Comparison of MANET Multicast Routing Protocols by Varying Number of Nodes

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Abstract – Mobile Ad hoc Network (MANET) is a free flowing network. There is no central control. Each node acts as a router. The routing protocols for this type of network needs lot of consideration because of the changing topology, limited bandwidth and energy. For multicast routing, mesh-based protocols are more robust against the topology changes than the tree based routing protocols. The mesh-based multicast routing protocol, ODMRP (On-Demand Multicast Routing Protocol) and the tree-based routing protocol, MAODV (Multicast Ad-hoc On-Demand Distance Vector) are considered for the comparison. To analyze the performance level of the mesh-based protocol against the tree-based protocol with the performance metrics such as throughput, routing overhead, transmission overhead, packet delivery ratio, dropping of packets and average end-to-end delay under a various number of nodes using NS2.To compare the performance metrics of two protocols, the number of nodes in the network is gradually increased from 10 to 110. The analysis of performance shows that the tree-based multicast routing protocol has higher packet delivery ratio, end-to-end delay than the mesh-based routing protocol.

Index Terms – MANET, Multicast routing, MAODV, ODMRP and Overhead.

1. INTRODUCTION

MANETs are self-organizing mobile ad hoc networks without the need for a pre-existing infrastructure. Every node in this 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 for forming the ad hoc network. Generally in ad hoc network, 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. The MANETs have a wide range of applications such as disaster relief, battlefields, and crowd control. The routing is important operation in this network because of its dynamic topology. A lot of routing protocols have been developed for different purposes. The MANET routing protocols are broadly classified into three categories: Proactive (table-driven), Reactive (on-demand) and Hybrid. [1].

- Proactive routing protocols: all routes are maintained all the time. The main disadvantages of such algorithms are the respective amount of data for maintenance and slow reaction on restructuring and failures.
- Reactive routing protocols: routes are established on demand. The main disadvantages of such algorithms are: high latency time in route finding and excessive flooding can lead to network clogging.
- Hybrid routing protocols: a combination of proactive and reactive approaches. The main disadvantages of such algorithms are: advantage depends on a number of nodes activated and reaction to traffic demand depends on the gradient of traffic volume.

The classification of MANET routing protocols based on data transmission mode: Unicast, Multicast, and Broadcast.

- Unicast: information is sent from one sender to only one receiver.
- Multicast: sending information from more than one sender to multiple receiver nodes. When compared to multiple unicast, multicast saves bandwidth.
- Broadcast: one sender sends information to all nodes in the network.

Multicast routing protocols again divided into three: Tree-based, Mesh-based and Hybrid.[2].

- Tree-Based: This type of routing protocols maintains only one path to reach a destination. It has two types: Source-Tree based routing protocols and Shared-tree based routing protocols. Examples are ACMR, STAMP, MAODV, AMRIS, LAM, LGT.
- Mesh-Based: These type protocols use several routes to achieve the destination. The mesh-based approaches sacrifice multicast efficiency in comparison to tree-based

approach. Examples are CAMP, ODMRP, DCMP, NSMP, FGMP, BODS,CQMP.

- Hybrid: It takes the advantages of both tree and mesh-based protocols. So these protocols are more robust and efficient. Examples are AMRoute, MCEDAR.

Mobile ad-hoc networks are flexible networks which support various group applications like spontaneous joint activities and emergency operations. In this network, nodes are in the form of mobile without a wired infrastructure. Due to this reason, topology is also dynamic. So routing is a critical process [3]. Different varieties of multicast routing protocols are proposed for ad hoc networks. The tree-based approaches are bandwidth-efficient and they do not always offer sufficient robustness due to mobility susceptible for link failure. The mesh-based routing protocols are very robust against dynamic topology because of they have redundant paths to a destination. The mesh-based multicast routing protocols have more data overhead and control overhead than the tree-based protocols [4].

However, in the MANETs, routing, specifically, multicasting routing is an extremely challenging process. Since nodes in these networks move unpredictably, the network topology changes frequently. Furthermore, there is a power limit due to the batteries of the node. The bandwidth limit is another serious constraint [5]. The multicast is the transmission of data in a group of nodes which is recognized by one and unique address. The use of multicast, rather unicast reduces the bandwidth, the energy cost, and the end-to-end delay for the group communication applications [6]. The main aim of this work is to explore the performance characteristics of tree-based and mesh-based multicast routing protocols. For this, in-depth simulation using different scenarios like the mobility of nodes, traffic source conditions, and multicast group characteristics are carried out. The performance of multicast routing protocol ODMRP, which is a mesh-based, is compared against with tree-based multicast routing protocol MAODV with a different number of nodes considered for the performance evaluation.

The following sections in this paper are arranged as follows: Section 2 depicts the overview of MAODV protocol and the overview of MAODV protocol and Section 4.

2. RELATED WORK

2.1. REVIEW OF MAODV PROTOCOL

The base protocol for MAODV is AODV. This is a tree-based multicast routing protocol in which nodes quickly respond to breakage of links in multicast trees by revising these intermittently. The Multicast AODV is based on bidirectional shared trees that are created and terminated when the multicast receivers join and leave the multicast groups. Normally the first node that wants to join the multicast group, selects itself as the multicast group leader. The sole purpose of this node is that it keeps count of the sequence number that is tied to the multicast group address. The group leader handles the sequence number by sending periodic Group Hello messages. The group leader and group sequence number form the tree in MAODV. Each group has a sequence number. The group leader updates the number to other nodes by means of Group Hellos (GRPHs) when changes are made. The first node joins the group acts as group leader. If the nodes want to join a group then they send a unicast route request (RREQ) with the address of group leader or broadcast a RREQ packet if the group leader is unknown. The route discovery process in MAODV is same as AODV [7]. This process reduces the control overhead.

When a node wishes to join the multicast group or it wants to send packets to the group, it needs to find the route to the group. This is done using two messages; RREQ and RREP in a so-called discovery cycle. The RREQ is used to discover a route towards a multicast (or unicast) destination. When the node sends this message, it initiates an RREP_WAIT_TIMER which has no default value as of writing this but which should be at least latency of single hop time the diameter of the network times two. If the node does not get an answer, then it retries twice by default. If there is still no answer, then the node selects itself as the group leader if it wants to join the tree. However, if it only wants to send data to the tree and it cannot find the tree, then it silently discards this traffic. The RREQs are sent as broadcasts throughout the network. To prevent broadcast storms, the AODV uses a technique called expanding ring search. When a node receives an RREQ for a multicast route, it first checks the Join-flag in the message. If the Join-flag is set, then the node may answer only if it is itself a member of the multicast tree and its sequence number for this tree is at least as great as the number in the RREQ. If the Join-flag is not set, then the node may answer, if it has an unexpired route to the multicast tree and its sequence number is at least as great as the number in the RREQ. If neither of the above is true, then the node must find the route towards the multicast tree itself. In addition, to this rebroadcast, a node does two things [8]:

- It creates a reverse unicast route for the node which originally sends the RREQ.
- It creates a multicast table entry for the multicast group in question.

A single node may get multiple replies to the RREQ message. It must choose the best out of these to be used for the multicast tree creation. For this reason, the next hop node that is selected by the node wishing to join the multicast tree is informed about this fact by sending an MACT message. The receiver of the MACT message updates its multicast routing table by setting the source of the message as a downstream next hop neighbour.

The MACT message has four flags that can be set. These are joined, prune, grp LDR and update. The membership of the multicast group is dynamic. Each node is free to join or leave the group at any time. However, since a node may also act as an intermediate multicast tree hop, it might not be able to leave the tree, even if it does not want to receive the traffic for the group. Actually, the fact is that a node may only leave the tree in two cases: 1) If it is a leaf node (no downstream multicast group neighbours) and 2) If it is an intermediate tree node and the last downstream node of it leaves the tree. The leaving of the tree is done by sending the MACT message with the prune-flag set.

The multicast group members reply its distance from group leader with group sequence number by means of a route reply (RREP) packet. A node sends a multicast activation message to the nearest member with an updated sequence number for joining the group. After receiving multicast activation (MACT) message, all the intermediate nodes are included as the members of the tree.

A prune message is sent to upstream by a node if it wants to leave a group. The maintenance of network partition is done through group hello (GRPH) message. When a node receives multiple GRPH packets, it starts a group election protocol which is used to select a single group leader. The MAODV maintains a routing table for the multicast routes. In addition, a node may also keep a multicast group leader table.

Even if the AODV and MAODV protocols may be used also in fixed networks, it is most likely that the implementations are seen in ad hoc networking. Since ad hoc networks are highly dynamic by nature, this means that also the multicast tree is highly dynamic. The changes in the network topology may lead to two different situations; a) A link is broken-What the node does is that it sends an RREQ with a Multicast Group Leader Extension.

This extension contains the old distance of the node to the group leader and the b) Multicast tree is partitioned- then it becomes a new group leader. It broadcasts group hello message with update-flag set indicating that there is a new group leader. When a network partition occurs, multicast trees per partition are formed3.

When the two network partitions become united once again, there are two multicast group members for a single multicast group. Then the group leader that has numerically lower IP address joins the tree of the other group leader. It does this by sending an RREQ with the repair-flag set.

The tree contains members of two distinct classes. The member can be either a node that has joined the multicast tree or a node that has not joined the multicast group but is forwarding the multicast packets towards other nodes in the tree. The MAODV uses four different message types for the creation of the multicast routing table. These messages are: Route request (RREQ), Route reply (RREP), Multicast activation (MACT) and Group hello (GRPH). The RREQ and RREP are used in the unicast operation of AODV. The others are used only for MAODV.

2.2 Review Of ODMRP Protocol

The on demand routing techniques use to avoid channel overhead and improve scalability. The On-Demand Multicast Routing Protocol (ODMRP) is an on-demand mesh based multicast routing protocol. A group of nodes forms a mesh that is known as forwarding nodes. These nodes send the packets to destinations and keep a message cache to detect the duplicate data and control packets4. They are responsible for forwarding multicast data on shortest path in order to build a forwarding mesh for each multicast group. By using mesh, the drawbacks faced in multicast trees are avoided. In ODMRP soft state approach is taken. There is a reduction of channel overhead by this ODMRP, which makes this scalable. It maintains the data structures such as member table, routing table, and forwarding group table and message cache [9].

The group membership and multicast routes are established and updated by the source on demand. Actually ODMRP is similar to on-demand unicast routing protocols, a request and reply phase comprises the protocol. While multicast host has packets to send then it broadcast to the entire network a member advertising packet called as Join_Req. This correspondingly updates the route. When a node receives a non-duplicate Join_Req, it stores the upstream node id and rebroadcast. An intermediate node on the receipt of a Join_Reply packet sets a forwarding flag. Then, they become a member of the forwarding group in that multicast group. The mesh maintenance is carried out by soft state approach. This protocol resilient against the link and node failure since it has a forwarding group. But it has higher control overhead and multiple transmission of the same data packet through the network. This leads to decrease the efficiency of the routing process [10].

When a node receives a JOIN TABLE, it checks if the next node ID matches its own ID. If it does, the node realizes that it is on the path to the source and thus is part of the forwarding group. It then sets the FG Flag and broadcasts its own JOIN TABLE. The JOIN TABLE is propagated by each forwarding group member until it reaches the multicast source via the shortest path. Through the shortest reverse path, the receivers reply to the request by sending a Join_Reply. The each node in sender to receivers that receives the Join_Request packet stores the upstream node identity before broadcasting the packet. The Join_Reply packet comprises the Source Id and the Next Node ID. This forms the forwarding group. When this packet reaches a multicast receiver it updates or creates the source entry in a member table. A multicast receiver can also be a forwarding group node if it is on the path between a multicast source and another receiver. The flooding redundancy among forwarding group helps overcome node displacements and channel fading. Hence, unlike trees, frequent reconfigurations are not required.

Suppose the route from S1 to R2 is S1-A-B-R2. In a tree configuration, if the link between nodes A and B breaks, R2 cannot receive any packets from S1 until the tree is reconfigured. The ODMRP, on the other hand, already has a redundant route (e.g., S1-A-C-BR2) to deliver packets without going through the broken link between nodes A and B. After the group establishment and route construction process, a multicast source can transmit packets to receivers via selected routes and forwarding groups. When receiving a multicast data packet, a node forwards only non-duplicate and the setting of the FG Flag for the multicast group has not expired. If a multicast source wants to leave the group, it simply stops sending Join_Req packets. If a receiver no longer wants to receive from a particular multicast group, it removes the corresponding entries from its Member Table and does not transmit the JOIN TABLE for that group. Not only the ODMRP can work with any unicast routing protocol, it can function as both multicast and unicast. Thus, the ODMRP can run without any underlying unicast protocol.

3. SIMULATION

3.1. Simulation Environment

A wireless network is simulated, with a minimum of 10 nodes moving in the defined area. Each node moves randomly in this area, with a speed selected in a range [0, v_{max}] with no pause time. Between mobile hosts, there is a TCP source generating 8 packets/second (with a packet size of 512 bytes). The duration of each simulation is 100 milliseconds. To have detailed traffic-related information over a simulation, the ns-2 code was modified to obtain the amount of network traffic over time. In this way, accurate information was obtained at every simulation time to evaluate the protocols from the traffic point of view.

Table.1 Simulation Parameters

Parameters	Values
Routing Protocols	MAODV,ODMRP
Mobility Model	Manhattan grid model
Simulation Duration	100 milliseconds
Number of nodes	10-110
Simulation Area	500x500m
Nodes Speed	0 to 20-meter per second(random)
Antenna	Omni antenna
MAC	802.11g
Traffic	CBR
Application	RTP
Data Packet Size	512 bytes
Rate	8 packets/sec

3.2. Simulation Results

Table.2 Performance Comparison of MAODV with ODMRP

No. Of nodes	Throughput		Packet delivery ratio		Jitter		Routing overhead		Dropped packets		Transmission overhead	
	MAODV	ODMRP	MAODV	ODMRP	MAODV	ODMRP	MAODV	ODMRP	MAODV	ODMRP	MAODV	ODMRP
10	High	Low	High	Low	High	Low	Low	Low	High	Low	Low	High
20	Low	High	High	Low	High	Low	Low	Low	High	Low	Low	High
30	Low	High	High	Low	High	Low	Low	Low	High	Low	Low	High
40	High	Low	High	Low	High	Low	Low	High	High	Low	Low	High
50	Low	High	High	High	High	Low	Low	Low	High	Low	Low	High
60	High	Low	High	Low	High	Low	Low	High	High	Low	High	Low
70	Low	High	High	Low	High	Low	Low	High	High	Low	High	Low
80	High	Low	High	Low	High	Low	Low	High	High	Low	Low	High
90	High	Low	High	Low	High	Low	Low	High	High	Low	High	Low
100	High	Low	High	Low	High	Low	Low	High	High	Low	High	Low
110	High	Low	High	Low	High	Low	Low	High	High	Low	High	Low

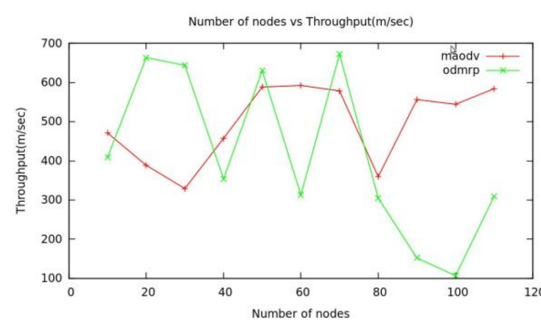

Figure.1 Number of Nodes Vs Throughput

Figure.2 Number of Nodes Vs Packet Delivery Ratio

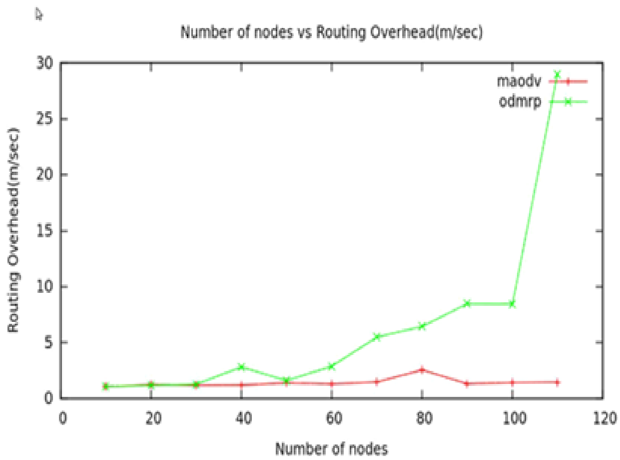

Figure.3. Number of Nodes Vs Routing overhead

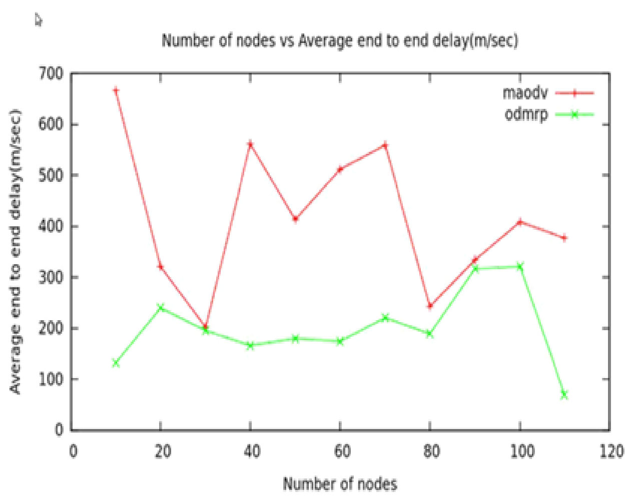

Figure.4 Number of Nodes Vs average end-to-end delay

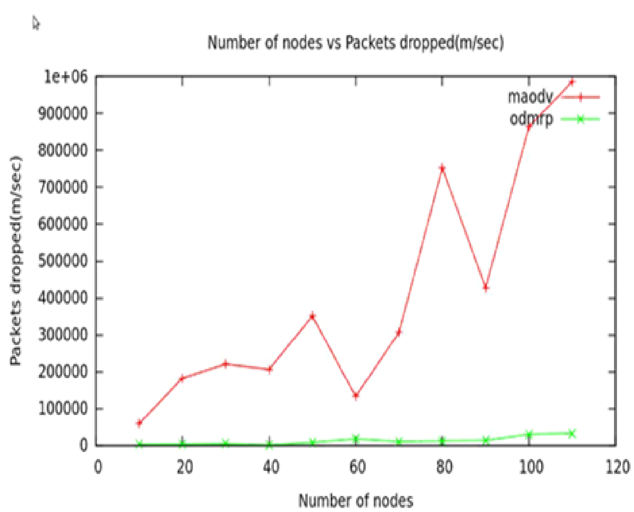

Figure.5 Number of Nodes Vs Packet dropped

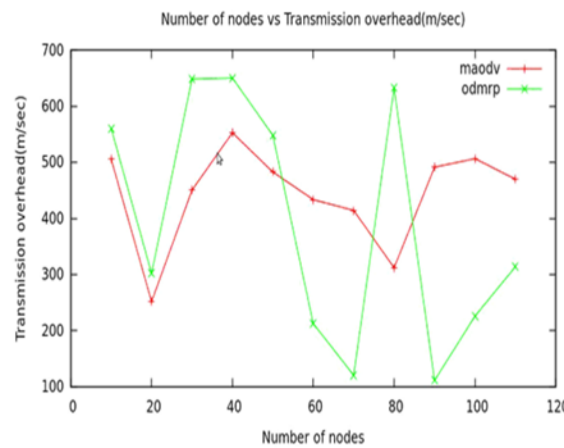

Figure.6 Number of Nodes Vs Transmission overhead

4. CONCLUSION

The various performance parameters have considered measuring the relative pros, cons of each multicast protocol with varying number of nodes. From the simulation results, MAODV has a higher average end-to-end delay which makes it unsuitable for multimedia and web applications. In the case of increasing the number of traffic sources, MAODV outperforms ODMRP in throughput and quality of service with less routing and transmission overhead. The ODMRP has less end-to-end delay than the MAODV. So this protocol is fit for the applications like video streaming. It has high overhead to lead unfair bandwidth utilization and network congestion. In future, we will consider various simulation parameters such as node's speed, pause time, interval time and multiple senders and receivers for analyzing the ODMRP protocol's performance against the MAODV protocol.

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