# Effective Multicast Routing Protocol for Ad Hoc Networks

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***Abstract*—** Most of the multicast routing protocols depend on creation of multicast tree for the transmission of packet from source to destination, which leads to maintain states of the neighboring node and it incures more cost. Maintaining the states of nodes also increases communication and processing overhead as well as requires more amount of memory. Almost all protocols maintain the path list in their routing table which also increases overhead while routing the packets.

In this paper we developed a stateless receiver-based multicast routing protocol that includes a list of the multicast destination members addresses (sinks), added in packet headers, to enable receivers to decide the best way to forward the multicast traffic.

***Keywords:*** *Stateless Routing, Multicasting, ETX metric, Wireless networks.*

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## I. Introduction

Many applications require data delivery to multiple destinations. Such applications use multicasting for the delivery of data. These applications range from member-based TV/Video broadcasting to push media such as headlines, weather, and sports [1], from file distribution and caching to monitoring of information such as stock prices, sensors, and security. Use of robust multicast routing in such dynamic network environment is an important design challenge for supporting these applications. In this paper we work on a Receiver-Based Multicast protocol that is RBMulticast. In proposed protocol the packet routing, splitting packet to multiple routes depends on the location information of multicast destination nodes [1].

In RBMulticast we include a list of the multicast destinations to the packet header. This prevents the overhead of creation and maintenance of multicast tree at intermediate sensor nodes. The necessary information for routing the packet is included within the packet header. In proposed system we does not require any state information such as wake-up time of neighbor or any operations like time synchronization. Our protocol does not create tree and it does not maintain neighbor table.

RBMulticast is a receiver-based protocol [2], the transmission of packet is decided by the potential receivers of the packet in distributed manner. Receiver based routing protocols are stateless and does not require routing tables. Proposed protocol can be compared to conventional routing protocols where the route is decided using the latest available information [1].

RBMulticast multicast routing uses the concept of virtual node and multicast region for forwarding packets source to multicast destination members. Protocol also determines when packets should be split into separate routes to finally reach the multicast members [4].

Our proposed protocol, explores the knowledge of the geographic locations of the nodes to remove the need for costly state maintenance. We proposed the advancement to the RBMulticast protocol by adding ETX [4] metric, which is used for selection of forwarder to transmit the packet from source to destination. Traditional protocol uses number of hop as a metric for transmission of packet from source to destination. The results show that performance of RBMulticast is better in terms of delay and network overhead. Proposed approach reduces the number of transmission required for a single packet delivery. We implement this protocol using java, and show the increased packet delivery ratio and effectiveness of modified RBMulticast. We compare the proposed protocol with the unicast routing protocol.

The expected transmission count (ETX) of a link is the number of data transmissions (including retransmission) required to send a packet over that link [7]. The ETX of a route is the sum of the ETX for each link in the route [11]. For example, the ETX of a three-hop route with perfect links is three; the ETX of a one-hop route with a 50% delivery ratio is two [11].

As mentioned in [4],[5],[6],[7] trees are used to connect the multicast members in existing multicast protocols for WSNs and MANETs.

## II. Related Work

In location-based approaches to multicast routing [10], nodes obtain location information by default as an application requirement. Most of the multicast algorithms rely on routing tables maintained at intermediate nodes for creating and maintaining the multicast tree. Destination-based communication is an opportunistic way of thinking about protocol design in that decisions are not required to be made at the sender side but instead are made at the receiver side [1].

ExOR [9] uses the ETX metric to choose a candidate forwarder set. ExOR offers better performances over existing routing protocols. Few problems exists in ExOR, after a transmission, candidates which are having lower priority have

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to wait for the forwarding of the candidate with higher priority in order. This is not an efficient way to do the spatial reuse. ExOR does not implement the multicast.

The algorithm is designed to transmit packets of the Internet Protocol to enable the maximum number of other services. The place of digital radio is widely taken by wire line internet services for portable devices [5]. Specialized integrated circuits are widely available at low cost.

To incrementally build a Steiner tree for multicast routing Takahashi-Matsuyama heuristic is used [12][13]. The multicast algorithm uses routing tables maintained at intermediate nodes for creating and maintaining the multicast tree [14], [15].

The multicast algorithms depend on routing tables maintained at intermediate nodes for creating and maintaining the multicast tree [5]. If location information is known, multicast routing is possible based only on location information without building any external tree structure. PBM[11] uses the number of next-hop neighbor nodes and total geographic distance from the present node to all multicast destination nodes and compares this to a predefined threshold to decide whether the packet should be split or not.

PBM is a generalization of Greedy-Face-Greedy (GFG) [11] routing to operate over multiple destinations. GMR [16] selects neighbors based on a cost over progress framework integrated with greedy neighbor selection. In Geocast delivers multicast packets by restricted flooding. If the current nodes are in forwarding zone then and then only they forwards the multicast packet. The forwarding zone calculated at runtime from global knowledge of location information.

The drawbacks of existence system:

1. There is no clear declaration of selection of the intermediate node for packet forwarding.

2. Existing work uses the condition of distance to select the next forwarding node.

3. No security related discussion in existing work.

## III. PROBLEM STATEMENT

The existing multicast routing protocols depend on different tree structures, in which the intermediate nodes need to store tree states or routing states for packet delivery. Maintaining state information is costly in multicast routing protocols. In our proposed system, we implemented stateless multicast protocol for ad hoc networks, in which it uses geographic location information for routing multicast packet and it also uses the ETX metric for forwarding the packet from one node to another node. We also go through the candidate selection. It uses RBMulticast Header for send and receive packet. The header of RBMulticast maintains list of destination nodes, which prevents the overhead of contructing and maintaining a multicast tree at intermediate sensor nodes.

## IV. RBMULTICAST PROTOCOL DESCRIPTION

### 1. RBMulticast Overview :

Once the RBMulticast module receives packet. Protocol retrieves the group list from its group table and assigns the group nodes to the multicast regions based on their locations. It uses these locations for calculation of “virtual nodes” location for each multicast region. The proposed RBMulticast replicates the packet for each multicast region that consists of one or more multicast members and appends a header consisting of a list of destination nodes (multicast members) in that region. The destination of a replicated packet is the “virtual node” of the corresponding multicast region, which can be determined in different ways e.g., as the geometric mean of the locations of all the multicast members in that multicast region. All packets for all multicast regions are inserted in the MAC queue, and are then broadcasted to the neighborhood [11].

Candidate selection is done before broadcasting packet to the neighboring nodes. Forwarding candidate is done using the distance of the virtual node and value of the ETX metric of neighboring node. Candidate selection is discussed in next section.

The node closest to the virtual node and having low ETX value takes responsibility for forwarding the packet. The procedure for transmitting packets is summarized in pseudocode in Algorithm 1.

Algorithm 1. RBMulticast Send
Required: Packet output from upper layer
To ensure: Packet inserted to MAC queue

1: Get group list GL from group table
2: for node n in group list GL do
3: for multicast region rr in 4 quadrants regions RR do
4: if n Є rr then
5: Add n into rr.list
6: end if
7: end for
8: end for
9: for rr Є RR do
10: if rr.list is non-empty then
11: Duplicate a new packet p
12: Add RBMulticast header (TTL, checksum, rr.list) to p
13: Insert p to MAC queue
14: end if
15: end for

When a intermediate node receives a multicast packet then it retrieves the destination node list from the RBMulticast packet header. Node checks destination list, if this node is present in the destination list, it removes itself from the list and passes a copy of the packet to the upper layers in the protocol stack.
The procedure executed after receiving packets is summarized in pseudocode in Algorithm 2.

Algorithm 2. RBMulticast Receive
Required: Packet input from lower layer
To ensure: Forwarded packets inserted to MAC queue

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Calculate checksum. Drop packet if error detected
Drop packet if not in Forwarding zone
Get destination list D from packet header
for node d in destination list D do
if I am d then
Duplicate the packet and input to upper layer
Remove d from list D
end if
end for
if TTL in header = 0 then
Drop the packet
return
end if
for d Є D do
for multicast region r in 4 quadrants regions R do
if d Є r then
Add d into r.list
end if
end for
end for
for r Є R do
if r.list is non-empty then
Duplicate a new packet p
Add RBMulticast header (TTL-1, checksum, r.list) to p
Insert p to MAC queue
end if
end for
```

Figure 1 gives an example of how RBMulticast works. The two multicast regions, the southwest and northwest quadrants, consists only one multicast member each, and thus a packet is sent directly to these multicast members. The northeast multicast region has three destination members, and thus a single packet is sent to the virtual node located at the geometric mean of the locations of the destination members (dotted circle with label 3 in the figure).

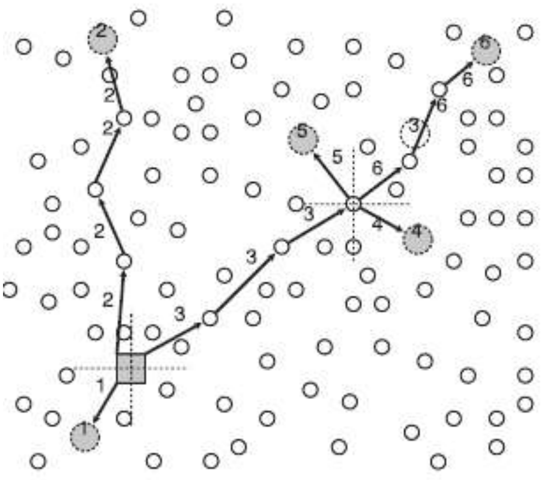

Figure 1: Example showing how RBMulticast work

1. Multicast Regions:

When a node receives a multicast packet it divides the network into multicast regions, and it will splits a copy of the packet to each region that consist of one or more multicast members. We show two possible divisions of the network into multicast regions in below Figures 2a and 2b.

2. Packet Splitting :

In Algorithm 1 and Algorithm 2, we describe the RBMulticast method that splits packets at intermediate nodes for which the multicast destinations exist in different regions [1]. This method is used in the protocol description because of its simplicity. In a variation of this method, namely, RBM-V, the packets are alternately split off at the neighbor nodes of the virtual node, which require extra time for splitting the packets compared to the former method [10].

1. Virtual Node :

We consider no knowledge of neighbor nodes and no routing tables, we assign a “virtual node” is located at the geographic mean of the destination members for each multicast region. Virtual node is considered as an temporary destination for the multicast packet in that region. The virtual nodes are not necessarily reachable as depicted in Figure 1. The idea behind this is that even if a virtual node does not exist, protocol can still find a route using the pretended receiver-based MAC protocol to get the packet closer to the location of the virtual node.

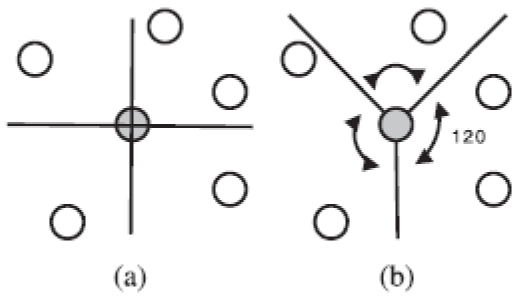


Figure 2: (a) dividing the space into four quadrants and (b) dividing the space into three 120 degree regions.

5. Geographic Mean i.e. location of Virtual Node:

$X$= Xini=1 $Y$= Yini=1

$(X,Y)$ Represent the location of virtual node.

Xi = x coordinate of location of node i.

Yi = y coordinate of location of node i.

n = Total no. of multicast destination in a region.

6. ETX calculation:

We use the ETX metric in this paper, a state-of-the art routing metric proposed by De Couto et al. A link's ETX metric counts the expected number of transmissions required to send a single packet across the link. Let Pf and Pr denote the loss probability of the link in the forward and reverse directions, respectively.

Then, the link's ETX [4] metric is calculated as:

$$ETX = 1/(1-pf).(1-pr) \qquad (1)$$

7. Candidate selection:

Before broadcasting a packet to the neighboring nodes, node in the network calculates the ETX metric using above mentioned method. After calculations of the regions and a separate multicast destination lists are generated then candidate selection process is done. In candidate selection process firstly the nodes which are closer to the virtual node

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and in the range of current forwarding node are selected [14]. These nodes are added to the temporary list *TCri* , which is the list belonging to the region *ri* , Now the nodes in the *TCri*, prioritized according to the closeness of the nodes to the virtual node. Nodes which are closer to the virtual node are given the higher priority. After sorting a list, Nodes are again sorted using their ETX values, Nodes with low ETX value and closer to the destination are given higher priority and nodes with higher ETX are given low priority.

Algorithm; candidate selection
Input: Neighboring nodes, ETX.
Output: actual Candidate list ACri.
1: //Get the neighbor list
2: Nlist = neighborlist();
3: For each i=1 to N //N=number of neighbor nodes
4: // Cal distance from virtual node
5: DVi = GetDistFrmVN ();
6: //Add node to temporary list
7: TCri = TCri Ui;
8: End for;
9: //Sort list according to the DVi
10: STCri = sort(TCri);
11: //Sort List according to the ETX values to get actual candidate list
12: ACri = sort(STCri)

## V. RESULTS AND DISCUSSION

We implemented the multicast routing algorithm using proposed methodology in java technology. We use jdk1.7 and above versions with eclipse indigo for our work. We implemented the unicasting and multicasting in java. We compared unicasting routing with multicast routing using packet delivery ratio, Routing overhead and delay.
Scenario:

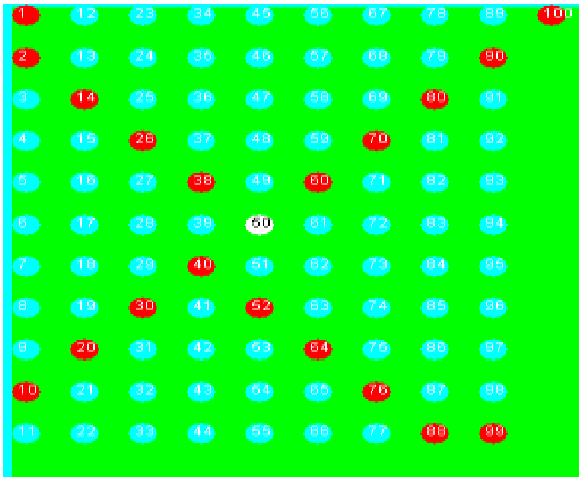

Figure 3: Scenario

1. Packet Delivery Ratio:

From Figure 4 we can see that the multicasting packet delivery ratio is much better than the existing unicasting protocol. We proved that the proposed multicast routing is more effective than the existing unicast routing protocol.

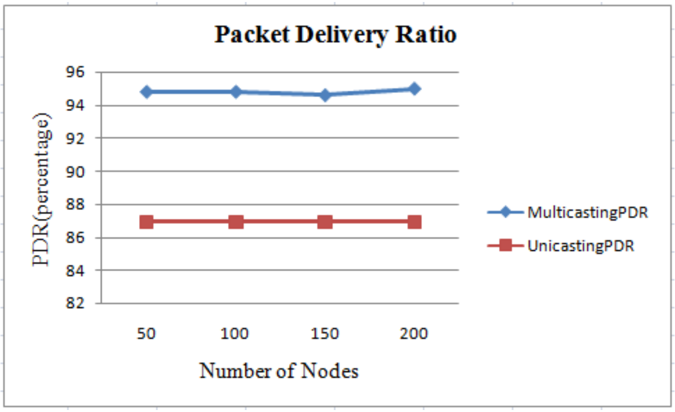


Figure 4: Packet delivery ratio versus number of nodes.

2. Routing Overhead:

Though are implementing the multicasting in our project work multicasting routing has minimum routing overhead. Existing system has the more routing overheads than the proposed method. This is shown in Figure 5.

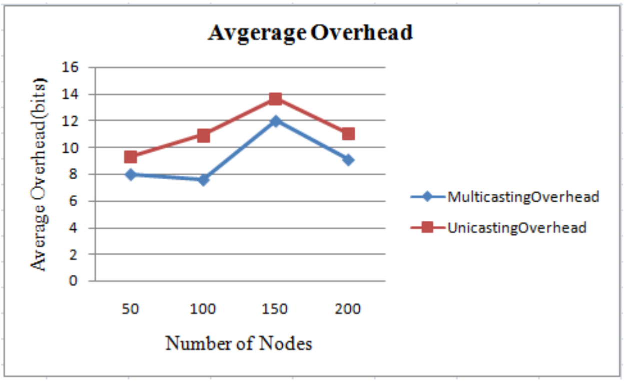


Figure 5: Average routing overhead versus number of nodes.

3. End to End Delay:

Our proposed protocol has minimum delay with increased number of nodes. Though we are implementing multicasting the proposed algorithm has low delay with respect to number of nodes in the network.

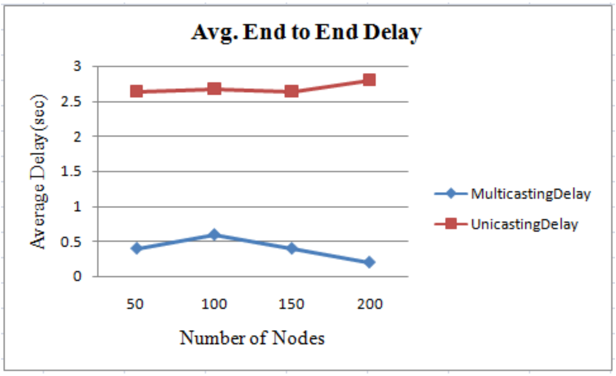


Figure 6: Average Delay versus number of nodes

## VI. CONCLUSION

In this paper, we presented a new stateless multicast protocol for ad hoc networks called Receiver-Based Multicast. RBMulticast uses geographic location information to route multicast packets, where nodes divide the network into geographic "multicast regions" and split off packets depending on the locations of the multicast members. RBMulticast saves a destination list inside the packet header; this destination list provides information on all multicast members to which this packet is targeted. Thus, there is no need for a multicast tree and therefore no tree state is stored at the intermediate nodes.

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