Static and Dynamic Study of the Performance of Multicast in Ad Hoc Networks Using ODMRP Protocol

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Abstract
An ad hoc network is a collection of wireless mobile nodes dynamically forming a temporary network without the use of any preexisting network infrastructure or centralized administration. On Demand Multicast Routing protocol (ODMRP) is a multicast routing protocol for mobile ad hoc networks. Its efficiency, simplicity, and robustness to mobility renders it one of the most widely used MANET multicast protocols. In this paper, our proposed scheme presents two different scenarios (static and dynamic) used to study the performance of ODMRP as a multicast routing protocol based on mesh topology and fmally concluded that protocol operates well in dynamic environment than in static one because the mobile node has a better packet delivery ratio than in static scenario.
Keywords: Multicast, Ad hoc, Simulation, ODMRP, MANET, MCBR

1. Introduction

Ad hoc wireless networks find applications in civilian operations (collaborative and distributed computing), emergency search-and-rescue, law enforcement, and warfare situations, where setting up and maintaining a communication infrastructure may be difficult of costly (1). In all these applications, communication and coordination among a given set of node are necessary. Multicast routing protocol plays an important role in ad hoc wireless networks to provide this communication. It is always advantageous to use multicast rather than multiple unicast, especially in the ad hoc environment, where bandwidth comes at a premium.

Conventional wired network Internet protocol (IP) multicast routing protocols such as DVMRP (2), MOSPF (3), CBT (4), and PIM (5) do not perform well in ad hoc networks because of the dynamic nature of the network topology. The dynamically changing topology coupled with relatively low bandwidth and less reliable wireless links, causes long convergence times and may give rise to formation of transient routing loops which rapidly consume the already limited bandwidth.

In a wired network, the basic approach adopted for multicasting consists of establishing a routing tree for a group of routing nodes that constitute the multicast session. Once the routing tree (or the spanning tree, which is an acyclic connected sub graph containing all the nodes in the tree) is established, a packet sent to all nodes in the tree traverses each node and each link in the tree only once. Such a multicast structure is not appropriate for ad hoc networks because the tree could easily break due to the highly dynamic topology.

Multicast tree structures are not stable and need to be reconstructed continuously as connectivity changes. Maintaining a routing tree for the purpose of multicasting packets when the underlying topology keeps changing frequently can incur substantial control traffic. The multicast tree used in the conventional wired network multicast protocols require a global routing sub- structure such as a link state (6) or distance vector (6) sub-structure. The frequent exchange of routing vectors or link state tables triggered by continuous topology changes yields excessive control and processing overhead. Further, periods of routing table instability lead to instability of the multicast tree, which in turn results in increased buffering time for packets, higher packet losses, and an increase in the number of retransmissions Therefore. Multicast protocols used in static wired networks are not suitable for ad hoc wireless networks. The classification of multicast routing protocols is shown in:

*Ad Hoc Multicast Routing Protocols
 -Application Depend
 -Application Independent
*Nature of Multicast Topology
 -Tree Based
 -Mesh Based
*Initialization Approach
 -Source Initiated
 -Receiver initiated
*Topology maintenance
 -Soft State
 -Hard State
Classification of Multicast routing protocols

2. On-Demand Multicast Routing protocol (ODMRP)

In the on –demand multicast routing protocol (ODMRP) (7), a mesh is formed by a set of nodes called forwarding nodes which are responsible for forwarding data packets between a source- receiver pair. These forwarding nodes maintain the message- cache which is used to detect duplicate data packets and duplicate JoinReq control packets.

2.1 Mesh Initialization phase

In the mesh initialization phase, a multicast mesh is formed between the sources and the receivers. To create the mesh, each source in the multicast group floods the JoinReq control packet periodically. Upon reception of the JoinReq control packet form a source, potential receivers can send JoinReply through the reverse shortest path. The route between a source and receiver is established after the source receives the JoinReply packet. For initializing the mesh, sources SI and S2 in the multicast group flood the JoinReply control packets the nodes that receive a JoinReply control packet store the upstream node identification number (ID) and broadcast the packet again. When receivers R1. R2. And R3 receive the JoinReq control packet. Each node sends a JoinReply control packet along the reverse path to the source. Here in fingure2. Receiver r2 receives JoinReq control packets form sources S1 and S2 through paths S1-12-13-R2 and S2-16-14-15-R2 respectively/. The JoinReply packet contains the source ID and the corresponding next node ID (the upstream node through which it received the JoinReply packet). When node 12 receives the JoinReply control packet from receiver R1, it sets a forwarding flag and becomes the forwarding node for that particular multicast group.After waiting for a specified time, it composes a new JoinReply packet and forwards it. The format of the JoinReply packet sent by the node R2 is shown in table I. in this way, subsequent forwarding of JoinReply packets by the intermediate nodes along the reverse path to the source establishes the route.

Table 1: Formation of JoinReply Packet sent by receiver R2 (1)

Source ID	**Next Node ID**
S1	**13**
S2	**15**

2.2 Mesh Maintenance Phase

In this phase, attempts are made to maintain the multicast mesh topology formed with sources, forwarding nodes, and receivers. To some extent, the multicast mesh protects the session form being affected by mobility of nodes. For example, due to movement of the receiver R3 (from A to B). When the route S2-16-14-17-18-R3 and this contributes to the high packet delivery ratio. ODMRP uses a soft state approach to maintain the mesh, that is, to refresh the routes between the source and the receiver, the source periodically floods the JoinReq control packet. When receiver R3 receives a new JoinReq control packet from node III (send by the source S2), if sends a JoinReply on new shortest path R3-III-II0-19-S2, thereby maintaining the mesh structure.

3. Simulation Environment

We use QualNet (8) simulator. A packet level simulator developed by Scalable Network technologies Inc. QualNet is the successor of GloMoSim (9), which provides a detailed and accurate model of the MAC and Channel and routing protocols. The Distributed Coordination Function (DCF) of IEEE 820.11 (10) for wireless LANs is used as the MAC layer protocol. The 820.11 DCF uses Request- To- Send (RTS) and Clear-To- Send (CTS) control packets (11) for "unicast' data transmission to a neighbouring node. The RTS/CTS exchange precedes the data packet transmission and implements a form of virtual carrier sensing and channel reservation to reduce the impact of the well-known hidden terminal problem (11). General simulation information and node parameters are show in table 2 and table 3 respectively.

Table 2: General Configuration

Simulation Time	**30 sec**
Number of Nodes	**12**
Source Node	**Nodel (S1)**
Destination	**(Node6, Node8, Node10)**

Table3: Node Parameters

MAC Protocol	**802.11**
Networks Protocol	**IPv4**
Routing Protocol	**ODMRP**
Transport Protocol	**UDP**
Application Protocol	**MCBR**

Multicast routing protocol used is ODMRP with parameters specified in table 4. Source node use MCBR (multicast constant bit rate) traffic with the parameters shown in table 5.

Table 4: ODMRP Parameters

Join Query Refresh Interval	**20 sec**
Forwarding Group Time out Value	**60 sec**
TTL for Control Packets	**64 sec**

Table 5: MCBR parameters

Multicast Group Address	**255.0.0.0**
Packet Size	**512 bytes**
Interval	**1 sec**
Start Time	**1 sec**
End Time	**25 esc**

Join query refresh interval is time for periodic Join Query Message Transmission with the propagation of"Join Query, Route is being refreshed. So it can be called "Route Refresh Interval. Forwarding group time out value is the Forwarding Group Timeout Interval. After expiring this value a node supporting ODMRP will not forward Data Packet. The value must be 3 to 5 times larger than "Route Refresh Interval, TTL specifies the Time to live value for ODMRP routing control packets. Source node start sending MCBR packets at time Isec to time 25 sec once every 1 sec and the packet size is 512 bytes with multicast group address 255.0.0.0.Webegin with simulating static scenario (i.e. there is no mobility).

4. Static Scenario

We use grid topology consists of 12 nodes .We use one source node (S1) and one multicast group that consists of 3 members R1 (node6), R2 (node8), R3 (node10).

4.1. Performance Results

We collect different performance metrics according to three views (i) ODMRP control packets results, (ii) MCBR client results and (iii) MCBR server results.

4.1.1. ODMRP Control Packets Results

Join queries originated form source node S1 =2 packets because simulation time =30 sec. and Join refresh interval =20 sec. so that the source node will send 2 Route Request packets.

4.1.2. MCBR Client Results

Total packets sent =29 packets per 25 sec. Throughput $=4.2*10^3$ bit/sec.

Table 6: Packet delivery ratio

Node ID	**Packet delivery Ratio**
Node 6	**22/29 = 0.76=76 %**
Node 8	**12/29 = 0.41 = 41 %**
Node 10	**22/29 = 0.76 = 76 %**

4.1.3. MCBR Server Results

Each node supposed to receive all packets sent from source node which equal 29 packets as shown previously. But total packets received at node 6 =22 packet, at node 8 =12 packet and at node 10 =22 packet yielding to total packet received by multicast group = 56 packets. We can compute packet delivery ratio (as shown in table 6).
Throughput $=3.2*10^3$ bit/sec at node 6, $1.8*10^3$ bit/sec at node 10. Total throughput = $(3.2+1.8+3.2)*10^3$ bit/sec.
Average end-to-end delay is shown in table7.

Table 7: End – to – End Delay

Multicast group member ID	**Average End to Delay**
Node 6	**$o.6*10^{-2}$ sec**
Node 8	**$1.2*10^{-2}$ sec**
Node 10	**$0.9*10^{-2}$ sec**

5. Dynamic Scenario

The same grid topology is use but with moving node 8 (R2) starting from time zero. Node 8 moves according to waypoint model. Node 8 traverse across four point provided that time elapsed between each point equal to one second.

5.1. Performance Results

The same as in static scenario, we collect different performance metrics according to three views: (i) ODMRP control packets results, (ii) MCBR client results and (iii) MCBR server results.

5.1.1. ODMRP Control Packets Results

Join queries originated form source node S1 =2 packets because simulation time = 30 sec and Join refresh interval =20 sec. so that the source node will send 2 Route Request packets.

5.1.2. MCBR Client Results

Total packets sent =29 packets 25 sec. Throughput =$4.2*10^3$bit/sec.

5.1.3. MCBR Server Results

Table 8: Packet delivery ratio

Node ID	Packet delivery Ratio
Node 6	20/29 = 0.69 = 69 %
Node 8	20/29 = 0.69 = 69 %
Node 10	18/29 = 0.62 = 62 %

Each node supposed to receive all packets sent from source node which equal 29 packets as shown previously. But total packets received at node 6 =20 packet, at node 8 =20 packet and at node 10 =18 packet yielding to total packet received by multicast group =58 packets. We can compute packet delivery ratio (as shown in table 8).

Throughput =$2.9*10^3$ bit/sec at node 6, $2.9*10^3$ bit/sec at node 8 and $2.6*10^3$bit/sec at node 10. Total throughput = $(2.9+2.9+2.6)* 10^3$ bit/sec. Average end-to-end delay is shown in table9.

Table 9: End-to-End Delay

Multicast group member ID	Average End to End Delay
Node 6	$6*10^{-3}$ sec
Node 8	$6.6*10^{-3}$ Sec
Node 10	$8.6*10^{-3}$ sec

6. Conclusion

We study the performance of ODMRP protocol which uses the soft state approach for maintaining the mesh, and present two different scenarios (static and dynamic) and show that in dynamic scenario ODMRP operates well because the mobile node has better packet delivery ratio than in static scenario, so that our simulation demonstrated ODMRP robustness and its ability to dynamically adapt to a mobile routing environment.

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