Performance Evaluation of Hybrid Multipath Progressive Routing Protocol for MANETs

Jay Kumar Jain
Research Scholar
Department of Computer Applications
MANIT Bhopal, INDIA

Sanjay Sharma
Professor
Department of Computer Applications
MANIT, Bhopal, INDIA

ABSTRACT
Researchers has been developed various routing protocols for Mobile Ad-hoc Networks (MANETs). Each protocol proposed and designed so far has its own merits and demerits. Researchers are trying continuously to develop advance routing protocols that can route messages towards their destination in an efficient way while consuming minimum amount of bandwidth and battery. In this work we are considering two well known MANET routing protocols, (1) Ad-hoc On-demand Distance Vector routing protocol, (2) Optimized Link State Routing protocol, and we have combined their preferred properties to formulate a new Hybrid routing protocol. In this paper we have proposed a routing protocol in hybrid category with the target of increasing the packet delivery ratio (PDR), throughput and decreasing end-to-end delay. Our extensive simulation based experimental studies shows that the performance of proposed Hybrid Multipath Progressive Routing Protocol is better than the AODV, OLSR and ZRP on above and many other parameters. We have simulated the results on Exata Cyber 1.1.

Keywords
HMPRP, AODV, Exata Cyber 1.1, MANETs

1. INTRODUCTION
Mobile Ad hoc Networks (MANETs) are a collection wireless mobile nodes that can freely and dynamically self-organize in to arbitrary and form temporary network topologies. An Ad Hoc network consists of mobile nodes without any base stations. It can be deployed quickly without infrastructure support. Because of node mobility and power limitation, routes are mainly muItihop in Ad Hoc network and routing protocols play crucial role in it [16]. Many routing protocols such as the AODV [1], Optimized Link State Routing (OLSR) [2] and Zone Routing protocol (ZRP) [3] have been developed by many researchers.

MANETs might operate autonomously or may be used to expand the present Web. In smaller areas collaborative computing and communications (Personal Area Network, conferences, Commercial sector etc) can be set up using MANETS.

In recent years, good forms of routing protocols are developed for MANETs. These protocols are usually classified into two categories: (i) Reactive (source driven) and (ii) Proactive (table driven) protocols. Reactive Routing Protocols (RRP) like AODV and DSR only creates a route between a couple of source and destination nodes when the source node really needs to send packets to the destination. Whereas these protocols can avoid network wide topology information flooding, they are usually subject to long latencies. In contrast, Proactive Routing Protocols (PRP) DSDV [4] and OLSR attempt at maintaining consistent and up-to-date routing information in every node by propagating updates throughout the network. Although a route to each other node is always available, such protocols introduce a major bandwidth overhead due to the broadcast nature of exchanging routing information over wireless media [6].

Mobile ad hoc networks (MANETs) are characterized by a limited channel bandwidth, dynamic topology and limited battery power at the nodes. Due to these characteristics, paths connecting source nodes with destinations may be very unstable and go down at any piece of time, making communication over the ad hoc networks extremely difficult. On the other side, since all nodes in an ad hoc network may be connected dynamically in an arbitrary manner, it is generally possible to establish more than one path between a source and a destination. When this feature of ad hoc networks is used in the routing process, it is called multipath routing.

In most of cases the ability of creating multipath routing from a source to a destination is used to provide a backup route. Whenever the primary route fails to deliver the packets in some way, the backup route is used. It provides a better fault tolerance in the sense of faster and efficient recovery from route failures. Multiple routes can also provide load balancing and route failure protection by distributing traffic between a set of disjoint paths. In the case of node-disjoints paths do not have any nodes in common, except the source and destination node hence do not have any links in common. Node-disjoint multipath routing allows the establishment of multiple routes, each consisting of a unique set of nodes between a source and destination. We know that MANETs consist of mobile nodes that cause faster link failures. This link failure due to cause two main reasons: (i) when a route breakage occurs, all packets that have already been transmitted on that particular route are dropped and therefore average PDR and throughput decreases; (ii) the transmission of data traffic is suspended for the time being till a new route is discovered and further it increases the average end-to-end delay [7].

In this paper the contents are organized as follows: AODV is described in section 2, our proposed algorithm and analysis are described in section 3, while section 4 describes simulations and corresponding results. The conclusion and future work are explained in section 5.

2. AD-HOC ON-DEMAND DISTANCE VECTOR ROUTING PROTOCOL (AODV)

The Ad-hoc On-Demand Distance Vector outing Protocol (AODV), is one of more trustable common routing algorithm in ad hoc networks and is depend on the principle of routes discovery as needed. AODV is a reactive algorithm that has some capabilities such as; low network utilization, low processing, memory overhead, and it perform well even in high mobility. AODV routing algorithm is a prominent method for building routes between network nodes. The request is formed on-demand rather than in advance. The routing table stores information concerning next hop to the destination and a sequence number which is received from destination and indicates the freshness of the received information. Basically, the neighbors could be notified when the corresponding route are broken. In AODV routing algorithm, the source node distributes a route request packet at the time when a path is needed to the destination node.

The source node initiates path discovery by broadcasting a route request (RREQ) packet to its neighbors. The RREQ has following fields: Source address, Source sequence number, Broadcast_id, Destination address, Destination sequence number, Hop count.

When intermediate nodes receive a route request packet, they update their routing tables for a reverse route to the source and like this process, when the intermediate nodes receive route reply packet (RREP), they update the forward route to the destination. The route reply packet contains the following fields: Source address, Destination address, Destination sequence number, Hop count, Life_time.

AODV protocol uses sequence numbers to determine the timeliness of each packet and to prevent creation of loops. AODV algorithm uses Route Error Message (RERR) route failures and link failures propagated by a RERR from a broken link to the source node of the corresponding route. When the next hop link breaks, RERR packets are sent by the starting node of the link to a set of neighboring nodes that communicate over the broken link with the destination [1].

3. RELATED WORK

Many research papers have been published on the subject of multi-path routing in ad hoc networks out of them some paper discussed below.

Thabotharan Kathiravelu, Sivamayam Sivasuthan [8], in 2011 take two well known MANET routing protocols, namely, the Ad-hoc On-demand Distance Vector routing protocol and the Epidemic routing protocol, and combine their preferred properties to form a new Hybrid protocol. they choose the AODV [1] and the Epidemic [9] routing protocols and selectively chooses their preferred properties, combine them and then formulate a new Hybrid protocol which can withstand the drawbacks commonly found in these two protocols when they are applied individually. Extensive simulation studies show that their newly proposed combined protocol outperforms the other two protocols in the considered test cases in terms of message delivery ratio, average message delay and the message loss ratio.

A node disjoint multipath routing protocol based on AODV was proposed in the paper in 2010 by Shunli Ding, Liping Liu [10]. The main goal is to discover multiple node-disjoint paths with a low routing overhead during a route discovery. They also pay attention to rest energy of nodes.

P. M. Jawandhiya, R. S. Mangrulkar and Mohmmad atique [11] in 2010 proposed a hybrid routing protocol with Broadcast Reply (HRP-BR) which combines the merits of both proactive and reactive approach. Like proactive approach, it maintains routing table at every node. However, it differs from proactive approach; that the routing table is not built prior to communication. Routing table is built in incremental steps during route discovery. Route discovery takes place like reactive approach only on demand. HRP-BR takes advantage of broadcast nature in MANET for route discovery and store maximum information in the routing tables at each node. Broadcast natures avoid handshaking of RTS and CTS and effectively utilize trans-receiver antennas which reduce power consumption and effectively utilize bandwidth. HRP-BR is compared with existing AODV routing protocol which shows significant reduction in routing overhead, end-to-end delay and increases packet delivery ratio.

Mamoun Hussein Mamoun [12] in 2011 proposed a new hybrid routing protocol for MANET called Location Aided Hybrid Routing Protocol for MANET (LAHRP). The proposed routing algorithm not only aims to optimize bandwidth usage of MANETs by reducing the routing overload but also extend battery life of the mobile devices by reducing the required number of operations for route determination. Although in the LAHRP, some features of both table- driven and on-demand algorithms were used to achieve these goals at some stages, LAHRP algorithm is a completely different approach in terms of position information usage and GPS.

4. THE PROPOSED ROUTING ALGORITHM AND ANALYSIS

As we have seen, proactive routing uses excess bandwidth to maintain routing information, while reactive routing involves long route request delays. Reactive routing also inefficiently floods the entire network for route determination. The HMPRP aims to address the problems by combining the best properties of both approaches. HMPRP can be classified as a hybrid reactive/proactive routing protocol.

The proposed routing algorithm that we have introduced is named Hybrid Multipath Progressive Routing Protocol (HMPRP) [16].

5. PERFORMANCE EVALUATION OF HMPRP

In order to evaluate the performance of the proposed routing algorithm (HMPRP) [16] in most of conditions, the set of experiments are done by using Exata Cyber simulator and the results are collected. Also, to emphasize the benefits of our algorithm, we compare the results with standard AODV, OLSR, ZRP routing algorithms which are obtained with the Exata Cyber simulator. Duration of all simulations is assumed 100 seconds. In this paper we focus on Constant Bit Rate (CBR) sources. Nodes mobility model is random and no node is added or is eliminated during the simulation. The final results between parameters of choice, after simulation it is presented in the form of metrics and graphs.

6. PROTOCOL SIMULATIONS

Simulator EXata CYBER 1.1 is used to create a simulation environment to develop and analyze the newly developed HMPRP protocol and compare its performance with the already existing ad hoc routing protocol AODV, ZRP and OLSR.

The random waypoint model is used to model mobility of nodes. This model was first used by Johnson and Maltz in the evaluation of DSR, and was later refined by the same research group.

We use 150 moving nodes in an area with size of 1500m*1500m. The node maximum speed is 10 m/s, transmit range of each node is 100 meters and the pause time is 30 seconds. Node uses the IEEE 802.11 defined physical layer media and 802.15 and 802.16 as and where required. Simulations are run for 100 simulated seconds. Traffic sources with 512 bytes data packets are CBR (constant bit rate). The source-destination pairs are spread randomly over the network and the number of sources is varied to change the offered load in the network. The sending rate is set to 1 packet per second. Total number of application in each model is 5, 10, 15, 20, 25, and 30 respectively. The position of the nodes is arranged according to the random waypoint model. The antenna used is omni directional.

7. PERFORMANCE METICES

7.1 Throughput

This is the parameter related to the channel capacity. The throughput is defined as the total amount of data a receiver receives from the sender divided by the time it takes for the receiver to get the last packet. The throughput is usually measured in bits per second (bit/s or bps) [15].

7.2 End-to-end delay

It represents the average value of the time that the received data packets take to reach the destination from their origin. This parameter includes the mean time (in seconds) taken by the data packets to reach their destinations. Delays due to route discovery, link repair, multihop forwarding, queuing and retransmissions and so on are included in the delay metric [13].

7.3 Packet delivery ratio

The packet Delivery Fraction is obtained by dividing the total number of the received data packets by the destinations by the total number of data packets originated by the sources and is obtained as follow [14].

Packet Delivery Ratio= Number of Packets Delivered/Number of Packets sent*100

Packet delivery ratio is defined as the total amount of data received divided by the total amount of data transmitted during the simulation.

8. EXPERIMENTS AND RESULTS

The EXata CYBER 1.1 Emulator has been used to analyze the parametric performance of Hybrid Multipath Progressive Routing Protocol (HMPRP), Ad-hoc On-demand Distance Vector Routing Protocol (AODV), OLSR and Zone Routing Protocol (ZRP). Simulations are run for 100 simulated seconds. Traffic sources with 512 bytes data packets are CBR (constant bit rate). The metric based analysis is shown in figure 2 to figure 4. We have done simulation 150 nodes using 5, 10, 15, 20, 25 and 30 CBR applications.

8.1 Throughput

The throughput is analyzed with varying CBR data traffic. According to our simulation results better performance is shown by HMPRP at all cases as shown in the figure 1. Throughput of ZRP is highly decreasing in all the cases but HMPRP outperforms all other protocols.

Table 1. Throughput

	5 CBR	10 CBR	15 CBR	20 CBR	25 CBR	30 CBR
HMPRP	3914.4	3579.6	3360.6	3483.65	3261.32	2991.57
AODV	3542	3376.6	3283.47	3225.8	2987.04	2815.5
OLSR	2611.2	2324.1	2051.87	2273.1	2214.28	2103.2
ZRP	1118.2	1110.3	1002.5	1129.3	918.091	990.269

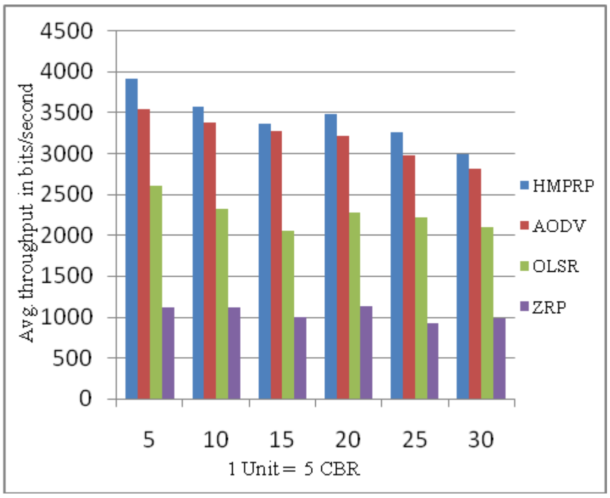

Fig 1: Throughput Vs No. of CBR

8.2 End-to-End Delay

Average end-to-end delay is the delay experienced by the successfully delivered packets in reaching their destinations. This is a good metric for comparing protocols and denotes how efficient the underlying routing algorithm is, because delay primarily depends on optimality of path chosen.

In figure 2 we see that the average packet delay increases with number of CBR while routing protocols try to find valid route to the destination. Besides the actual delivery of data packets, the delay time is also affected by route discovery, which is the first step to begin a communication session .In this analysis it is observed as expected the delays are more for ZRP in comparison to HMPRP and AODV. Delays are incurred by ZRP'S IARP and IERP methods. The end-to-end delay of HMPRP is also less than to AODV and OLSR because it has reduced routing overhead and queuing delay whereas OLSR are proactive protocol it has already routing table.

Table 2. Avg. End-to-end Delay

	5 CBR	10 CBR	15 CBR	20 CBR	25 CBR	30 CBR
HMPRP	0.061951	0.138695	0.183071	0.201614	0.25076	0.288552
AODV	0.077122	0.165678	0.233979	0.270202	0.345636	0.451073
OLSR	0.106056	0.176691	0.23152	0.255126	0.301822	0.374468

ZRP	0.263781	1.63349	3.15431	4.0188	6.47597	10.0905

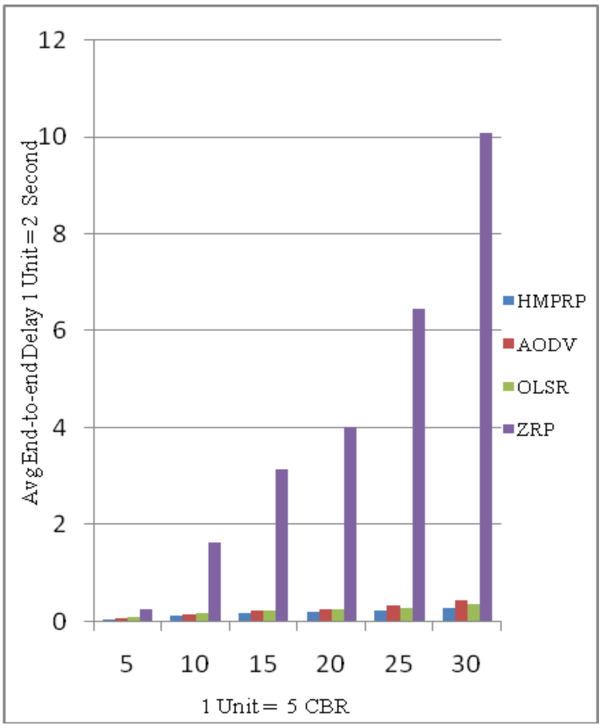

Fig 2: Avg. End-to-End Delay Vs No. of CBR

8.3 Packet Delivery Ratio

The fraction of successfully received packets, which is survive while finding their destination. This performance measure also determines the completeness and correctness of the routing protocol.

Table 3 and figure 3 shows the results with 5, 10, 15, 20, 25 and 30 CBR and 150 nodes respectively. HMPRP shows high increase in its delivery ratio with increasing load as shown in the figure 3 and it is also performing better than AODV, OLSR and ZRP. For highly active networks AODV, OLSR and ZRP have variable PDR but HMPRP maintain consistency with increase network size. There is a good improvement in PDR for HMPRP due to hybrid nature.

Table 3. Packet Delivery Ratio

	5 CBR	10 CBR	15 CBR	20 CBR	25 CBR	30 CBR
HMPRP	94.747	86.666	81.279	84.242	78.424	71.818
AODV	85.656	81.919	78.855	77.929	70.505	65.723
OLSR	60	53.131	46.532	51.313	49.131	46.532
ZRP	26.666	24.848	20.779	22.626	16.299	13.636

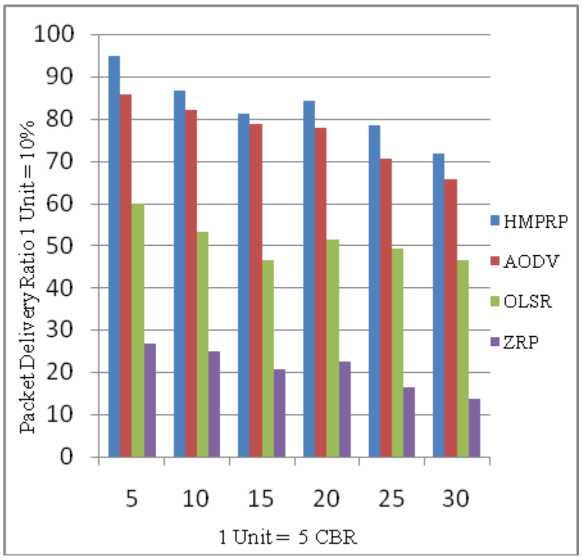

Fig 3: Packet Delivery Ratio Vs No. of CBR

9. CONCLUSION

This paper presented a new HMPRP protocol for mobile ad hoc networks depend on received signal strength with the modification of AODV routing protocol and OLSR protocol. We evaluate the performance of HMPRP with three different routing protocols (AODV, OLSR, and ZRP) for mobile Ad-hoc networks. Different kinds of protocols are included in this comparison, as we have on demand, table driven and hybrid routing. We have done comparison on the basis of varying CBR. The result obtained on the basis of three performance metrics are average end to end delay; average throughput and packet delivery ratio. HMPRP shows best results in measuring end to end delay, throughput and packet delivery ratio. HMPRP delivers almost 90 percent of transmitting packets while AODV delivers approximately 85 percent in all cases and end-to-end delay of HMPRP is very less compare to other three protocols in all cases.

10. REFERENCES

[1] C.Perkins and E.Belding-Royer, "Ad hoc On-Demand Distance Vector (AODV) Routing" Internet Engineering Task Force, RFC3561, July 2003.

[2] P. Jacquet, P. Muhlethaler, and A. Qayyum, "Optimized Link State Routing Protocol", IETF Internet Draft, draft-ietf-manet-olsr-10.txt, (June 2002).

[3] Z. Haas and M. Pearlman, "The zone routing protocol (ZRP) for Ad Hoc networks", IETF Internet Draft, draft-ietf-manet-zone-zrp-04.txt, (July 2002).

[4] C. E. PERKINS and P. BHAGWAT, “Highly Dynamic Destination- Sequenced Distance Vector (DSDV) for Mobile Computers,” in Proc.ACM SIGCOMM, Aug. 1994.

[5] RFC 5614, Aug. 2009.Ashwani Kush, Phalguni Gupta and C.Jinshong Hwang “A Hybrid Stable Routing Protocol for Mobile Ad Hoc Networks” Global Mobile Congress 2009 12-14 Oct. 2009.

[6] Xiaolong Li Homayoun Yousefi'zadeh "A Hybrid Cross-Layer Routing Protocol for MANETs", Computer Communications and Networks (ICCCN), 2011 Proceedings of 20th International Conference on july 31 2011-Aug. 4 2011

[7] Chhagan Lal ,V.Laxmi and M.S.Gaur "A Node-Disjoint Multipath Routing Method based on AODV protocol for MANETs", 2012 26th IEEE International Conference on Advanced Information Networking and Applications.

[8] Thabotharan Kathiravelu, Sivamayam Sivasuthan, "A Hybrid Reactive Routing Protocol for Mobile Ad-hoc Networks" 2011 6th International Conference on Industrial and Information Systems, ICIIS 2011, Aug. 16-19, 2011, Sri Lanka.

[9] A. Vahdad and D. Becker, Epidemic routing for partially connected ad hoc networks," Duke University, Tech. Rep., April 2000.

[10] Shunli Ding and Liping Liu "A node-disjoint multipath routing protocol based on AODV", 2010 Ninth International Symposium on Distributed Computing and Applications to Business, Engineering and Science.

[11] P.M. Jawandhiya, R.S. Mangrulkar, Mohammad Atique and M. S. Ali, " A Novel Hybrid Routing Protocol for Mobile Adhoc Network", International Journal of Advancements in Technology http://ijict.org/ , Vol 1, No 2 (October 2010), pp 185-196.

[12] Mamoun Hussein Mamoun "Location Aided Hybrid Routing Algorithm for MANET", International Journal of Engineering & Technology IJET-IJENS Vol: 11 No: 01.

[13] Jorjeta G.Jetcheva and David B. Johson, "A Performance Comparison of On-Demand Multicast Routing Protocols for Ad Hoc Networks," school of computer science, computer science department, Pittsburgh, December 15, 2004.

[14] David Oliver Jorg, "Performance Comparison of MANET Routing Protocols In Different Network Sizes", Computer Science Project, Institute of Computer Science and Applied Mathematics, Computer Networks and Distributed Systems (RVS), University of Berne, Switzerland, 2003.

[15] U. T. Nguyen and X. Xiong, "Rate-adaptive Multicast in Mobile Adhoc Networks," IEEE International Conference on Ad hocand Mobile Computing, Networking and Communications 2005 (WiMob 2005), Monreal, Canada, August 2005.

[16] Jay kumar Jain and Sanjay Sharma "Performance Improvement of AODV Protocol using Hybrid Analysis for MANETs", Journal of Engineering, Science & Management Education, NITTR, Bhopal Vol. 6, Issue II, June 2013.