

# Adjoining Ant's Activities in Adhoc-demand Multipath Distance Vector Routing

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## Abstract

**Objective:** This paper tries to devise a new algorithm based on ACO as well as multipath routing in Adhoc Multipath Distance Vector (AOMDV) environment. **Methods/Statistical Analysis:** Routing is a technique of transmitting data from source node to the destination node. Path breaks frequently in MANET due to the moving nodes. Multipath Routing presents a solution towards this problem, because of the presence of alternative paths. So, communication does not halt. Ant Colony Optimization (ACO) is a newer field of swarm intelligence to tackle optimization problems. **Findings:** The new algorithm is named A-AOMDV and is compared with other multipath and unipath protocols. Some of the performance metrics are chosen to compare and evaluate the new routing algorithm with traditional algorithms like Throughput, Jitter, Number of packets send, End to End Delay, Packet Lost, Delivery Ratio. Based upon the obtained results, the comparison graphs have also been made while evaluating parameters. The results are very encouraging and the new algorithm has outperformed other algorithms used for the purpose of comparison. **Applications:** Data communication can take place through alternative paths using efficient multipath routing protocol and easily tackle problems of disconnections during data communication.

**Keywords:** AOMDV, A-AOMDV, DSDV, MDART, MANET

## 1. Introduction

Mobile Ad hoc Network<sup>1</sup> is a collection of mobile hosts or nodes constituting a temporary network without any maintained infrastructure or any support of the base station. In MANET, mobile host or nodes communicate with each other using multi-hop access points or wireless links. There is no fixed infrastructure to route packets or data towards the destination. Each node which is present in the network behave like a router and forward data packets to another nodes in the network. Mobile Ad hoc networks<sup>2</sup> are characterized by multihop wireless links. MANET is frequently change its topology because nodes are not stable in one place. The mobile ad hoc network is efficient and dynamic routing protocols. These nodes can move freely in the network and organize themselves randomly. Each host or node can dynamically enter and leave the network. MANET called as a name packet radio networks in past decades before in defence research. These days researchers taking interest in this field because

low-cost devices are easily availability in this network with radio interfaces. Interest is partly fired by growing energy for running common network protocols in a dynamic environment with wireless connection without the requirement of infrastructures<sup>3</sup>. Internet Engineering Task Force (IETF) has formed a working group to devise a framework for routing protocol in MANETs. The applications of ad hoc networks typically come under two categories:

- MANET as shown in Figure 1 such as mobile cell phones, laptops, Personal Digital Assistants etc.
- Ad hoc sensor networks found in many industrial applications, which have specific aim is to forward information from one place to another.

Thus, the network topology may change frequently and rapidly because dynamic. Mobile adhoc network has easily adapt itself in the present topology. A MANET may work as a self-configured independent network which is connected to the Internet through gateway nodes.

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**Figure 1.** Mobile Adhoc Network.

Ant Colony Optimization<sup>4,5</sup> is a mathematical model which uses, the behaviors of real ant colonies. Real ants work collectively and follow each other. Researchers use this technique to find the best route towards the destination. Different algorithms based on ACO are Ant System (AS), Rank-Based Ant System ( $AS_{rank}$ ), Min-Max Ant System (MMAS), Elitist Ant System (EAS), Approximate Nondeterministic Tree Search (ANTS), Ant Colony System (ACS), Hyper-Cube Framework for ACO and many more. In the ant based routing protocol<sup>6</sup>, every node generates ants with control packets in order to find paths from the source to the destination node. The ant's data packets change its path after calculated the pheromone value present on the path. The paths on which more ants will be found showing that pheromone is dense or less value calculated on other paths. According to this pheromone value the ants will use the shorter paths. Thus, the shortest path will be calculated and determined than all ants will use this path for transmission. Moreover, one or more than one path can be identified in MANET because of the movement of all nodes. Whenever, the process is not able to find the best path, the other alternate paths should be accessible for the movement of the node from source to destination. When topology changes; better and alternate paths can be found.

## 2. DSDV

Destination Sequenced Distance Vector routing (DSDV)<sup>6,7</sup> is conciliated from the established Routing Information Protocol to ad hoc network routing. DSDV

added a sequence number in each route table entry of the conventional Routing Information Protocol. The mobile nodes can easily distinguish stale route information from the new with the use of the newly added sequence number. This prevents the formation of routing loops. Every network node maintains a table listing the information about the routes to all the other nodes. Routing table contains information about the IP address of the node, the hop count and last sequence number to reach the other node. All such details in the routing table also help to search the next hop neighbor to reach the destination node and the timestamp to update for that node. This update message for DSDV consists of mainly three fields Sequence Number, Destination Address and Hop Count. Each node uses two processes to send out the DSDV updates. These updates are:-

- Regular Updates:- Each node periodically broadcasts the full routing table. Any updates are also sent out after every fixed update interval.
- Trigger Updates:- This updates will send on receiving any change caused in the DSDV routing table. These are small updates that may be caused any time in-between the other updates.

The updates are assumed based on the parameter used for a particular node. The sequence number is the main factor for deciding the acceptance of an update. If any node finds the sequence number of the update message is more disregarding of the metric than it will accept the update in the routing table. Whenever the update with the same sequence number is received than the update with less metric or hop count is given priority. In the high mobility of the nodes, there is a maximum chance of route variations. Then, we will use the weighted settling time. Whereas any update message with any change in parameter will not be advertised to other nodes. The node will have to wait for the weighted settling time to make sure that it did not receive the update from its old neighbor. DSDV uses a request queue and it has to buffer packets that have no roots in between source to destination.

## 3. M-DART

M-DART<sup>8,9</sup> is proactive protocol and it is an extension of the DART protocol. MDART discover all the available routes between a source node and a destination node. M-DART uses dynamic routing to find a optimum route. Multipath

dynamic address routing is based on a Distributed Hash Table(DHT) based shortest path routing protocol which is known as DART. MDART is able to improve the tolerance of a tree-based address space. MDART is totally against channel impairments as well as mobility of the node. Moreover, the multi-path feature also improves the performance in case of static topologies. M-DART have mainly two major aspects by which we can compare with other multi-path routing protocols. Firstly, MDART discovers the redundant routes. MDART takes guarantee to give communication free and coordination free route. In MDART, the discovering though the network and it does not require any other communication or coordination overhead. Secondly, MDART discovers all the available redundant paths between source and destination.

#### 4. AOMDV

Ad Hoc on Demand Distance Vector Routing Protocol<sup>10</sup> is multiple path routing protocol. AOMDV is a loop-free, link disjoint and on demand routing protocol. AOMDV is an extension of the AODV<sup>11</sup> which is a single path routing protocol. In the routing table, every entry for destination contains a record in the form of a list of the subsequent node and their equivalent hop count. A sequence number is associated with each next node and helps a node in storing the up to date information for a route. The node preserves the publicized hop count representing the maximum number of intermediate nodes in order to reach the destination. This hop count is sent to all nodes as route announcement of the destination. If node finds the alternative path has a lesser hop count than the advertised hop count for destination. The alternative paths can be used to give freedom from loops<sup>12</sup>. The maximum hop count is used in the route, and the advertised hop count therefore does not change for the same sequence number. Whenever destination receives a route advertisement from the node with the greatest sequence number, than the next-hop list as well as the advertised hop count are reinitialized. The AOMDV routing protocol can be used to find both types of path in MANET these are the link-disjoint and the node-disjoint routes. To find node-disjoint routes, each node in the network does not immediately reject duplicate Route Request packet (RREQ). Each Route Request packet (RREQ) arriving through a different neighbor of the source that defines a node-disjoint path. Whenever any

two RREQs packets arriving at an intermediate node from a different neighbor node cannot be broadcast duplicate RREQs, than different neighbor of the source node could not traverse the same node. To get multiple link-disjoint routes, the only destination node replies to duplicate RREQs arriving from unique neighbors. After the first hop, the RREPs starts follow the reverse paths, which are node-disjoint and link-disjoint. In the route discovery process, AOMDV has more message overheads. These overhead messages increased flooding in the network or route. In the multipath protocol, the multiple Route Request (RREQ) detects and those results of the request are in longer overhead.

#### 5. A-AOMDV

Ant Based-Adhoc on Demand Multipath Routing Protocol<sup>13</sup> is a novel protocol based on the swarm intelligence technique. The protocol uses the technique of Ant Colony Optimization (ACO) along with the multipath routing<sup>14</sup> in the MANET environment. Two types of ants are used in this algorithm<sup>15,16</sup>. One is called the FANT i.e. forward ant and the other is BANT i.e. backward ant. FANT is created at the place of the sender node and travel on the way to the receiver node to find the path. When FANT reaches at the target node, it is being made to die. The BANT is then created at destination node and sends back to the sender. BANT follows reverse path which was traversed by FANT. The forward ant chooses next node with the help of probability ( $\Omega_{ij,d}$ ) which can be evaluated as follows, which is present at the node  $i$  chooses the next node  $j$  by probability ( $\Omega_{ij,d}$ ) and is heading in the direction of the destination  $d$  is calculated as follows:

$$\Omega_{ij,d} = \frac{\rho_{ij,d} + (\text{Cos}\alpha)\theta\tau_{ij}}{(\text{Cos}\alpha)\theta|N_i| + (1 - \theta)(\text{Cos}\alpha)} \quad (1)$$

Where  $i$  is the current node,  $d$  is the destination node,  $j$  is the chosen next node,  $\rho_{ij,d}$  is the pheromone value and  $\theta$  is the heuristic function.  $v_1$  and  $v_2$  represent the axial orientation vector and help in calculate the cosine value  $\text{Cos}\alpha$ .  $|N_i|$  represents the number of neighbours for node  $i$  and  $\Gamma_{ij}$  is the heuristic value that further dependent on the length of queue over the link  $i-j$  which can be evaluated as follows:

$$\Gamma_{ij} = 1 - \left( I_{ij} / \sum_{i=1}^{|N_i|} I_{ij} \right) \quad (2)$$

$$\cos \alpha = \frac{v1.v2}{|v1|. |v2|} \tag{3}$$

If the selected node is already present in the path, then this path is not explored further and is being dropped. But, if next node has not been the member of the selected node list then this node is selected for sending the packets<sup>16</sup>. Pheromone on the favorable path is increased with the help of equation 4 whereas its quantity is reduced on unselected paths as shown in equation 5 below:

$$\rho(i) = \rho(i) + r * (1 - \rho(i)) + r^2 \rho_{high} / C \tag{4}$$

$$\rho(i) = \rho(i) - r * \rho(i) - r^2 * \rho_{high} / (C * (|N_i| - 1)) \tag{5}$$

Where  $|N_i|$  sums the quantity of nodes in neighborhood of node  $i$ .  $\rho_{high}$  represents the largest value of pheromone in the current running loop.  $C$  denotes a constant which depends on the time of the experiment. In this simulation, we used  $C$  as 1000 because we took simulation time in milliseconds.  $r$  is the constant dimensionless reinforcement factor ranges between  $(0,1]$ .

In A-AOMDV, data structure for above ACO<sup>17</sup> arrangement is made in NS-2 using C/C++ library and is mounted as a routing agent in the AOMDV environment with the following selection criteria:

- On selection of multiple paths, we are choosing only the best two paths based on the highest pheromone quantity.
- A-AOMDV uses link disjoint paths.
- Path selection fluctuates on feeling positive change in pheromone value of other paths.
- Stale route problem can be tackled with the help of updated pheromone value of paths.
- Uniform timeout cache route policy is followed.

## 6. Results and Discussions

To implement the new devised protocol, NS-2 is chosen for the practical work. The network of 60 nodes is simulated in the wireless environment. To evaluate the new algorithm, we also simulated the other MANET protocols in multipath and unipath environment with the same parameters as used in A-AOMDV. The results obtained after simulation of all the algorithms were compared on various parameters like average throughput, number of packets sent, packet drop, end to end delay, delivery ratio and jitter.

### 6.1 Throughput

The data send from source node towards the destination node in unit time is called the throughput. We measured this as average throughput and calculated in bytes/second.

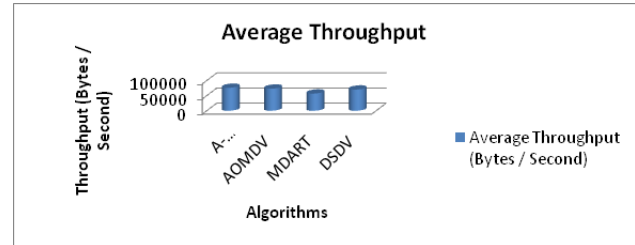


Figure 2. Average Throughput (Measured in Bytes / Second).

On seeing the Figure 2 graph, we can easily say that A-AOMDV has better throughput value than its rivals. So, A-AOMDV shows better response in case of average throughput.

### 6.2 Packet Loss

This parameter measures the drop in the number of packets that are moving from intermediate nodes. This parameter should be minimized for better performance of the algorithm.

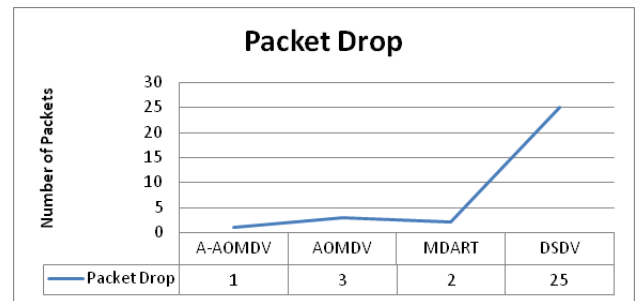


Figure 3. Number of Packets Dropped.

The graph shown in Figure 3 clearly represents that a lesser number of packets are dropped in case of A-AOMDV than in other algorithms. This shows the accuracy of the algorithm in flooding the packets towards the destination with better precision.

### 6.3 Delivery Ratio

Delivery ratio basically measures the percentage of the packets successfully reached the destination. This metric measures the truthfulness of the selected paths and represents lesser loss rate in data packets.

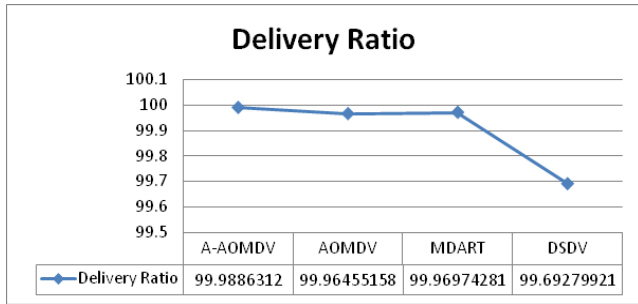


Figure 4. Delivery Ratio.

A-AOMDV again leaves its competitors behind even in this parameter. A-AOMDV has shown in Figure 4 the largest value of delivery ratio and hence proved better than others.

### 6.4 Jitter

The drift in time observed by data packets is known as jitter while they travel from peer to peer. A smoother network presents lower value in jitter. So the algorithm with the lower value of jitter dominates the others.

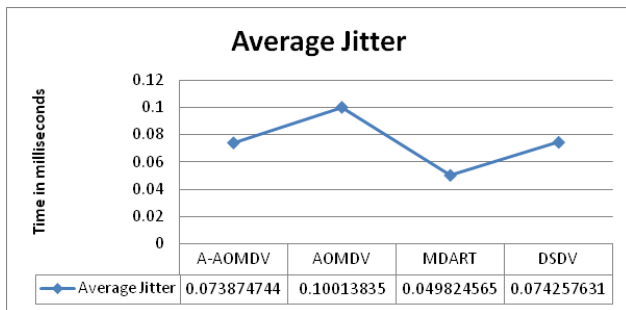


Figure 5. Average Jitter.

Line graph shown in Figure 5 helps us in judging the average value of jitter observed by all algorithms. MDART has the lowest value of jitter whereas A-AOMDV secured second position when compared with the parameter of the jitter, which is still better than the other two algorithms used in comparison.

### 6.5 End to End Delay

End to End delay is evaluated as the time taken by the packet in reaching to the destination from the source. We can calculate it by measuring the difference among the time when the packet began the journey to the time when the packet finished the journey.

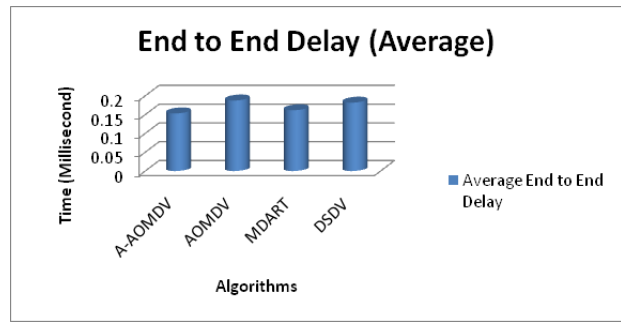


Figure 6. End to End Delay (Average).

The 3-D bar graph shown in Figure 6 represents that the packets in A-AOMDV algorithm travel to destination with least delay as compared to other algorithms. Therefore, it can be stated that A-AOMDV holds the first position when compared on the basis of the average end to end delay.

### 6.6 Number of Packets Send

The capacity to send the data packets into networks is evaluated by this parameter. More value of the number of packets represents better capability to send more packets. So, an algorithm having a larger value in this parameter dominates the other algorithms with lower value.

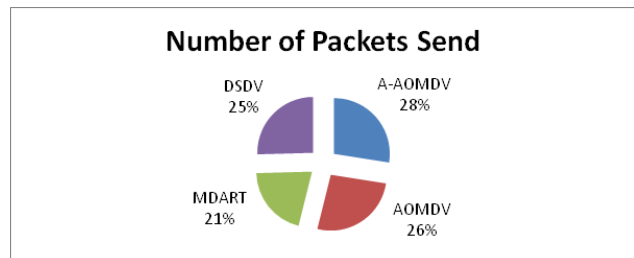


Figure 7. Number of Packets Send.

The bar chart shown in Figure 7 represents that A-AOMDV shares 28% of the overall packets send into the network. Other algorithms have lower value than that of A-AOMDV. So, it can be easily stated that A-AOMDV can send more packets than other protocols used for simulation.

## 7. Conclusion

Routing data poses great challenge in Mobile Adhoc



Networks. The path used for transmitting the data packets breaks frequently due to the moving nature of the nodes. So, it is often desirable to find a new route for data transmission. That is the reason; the multipath routing came into existence. In multipath routing, if the path break occurs, the data can still be transmitted via the available substitute paths. This practical paper devises a novel algorithm (A-AOMDV) with the help of the ant colony optimization and implements that concept on the multipath routing in AOMDV environment. The new algorithm performed better than all other algorithms used for the purpose of comparison. The new algorithm was tested on six parameters like packet lost, throughput, end to end delay, delivery ration and jitter. The results shown in the previous section have already proven that A-AOMDV has shown better performance than all other algorithms used for the purpose of comparison. A-AOMDV outperforms other algorithms in five parameters out of the six parameters taken for the purpose of comparison. Therefore, the new devised algorithm has shown superior performance as compared to the other protocols like AOMDV, MDART and DSDV.

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