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Delay Optimal Multicast Routing for Wireless Ad-Hoc Networks

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***Abstract*—In this research paper we are proposing a delay minimization algorithm for minimizing end to end delay for multicasting on a tree based wireless network with multiple source and multiple destinations. Our algorithm uses two stages, first is level division and second is for selecting best path among all paths from tree. The second stage is DOMA (Delay Optimal Multicast Algorithm) algorithm. Our algorithm divides the tree into its sub trees and finds the best delay optimal path. The algorithm is compared with Tree Pruning (TPA) algorithm. In tree pruning algorithm the whole tree is used for routing. Simulation result shows that our algorithm has lower end to end delay as compared with TPA.**

***Keywords*—Multicast Routing, Delay minimal algorithm, MAODV, Shortest path.**

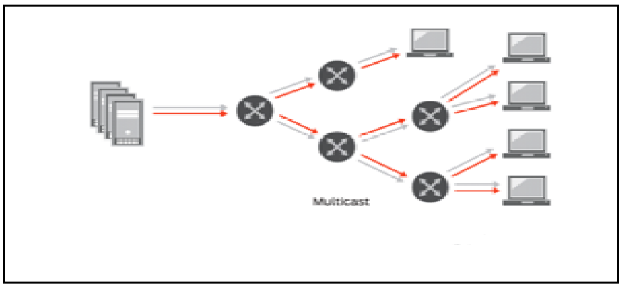
I. Introduction

A wireless network is a collection of wireless nodes that communicate with each other over wireless connections. There are several multicast routing protocols which have been offered in the past few years. Based on the routing structure they can be grouped into two categories: tree-based protocols and mesh-based protocols. The tree-based multicast routing protocol survives a single route between any sender-receiver pair and occupies the advantage of high multicast efficiency. These protocols are not built-up strong against frequent topology changes and consequently drop the data packet at highly mobile environment. The mesh-based multicast routing protocols provides the redundant routes to group members for maintaining connectivity. The problem of low packet delivery ratio due to frequent link failure is alleviated because of redundant routes. However mesh-based multicast routing protocols are better against node mobility but give low multicast efficiency. A hybrid multicast routing provides the advantage of mesh-based and tree-based protocols [1].

Multicast is simple one -to-many or many-to-many distribution. It is group communication where information is directed to a group of destination computers simultaneously. The figure illustrated above is the representation of unicasting and multicasting. One message is passed to the many recipients. In this figure first mobile node is sending one message to a black node, that means mobile node is unicasting a message to a black node then this black bode is forwarding that message to two other black nodes which means the black node is multicasting that message to the other two black nodes.

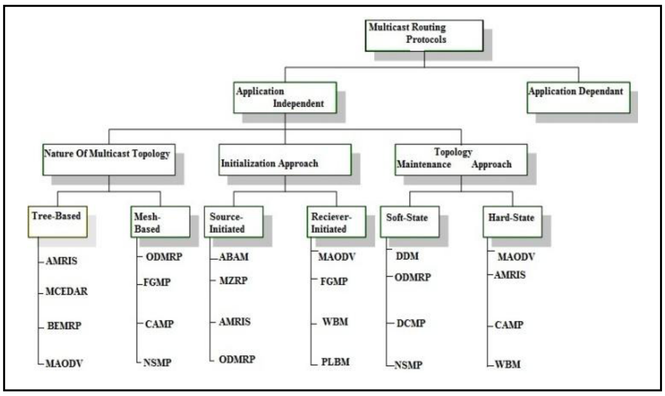
The Multicasting is a technique in which bandwidth is consumed. Multicasting minimizes the traffic by sending a particular message to a group of receivers. The receivers can be anywhere in the network. If a new host wants to connect to the multicast network, it sends a information message to the local router and by this process multicast tree is formed. The multicast tree is formed using multicast routing protocol.

Fig. 1. Unicasting and multicasting.



In past some years there are many protocols [2],[3],[4],[5],[6],[7],[8] have been proposed to provide multicasting service to the network. They can be classified in many categories like topology, their behavior etc.

Fig. 2. Classification of Multicast Protocols



There are many routing protocols are also used in past years in Wireless networks. Some of the protocols are shown in the Table 1 in detail.

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Some routing protocols which are used earlier in Wireless Ad-hoc networks are listed below in table1.

TABLE I

ROUTING PROTOCOLS FOR WIRELESS AD-HOC NETWORKS

S.NO.	Routing Protocols	
	Protocols	*Description*
1	AODV	Ad-hoc On Demand Distance Vector Routing Protocol.
2	MAODV	Multicast Ad-hoc hoc On Demand Distance Vector Routing Protocol.
3	B.A.T.M.A.N	Better Approach To Mobile Ad-hoc Networking.
4	Babel	It is a Distance Vector routing protocol for IPv6 and IPv4.
5	DNVR	Dynamic Nix-Vector Routing.
6	DSDV	Destination Sequenced Distance vector routing protocol.
7	DSR	Dynamic source Routing.
8	HSLS	Hazy-Sighted Link State.
9	HWMP	Hybrid Wireless Mesh Protocol.
10	IWMP	Infrastructure Wireless Mesh Protocol.
11	MRP	Wireless Mesh Routing Protocol.
12	OLSR	Optimized Link State Routing Protocol.
13	OSPF	Open Shortest Path First Algorithm.
14	PWRP	Predictive Wireless Routing Protocol.
15	TORA	Temporarily Ordered Routing Algorithm.

II. RELATED WORK

Since past some years many researchers focused in the field of wireless multicast. They worked for the betterment of wireless multicast networks. A big variety of multicast routing algorithms have been proposed focusing on many routing aspects such as end to end delay, packet delivery ratio, QoS, energy consumption, throughput and many more.

A multicast algorithm MAODV (Multicast Ad-hoc On Demand Distance Vector) for tree is proposed in [9]. This algorithm constructs a multicast tree with forwarding nodes and multicast destinations. This algorithm has large end to end delay due to traffic congesting and link failure. Link failures occur in this algorithm because of high mobility of nodes.

In [10], a new heuristic algorithm DVCSP (The Delay And Delay Variation Constrained Shortest Path Algorithm) was proposed. This algorithm has two phases, first is the delay constraint phase and second is delay variation constraint phase. Other heuristic algorithms are examined and compared with the proposed algorithm via simulation. Two performance factor were taken, failure rate and average cost per path.

In [11], In this paper, an efficient heuristic algorithm, namely, Economic Delay and Delay-Variation Bounded Multicast (EDVBM) algorithm was proposed, based on a novel heuristic function. This algorithm constructs a multicast tree node by node. This algorithm chooses best node using every iteration. This algorithm was compared with an existing Zhang's algorithm through simulations. It was found that the end to end delay was more than that of existing algorithm.

In [12], a multi-source multi-cast algorithm was proposed for wireless Ad-hoc networks. This algorithm has two stages first is Level Division and second is Tree Pruning Algorithm (TPA). The level division algorithm divides the tree into levels. This method gives information of hop distance of destination to the source. This algorithm was compared with well known tree based multicast algorithm MAODV via simulations. This algorithm has lower end to end delay as compared to MAODV under low to moderate node mobility. This algorithm does not perform well in drastic change of topology and in high mobility.

III. DELAY OPTIMAL MULTICAST ALGORITHM WITH LEVEL DIVISION

Our algorithm is has two parts, first is level division algorithm and second is Delay Optimal Multicast Algorithm (DOMA).

The purpose of level division is to calculate hop distance from source to destination. If source gets information about destination node then it can send the packet easily to that node. It can also use unicast route for packet delivery. This method is helpful to tolerate with traffic congestion.

In second algorithm we used weighted graph model for communication. A source node multicasts the route request message, the destination node gets the message and sends the route reply message by using minimum weight path. If a node having two children then the weight of that node is 2. The route reply message uses the path which has minimum weight. After the source node gets the route reply message it starts sending the packets using that minimum weight path. In this way the packet is sent with minimum cost and end to end delay is also minimized. This algorithm divides the tree into its sub trees and finds the best path in terms of delay.

If link failure occurs then the algorithm finds second alternative best path among all path from the tree. This algorithm makes the tree as a graph with set of vertices and edges.

Some notations for the algorithm are given in the table-

Table II

NOTATIONS USED IN DESCRIPTION OF THE ALGORITHM

S.NO		
	Notations	***Descriptions***
1	G	Set of All nodes
2	M	Set of all Multicast Destinations
3	P_k	Parents set of node **k**
4	S_k	Sibling set of node **k**
5	C_k	Children set of node **k**
6	$Sequence_k$	Sequence number of node **k**
7	$Neighbor_k$	Neighbor set of node **k**
8	$Seen_k$	Set of multicast destination node **k** sees
9	$Cover_k$	Set of multicast destination node **k** needs to cover
10	hop[k]	Hops between node **k** and its nearest route

A. *level division algorithm*

Algorithm 1: Level Division algorithm [12]

Input: no. of nodes deployed (n), set of nodes deployed (Si).

Output: a multicast tree generated using the communication among the nodes, Ti.

1: procedure HOPDISTANCEMESSAGE
2: if node n receives packet then
3: if n = source then n is source.
4: $sequence_n$ ++
5: Send Message hop[n] = 0
6: Wait For hop distance message
7: else n is not source.
8: if packet.seq < $sequence_{packet.sender}$ then
9: Discard packet
10: else
11: if packet.hop < hop[n] − 1OR hop[n] = −1 then
12: hop[n] ← packet.hop+ 1
13: $sequence_{packet.sender}$ ← packet.seq +1
14: Send Message hop[n] = packet.hop + 1
15: Wait For hop distance message
16: end if
17: end if
18: end if
19: else
20: Wait For hop distance message
21: end if
22: if all hop distance messages received correctly then
23: UPDATE TREE
24: Go to Delay optimal Multicast Algorithm (DOMA)
25: end if
26: end procedure

B. *Delay Optimal Multicast Algorithm (DOMA)*

Algorithm 2: Delay Optimal Multicast Algorithm

The algorithm is executed if T_0, the tree satisfies shortest path, satisfies algorithm (1) but does not satisfy algorithm (2).

1: begin procedure
2: let T = T_0 // T is the tree returned by the algorithm
3: find the first k shortest paths from s to w in the original graph G = (V,E) , such that delay from s to w over these paths is less than Δ
4: for i = 1 to k; do //construct multicast tree for each path
5: Initialize T' = (V, A) to include all the nodes and links of paths p
6: let U = M – (M ∩V) to be set of destinations not connected to tree T
7: while U ≠ ϕ do
8: pick any node u € U // will connect u to tree T
9: pick each node v € V // find a path from v to u
10:Construct a new graph G' starting with initial graph G and executing all nodes V–{v} and all links in A and all nodes in u – {U} and their links
11: find the first l shortest paths from v to u in new graph G'
12: of these l paths choose the best one and choose it q
13: end of for each node v € V loop
14: Update T' = (V, A) to include all nodes and links in q.
15: Update U = M – (M ∩V) // node u and possibly other nodes in U have now been connected to T
16: end of while loop
17: If T satisfies constraint (1) returns T and stop
18: let T' be tree with smallest value Δ
19: end of for i loop
20: return tree T_0
21: end of algorithm

IV. SIMULATION RESULTS

We simulate our proposed algorithm in NS-2. Our algorithm is tested and compared with Tree Pruning Algorithm via simulations. We are taking four different scenarios. In first scenario there are one source and multiple destinations. In this scenario five more sub scenarios are taken with increasing number of nodes density. Number of nodes is varied form 40,60,80,90 and 100. In second scenario there are three source and multiple destinations. Here is also nodes are increased by 40,60,80,90 and 100. And in third scenario there are five source and multiple destinations and node density is increased by 40,60,80,90 and 100. In each scenario five scenarios are taken with increasing number of nodes. The simulation is performed with varying 40 to 100 nodes. And in fourth scenario the performance under node mobility is analyzed. In this scenario node density is increased by 10, 15, 20,25,30,35 and 40.

The parameters for evaluation taken are packet delivery ratio, average delay, and maximum delay. Packet delivery ratio is the ratio of number of data packets received to the destination to the number of packets sent by the source node.

$$PDR = \frac{\text{Total No.of Packets received at destination}}{\text{No.of Sent Packets}}$$

Average delay is average end to end delay over all packets. It is calculated as the total delay duration of all successfully transmitted data packets from source node to destination node.

Maximum delay is the maximum of all end to end delays. Maximum delay and average delay are measured in seconds or milliseconds.

Performance under node mobility is calculated in average delay.

Following Graph represents comparison results of (DOMA) with TPA Algorithm.

Fig. 3. Packet delivery ratio for single source multiple destination scenario

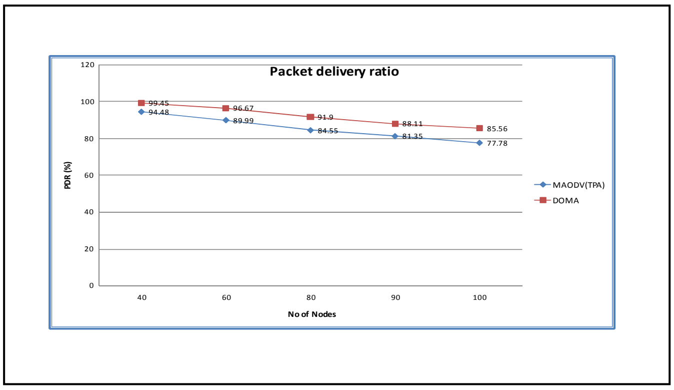

Fig. 4. Average delay for single source multiple destination scenario

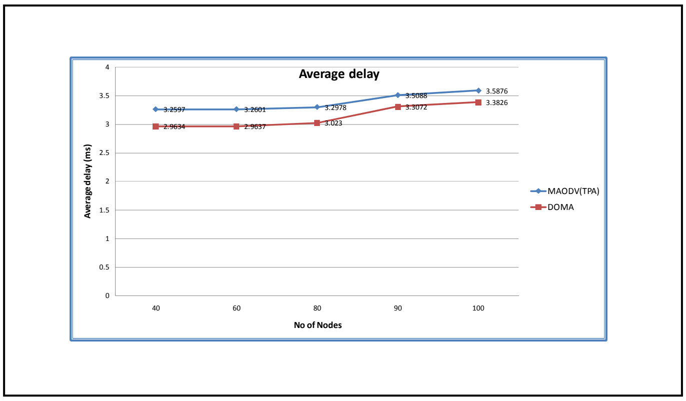

Fig. 5. Maximum delay for single source multiple destination scenario

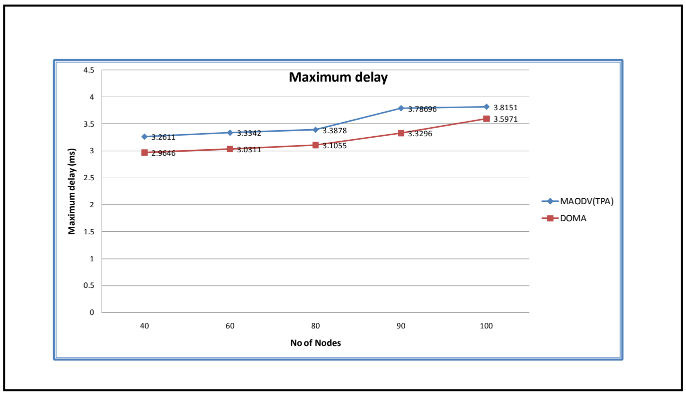

Fig. 6. Packet delivery ratio for three source multiple destination scenario

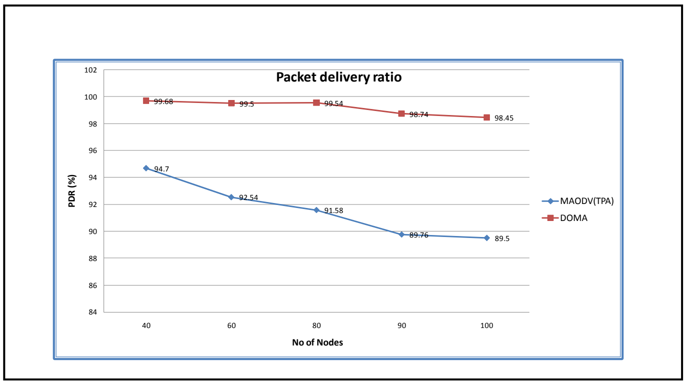

Fig. 7. Average delay for three source multiple destination scenario

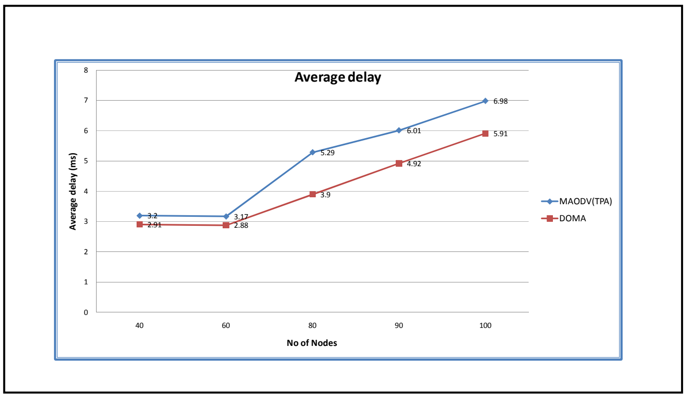

Fig. 8. Maximum delay for three source multiple destination scenario

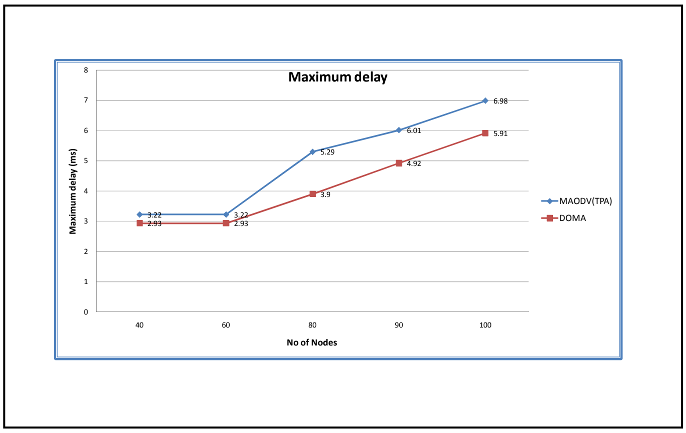

Fig. 9. Packet delivery ratio for five source multiple destination scenario

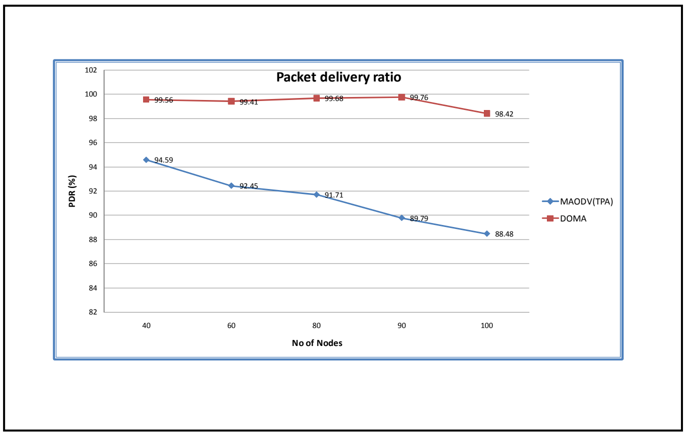

Fig. 10. Average delay for five source multiple destination scenario

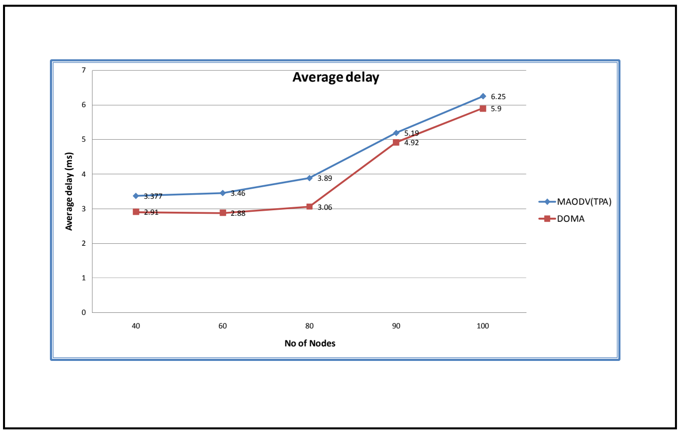

Fig. 11. Maximum delay for five source multiple destination scenario

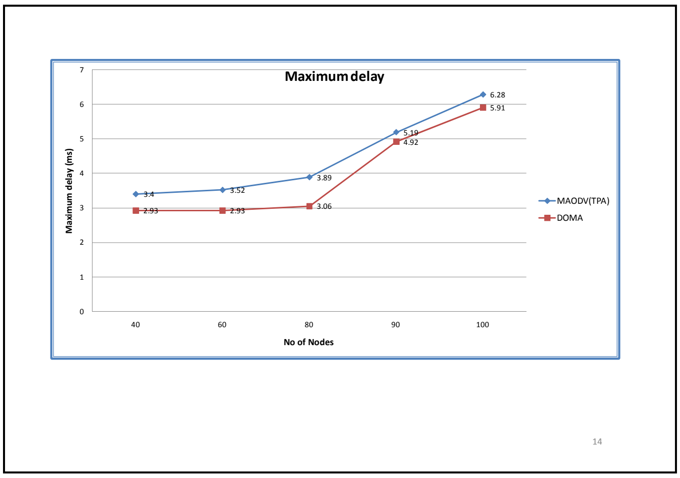

Fig. 12. effect on average delay with node mobility.

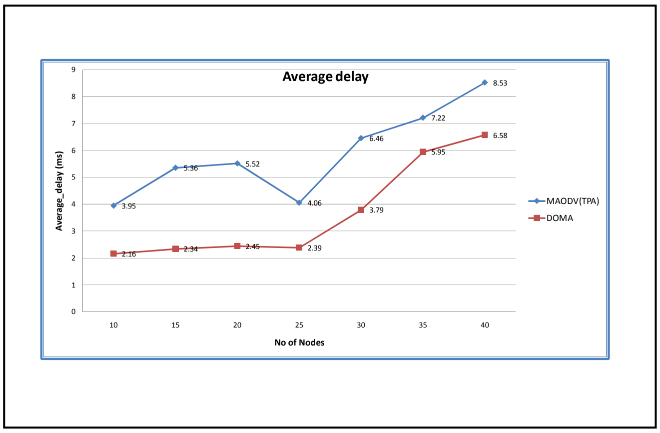

Figure 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12 shows the comparison results between proposed algorithm DOMA and existing TPA algorithm. The simulation results show that our proposed Algorithm i.e. (DOMA) With Level Division Algorithm has lower end to end delay as compared to existing TPA algorithm. Here packet delivery ratio is in percentage and average delay and maximum delay is in millisecond (ms).

Conclusion

In this research work we propose a multisource multicast algorithm Delay Optimal Multicast Algorithm (DOMA) for wireless Ad-doc networks to minimize delay. This algorithm is tested and compared with existing Tree Pruning Algorithm (TPA). Simulations are performed on 4 different scenarios with increasing number of nodes. Simulation results shows that our algorithm has lower end to end delay as compared to existing system. Effect of node mobility on delay is also better than the existing TPA algorithm.

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