig. 4 Avg. no. of Error Reply Packet received vs Traffic Load

- [8] Qi Zhang , Dharma P. Agrawal, Dynamic probabilistic broadcasting in MANETs, *Journal of Parallel and Distributed Computing* 65(2), pp 220-233, February 2005.
- [9] B. Williams, T. Camp, Comparison of broadcasting techniques for mobile ad hoc networks, in: *Proceedings of the ACM International Symposium on Mobile Ad Hoc Networking and Computing (MOBIHOC 2002)*, pp. 194–205, 2002.
- [10] Perkins C, Bhagwat P, “Highly Dynamic Destination-Sequenced Distance-Vector Routing(DSDV) Routing”,*SIGCOMM’94 Computer Communication Review*, vol 24, no. 4,p 234-244, October 1994.
- [11] J.J. Garcia-Luna-Aceves, M. Spohn, “Source-Tree Adaptive Routing in Wireless Networks”, *Proceedings of the 7th Annual IEEE international conference on Network Protocols*, Toronto, Canada, October 31-November 3, 1999. <http://www.ieee-icnp.org/1999/papers/1999-29.pdf>.
- [12] Charles Perkins, Elizabeth Royer, and Samir Das. “Ad hoc on demand distance vector (AODV) routing”. IETF RFC No. 3561, July 2003.
- [13] Josh Broch, David Johnson, and David Maltz. “The dynamic source routing protocol for mobile adhoc networks for IPv4 IETF RFC 4728, Feb 2007.
- [14] D. Johnson and D. Maltz. “Dynamic source routing in ad hoc wireless networks”. In T. Imielinski and H. Korth, editors, *Mobile computing*, chapter 5. Kluwer Academic, 1996.
- [15] Ian D. Chakeres and Charles E. Perkins. *Dynamic MANET on demand (DYMO) routing protocol. Internet- Draft Version 06*, IETF, October 2006.
- [16] V. Park, and S. Corson, “Temporally-Ordered Routing Algorithm (TORA) Version 1 Functional Specification”, draft-ietf-manet-tora-spec-04.txt, July 2001.
- [17] Zygmunt J. Haas, Marc R. Pearlman, and Prince Samar, “The Zone Routing Protocol (ZRP) for Ad Hoc Networks”, draft-ietf-manet-zone-zrp-04.txt, July, 2002.