An Efficient and Enhanced Protocol for Wireless Mobile Ad-hoc Network with Multicast Routing

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***Abstract*— MANETs (Mobile Ad-hoc Networks) are a kind of wireless infrastructure that has a routable network environment on the top of a link layer ad-hoc network. Ad-hoc networks are self configurable unique type of networks which require no central access point or infrastructure for their manoeuvre. Multi hop Ad-hoc networks can work efficiently with multicast operation in terms of bandwidth utilization. In this paper we are analyzing an efficient multicast routing protocol operation for mobile ad-hoc network. The key concept is to use network status information to enhance network routing. The simulation is carried out with Network Simulator (NS-2.35). The simulation results show better performance in terms of throughput, packet delivery ratio, and lower latency as compared to existing protocols.**

***Keywords*— MANETs, AODV, Multicast AODV, packet delivery ratio, end2end delay.**

INTRODUCTION

It is a universal vogue nowadays for computing and communication at anywhere, anytime with the facilitation of mobile ad-hoc networks. In MANET [7] the topology is changed by the mobility of wireless nodes, they are self configuring and do not require any infrastructure for their operation, thus enabling omnipresent computing and communication by the advance of wireless communication technology, availability and accessibility of many portable, compact and lightweight computing devices. The escalation of laptops and mobile devices with IEEE802.11/Wi-Fi wireless networking have made MANETs a popular research topic since the mid of 1990s. Ad-hoc network supports peer to peer [1] communication which enables wide range of support for applications such as battle-field operation over wireless network, disaster, calamity relief coordination, teleconferencing, and vehicular communication. These group oriented applications are all based on precise and timely data delivery.

Multicast in wireless network is a diverse technique through which the message can be transferred to multiple nodes simultaneously using fewer links. The information is delivered to each of the links only once, and copies are created when the link to the destination splits, thus creating an optimal distribution path. In general, for multicast transmissions there are two types of nodes, one is the source node and another one is multicast member node. Here source node primarily spreads out a multicast data to multiple multicast member nodes that want to receive that data and join the multicast group.

Wireless multicast seizes the advantage of broadcast nature of channel to multicast data simultaneously and efficiently to multiple location-independent nodes, therefore lowering down the wireless resource consumption. As a consequence multicast data transmission is a bandwidth efficient communication.

The main aim of this paper is to analyze the performance of efficient and enhanced multicast protocol for wireless mobile multi-hop ad-hoc network. The analysis is carried out with in-depth simulation for different scenarios for various parameters like throughput vs. end2end delay, packet delivery ratio and jitter at sending and receiving nodes.

OUTLINES FOR MULTICAST ROUTING PROTOCOLS

Multicast routing protocols for wireless communications, commonly, can be classified into two categories according to the nature of multicast network topology, a tree and mesh [2]. Both the topologies have their own diverse features which can be defined on the basis of the dynamics of network topology, scalability, robustness, efficiency, control overhead, quality of service, dependency on the unicast routing protocol or resource management. As an example, battle field or disaster relief requires a quick setup, for which tree based multicast routing protocol is the best suited while the mesh based multicast routing protocol uses mesh for transmitting data for which it uses path redundancy for the above mentioned requirements.

PROTOCOL DESCRIPTION

There are several multicast protocols for wireless ad-hoc networks [3] which work in different challenging environments. These can be categorized into source based and mesh based multicast routing protocols. Here tree based multicast ad-hoc on demand distance vector routing protocol (MAODV) is being used.

MAODV, which is a modified, efficient and enhanced multicast extension of AODV [4], is a routing protocol for ad-hoc mobile networks that can multicast with the addition of broadcast and unicast data transmission [5]. With the route discovery mechanism, routes are established on demand providing low latency. This works on broadcast routing discovery mechanism for exploring the multicast routing and unicast route reply discovery cycle. MAODV uses a bi-directional shared multicast tree for each multicast group, consisting of group leader with group members and several routers where each multicast group has a unique multicast group address and a group sequence number. The group member that first constructs the tree is designated as the group leader. Every broadcast packet has its own sequence number referred as a Broadcast ID. The sequence number and the network address of the source node are collectively used to prevent packets from being broadcasted multiple times by the same link. The GRPH (Group Hello) message is broadcasted at regular intervals (`group_hello_interval`) in whole of the network to maintain the group sequence number by the group leader.

MAODV operates somewhat as existing AODV [6]. The first node that wants to join the group acts as group leader. Figure 1 shows that node can join a group by simply transmitting route request (RREQ) packet if they have the address of group leader or a broadcast RREQ packet if group leader is unknown.

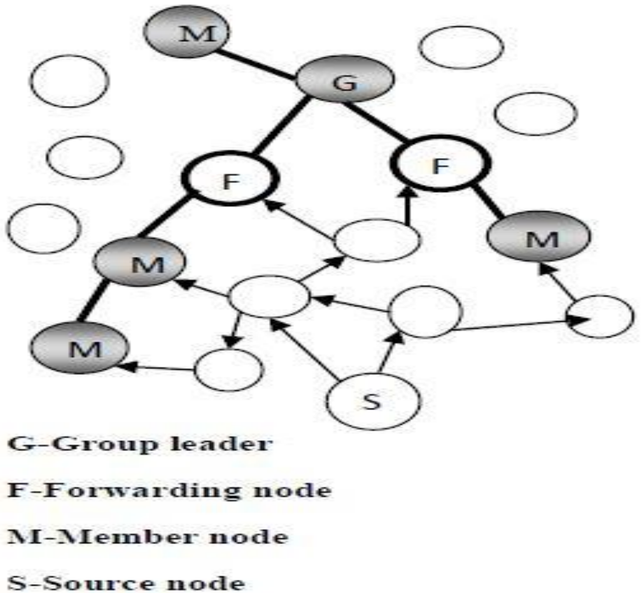

Figure 1. RREQ propagation

RREQ packet field includes the following information's:

<J_flag, R_flag, BCAST_ID, Source_Addr, Dest_Addr, Source_SeqNo, Dest_SeqNo, Hop_Cnt >

J, R are the join and request flags used by multicast group RREQs. Whereas BCAST_ID, Source_Addr, Dest_Addr, Source_SeqNo, Dest_SeqNo, Hop_Cnt are the broadcast id of RREQ, source and destination address along with their sequence number and hop count used by RREQ packet to discover the group.

When a group member of the multicast group receives the RREQ, it replies its distance from group leader and group sequence number by means of a RREP packet. Figure 2 shows RREP message sent back to the source.

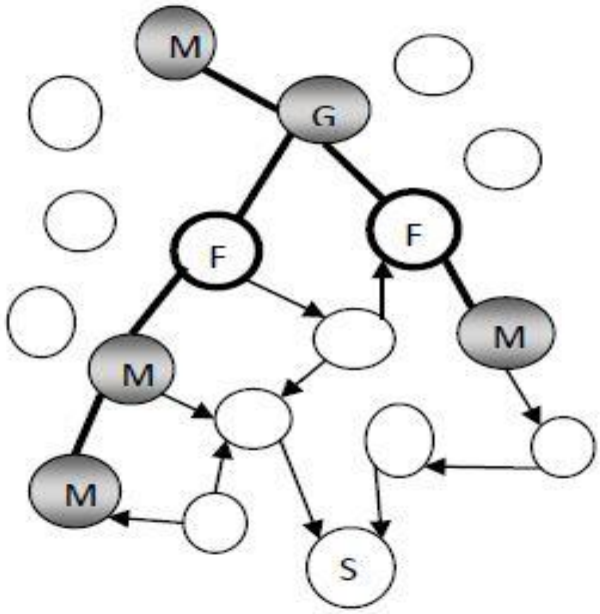

Figure 2. RREP replied back to source

The packet format of RREP includes the following information:

<R_flag, U_flag, Dest_Addr, Dest_SeqNo, Hop_Cnt, Life_Time >

Multicast routing uses R and U flags for repair and update in the table. Dest_Addr is set to destination address used by the RREQ packet, Dest_SeqNo is the destination sequence number in multicast group and Hop_Cnt is the number of hops to the destination from the source node.

The node requesting to join the multicast group, which consists of group member and the node connecting the group member, sends multicast activation (MACT) message to the nearest member with an updated sequence number. After reception of MACT all the intermediate nodes become the members of the tree. As it is Multicast Routing the source node may receive more than one RREP, to avoid this duplication the source node waits `rte_discovery_timeout` after transmitting RREQ packet before opting for a route. The `rte_discovery_timeout` is a reconfigurable parameter suited according to size of the network. Source node selects the route with high sequence number and lesser number of hops to the destination during the route discovery timeout period. At the end of route discovery timeout period, it enables the 'select next hop' in its multicast route table, after that source node sends a multicast activation (MACT) message to next hop. MACT packet contains the following information:

< *P_flag, GL_flag, Source_Addr, Source_SeqNo, Dest_Addr* >

P and GL flags are used for pruning and choosing the group leader. In MAODV, routes may be eliminated which are not along the path determined by the RREP with `active_route_timeout`. In figure 3 multicast join operation is completed by adding a multicast tree branch to the source.

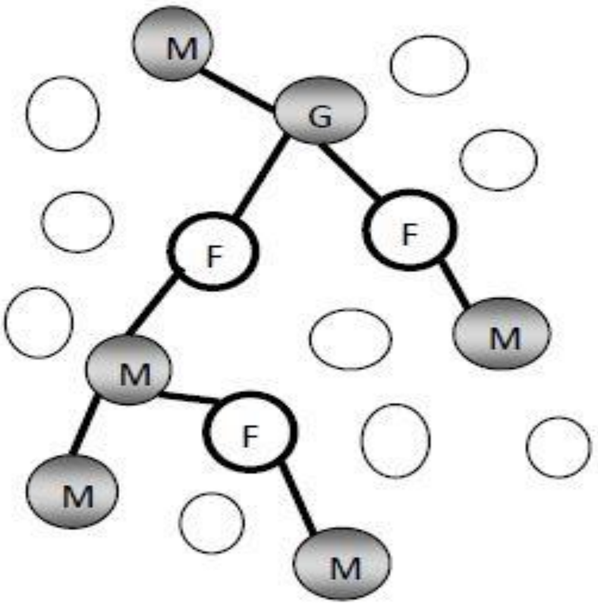

Figure 3. Multicast tree branch addition from source to group.

In MAODV all nodes in the network maintains two routing tables one is unicast routing table and the other one is multicast routing table for their proper operations. Figure 4 describes the fields used by unicast routing table while figure 5 shows the main fields of multicast routing table.

destination IP address	next hop IP address	hop count to destination

Figure 5. Main fields of unicast routing table.

Destination group IP address	Group leader IP address	Hop count to destination group leader
Next hop	Group sequence number	
Next hop IP address	Link direction (up/down) stream	Activation flag 1: set 0: unset

Figure 2. Main fields of multicast routing table

After the Multicast Join Operation the node can send or receive the data according to its requirements. The below simulation results show the multicast AODV protocol out-performs the existing AODV protocol in terms of packet delivery ratio, average throughput of data sent, received, dropped during the transmission period.

PERFORMANCE EVALUATION

In this section, the simulation of modified multicast AODV protocol is done through the latest version of Network Simulator (NS-2.35) [8] and is compared with existing AODV protocol.

SIMULATION ENVIRONMENT

As explained above NS2 is used for the performance evaluation of multicast routing protocol. NS2 is a discrete event simulator targeted at networking research. NS present ample support for replication of TCP, routing, and multicast protocols over wired and wireless (local and satellite) networks. Several simulations with different scenarios and multicast traffic were simulated to examine the performance of an efficient and enhanced protocol for wireless ad-hoc network with multicast extension. The simulation parameters are explained below:

1. Area: 1500x500;
2. Simulation Run Time: 500 seconds;
3. Number of nodes: 50;
4. Simulation Repetition: 10;
5. Physical/Mac layer: IEEE 802.11 at 2 Mbps;
6. Transmission range: 250 meters;
7. Mobility Model: Random way point model node movement speed ranges from 1 m/s to 4m/s;
8. Packet length: 32 bit, 64 bit, 128 bit, 256 bit;
9. Traffic: CBR multicast traffic.

PERFORMANCE METRICES

Performance of the efficient and enhanced AODV with multicast extension (MAODV) protocol has been analyzed using different parameters.

(a) Packet Delivery Ratio

Packet Delivery Ratio (PDR) is the ratio of number of total data packet delivered to receiver node to that of total number of data packet sent by source node. Figure 5 and 6 are showing the numbers of data packets received and the numbers of data packets dropped respectively. In our simulation the modified AODV with multicast achieves PDR up to 95.56 %.

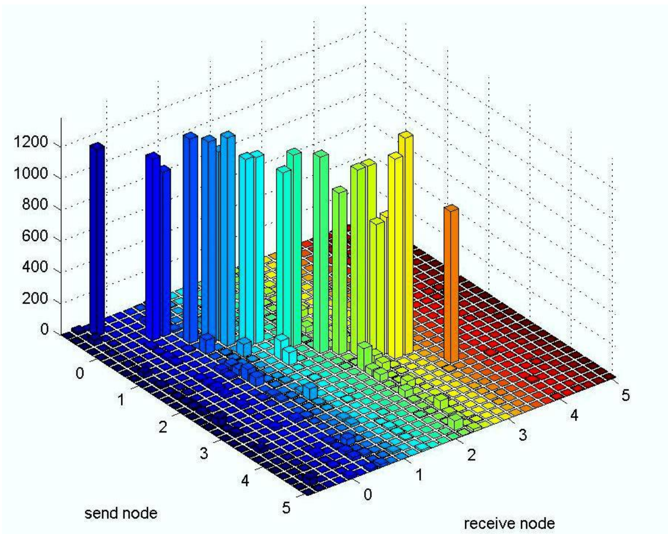

Figure 5. No. of packets received by all nodes.

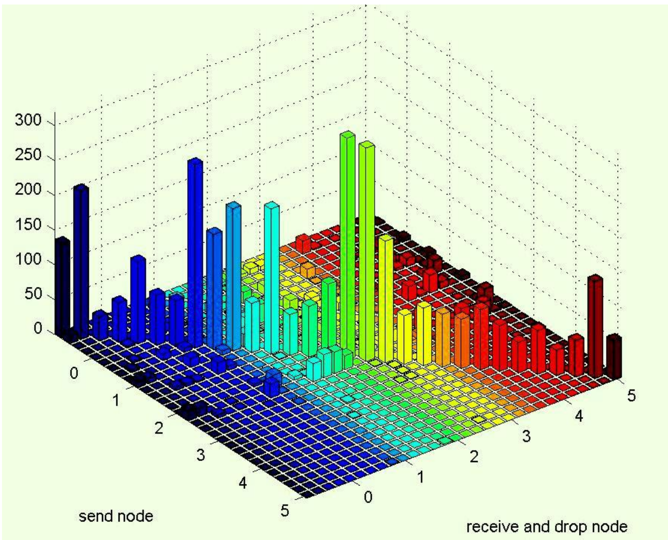

Figure 6. No. of packets dropped by all nodes

(b) End2End Delay

It is the latency of packets traversing the path in the wireless network from source node to receiver node. Figure 7 shows the Cumulative Distribution End2End Delay for both conventional AODV and modified AODV with multicast extension (MAODV). It can be clearly seen from the graph that MAODV outperforms the AODV as the curve for MAODV is sharper than conventional AODV.

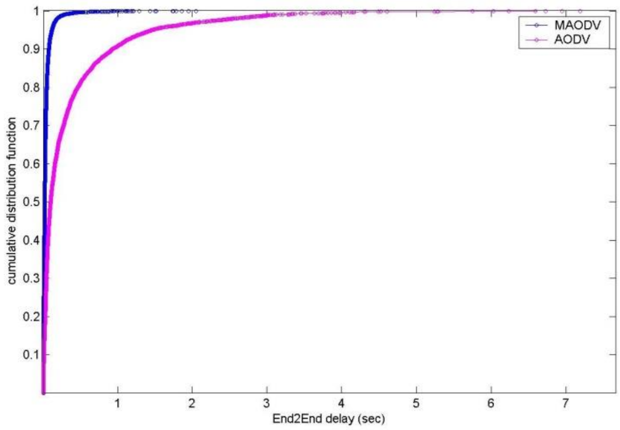

Figure 7. CDF vs. End2End delay

(c) Throughput vs. End2End Delay

Figure 8 shows the graph for Throughput vs. Delay. As from the graph, the average simulation End2End Delay for AODV reaches up to 2 seconds while that for MAODV its only 0.6 seconds. Therefore MAODV performs well as it has low delay as compared to conventional AODV.

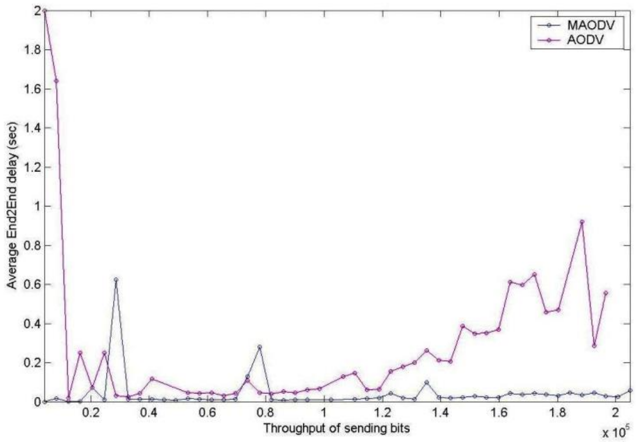

Figure 9. Throughput vs. End2End delay

CONCLUSION

The existing AODV protocol offers a vital support for unicast routing in wireless network, but multicast routing of data packets over wireless networks is being demanded increasingly in recent years which leads to the proposal of several different multicast protocols. Here in this paper, simulation of an efficient & enhanced protocol for wireless ad-hoc networks with multicast extension (MAODV) has been done, which is tested and analyzed over different scenarios. Form the results it is concluded that MAODV outperforms the existing Ad-Hoc on Demand Distance Vector routing protocol in matrices of Packet Delivery Ratio, Throughput and End2End Delay.

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