

# Scalable and Efficient Congestion Controlled Multicasting in MANETs

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**Abstract-** A Mobile Ad-hoc Network (MANET) is a self configuring network composed of mobile nodes without any fixed infrastructure. In MANETs, there is no difference between a host node and a router so that all nodes can be source as well as forwarders. Multicasting deals with group communications, which is important in MANETS. 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. In this paper we propose a new Efficient Geographic Multicast Protocol (EGMP) with congestion control. EGMP with congestion control uses a virtual-zone-based structure to implement scalable and efficient group membership scheme. 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. Simulation results demonstrate that, compared to Scalable Position-Based Multicast (SPBM), EGMP with congestion control has significantly lower control overhead, data transmission overhead, and multicast group joining delay, hence reducing congestion.

**Index Terms**—Multicast, congestion control, mobile ad hoc networks, node overhead.

## 1 INTRODUCTION

IN MANETs, multicasting plays a crucial role to support the applications (military and disaster relief) which involve the transmission of a datagram to a group of zero or more hosts identified by a single destination address, and so is intended for group oriented computing. There are increasing interests and importance in supporting group communications over Mobile Ad Hoc Networks (MANETs). Example applications include the exchange of messages among a group of soldiers in a battlefield, communications among the firemen in a disaster area, and the support of multimedia games and teleconferences. With a one-to-many or many-to-many transmission pattern, multicast is an efficient method to realize group communications. The use of multicasting within MANETs has many benefits. It can reduce the cost of communication and improve the efficiency of the wireless channel when sending multiple copies of the same data by exploiting the inherent broadcasting properties.

Instead of sending data via multiple unicasts, multicasting minimizes channel capacity consumption, sender and router processing, energy consumption, and delivery delay, which are considered important MANET factors. However, there is a big challenge in enabling efficient and congestion controlled multicasting over a MANET whose topology may change constantly.

In addition, multicasting provides a simple yet robust communication method whereby a receiver's individual address remains unknown to the transmitter or changeable in a transparent manner by the transmitter. 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. The existing small-group-based geographic multicast protocols normally address only part of these problems. In this work, we propose an efficient geographic multicast protocol, EGMP, which can scale to a large group size and large network size.

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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.

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. 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. 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.

### **1.1. Zone Based Mechanism in EGMP**

EGMP [11],[12] can scale 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. Instead of addressing only a specific part of the problem, it includes a zone-based scheme to efficiently handle the group 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 reference origin. A number of unicast routing, geographic routing protocol have been proposed in mobile ad hoc networks [1], [2], [3], [4], [5]. The existing geographic routing protocol generally assume mobile nodes are aware of their own position through certain positioning system (for example GPS) and source can obtain the destination position through some type of location service [6], [7].

An intermediate node makes its forwarding decisions based on the destination position inserted in the packet header by the source and the positions of its one-hop neighbors learned from periodic beaconing of the neighbors. By default, the packets are greedily forwarded to the neighbor that allows for the greatest geographic progress to the destination. When no such a neighbor exists, perimeter forwarding is used to recover from the local void, where a packet traverses the face of the planarized local topology sub graph by applying the right hand rule until the greedy forwarding can be resumed. Similarly to reduce the overhead and support more reliable multicasting, position information is used to guide the multicast routing.

### **1.2. Motivation**

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.. Due to the rapid mobility of the nodes in the network, congestion occurs resulting in loss of data packets.

To prolong proper communication, there have been a flourish of research efforts in the last few decades in this field. Despite these intensive efforts, the node overhead of MANETS remains a performance bottleneck and is perhaps one of the key factors that hinder its wide-scale deployment.

The rest of the paper is organized as Follows. The following Section 2 outlines Related Work. Section 3 presents the Literature Survey, section 4 presents the proposed scheme to reduce control overhead by controlling congestion. We evaluate our method in Section 5 using simulation. Finally, Section 6 concludes the paper.

## **2 RELATED WORK**

### **2.1 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. 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.

### **2.2 Neighbor Table Generation**

For efficient management of states within a zone, a leader is elected with a minimum overhead. As a node employs periodic BEACON broadcast to distribute its position in the underneath geographic unicast routing [4], to facilitate leader election and reduce overhead, EGMP inserts a message with a BEACON, a flag indicating whether the sender is zone leader. With zone size, a broadcast message will reduce the beaconing overhead, instead of using fixed-interval beaconing, the beaconing here is done by sending a beacon by a nonleader node at period of Intvalmax and a leader node will send a beacon in the period of Intvalmin to announce its leadership role. When a node is receiving a beacon from its neighbor it will record its node ID, position, and flag contained in the message in its neighbor table. To avoid routing failure due to outdated topology

information, an entry will be removed if not refreshed within a period TimeoutNT or the corresponding neighbor is detected unreachable by the MAC layer protocol.

### **2.3 Zone Leader Election**

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 Intvalmax period for the beacons from other nodes. Every Intvalmin a node will check its neighbor table and determine its zone leader under different cases: 1) the neighbor table contains no other node in the same zone; it will announce itself as a 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 beacon 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, then the node with the flag set is the leader.

### **2.4 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.

### **2.5. 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. In this section we discuss our maintenance schemes.

### 2.5.1 Moving between Different Zones

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. Whenever a node  $M$  moves into a new zone, it will rejoin a multicast group  $G$  by sending a JOIN\_REQ message to its new leader. During this joining process, to reduce the packet loss, whenever the node broadcasts a BEACON message to update its information to the nodes in the new zone, it also unicasts a copy of the message to the leader of its previous zone to update its position. Since it has not sent the LEAVE message to the old leader, the old leader will forward the multicast packets loss and facilitates seamless packet transmissions during zone crossing. When the rejoining process finishes,  $m$  will send a LEAVE messages to its old leader. To handle leader mobility problem, if a leader finds its distance to the zone border is less than a threshold or it is already in a new zone, it assumes it is moving away from the zone where it was the leader, and it starts the handover process. To look for the new leader, it compares the positions of the nodes in the zone it is leaving from and selects the one closest to the zone center as the new leader. It then sends its multicast table to the new leader, which will announce its leadership role immediately through a BEACON message. It will also send a JOIN\_REQ message to upstream zone. During the transition, the old leader may still receive multicast packets. It will forward all these packets to the new leader when the handover process is completed. If there is no other node in the zone and the zone will become empty, it will use the method introduce in the next section to deliver its multicast table. In the case that the leader dies suddenly before handing over its

multicast table, the downstream zones and nodes will reconnect to the multicast tree through the maintenance process.

### 2.5.2 Dealing with Empty Zones

A zone may become empty when all the nodes move away, the tree zone may become empty, and the multicast tree will be adjusted correspondingly to keep the multicast tree connected. when the leader is moving away from a nonroot tree zone and the zone is becoming empty, it will send its multicast table to the upstream zone. The upstream zone leader will then takes over all its downstream zones, and delete this requesting zone from its downstream zone list. The new upstream zone needs to send JOIN\_REPLY messages to all the newly added downstream zones to notify them the change. When receiving the JOIN\_REPLY messages, these downstream zones will change their upstream zone ID accordingly. If the empty zone is the root zone, since the root zone has no upstream zone, the leader will check its neighboring zones and choose the one closest to the root zone as the new root zone. The leader then forwards its multicast table to the new zone, and floods a NEW\_ROOT message to announce the change.

In summary, our contributions in this work include:

1. 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.
2. 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.
3. Introducing 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. With nodes self-organizing into zones, zone-based bidirectional-tree-based distribution paths can be built quickly for efficient multicast packet forwarding.

4. Addressing the empty zone problem, which is critical in a zone-based protocol, through the adaptation of tree structure.
5. Evaluating the performance of the protocol through quantitative analysis and extensive simulations. Our analysis results indicate that the cost of the protocol defined as the per node control overhead remains constant regardless of the network size and the group size. Our simulation studies confirm the scalability and efficiency of the proposed protocol.

### 3 LITERATURE SURVEY

Geographic routing protocols [4] are generally more scalable and reliable than conventional topology-based routing protocols [8][9] with their forwarding decisions based on the local topology. In manets, geographic routing protocols unicast routing [2], [4] 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 [6]. In one recent report [4], the GPSR protocol is used in which 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, but could not guarantee the delivery of the packets to the destination.

Similarly in another recent report [10], SPBM protocol is used in which the packets from the source with the header are forwarded and 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. Hence, to reduce the overhead of topology maintenance for dynamic manet and support more reliable multicasting with controlled congestion, an option is to make use of the position information to guide multicast routing used in congestion controlled EGMP.

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. Although efforts were made to develop more scalable topology-aware protocols, the topology-based multicast protocols are generally difficult to scale to a large network size, as the construction and maintenance of the conventional tree or mesh structure involve high control overhead over a dynamic network. This work attempts to improve the stateless multicast protocol [2], 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. As the focus of our paper is to improve the scalability of location-based multicast with congestion control, a comparison with topology based protocols is out of the scope of this work. However, we note that at the similar mobility and system setup, the delivery ratio of is much lower than that of EGMP, and the delivery ratio in varies significantly as the group size changes. In addition, topology-based routing by nature is more vulnerable to mobility and long path transmission, which prevents topology-based protocols from scaling to a large network size.

In DSM, each node floods its location in the network. A source constructs a Steiner tree and encodes the multicast tree into each packet, and delivers the packet by using source routing. LGT requires each group member to know the locations of all other group members, and proposes two overlay multicast trees: a bandwidth-minimizing LGS tree and a delay-minimizing LGK tree. In PBM, a multicast source node finds a set of neighboring, next hop nodes and assigns each packet destination to one next hop node. The next hop nodes, in turn, repeat the process. Thus, no global distribution structure is necessary. GMP attempts to build a more efficient multicast tree through a centralized calculation for tree construction, and is also more applicable for a smaller group. The focus of EGMP, however, is to

improve the scalability and efficiency of geometric multicast.

In SPBM, the network terrain is divided into a quadtree with L levels. The top level is the whole network and the bottom level is constructed by basic squares. Each higher level is constructed by larger squares with each square covering four smaller squares at the next lower level. All the nodes in a basic square are within each other's transmission range. At each level, every square needs to periodically flood its membership into its upper level square. Such periodic flooding is repeated for every two neighboring levels and the top level is the whole network region. Significant control overhead will be generated when the network size increases as a result of membership flooding.

With this proactive and periodic membership updating scheme, the membership change of a node may need to go through L levels to make it known to the whole network, which leads to a long multicast group joining time. Instead of using multiple levels of flooding for group membership management, EGMP uses more efficient zonebased tree 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 networkwide flooding, thus it can be scalable to both the group size and network size.

Finally, a lot of work have been done on geocasting. Different from general multicasting, in which the destinations are a group of receivers, the destination of geocasting is one or multiple geographic regions (squares are normally defined). When packets reach the destined region, they will be sent to the nodes in the region through flooding or other methods. There is no need of forming multicast infrastructure to deliver packets to group members that may distribute widely in the whole network domain and change their positions as nodes move.

#### 4. PROPOSED SYSTEM

The Following Proposed System Consists of Problem Definition, Software Architecture and finally the proposed Solution.

#### 4.1 Problem Definition

Group communications in MANETs are employed through multicasting. In this paper, we envision employing such communications by dividing the entire network into virtual zone based structure, where each zone consists of several nodes. In each of these zones, a zone leader is elected which maintains the group membership management, such as the group leave or join. A queue is maintained at each leader node, where the size of the queue is limited. If multiple groups use the same intermediate node for data transmission, and if the size of the queue crosses the threshold value, then node overhead occurs which results in congestion. Hence in order to control this, an alternative path is chosen based the load at each node, hence choosing an intermediate node with lesser load.

#### 4.2. Software Architecture

The software architecture of the proposed system is shown below:

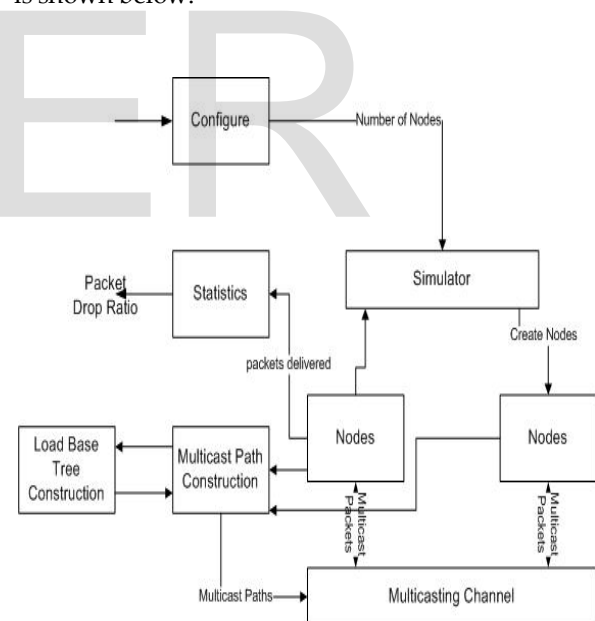


Figure 1. System Architecture of the Proposed System

The working of EGMP proposed architecture model illustrated in Figure 1 works by dividing the network into virtual zone based structure. Each of these zones have zone leaders that are elected by the relatively other nodes in the zone. When some sender node has packets to send to the

destination, the multicast path must be constructed based on the load at each node, and further the proper multicast channel is chosen to multicast the packets to the destination. The statistical parameters that are chosen are the control overhead, joining delay and packet transmission that deal with scalability and efficiency which leads to the overall performance calculation.

The following are the elements of software architecture:

**Nodes:** The nodes are the primary working components that perform various activities like, group leader election, data collection, transfer data among the other nodes. The zone leaders are responsible for the group membership management.

**Multicasting Channel:** Different paths are constructed from the source to the destination through selection of the nodes that form a group for transmission of packets.

**Load Based Tree Construction:** The load at each node is checked with respect to the threshold value at the intermediate nodes, and the nodes with lesser load is selected for tree construction.

**Multicast Path Construction:** A multicast path is constructed for the tree constructed based on the load.

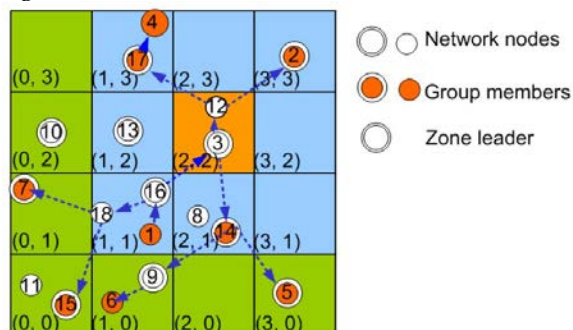
### 4.3 Proposed Solution

It has two parts

4.3.1 How to overcome empty zone problem.

4.3.2 How to avoid congestion based on load at the intermediate nodes that participate in the packet transmission.

Figure below shows the zone based structure.



#### 4.3.1 How to overcome empty zone problem.

A zone may become empty when all the nodes move away, the tree zone may become empty, and the multicast tree will be adjusted correspondingly to keep the multicast tree connected. When the leader is moving away from a nonroot tree zone and the zone is becoming empty, it will send its multicast table to the upstream zone. The upstream zone leader will then take over all its downstream zones, and delete this requesting zone from its downstream zone list. The new upstream zone needs to send JOIN\_REPLY messages to all the newly added downstream zones to notify them the change.

When receiving the JOIN\_REPLY messages, these downstream zones will change their upstream zone ID accordingly. If the empty zone is the root zone, since the root zone has no upstream zone, the leader will check its neighboring zones and choose the one closest to the root zone as the new root zone. The leader then forwards its multicast table to the new zone, and floods a NEW\_ROOT message to announce the change. Zone depth is used to compare the distances of different zones to the destination zone. The formula for zone depth is;

$$\text{dis}(a,b) = (a-ad)^2 + (b-bd)^2$$

where (a,b) is zone and (ad,bd) is the destination zone.

#### 4.3.2 How to avoid congestion based on load at the intermediate nodes that participate in the packet transmission.

To avoid the overhead in the system, a node can get two geographic closer relay nodes and choose the one which is less loaded. ECN (Explicit Congestion Notification) is used to determine congestion that relies on Random Early Detection which supports active queue management to determine the load at each node.

The average queue size is compared to min and max thresholds. Here the conditions are checked, and based on that the packets are marked as ECN. When the active queue management detects congestion on a router, the congestion is made known to the source. Due to the selection of a lesser loaded nodes, congestion can be reduced and the throughput of the system can be increased.

## 5 SIMULATION RESULT

Extensive simulations have been conducted to evaluate the performance of the proposed system in a large scale networks. For the experiments, we used a simulator implemented in Java and executed the simulator on a PC with Pentium Dual Core Processor, minimum of 20GB of hard disk drive, 16GB of RAM, Windows XP and Java. In the simulations, 100 nodes are randomly deployed in a 650 m x 650 m field. The Simulation was carried out different number of nodes using Prowler Simulator.

A mobile adhoc network simulation environment which comprises of Net bean Development Tool and for Coding Java was installed. The nodes in the network are mobile. As the nodes move from one zone to the other, the zone leaders are elected accordingly where each zone has only one zone leader. Data transmission occurs from the source to the destination node. Load at each node is checked, and the nodes with lesser load is selected for the data transmission, to avoid congestion.

We show Simulation results obtained through computer simulations in Fig.2 for packet delivery ratio, Fig.3 for control overhead and Fig.4 for average joining delay.

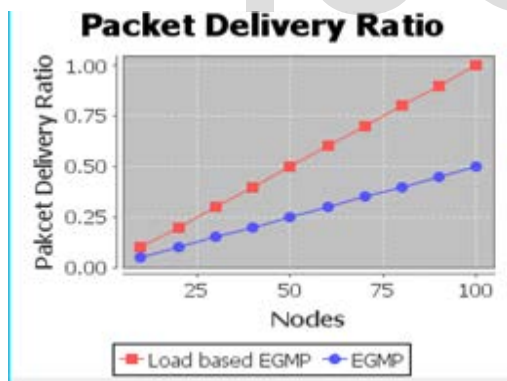


Figure 2. Packet Delivery Ratio

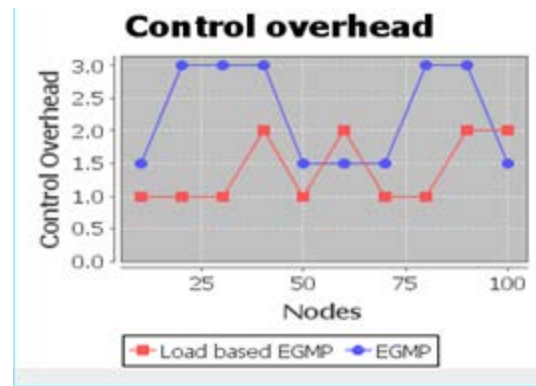


Figure 3. Control Overhead

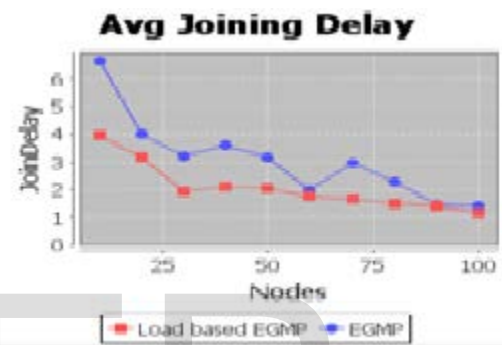


Figure 4. Average Joining Delay

All Fig.2, Fig.3 and Fig.4 show that our proposed method (load based EGMP) takes congestion under concern and deliver the data with lesser control overhead. The above results support that our proposed method reduces much of control overhead and hence increases the performance, thus increasing the scalability and efficiency.

## 6 CONCLUSION AND FUTURE WORK

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 congestion controlled multicasting protocol, for MANETs. 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 with congestion control significantly reduces the tree construction and maintenance overhead, and



enables quicker tree structure adaptation to the network topology change. We also developed a scheme to handle the empty zone problem, which is challenging for the zone-based protocols. When multiple source nodes of different zones try to send data to multiple destinations via the common intermediate node, there will be congestion or node overhead occurring at the intermediate node that might lead to delay in packet delivery, hence reducing the scalability or efficiency as the number of the nodes and network size increases. Hence this can be overcome by using congestion avoidance algorithm that checks load at each node prior to sending the data, that avoids node overhead. Some more issues are left open for future research such as consumption of bandwidth and avoiding duplication of packets and link failures. It is a very interesting and complicated problem, which is to be studied in the future.

## REFERENCES

- [1] L. Ji and M.S. Corson, "Differential Destination Multicast: A MANET Multicast Routing Protocol for Small Groups," Proc. IEEE INFOCOM, Apr. 2001..
- [2] X. Xiang, Z. Zhou, and X. Wang, "Self-Adaptive On Demand Geographic Routing Protocols for Mobile Ad Hoc Networks," Proc. IEEE INFOCOM, May 2007.
- [3] P. Bose, P. Morin, I. Stojmenovic, and J. Urrutia, "Routing with guaranteed Delivery in Ad Hoc Wireless Networks," Proc. Workshop Discrete Algorithms and Methods for Mobile Computing and Comm. (DialM'99), Aug. 1999.
- [4] B. Karp and H.T. Kung "Greedy Perimeter Stateless routing for wireless Networks," Proc. ACM/IEEE MobiCom, pp.243-254, Aug. 2000.
- [5] F. Kuhn, R. Wattenhofer, Y. Zhang, and A. Zollinger, "Geometric Ad-Hoc Routing: Of Theory and Practice," Proc. Int'l Symp. Principles of Distributed Computing(PODC), 2003.
- [6] J. Li et al., "A Scalable Location Service for Geographic Ad Hoc Routing,"Proc. ACM/IEEE MobiCom, pp. 120-130, 2000.
- [7] S. Giordano and M. Hamdi, "Mobility Management: The virtual Home Region," technical report, Oct.1999.
- [8] C.Wu, Y.Tay, and C.K. Toh, "Ad Hoc Multicast Routing Protocol Utilizing Increasing Id-Numbers (AMRIS) Functional Specification," Internet draft, Nov. 1998.
- [9] C. Gui and P. Mohapatra, "Scalable Multicasting for Mobile Ad Hoc Networks," Proc. IEEE INFOCOM, Mar. 2004.
- [10] M. Transier, H. Fubler, J. Widmer, M. Mauve, and W.Effelsberg, "A Hierarchical Approach to Position-Based Multicast for Mobile Ad-Hoc Networks," Wireless Networks, vol. 13, no. 4, pp. 447-460, Aug. 2007.

- [11] X. Xiang and X. Wang, " An Efficient Geographic Multicast Protocol for Mobile Ad Hoc networks," Proc. IEE Int'l Symp World of Wireless, Mobile and Multimedia Networks, June 2006.
- [12] X. Xiang, X. Wang and Y. Yang, "Supporting Efficient and Scalable Multicasting over MANET's" April 2011.