# Analysis of Multicast Routing Protocols Using Quality of Service

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***Abstract*—Multicasting is kind of subset of broadcasting in which we have to send data to the selected number of receivers present in the group. The group is called as multicasting group. The routing protocols are being for the sending of packets and managing of nodes. The objective of this paper is to research the current state of the art of existing multicast routing protocols for MANETs, and compare different approaches. There are three main classes of routing protocols for MANETs: reactive, proactive and hybrid. By studying advantages and disadvantages of each one, a new hybrid routing protocol is proposed. The new scheme of protocol, considers utilizing merits of both ODMRP and MAODV protocols, and implements them as a hybrid approach. It allows that a mobile node flexibly runs either a mesh or a tree routing protocol with its velocity and its traffic. The study is done by performance analysis of two well-known multicast routing protocols which are MAODV and ODMRP. Some of the perspective is being studied and an outer diagram is being proposed of new routing protocol. The two routing protocols are being compared on the basis of different parameters.**

***Index Terms*—MANENTS, routing protocols, quality of services**

## I. Introduction

The recent technological advancements introduced a fresh and different type of wireless systems which are known as Mobile Ad-Hoc Networks. They do not need any fixed or supporting infrastructure in fact they offers quick network deployment.

This paper presents the simulation and analysis of the performance of existing proactive and reactive multicast routing protocols over WMNs. Three prominent multicast routing protocols are selected for performance comparison; they are On Demand Multicast Routing Protocol (ODMRP), Multicast Ad hoc On Demand Distance Vector (MAODV) Protocol and Multicast Open Shortest Path First (MOSPF). Among them, MOSPF is a proactive routing protocol while MAODV and ODMRP are reactive multicast routing protocols. MAODV fabricates and maintains a shared multicast tree for each multicast group and ODMRP is a mesh-based approach and uses a forwarding group concept. Their aim is to investigate the relative strength and weaknesses of each protocol [1].

This paper describes the benefits of multicasting, the Multicast Backbone (MBONE), Class D addressing, and the operation of the Internet Group Management Protocol (IGMP). The paper explores a number of different algorithms that may potentially be employed by multicast routing protocols: Flooding, Spanning Trees, Reverse Path Broadcasting (RPB), Truncated Reverse Path Broadcasting (TRPB), Reverse Path Multicasting (RPM), and Core-Based Trees. It describes how the previous algorithms are implemented in multicast routing protocols available today: Distance Vector Multicast Routing Protocol (DVMRP), Multicast OSPF (MOSPF) (Moy, March 1994), and Protocol-Independent Multicast (PIM) [2].

A number of different routing protocols proposed for use in multi-hop wireless ad hoc networks are based in whole or in part on what can be described as on-demand behavior. By on demand behavior, they mean approaches based only on reaction to the offered traffic being handled by the routing protocol. In this paper, they analyze the use of on-demand behavior in such protocols, focusing on its effect on the routing protocol's forwarding latency, overhead cost, and route caching correctness, drawing examples from detailed simulation of the dynamic source routing (DSR) protocol. They study the protocol's behavior and the changes introduced by variations on some of the mechanisms that make up the protocol, examining which mechanisms have the greatest impact and exploring the tradeoffs that exist between them [3].

An efficient algorithm named is proposed to improve the route discovery mechanism in MAODV for QoS multicast routes. QoS-MAODV especially can establish a multicast tree with the minimum required bandwidth support and decrease the end-to-end delay between each destination and the source node. It can establish QoS routes with the reserved bandwidth on per chosen flow. To perform accurate resource reservation, they have developed a method for estimating the consumed bandwidth in multicast trees by extending the methods proposed for unicast routing. The simulation results show that QoS-MAODV protocol produces higher throughput and lower delay in comparison with MAODV protocol [4].

The extension of Ad-Hoc On-Demand Distance Vector Routing (AODV), an algorithm for the operation of such ad-hoc networks, to offer novel multicast capabilities which follow naturally from the way AODV establishes unicast routes. AODV builds multicast trees as needed

Manuscript received July 4, 2014; revised October 30, 2014.



doi: 10.12720/ijsps.3.2.139-145

(i.e., on-demand) to connect multicast group members. Control of the multicast tree is distributed so that there is no single point of failure. AODV provides loop-free routes for both unicast and multicast, even while repairing broken links. In paper they continued improvements to the basic algorithm (e.g., for Quality of Service (QoS) applications, for client/server discovery, or for utilizing asymmetric routing paths) will benefit both unicast and multicast data transmission. AODV currently utilizes only symmetric links between neighboring nodes, but otherwise does not depend specifically on particular aspects of the physical medium across which packets are disseminated [5].

The standard unicast routing and forwarding to fulfill multicast functionality has been employed. The advantages of this approach are robustness and low overhead. However, efficiency is an issue since the generated multicast trees are normally not optimized in terms of total link cost and data delivery delay. The authors propose an efficient overlay multicast protocol to tackle this problem in MANET environment. The virtual topology gradually adapts to the changes in underlying network topology in a fully distributed manner. A novel Source-Based Steiner tree algorithm is proposed for constructing the multicast tree. The multicast tree is progressively adjusted according to the latest local topology information [6].

The author present a Position-Based Multicast routing protocol (PBM), which uses the geographic position of the nodes to make forwarding decisions. In contrast to existing approaches PBM neither requires the maintenance of a distribution structure (i.e., a tree or a mesh) nor resorts to flooding. PBM is a generalization of existing position-based unicast routing protocols, such as face-2 or Greedy Perimeter Stateless Routing (GPSR). As it is common for position-based approaches, we assume that the position of the destination(s) is known to the sender (e.g., by means of a location service), that each node knows its own position (e.g., by use of GPS), and that each node knows the position of its direct neighbors [7].

A distributed algorithm called L-REMiT for extending the lifetime of a source-based multicast tree in wireless ad hoc networks (WANET) has been presented. The lifetime of a multicast tree is the duration from the formation of the tree to the time when the first node fails due to battery energy exhaustion. L-REMiT assumes that the energy consumed to forward a packet is proportional to the forwarding distance and that WANET nodes can dynamically adjust their transmission power. The task of extending the lifetime of a multicast tree is formulated as the task of extending the lifetime of bottleneck nodes in the tree. The number of multicast packets which a bottleneck node can forward, as determined by its residual battery energy and the distance of its farthest child node, is minimum over all the nodes in the multicast tree [8].

The paper presents the protocol for unified multicasting through announcements (PUMA) in ad-hoc networks, which establishes and maintains a shared mesh for each multicast group, without requiring a unicast routing protocol or the reassignment of cores to groups. PUMA achieves a high data delivery ratio with very limited control overhead, which is almost constant for a wide range of network conditions. They compare PUMA with ODMRP and MAODV, which are representatives of mesh-based and tree-based multicast routing in ad hoc networks. The results from a wide range of scenarios of varying mobility, group members, number of senders, tree load, and number of multicast groups show that PUMA attains higher packet delivery ratios than ODMRP and MAODV, while incoming far less control overhead [9].

This paper proposes a new ad hoc multicast routing protocol called Neighbor-Supporting Multicast Protocol (NSMP). NSMP adopts a mesh structure to enhance resilience against mobility. And NSMP utilizes node locality to reduce the overhead of route failure recovery and mesh maintenance. NSMP also attempts to improve route efficiency and reduce data transmissions. Our simulation results show that NSMP delivers packets efficiently while substantially reducing control overhead in various environments [10].

The proposed multicast protocol adapts a core-based approach which establishes multicast connectivity among members through a designated node (core). An initial multicast connection can be rapidly setup by having the core flood the network with an announcement so that nodes on the reverse paths to the core will be requested by group members to serve as forwarding nodes. In addition, each member who is not the core periodically deploys a small packet that behaves like an ant to opportunistically explore different paths to the core [11].

## II. Proposed Multicast Protocols

### *A. Introduction*

I have proposed new routing protocol under the extensive simulations study of two best routing protocols of MANET. The routing protocols are:

a) ODMRP
b) MAODV

As explained ODMRP is mesh based routing protocol and MAODV is tree based protocol. Here these two protocols are representing two different categories of multicast routing protocols. Using qualities of the above routing protocols a proposal of new routing protocol is done.

The protocol simply operates in two different modes mesh mode and tree mode. The mode in which the proposed routing protocol works depend upon the condition provided by parameters defined for it.

Parameters

First of all, there are some parameters that have to be described to understand the operation of proposed protocol:

### *B. V=Velocity*

Periodically, the node checks its velocity to know if topology changes can happen. The velocity to have into account to switch from an operation mode to another is the average velocity. That is, the node checks with GPS (Global Positioning System) its position periodically. The average velocity necessary to change from the last position to the current position is the V.

### C. X=Threshold Velocity

After reviewing different performance studies of ODMRP it is concluded that it is better than MAODV in all the range of mobility since the point of view of the throughput, the total amount of generated network traffic and jitter. However, when the nodes are semi-static (at very low velocities) the MAODV can perform better in terms of delay end-to-end. In a network with not many topology changes MAODV can almost always give the shortest path available. As mentioned, ODMRP usually performs better than MAODV in every mobility environment, but at less than threshold velocity it can be interesting to use MAODV since the network is more similar to a static network than to a Mobile Ad-hoc network.

To complete this document author has to calculate threshold according to the no. of nodes, traffic and other protocol features present at that instant of time.

### D. N=Number of Nodes in the Area

N is the number of nodes working in the same area.

### E. Y=Threshold Number of Nodes in an Area

In tree mode it works in the same way that MAODV. MAODV reduces the number of “superfluous” forwarding, reduces the size of LS updates, and reduces the table size. However, while the number of nodes into an ODMRP area increases, the number of control packets increase. If the number of nodes increases, the local storage (Kbytes/node) increases. In the same study it is demonstrated that the packet delivery ratio decreases if the number of nodes is bigger than threshold.

### F. T=Traffic

T is the traffic that a node manages. This traffic is just data traffic (with no control traffic), and can be both the traffic generated by the node and the traffic routed by the node and generated in others nodes.

### G. Z=Threshold Value of Traffic

As explained before, when the traffic in the network is high, the nodes need to know the route to the destination as fast as possible. In this case a tree routing protocol outperforms the mesh one because it already has the route when necessary. However, it is quite difficult to define a threshold value for the traffic of a fixed node. In this protocol, define a high value for Z, because ODMRP can perform well for a lot of values of the traffic injected, and to decide to change to MAODV the traffic must be quite high.

### H. Operation

The protocol will work using different features depending on its velocity, traffic and environment. It defines 6 different states for a node: Initial, T1 (Tree 1), T2 (Tree 2), T3 (Tree 3), M1 (Mesh 1) and M2 (Mesh 2) states. Figure illustrates a diagram state describing the behavior of a node. Hereafter, each state is described:

- **Initial state**: When a node is reset it begins in an initial state. In this state the node must check its velocity and its traffic to decide in which mode it has to work. It defines “condition 1” as: “(V<=X) OR (T>Z)”. If condition 1 doesn’t happen then it will work in the tree mode (Tree 1), but if condition 1 happens, then it will try to work in the mesh mode. Hence, the node will pass to the Tree 3 state.
- **Tree 1**: In this state, the node works using the MAODV features. While condition 1 is not fulfilled and the node does not have connectivity with an area it will remain in the same mode of operation. In the case that the node discovers a node or more working in the Mesh 1 or Mesh 2 modes then it will work in the Tree 2 mode. If condition 1 is fulfilled, then it will try to work in Mesh mode (Tree 3).
- **Tree 2**: In this state, the node works using the MAODV features, but also must process the control messages coming from the mesh zone. This is because it needs these messages to have, in its routing table, the mesh destinations.

While there is no condition 1 and while the connectivity with any node working in the Mesh 1 or Mesh 2 modes continues the node will remain in the same state. If condition 1 is not fulfilled but the router loses the connectivity with the mentioned routers, then it will come back to the Tree 1 state. If condition 1 occurs then it will try to work in mesh mode (Tree 3 state).

- **Tree 3**: This state exists for the reason that when a node decides that to work in mesh mode is better; firstly it must join or create an area. In this state the node still works using the MAODV features, but also has to generate and to process the mesh control messages. If there is no condition 1 happened, the node will come back to the Tree 1 state. But while condition 1 happens, the node will try to join or to create an area. If it listens another node working in Tree, Mesh 1 or Mesh 2 modes, then it will join the area unless in the area the number of nodes N is >Y. If N>Y the node remains in the same state waiting to listen to other area with less number of nodes.
- **Mesh 1**: In this state the router works using the ODMRP features. If condition 1 is not fulfilled, the node will go to the Reactive 1 state. But when condition 1 is fulfilled, the node will continue working in this state unless it discovers a node working in the Tree 1 or Tree 2 states. Then it will go to the Mesh 2 state.
- **Mesh 2 (area border router)**: In this state the node works using the ODMRP features but it has to understand the tree routing messages because it needs to have in its routing table all the tree 2 nodes connected with it.

When an ABR (Area Border Router) receives a tree routing message it must look for the destination. If the destination is inside its own area, then it answers to that message reactively. If not, it forwards them to all the others ABRs of its area. The intermediate nodes are purely tree based, but they know what they have to do with those packets looking. If condition 1 is not fulfilled the node will go to the Tree 1 state. But while condition 1 occurs the node will continue working in this state unless it lost all the connectivity with the nodes working in the Tree 1 or Tree 2 states. In this case it will go to Mesh 1 mode.

A node goes to Initial State from every state when it is reset.

### *I. Message Format*

As this proposed protocol is hybrid protocol so the message format is changed from state to state in which the nodes is there. So it uses the format according to the state in which the node is lying. As the protocol majorly contains the feature of the ODMRP so the extra field is going to be added to the routing field to keep the tracks of the tree based features. It should also consider the field which should keep track of the parameters proposed hare and also has a field which checks the status of condition1.

### *J. Drawback*

The major drawback in the proposed protocol is that the control head of packets are very heavy as the condition 1 is going to full filled. This is because extra fields are going to be added into the ODMRP, which leads to the wastage of Bandwidth.

## III. Work Done, Simulation Results and Discussion

### *A. Work Done*

The network size is 1500m×1500m area for scenario simulation. There is no network partitioning throughout the entire simulation. The data transmission rate (unicast and multicast) and data transmission rate for broadcast is 2Mbits/s. At physical layer PHY 802.11b and at MAC layer MAC 802.11 is used. Multiple runs with different seed numbers are conducted for each scenario and collected data is averaged over those runs.

TABLE I. Summary of Simulation Environment

| Parameters | Values |
|---|---|
| Network Size | 1500m×1500m |
| Path Loss Model | Two ray propagation model |
| Fading model | None |
| Physical Layer Protocol | PHY 802.11b |
| Data Link Layer Protocol | MAC 802.11s |
| Data rate | 2Mbps |
| Shadowing model | Constant |
| Channel frequency | 2.4GHz |
| Number of source | 1 |
| Traffic model | CBR |
| Multicast routing protocol | ODMRP, MAODV |

The main traffic source in the simulation is Constant Bit Rate (CBR) traffic. The senders and receivers are chosen randomly among multicast members. A member joins the multicast session at the beginning of the simulation and remains as a member throughout the simulation. The packet size without header is 512 bytes. The length of the queue at every node is 50 Kbytes where all the packets are scheduled on a first-in-first-out (FIFO) basis. The parameters are summarized in Table I.

### *B. Steps Involved in Simulation*

1. Creating a new scenario.
2. Selecting no nodes.
3. Assigning the properties of nodes.
4. Selecting type of medium.
5. Apply the application between desired nodes.
6. Save the scenario and then check the output.

### *C. Simulation Results*

In this chapter, the performance of ODMRP, MAODV is investigated and analyzed based on the results obtained from the simulation. A number of experiments are performed to explore the performance of these protocols with respect to a number of parameters such as traffic load, mobility speed and node placement. Taking CBR as traffic model and uniform placement model, the values of Throughput, Packet delivery ratio, End to End delay with respect to No of nodes and Mobility of nodes.

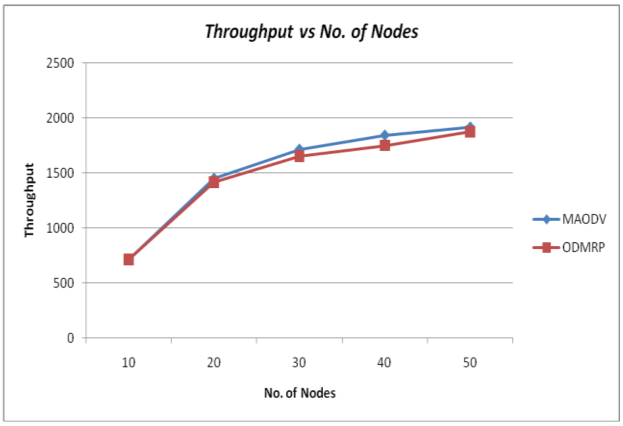



Figure 3.1. Graph shows throughput (bits/s) vs. no. of nodes

As shown in Fig. 3.1, both Protocols show continuous rise in the Throughput as the no. of nodes increases from 10 to 50 but there is difference in the slope of both after the no. of nodes are 20. The slope of ODMRP is lower than that of MAODV.

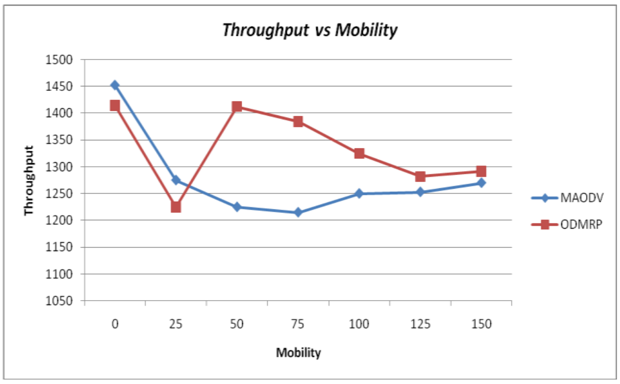



Figure 3.2. Graph shows throughput (bits/s) vs. mobility (m/s)

As shown in Fig. 3.2, initially both the protocols show decrease in throughput as the speed of the nodes are increased from 0 to 25 m/s. After that the ODMRP shows the steep increase in the throughput value till 50 m/sec and it starts decreasing as the mobility increases. As compared to MAODV its value of throughput go on decreases but at the slower rate.

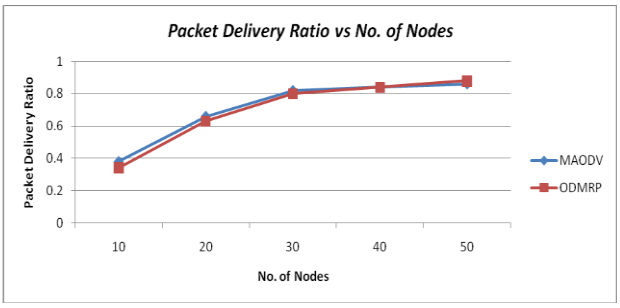



Figure 3.3. Graph shows packet delivery ratio vs. no. of nodes

As shown in Fig. 3.3, both the protocols show the constant rise in the PDR with increase in the no. of nodes but ODMRP crosses the MAODV at the 40 landmark.

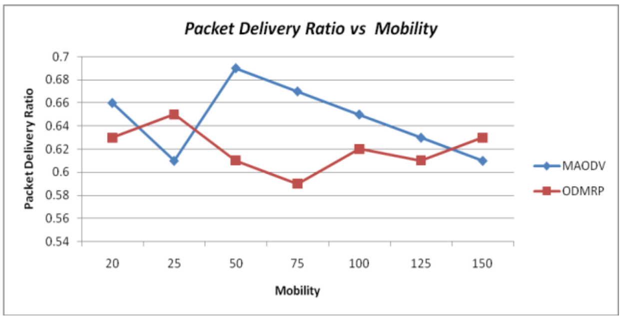



Figure 3.4. Graph shows packet delivery ratio vs. mobility (m/s)

As shown in Fig. 3.4, both routing protocols show opposite behavior in the above graph initially as the mobility increases PDR decreases for MAODV whereas the ODMRP shows slight increase in PDR value. Then afterwards the ODMRP starts decreasing and MAODV starts increasing but MAODV again start decreasing after next 25 m/s increase in mobility.

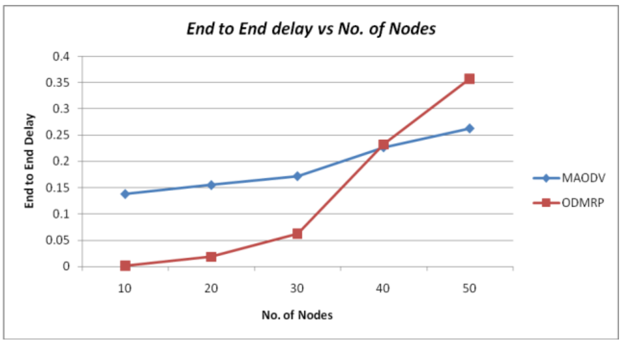



Figure 3.5. Graph shows end to end delay vs. no. of nodes

As shown in Fig. 3.5, both the protocols show the constant rise in the ETED with increase in the no. of nodes but ODMRP crosses the MAODV at the 40 landmark. This implies that slope of ODMRP is greater than that of MAODV.

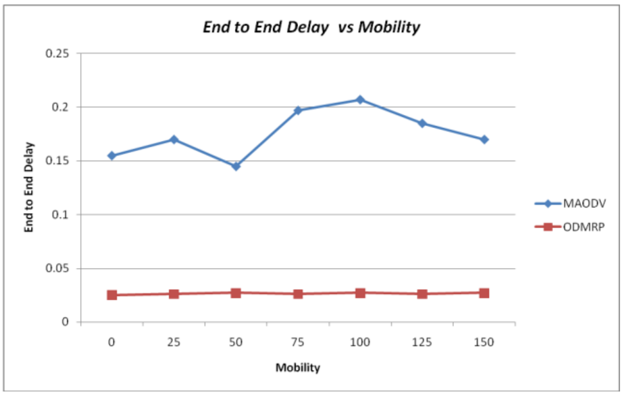



Figure 3.6. Graph shows end to end delay vs. mobility

As seen in the Fig. 3.6 with increase in mobility there is no effect on the value of end to end delay of ODMRP but the MAODV has high ETED as compared to ODMRP. MAODV shows varying increasing and decreasing value of ETED with increase in mobility.

Now, the behavior of the protocol will checked in different placement models such as Grid, Random and Uniform one by one.

After creating scenario of above specification table shows parameter results:

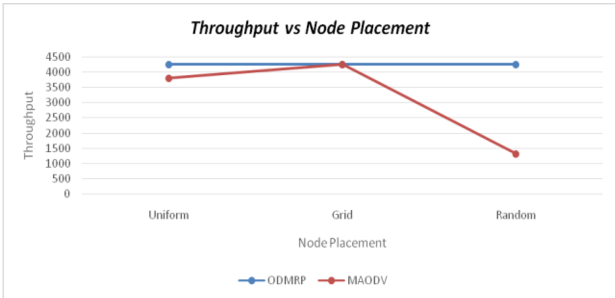



Figure 3.7. Graph shows throughput vs. node placement

As shown in Fig. 3.7, ODMRP remain constant for all three placement models where as in case MAODV the Grid Model has highest throughput and the Random Model has lowest.

Now we will compare another parameter named average end to end delay (sec) of random, grid, uniform placement models of nodes.

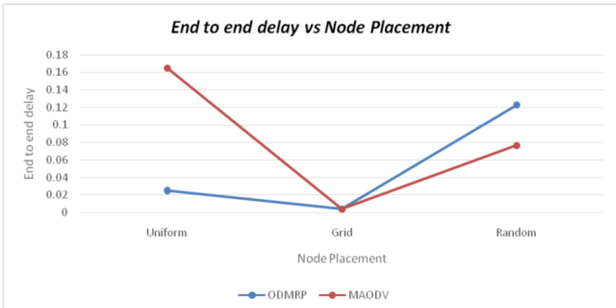



Figure 3.8. Graph shows end to end delay vs. node placement

As shown in Fig. 3.8, in case of ODMRP, grid model has the lowest value ETED parameter and highest for random whereas MAODV, grid model has the lowest value of ETED parameter and highest for uniform.

Now we will compare another parameter named average end to end delay (sec) of random, grid, uniform placement models of nodes.

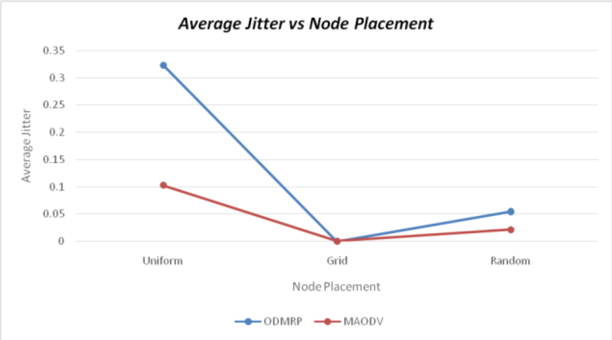



Figure 3.9. Graph shows average jitter vs. node placement

As shown in Fig. 3.9, in case of ODMRP, grid model has the lowest value ETED parameter and highest for random whereas in MAODV, grid model has the lowest value of ETED parameter and highest for uniform.

### D. Terminology

Here in this section, the definition of all the routing parameters is provided used in figures and graphs.

*Packet delivery fraction:* The fraction of packets sent by the application that are received by the receivers.

*Average end-to-end delay:* End-to-end delay indicates how long it took for a packet to travel from the source to the application layer of the destination. Average of the delay incurred by the data packets that originate at the source and delivered at the destination. End-to-end delay evaluates the ability of the protocol to use the network resources efficiently.

*Jitter:* Jitter is the variation in the time between packets arriving, caused by network congestion, timing drift, or route changes.

*Throughput:* 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 amount of the date can be transferred from one place to another or processed in a specific period of time.

## IV. Conclusions

The results obtained shows that MAODV protocol will perform better in the networks with static traffic and with a number of source and destination pairs relatively small for each host. In this case, MAODV uses fewer resources than ODMRP, because the control overhead is small. Also, they require less bandwidth to maintain the routes. Besides, the routing table is kept small reducing the computational complexity.

The ODMRP protocol is more efficient in networks with high density and highly sporadic traffic. The quality metrics are easy to expand to the current protocol. Hence, it is possible for ODMRP to offer QoS. However, ODMRP requires that it continuously have some bandwidth in order to receive the topology updates messages.

The protocol proposed is outlined on the basis of practical and theoretical study of above two protocols. The feasibility of the protocol is not checked practically, so the above protocol is just an outline. The protocol proposed work on the parameters defined section III, E, the switching capability of a protocol is based on the results obtained after comparison of these two routing protocols.

## References


[1] M. S. Azad, *et al.*, "Performance comparison of proactive and reactive multicast routing protocols over wireless mesh networks," *International Journal of Computer Science and Network Security (IJCSNS)*, vol. 9, no. 6, pp. 55-62, Jun. 2009.

[2] J. Moy, *Multicast Extensions to OSPF*, *Network Working Group Proteon, Inc.*, Mar. 1994.

[3] D. A. Maltz, J. Broch, J. Jetcheva, and D. B. Johnson, "The effects of on-demand behavior in routing protocols for multihop wireless ad hoc," *IEEE Journal on Selected Areas in Communications*, vol. 17, no. 8, pp. 1439-1453, Aug. 1999.

[4] B. O. V. Lashkari and M. Dehghan, "QoS-Aware multicast Ad hoc on-demand distance vector routing," in *Proc. World Congress on Engineering*, London, U.K., Jul. 2-4, 2007.

[5] E. M. Royer and C. E. Perkins, "Multicast operation of the ad hoc on-demand distance vector routing protocol," in *Proc. MobiCom*, 1999, pp. 207-218.

[6] C. Gui and P. Mohapatra, "Efficient overlay multicast for mobile Ad Hoc networks," in *Proc. IEEE WCNC*, New Orleans, LA, Mar. 2003.

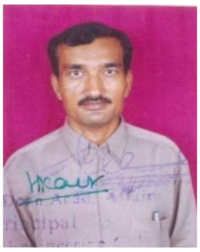
[7] H. Mauve, H. Füßler, J. Widmer, and T. Lang, "Poster: Position-Based multicast routing for mobile ad-hoc networks. mannheim," in *Proc. Fourth ACM International Symposium on Mobile Ad Hoc Networking and Computing: MobiHoc*, Germany, 2003.

[8] J. J. Garcia-Luna-Aceves and E. L. Madruga, "The core-assisted mesh protocol," *IEEE Journal on Selected Areas in Communications*, vol. 17, no. 8, pp. 1380-1384, Aug. 1999.

[9] S. Lee and C. Kim, "Neighbor supporting ad hoc multicast routing protocol," in *Proc. 1st ACM International Symposium on Mobile Ad Hoc Networking and Computing*, Boston, Massachusetts, USA, 2000.

[10] C.-C. Shen and C. Jaikaeo, "Ad hoc multicast routing algorithm with swarm intelligence," *Mobile Networks and Applications*, vol. 10, pp. 47-59, 2005.

[11] T.-C. Chiang and Y.-M. Huang, "Multicast routing representation in ad hoc networks using fuzzy petri nets," in *Proc. IEEE 18th International Conference on Advanced Information Networking and Applications*, 2004, pp. 1-4.

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