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Modified Efficient Geographic Multicast Protocol in Multicasting over Mobile Ad Hoc Networks for QOS Improvements

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Abstract— **By the development of new network technologies, multicasting has become one of the important networking services. MANET (Mobile Ad hoc Network) a self-configuring infrastructure less network of mobile devices connected by wireless links. But, it is big challenge to implement the well-organized and scalable multicast in MANET due to the difficulty in group membership scheme and multicast packet forwarding over a dynamic topology. During recent years several multicast protocols have also been designed specifically for MANETs like ODMRP and MAODV. These protocols all follow the traditional multicast approaches, i.e. distributed group membership management and distributed multicast routing state maintenance. Efficient Geographic Multicast Protocol (EGMP) uses a virtual-zone-based structure to implement scalable and efficient group membership scheme. In board network, a zone based bidirectional tree is constructed to achieve more efficient membership management and multicast delivery. The position information is used to guide the zone structure building, multicast tree construction, and multicast packet forwarding, which efficiently reduces the overhead for route searching and tree structure maintenance. These approaches, especially when applied for use with small and sparsely distributed groups, may become even less efficient and more expensive to function in MANETs due to bandwidth constraints, network topology dynamics, and high channel access cost. Similarly, to reduce the topology maintenance overhead and support more reliable multicasting, an option is to make use of the position information to guide multicast routing. Several strategies have been proposed to further improve the efficiency of the protocol. We propose a Modified Efficient Geographic Multicast Protocol (MEGMP). Making use of the position information to design a scalable virtual-zone-based scheme for efficient membership management, which allows a node to join and leave a group quickly. Geographic unicast is enhanced to handle the routing failure due to the use of estimated destination position with reference to a zone and applied for sending control and data packets between two entities so that transmissions are more robust in the dynamic environment Supporting efficient location search of the multicast. An important concept is zone depth, which is efficient in guiding the tree branch building and tree structure maintenance, especially in the presence of node mobility. Nodes self-organizing into zones, zone-based bidirectional-tree-based distribution paths can be built quickly for efficient multicast packet forwarding. The scalability and the efficiency of MEGMP are evaluated through simulations and quantitative analysis.**

Index Terms — **Geographic Routing, Wireless Networks, Mobile Ad Hoc Networks, Multicasting, Protocol.**

I. 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. 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.

In this work, we propose a Modified Efficient Geographic Multicast Protocol, MEGMP, which can extent to a large group size and large network size. The protocol is designed to be comprehensive and self-contained, yet simple and efficient for more reliable operation and consumes less energy when compared to existing one. Instead of addressing only a specific part of the problem, it includes a zone-based scheme to efficiently handle the group membership management, and takes advantage of the membership management structure to efficiently track the locations of all the group members without resorting to an external location server. The zone structure is formed *virtually* and the zone where a node is located can be calculated based on the position of the node and a reference origin. Conventional topology-based multicast protocols include tree-based protocols and mesh-based protocols. Tree-based protocols construct a tree structure for more efficient forwarding of packets to all the group members. Mesh-based protocols expand a multicast tree with additional paths which can be used to forward packets when some of the links break.

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,

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in the existing the zones are partitioned according to the position but in proposed protocol the zones are partitioned according to the transmission range of the mobility nodes. At the initial stage all the nodes are at sleep mode. Because of the sleep mode the energy and power utilization becomes very less. 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, MEGMP 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.

II. RELATED WORK

Multicasting in mobile ad hoc networks is a relatively unexplored research area, when compared to the area of unicast routing for MANET. Many applications envisioned for mobile ad-hoc networks rely on group communication. As a consequence, multicast routing in mobile ad-hoc networks has attracted significant attention over the recent years.

Geographic routing protocols [13] are generally more scalable and reliable than conventional topology-based routing protocols [8] [4] with their forwarding decisions based on the local topology. In MANET, geographic routing protocols unicast routing [9], [13], [14] have been proposed in recent years for more scalable and robust packet transmissions. In the existing position based geographic routing protocols generally assume mobile nodes are aware of their own positions through certain positioning system like Global Positioning system (GPS), and a source can obtain the destination position through some type of location service [21] [22]. In GPSR [13], the intermediate node makes its forwarding choices based on the destination position inserted in the packet header by the source and the positions of its one-hop neighbors learned from the periodic change of the neighbors. Similarly in SPBM [20], the packets form the source with the header are forwarded are based on the next hop position. In order to extend position-based unicast routing to multicast, SPBM provides an algorithm for duplicating multicast packets at intermediate nodes if destinations for that packet are no longer located in the same direction.

Similarly, to reduce the overhead of topology maintenance for dynamic Manet and support more reliable multicasting, an option is to make use of the position information to guide multicast routing. However, there are many challenges in implementing an efficient and robust geographic multicast scheme in 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 increase, which constrains the application of geographic multicasting only to a small group.

Topology-Based Multicast Routing Protocols [20]:

Topology-based multicast protocols for mobile ad-hoc networks can be categorized into two main classes: tree-based and mesh-based protocols. The tree-based approaches build a data dissemination tree that contains exactly one path from a source to each destination. Topological information is used for its construction. The trees can be sub-classified further into source trees and shared trees.

Position-Based Unicast and Multicast Routing Protocols[20]:

The forwarding decisions in position-based routing are usually based on the node's own position, the position of the destination, and the position of the node's direct radio neighbors. Since no global distribution structure—such as a route—is required, position-based routing is considered to be very robust to mobility. It typically performs best when the next-hop node can be found in a greedy manner by simply minimizing the remaining distance to the destination. However, there are situations where this strategy leads to a local optimum, and no neighbor can be found greedily to forward the packet further, although a route exists. This paper deals with the "Location-Guided Tree Construction Algorithms", the sender includes the addresses of all destinations in the header of a multicast packet. In addition, the location of all destinations is included as well. It remains open how the sender is able to obtain the position information, and the scaling limitations.

Location-Based Multicast Protocols [26]:

Two approaches may be used to implement location based Multicast: First, maintain a multicast tree, all nodes within multicast region at any time belong to the multicast tree. The tree would need to be updated whenever nodes enter or leave the multicast region. Second, do not maintain a multicast tree. In this case, the multicast may be performed using some sort of "flooding" scheme. This paper considers multicast group members send a packet to specific multicast region.

III. EXISTING PROTOCOL AND ITS PERFORMANCE

In this section, we will describe the EGMP protocol in details. We first give an overview of the protocol and introduce the notations to be used in the rest of the paper in Section 3.1. In Sections 3.2 and 3.3, we present our designs for the construction of zone structure and the zone-based geographic forwarding.

3.1 Protocol Overview

EGMP supports scalable and reliable membership management and multicast forwarding through a two-tier virtual zone- based structure. At the lower layer, in reference to a predetermined virtual origin, the nodes in the network self organize themselves into a set of zones, and a leader is elected in a zone to manage the local group membership. At the upper layer, the leader serves as a representative for its zone to join or leave a multicast group as required. As a result, a network-wide zone-based multicast tree is built. For efficient and reliable management and transmissions, location information will be integrated with the design and used to guide the zone construction, group membership management, multicast tree construction and maintenance, and packet forwarding. The zone-based tree is shared for all the multicast sources of a group.

Some of the notations to be used are:

- **Zone:** The network terrain is divided into square zones.

- **r:** Zone size, the length of a side of the zone square. The zone size is set to $r \leq r_t/\sqrt{2}$, where r_t is the transmission range of the mobile nodes.
- **zone ID:** The identification of a zone. A node can calculate its zone ID (a, b) from its position coordinates (x, y) as: $a = [x\text{-}x_0/r]$, $b=[y\text{-}y_0/r]$, where (x_0, y_0) is the position of the virtual origin, which can be a known reference location or determined at network setup time. A zone is virtual and formulated in reference to the virtual origin. For simplicity, we assume the entire zones IDs are positive.
- **zLdr:** Zone leader. A zLdr is elected in each zone for managing the local zone group membership and taking part in the upper tier multicast routing.
- **tree zone:** The tree zones are responsible for the multicast packet forwarding. A tree zone may have group members or just help forward the multicast packets for zones with members.
- **root zone:** The zone where the root of the multicast tree is located.
- **zone depth:** The depth of a zone is used to reflect its distance to the root zone. For a zone with ID (a, b), its depth is

$$\text{Depth} = \max(|a_0-a|, |b_0-b|)$$

where (a_0, b_0) is the root-zone ID.

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.

3.2 Neighbor Table Generation and Zone Leader Election

A node constructs its neighbor table without extra signaling. When receiving a beacon from a neighbor, a node records the node ID, position, and flag contained in the message in its neighbor table. The zone ID of the sending node can be calculated from its position. To avoid routing failure due to outdated topology information, an entry will be removed if not refreshed within a period $Timeout_{NT}$ or the corresponding neighbor is detected unreachable by the MAC layer protocol. A zone leader is elected through the cooperation of nodes and maintained consistently in a zone. When a node appears in the network, it sends out a beacon announcing its existence. Then, it waits for an $Intval_{max}$ period for the beacons from other nodes. Every $Intval_{min}$ a node will check its neighbor table and determine its zone leader under different cases: 1) the neighbor table contains no other nodes in the same zone; it will announce itself as the leader. 2) The flags of all the nodes in the same zone are unset, which means that no node in the zone has announced the leadership role. If the node is closer to the zone center than other nodes, it will announce its leadership role through a signal message with the leader flag set. 3) More than one node in the same zone have their leader flags set, the one with the highest node ID is elected. 4) Only one of the nodes in the zone has its flag set, and then the node with the flag set is the leader.

3.3 Multicast Tree Construction

In this section, we present the multicast tree creation and maintenance schemes. In EGMP, instead of connecting each group member directly to the tree, the tree is formed in the granularity of zone with the 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.

3.4 Multicast Route Maintenance and Optimization

In a dynamic network, it is critical to maintain the connection of the multicast tree, and adjust the tree structure upon the topology changes to optimize the multicast routing. 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 a much lower rate of zone membership change and hence a much lower overhead in maintaining the zone-based tree. As the tree construction is guided by location information, a disconnected zone can quickly reestablish its connection to the tree. In addition, a zone may be partitioned into multiple clusters due to fading and signal blocking.

3.5 Performance Evaluation

A multicast source broadcasts a Join-Query message to the entire network periodically. An intermediate node stores the source ID and the sequence number, and updates its routing table with the node ID (i.e., backward learning) from which the message was received for the reverse path back to the source. A receiver creates and broadcasts a Join Reply to its neighbors, with the next hop node ID field filled by extracting information from its routing table. The ID neighbor node whose matches the next hop node ID of the message realizes that it is on the path to the source and is part of the forwarding group. It then broadcasts its own Join Table built upon matched entries. This whole process constructs (or updates) the routes from sources to receivers and builds a mesh of nodes, the forwarding group. Table 1 lists the simulation parameters of EGMP with beacon interval 200sec. The simulations for ODMRP are based on the codes carried with the simulator, with the parameters set as in [9].

Parameter	Value
r(zone size)	75m
$Intval_{min}$	2 sec
$Intval_{max}$	4 sec
$Intval_{active}$	3 sec
$Timeout_{NT}$	3 sec

Table 1: Parameter Values for EGMP Simulations

We fixed several bugs in the GloMoSim codes which would prevent a forwarding group node from sending JOIN TABLES. The improvement doubles the delivery ratio and reduces the control overhead of ODMRP. Additionally, we implemented SPBM in GloMoSim according to [20] and the ns2 codes provided by the authors with the same parameter settings except that the square size was set to 150 m so that the nodes in a square are within each other's transmission range. The number of levels of the quad-tree changes accordingly with the square size and the network size we used. For packet forwarding in SPBM, different from the scheme described in [20], we used the square center as the destination position, which improves the delivery ratio of SPBM.

The work attempts to improve the stateless multicast protocol, which allows it a better scalability to group size. In contrast, EGMP uses a location-aware approach for more reliable membership management and packet transmissions, and supports scalability for both group size and network size.

IV. MODIFIED EFFICIENT GEOGRAPHIC MULTICAST PROTOCOL(EGMP)

EGMP uses a virtual-zone-based structure to implement scalable and efficient group membership management. A network wide zone-based bidirectional tree is constructed to achieve more efficient membership management and multicast delivery. The position information is used to guide the zone structure building, multicast tree construction, and multicast packet forwarding, which efficiently reduces the overhead for route searching and tree structure maintenance. Several strategies have been proposed to further improve the efficiency of the protocol. Making use of the position information to design a scalable virtual-zone-based scheme for efficient membership management, which allows a node to join and leave a group quickly. Geographic unicast is enhanced to handle the routing failure due to the use of estimated destination position with reference to a zone and applied for sending control and data packets between two entities so that transmissions are more robust in the dynamic environment Supporting efficient location search of the multicast. Group members, by combining the location service with the membership management to avoid the need and overhead of using a separate location server. An important concept zone depth, which is efficient in guiding the tree branch building and tree structure maintenance, especially in the presence of node mobility. Nodes self-organizing into zones, zone-based bidirectional-tree-based distribution paths can be built quickly for efficient multicast packet forwarding.

4.1 Framework Setup:

Routing in a communication network is the process of forwarding a message from a source host to a destination host via intermediate nodes. A wireless ad hoc network consists of mobile nodes (MNs) with wireless communication capabilities for specific sensing tasks. Modify mobility and driver partition which apt to node placement under zone process thus creates the framework for our proposed protocol. Mobility describes the node movement and the driver initializes position of each and every nodes. Each and every protocol developed under three states which are initialization, packet event section and finalization. Some more function which consists of edge calculation, report generation etc... These functions executed under several instances which are depend under the nodes position. In EGMP, making use of the position information to design a scalable virtual-zone-based scheme for efficient membership management, which allows a node to join and leave a group quickly. Geographic unicast is enhanced to handle the routing failure due to the use of estimated destination position with reference to a zone and applied for sending control and data packets between two entities so that transmissions are more robust in the dynamic environment.

4.2 Input Configuration:

The design phase is a multi step process which focuses on system creation with the help of user specifications and information gathered in the above phases. It is the phase where the system requirements are translated to operational details. System has to be designed for various aspects such as input, output etc. Based upon edge calculation the nodes are placed. According to our proposed protocol we configure some input parameters some are simulation time, Mac protocol, radio type, number of nodes, etc…

V. RESULTS AND DISCUSSIONS

We implemented the MEGMP protocol using Global Mobile Simulation (GloMoSim) [18] library. The simulations were run with 32 nodes randomly distributed in an area of 950m x 950 m. The nodes moved following the modified random waypoint mobility model. The moving speed of nodes are uniformly set between the minimum and maximum speed values which are set as as 1 m/s (with pause time as 100 seconds) and 20 m/s, respectively, except when studying the effect of mobility. Each simulation lasted 200 simulation seconds. A simulation result was gained by averaging over six runs with different seeds.

We focus on the studies of the scalability and efficiency of the protocol under the dynamic environment and also in consideration with the energy and power utilization of nodes. The performance of the proposed MEGMP algorithm is evaluated via glomosim simulator. Performance metrics are utilized in the simulations for performance comparison:

Packet arrival rate: The ratio of the number of received data packets to the number of total data packets sent by the source.

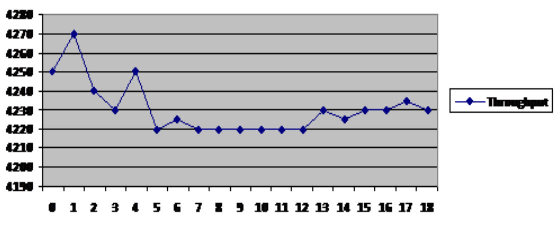

Figure 1. Packet arrival rate of Proposed Protocol

Average end-to-end delay: The average time elapsed for delivering a data packet within a successful transmission.

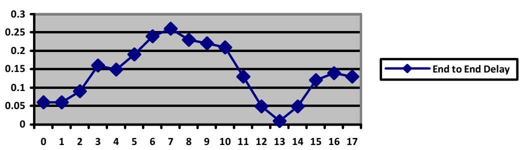

Figure 2. Packet arrival rate of Proposed Protocol

Energy consumption: The energy consumption for the entire network, including transmission energy consumption for both the data and control packets.

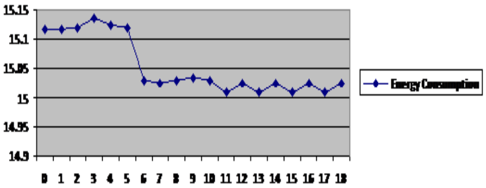

Figure 3. Energy consumption of Proposed Protocol

Collision rate: The average Collision rate for the entire data transmission from source to destination is much controlled and reduced when compared to the existing protocol.

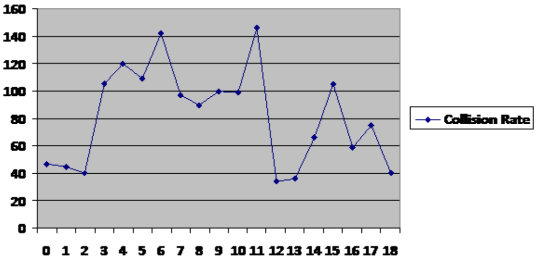

Figure 4. Collision Rate of Proposed Protocol

Communication overhead: The average number of transmitted control bytes per second, including both the data packet header and the control packets.

V. CONCLUSIONS

There is an increasing demand and a big challenge to design more scalable and reliable multicast protocol over a dynamic ad hoc network (MANET). In this paper, we propose an efficient and scalable geographic multicast protocol, EGMP, for MANET. The scalability of EGMP is achieved through a two-tier virtual-zone-based structure, which takes advantage of the geometric information to greatly simplify the zone management and packet forwarding. A zone-based bidirectional multicast tree is built at the upper tier for more efficient multicast membership management and data delivery, while the intrazone management is performed at the lower tier to realize the local membership management. The position information is used in the protocol to guide the zone structure building, multicast tree construction, maintenance, and multicast packet forwarding. Compared to conventional topology-based multicast protocols, the use of location information in EGMP significantly reduces the tree construction and maintenance overhead, and enables quicker tree structure adaptation to the network topology change. We also develop a scheme to handle the empty zone problem, which is challenging for the zone-based protocols. Additionally, MEGMP makes use of geographic forwarding for reliable packet transmissions, and efficiently tracks the positions of multicast group members without resorting to an external location server.

Compared to the classical protocol ODMRP, both geometric multicast protocols SPBM and EGMP could achieve much higher delivery ratio in all circumstances, with respect to the variation of mobility, node density, group size, and network range.

Our results indicate that geometric information can be used to more efficiently construct and maintain multicast structure, and to achieve more scalable and reliable multicast transmissions in the presence of constant topology change of MANET. Our simulation results demonstrate that MEGMP has high energy consumption, high packet delivery ratio, and low control overhead and multicast group joining delay under all cases studied, and is scalable to both the group size and the network size. Compared to the geographic multicast protocol SPBM and EGMP, it has significantly lower control overhead, data transmission overhead, and multicast group joining delay.

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BIOGRAPHY

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