Advanced EGMP Based Multicast For Ad-Hoc MIMO

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***Abstract*— Group communications is the most common requirement in today's advanced wireless mobile communications. Several mobile applications in MANETs (Mobile Ad hoc Networks) involve group communications among zones and as well as nodes. The most compromising technique for achieving group communications is multicasting and because of advanced developments in technologies multicasting becomes as one of the most important networking service. However implementing a robust and efficient multicasting is a very challenging task because of multicasting of packet forwarding and efficient group management. Therefore in this paper we propose a systematic novel method known as EGMP (Efficient Geographic Multicast Protocol). To implement scalable and efficient group membership scheme a virtual a virtual-zone-based structure is used. In EGMP, to achieve most efficient group management a zone based bi directional tree is implemented. Here the position information of each individual node is used to construct the zone, multicast tree construction, and multicast packet forwarding, which greatly decreases the overhead for route searching and tree structure maintenance. An efficient distributed algorithm is used in efficient EGMP to support dynamic changes to the multicast group during the construction of tree and effectively allows overlapping join/leave operations. Finally, the simulation results demonstrates that EGMP has excellent packet delivery ratio, low control overhead and multicast group joining delay under all test scenarios, and EGMP is scalable for both group size and network size.**

***Index Terms* — Geographic Routing, Wireless Networks, Mobile Ad Hoc Networks, Multicasting, Routing, wireless networks, mobile ad hoc networks, multicast, protocol.**

I. INTRODUCTION

The increasing demand for flexibility as well as technological advances in mobile communication devices such as wireless LANs, laptop computers and smart phones, wireless communications are becoming more and more common. There are several advanced efforts to enable wireless communication over mobile networks. Multicasting is one such effort that strives to provide support for wireless communication in mobile networks. 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). Multicast is a fundamental service for supporting information exchanges and collaborative task execution among a group of users and enabling cluster-based computer system design in a distributed environment.

Therefore in this project, we propose an efficient multicasting protocol named as EGMP which is very helpful while dealing with large size group networks. This scheme effectively handles the group membership management by using the concept of zone. By using EGMP we can more accurately track the address of the members of the group. In this paper we discusses about the virtual zone formation, node, cluster and cluster leader which are very important for implementation of this project. Virtual zones are formed by using the location of the node and a reference point or origin. With the help of node location information, quick and robust paths are implemented during the packet distribution among all the nodes in network.

The remaining of this paper is arranged as; in section II we describes about the related work of this specific paper. Section III describes the most important and core part of this entire project i.e. EGMP protocol clearly. Section IV explains about a theoretical approach of evaluation of proposed scheme results and in section V we clearly describe about the performance evolution and simulation results.

II. RELATED WORK

In mobile Ad hoc communications, when compared to unicast routing multicasting is a relatively un-explored research area. In ad-hoc networks several applications are envisioned on group communications only. Therefore, the multicast routing has greatest importance and attracts significant attention over the recent years.

Generally, the conventional topology-based routing protocols [8] [4] are less reliable and scalable than geographic routing protocols because of their forwarding decisions based on the local topology. In recent years, for more scalable and robust packet transmissions geographic routing protocols unicast routing [9], [13], and [14] have been proposed. In the existing position based geographic routing protocols the nodes are aware of their original positions using certain positioning system like Global Positioning system (GPS), similarly the a source can obtain the destination position through some type of location service. And based on the position of the destination the intermediate node makes its forwarding choices. Similarly in the case of SPBM, the packets form the source are forwarded are purely depends on the next hop position. 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. A simple way to extend the geography-based communication is just to keep the positions and addresses of all the group members into the header of the packet.

Topology-Based Multicast Routing Protocols:

There are two main categories in topology based multicast routing protocol:

1. Tree based approach
2. Mesh based approach

To transfer the data from source to destination, only a single path will exists in tree based approach using topological information. However the tree is again classified as source and shared trees.

Position-Based Unicast and Multicast Routing Protocols:

The position-based routing is very effective and robust for mobility of nodes and as well as for information. In this approach the information forwarding routing decisions are purely based on node's own position and destination position. The position based approach performs well whenever the next node has to be found in a greedy manner, which reduces the remaining distance to the destination.

III. EFFICIENT GEOGRAPHIC MULTICAST PROTOCOL

EGMP (Efficient Geographic Multicast Protocol) protocol, the core part of this entire project is completely discussed in this section.

Using a *two tier virtual zone- based* structure EGMP efficiently manages the multicast forwarding management. Management of multicast forwarding using several individual nodes is very interesting and complex task. Initially in the first layer all the individual nodes are formed a set of zone by organizing themselves based on already predetermined virtual origin. To manage all the group activities a *zone leader* is elected among all the nodes which are interested to form a zone. In the second layer this *zone leader* acts as a representative for this zone and performs zone joining or leaving activities. Therefore as a result of this two layer tasks a zone-based virtual multicast tree is implemented. To implement a zone and effective management of multicast tree construction, group membership management and maintenance and packet forwarding location information of the every node is used.

Some of the notations to be used are:

Zone: the complete terrain of the network is divided as zones based on the availability of nodes and distance. Mostly all the zones are considered in the shape of squares. Make a note that the implementation of a zone structure does not depend on the shape of the network terrain or region.

r: r is defined as the size of the zone which is nothing but the length of the square and it is set to be as $r \le r_t/2$, where r_t is the transmission range of the mobile nodes.

Zone ID: Zone ID refers to the identification of a zone.

By using the known position of the virtual origin the zone ID can be calculated. The positions of the virtual origin are predetermined while in the formation of zone.

zLdr: as discussed above manage all the group activities a *zone leader* is elected Zone leader zLdr is elected in each zone.

Tree zone: the tree zone consists of group members to forward the information or data packets and be responsible for multicast forwarding of data packets.

Root zone: in the root zone the root of the entire 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

$$Depth = \max(|a0-a|, |b0-b|)$$

Where (a0, b0) is the root-zone ID.

For illustration consider a zone structure as an example as shown in below figure 1. In the zone, the depth of the root zone is '0" and the immediately surrounding 8 zones have the depth of '1' and similarly the seven zones in the outer side have a depth of '2'.

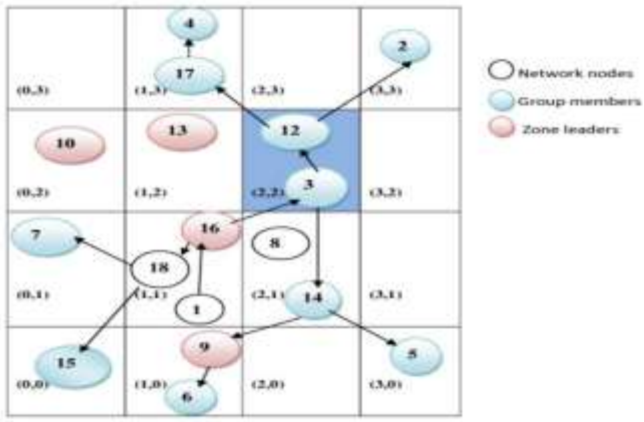

Figure1. Zone structure

As in classical approaches, the EGMP never track the individual movement of every nod instead it finds only the membership management of nodes.

The remaining part of this paper describes about the generation of neighbouring table and the election of zone leader.

3.1 Neighbour Table Generation and Zone Leader Election:

Every individual node the zone will maintain a neighbouring table which consists of ID of the node, position if the node and the flag contained in the message. Whenever a node receives a beacon signal from the other nodes it will records ID of the node, position if the node and the flag contained in the message which are the entries of neighbour table. Using position of the node the zone ID is calculated. For maintaining robust routing paths the entry will be removed if it is not updated in the time span of $Timeout_{NT.}$ And through the cooperation of all these nodes a zone leader is elected as a representative of this entire zone and the zone leader will multicast a beacon signal to announce its existence and it will wait $Intval_{max}$ time for getting back the beacon signals from all its zone members. Here in the period of every $Intval_{min}$, every node will node will examine its neighbour table and find out its zone leader under different cases:

1. If no any other node is recognized in its neighbor table, then those nodes announce itself as a zone leader.
2. If there is no node is elected as a zone leader then the node whish id very closer to the center is announced as a zone leader by setting the leader flag.
3. If there is more than one leader flags of the nodes are set, then the node with the highest node ID is elected as leader...
4. Only one of the nodes in the zone has its flag set, and then the node with the flag set is the leader.

Node ID	Position	Flag	Zone ID
16	(x16,y16)	1	(1,1)
1	(x1,y1)	0	(1,1)
7	(x7,y7)	1	(0,1)
13	(x13,y13)	1	(1,2)

Table 1: The neighbour table of node 18 in fig. 1

3.2 Multicast Tree Construction:

The multicast tree creation and maintenance is briefly explained in this session. When compared to classical multicasting in EGMP the data transformation tree will formed with the guidance of location information of the every node in the zone which is greatly used to reduce the overhead on tree management. To enable quick group joining and leaving a path is recognized first by sending a control message. In the remaining description we use G, S, and M, respectively, to represent a multicast group, a source of G and a member of G.

3.3 Initialization:

Whenever the task of multicasting is initiated the source node 'S' will send a flooding message NEW SESSION (G; zone IDS) in the network to announce its existence. This flooding message contains G and the ID of the zone where S is resided. Whenever a node 'M' receives the flooding message sent by source, and if it is interested to join in 'G', then it will send a JOIN REQ(M; PosM; G; fMoldg) message to its zLdr which consists of its address, position, and group to join. If the zone leader accepts the JOIN REQ message then the zone leader acknowledges the node with JOIN REPLY message to confirm its joining request. And the node will set the *Acked flag* to represent the joining procedure is completed. In the each node are acts as a fragment leader of its fragment to getting access of the routing table of another node of the same zone. And the fragment leader is responsible for coordinating mergers with other fragments and for updating group members in its fragment.

3.4 Connection Phase:

The objective of the connection phase is to provide a robust connection to join fragments. In this process the fragment leader which has the lower ID will send a CONNECT message along the shortest path between the fragments. And while receiving the CONNECT message, if a message transmitted node is not reserved and is not a member of another fragment then it will forwards the CONNECT message along the shortest path. Otherwise the merge will fails, if the node receiving a CONNECT belongs to other fragment. Then the acknowledged with NACK message to cancel all its reservations.

Then again all this entire process will starts by choosing a most preferred node. If the CONNECT message reaches the tail successfully through the shortest path between the fragments, a MERGED message is acknowledged along the shortest path between the fragments to make all the reservations permanent. And node ID with the lowest ID will becomes as the leader of the combined fragment.

3.5 Join Requests:

Whenever the tree setup is completed and for joining or enter the new nodes into multicast group, the process is as follows: the new upcoming node will make a contact with any member of the multicast group and through that member sends a merge request to its preferred fragment. Here new node considered itself as a leader of the singleton fragment. Here two possibilities are available.

1. The multicast tree is already implemented.
2. The tree generation is still underway

And the upcoming node does not know the status of the tree and it knows only the identity of the source node. Therefore, the node sends a JOIN REQUEST to the source and if the tree is already implemented then this request is processed successfully. Otherwise, the join request must be intercepted by our tree-building protocol and processed as a late join.

3.6 Leave Requests:

When compared to join requests the leave requests are more complicated, since the nodes may involve in several transformation. If the leaving node is singleton fragment then there is no problem and it id ease to leave that node by sending a message NOT INTERESTED to the source by node. And the node receiving the NOT INTERESTED message in response to a MERGE REQUEST, notes that the node as deleted or leaved.

3.7 Termination and Tree Refinement:

Whenever there is only one fragment is exists then the algorithm is automatically terminates. In some instances to build a multicast tree the multicast group has to postpone and this is possible by bounding the number of joins that a fragment accepts. If the tree is already implemented then subsequent JOIN REQUEST is processed. Once the algorithm has completed, it may be beneficial to run an optional protocol that prunes leaf node that are marked deleted or are Steiner nodes. The state information maintained by multicast group member and Steiner nodes may be reduced or eliminated once the tree is built.

3.8 Multicast Route Maintenance and Optimization:

It is very complex to maintain the implementation of multicast group, tree, multicast tree connection and structural changes in tree based on topology changes in dynamic networks. In practical implementations, because of movement of the nodes *empty zone* problem is raised and it is most complex to handle it. As compared to managing the connections among all individual nodes, there is a lower rate of zone membership change and hence a much lower overhead while maintaining the zone-based tree.

IV. PERFORMANCE EVALUATION

Parameters and Metrics:

In this session we discuss about all the parameters and metrics that we consider for the evaluation of performance of proposed method and the following parameters are considered for performance evaluation:

1. *Packet delivery ratio*: packet delivery ratio is defined as the number of packets received divided by the number of packets expected to receive.
2. *Normalized control overhead*: Here the Normalized control overhead is nothing but the ratio of total number of control message transmissions and the total number of received data packets.
3. *Normalized data packet transmission overhead*: The total number of data packet transmissions divided by the number of received data packets.
4. *Joining delay*: The average time interval between a member joining a group and its first receiving of the data packet from that group. To obtain the joining delay, the simulations were rerun with the same settings except that all the members joined groups after the source began sending data packets.

V. SIMULATION RESULTS

The simulation results for this proposed scheme are simulated using matlab tool.

1. *Performance Metrics vs. Moving Speed*

It is critical and challenging for a multicast routing protocol to maintain a good performance in the presence of node mobility in an ad hoc network. We evaluate the protocol performance by varying maximum moving speed from 10m/s to 50m/s.

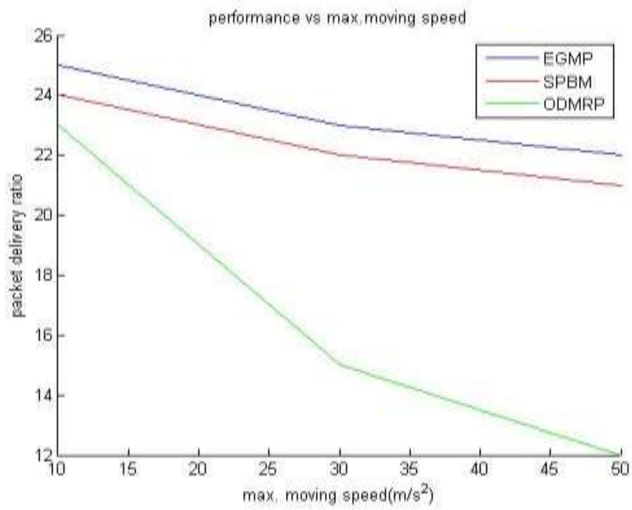

Fig 1 (a) PDR vs. Moving speed

From Fig 1a, the packet delivery ratios of EGMP, SBPM and ODMRP reduce as mobility increases, while the packet delivery ratio of ODMRP drops much faster.

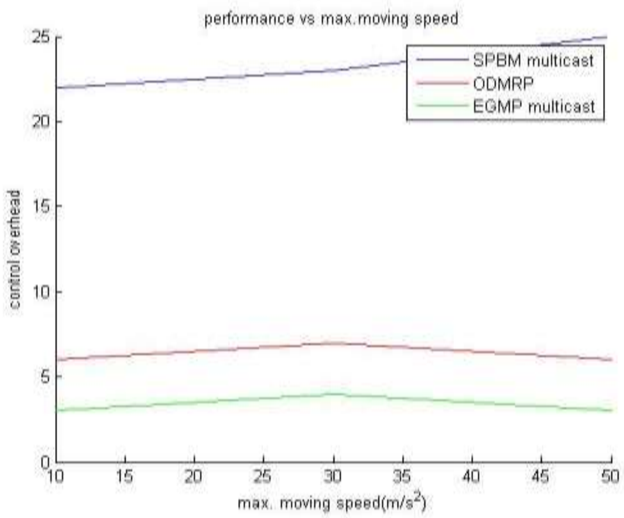

Fig 1 (b) Control overhead vs. Moving speed

The control overhead of EGMP seems to be lower than those of ODMRP and SPBM at different moving speeds (Fig (b)). The control overheads of all the protocols increase at higher mobility.

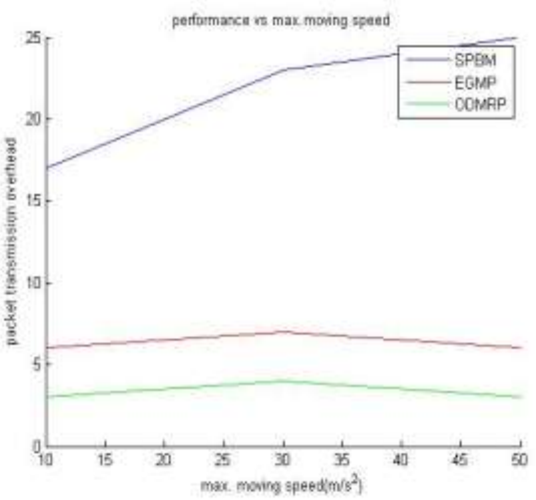

Fig 1 (c) Packet transmission overhead vs. Moving speed

In EGMP, when a node wants to join a group, it will start the joining process immediately, and with the efficient tree structure assumed, the nodes can join the multicast structure very fast as shown in Fig (c).

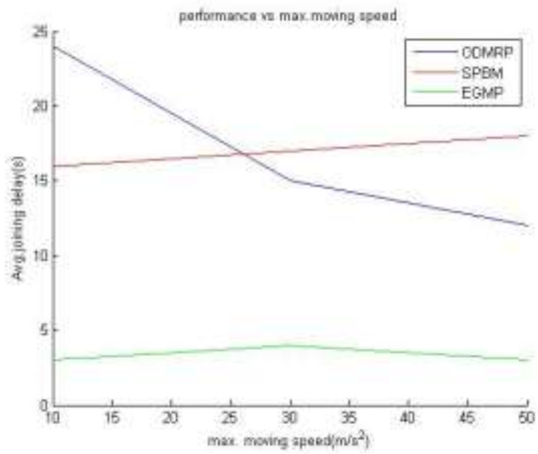

Fig 1 (d) Avg.joining delay vs. Moving speed

SPBM seems to have the largest joining delay most of the time when compared with ODMRP and EGMP.

2. Performance Metrics vs. Node Density

Geographic routing is sensitive to the node density and performs better in a dense network. Node density is also closely related to the performance of zone-based protocols. When the node density is low, there will be more empty zones, which will negatively affect the performance.

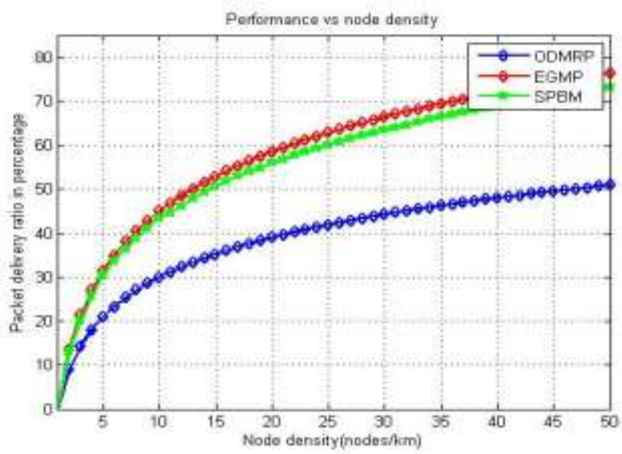

Fig 2 (a) PDR vs. Node density

Both EGMP and SPBM have higher delivery ratios at a higher node density (Fig 2(a)). The delivery ratios of all three protocols are lower when the network is sparsely populated. However, when the node density is higher than 50 nodes/km2, the increase of delivery ratio becomes slower, as there are more collisions among nodes and hence more packet loss.

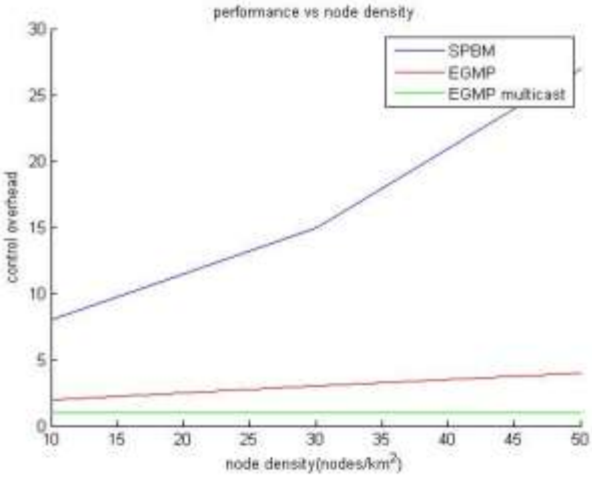

Fig 2 (b) Control overhead vs. Node densities

In Fig 2(b), the control overhead of SPBM rises quickly with the increase of node density as more nodes are involved in the periodic multi-level flooding for the membership management. When the network is very sparse, EGMP has a slightly higher control overhead than that of ODMRP.

PBM has the highest Packet Transmission overhead when compared with other two protocols (Fig 2(c)). The Packet transmission overheads of both EGMP and ODMRP increase, when the mobility increases.

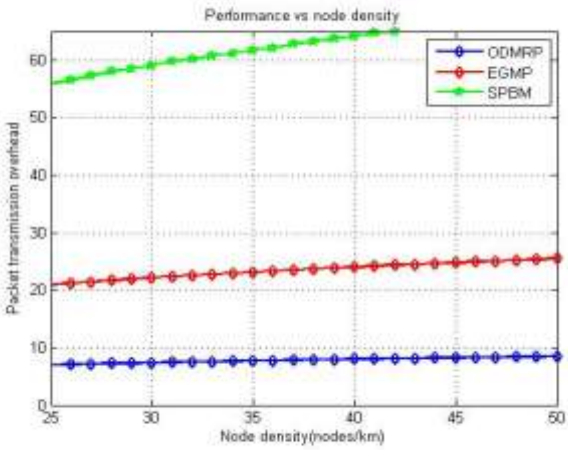

Fig 2 (c) Packet transmission overhead vs. Node density

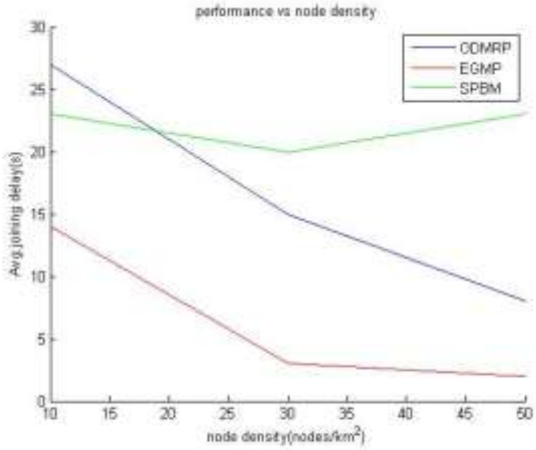

Fig 2 (d) Avg.joining delay vs. Node density

The average joining delay of SPBM is more at high mobility Fig 2(d) and the average joining delay of ODMRP is high at low mobility when compared with other two protocols.

3. Performance Metrics vs. Group Size

The protocol performances with the group size varied from 10 members to 20 members are evaluated.

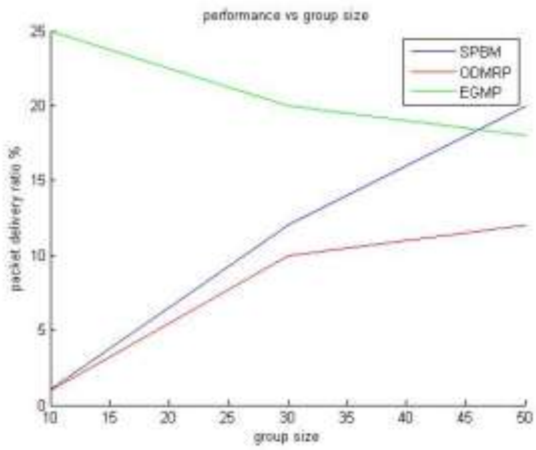

Fig 3 (a) PDR vs. Group size

Fig 3(a) demonstrates that EGMP can scale to a large group size and perform well with various group sizes. When the group size increases, the delivery ratios of ODMRP and SPBM rise. In EGMP, Packet delivery ratio is more when group size is small when compared with ODMRP and SPBM.

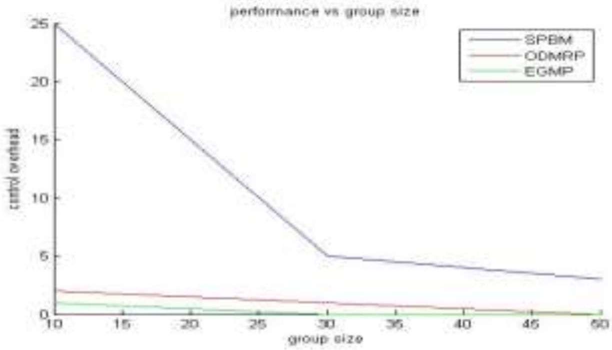

Fig 3 (b) Control overhead vs. Group sizes

In Fig 3(b), ODMRP and SPBM are seen to have very high multicast control overheads when the group size is small. While in EGMP, the multicast overhead remains very low at different group sizes.

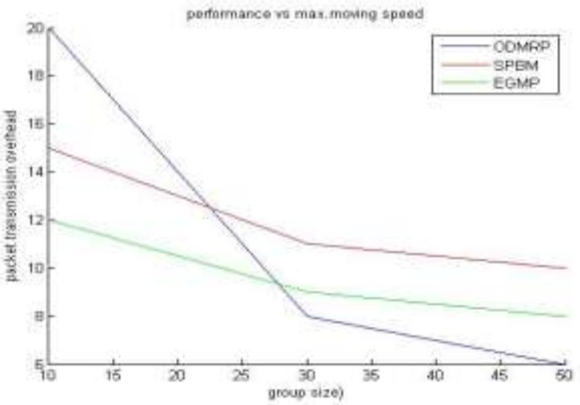

Fig 3 (c) Packet transmission overhead vs. Group size

In Fig 3(c), the data packet transmission overheads of all the protocols reduce when the group size increases as a result of the higher aggregations of packet transmissions. ODMRP has a high packet transmission overhead when the group size is small.

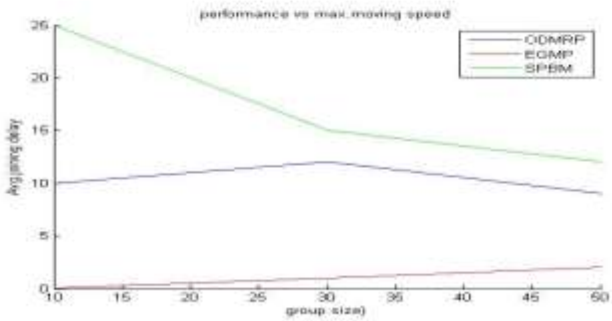

Fig 3 (d) Avg. joining delay vs. Group size

In Fig 3 (d), the change of group size has different impacts on the joining delay of the three protocols. In ODMRP, the joining delay is lower when the group size is small. In GMP, the joining delay is increased when the group size increases. The joining delay of SPBM drops as the group size goes up.

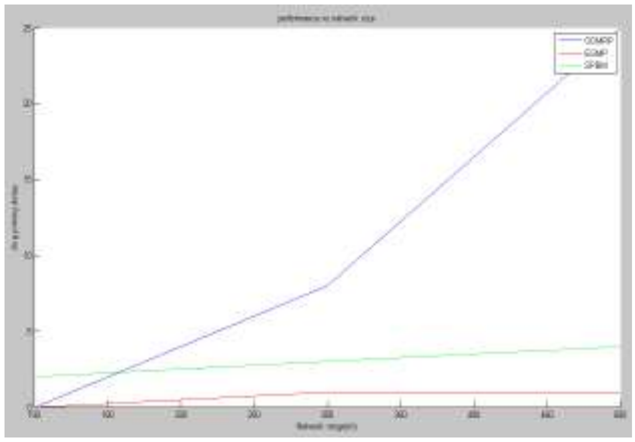

Fig 4: performance of Ad hoc MIMO network wrt Network range and joining delay

The network range is a very important factor in the discussion of formation of Ad Hoc MIMO. While constructing the Ad Hoc MIMO joining delay plays a very critical role. For any network the network range is as huge as possible and join delay is as low as possible. Figure 4 represents that our proposed EGMP methods is best other than two possibilities. i.e. ODMRP and SPBM. From the results it is clear that EGMP achieves low joining delay rates, since the EGMP method is a systematic method for network formation and maintenance and the zone leader contains every node position information and new joining node information which makes the joining process as early and as simple other then two.

VI. CONCLUSIONS

In this paper we proposed a systematic method known as Efficient Geographic Multicast Protocol and we successfully implement a scalable and efficient group membership scheme by using a virtual-zone-based structure. In EGMP, to achieve most efficient group management a zone based bi directional tree is implemented. Here the position information of each individual node is used to construct the zone, multicast tree construction, and multicast packet forwarding, which greatly decreases the overhead for route searching and tree structure maintenance. An efficient distributed algorithm is used in efficient EGMP to support dynamic changes to the multicast group during the construction of tree and effectively allows overlapping join/leave operations. Finally, the simulation results demonstrates that EGMP has excellent packet delivery ratio, low control overhead and multicast group joining delay under all test scenarios, and EGMP is scalable for both group size and network size. Compared to the geographic multicast protocol and SPBM, EGMP has significantly lower control overhead, data transmission overhead, and multicast group joining delay.

REFERENCES

[1] H. Kopka and P.W. Daly, *A Guide to LATEX*, third ed. Harlow, U.K.: Addison-Wesley, 1999.
[2] L. Ji and M. S. Corson. Differential destination multicast: a MANET multicast routing protocol for small groups. In *Proc. IEEE Infocom01*, Anchorage, Alaska, April 2001.
[3] E. M. Royer and C. E. Perkins. Multicast operation of the ad hoc on-demand distance vector routing protocol. In *Proceedings of the ACM/IEEE International Conference on Mobile Computing and Networking (MOBICOM)*, August 1999, pp. 207218.
[4] C. Wu, Y. Tay, and C.-K. Toh. Ad hoc multicast routing protocol utilizing increasing id-numbers (AMRIS) functional specification. *Internet draft*, November 1998.
[5] X. Zhang and L. Jacob. Multicast zone routing protocol in mobile ad hoc wireless networks. in *Proceedings of Local Computer Networks*, 2003 (LCN 03), October 2003.
[6] C.-C. Chiang, M. Gerla, and L. Zhang. Forwarding group multicast protocol (FGMP) for multihop mobile wireless networks In *AJ. Cluster Comp, Special Issue on Mobile Computing*, vol. 1, no. 2, pp. 187196, 1998.
[7] J. J. Garcia-Luna-Aceves and E. Madruga. The core-assisted mesh protocol. In *IEEE JSAC*, pp. 13801394, August 1999.
[8] M. Gerla, S. J. Lee, and W. Su. On-demand multicast routing protocol (ODMRP) for ad hoc networks in *Internet draft*, draft-ietf-manet-odmrp-02.txt, 2000.
[9] S. Lee, W. Su, J. Hsu, M. Gerla, and R. Bagrodia. A performance comparison study of ad hoc wireless multicast protocols. In *IEEE INFOCOM*, 2000.
[10] E. Kaplan. Understanding GPS. Artech House, 1996.
[11] X. Xiang, Z. Zhou and X. Wang. Self-Adaptive On Demand Geographic Routing Protocols for Mobile Ad Hoc Networks. *IEEE INFOCOM07 minisymposium*, Anchorage, Alaska, May 2007.
[12] P. Bose, P. Morin, I. Stojmenovic and J. Urrutia. Routing with guaranteed delivery in ad hoc wireless networks. In *Workshop on Discrete Algorithms and Methods for Mobile Computing and Communications (DialM ´ 99)*, August 1999.
[13] B. Karp and H. T. Kung. Greedy perimeter stateless routing for wireless networks. In *Proceedings of the ACM/IEEE International Conference on Mobile Computing and Networking (MOBICOM)*, pages 243–254, August 2000.
[14] F. Kuhn, R. Wattenhofer, Y. Zhang and A. Zollinger. Geometric ad-hoc routing: Of theory and practice. In *Int. Symposium on the Principles of Distributed Computing (PODC)*, 2003.

BIO DATA

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