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Selective Destination Multicasting over Mobile Ad Hoc Networks

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Abstract

Mobile Ad-hoc network (MANET) is a self-configuring wireless system, which connect the mobile devices without use of any fixed network infrastructure or centralized co-ordination. Group communications are the major role in MANET communication which is efficiently implemented by Multicasting. But, there are big challenges to implement efficient and reliable multicasting due to difficult in group membership management and multicast packet delivery over a dynamic MANET. In recent years various multicast protocols have been designed distinct for MANETs. All these multicast protocols follow the conventional multicast approaches. We propose a Selective Destination Geographic Multicast Protocol (SDGMP). It uses a virtual zone based structure to implement reliable and efficient group membership management. Position information is used to track individual nodes location. The virtual zone is divided into cluster to attain more efficient group management and multicast packet delivery. To further improve the efficiency, SDGMP introduces the concept of selective destination multicasting for efficient packet delivery. The efficiency of the SDGMP is evaluated through simulations and performance evaluation. The simulation results show that SDGMP has high packet delivery ratio, low packet drop ratio, energy consumption and delay.

Keywords: *Multicasting, Geographic Routing, Virtual Zone, Group membership management, Packet delivery, Selective Destination.*

1. Introduction

A mobile ad-hoc network (MANET) is a wireless system which connects mobile devices without use of any network infrastructure and central co-ordination. A lot of applications implemented for mobile ad-hoc networks depend on group communication. Significant examples of MANETs are emergency warnings, rescue operations, disaster relief efforts, military networks, video conference and information sharing. Group communications are major role in MANET communication which may be efficiently implemented by Multicasting. Multicasting in mobile ad hoc networks is an unexplored area, when compared to the unicast in MANET. Multicasting defines a delivery of a message to a multiple nodes simultaneously in a single transmission. Multicasting minimizes channel capacity consumption, energy consumption, cost and delivery delay, while multicasting the data instead of multiple unicasts. But, there are big challenges to implement efficient and reliable multicast due to difficult in group management and multicast packet delivery over a dynamic MANET. Multicast routing in mobile ad-hoc networks has evoked sufficiently great attention over the recent years. In recent years, geographic routing [7], [11] has been proposed for unicast communication in MANET. These are used global positioning system (GPS) to locate mobile nodes destination positions. The overall transmissions carried out from source to destination through neighbors. The neighbors placed within one hop positions identified by the periodic beaconing of the each neighbors. Source node is used location service [11] to determine the members destination Positions. The intermediate node to put all the group nodes destination position into the packet header to delivered the packet. The position information is used to guide the geographic routing to reduce the topology maintenance overhead and provide efficient multicasting. In geographic unicast routing, the destination position is inserted in to the packet header while data forwarding. When extend a geographic unicast to multicast, it creates a lot of overhead due to a larger group size. So these are suitable only for the small multicast groups.

In this work, we propose a selective destination Geographic multicasting protocol (SDGMP). SDGMP can efficiently implement the multicasting data delivery and group membership management. This protocol is designed to be flexible and simple. This proposed SDGMP uses a virtual zone structure for more efficient and reliable group membership management and packet delivery in the presence of high network dynamics. Here all the zones in this virtual zone structure should be act as a core zone.

Each core zone elects leaders to manage their group members and can JOIN/LEAVE a new member to its group. As a result of the zone leader election, zone based multicast cluster is formed to achieve more efficient group membership management and multicast packet delivery. To furthermore improve the efficiency of the SDGMP protocol is introducing the concept of selective destination multicasting for efficient data delivery in dynamic mobile ad-hoc networks.

2. Related Work

In this section we first describe the basic conventional multicast protocols and then discuss about a few geographic multicast protocols in detail. The Conventional multicasting protocols [10], [12], [13], [14], [15], can be categorized into either tree based or mesh based. In tree based multicast routing protocols (e.g., MAODV [13], AMRIS [15] and MZRP [10]), a shared multicast tree is used to multicast the data from a source to destination multicast group. Mesh based protocols (e.g., FGMP [14], and ODMRP [12]) establish redundant paths that connect the sources and destinations. They are more flexible to link failures and node mobility. Both tree based and mesh based approaches scale poorly over dynamic topology changes over MANET. In contrast, Geographic routing protocols (e.g., EGMP [4], SPBM [8]) were generally more efficient and reliable than conventional topology based routing protocols with their forwarding decisions based on the local topology. It uses a location aware service to attain more efficient membership management and packet delivery.Let we discuss about some geographic multicasting protocols such as SPBM and EGMP.

Scalable position based multicast protocol (SPBM) [8] was comprised multicast forwarding and group management. In SPBM protocol, the network field is divided into an L level of quad-tree structure. At each level, every lower level square periodically floods their membership to the upper level square. The periodic flooding for every two neighboring levels should be repeated. As a result of repeated flooding, significant control overhead will be increased, when the network size increases. The SPBM data forwarding is based on whether the members placed in a given direction or not. The packets are forwarded from source to destination, which is based on the next hop position. So overhead occur because of intermediate nodes. Alternatively, and EGMP [4] used more efficient virtual zone structure to allow nodes to quickly join or leave the multicast group. EGMP does not use any periodic network wide flooding.

Efficient geographic multicast protocol (EGMP) [4] provides reliable and scalable group membership management and multicast zone forwarding through a two tier virtual zone structure. At the lower tier, the network nodes are grouped together and every zone elected a leader to achieve group membership management. In the upper tier, the leader manages group members to join/leave multicasting group and maintaining bi-directional multicasting tree. The major problems in the EGMP are single core zone structure for maintain group membership management. All the multicasting data can be managed only by single core zone. This makes big overhead in multicast group membership management. But in proposed SDGMP, consider all the zones in a virtual zone structure a core zone. Then the next issue is zone based multicasting tree which are located in the core zone. The whole multicasting data will be forwarded through this tree and it has huge overhead to join/leave multicasting group. So it will make delay and data transmission overhead due to dynamic topology changes. In SDGMP uses the zone cluster to multicast the data. While data forwarding, the source node N inserts all the next hop nodes and destinations. This makes additional header overhead while data forward towards single core zone. Finally in EGMP [4], there is no priority to individual node and they consider all nodes are as same and multicast the data.

So the topology based and geographic multicast protocols [4], [5], [6], and [8] are difficult to achieve following components due to the network dynamics.

- *Group membership management:* The frequent changes of the group members as each node needs JOIN/LEAVE a multicast group consistently, and management of a group may difficult as a group size or network size increases.
- *Multicast Packet delivery:* The multicast packets are forwarded along a tree structure, which are leads to packet loss due to dynamic topology, particularly in large networks possible in longest network path.

To overcome these limitations, we have to implement the proposed selective destination geographic multicasting protocol (SDGMP) to achieve efficient group membership management and packet delivery.

3. Proposed Work: Selective Destination Multicast Protocol (SDGMP)

In this section we describe the SDGMP protocol. We first give the detail about overview of SDGMP protocol in section 3.1 and the rest of the paper in section 3.2, 3.3, and 3.4 presents virtual zone structure creation process, multicast zone cluster formation and the multicast packet delivery.

3.1 SDGMP Overview

SDGMP support efficient, reliable group membership management and multicast packet delivery through virtual zone structure. In SDGMP, the zone structure is designed virtually based on a zones reference point. The virtual zone

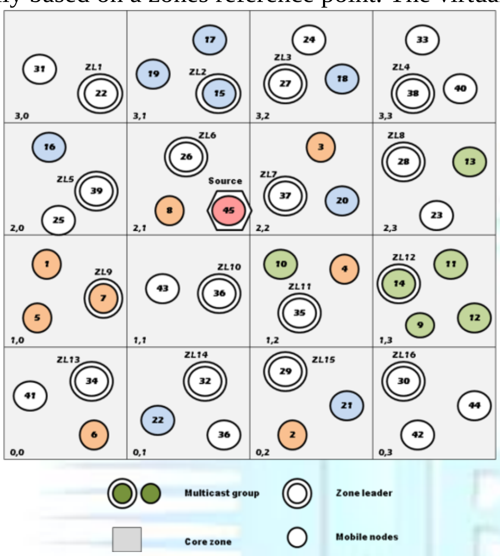

Fig. 1 Virtual zone structure and multicast session example.

structure does not depend on the network shapes. Hence SDGMP not needed to track the individual nodes mobility in the zone but only to track the changes of multicast group members. Furthermore, SDGMP uses position information to find the nodes position within the zone, which uses virtual zone to support reliable packet delivery. In SDGMP, all the zones in the virtual zone structure should be act as the core zone, which manages all multicast information and group member details. Each core zone is elected a leader to manage their group members and can JOIN/LEAVE a new member to its group. As a result of the leader election in each zone, the virtual zone should be divided into multicast cluster. The nodes in the zones are grouped together based on the zone cluster to organizing the multicasting group. Each zone includes zone leader and its group members to manage their group. The nodes which are joined in the multicast group can cross multiple zones. The source nodes are initialized within the virtual zone for multicasting the data to the group members. Thus we have to make the geographic multicasting efficiently. By using virtual zone, achieve reliable and efficient group membership management and transmissions of the location information will be integrated with the zone design. It is used to guide the zone construction, group membership management, multicast cluster formation and packet delivery. There are following notations related to virtual zone which defined in Fig. 1,

Zone: The network region is virtually divided into square zones.

Zone size(r): The size of zone which cover the transmission range of mobile nodes.

Zone ID: The Identification of zone (a, b) which can be calculated based on nodes (X, Y) Position coordinates as, $a=(X-X_0/r)$ and $b=(Y-Y_0/r)$ where (X_0, Y_0) is the virtual zones origin.

Zone leader: A representative elected for every zone to manage group members and route the multicast packet to destinations.

Core zone: Each zone act as a core zone which manage the whole multicast communication process such as location information, group membership management and packet delivery.

3.2 Group Membership Management

SDGMP uses the virtual zone structure to achieve the efficient group membership management, which organizes the network to track the nodes in efficient manner. Furthermore, the leader election and zone cluster concepts to achieved reliable and efficient group membership management with the presence of network dynamics.

3.2.1 Neighbor Determination and Leader Table

A node within the virtual zone identifies its own position through some type of positioning system (GPS) and their topology information should be calculated based on the beacon broadcast to its neighbors. When a node appears in the network, it will announce its existence through beacon broadcast. In SDGMP there is no need to fixed or periodic beacon broadcast to reduce the beaconing overhead. But, once the neighbor topology information updated that it should be maintained in the zone leaders table. The zone leader announces its membership through information stored within a leader table which includes the field's zoneID, nodeID, position and flag. The zone ID is calculated based on the nodes position. Flag field indicates a node is a zone leader or not. The leader table is updated when changes are made in the leader table, which is known by others through table information. For example the Table 1 shows the leader table for node 14 which has 6 group members from the figure1. All the multicast group nodes details are updated in the leader table, which should be maintained by leaders. Instead of maintain table in all nodes, zone leader only responsible to manage the leader table. The Leader should be elected within the zone for efficient group management.

Table 1: Leader table of node 14 in Fig. 1

Node ID	***Zone ID***	***Flag***	***Position***
9	(x9,y9)	0	(1,3)
10	(x10,y10)	0	(1,2)
11	(x11,y11)	0	(1,3)
12	(x12,y12)	0	(1,3)
13	(x13,y13)	0	(1,3)
14	(x14,y14)	1	(0,0)

3.2.2 Zone Leader Election

A zone leader election is happened when the node enter into the network and announces it position information through beacon, that should be recorded into the leader table. A zone leader can be elected through the coordination of nodes are grouped together in the zone. The leader of the zone can be efficiently elected to organize a multicast group.

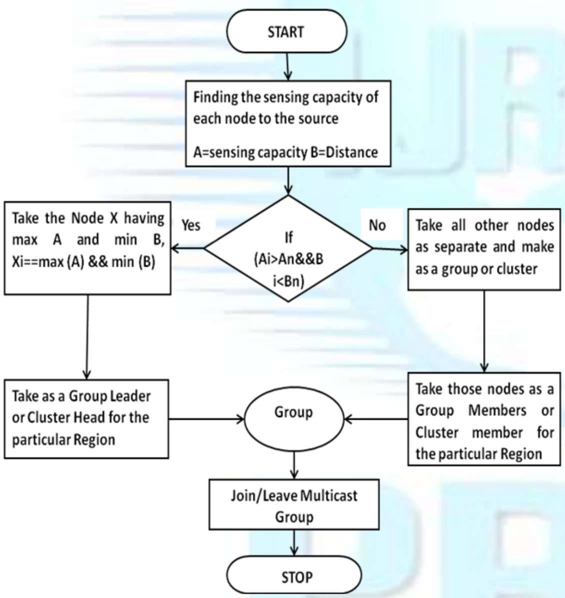

Fig. 2 Zone leader election technique

Fig. 2 shows that the nodes which are nearer to the source and have high sensing capacity should be elected as a leader for the particular zone. The elected leaders are updating its leader information to all nodes in the network through leader table. Each leader in the zone has to be maintaining the leader table and multicast group membership management. The elected leaders are organized well with in virtual zone by periodic updates. When a multicasting group members moves into another zone, queries the zone leader for joining process. Such joining nodes information updated within its zone leader table. The zone leaders are responsible for JOIN/LEAVE multicast group members.

3.2.3 Multicast Zone Cluster Formation

Instead of using multicast tree, SDGMP uses cluster to multicast the data. Clustering is an efficient method to grouping nodes which prevents unnecessary flooding. SDGMP uses the zone based cluster to achieve multicast group membership management and reliable packet delivery. By using the leader election, each zone has to be divided into a cluster which includes cluster head or zone leader and several cluster members or group members. Based on the leader election, nodes which are near to the source and have high capability in the zone are elected as a cluster head or zone leader and other nodes in the zone are grouped as group members. Cluster head only maintain all the detail about its member for efficient multicasting within the zone. Thus the cluster head plays an important role in networks which are responsible for administration, organization, coordination and communication between zones. This overcomes data transmission overhead, control overhead, joining/leaving delay. Thus the SDGMP become an efficient group membership management by using virtual zone clusters.

3.3 Multicast Packet Delivery

Here we discuss about the packet forwarding in SDGMP using following multicasting methods.

3.3.1 Packet Sending from Source

After the multicast cluster is formed, the multicasting packets are sent to the multicast group members by the source. A source node is one of the members in the multicast group. By the help of group membership management, source node S knows about the local group members and their position through zone leaders which are recorded in the zone leader table. The Multicasting packets will be sent through a virtual zone cluster from the source to the member zones, and then from the zone leader to the group members. The nodeID and zoneID is used to identifies the members zone and group members position When a source S needs to send data, it checks the flag in the leader table whether it is a leader or not. Then it will track the zone leaders and sends the multicast packets to its leader. When the leader of the destination zone receives a multicast packets and then it forwards the packets to its group members. So the multicast packets are first delivered by source to member zones with the help of zoneID and then delivered to the member nodes in its own zone through the zone leader with the help of nodeID. For example node 45 in Fig.1, is a source needs to send multicast packets to its group members, it checks the membership details and then send the multicast packet to its group members zone (1, 0), (1, 3) and (3, 1).Then the corresponding zone leaders, send the packet to its group members. When source S is not on the multicast group, first join into multicast group through JOIN queries and then multicast the information.

3.3.2 Selective Destination Multicasting

To improve the multicasting efficiency, we introduce the concept of selective destination multicasting for efficient data delivery. In actual multicasting there is no priority to individual nodes and all group members are same as to deliver the data. Instead of multicasting to all nodes in the group of a zone, selective destination multicasting is achieved. In selective multicasting, we are going to give priority to each node by selecting them to group together for multicasting the data. By this selective destination method we will be able to communicate to specific nodes in the particular region in a hierarchical manner. By this way we can able to deliver all the data to particular selective nodes efficiently. With this method, nodes are grouped with the help of zone ID and node ID by the source on beginning of multicasting. For example the source 45 need to multicast packets, it randomly selects the group members through zoneID and nodeID. Likewise nodes (4, 10, 12) placed in [(1, 2), (1, 3)] are selected for multicast the packets. This selective multicasting is especially used for multicasting the confidential information to the selected group members. Such a way to become efficient geographic multicasting which is achieved more packet delivery over dynamic network changes.

3.4 Multicast Route Maintenance

In dynamic network topology may critical to maintain a zone membership changes. When a node moves in to another zone, the moving node informs its position to the current zone leader which is to be updated into its leader table. Sometimes the zone may become empty because of all the nodes are moved away from the zone. Such conditions a moved node may join into the new zone by JOIN/LEAVE queries, then the correspondent leader add with its group and that information should be updated with in its leader table. Likewise the handover and empty zone problem become overcome in SDGMP.

4. Performance Evaluation

We implemented the SDGMP protocol with the help of Network Simulator (NS-2). The simulations were done with 100 nodes randomly deployed in 2000 m × 2000 m network area. Whole simulation takes 200 simulation seconds. The minimum moving speed was set as 1 m/s. We use IEEE 802.11b Mac protocol which has transmission range of 250m. First initialize the source and source home, and then 16 multicast groups with 5 members. Each source sends CBR data packets with 512 bytes at 5 kbps in 0.1 intervals. We focus the following network parameters to improve the multicasting efficiency and reliability of the SDGMP protocol under the dynamic network. Then to analyze the performance of SDGMP by comparing the actual multicasting with the selective based multicasting.

4.1 Packet Delivery Ratio

It is the ratio of the no of packets received and no of packets expected to receive. The packet delivery of both actual multicasting and selective multicasting using SDGMP is compared in Fig. 3 (a).It shows when the no of packets increased, the delivery ratio may slightly decreased due to node movements. When compared to other geographic multicasting protocols SDGMP provides better data delivery ratio.

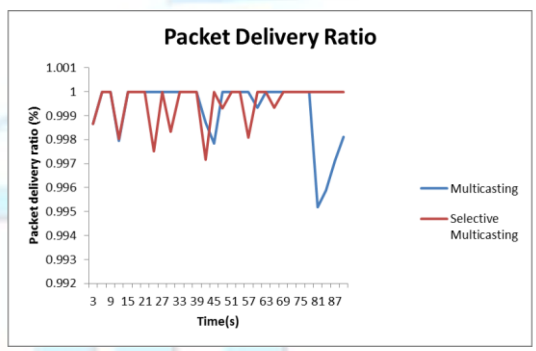

Fig. 3 (a) Packet delivery ratio

4.2 Packet Drop Ratio

It is ratio of the no of packets dropped in given time interval. Fig. 3 (b) shows that the comparison of SDGMP multicasting and selective multicasting packet drops during data forwarding. It provides the better packets drop ratio, when compared to other geographic multicast protocols.

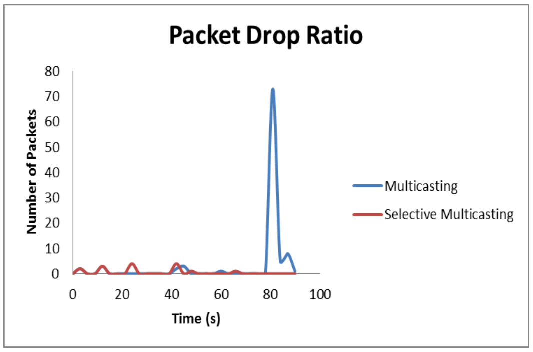

Fig. 3 (b) Packet drop ratio

4.3 Energy Consumption

The energy is an important factor in mobile ad-hoc networks because of mobility. In Fig. 3 (c) shows that the energy consumption of multicasting and selective multicasting using SDGMP, which is reduced gradually in a given time period.

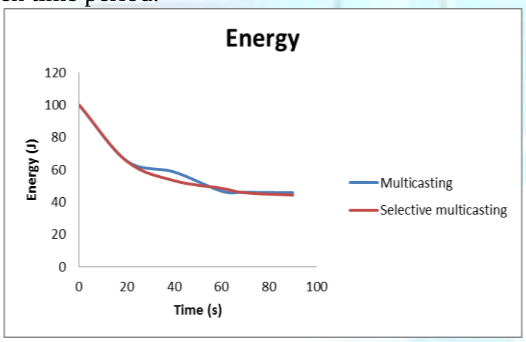

Fig. 3 (c) Energy consumption

4.4 Average Delay

The average time interval between a multicast packets send from source and packets received at destination. Fig. 3 (d) shows the average end to end delay between multicast and selective multicast using SDGMP protocol.

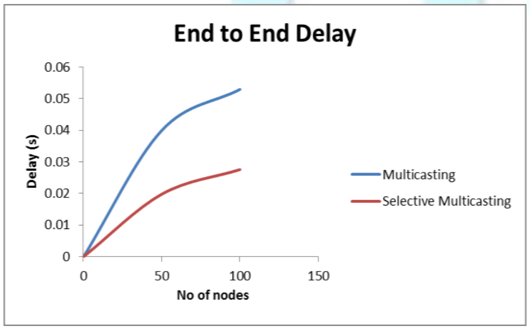

Fig. 3 (d) Average delay

4. Conclusion and Future work

In this work proposed a Selective Destination Geographic Multicasting Protocol (SDGMP) and it can efficiently implement multicasting data delivery and group membership management. This protocol is designed to be flexible and simple. It uses a virtual zone structure for more efficient and reliable group membership management and packet delivery in the presence of high network dynamics. Here all the zones in the virtual zone structure should be act as a core zone. Each core zone elected leaders to manage their group members and can JOIN/LEAVE a new member to its group. As a result the zone leader election, zone based multicast cluster is formed to achieve more efficient group membership management and multicast packet delivery. While SDGMP packet forwarding, Source node need to track the exact position and location of the multicast group sources to avoid the network wide periodic flooding of source. Many of the multicasting protocols may challenges to provide scalable and reliable multicast communication. When compared to other geographic multicast protocol, SDGMP is flexible and more specific. The simulation results shows SDGMP has high packet delivery ratio, low packet drop ratio, energy consumption, and low delay under various node densities, moving speeds, number of groups, group sizes and network sizes. The future work can further improve the efficiency and scalability of the SDGMP protocol with QOS Improvements.

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