Multicast Zone Routing Protocol in Wireless Ad-hoc Networks

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Abstract
Continuously changing topology in Mobile Ad-hoc networks creates many problems regarding to the routing. Proactive and Reactive Techniques are not much efficient to resolve the routing issues as both have drawbacks. Zone Routing Protocol is a hybrid protocol which combines the most beneficial functions of both proactive and reactive schemes. As within the defined zone it uses proactive scheme and outside the zone it uses the reactive scheme. In this paper, we present Multicast ZRP which uses the multicasting scheme along with three sub-protocols regarding to the reactive and proactive approaches usage. We also discussed routing in Ad-hoc networks, comparison of proactive and reactive advantages, Architecture and Routing of ZRP with IARP, IERP and BRP with detailed examples. We extend Zone Routing protocol by using the application of Multicasting which constructs the multicast tree routing and their Route Request & Route Reply procedures with detailed examples.

Key words:
Ad-hoc Networks, Multicasting, Zone routing, Multicast Routing Tree

1. Introduction

Ad-hoc Network are wireless Network that have no fixed topology but changes the topology rapidly with large span.As such networks are infrastructure-less so these are easy to deploy and are much cheap than those of infrastructure-Based. Ad-hoc Network are used firstly in Military Applications and later on in Computing Industry. In such Networks nodes are highly mobile ,act as routers also and can connect with each other dynamically or can be disconnected due to power loss or can move in another network [1] [3].

The main challenge in Ad-hoc Network is designing Routing Protocols that can adopt such Network behavior and work accordingly. Many protocols have been designed for wireless Ad-hoc Network which are basically divided into two categories for communication in Ad-hoc Network that are Pro-Active and Re-Active. Proactive has good reliability with high overhead and low latency while being up-to-date regarding to the topology. With increasing number of nodes it has poor scaling.While, Reactive work on demand routing technique with high latency and low overhead. Zone Routing Protocol (ZRP) is a hybrid protocol that has been designed by the combination of most reliable properties of both proactive and reactive approaches [2].

Typically,group Communication (Multicasting) is much common , helpful and mostly used rather than the on-to-one communication (Unicasting). Multicasting Protocols designed for static Network cannot have good performance in Wireless Ad-hoc Networks because of mobility of nodes and limitations of bandwidth. Many Multicast Wireless Ad-hoc Routing Protocols have been designed.

Some of these are Tree based like Reservation Based Multicast (RBM) and Ad-Hoc Multicasting Routing Protocol (AMRoute) while some are Mesh Based like Core-Assisted Mesh Protocol (CAMP) and On-Demand Multicast Routing Protocol (ODMRP). In mesh-based most of the resources of the network are wasted because of transmission of duplication of data. In Tree-Based resources of networks are managed in a proper way by specific protocols [5].

In this paper, we elaborate the working of Zone Routing Protocol (ZRP) with the applications of Multicasting approach and named it “Multicast Zone Routing Protocol (MZRP)” which would use the application of IntrAzone Routing Protocol (IARP), IntErZone Routing Protocol (IERP) and Border-casting Resolution Protocol (BRP) for the efficient utilization of resources of Network with much better performance than Zone Routing Protocol (ZRP) [4] [6].

2. Related Work

IERP is the Reactive protocol and IARP and BRP are the Proactive protocols used in Wireless Ad-Hoc Networks. Zone routing Protocol (ZRP) is hybrid protocol which is based on both proactive and reactive approaches. All of these are helpful and related to the protocol which is presented in this paper [2][4].

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Zone Routing Protocol (ZRP)

This protocol is designed and presented by "Zygmunt Haas" of Cornell University,New York USA.This protocol is hybrid protocol using both proactive and reactive techniques.Node itself connected with others in a defined zone. The minimum distances of respective nodes in a zone is always according to the radius of the zone. The zone radius property has prime importance in ZRP [2].

Intra-Zone Routing Protocol (IARP) always work in a defined zone of the node using Proactive approach. It contains the routing table where there is the destination for each entry, subnets along with routing lists. It requires the Neighbor Discovery Protocol for ensuring the message transmission to the specific node discovered. Inter-Zone Routing protocol (IERP) starts its working when Intra-Zone would have no more access to the nodes outside the zone. Reactive approach discovers the node destination for message transformation using Bordercasting Resolution Protocol (BRP) in which node is forwarding message to its borderline nodes allow these nodes to detect the destination node. If destination node is not present in this node then repeat use again the Bordercasting approach for further detection of destination node [7].

3. Zone Routing Protocol

3.1 Introduction

As the Proactive routing uses the most of the bandwidth of the network which causes its wastage and Reactive routing causes lots of delays. So, here we introduce the Zone Routing Protocol which has the most promising and best characteristics of both Proactive and Reactive techniques and thus called "Hybrid Proacitve/Reacitve Routing Protocol".

ZRP lessens the scope of Proactive approach by introducing the fixed zone of the network for the nodes and in the fixed zone information maintenance is easier while on the other hand the amount of idle information of the route which is never consumed is shortened and the stable nodes can be accessed by the Reactive approach.

Nodes which are present in different subnets or zones must share their information to a zone or subnet which is in that network is common. In such a way,different zones overlap and hence the risk of congestion in such manner is much reduced by detecting the routes which are optimal through the overlapped zones.

As ZRP is a "Hybrid Proacitve/Reacitve Routing Protocol" and thus consists of "IntErzone Routing Protocol"[11] , "IntrAzone Routing Protocol"[12] and "Bordercast Resolution Protocol" [13]. These protocols are shortly described in further sections:

3.2 IntrAzone Routing Protocol (IARP)

It Works on the Proactive Routing Technique.Its scope depends on the zone radius. The scope of routing zone is defined as the minimum distance of all the present nodes to the central node zone must be less or equal to the zone radius defined and all these nodes are known as Peripheral Nodes. Each node broadcasts its information about routing only within the routing zone that belongs to it. Because of this nodes contains the Routing Table which includes all the information of the routes to the different nodes present in its Routing zone. If the destination node is within the Routing zone then using the IARP any node can get the route without any problem and delay.

3.3 IntErzone Routing Protocol (IERP)

It works on the Reactive Routing Technique. IERP is a protocol which helps the node to find the route which is not yet discovered and thus not have any information in the Route table. It works along with another protocol known as "Bordercast Resolution Protocol"

3.4 Bordercast Resolution Protocol (BRP)

It works on the information provided by the IARP and passes the information outside the zone for detecting the destination Route using the technique named "Multicasting". If the peripheral nodes finds the destination node then they reply back to the source node about the information got about the destination node route and if not then the peripheral nodes passes the query to the nodes present to the other peripheral nodes of next zone present on the border of the routing zone using the technique named "Bordercasting". By using this method the query spreads in all over the network for detection of destination route and by using the same reply back route the response of query come to the source node for further transmissions.

BRP always works when IERP is invoked for the outside zone detection of destination nodes and selects the most appropriate rout for the source node to transmit data. BRP consumes much less energy and other resources of the network as compared to broadcasting technique which passes the query to all the nodes present in the range defined.

4. Routing In Ad-hoc Networks

There are many Routing Protocols which have been designed for Ad-hoc networks.These are categorized in two main categories: “Proactive” and “Reactive” [1] [8].

Proactive protocols are always use the updated Topology oof the network and with the help of this updated topology route is known and can be available anytime when there is a packet to send.

Reactive protocols are not responsible for determining the connectivity of the network. There is no topology or updated rout present for data packet to send.In this technique when there is a packet to send a procedure of route determination is implored. This approach is based on the queries which are submerged through the whole network [2] [9].

5. Pro-Active & Re-Active Comparison

Both of the Techniques have many Advantages and Disadvantages. As Proactive Routing protocol uses the current updated information of the routing of the network before sending a packet which results the minimum delay for a packet before it is sent though the route.On the other hand Reactive approach has to define the rout before sending packet which results the delay as routing information is not present in the memory (cashes) [10].

Reactive scheme uses the minimum bandwidth which is quiet useful as the routing information is only available if the packet sending request is invoked for routing through the network. Thus much of the bandwidth is saved in such routing [8] [10].

Proactive scheme uses most of the bandwidth for the routing updated information which can be used anytime as the nodes are highly mobile and the rout is continuously changing so much of the bandwidth is wasted using such technique [9] [10].

6. Architecture of Zone Routing Protocol

As the name shows that it is based on the zones of the nodes present in the network. The zones of all nodes are defined separately and the zones of the nodes present in neighbors can overlap. The zone of the node is according to the radius defined. All the nodes present in a zone of the specific node must have less or equal distance to its defined radius and thus forms a zone of that specific node [11].

An example of Zone Routing is explained by the following figure:

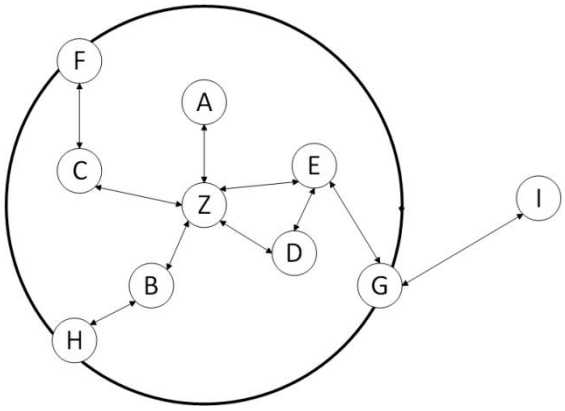

Fig. 1 Routing Zone Example with radius=2 hops

In the figure routing zone of Z consists of the nodes form A-H but not I. The zone of the central node Z is the radius defined which is equal to 2 hops and its not defined by a physical distance as it is defined in hops. There are two types of nodes in the network. The nodes which have minimum distance from the central node is equal to the radius hops defined are called “Peripheral Nodes” and the nodes which have minimum distance from the central node is less than the radius hops defied are called “Interior Nodes”.

The nodes from A to E are interior nodes and the nodes from F to H are peripheral nodes and the node I is present in outside the zone. Note that the node G is reached by two paths. One is through Z-E-G with the hop length of 2 and the other path which is Z-D-E-G with the hop length of 3. As the nodes is present in the zone with the presence of minimum length of 2 hops Because it is equal to or less than the radius hops defined [12][14].

ZRP works on the basis of Proactive protocol named “IntrAzone Routing Protocol (IARP)” and Reactive one which is known as “IntErzone Routing Protocol (IERP)”.

IARP conserve the information about the route which is inside the zone while IERP works when it is invoked if the destination node is present outside the zone and this protocol provides the enhanced facility for the discovery of route and its maintenance. Instead of using the technique Broadcasting ZRP works for its broad routing through “Bordercasting” which is explained before and it works along with IERP and by the information received by IARP and this service is achieved by the protocol named “Bordercasting Resolution Protocol” [13][14].

For the detection of neighbors and failure of links during routing ZRP depends on the special protocol named “Neighbor discovery Protocol (NDP)”. NDP is originally provided by the MAC Layer. NDP works on the beacons.

Through transmitting beacons by the NDP and receiving it the routing table of neighbors are updated. Neighbors who has no beacon are automatically removed from the routing table. If the MAC layer does not provide the Protocol for neighbor discovery then this discovery workout is provided by the IARP. When NDP updates the table of neighbor routing then updates are apprises IARP. IERP uses the updates provided by the IARP for responding the queries with the help of BRP [15][16].

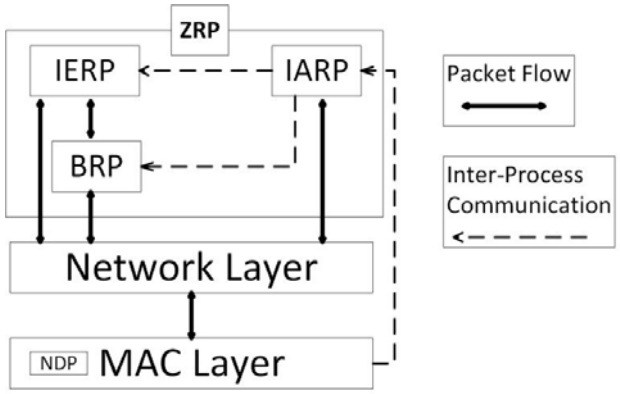

Fig. 2 Zone Routing Protocol Architecture

The relation between the described components of zone routing protocol is shown in the Figure 2. Packet flows in between MAC layer, Network Layer and the Zone Routing Protocol components (IARP, IERP & BRP). Inter Process communication develops in between MAC layer and IARP. Also in between IERP, IARP & BRP.

7. Routing Of ZRP

When a node has to send the packet then it will check the destination of node that if it is present in the local routing then it will use the Proactive scheme and if the the destination node is present int outside the zone then it will use the Reactive scheme [15].

Now there are two types of routing which belongs to the reactive routing named “Route Request” and “Route Reply”. In the first phase of route request source node will send the packet to its peripheral nodes for the detection of destination node present in their zone. If the receiver of packet request knows the destination then it will reply back to the source node using the same route. If it will not find the destination node in its zone then the process continues for the detection of destination node route with using the techniques of Bordercasting of packets using “Bordercast Resolution Protocol” along with IERP scheme as a reactive approach.

In this way the packet will spread all over the network and if there is redundant packet then these packets will be discarded.

When the packet transmission to the destination is completed then the routing information sequence is reversed and this sequence is used to reply back to the source node using that copied route [16].

The proposed “Multicast” technique which minimizes the consumption of resources of the network. BRP uses the same scheme as it transmit the packet through Bordercasting in which the node sends the packet to the peripheral nodes and the nodes present in the interior side (Interior nodes) will be aware of the topology which will be provided by the peripheral nodes.

Zone radius of the network has very prominent functions for the performance of protocol as if radius is less (i.e; 1) in this case then the routing will be purely “Proactive” and it will provide the routing table information. If the radius is greater than the defined then the routing will be “Reactive” [15][16].

7.1 IARP Routing (Proactive)

The Protocol based on the routing table which is updated according to the node mobility and state changing in which there is address of destinations to for each node.

Example network for few nodes is given below in which zone of node Z is elaborated with radius of 2 hops. Z node knows all the routes to every node but within its zone and this happens because of IARP. If the destination node is not available in the zone of Z node then it will pass the query to its bordered nodes for further detection of destination outside the zone which will explain in the next example using IERP.

Here Z node knows all the routes to its possible nodes within the zone as it knows the route to the I node as well as it knows all the bordered nodes which are F,H and G in this case.

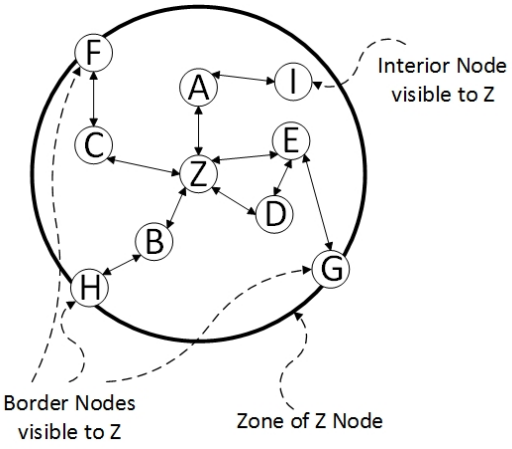

Fig. 3 IntrAzone Routing Example with radius=2hops

7.2 IERP Routing (IERP)

Example of somehow large network for the elaboration of IERP is given below in which A-U nodes are present but in different zones as some nodes are nor visible to the central node of a zone. Node Z knows all the peripheral and interior nodes of its zone but not aware of the nodes outside the zone.

For Example, if node Z has to pass the query to the node U which is outside of its zone then it will find it using the IERP scheme. Node Z passes the query to its peripheral nodes for the detection of destination node route. Now these nodes will bordercast the query for finding the destination node. Here G node will bordercast and will pass the query to the node O which will use the inside route zone through O-P-S-U or it will bordercast once again and will find the node U through O-S-U and this will reply back to the source node (i,e; Z) using that same route saved.

In the example diagram, in last zone O finds many routes to U like O-M-R-S-U , O-M-P-S-U , O-P-S-U and the shortest and most reliable one O-S-U using BRP which always helps the IERP for its complete working form source to destination routing.

Using the request route the finalized and ideal route will be saved for the reply back route which is a kind of guarantee of the perfect route as an ideal and shortest route for the node to communicate transmit data from source to destination in every transmission within the network and in between the ranges and zone defined for nodes.

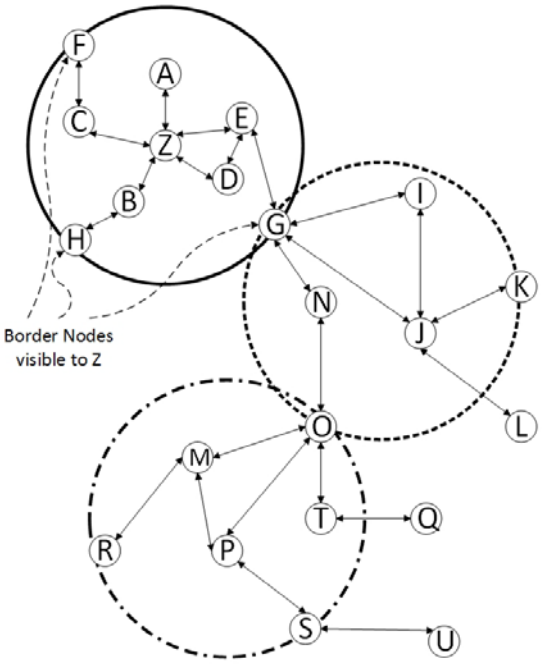

Fig. 4 IntErzone Routing Example with radius=2 hops

8. Multicast Zone Routing Protocol

The proposed Multicasting Protocol uses a shared tree for routing. There will make a group as multicasting is in between some nodes of the network and we will assume it as group in which there will be group leader and whenever it transmit any message it will include all the information about the nodes and group leader node of that specific multicast group.

Using the ZRP Proactive protocol (i.e; IARP) and using the Multicast scheme we make the ZRP protocol more efficient as MZRP will then be able to track all the information of a single group in each routing. While using IERP along with mulicasting MZRP will be able to hold the information of other groups outside of any specific zone by constructing the shared tree of multicasting groups routing information.

Link breakage in routing by some problem will be repaired by the MZRP and also it removes the redundancy of the routes in between the members of group tree (Multicast group tree) [17].

8.1 Multicast IARP

In IARP using multicasting there are two types of nodes one which interconnect the member nodes of multicasting group and forward any message or query to all the members of the group. The other are the multicast routing

group members which receives the updated multicasting group information and keep the local routing of group and all its members and in this way if there is present any group member within its zone then it became easier for any node to join that group as there will be less routing requests.

8.2 Multicast IERP

i. Procedure of Route Request

If any node wants to be the member of multicast routing group or a part of multicsat tree or wishes to send a packet then it will send Multicast Route Request (MRReq). Now there is two kinds of requests which depends on the information and routing condition. If the node knows the route to any of the group member then it will Unicast MRReq the message for joining of the group. That interior node will forward this message and will save the reverse route in its tree for reply back.

Now if the node does not know the exact route it will Bordercast MRReq. When the request reaches to the peripheral nodes through the bordercasting then all the peripheral nodes sends the unicast Req for ensuring that either they have an exact route to that group or not, as there can be many nodes on borders of the zone (peripheral nodes) and some of them could be peripheral node of 2 zones at a time. If any of the peripheral node finds that destination multicast group then it will pass the MRReq and will save the route for reply back to the source. If the destination does not exists then the source node can create a Multicast group routing tree and declare itself as the group leader and starts forwarding message as a group leader to the other Multicast groups.

ii. Procedure of Route Reply

After the MRReq sent to the destination node through any route then the destination node will check that either it is the part of multicast tree of that specific group then it will send the Multicast Route Activation Request (MRAReq) back to the source node using the same save route to activate the branch of routing tree for itself [16][17].

9. Construction Of MZRP Routing Tree

For the construction or connection of a node to the specific group routing tree outside of its zone or transmission range we assume the following structure (Figure 5) of nodes as an example.

In the below structure, suppose C node wants to join a Multicast routing group named “MC” and there is no group member in its transmission range so it will MRReq using Bordercasting when the peripheral nodes (Bordered nodes) will receive request they will further bordercast the request and we know that there is no such group in the network then C will not receive any reply of the request. Now the node C will create a group named “MC” and assume itself the group leader of this group, C node will now broadcast the group leader information and membership in the whole network but within its local routing range of zone. Now all the nodes (A, B, D, E, F, G, and H) knows that C is the group leader of the multicast group “MC”.

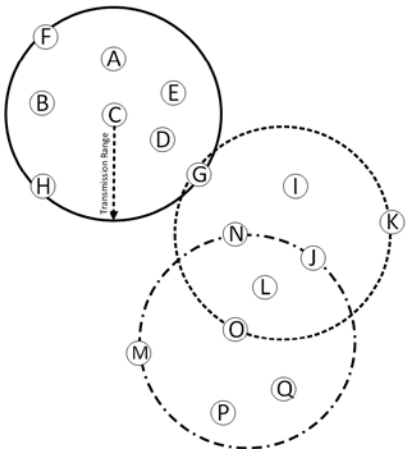

Fig. 5 MZRP Routing Example with radius=2 hops

Suppose that the node O wants to be the part of MC group and it will bordercast the request as it is not aware of the direct route to the C. Now many nodes will receive message but G will forward the request as this node knows the route to C. After receiving the request, node C will send Multicast Route Activation Request (MRAReq) to the O node using that forwarding node G.

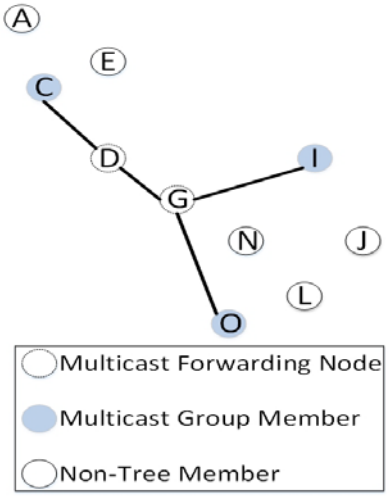

Fig. 6 Multicast ZRP Routing Tree

After adding a new node "O" to the multicast group "MC" as its branch then the node "G" OR "G & D" (if G unicasts the message to D and then D unicasts to C) will be called the Multicasting Forwarding Node for this route. After this tree completion if a node I wishes to join the tree then the G node will react as Multicasting Forwarding Node for I too and after the request and then Activation procedure the following tree will be constructed.

The above constructed tree (after the creation of new multicast group) shows that the nodes C, I and O are Multicast Group Members.D and G are Multicast forwarding Nodes and all the others nodes are Non-Tree Members.

10. Conclusion

Multicast Zone Routing Protocol capsulize the two different routing methods along with the multicasting technique by which it become purely up-to-date routing tables for inside of the zone with MIARP which reduces the routing overhead and it can discover any node outside the zone using the MIERP along with the most beneficial technique BRP which increases the reliability of routing for the nodes which are out of range to the source node. It removes the loops of routing and selects the most reliable route. ZRP is among those protocols which are being standardized and evaluated till date. We conclude that the MZRP is far better than the single proactive and reactive protocol working as it concatenate the beneficial aspects of these routing techniques. With the structure of zone for routing efficiency MZRP and its sub-component protocols generate routes for every node much effectively by using grouped multicast tree generation.

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