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UNICAST FORWARDED MULTI-SOURCE MULTICAST ROUTING PROTOCOL FOR MANET

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Abstract
In mobile ad hoc network, nodes co-operatively form a network independent of any fixed base station infrastructure. Every node in a mobile ad-hoc network can function as a router and forwards the data packets to the other nodes. Multicasting plays an important role whenever group communications are required. Most of the existing multicast routing protocols in mobile ad hoc networks consider only one source in a multicast group and become inefficient when the protocol is extended to multi-source multicasting. In this paper, we propose a unicast forwarded multi-source multicast routing protocol, for ad hoc networks which is having more than one source in a group. Here, the sources of the group also act as a receiver for other sources in that group. The proposed routing method is a cluster based one and avoids the flooding or broadcasting of control packets to form routing structure. On executing source joining and receiver joining procedures, a complete path for multicast data transfer was established. As the join request control packets are forwarded only through cluster-heads and junction nodes, lower amount of control overhead is incurred. Simulation result shows that the proposed protocol maintains the delivery ratio with reduced control overhead and utilizes the bandwidth efficiently.

Keywords:
Ad-Hoc Networks, Multicasting, PUMA, Packet Delivery Ratio, Control Overhead

1. INTRODUCTION

Mobile ad hoc network (MANET) is a group of wireless nodes without any central infrastructure, which self-organize into a network in order to communicate with each other. These network are generally characterized by bandwidth constrained, unpredictable dynamic topology. Due to their inherent broadcast capability, MANET is well suited for multicast applications. Every node in a mobile ad-hoc network can function as a router and forward the data packets to the other nodes. Because of the mobility and limited radio propagation range of the wireless device, most of the time the communication is multi hoped among the nodes. Also, a link that exists at one time may not exist at the next time.

If the same data or message packet has to be delivered to multiple receivers, then the unicast communication results in bandwidth inefficiency. In multicasting a single packet is send to multicast address to deliver a copy of the packet to each members of the multicast group. Multicast communications are also called as one-to-many and many-to-many communication. In many-to-many situations, more than one source is available, but it is not of broad cast nature.

By combining the applications of ad-hoc networks with multicasting, it is possible to provide large number of group application like military communication, rescue operations and conferences.

Multicast routing protocols can be classified as tree based, mesh based and cluster based protocols. Tree based protocols develop a shared multicast tree based on hard state. Multicast group leader maintains the up to date tree information by sending periodic group hello messages. This approach has the benefit of high data forwarding efficiency. Mesh based protocols uses a forwarding group concept. Here a group of nodes acts as a multicast forwarding nodes for each multicast group. To maintain the topology, mesh based protocol requires more control signals which leads to increase in control overhead.

On Demand Multicast Routing Protocol (ODMRP) is a routing protocol for mobile ad-hoc networks [1]. It is a state-of-the-art protocol, based on which many protocols were developed [2], [3]. PUMA is a Protocol for Unified Multicasting through Announcement used in ad hoc network [4]. It is one of the best performing protocol [5] and does not require any pre-assigned core and unicast routing protocol for its operation. Very simple multicast announcement signaling is used here for the creation and maintenance of the multicast routing structure. The limitation of PUMA is that, all the nodes must receive periodic signaling packet regarding each multicast group, regardless of whether nodes have interest in the group or not.

Recently the concept of cluster based multicast routing scheme for ad hoc networks are proposed [6], [7]. Using the clustering technique, a large network can be divided into several sub-networks with only a few cluster-heads needed to maintain local information, thus preventing flooding of worthless packets. This will avoid the wastage of bandwidth, which is an important resource in ad hoc networks.

Most of the existing multicast routing protocols in ad hoc networks are designed for single source multicasting. However, a multicast group may contain multiple sources due to different kind of applications and services provided simultaneously by the networks. Due to the complexity involved, many protocols are proposed for static conditions of the node [8] – [10]. To achieve efficient multicasting in the multi-source environment, this work employs the clustering technique and proposes a new Unicast Forwarded Multi-Source Multicast Routing Protocol (UFMMRP) for MANET. The goal of this work is to provide multicasting performance with multiple sources which utilize lower amount of control overhead.

The remainder of this paper is organized as follows. The proposed unicast forwarded multi-source multicast routing protocol is explained in section 2. The performance results are analyzed in section 3. Conclusions and future work are given in section 4.

2. UNICAST FORWARDED MULTI-SOURCE MULTICAST ROUTING PROTOCOL

Ad hoc networks are wireless, multi hop dynamic networks established by a collection of nodes without any centralized infrastructure. In the proposed, method unicast communication exists between cluster-heads. Three important phases of the proposed work are: Cluster setup phase, Route setup phase and Data delivery phase.

2.1 CLUSTER SETUP PHASE

Cluster-head election is one of the important factors that decide the performance of a cluster based protocol. In the proposed work, node weight estimation and cluster-head elections are done as per the Weighted Cluster Algorithm (WCA) [11]. Node weight calculations are done at the start of the simulation. Each node broadcast a hello message to its one-hop neighbours. Information regarding the node position, cluster-head address and cluster-head distance are contained in the hello message. On receiving the hello message from other node, each node updates its neighbour table. Cluster-heads maintain the cluster member information as well as the local topology within the same cluster using the neighbour table. Multicast table is used to maintain the information about the sources and multicast receivers of the group. Cluster-head table is used to maintain the details of adjacent cluster-heads.

2.2 ROUTE SETUP PHASE

The important procedures to be executed in this phase are,

1) Junction node selection procedure
2) Source joining procedure and
3) Receiver joining procedure

After executing the above procedures, a complete route is established between the sources and multicast receivers of the group. Source join request and receiver join request messages are not broadcasted or flooded throughout the network like other protocols.

2.2.1 Junction Node Selection:

Cluster to cluster communication takes place through the cluster-heads and junction nodes. If the cluster-head of one cluster receives hello message from member node of other cluster region, then that node is identified as junction node between those clusters. For upstream and downstream communication between two cluster-heads, different junction nodes are used. Then, the cluster-head table is updated and details regarding the junction node are stored. Selection of junction node is an important task and definitely it has an impact on the performance of the cluster based protocol.

2.2.2 Source Joining:

Source nodes are cluster member nodes as well as group member nodes, which are interested in sending data packets to the multicast receiver nodes. Source nodes send the *source_join request* (*S_JR*) message only to its cluster-head. On receiving this request, the cluster-head forward this request to its adjacent cluster-heads through junction nodes. This process continues until all the cluster-heads receive this *source_join request* message. Therefore, all the cluster-heads have details regarding the source address and the path to reach it. In multi-source environment, all the sources have to execute the source joining procedure.

The Fig.1 shows the method of source joining and how the *source_join request* message reaches all the cluster-heads through the junction nodes.

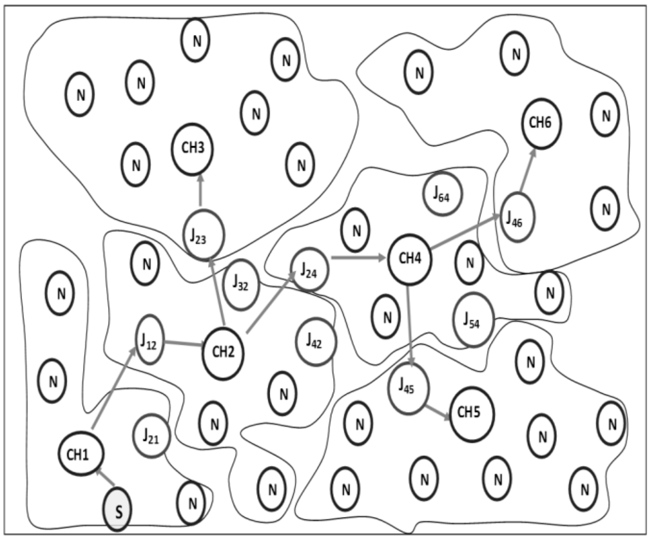

Fig.1. Source Joining Procedure

2.2.3 Receiver Joining:

The multicast group nodes which are interested in receiving the data packets from the source are multicast receivers. Multicast receivers send a *receiver_join request* (*R_JR*) message only to their cluster-heads. The cluster-heads forward this request message to their neighbour cluster-heads based on the entry in their multicast table. This process continues until the *receiver_join request* message reaches the cluster-head which has control over the source. On receiving the receiver's request, all the cluster-heads update their multicast table entry.

In the multi-source environment considered, the sources also have to act as a receiver for other sources in that group. Therefore, sources also need to send the *receiver_join request* message to their cluster-head, so that they are able to receive the data from other sources. Complete path between sources and multicast receivers of a group are established and ready for multicast data delivery on completion of the source joining and receiver joining procedure. In the proposed method, *S_JR* and *R_JR* message are not broadcasted. This will reduce the control overhead to a large extent.

2.3 DATA DELIVERY PHASE

Source nodes send the data packets to its cluster-head. The cluster-head checks the multicast table for the addresses of the receiver nodes and their corresponding cluster-head addresses. In multi-source scenario, some of the source nodes act also as a receiver node. Therefore, data has to be delivered to those nodes also. If the multicast receivers exist in different cluster region, copy of the data packet is sent to cluster-heads of those cluster regions.

Data is not sent to the cluster-heads which have no multicast receiver members or no multicast receiver entry. That is, in the proposed method, the data packet or copy of the data packet is send only to the cluster-heads which have multicast receiver nodes. Finally, the cluster-heads deliver the data packets or messages only to multicast receiver nodes after verifying the entry in the multicast table maintained by that cluster-head.

3. SIMULATION RESULTS

This simulation models a network of 50 mobile nodes randomly placed within a 1000 m × 1000 m area. Two ray ground propagation model was used and the MAC layer is IEEE 802.11. Each simulation is executed for 180 seconds. Radio propagation range is 200 meters with omni directional link and carrier sense range is 200 meters. The channel capacity is 2Mbits/sec. At this stage no movement or mobility is given to any of the nodes.

Following metrics are used to study the performance of the proposed multicast protocol,

Control Overhead Bytes: The total number of control bytes originated and forwarded by the protocol.

Packet Delivery Ratio: It is defined as the ratio of number of multicast data packets delivered to all the multicast receivers to the number of multicast data packets supposed to be delivered to multicast receivers. This ratio represents the routing effectiveness of the multicast protocol.

Normalized Routing Load: It is the ratio of number of control packets to the number of delivered data packets.

3.1 IMPACT OF INCREASING GROUPS

Increase in number of groups indicates the increase in numbers of sources. The scenario of data transmission by the sources at different time is considered. Fig.2 to Fig.4 shows the performance results under different number of groups.

As the number of groups increases, correspondingly numbers of sources and multicast receivers are also increased. As expected, the control overhead increases for both the proposed method and PUMA. However, Fig.2 clearly shows that, the proposed method incurs only a lower amount of control overhead bytes compared to PUMA. Thus, they need a large number of control packets and it increases to a large extent the control over head.

It is mainly due to the fact that, the proposed method sends the joint request messages only to the cluster-heads through the junction nodes. The normalized routing load plays an important role in indicating the effectiveness of channel utilization of a routing protocol.

The effect of increase in number of groups on normalized control overhead, as shown in Fig.3 indicates that the channel utilization of the proposed method is higher than PUMA. Packet delivery ratio analysis shown Fig.4 implies that, there will not be much degradation takes place in delivering the data.

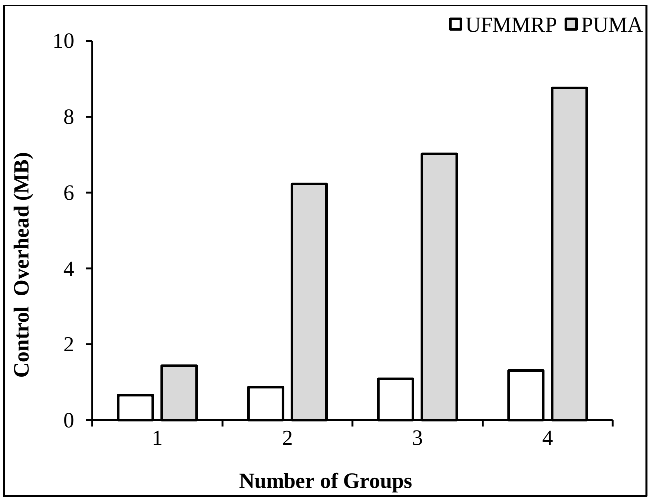

Fig.2. Control Overhead vs. Number of Groups

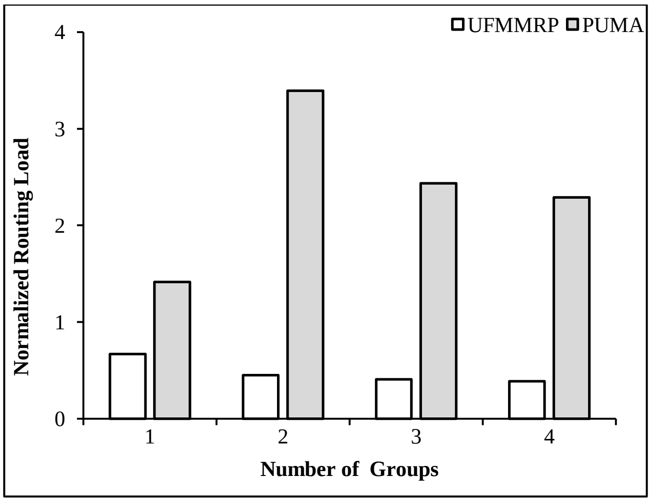

Fig.3. Normalized Routing Load vs. Number of Groups

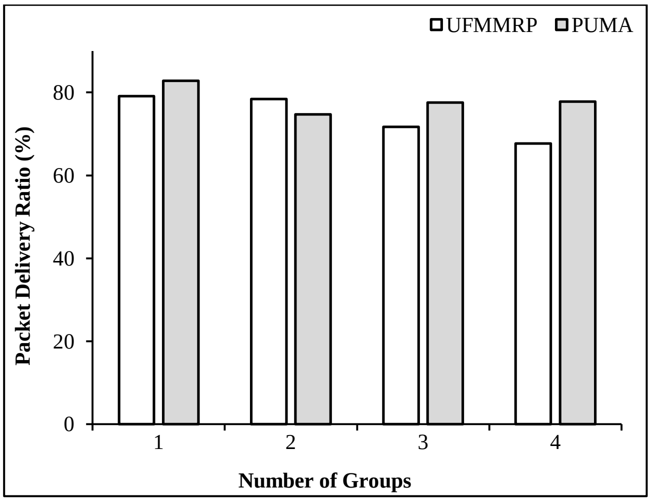

Fig. 4 Packet Delivery Ratio vs. Number of Groups

3.2 IMPACT OF CONFERENCING MODE

For this analysis, one group with multiple numbers of sources is considered. Number of sources is increased as 1, 2, 3 and 4. Each source sends 200 packets per second. Simulation is conducted for the two scenarios: (1) sources transmit the data at different time (Different TT) and (2) sources transmit the data simultaneously (Same TT). It is similar to conferencing, in which multiple nodes may interact with each other in the network. This analysis shows the effectiveness in utilizing the cluster-heads and data delivery path.

Due to congestion, a large amount of packet loss will take place as expected and packet delivery ratio is reduced as shown in Fig.5. If the number of packet is reduced or size of the packet is reduced, definitely the delivery ratio will gets increased. However, Fig.6 indicates that, there will not be much change in the control overhead.

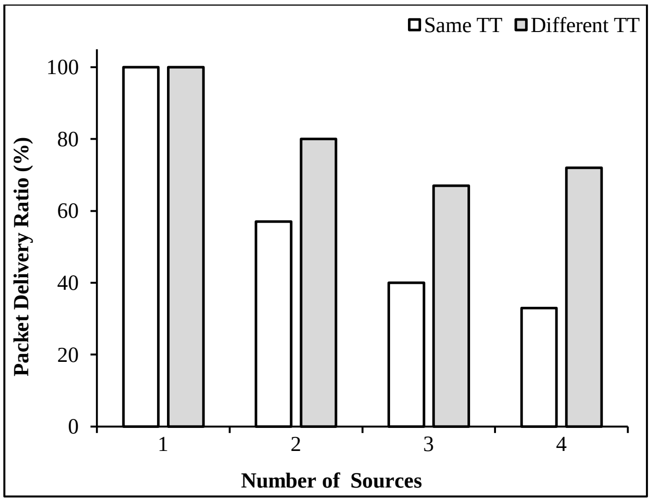

Fig.5. Packet Delivery Ratio vs. Number of Sources

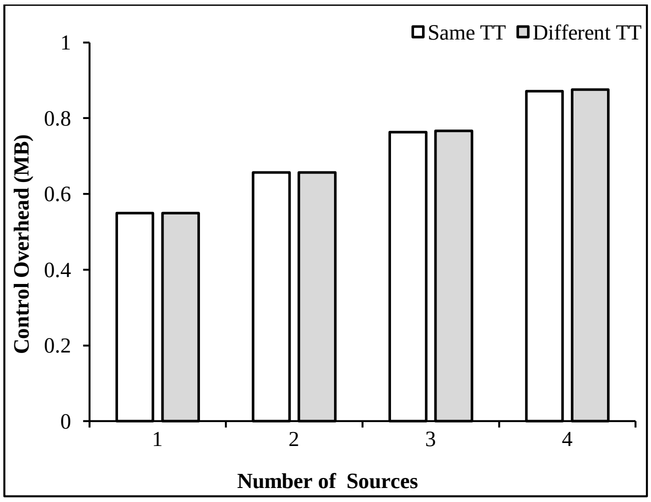

Fig.6. Control Overhead vs. Number of Sources

4. CONCLUSION

This paper proposes a unicast forwarded multi-source multicast routing protocol for MANET. The key contribution of this paper is the establishment and maintenance of routing structures for multi-source multicasting without the need to flood the control packets throughout the network. In the proposed method, source joining and receiver joining messages are not broadcasted throughout the network. In addition to this, the multicast tables maintained by the cluster-heads are used as a shared resource for route establishment and helps in data delivery in the multi-source environment. Therefore, the control overhead is minimized to a large extent and bandwidth is efficiently utilized.

In future, mobility to the nodes can be given to test its performance.

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