

Efficient and Scalable Multicasting over Mobile Ad Hoc Networks

Ms. Deepali R. Gadgail, Prof. S. S. Dhande

Abstract— Group communications are important in Mobile ad hoc Networks (MANET). A mobile ad hoc network (MANET), is a dynamic self-configurable wireless network, which has no fixed infrastructure or central administration. Multicast is an efficient method for implementing group communications. By the development of new network technologies, multicasting has become one of the important networking services. Designing multicast routing protocol is a big challenge due to difficulty in achieving group membership management, packet forwarding and maintenance of multicast structure over the dynamic network topology. In order to implement group communication, Efficient Geographic Multicasting Protocol (EGMP) came into existence. EGMP uses a hierarchical structure to implement scalable and efficient group membership management. And a network-range zone-based bi-directional tree is constructed to achieve a more efficient multicast delivery. The position information is used to guide the hierarchical structure building, multicast tree construction and multicast packet forwarding, which efficiently reduces the overhead for route searching and tree structure maintenance. EGMP has high packet delivery ratio, low control overhead and multicast group joining delay under all test scenarios, and is scalable to both group size and network size.

Index Terms— Routing, Mobile ad hoc Networks (MANET), Multicasting, Protocols, zone, EGMP.



1 INTRODUCTION

Ad-Hoc Networks also called as Mobile Ad-Hoc Network (MANET) is a group of wireless mobility nodes which is self organized into a network without the need of any infrastructure. Group communications are important in mobile ad hoc network (MANET). It is a big challenge in developing a robust multicast routing protocol for dynamic Mobile Ad-Hoc Network (MANET). MANETs are used in many magnificent areas such as disaster relief efforts, emergency warnings in vehicular networks, support for multimedia games and video conferencing. As a consequence, multicast routing in mobile ad-hoc networks has attracted significant attention over the recent years. Multicast is the delivery of a message or information to a group of destinations simultaneously in a single transmission using routers, only when the topology of the network requires it. Multicasting is an efficient method in realize group communications with a one-to-many or many-to-many relationship transmission pattern. However, there is a big challenge in enabling efficient multicasting over a MANET whose topology may change constantly. *Conventional* MANET multicast protocols [3]–[8], [28] can be ascribed into two main categories, tree-based and meshbased. The Tree-based Multicasting Protocols concept is borrowed from the multicasting protocols in wired networks. Since efficiency can be achieved and robustness is not a critical issue in the stable wired network, most multicast methods are tree-based, either *source-* or *shared-tree-based*. The former one will construct a multicast tree among all the member nodes for each source node; usually this is a shortest path tree. This kind of protocol is more efficient for the multicast, but has too much routing information to maintain and has less scalability[10].

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The latter one constructs only one multicast tree for a multicast group including several source nodes. Every source uses this tree to do multicast. Usually the shared tree constructed is a minimum spanning tree. Since the path between a sender and a receiver is not necessarily the shortest path, the shared-tree-based protocol is less efficient than the source-based protocol in doing multicast, but it reduces the overhead greatly by maintaining less routing information. To let these multicasting protocols work in MANET, some modification and extension should be made. Correspondingly The Mesh-based Multicasting Protocols are much more suited for MANET, which demands more robustness of the protocol. That is, when a route fails, which is common in mobile ad hoc networks, there should be another route to deliver the data. It is the redundancy of the routes that provides the fault tolerance.

Conventional multicast protocols generally do not have good scalability due to the overhead incurred for route searching, group membership management, and creation and maintenance of the tree/mesh structure over the dynamic MANET. A straightforward way to extend the geography-based transmission from unicast to multicast is to put the addresses and positions of all the members into the packet header, however, the header overhead will increase significantly as the group size increases, which constrains the application of geographic multicasting only to a small group. Besides requiring efficient packet forwarding, a scalable geographic multicast protocol also needs to efficiently manage the membership of a possibly large group, obtain the positions of the members and build routing paths to reach the members distributed in a possibly large network terrain. Furthermore, these conventional multicast protocols generally do not have good scalability due to the overhead for route searching, group membership management, and tree/mesh structure creation and maintenance

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over the dynamic topology of MANET. In topology-based cluster construction, a cluster is normally formed around a cluster leader with nodes one hop or k-hop away, and the cluster will constantly change as network topology changes. Although number of efforts were made to develop the scalable topology-based routing protocols. Now, In contrast, there is no need to involve a big overhead to create and maintain the geographic zones proposed in this work, which is critical to support more efficient and reliable communications over a dynamic MANET. By making use of the location information, EGMP could quickly and efficiently build packet distribution paths, and reliably maintain the forwarding paths in the presence of network dynamics due to unstable wireless channels or frequent node movements.

EGMP can scale to large group size and network size and can efficiently implement multicasting delivery and group membership management. EGMP uses a hierarchical structure to achieve scalability. The network terrain is divided into geographical non overlapping square zones, and a leader is elected in each zone to take charge of the local group membership management. A zone-based bi-directional multicast tree is built in the network range to connect those zones having group members, and such tree-structure can utilize the network resource efficiently. This scheme will build and maintain the intrazone and interzone topology for supporting scalable and efficient multicast forwarding. The position information to implement hierarchical group membership management, and combine location service with the hierarchical membership management to avoid network-range location searches for the group members, which is scalable and efficient. With location guidance and our efficient membership management structure, a node can join or leave a group more quickly. With nodes self-organizing into zones, a zone based bi-directional tree is built in MANET environment. Based on geographic routing, the maintenance of the tree is simplified and the transmission is more robust in dynamic environment. An important concept of *zone depth*, which reflects the relationship between a member zone and the zone, where the root of tree exists. The zone depth is efficient in guiding the tree branch building and tree structure maintenance, especially in the presence of node mobility. This scheme will also handle the empty zone problem, a challenging problem in designing a zone-based protocol. In EGMP, whenever an on-tree zone becomes empty, the tree structure is adjusted accordingly to keep the tree connected.

2. Efficient geographic Multicast Protocol

In this section, we will describe the EGMP protocol in details. We present the zone structure building process and the zone-supported geographic routing strategy we introduce the processes for the multicast tree creation, maintenance and the multicast packet delivery. EGMP uses a two-tier structure. The whole network is divided into square. The whole network is divided into square zone. In each zone, a leader is elected and serves as a representative of its local zone on the upper tier. The leader collects the local zone's group membership information and represents its associated zone to join or leave the multicast sessions as required. As a result, a network-range core -zone -based multicast tree is built on the upper tier to connect the member zones. For efficient and reliable management and transmissions, location information will be integrated with the design and used to guide the zone con-

struction, group membership management, multicast tree construction and maintenance and packet forwarding [8].

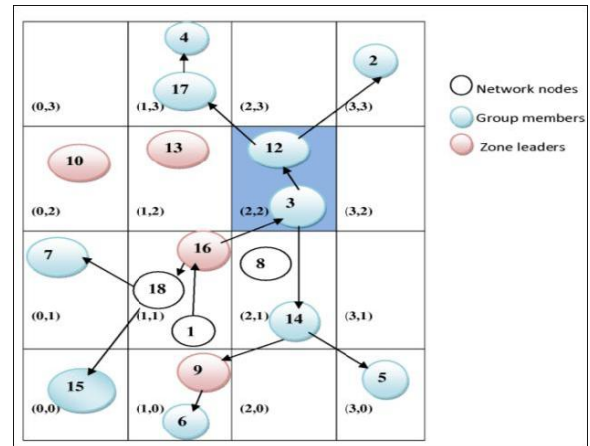


Fig 1: zone structure and multicast session example

In EGMP, the zone structure is virtual and calculated based on a reference point. Therefore, the construction of zone structure does not depend on the shape of the network region, and it is very simple to locate and maintain a zone. The zone is used in EGMP to provide location reference and support lower -level group membership management. A multicast group can cross multiple zones. With the introduction of virtual zone, EGMP does not need to track individual node movement but only needs to track the membership change of zones, which significantly reduces the management overhead and increases the robustness of the proposed multicast protocol. We choose to design the zone without considering node density so it can provide more reliable location reference and membership management in a network with constant topology changes.

A. Zone-Supported Geographic Forwarding :

With a zone structure, the communication process includes an intrazone transmission and an interzone transmission. In our zone structure, as nodes from the same zone are within each other's transmission range and aware of each other's location, only one transmission is required for intra zone communications. Transmissions between nodes in different zones may be needed for the network-tier forwarding of control messages and data packets. In EGMP, to avoid the overhead in tracking the exact locations of a potentially large number of group members, location service is integrated with zone - based membership management without the need of an external location server. In previous, the underlying geographic unicast protocol (e.g. GPSR) will forward the packet to node 18 greedily as it closer to the destination. The perimeter mode may be used to continue the forwarding. This still cannot guarantee the packet to arrive at node 7, as the destination is a virtual reference point. Such a problem is neglected by the previous geographic protocols that use a region as destination [7].

B. Multicasting Tree Construction

In this section, we present the multicasting tree creation and maintenance schemes. In EGMP, instead of connecting each group member directly to the tree, the tree is formed in the granu-

larity of zone with guidance of location information, which significantly reduces the tree management overhead. With a destination location, a control message can be transmitted immediately without incurring a high overhead and delay to find the path first, which enables quick group joining and leaving. In the following description, except when explicitly indicated, we use G, S, and M, respectively, to represent a multicast group, a source of G and a member of G.

C. Multicast Group Join

When a node M wants to join the multicast G, if it is not a leader node, it sends a JOIN-REQ(M, PosM, G, {Mold}) message to its zLdr, carrying its address, position, and group to join. The address of the old group leader Mold is an option used when there is a leader handoff and a new leader sends an updated JOIN-REQ message to its upstream zone. If M did not receive the NEW-SESSION message or it just joined the network.

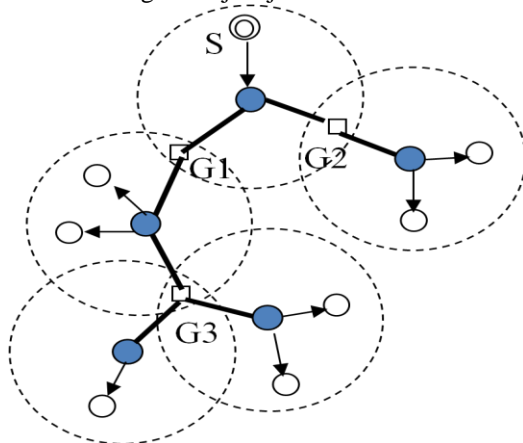


Fig 2. Group join

D. Packet Sending from the source

After the multicast tree is constructed, all the source of the group could send packets will be forwarded along the tree. In most tree-based multicast protocols, a data source needs to send the packets initially to the root of the tree. The sending of packets to the root would introduce extra delay especially when a source is far away from the root. Instead, EGMP assumes a bi-directional tree-based forwarding strategy, with which the multicast packets can flow not only from an upstream node/zone down to its downstream node/zones, but also from a downstream node/zone up to its upstream node/zone.

E. Multicast Data Forwarding

Maintain the multicast table, and the number zones normally cannot be reached within one hop from the source. When a node N has a multicast packet to forward to a list of destinations (D1;D2;D3;:), it decides the next hop node towards each destination using the geographic forwarding strategy. After deciding the next hop nodes, N inserts the list of next hop nodes and the destinations associated with each next hop node in the packet header. An example list is (N1;D1;D3;N2;D2;:) where N1 is the next hop node for the destinations D1 and D3, and N2 is the next hop node for D2. Then N broadcasts the packet promiscuously. Upon receiving the packet, a neighbor node will keep the packet if it is one of the next hop nodes or destinations, and drop the packet

otherwise. When the node is associated with some downstream destinations, it will continue forwarding packets similarly as done by node N.

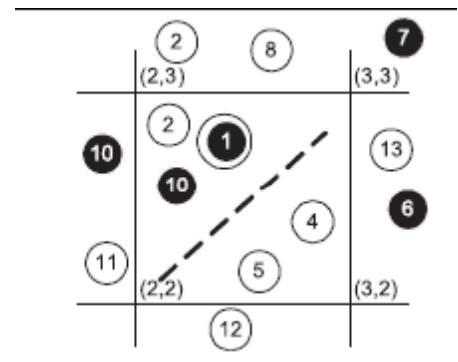


Fig. 3. multiple clusters in one zone.

F. Multicast Route Maintenance and Optimization

In the zone structure, due to the movement of nodes between different zones, some zones may become empty. It is critical to handle the empty zone problem in a zone-based protocol. Compared to managing the connections of individual nodes, however, there is much lower rate of zone membership change and hence a much lower overhead in maintaining the zone-based tree. When a member node moves to a new zone, it must rejoin the multicast tree through the new leader. When a leader is moving away from its current zone, it must handover its multicast table to the new leader in the zone, so that all the downstream zones and nodes will remain connected to the multicast tree.

PERFORMANCE EVALUATION

A. Simulation Environment We simulated EGMP protocol within the global mobile simulation (Glomosim) library. The nodes are randomly distributed in the area of 3000m*1500m with a default node density 50 nodes/km². We use IEEE 802.11 as the MAC layer protocol.

B. Parameters and Metrics We studied the following metrics for the multicast performance evaluation: 1) *Packet Delivery Ratio*: the ratio of the number of packets received and the number of packets expected to be received. So for the multicast packet delivery, the ratio is the total number of received packets over the multiplication of the group size and the number of originated packets. 2) *Number of transmissions per node every second*: The average number of transmissions of the multicast packets including the data packets and control messages per node every second during the multicast session. This metric studies the efficiency of the protocol including the efficiency for the data delivery and the efficiency for multicast structure building and maintenance. 3) *Average path length*: The average number of hops traversed by each delivered data packet. 4) *Joining Delay*: The time interval between the first JOIN-REQ sent out and the JOIN-REPLY received.

CONCLUSION

We have designed an efficient and robust geographic multicast protocol for MANET in this paper. This protocol

uses a zone structure to achieve scalability, and relies on underneath geographic unicast routing for reliable packet transmissions. We build a zone – based bi-directional multicast tree at upper tier to achieve more efficient multicast membership management and delivery, and a zone at lower tier to realize the local membership zone management. We also develop a scheme to handle the empty zone problem which is challenging for the zone- based protocols.. The position information is used in the protocol to guide the zone structure building , multicast tree construction and multicast packet forwarding..As compared to traditional multicast protocols , our scheme allows the overhead in tree structure maintenance and to the topology change more quickly . simulation results show our protocol can achieve higher packet delivery ratio in a large – scale network. They are going to enhance our protocol without the help of core zone , to achieve more optimal routing and low control overhead.

References

1. E. M. Royer and C. E. Perkins. Multicast operation of the ad hoc on-demand distance vector routing protocol. in *Proceedings of the ACM/IEEE International Conference on Mobile Computing and Networking (MOBI-COM)*, August 1999, pp. 207218.
2. C. Wu, Y. Tay, and C.-K. Toh. Ad hoc multicast routing protocol utilizing increasing id-numbers (AMRIS) functional specification. *Internet draft*, November 1998.
3. X. Zhang and L. Jacob. Multicast zone routing protocol in mobile ad hoc wireless networks. in *Proceedings of Local Computer Networks*, 2003 (LCN 03), October 2003.
4. C.-C. Chiang, M. Gerla, and L. Zhang. Forwarding group multicast protocol (FGMP) for multihop mobile wireless networks In *AJ. Cluster Comp, Special Issue on Mobile Computing*, vol. 1, no. 2, pp. 187196, 1998.
5. J. J. Garcia-Luna-Aceves and E. Madruga. The core-assisted mesh protocol. In *IEEE JSAC*, pp. 13801394, August 1999.
6. M. Gerla, S. J. Lee, and W. Su. On-demand multicast routing protocol (ODMRP) for ad hoc networks. in *Internet draft*, draft-ietf-manet-odmrp- 02.txt, 2000.
7. S.M.Das , H. Pucha and Y.C .Hu, “ Distributed Hashing for Scalable Multicast in wireless Ad Hoc Network”, *IEEE Trans.Parallel and Distributed Systems*, vol.19,no.3,pp.347-362,Mar.2008.
8. S. Basagni, I. Chlamtac, and V. R. Syrotiuk. Location aware, dependable multicast for mobile ad hoc networks. *Computer Networks*, 36(5-6):659–670, August 2001.
9. V. Devarapalli and D. Sidhu. MZR: A multicast protocol for mobile ad hoc networks. In *ICC 2001 Proceedings*, 2001.
10. M. Mauve, H. Fubler, J. Widmer, and T. Lang. Position-based multicast routing for mobile ad-hoc networks. *ACM MOBIHOC*, June 2003.
11. K. Chen and K. Nahrstedt. Effective location-guided tree construction algorithms for small group multicast in manet. *IEEE INFOCOM*, pages 1180–1189, 2002.