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# Evaluation of Multicasting Algorithms in Manets

Alexandros Vasiliou and Anastasios A. Economides

***Abstract*—** Disaster relief, education, and military are common situations where mobile nodes need to communicate in areas without any preexisting infrastructure. In these situations, MANETs (Mobile Ad-Hoc Networks) are used. When these nodes need one-to-many or many-to-many communication then multicasting is employed. Two of the best multicast protocols, MAODV (Multicast Ad-hoc On-demand Distance Vector Routing Protocol) and ODMRP (On Demand Multicast Routing Protocol), are compared. The performance measures to be evaluated are the PDR (Packet Delivery Ratio) and the Latency. Previous studies evaluate these algorithms with respect to the network traffic and the node speed. This study evaluates these algorithms with respect to the network traffic, the node speed, as well as the area and the antenna range for different simulation scenarios. MAODV performs better for high traffic. ODMRP performs better for large areas and high node speeds and poorer for small antenna ranges.

***Keywords*—** MANET, Mobile Ad-Hoc Networks, Multicasting, Performance Evaluation.

## I. Introduction

MANETs are self organizing mobile ad hoc networks without the need for a pre-existing infrastructure. Every node is acting as a sender, as a receiver and as a router at the same time. Devices such as laptops, PDAs, mobile phones, pocket pc with wireless connectivity are commonly used. If two nodes are in the transmission range of each other then they can communicate directly. Otherwise, they reach each other via a multi-hop route. MANETs have a wide range of applications such as disaster relief, battlefields, and crowd control.

However in MANETs, routing and multicasting are extremely challenging.

Nodes in these networks move unpredictably, thus the network topology changes frequently. Furthermore, there is a power limit due to the batteries of the node devices. Bandwidth limit is another serious constrain.

Multicast is the transmission of data in a group of nodes which is recognized by one and unique address. Groups exist in most MANETs scenarios and the use of multicast, rather unicast reduces the bandwidth and energy cost, and the end-to-end delay [1].

Two basics architectures are used in multicast MANET protocols. Tree-based protocols, where MAODV seems to be the most discussed tree-based protocol [2], and mesh based protocols, where ODMRP is considered to be the best mesh-based protocol [3].

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Hybrid architecture is discussed in [4]. Technologies such as GPS (Global Position System) can be used to predict the move of the node and provide universal timing [5].

In this paper we compare MAODV and ODMRP extending the experiments in [6] and investigating additional simulations parameters, such as the area and the antenna range. We evaluate the PDR and Latency for different traffic, speed of the nodes, areas where the nodes move, and antenna range.

This paper is organized as follows. In section II, MAODV and ODMRP are described. In section III, the simulation scenarios are defined. In section IV the simulation results are discussed. Finally, in section V, conclusions are drawn.

## II. Manet Multicast Protocols

### *A. MAODV*

MAODV is the multicast extension of the AODV protocol. It is an On-Demand protocol, so it discovers the routes only when it has something to send. It is a hard state protocol, so if a member node of a multicast group wants to terminate its group membership, it must ask for it. When a mobile node wants to join a multicast group or wants to send a message but does not have a route to the group, a Route Request (RREQ) is originated. MAODV is a tree based protocol. All the nodes that are members of a multicast group together with the nodes that are not members of the group but their position are very critical for forwarding the multicast information, compose the tree structure. Every multicast group is identified by a unique address and group sequence numbers for tracing the freshness of the group situation. When a node sends a not join RREQ any node with fresh enough route (based on group sequence number) to the multicast group may respond. If the message is a join RREQ then only member nodes of the multicast group can answer. If a node wants to be member of a multicast group that does not exists, then this node is becoming the leader of that multicast group and is responsible for maintaining the multicast group. This is established through a Group Hello message. Nodes use the Group Hello information to update their request table. A node keeps not only the unicast routing table but also a multicast routing table for the group tree structure. This table contains the multicast group address, the multicast group leader address, the multicast group sequence number, hop count to the multicast group leader next hop information and the lifetime**.** Nodes in a tree structure are described as downstream and upstream nodes. A downstream node is a neighborhood node which is further from the group leader (more hop counts from the group leader). An upstream node is a neighborhood node which is nearer to the group leader (less hop counts from the group leader). It is obvious that a group leader has only downstream nodes. When a node leaves the multicast group, the tree structure needs pruning. When a link breaks, the most downstream node is responsible for repairing the breakage [1], [2], [6], [7], [8].

### *B. ODMRP*

ODMRP is also an On-Demand protocol. It is a mesh architecture protocol, so it has multiple paths from the sender to the receivers, contrary to the MAODV which is a tree based protocol and has only one path to the receivers. When a node has information to send but no route to the destination, a Join Query message is broadcasted. The next node that receives the Join Query updates its routing table with the appropriate node id from which the message was received for the reverse path back to the sender (backward learning). Then the node checks the value of the TTL (time to live) and if this value is greater than zero it rebroadcasts the Join Query. When a multicast group member node receives a Join Query, it broadcasts a Join Reply message. A neighborhood node that receives a Join Reply consults the join reply table to see if its node id is the same with any next hop node id. If it is the same then the node understands that it is on the path to the source and sets the FG_FLAG (Forwarding Group flag). ODMRP is a soft state protocol, so when a node wants to leave the multicast group it is over passing the group maintaining messages [1], [3], [6], [7], and [9].

## III. SIMULATION SCENARIOS

We use the NS-2 simulator with the MAODV implementation for ns-2.26 [10] and the monarch project [11] for simulating the ODMRP protocol.

### A. Different traffic

In these scenarios, we compare the performance of MAODV and ODMRP for different traffic: 1, 5, 10, 20 and 50 KByte/sec. We measure the PDR (Packet Delivery Ratio) and the Latency for the two protocols. PDR is the ratio of the number of packets sent to the number of packets received and shows the reliability of the protocol. Latency is the average end-to-end packet delay.

TABLE I SIMULATION PARAMETERS FOR THE DIFFERENT TRAFFIC SCENARIOS

| | |
|---|---|
| Number of nodes | 50 |
| Number of senders | 1 |
| Number of receivers | 20 |
| Speed | 1m/sec |
| Antenna range | 250m |
| CBR | 1, 5, 10, 20, 50 KByte/sec |
| Area | 1000m * 1000m |

### B. Different areas

In these scenarios, we compare the performance of MAODV and ODMRP for different areas. The nodes may move in areas of: 100m*100m, 500m*500m, 1000m*1000m, 1500m*1500m, and 2000m*2000m. We measure the PDR and the Latency for the two protocols.

TABLE 2. SIMULATION PARAMETERS FOR THE DIFFERENT AREA SCENARIOS.

| | |
|---|---|
| Number of nodes | 50 |
| Number of senders | 1 |
| Number of receivers | 20 |
| Speed | 1m/sec |
| Antenna range | 250m |
| CBR | 1 KByte/sec |
| Area | 100m*100m, 500m*500m, 1000m*1000m, 1500m*1500m, 2000m*2000m |

### C. Different speeds

In these scenarios, we compare the performance of MAODV and ODMRP for different node speeds: 1m/sec, 5m/sec, 10m/sec, 15m/sec, and 20m/sec. We measure the PDR (Packet Delivery Ratio) and the Latency for the two protocols.

TABLE3. SIMULATION PARAMETERS FOR THE DIFFERENT SPEED SCENARIOS

| | |
|---|---|
| Number of nodes | 50 |
| Number of senders | 1 |
| Number of receivers | 20 |
| Speed | 1, 5, 10, 15, 20 m/sec |
| Antenna range | 250m |
| CBR | 1 KByte/sec |
| Area | 1000m*1000m |

D. Different antenna ranges

In these scenarios, we change the antenna range and measure how MAODV and ODMRP perform. Using antenna range of: 100m, 150m, 200m, 250m, 500m, we measure the PDR and the Latency for the two protocols.

TABLE 4. SIMULATION PARAMETERS FOR THE DIFFERENT ANTENNA RANGE SCENARIOS

| | |
|---|---|
| Number of nodes | 50 |
| Number of senders | 1 |
| Number of receivers | 20 |
| Speed | 1 m/sec |
| Antenna range | 100, 150, 200, 250, 500 m |
| CBR | 1 KByte/sec |
| Area | 1000m*1000m |

## IV. SIMULATION RESULTS

Fig. 1 shows the severe PDR degradation as the traffic increases for both protocols. None outperforms the other in all cases.

Fig. 2 shows that the PDR of MAODV is better for small areas up to 1000m*1000m. For larger areas ODMRP performs better.

Fig. 3 shows that the PDR of MAODV is better for node speed up to 10m/sec. ODMRP is not influenced by the node speed and performs better than MAODV for speed larger than 10m/sec.

Fig. 4 shows that changing the antenna's range has the same influence on both protocols. Note also that for antenna range= 100m, ODMRP cannot perform.

Fig. 5 shows that both protocols have the same extremely small latency for traffic up to 10 KBytes/sec. For heavier traffic MAODV outperforms.

Fig. 6 shows that ODMRP achieves smaller latency up to areas of 1500*1500m. In areas of 2000*2000m MAODV achieves smaller latency.

Fig. 7 shows that ODMRP's latency is the smallest for any node speed.

Fig. 8 shows that ODMRP cannot function for antenna range= 100m. ODMRP's latency is smaller for antenna range of 150 and 200m. MAODV performs better for antenna range= 250m.

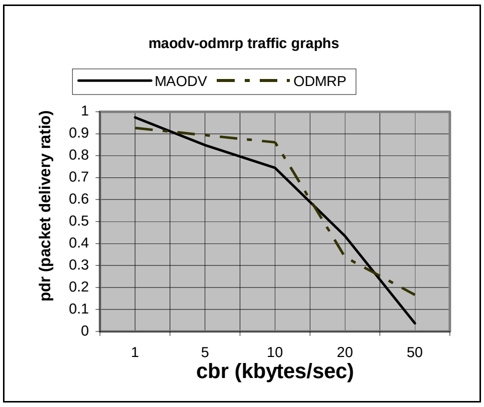


Fig.1 PDR versus traffic.

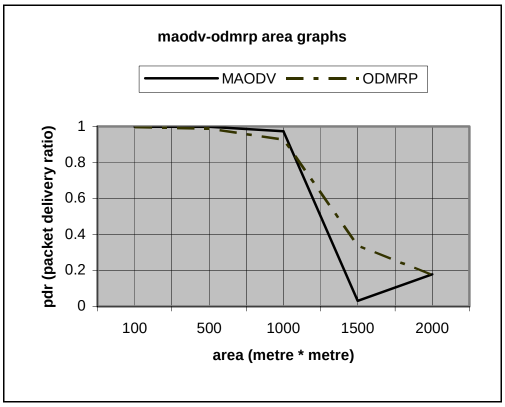


Fig. 2 PDR versus area.

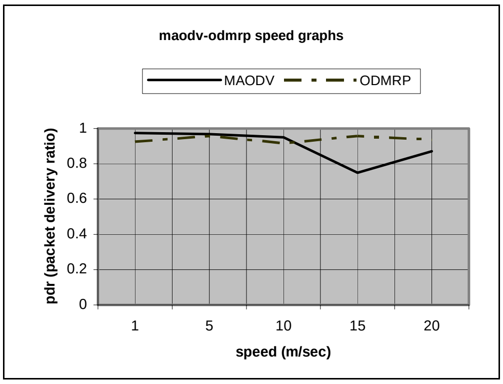


Fig. 3 PDR versus node speed.

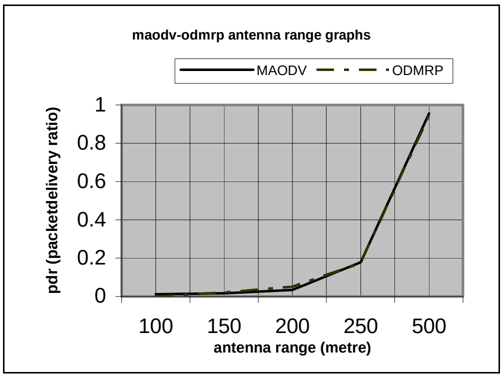


Fig. 4 PDR versus antenna range.

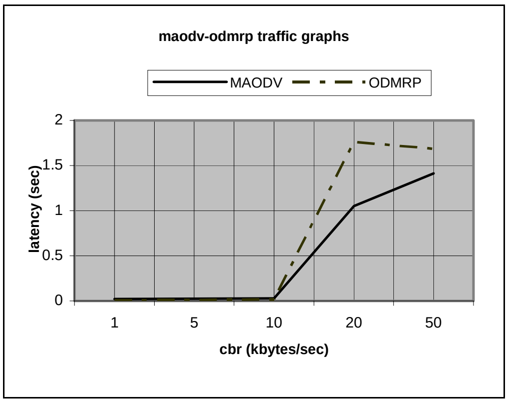


Fig.5 Latency versus traffic.

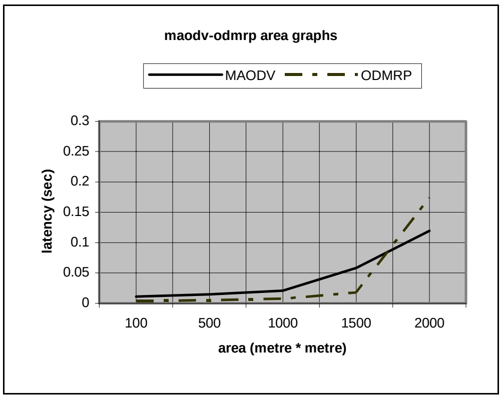


Fig. 6 Latency versus area.

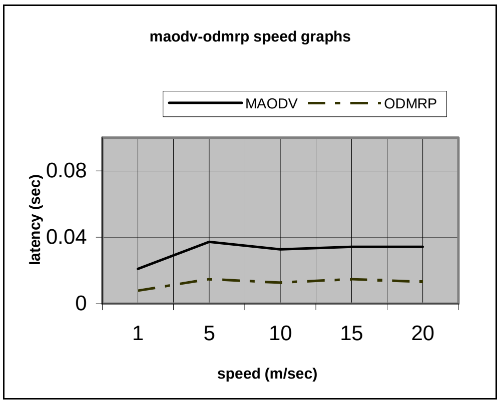


Fig. 7 Latency versus node speed.

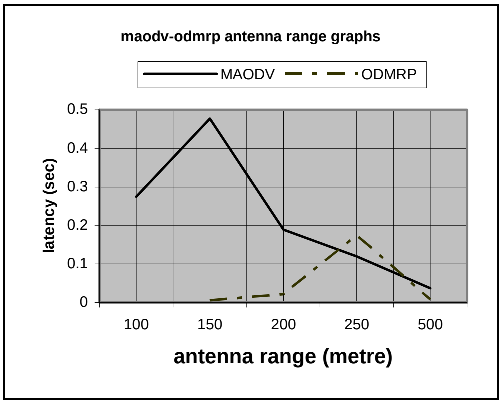


Fig. 8 Latency versus antenna range.

## V. Conclusion

Concluding, the two protocols behave differently for different scenarios. For traffic up to 10 KBytes/sec, ODMRP is slightly better, and after that point MAODV performs better. For small areas, MAODV achieves better PDR while ODMRP achieves better latency. For large areas, ODMRP achieves better PDR while MAODV achieves better latency. For different node speeds, both protocols perform well with ODMRP performing better as the speed increases. For different antenna range, both protocols perform similarly with ODMRP achieving better latency but being unable to function for antenna range of 100m. Depending on the application, one may choose one of these protocols.

## References

[1] P. Mohapatra, J. Li, C. Gui " *Multicasting in Ad Hoc Networks*", book chapter, Kluwer Press, 2004.

[2] Elizabeth M. Royer , Charles E. Perkins, "*Multicast Operation of the Ad-hoc On-demand Distance Vector Routing Protocol*", Proceedings of MobiCom '99, Seattle, WA, August 1999, pp. 207-218.

[3] S.-J. Lee, M. Gerla, and C.-C. Chiang, "*On-demand multicast routing protocol*" Proceedings of IEEE WCNC, 1999, pp. 1298-1302.

[4] C.Chiang, M.Gerla, and L.Zhang " *Adaptive shared tree multicast in mobile wireless networks*" Proceedings of IEEE Globecom '98, pp. 1817-1822.

[5] X. Hong, K. Xu, and M. Gerla, "*Scalable Routing Protocols for Mobile Ad Hoc Networks*"m IEEE Network, July-Aug, 2002, pp. 11-21.

[6] Thomas Kunz and Ed Cheng "*Multicasting in Ad-Hoc Networks: Comparing MAODV and ODMRP*", Proceedings of the Workshop on Ad hoc Communications, Bonn, Germany, September 2001.

[7] D.Lundberg " *Ad Hoc Protocol Evaluation and Experiences of real world Ad Hoc networking*" Uppsala University Department of Information Technology , technical report 2004-026, June 2004.

[8] Thomas Kunz, "*Reliable Multicasting in MANETs*", Contractor Report, Communications Research Centre, Ottawa, Canada, July 2003.

[9] R. Bagrodia, M. Gerla, J. Hsu, W. Su, and S.-J. Lee, "*A performance comparison study of ad hoc wireless multicast protocols*", Proc. of the 19th Annual Joint Conf. of the IEEE Computer and Communications Societies, March 2000, pp. 565 –574.

[10] Y.Zhu and T.Kunz " *MAODV Implementation for NS-2.26* " Systems and Computing Engineering, Carleton University, Technical Report SCE-04-01, January 2004.

[11] http://monarch.cs.rice.edu

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