Modified Efficient Geographic Multicasting Protocol in MANET

B.J.Praveena[#1], P.Saiteja[*2], G.Karthik[*3], and K.Sreekar[*4]

[#] *Department of computer science and engineering, Matrusri engineering college, Hyderabad, India*

[*] *Department of computer science and engineering, Matrusri engineering college, Hyderabad, India*

***Abstract*— Group communication is an important aspect in wireless sensor network, based on the group communication in wireless communication there were many multicast protocol were created to organize efficient communiciation in MANET. Mobile ad hoc network is a self-directed structure of mobile nodes connected by wireless links. All nodes operate not only as an end system, but also as work as a router to forward the packets. Ad hoc wireless networks are characterized by multi-hop wireless connectivity, infrastructure less and habitually changing topology. It may be necessary for one mobile node to schedule other hosts for forwarding a packet from source to destination node due to the constrained transmission range of wireless network interfaces. Therefore a self-motivated routing protocol is required for these networks to work properly. A number of Routing protocols have been created to achieve this task. In this paper we use Energy Efficient Geographic Multicasting Protocol (EEGMP) protocol which uses a MAC layer protocol IEEE 802.15.4. Here a network wide Zone based bidirectional tree is constructed to achieve the efficient group membership management. Every node is aware of its own position which efficiently reduces the overhead for route searching and also comparing EGMP with MAODV are evaluated using network simulator NS2.**

***Index Terms*— MANET, EGMP, Multicast routing, MAODV**

I. Introduction

Group communications is important in Mobile Ad Hoc Networks (MANET). Sending action direction to the soldiers in a battlefield and communications among the firemen in a disaster area are some examples of these applications. Group communications are also very important in supporting multimedia applications such as gaming and conferencing. With a one-to-many or many-to-many transmission pattern, multicast is an ef- ficient method to realize group communications. The high dynamics of MANET, however, makes the design of routing protocols much more challenging than that of wired network. The conventional MANET multicast protocols can be divided into two main categories, tree-based and mesh-based. The tree-based protocols (e.g., LAM [19], MAODV [26], AMRIS [30]) construct a tree structure for the multicast delivery, and the tree structure is known for its efficiency in utilizing the network resource optimally. However, maintaining tree structure in these conventional protocols is very difficult, and the tree connection is easy to be broken and the transmission is not reliable. The mesh-based protocols (e.g., FGMP [9], Core-Assisted Mesh protocol [15], ODMRP [16]) are proposed to enhance the robustness by providing redundant paths between the source and destination pairs at the cost of higher forwarding overhead. Furthermore, these conventional multicast protocols generally do not have good scalability due to the overhead for route searching, group membership management, and tree/mesh structure creation and maintenance over the dynamic topology of MANET

A multicast routing protocol for WSN is to support the distribution of information from a sender to all the receivers of a multicast group using available bandwidth efficiently in the presence of frequent topology changes. The need for one-tomany multicast data dissemination is quite frequent in critical situations such as disaster recovery or battlefield scenarios [15]. Though the selected multicast routing protocols were primarily designed for Mobile Adhoc Network (MANET), they can be used for WSN. But, it still has a lot of challenges like limited energy, limited bandwidth, short memory, limited processing ability, scalability and robustness [1], [2], [5], [16]. These considerable techniques are required to design the multicast routing protocols efficiently that would be increase the life time of a WSN. Such limitations become confronts for analyse the performance of six multicast routing protocols for WSN.

We propose an efficient geographic multicast protocol (EGMP). EGMP can scale to large group size and network size and can efficiently implement multicasting delivery and group membership management. EGMP uses a hierarchical structure to achieve scalability. The network terrain is divided into geographical nonoverlapping square zones, and a leader is elected in each zone to take charge of the local group membership management. A zone-based bi-directional multicast tree is built in the network range to connect those zones having group members, and such tree-structure can utilize the network resource efficiently. Our contributions in this work include:

1) We design a scheme to build and maintain the intrazone and interzone topology for supporting scalable and efficient multicast forwarding.

2) We make use of the position information to implement hierarchical group membership management, and combine location service with the hierarchical membership management to avoid network-range location searches for the group members, which is scalable and efficient. With location guidance and our efficient membership management structure, a node can join or leave a group more quickly.

3) With nodes self-organizing into zones, a zonebased bi-directional tree is built in MANET environment. Based on

geographic routing, the maintenance of the tree is simplified and the transmission is more robust in dynamic environment.
4) We introduce an important concept zone depth, which reflects the relationship between a member zone and the zone where the root of the tree exists. The zone depth is efficient in guiding the tree branch building and tree structure maintenance, especially in the presence of node mobility.
5) We also design a scheme to handle the empty zone problem, a challenging problem in designing a zone-based protocol. In EGMP, whenever an on-tree zone becomes empty, the tree structure is adjusted accordingly to keep the tree connected.

II. RELATED WORK

Sung-Ju Lee et al [7] evaluated the scalability and performance of ODMRP for adhoc wireless networks. In 2004, R. Vaishampayan [9] compared the mesh based and tree based multicast routing in MANET with varying the parameters of mobility, group members, number of senders, traffic nodes and the number of multicast groups and concluded that PUMA attains higher packet delivery ratios than ODMRP and MAODV. In 2007, Andrea Detti et al [11] proved that OBAMP has a low-latency and a high delivery ratio, even when the group size increases by analyze the performance of OBAMP and compared it with two state-of-the-art protocols, namely ODMRP and ALMA. In 2011, Pandi Selvam et al [17] compared the performance of two on-demand multicast routing protocols, namely MAODV and ODMRP in MANET. In 2012, Sejal Butani et al [18] chosen PUMA for multicast ad hoc network based on comparison of various multicasting protocols and concluded that PUMA provides less routing overhead, high throughput and better packet delivery ratio as compared to MAODV and ODMRP in MANET.

Performance comparison among ODMRP, MAODV, PUMA, OBAMP, ALMA and ALMA-H of MANET and Wireless Mesh Network (WMN) multicast routing protocols (Reactive, Proactive and Hybrid) is already done by the researchers [7], [9], [11], [19], [20] whereas A.M. Zungeru et.al [16] compared the different MANET routing protocols and presented a comprehensive survey in WSN, Abid ali minhas et.al [21] compared the MAODV, TEEN (Threshold-Sensitive Energy Efficient Sensor Network), SPEED (A Stateless Protocol for Real-Time Communication) [22], MMSPEED (Multi-path and Multi-SPEED) for WSN and also some simulation results have been published before. To the best of the author's knowledge no performance comparative study has been found yet representing the relative merits and demerits of six state-ofthe-art multicast routing protocols considered in this paper for WSN. The main objective of this work is to select the efficient multicast routing protocol for WSN among six multicast routing protocol based on relative strength and weakness of each protocol. Therefore, evaluating the performance of these six multicast routing protocol in WSN is essential in order to analyze their behavior and effectiveness.

III. EFFICIENT GEOGRAPHIC MULTICAST PROTOCOL

EGMP uses a two-tier structure. The whole network is divided into square zones. In each zone, a leader is elected and serves as a representative of its local zone on the upper tier. The leader collects the local zone's group membership information and represents its associated zone to join or leave the multicast sessions as required.

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

EGMP uses a virtual-zone-based structure to implement scalable and efficient group membership management. A network wide 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. Several strategies have been proposed to further improve the efficiency of the protocol. 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 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. 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. Nodes self-organizing into zones, zone-based bidirectional-tree-based distribution paths can be built quickly for efficient multicast packet forwarding.

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. Some of the notations to be used are:

Zone: The network terrain is divided into square zones.

zone: The network terrain is divided into square zones

Zone size. The length of a side of the zone square. In our zone structure, the intrazone nodes can communicate directly with each other without the need of any intermediate relays, so that zone size ≤ √r 2 , where r is the mobile nodes' transmission range.

zone ID: The identification of a zone. A node can calculate its zone ID (a, b) from its pos (x, y) as: a = [x−x0 rzone] and b = [y−y0 rzone], where (x0, y0) is the position of the virtual origin, which is set at the network initial stage as one of the network parameters. For simplicity, we assume all the zone IDs are positive.

zone center: For a zone with ID (a,b), the position of its center (xcenter, ycenter) can be calculated as: xcenter = x0+(a+0.5)×rzone, ycenter = y0+(b+0.5)×

rzone. A packet destined to a zone will be forwarded towards the center of the zone.

zLD: Zone leader. A zLD is elected in each zone for managing the local zone group membership and taking part in the upper tier multicast routing.

tZone: The zones on the multicast tree. The tZones are responsible for the multicast packet forwarding.

A tZone may have group members or not. core zone: The core zone is the root of the multicast tree. zone depth: For each multicast session, a zone's depth reflects its distance to core zone. For a zone with ID (a, b), its depth is depth = max(|a0−a|, |b0−b|), where (a0, b0) is core-zone ID. For example, in Fig. 1, for the five zones surrounding the core zone, depth = 1. And the outer six zones have depth as two. The depth of core zone is zero.

zNode: Zone node, a node located in the same zone as the node being mentioned

IV. Proposed Model

In this section, we first describe the zone construction process, including the intrazone and interzone topology building and zLD election. We then introduce the zonesupported geographic unicast routing which will be used in our protocol. 1) Intrazone and interzone topology building: In the underneath geographic unicast routing protocols, nodes periodically broadcast a BEACON message to distribute a node's position. We insert in the BEACON message a flag indicating whether the sender is zLD to ease leader election. Since rzone <= √r 2 , the broadcasting will cover the whole local zone. To reduce the beaconing overhead, we enhance the fixed-interval beaconing mechanism in the underneath unicasting protocol to a more flexible one. A non-leader node will send a beacon only when its moving distance from last beaconing is larger than or equal to Dbeacon, or the time interval from last beaconing is longer than or equal to Intvalmax, or it moves to a new zone. A zLD is forced to send out a beacon every period of Intvalmin to announce its leadership role.

A. Zone Structure Building and Geographic Routing

Multicast Tree Construction and Packet Delivery In this section, we will present the multicast tree creation and maintenance schemes, and describe the multicast packet delivery strategy. And 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.
1) Multicast session initiation and termination: When S wants to start a multicast session G, it will announce 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 zone ID of the core zone for group G. When a node M receives this message and is interested in G, it will join G
2) Multicast group joining: When a node M wants to join G, if it is a non-leader node, it sends a JOIN REQ(M, zoneIDM, G) message to its zLD. If a zLD receives a JOIN REQ or itself will join G, it will begin the leader joining procedure as follows. If the received JOIN REQ comes from a member M of the same zone, the zLD adds M to the downstream node list in its multicast table. If the message is from another zone, it will compare the depth of the request zone with that of its own zone. If its depth is smaller, i.e., its zone is closer to the core zone than the request zone, it will add the request zone to its downstream zone list; otherwise, it just continues forwarding the JOIN REQ message towards the core zone. If new nodes or zones are added to the downstream list, the leader will check the core-zone ID and the upstream zone ID and take corresponding action. If it doesn't know the core zone, it starts an expanded ring search. When knowing the core zone, if its upstream zone ID is unset, the leader will represent its zone to send a JOIN REQ message towards the core zone; otherwise, the leader will send back a JOIN REPLY to the source of JOIN REQ (which may be multiple hops away and geographic unicasting is used for this transmission). When the source of the JOIN REQ message receives JOIN REPLY, if it is a node, it sets the isAcked flag in its membership table and the joining procedure is finished. If the join request is from a zone, the leader of the request zone will add the upstream zone ID as the source zone ID of the JOIN REPLY message, and then send JOIN REPLY to unacknowledged downstream nodes or zones.

B. Multicast Routing protocol

Phase1: Neighbor-Group creation and Multicast Neighbor selection is done through two sub-phases namely: Neighbor-List creation and Multicast group selection. The sub-phases are detailed below:

Neighbor-List creation: The current one-hop neighbor collection is the responsibility of the Neighbor-List creation sub phase. The current one-hop neighbor of a particular node forms the neighbor-list set. The neighbor nodes share this list for selection of distant nodes. As the sparse and partially connected area incorporates in deterministic high mobility, the Neighbor-List is to be updated dynamically. A pro-active approach of sending periodic „hello" message is undertaken to encounter the above issue. The hello messages are network layer based; they are sent out by the network layer. It is more convenient to send the "hello" messages through the network layer because routing functions can be performed without consideration of the underlying MAC layer technology Multicast group selection The existing Border node Based Routing (BBR) protocol floods the network without considering the relative distance between the nodes, resulting in an inefficient bandwidth utilization; Considering this issue, the MAV-AODV protocol introduces a threshold τ to classify the current one-hop neighbors which will receive the multicast data packet with respect to the current forwarding(Distant) node. The multicast packet receiving nodes are selected on the basis of transmission time (as transmission time in low node density, light traffic area is directly dependent on physical distance between nodes, other factors are negligible). The „hello" messages contain the current timestamp before it has been sent out.

The current forwarding node receives „hello" messages from its current one hop neighbors and computes the transmission time and averages two recent successive transmission times of all the one-hop neighbors and then compares with a threshold τ for selection of data packet receiving neighbors. A node k is added to the multicast group of current forwarding node F if the following condition is satisfied. : $TTk(i+1) + TTk(i) \geq 2\tau$, for all k in the one-hop Neighbor-List of F (1) Where, TTk(i) is the computed transmission time for node k at the ith time instant τ is proportional to transmission range of nodes To optimize the utilization of bandwidth and reduce the broadcast overhead, instead of the broadcast behavior of the BBR protocol ,multicasting is adopted in the proposed DBMR protocol.

Phase2: Distant node selection The Distant nodes are selected per multicast event. A Distant node is responsible for storing received multicast data forwarding to appropriate nodes at appropriate time. The Current forwarding(Distant) node multicasts the received data packets only to the nodes those who are the members of the multicast group. It is the responsibility of a particular node to decide whether it is Distant node or not; the current one-hop neighbor information and the received multicast information are used as selection information.

Criteria for the distant node selection procedure The Distant node/nodes selection criteria in DBMR are similar to the selection of Border node/nodes in the BBR protocol. The selection of a distant node is based on minimum common neighbor approach. The minimum common neighbor approach is undertaken upon the intuitive notion that a Distant node situated at the edge of a transmission range should have a fewer common neighbor or the Distant node/nodes must should have a maximum uncommon neighbor with the current multicast source node as compared to those that are closer to the forwarding node (multicast source node).
Implementation of Distant node selection.

The multicast routing protocol involves store-carry and forward approach like the delay tolerant network. The original creator or source of a data packet is by default a distant node. Three tables are needed to be maintained by a particular node namely- Neighbor-List, selection table, and message table. The Neighbor-List contains the one-hop neighbor information. Selection table stores the necessary information for the selection of distant node/nodes. Message table buffers the data packets with the sequence no (packet id). The message table is searched when a new node comes in contact of a particular node to check whether it is a destination of a data packet or not. Reception of duplicate packets is discarded by checking the packet sequence no (packet id). If a new packet arrives a node will perform appropriate action in a specific condition. The condition wise approaches are discussed below:

C. *Estimated Link Lifetime*

The node versatility data given by MAV-AODV convention empowers us to ascertain an imperative portability parameter of the connection: the connection lifetime (tlink). The presence of the connection is reliant on spatial separation between the nodes (Dij), and additionally the greatest scope of correspondence between them (R), i. e., the length of D2(t) _ R2, the nodes i and j are still neighbors. To ascertain (tlink), we must at present think seriously about another vital viewpoint. In the event that two vehicles have fundamentally the same mobilities (for instance, two vehicles moving in the same heading near one another and with comparable speeds), the join lifetime tends towards interminability. To address this issue, in our work, we express a maximum point of confinement given by characterizing tmaxlifetime. At the point when a guide message touches base at a node, it figures the evaluated connection lifetime. Each of the system hubs makes this figuring and stores this assessment in their separate directing tables, which is continually redesigned by the MAV-AODV convention

D. *Multicast data forwarding*

In our protocol, only zLD will maintain the multicast table, and the member zones normally cannot be reached within one hop. When a node N has a multicast packet to be forwarded to a list of destinations (D1, D2, D3, . . .), it decides the next hop towards each destination (For a zone, its center is used) using the geographic forwarding strategy After deciding the next hops, N inserts the list of next hops and associated destinations in the packet header. An example list is (N1 : D1, D3; N2 : D2; . . .) where N1 is the next hop for the destinations D1 and D3, and N2 is the next hop for D2. And 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 hops or destinations, and drop the packet otherwise. If the node is a next hop for other destinations, it will continue forwarding the packets similarly as node N.

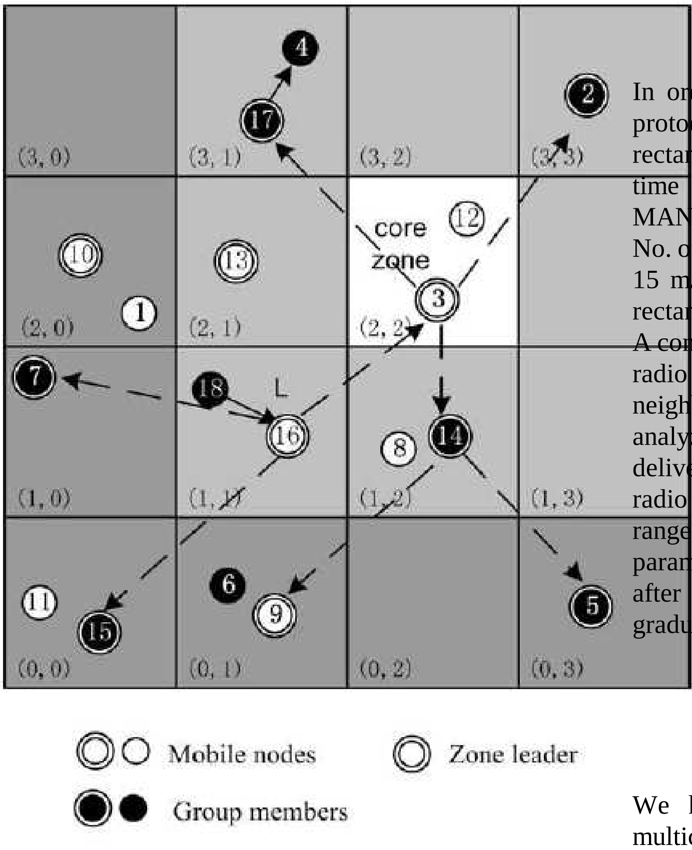

Fig 1:

For example, in Fig. 3, after node 3 receives the multicast packet from zone (1, 1), it will forward the packet to the downstream zones (1, 2), (3, 1) and (3, 3). It decides the next hop for each destination and inserts the list (12: (3,1),(3,3); 14: (1,2)) in the packet header. After broadcasting the packet promiscuously, its one-hop neighbors node 12, node 14 and node 8 will receive the packet. They check the next hops. Node 8 will drop this packet. Node 12 and node 14 will continue forwarding this packet. Node 12 replaces the list carried in the packet header as (17: (3,1); 2: (3,3)) and broadcasts this packet. E. Multicast Route Maintenance and Optimization In a dynamic network, it is critical to maintain the multicast tree structure to keep its connection, and adjust the tree structure upon topology change to optimize the multicast routing. In the zone structure, node will move between different zones and sometimes empty zones will appear, which is a key problem in a zone-based protocol. In this section, we will address these issues. 1) Moving between different zones: When a member node moves to a new zone, it must rejoin the multicast tree through the new zLD. When a zLD is moving away from its current zone, it must handover its multicast table to a new zLD, otherwise all the downstream zones and nodes will lose the connection to the multicast tree. Whenever a node M moves into a new zone, it will rejoin G by sending a JOIN REQ to its new zLD. 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 one copy of the BEACON to its old zone to update its position. Since it hasn't sent LEAVE message to the old zLD, the old zLD will unicast the multicast packet to M. When the rejoining process finishes, M will send a LEAVE message to its old zLD

V. IMPLEMENTATION AND EVOLUTION

In order to evaluate the performance of Multicast routing protocol, I have used NS-2 simulator version 2.35. A rectangular field of 1000m×1000m is chosen and simulation time taken is 900 seconds. Simulation setup to generate MANET in NS-2 The MAC protocol used is IEEE 802.11. No. of nodes is 30, and speed of nodes is within the range 0 to 15 m/s. Initially, all the nodes are uniformly placed in the rectangular area with the average distance Lav= 171.4 meters. A connectivity parameter α is defined as the ratio between the radio transmission range (R) and the average distance among neighboring nodes. The performance of multicast routing is analyzed in terms of two performance indices- Packet delivery ratio and Average end-to-end delay as a function of radio range. In Fig.4 it is seen that with the increasing radio range, more precisely with the increase in the connectivity parameter α, the packet delivery ratio increases rapidly, but after reaching about 100m the ratio remains constant then gradually approaches towards 99%.

VI. CONCLUSION

We have designed an efficient and robust geographic multicast protocol for MANET in this paper. This protocol uses a zone structure to achieve scalability, and relies on underneath geographic unicast routing for reliable packet transmissions. We build a zone-based bidirectional multicast tree at the upper tier to achieve more efficient multicast membership management and delivery, and use a zone structure at the lower tier to realize the local membership management. We also develop a scheme to handle the empty zone problem which is challenging for the zone-based protocols. The position information is used in the protocol to guide the zone structure building, multicast tree construction and multicast packet forwarding. As compared to traditional multicast protocols, our scheme allows the use of location information to reduce the overhead in tree structure maintenance and can adapt to the topology change more quickly. Simulation results show our protocol can achieve higher packet delivery ratio in a largescale network. In future work, we are going to enhance our protocol without the help of core zone, to achieve more optimal routing and lower control overhead..

Fig 2: Packet delivery ratio of MEGMP and MAODV

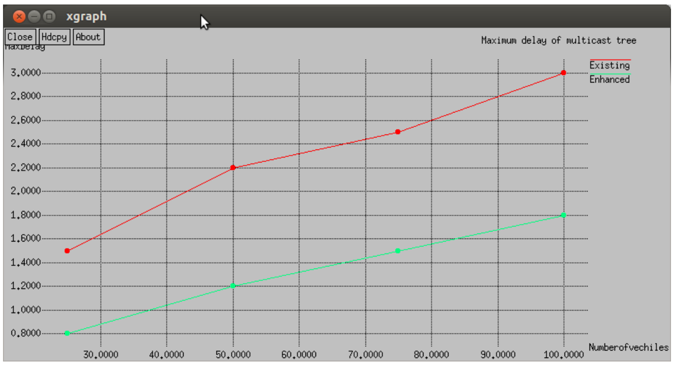

Fig 3: Maximum Delay

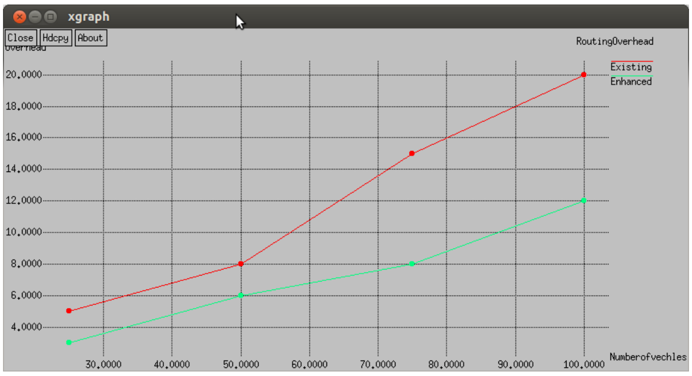

Fig 4: Routing Overhead

REFERENCES

[1] M. Abolhasan, T. Wysocki, and E. Dutkiewic. Scalable routing strategy for dynamic zones-based manets. GLOBECOM ’02. IEEE, 1:17–21, November 2002.

[2] A. Ballardie. Core Based Trees (CBT) Multicast Routing Architecture. RFC 2201, September 1997.

[3] S. Basagni, I. Chlamtac, V. Syrotiuk, and B. Woodward. A distance routing effect algorithm for mobility (DREAM). In Proceedings of the ACM/IEEE International Conference on Mobile Computing and Networking (MOBICOM), pages 76–84, 1998.

[4] S. Basagni, I. Chlamtac, and V. R. Syrotiuk. Location aware, dependable multicast for mobile ad hoc networks. Computer Networks, 36(5-6):659–670, August 2001.

[5] L. Blazevic, S. Giordano, and J.-Y. L. Boudec. Self organized terminode routing. Cluster Computing Journal, 5(2):205–218, April 2002.

[6] P. Bose, P. Morin, I. Stojmenovic and J. Urrutia. Routing with guaranteed delivery in ad hoc wireless networks. Workshop on Discrete Algorithms and Methods for Mobile Computing and Communications (DialM 99), Aug. 1999.

[7] J. Broch, D. A. Maltz, D. B. Johnson, Y-C. Hu and J. G. Jetcheva. A Performance Comparison of MultiHop Wireless Ad Hoc Network Routing Protocols. Proceedings of the ACM/IEEE International Conference on Mobile Computing and Networking (MOBICOM), pages 85–97, 1998.

[8] K. Chen and K. Nahrstedt. Effective location-guided tree construction algorithms for small group multicast in manet. IEEE INFOCOM, pages 1180–1189, 2002.

[9] C.-C. Chiang, M. Gerla, and L. Zhang. Forwarding group multicast protocol (FGMP) for multihop, mobile wireless networks. AJ. Cluster Comp, Special Issue on Mobile Computing, 1(2):187–196, 1998.

[10] C. de Morais Cordeiro, H. Gossain, and D. P. Agrawal. Multicast over wireless mobile ad hoc networks: Present and future directions. IEEE Network, pages 52–59, January/February 2003.

[11] H. Du, H. Hassanein, and C. Yeh. Zone-based routing protocol for high-mobility manet. IEEE CCECE 2003. Canadian Conference on, 2:4–7, May 2003.

[12] Y. Ko and N. Vaidya. Location-aided routing in mobile ad hoc networks. MOBICOM, Dallas, Texas, USA, Aug. 1998.

[13] 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.

[14] J. Li. et al. A scalable location service for geographic ad hoc routing. In Proc. 6th Annual ACM/IEEE Int’l. Conf. Mobile Comp. Net.(MOBICOM), pages 120–130, 2000.

[15] J. J. Garcia-Luna-Aceves and E. Madruga. The core-assisted mesh protocol. IEEE JSAC, pages 1380–1394, August 1999. [

[16] M. Gerla, S. J. Lee, and W. Su. On-demand multicast routing protocol (ODMRP) for ad hoc networks. Internet draft, draftietf-manet-odmrp-02.txt, 2000.