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A Novel Multicast Approach for MANETS Using Multicast Tree

P. Thanga Selvi[1], K. Shanthi[2]

[1]PG Student, [2]Assistant Professor, Department of Computer Science and Engineering, Cape Institute of Technology, Levengipuram, Tamil Nadu, India

***Abstract*—Group communications are important in Mobile Ad hoc Networks (MANET). Multicast is an efficient method for implementing group communications. However, it is challenging to implement efficient and scalable multicast in MANET due to the difficulty in group membership management and multicast packet forwarding over a dynamic topology. We propose a novel Efficient Geographic Multicast Protocol (EGMP). EGMP uses a virtual-zone-based structure to implement scalable and efficient group membership management. A network-wide zone-based bi-directional tree is constructed to achieve more efficient membership management and multicast delivery. The position information is used to guide the zone structure building, multicast tree construction and multicast packet forwarding, which efficiently reduces the overhead for route searching and tree structure maintenance. Several strategies have been proposed to further improve the efficiency of the protocol, for example, introducing the concept of zone depth for building an optimal tree structure and integrating the location search of group members with the hierarchical group membership management. Finally, we design a scheme to handle empty zone problem faced by most routing protocols using a zone structure. The scalability and the efficiency of EGMP are evaluated through simulations and quantitative analysis. Our simulation results demonstrate that EGMP has high packet delivery ratio, and low control overhead and multicast group joining delay under all test scenarios, and is scalable to both group size and network size. Compared to Scalable Position-Based Multicast (SPBM), EGMP has significantly lower control overhead, data transmission overhead, and multicast group joining delay.**

***Keywords*—Routing, wireless networks, mobile ad hoc networks, multicast, protocol.**

I. INTRODUCTION

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. However, there is a big challenge in enabling efficient multicasting over a MANET whose topology may change constantly. *Conventional* MANET multicast protocols can be ascribed into two main categories, tree-based and mesh based. However, due to the constant movement as well as frequent network joining and leaving from individual nodes, it is very difficult to maintain the tree structure using these conventional tree-based protocols (e.g., MAODV, AMRIS, MZRP, and MZR). The mesh-based protocols (e.g., FGMP, Core-Assisted Mesh protocol, ODMRP are proposed to enhance the robustness with the use of redundant paths between the source and the destination pairs. Conventional multicast protocols generally do not have good scalability due to the overhead incurred for route searching, group membership management, and creation and maintenance of the tree/mesh structure over the dynamic MANET. For MANET unicast routing, geographic routing protocols have been proposed in recent years 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 (e.g., GPS), and a source can obtain the destination position through some type of location service. In 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 the 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 subgraph by applying the right-hand

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, this 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 bi-directional-tree-based distribution paths can be built quickly for efficient multicast packet forwarding.
4) Addressing the empty zone problem, this is critical in a zone-based protocol, through the adaption 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. We organize the rest of this paper as follows. In Section 2, we discuss some related work. We present a detailed design of the EGMP protocol in Section 3, and quantitatively analyze the per-node cost of EGMP in Section 4. Finally, we give our simulation results in Section 5 and conclude the paper in Section 6.

II. Related Works

In this section, we first summarize the basic procedures assumed in conventional multicast protocols, and then introduce a few geographic multicast algorithms proposed in the literature. 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. The work in attempts to improve the stateless multicast protocol which allows it a better scalability to group size. In contrast, EGMP uses a location-aware approach for more reliable membership management and packet transmissions, and supports scalability for both group size and network size.

As the focus of our paper is to improve the scalability of location-based multicast, a comparison with topology-based protocols is out of the scope of this work. However, we note that at the similar mobility and system set-up, 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.

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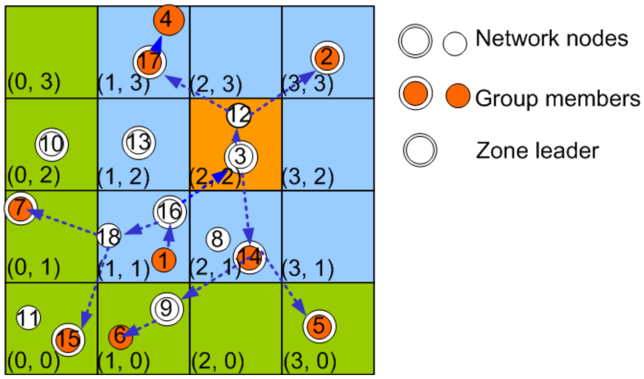

Zone structure and multicast session example.

III. Efficient Geographic Multicast Protocol

In this section, we will describe the EGMP protocol in details. We first give an overview of the protocol and introduce the notations to be used in the rest of the paper in Section. In Sections we present our designs for the construction of zone structure and the zone-based geographic forwarding. Finally, in sections. We introduce our mechanisms for multicast tree creation, maintenance and multicast packet delivery.

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 pre-determined virtual origin, the nodes in the network self-organize themselves into a set of zones as shown in Fig. 1, 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.

Zone center: For a zone with ID (a,b), the position of its center (*xc; yc*) can be calculated as: *xc* = *x*0 + (*a*+ 0:5) £ *r*, *yc* = *y*0 + (*b* + 0:5) £ *r*. A packet destined to a zone will be forwarded towards the center of the zone.

zLdr: Zone leader. A zLdr is elected in each zone for

managing the local zone group membership and taking part in the upper tier multicast routing.

tree zone: The zones on the multicast tree. The tree zones are responsible for the multicast packet forwarding. A tree zone may have group members or just help forward the multicast packets for zones with members.

root zone: The zone where the root of the multicast tree is located.

zone depth: The depth of a zone is used to reflect its distance to the root zone. For a zone with ID (*a; b*), its depth is:

depth = max(*ja*0 ¡ *aj; jb*0 ¡ *bj);*

Where (*a*0*; b*0) is the root-zone ID. For example, in Fig. 1, the root zone has *depth* zero, the eight zones immediately surrounding the root zone have *depth* one, and the outer seven zones have *depth* two.

Neighbor Table Generation and Zone Leader Election

For efficient management of states in a zone, a leader is elected with minimum overhead. As a node employs periodic BEACON broadcast to distribute its position in the underneath geographic unicast routing to facilitate leader election and reduce overhead, EGMP simply inserts in the BEACON message a flag indicating whether the sender is a zone leader. With zone size *r* · *rt*=*p*2, a broadcast message will be received by all the nodes in the zone. To reduce the beaconing overhead, instead of using fixed-interval beaconing, the beaconing interval for the underneath unicast protocol will be adaptive. A non-leader node will send a beacon every period of *Intvalmax* or when it moves to a new zone. A zone leader has to send out a beacon every period of *Intvalmin* to announce its leadership role. A node constructs its neighbor table without extra signaling.

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When receiving a beacon from a neighbor, a node records the node ID, position and *flag* contained in the message in its neighbor table. Table 1 shows the neighbor table of node 18 in Fig. 1. The zone ID of the sending node can be calculated from its position, as discussed earlier. 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. TABLE 1: The neighbor table of node 18 in Fig. 1.

nodeID	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)

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 nodes in the same zone, it will announce itself as the leader. 2) The flags of all the nodes in the same zone are unset, which means that no node in the zone has announced the leadership role. If the node is closer to the zone center than other nodes, it will announce its leadership role through a 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.

Zone-supported Geographic Forwarding

With a zone structure, the communication process includes an intra-zone transmission and an inter-zone transmission. In our zone-structure, as nodes from the same zone are within each other's transmission range and are aware of each other's location, only one transmission is required for intra-zone communications. Transmissions between nodes in different zones may be needed for the network-tier forwarding of control messages and data packets.

As the source and the destination may be multiple hops away, to ensure reliable transmissions, geographic unicasting is used with the packet forwarding guided by the destination position. However, in normal geographic unicast routing, location service is required for the source to obtain the destination position. In EGMP, to avoid the overhead in tracking the exact locations of a potentially large number of group members, location service is integrated with zone-based membership management without the need of an external location server. At the network tier, only the ID of the destination zone is needed. A packet is forwarded towards the center of the destination zone first. After arriving at the destination zone, the packet will be forwarded to a specific receiving node or broadcast depending on the message type. Generally, the messages related to multicast group membership management and multicast data will be forwarded to the zone leader to process.

Multicast Tree Construction

In this subsection, 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.

Multicast session initiation and termination

When a multicast session G is initiated, the first source node S (or a separate group initiator) announces the existence of G by flooding a message *NEW SESSION*(*G; zoneIDS*) into the whole network. The message carries G and the ID of the zone where S is located, which is used as the initial *rootzone* ID of group G. When a node M receives this message and is interested in G, it will join G using the process described in the next subsection.

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A multicast group member will keep a membership table with an entry (*G; root zID; isAcked*), where G is a group of which the node is a member, root zID is the root-zone ID and isAcked is a flag indicating whether the node is on the corresponding multicast tree. A zone leader (zLdr) maintains a multicast table. When a zLdr receives the NEW SESSION message, it will record the group ID and the root-zone ID in its multicast table. Table 2 is an example of one entry in the multicast table of node 16 in. The table contains the group ID, root-zone ID, upstream zone ID, downstream zone list and downstream node list. To end a session G, S floods a message END SESSION(G).

Multicast group join

When a node M wants to join the multicast group G, if it is not a leader node, it sends a *JOIN REQ*(*M; PosM; G; fMoldg*) message to its zLdr, carrying its address, position, and group to join. The address of the old group leader *Mold* is an option used when there is a leader handoff and a new leader sends an updated JOIN REQ message to its upstream zone. If M did not receive the NEW SESSION message or it just joined the network, it can search for the available groups by querying its neighbors. If a zLdr receives a JOIN REQ message or wants to join G itself, it begins the leader joining procedure as shown in Fig. 3. If the JOIN REQ message is received from a member M of the same zone, the zLdr adds M to the downstream node list of its multicast table. If the message is from another zone, it will compare the *depth* of the requesting zone and that of its own zone. If its zone depth is smaller, i.e., its zone is closer to the root zone than the requesting zone, it will add the requesting zone to its downstream zone list; otherwise, it simply continues forwarding the JOIN REQ message towards the root zone.

If new nodes or zones are added to the downstream list, the leader will check the root-zone ID and the upstream zone ID. If it does not know the root zone, it starts an expanded ring search. As the zone leaders in the network cache the root-zone ID, a result can be quickly obtained.

With the knowledge of the root zone, if its upstream zone ID is unset, the leader will represent its zone to send a JOIN REQ message towards the root zone; otherwise, the leader will send back a JOIN REPLY message to the source of the JOIN REQ message (which may be multiple hops away and the geographic unicasting described in Section 3.3 is used for this transmission). When the source of the JOIN REQ message receives the JOIN REPLY, if it is a node, it sets the isAcked flag in its membership table and the joining procedure is completed. If the leader of a requesting zone receives the JOIN REPLY message, it will set its upstream zone ID as the ID of the zone where the JOIN REPLY message is sent, and then send JOIN REPLY messages to unacknowledged downstream nodes and zones.

Multicast Packet Delivery

In this subsection, we explain how the multicast packets are forwarded to the members. After the multicast tree is constructed, all the sources of the group could send packets to the tree and the packets will be forwarded along the tree. In most tree-based multicast protocols, a data source needs to send the packets initially to the root of the tree. If this scheme is used and node 5 in Fig. 1 is a source, node 5 needs to unicast the packets initially to root zone (2, 2). The sending of packets to the root would introduce extra delay especially when a source is far away from the root. Instead, EGMP assumes a bi-directionaltree- based forwarding strategy [23], with which the multicast packets can flow not only from an upstream node/zone down to its downstream nodes/zones, but also from a downstream node/zone up to its upstream node/zone. A source node is also a member of the multicast group and will join the multicast tree. When a source S has data to send and it is not a leader, it checks the isAcked flag in its membership table to find out if it is on the tree. If it is, i.e., its zone has joined the multicast tree, it sends the multicast packets to its leader. When the leader of an ontree zone receives multicast packets, it forwards the packets to its upstream zone and all its downstream nodes and zones except the incoming one.

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For example, in Fig. 1, source node 1 sends the packets to its leader node 16, which will send the packets to its upstream zone (2, 2) and its downstream zones (0, 1) and (0, 0), but not to the downstream node 1 which is the incoming node. When the packets are received by leader node 3 of the root zone, it continues forwarding the packets to its downstream zones (1, 3), (3, 3), (2, 1) except the incoming zone (1, 1). The arrows in the figure indicate the directions of the packet flows.

When a source node S is not on the multicast tree, for example, when it moves to a new zone, the isAcked flag will remain unset until it finishes the rejoining to G through the leader of the new zone. To reduce the impact of the joining delay, S will send packets directly to the root zone until it finishes the joining process.

Multicast data forwarding

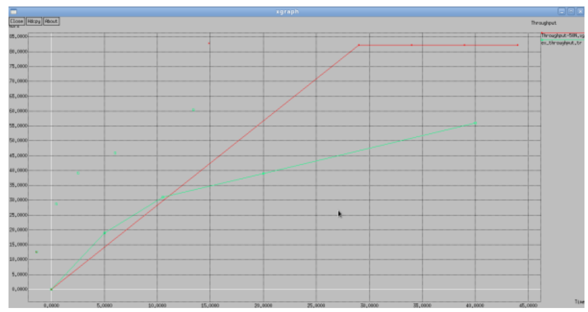
In our protocol, only zLdrs maintain the multicast table, and the member zones normally cannot be reached within one hop from the source. When a node N has a multicast packet to forward to a list of destinations ($D1;D2;D3;:$), it decides the next hop node towards each destination (for a zone, its center is used) using the geographic forwarding strategy described in Section 3.3. After deciding the next hop nodes, N inserts the list of next hop nodes and the destinations associated with each next hop node in the packet header. An example list is ($N1 : D1;D3;N2 : D2; : : :$), where $N1$ is the next hop node for the destinations $D1$ and $D3$, and $N2$ is the next hop node for $D2$. Then N broadcasts the packet *promiscuously* (for reliability and efficiency). Upon receiving the packet, a neighbor node will keep the packet if it is one of the next hop nodes or destinations, and drop the packet otherwise. When the node is associated with some downstream destinations, it will continue forwarding packets similarly as done by node N.

IV. COST ANALYSIS

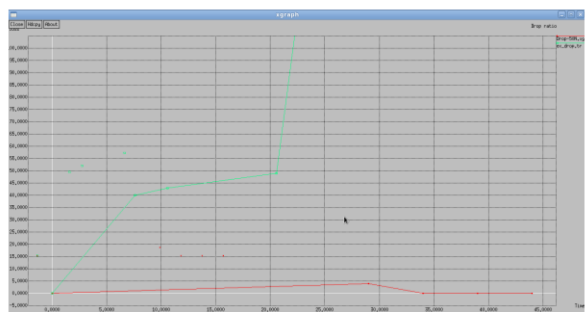
In this section, we will quantitatively analyze the *per node cost* of the protocol, which is defined as the average number of control messages transmitted by each node per second. The notations to be used in this section are listed in Table 3. The cost of the overall protocol consists of the following three components: zone building and geographic routing, tree construction, and tree maintenance.

V. SIMULATION RESULTS

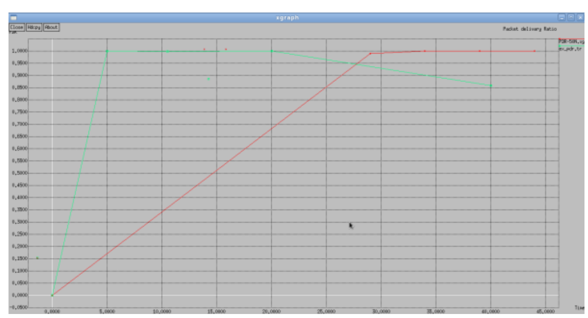
The performance of this paper may be analyzed by many factors. The main factors which are used are throughput, drop ratio, packet delivery ratio, received ratio.



Throughput



Drop Ratio



Packet Delivery Ratio

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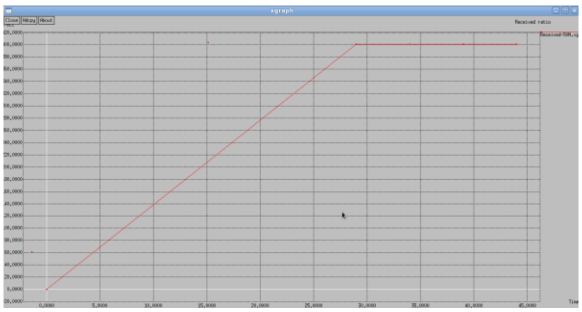

Received Ratio

VI. CONCLUSION

There is an increasing demand and a big challenge to design more scalable and reliable multicast protocol over a dynamic ad hoc network (MANET). In this paper, we propose an efficient and scalable geographic multicast protocol, EGMP, for MANET. The scalability of EGMP is achieved through a two-tier virtual-zone-based structure, which takes advantage of the geometric information to greatly simplify the zone management and packet forwarding. A zone-based bidirectional multicast tree is built at the upper tier for more efficient multicast membership management and data delivery, while the intra zone management is performed at the lower tier to realize the local membership management. The position information is used in the protocol to guide the zone structure building, multicast tree construction, maintenance, and multicast packet forwarding. Compared to conventional topology-based multicast protocols, the use of location information in EGMP significantly reduces the tree construction and maintenance overhead, and enables quicker tree structure adaptation to the network topology change. It also develop a scheme to handle the empty zone problem, which is challenging for the zone-based protocols. Additionally, 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.

REFERENCES

[1] H. Kopka and P.W. Daly, A Guide to LT X, 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 Network-ing (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.

[15] J. Li and et al. A scalable location service for geographic ad hoc routing. In Proceedings of the ACM/IEEE International Conference on Mobile Computing and Networking (MOBICOM) , pages 120–130, 2000.

[16] S. Giordano and M. Hamdi. Mobility management: The virtual home region. In Tech. report, October 1999.

[17] S. Basagni, I. Chlamtac, and V. R. Syrotiuk, Location aware, dependable multicast for mobile ad hoc networks, Computer Networks, vol. 36, no. 5-6, pp. 659670, August 2001.

[18] K. Chen and K. Nahrstedt. Effective location-guided tree construction algorithms for small group multicast in MANET. In IEEE INFOCOM, 2002, pp. 11801189.

[19] M. Mauve, H. Fubler, J. Widmer, and T. Lang. Position-based multicast routing for mobile ad-hoc networks. In Poster section in ACM MOBIHOC, June 2003.

[20] M. Transier, H. Fubler, J. Widmer, M. Mauve, and W. Effelsberg. A Hierarchical Approach to Position-Based Multicast for Mobile Ad-hoc Networks. In Wireless Networks, vol. 13 no. 4, Springer, pp. 447-460, August 2007.