Joining Delay, Packet Delivery and Limitations of EGMP

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Abstract: *To implement this group communication, we propose an Efficient Geographic Multicast Routing protocol (EGMP) with the help of virtual zone based structure. In this paper, we proposed a novel Efficient Geographic Multicast Protocol (EGMP). A network wide zone-based bi-directional tree is used to achieve efficient membership management and multicast delivery. In Efficient EGMP an efficient distributed algorithm is used, that support dynamic changes to the multicast group during tree building and allows overlapping join/leave operations. 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. EGMP does not depend on any specific geographic unicast routing protocol. Our simulation results demonstrate that EGMP has high throughput, high packet delivery ratioand low flow blocking compared to AOMDV and is scalable to both group size and network size.*

Keywords: JOIN-REQ, SPBM , ODMRP (On Demand Multicast Routing Protocol)

1. Introduction

In MANET unicast routing, geographic routing protocols [1] have been proposed for more scalable and robust packet transmissions. The existing geographic routing protocols generally assume mobile nodes are aware of their own positions through certain positioning system (GPS), and a source can obtain the destination position through some type of location service [1].In this paper, we propose an efficient geographic multicast protocol, EGMP, which can scale to a large group size. The protocol is designed to be comprehensive and self-contained, yet simple and efficient for more reliable operation. 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. We propose a Efficient Geographic Multicast Protocol, EGMP, which can extent to a large group size and large network size and this protocol will provide efficient multicast packet transmissions in a dynamic mobile ad hoc network environment. EGMP makes use of position information to support reliable packet forwarding. 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. EGMP can scale to large group size and network size and can efficiently implement multicasting delivery.

2. Related Work

EGMP uses a location-aware approach for more reliable membership management and packet transmissions, and supports scalability for group size.[1] In this paper, zone-supported geographic forwarding is introduced to reduce the routing failure, and provide mechanism to handle zone partitioning. In addition, we introduce a path optimization process to handle multiple paths, and provide a detailed cost analysis to demonstrate the scalability of the proposed routing scheme. EGMP does not make any assumption of the network size in advance, and the change of the membership of a zone does not need to be sent to a far-away RP but only needs to be updated locally. Instead of using one RP as a core for group membership management, which may lead to a point of failure, EGMP introduces the root zone which is much more stable than a single point, and manages group membership more efficiently within the local range. Instead of using the overlay-based multiple unicast transmissions, EGMP takes advantage of the promiscuous mode transmission to forward packets along more efficient transmission paths. EGMP uses more efficient zone-based structure to allow nodes to quickly join and leave the group. EGMP introduces root zone and zone depth to facilitate simple and more reliable group membership management. EGMP does not use any periodic network-wide flooding, thus it can be scalable to both the group size and network size. EGMP supports scalable and reliable membership management and multicast forwarding through a two-tier virtual-zone-based structure. To reduce the forwarding overhead and delay, EGMP supports bidirectional packet forwarding along the tree structure. That is, instead of sending the packets to the root of the tree first, a source forwards the multicast packets directly along the tree.

2.1 Leader Selection and Leaving in Efficient Geographic Multicast Protocol

EGMP handles the zone partitioning problem as follows: If there are multiple clusters in a zone, because these clusters

are not aware of the existence of each other, each cluster will elect a leader. When an upstream zone leader receives JOIN_REQ messages from multiple leaders of the same zone and the new message is not sent as a result of leader handover (in which case the old leaders address needs to be carried), it detects that the downstream zone has partitioned into multiple clusters. It identifies a cluster by its zone id and the leader's address. When sending a packet to the cluster, it uses the leader's position instead of the zone center (in which case the zone ID is carried as the destination) as the transmission reference. Even though the leader may move, its position carried in JOIN_REQ message can still be used as a reference to forward packets to its cluster. When receiving a packet with the position of the leader as the reference, a cluster leader can learn that multiple clusters exist within its zone. In case that not all the clusters of a partitioned zone send JOIN_REQ messages, the upstream zone leader may not be aware of the partitioning of the downstream zone. When a cluster leader receives a packet destined to its zone but does not match its status, it will send an update message to its upstream zone. For example, when a cluster leader receives a JOIN_REPLY message or a multicast packet but did not send JOIN_REQ message, it will send a LEAVE message to the upstream zone. When receiving messages from multiple leaders of the same zone, the upstream leader can detect zone partitioning. It will resend the previous message to the target cluster with the position of the zone leader as the destination [4]

When the leader of a cluster changes, if the cluster is on tree, the new leader sends a JOIN_REQ message to its upstream zone immediately which also carries the old leader's address. With multiple clusters in its upstream zone, the JOIN_REQ message from a zone leader will generally be intercepted by one of the clusters, which will be responsible for forwarding the packets to the zone. Some clusters may merge later into a larger cluster, and through the leader election procedure, only one of the leaders will win as the new cluster's leader. The new leader will send a JOIN_REQ message to the upstream zone to refresh the cluster's information.

2.2 Limitations of EGMP

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 pre-determined 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. To further reduce the forwarding overhead and delay, EGMP supports bi-directional packet forwarding along the tree structure. That is, instead of sending the packets to the root of the tree first, a source forwards the multicast packets directly along the

tree. At the upper layer, the multicast packets will flow along the multicast tree both upstream to the root zone and downstream to the leaf zones of the tree. At the lower layer, when an on tree zone leader receives the packets, it will send them to the group members in its local zone. In EGMP, we assume every node is aware of its own position through some positioning system or other localization schemes. 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.[3]

In EGMP the group members are not directly connected to form a tree. Instead of this the tree is formed in the granularity of zone with the guidance of location information. And this will reduce the tree management overhead. The control messages are transmitted with the help of destination location. Thereby reducing overhead and delay to find the path first, this enables quick group joining and leaving. The basic algorithm generates a correct tree provided the following conditions hold:

- The multicast group is known to all participants.
- The multicast group does not change once execution of the algorithm has begun.

A practical distributed algorithm must handle changes to the multicast group during tree setup. Two types of changes are possible: additional nodes may wish to join the multicast group and current members of the multicast group may wish to leave. The modifications proposed in this section extend the basic algorithm to support concurrent changes to the multicast group during generation of the tree.[2]

3. Performance Evaluation

In this section, we study the performance of EGMP by simulations. We are mainly interested in the protocol's scalability and efficiency in a dynamic environment. We implemented the EGMP protocol using NS2 Simulation. A multicast source broadcasts Join-Query messages 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 from which the message was received for the reverse path back to the source. A receiver creates and broadcasts a Join Reply to its neighbours, with the next hop node ID field filled by extracting information from its routing table. The neighbour node who's ID 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. We focus on the studies of the scalability and efficiency of the protocol under the dynamic

environment and the following metrics were used for the multicast performance evaluation:

a) Packet delivery ratio:
The ratio of the number of packets received and the number of packets expected to receive. Thus for multicast packet delivery, the ratio is equal to the total number of received packets over the number of originated packets times the group size. In EGMP packet delivery ratio was high when compare to other protocol.

b) Normalized control overhead:
The total number of control message transmissions divided by the total number of received data packets. Each forwarding of the control message was counted as one transmission. Control overhead was less in EGMP.

c) Normalized data packet transmission overhead:
The ratio of the total number of data packet transmissions and the number of received data packets. Packet transmission overhead is less in EGMP.

d) Joining delay
The average time interval between a member joining a group and its first receiving of the data packet from that group. Joining delay is also less in EGMP.

On comparing the performance of EGMP with geographic multicast protocol SPBM, EGMP has lower control overhead, lower group joining delay, higher packet delivery ratio, lower data transmission overhead, higher bandwidth utilization, and higher performance. SPBM is seen to have more than six times overhead of EGMP due to the use of periodic local and network-wide flooding in its membership management. And also in EGMP, when a node wants to join a group it will start the joining process immediately because of this joining delay is less. Whereas in SPBM the joining delay will be high most of the time because of the use of periodic multilevel membership update mechanism, it may take a long time for a bottom level square of SPBM to distribute its membership change to the upmost level. And also the increase of mobility also leads to significant increase of transmission of SPBM, as the membership change of a low layer square in SPBM cannot be distributed quickly to upper layer which results in outdated membership information and higher packet transmission overhead. Whereas EGMP will have lower packet transmission overhead. Further in SPBM when there is an existence of collision, it cannot repair it locally but in EGMP when there is existence of collision the packets can travel through any other shortest path and reduces delay in packet transmission to the destination. All these comparison results have shown that EGMP will produce high quality trees when compared to geographic multicast protocol SPBM.[3]

3.1 Protocol Overview

EGMP uses a two-tier structure. The whole network is divided into square zones. 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. The source sends the multicast packets directly onto the tree. And then the multicast packets will flow along the multicast tree at the upper tier. When an on tree zone leader receives the packets, it will send the multicast packets to the group members in its local zone. To implement this two-tier structure, we need to address a number of issues. For example, how to build the zone structure? How to elect the zone leader and handle its mobility? A zone may become empty due to the node movements, and how to keep the tree connected when an on-tree zone becomes empty? A member node may move from one zone to another, how to reduce the packet loss during mobility? In the following sections, we will give the answers to these questions. In EGMP, we assume every node is aware of its own position through some positioning system (e.g., GPS). The forwarding of data packets and most control messages is based on the geographic unicast routing protocols [2].

3.2 Simulation Environment

We simulated EGMP protocol within the Global Mobile Simulation (GloMoSim) [5] library. The nodes are randomly distributed in the area of $3000m \times 1500m$ with a default node density 50 nodes/km2. We use IEEE 802.11 as the MAC layer protocol. The nodes move following the *random waypoint* mobility model. The transmission range is 250m. Each traffic flow is sent at 8 Kbps using CBR with packet length 512 bytes, and each simulation lasts 900 simulation seconds. A simulation result is gained by averaging over several runs with different seeds. The moving pause time is set as 0 second, minimum speed is 0 km/h and the default maximum speed is 72 km/h [4].

4. Protocol Performance

We evaluate the performance of EGMP with different node densities, moving speeds and group sizes. As far as we know there is no other comprehensive geographic multicast protocol available now. Since every part of multicast protocol including the membership management, tree/mesh construction, multicast packet forwarding and the location service for a geographic protocol will impact the multicast protocol performance, for the performance references, the simulation results are referred.[4] the delivery ratio of EGMP keeps at more than 85%. When the group size is 10, the difference between the delivery ratio of EGMP and ODMRP is nearly 50%. The path length of EGMP keeps at around average 4.8 hops with different group sizes.[4]

EGMP performs better with higher node density. Even when the node density is as low as 20 nodes/km2, the performance of EGMP is comparable to ODMRP. When the node density increases, the performance of EGMP becomes better due to the more stable zone structure. When the node density is higher than 80 nodes/km2, the increase of delivery ratio becomes slower. At high density the collisions among neighbouring nodes will increase and cause more packet loss. Since part of the EGMP transmission load is generated from the zone structure maintenance which is not included in ODMRP, when the node density increases, this part of transmission load decreases with the more stable zone

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structure. So, the transmission load of EGMP decreases much faster than ODMRP as the node density increases.[4]

5. Conclusions

In this paper, the performance metrics such as packet delivery ratio, control overhead, packet transmission overhead and average joining delay of the protocol EGMP is dealt. Our simulation results shows that EGMP has high packet delivery ratio and low control overhead and multicast group joining delay under all cases, and is scalable to group size. 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. 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. EGMP 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. EGMP has significantly lower control overhead, data transmission overhead, and multicast group joining delay. Our simulation results demonstrate that EGMP has 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.

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