Performance Analysis of AOMDV and AODV Routing Protocol in MANET

Preeti Gupta, Suman Pandey
Department of Computer Science and Engineering
KNIT, Sultanpur, Uttar Pradesh, India

Abstract: A Mobile Ad-hoc Network (MANET) is a dynamic wireless network that can be formed without the need for any pre-existing infrastructure in which each node can act as a router. A variety of routing protocols have been proposed and several of them have been extensively simulated or implemented as well. In this paper, we evaluate the performance Adhoc On demand Multipath Distance Vector (AOMDV) routing protocol with respect to Adhoc On demand Distance Vector (AODV). Also, we note that on evaluating the performance of AODV and AOMDV, AOMDV incurs more throughputs, less packet loss than AODV. It also has less route failure when mobility is high.

Keywords: Mobile ad hoc networks, Multihop wireless networks, on-demand routing, Multipath Routing, alternate path routing, Distance vector routing, Disjoint paths

I.   INTRODUCTION

Mobile Ad-hoc network (MANET) is a collection of mobile nodes which shares wireless channel without any centralized control. There is no fixed router. Any node can act as router. The mobile node can be a router and end system as well. In Figure1, five nodes are connected through the wireless channel without any centralized control.
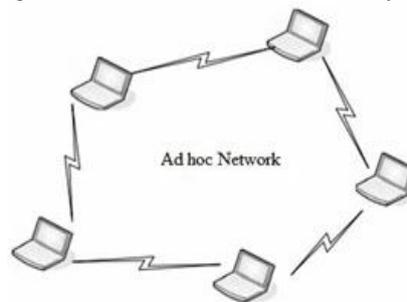

Figure 1

It has uncontrolled mobility, limited bandwidth to share among wireless channel and limited battery power. Due to these limitations MANET requires an efficient routing protocol that has less overhead.

On-demand routing protocols are source-initiated route discovery process. Whenever a source needs a route, it initiates a route discovery process by sending a route request for the destination and waits for a route reply. Every route discovery process insures significant latency and overhead. This is also true for large networks. To make the routing algorithm more efficient it is required to keep the routing overhead less.

On–demand multipath routing protocol has low routing overhead as compared to other on-demand routing protocols. On–demand multipath routing protocol discovers multiple paths between a pair of source and destination. If a route is fails, it opt the another route. So a route is discovered only when all the routes are fail. However, in single path protocol a route is discovered whenever the only path from source to destination fails. Thus it lowers the overhead because of fewer route discovery operations.

In this paper, we compare the ad-hoc on-demand distance vector routing protocol with ad-hoc on-demand multipath distance vector routing protocol. AOMDV routing protocol is an extension of AODV routing protocol which discovers multiple path between a pair of source and destination in every route discovery. The multiple paths should be loop free and disjoint.

II.   AD HOC ON-DEMAND DISTANCE VECTOR ROUTING

AODV is an on-demand routing protocol. It has two key features: a) Route Discovery b) Route Maintenance.

2.1.   Route Discovery

It finds routes on an "as needed" basis. Whenever a traffic source requires route to the destination, it initiates a route discovery by flooding a route request packet (RREQ) and waits for reply (RREP). The RREQ packet contains the

following information: 1) Type of packet- RREQ , RREP ,RRER etc. 2) Hop_count- number of hop packet travels 3) Bcast_ID- unique id 4) Dest_IP – IP address of destination 5) Dest_seq – destination sequence number 6) Source_IP- IP address of source 7) Source_seq- source sequence number 8) Timestamp

As the request packet reaches to the intermediate node, it checks whether it is first copy of RREQ packet. If it is then it set up a reverse path to the source using previous hop of the RREQ as the next hop in the routing table. It then checks in its routing table for the route to the destination. If route is available, it unicast a RREP back to the source using reverse path, otherwise it re-broadcasts the RREQ packet over the network. When node receives duplicates copies of RREQ, it immediately discarded.

2.2. Route Maintenance

When a node detects an error such as link failure, power failure etc., it generates a RRER packet. The RRER packet sends to all traffic sources which have a route via failed link and erase all broken routes on the way. When a traffic source receives a RRER, it starts a new route discovery if it still needs a route.

2.3. Sequence number and Loop Freedom

Sequence number is an important field in RREQ, RREP and RERR packet. Every node maintains two type of sequence number. First is, sequence number for itself and second is the sequence number for destination which is called destination sequence number. It the highest known sequence number.

When a node receives multiple RREQ packets it compares the sequence numbers in the RREQ packet. The RREQ having highest sequence number is retained. RREQ with highest sequence number is assumed to have more fresh information. In case of same sequence number, packet with highest hop count is accepted. It impose a total ordering among nodes on any valid route to a destination d.This is called route update rule. The update rule ensures loop freedom. In AODV, when a link fail from i to j node i locally increment sequence number and hop count to destination to ∞. This prevents i from later forming a path to destination.

III. AD-HOC ON-DEMAND MULTIPATH DISTANCE VECTOR ROUTING

AOMDV routing protocol is a extension of AODV routing protocol. It computes alternate path between a pair of source and destination with minimal overhead over AODV.

3.1. Protocol Overview

AOMDV shares many characteristics of AODV. It is based on distance vector and hop by hop routing approach. It also has two key features similar to AODV: 1) Route Discovery 2) Route Maintenance. The main difference between AODV and AOMDV is the number of route found in each route discovery.

Route Discovery: When a traffic source requires a route, it sends a RREQ packet over the network and waits for RREP. In contrast to AODV it receives all the duplicate RREQ packet and set up reverse path through all routes towards source. It examines all the duplicate copies and only those copies are retained that preserve loop freedom and disjoint. The AOMDV route update rule is applied at each node to ensure loop freedom and disjointness properties.

When an intermediate node receives RREQ packet, it checks whether there are one or more valid forward path to the destination. If so, it generates a RREP packet and sends it back to the source via reverse path. The RREP includes only forward path that are not used in any previous RREP and once when path is created towards destination, intermediate nodes does not propagate the RREQ further.

When destination node receives RREQ, it also form reverse path in the same way as intermediate node. It adopts somewhat "looser" approach for generating RREP. It generates RREP in response of every RREQ packet that arrives via loop-free and disjoint path. When an intermediate node receives RREP, it follows route update rule to produce loop-free and disjoint route.

Route Maintenance: Route maintenance in AOMDV is simply the extension of AODV route maintenance. AOMDV also uses RERR packet for sending error message. A node sends a RERR for destination when path fails. As AOMDV has multiple paths, when a node finds that a link fails it immediately chose alternative path.

Another problem in AOMDV is timeout for each path. It is more difficult in AOMDV to manage timeout compared to AODV. With multiple paths, AOMDV has higher possibility of stale routes. This problem can be avoided by using small timeout. It also uses HELLO message to remove stale routes.

Packet Forwarding

In AOMDV, a node has multiple paths for forwarding data packets. A data packet is to be forwarded to the route until there is no failure. Here we use a simple approach when a link failure occurs. In that case, it simply chose route in order of their creation.

3.2. Properties

In this section, we discuss loop freedom and path disjointness properties of AOMDV.

Loop freedom

The concept of loop freedom in AOMDV is similar to that of in AODV. With multiple paths, there is choice of path selection. Which of the path among multiple paths is to be advertised to others and which of the advertised paths should a node accept?

Sufficient condition for loop freedom
1. For different sequence number: In AOMDV, multiple paths maintain by a node should have same sequence number. With this restriction, we can maintain a loop freedom similar to AODV. All routes with older sequence number are discarded.
2. For same sequence number: Route with shorter hop count is advertised. Once a shorter route is to be advertised, no route shorter than that is advertised.
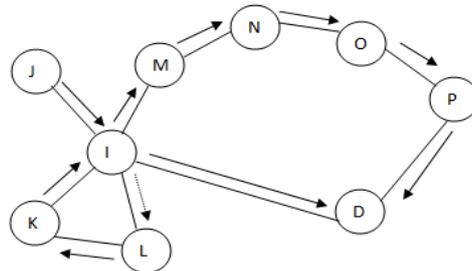

Figure 2. Example of loop freedom

Path Disjointness
In addition to loop freedom AOMDV finds disjoint multiple paths. When more than one path have common node or link than it likely be congested due to traffic and node or link may fail. Thus it is necessary to have multiple paths with disjoint node or link. With this theory, we can categorize disjointness as: 1) Node disjoint 2) link disjoint. In this paper we are considering only link disjoin property of AOMDV. Any node P to a destination D, all paths from P to D are disjoint. This can not be state that the all path in the network are disjoint.
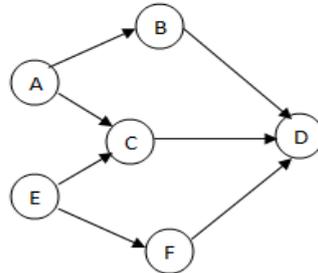

Figure 3. All paths in the network may not be disjoint

In figure 3, D is the destination. Node A and E has two disjoint paths to D: A-B-D, A-C-D, E-C-D and E-C-F. But the paths A-C-D and E-C-D are not disjoint; they share a common link C-D.
To ensure link disjointness from a node P to destination D, every node must have different next hops and last hops. Both the next hop and last hop plays an important role to determine link disjointness.
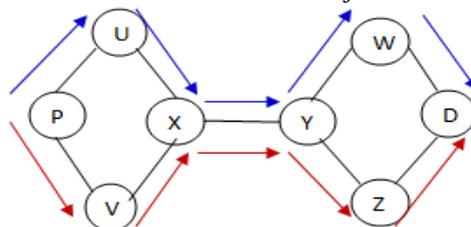

Figure 4. Idea of link disjointness

The two paths P-U-X-Y-W-D and P-V-X-Y-Z-D are not link disjoint. The two paths P to D satisfy differing next and last hops condition but this condition is not true at node X. To be more precise, we make another restriction that every node in the path must satisfy the condition. In that case only one path is possible i.e. either P-U-X-Y-W-D or P-V-X-Y-Z-D.
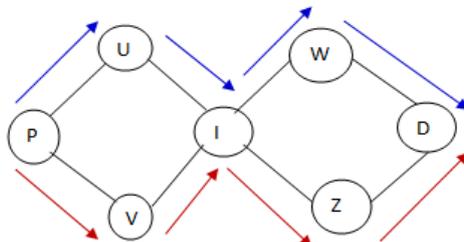

Figure 5. Two link disjoint path (P-U-I-W-D and P-V-I-Z-D) are possible.

In the above figure, every node on a path ensures that all paths to destination from that node differ in their next hop and last hops.

IV.   SIMULATION AND PERFORMANCE EVALUATION

4.1. Simulation Process

We simulated the algorithm by using NS-2.35.In our evaluation of AODV and AOMDV protocols performance, the number of mobile nodes is 100 with randomly distributed in a 500m X 500m region, nodes move according to the widely used random waypoint Model. The traffic is initially generated by 5 CBR sources. Then the number of connections is varied with 10, 15, 20 and 25 different CBR connections.

Similarly, the second simulation environment is created in a network of 100 nodes with 20 connections and node speed is varied from 1 to 5m/s in unit interval. Third simulation scenario is run in the environment of CBR protocol with varying the number of nodes 30, 40, 60, 80 and 100.

4.2. Methodology

To compare two on-demand ad-hoc routing protocol, it is best to use identical simulation environments for their performance evaluation.

4.3. Simulation Environment:

We make use of ns-2.35 which has support for simulating a multi-hop wireless ad-hoc environment completed with physical, data link, and medium access control (MAC) layer models on ns-2. The protocols maintain a send buffer of 64 packets. It contains all data packets waiting for a route, such as packets for which route discovery has started, but no reply has arrived yet. To prevent indefinite buffering of packets, packets waiting in the buffer for more than 30s are dropped.

All packets sent by the routing layer are queued at the interface queue till the MAC layer transmits them. The maximum size for interface priority queue is 50 packets and it maintains it with two priorities, each served in FIFO order. Routing packets get higher priority than data packets. Our evaluations are based on the simulation of 50 wireless nodes forming an ad hoc network, moving about over a square (500m x 500m) flat space for 150s of simulated time. A square space is chosen to allow free movement of nodes with equal density. To enable fair and direct comparisons between the routing protocols, identical loads and environmental conditions had to be maintained.

4.4. Movement Model:

In the simulation, node movement is due to random waypoint model. The scenario files used for each simulation are characterized by different pause times. Each mobile node begins the simulation by remaining stationary for the pause time duration. On expiry of pause time, the node chooses a random destination in the 500m x 500m simulation space and moves there at a uniform speed. Upon reaching the destination, the mobile node pauses again, selects another destination and proceeds there. This behavior is repeated for the entire duration of the simulation. We ran the simulation with movement patterns generated for 7 different pause times: 0, 50, 100, 250, 500 and 1000s. A pause time of 0 seconds correspond to continuous motion and a pause time of 1000s (the length of the simulation) corresponds to no motion.

4.5. Communication Model:

We choose the traffic sources to be constant bit rate (CBR) source. The source and destination pairs were spread randomly over the network. Only 512-byte data packets were used. Varying the number of CBR traffic sources was approximately equivalent to varying the sending rate.

4.6. Performance Matrices

For analyzing the performance of AOMDV, we have taken the following matrices:

Packet delivery ratio

The ratio of data packets delivered to the destinations to those generated by the constant bit rate

Average End-to-End delay of data packets

This includes all possible delays caused by buffering during route discovery, queuing at the interface queue, retransmission delays at the MAC, propagation and transfer times.

Throughput

Throughput is the measure of how fast we can actually send packets through network. The number of packets delivered to the receiver provides the throughput of then network. The throughput is defined as the total amount of data a receiver actually receives from the sender divided by the time it takes for receiver to get the last packet.

Energy consumed

Energy used by node for route discovery, route maintenance and packet forwarding.

4.6. Performance Analysis

To analyze the performance of AOMDV with respect to AODV, we take the three scenarios as explained below in table 1, table 2, and table 3.

Scenario 1:

In this scenario some parameters with specific value are considered. Those are as shown in table:

Table1. scenario-1

Parameter	Value
Simulation Time	150 s

Simulation Area	500X 500 m2
Number of Nodes	50
Routing Protocols	AODV, AOMDV
Mobility Model	Random Waypoint
No. of Connection	5, 10, 15, 20, 25
Traffic type	CBR (Constant Bit Rate)
Transport Protocol	UDP (User Datagram Protocol)
Initial Energy	200J

Scenario 2:
In this scenario some parameters with specific value are considered. Those are as shown in table:

Table 2.scenario-2

Parameter	Value
Simulation Time	150 s
Simulation Area	500X 500 m2
Number of Nodes	30,40,60,80,100
Routing Protocols	AODV, AOMDV
Mobility Model	Random Waypoint
Node Speed	5 m/s
No. of Connections	20
Traffic type	CBR (Constant Bit Rate)
Transport Protocol	UDP (User Datagram Protocol)
Initial Energy	200J

Scenario 3:
In this scenario some parameters with specific value are considered. Those are as shown in table:

Table3. Scenario 3

Parameter	Value
Simulation Time	150 s
Simulation Area	500X 500 m2
Number of Nodes	50
Routing Protocols	AODV, AOMDV
Mobility Model	Random Waypoint
Node Speed	10,20,30,40,50 m/s
No. of Connections	20
Traffic type	CBR (Constant Bit Rate)
Transport Protocol	UDP (User Datagram Protocol)
Initial Energy	200J

For analyzing the above metrics we have consider different scenario as explained in table 1, table2 and table 3. Now take senario1.

Scenario 1
Analysis of AOMDV and AODV with respect to Average Delay, Average throughput and Energy consumed.
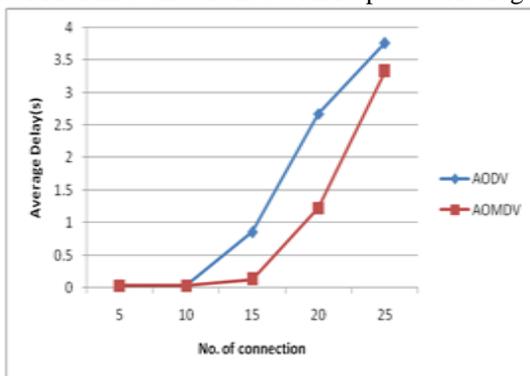

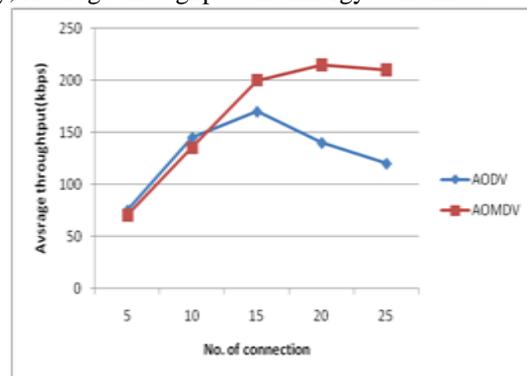Figure 6. No. of connection Average Delay(s)   Figure 7. No. of connection Vs Average throughput

Simulation environments were run for 150 seconds on five different scenarios with number of connections varying 5, 10, 15, 20 and 25.

Average Delay

The X-axis of the graph represents the number of connection and Y-axis represents the Average delay. When the no. of connection is less, both AODV and AOMDV perform similar. As the no. of connection is increases to 15, congestion & traffic loss starts to occurs . But due to AOMDV being a multi path routing protocol, even if the current link breaks, the network will find an alternate path from the source to the destination node and have a better chance of packet delivery which results better throughput. Energy consumed by AOMDV is greater than AODV due its multipath nature.

Throughput

From the graph in Figure. 2. we come to the conclusion, the number of packets dropped in AODV is more than the number of packets dropped in AOMDV. This is because of the fact that due to AODV being a unipath routing protocol, if a link is broken, the packet will not be delivered to the destination node. Thus that packet will get dropped. But due to AOMDV being a multipath routing protocol, even if the current link breaks, the network will find an alternate path from the source to the destination node and have a better chance of packet delivery; hence less number of packets will be dropped for AOMDV.

In Figureure5.2 the X-axis of the graph represents the number of connection and Y-axis represents the Average throughput. When the number of connection is less, both AODV and AOMDV performs similar manner. But as the number of connection increases in the same deployment area congestion in network will increases which results in packet loss .Packet loss in both AODV and AOMDV with the increase of number of connection, but due to multipath nature of AOMDV, packet loss in AOMDV is less as compare to AODV which result in better throughput.

Energy Consumed

The X-axis of the graph represents the number of connection and Y-axis represents the Average delay. As the route discovery procedure of both the protocol id different since AODV is unipath routing protocol and AOMDV is multipath routing
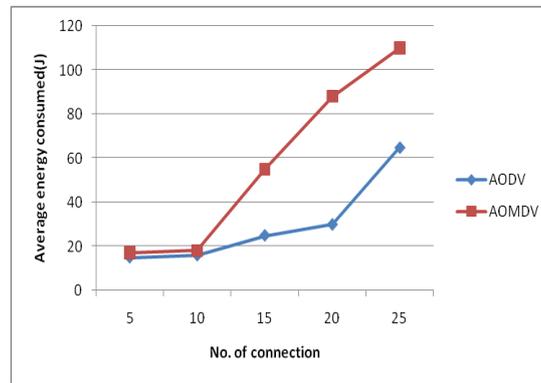

Figure 8. No. of connection Vs Energy Consumed (J)

protocol. As we know the AOMDV creates multiple paths and for this it has to maintain several tables to store route information thus AOMDV node uses more energy to find multiple path between source and destination as compared to AODV.

Scenario 2

Analysis of AOMDV and AODV with respect to Packet Delivery Ratio, Average Delay, Average throughput and Energy consumed.

From the following graph we have concluded that AOMDV has a better PDF, Average throughput, Average Delay and Energy consumed as compared to AODV for each set of nodes. This is because in the time waited at a node, AOMDV can find an alternate route if the current link has broken whereas AODV is rendered useless at that point As the number of nodes is increases in the same deployment area, traffic increases which results congestion and data loss but due to multipath nature of AOMDV it gives better packet delivery ratio, throughput and less packet delay as compared to AODV**.**
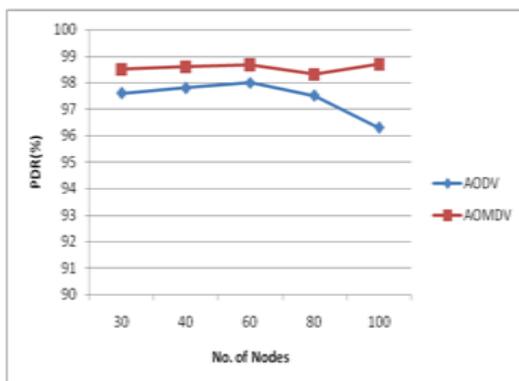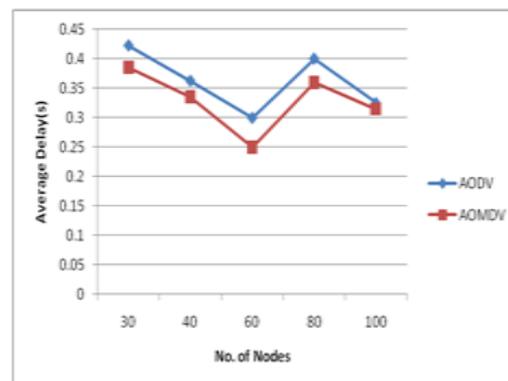

Figure9. No. of Nodes Vs PDR

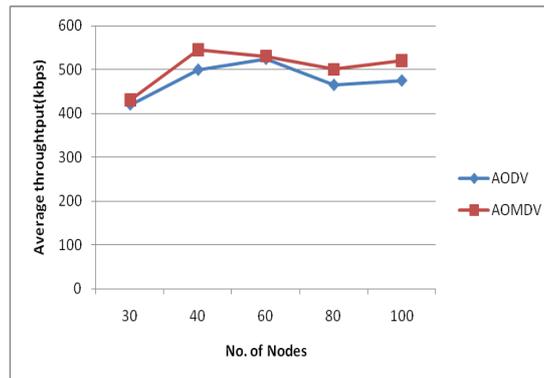Figure 10. No. of nodes Vs Average Delay

Figure 11. No. of Nodes Vs Average throughput (kbps)

Scenario 3

Analysis of AOMDV and AODV with respect to Packet Delivery Ratio, Average Delay, Average throughput and Energy consumed.

From the above analysis, AOMDV has better Packet Delivery ratio, Average throughput, energy consumed and Average Delay. As the node speed increases, more link failure takes place and gets more data loss. In both AODV and AOMDV PDR decrease with the increase of node speed. But AOMDV always has more PDR as compared to AODV.
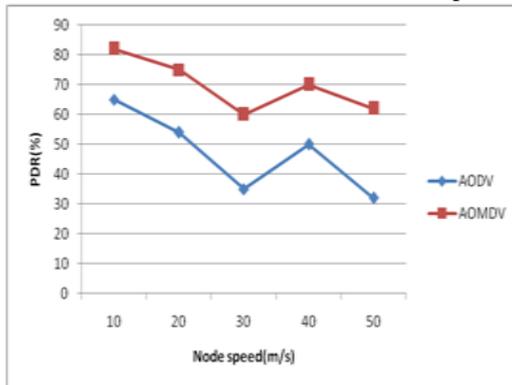

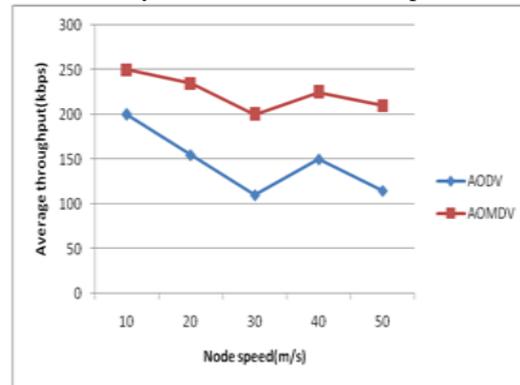Figure 12. Node speed Vs Packet throughput (kbps)

Figure 13. Node speed Vs Average Delivery Ratio

V. CONCLUSION AND FUTURE WORK

The work of our paper shows that as the number of nodes, number of connections and node speed is increases the chance of link failure is decreases. And thus AOMDV deliver better throughput, less number of packet loss and better average end to end delay. But the energy consumed to maintain multiple routes by each node in a path is high compared to AODV. This will lead to low remaining energy and more number of link failures due to energy loss.

This part of our paper is treated as future work. We can improve energy loss by optimizing it or use the wasted energy in some useful way. We can also analyze it by some another scenarios such as TCP connection and varying transmission range.

REFERENCES

[1]   C. Siva Ram Murthy and B.S Manoj, Mobile Ad Hoc Networks- Architectures & Protocols, Pearson Education, New Delhi, 2004.Manner, J., et al., "Mobility Related Terminology", Work in Progress, July2001.

[2]   Nasipuri A, Castaneda R, Das SR. Performance of multipath routing for on-demand protocols in mobile ad hoc networks. ACM/Kluwer Mobile Networks and Applications (MONET) 2001; 6(4): 339–349.

[3]   Perkins CE, Belding-Royer E, Das SR. Ad hoc on-demand distance vector (AODV) routing. http://www.ietf.org/rfc/rfc3561. 5txt, July 2003. RFC 3561

[4]   Anju Gill , Chander Diwaker," Comparative Analysis of Routing in   MANET", International Journal of Advanced Research in Computer Science   and Software Engineering, Volume 2, Issue 7, July 2012**.**

[5]   L. M. Feeney, "A taxonomy for routing protocols in mobile ad hoc networks", Tech. Rep., Swedish Institute of Computer Science, Sweden, October 1999.

[6]   Perkins CE, Bhagwat P. Highly dynamic destination-sequenced distance-vector routing (DSDV) for mobile computers. In Proceedings of ACM Sigcomm, 1994.

[7]   Perkins CE, Royer EM. Ad hoc on-demand distance vector routing. In Proceedings of IEEE Workshop on Mobile Computing Systems and   Applications (WMCSA), 1999.

[8]   Johnson D, Maltz D. Imielinski T, Korth H (eds). Kluwer Academic: Hingham, MA, USA, 1996. . Dynamic source routing in ad hoc wireless networks in Mobile Computing, chapter 5

[9]   Nasipuri A, Castaneda R, Das SR. Performance of multipath routing for on-   demand protocols in mobile ad hoc networks. ACM/Kluwer Mobile Networks and Applications (MONET) 2001; 6(4): 339–349.

[10] Ogier R, Shacham N.Adistributed algorithm for finding shortest pairs of disjoint paths. In Proceedings of IEEE Infocom, 1989.

[11] Sidhu D, Nair R, Abdallah S. Finding disjoint paths in networks. In Proceedings of ACM Sigcomm, 1991.

[12] Papadimitratos P, Haas ZJ, Sirer EG. Path set selection in mobile ad hoc networks. In Proceedings of ACM MobiHoc, 2002.

[13] Marina MK, Das SR. Performance of route caching strategies in dynamic source routing. In Proceedings of Workshop onWireless Networks and[14].Mobile Computing (WNMC) in conjunction with International Conference   on Distributed Computing Systems (ICDCS), 2001.

[15] Samar P, Wicker SB. On the behavior of communication links of a node in a   multi-hop mobile environment. In Proceedings of ACM MobiHoc, 2004.

[16] Tsirigos A, Haas ZJ. Multipath routing in the presence of frequent topological   changes.IEEE Communications Magazine 2001; 39(11)

[17] Perkins CE, Introduction to Network Simulator-2.

[18] http://www.isi.edu/nsnam/ns/tutorial/

[19] Andrew S, Tanenbaum,Computer Network: Prentice hall India, 4th Edition

[20] William Stalling .Computer networking with Internet Protocols and Technology. Publishing House of Electronics Industry,2006