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IMPROVING ENERGY EFFICIENT MULTICAST ROUTING PROTOCOL FOR ZONE BASED MOBILE ADHOC NETWORKS

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Abstract— 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. To reduce the topology maintenance overhead and support more reliable multicasting, an option is to make use of the position information to guide multicast routing for that introducing efficient geographic multicast protocol, EGMP. The protocol is designed to be comprehensive and self-contained, yet simple and efficient for more reliable operation. EGMP uses a virtual-zone-based structure to implement scalable and efficient group membership management. Additionally we use node life time prediction algorithm in which If there are two nodes that have the same residual energy level, an active node that is used in many data-forwarding paths consumes energy more quickly, and thus, it has a shorter lifetime than the remaining inactive node. The node lifetime that is based on its current residual energy and its past activity solution that does not need to calculate the predicted node lifetime from each data packet. 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.

Keywords— Routing, Wireless Networks, Multicast, Protocol.

I. INTRODUCTION

An ad-hoc network is a wireless network formed by wireless nodes without any help of infrastructure. In such a network, the nodes are mobile and can communicate dynamically in an arbitrary manner. The network is characterized by the absence of central administration devices such as base stations or access points. Furthermore, nodes should be able to enter or to leave the network easily. In these networks, the nodes act as routers. They play an important role in the discovery and maintenance of the routes from the source to the destination or from a node to another one. This is the principal challenge to such a network. If link breakages occur, the network has to stay operational by building new routes. The main technique used is the multi-hopping which increase the overall network capacity and performances. By using multi-hopping, one node can deliver data on behalf of another one to a determined destination. Thus, the problem of range radio is solved.

A Mobile Ad hoc Network (MANET) represents a system of wireless mobile nodes that can self-organize freely and dynamically into arbitrary and temporary network topology. On one hand, they can be quick deployed anywhere at any time as they eliminate the complexity of infrastructure setup. On the other hand, other problems arise, such as route errors or higher overhead, caused by the mobility of nodes. In order to avoid some designing bugs or problems, it is necessary to analyze the designed protocols formally before protocols are deployed or applied. Considering the particularities of MANET, the secure traits are different from the traditional security such as secrecy and authenticity. Formal analysis methods have used for many years in cryptographic protocols, however, there are no mature theories and methods in MANET

II. MULTICASTING

Multicast is the delivery of a message or information to a group of destinations simultaneously in a single transmission using routers, only when the topology of the network requires it.

Eg. for multicasting

Red node – source , Green node - Destination

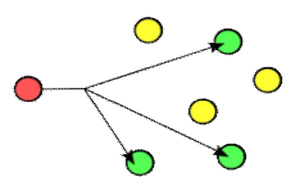

Fig 1 : Basic Structure of Multicast Routing

For example, a situation where a research project team engaged in excavation work constructs an ad hoc network on a mountain. The results obtained from the investigation may consist of various types of data such as numerical data, photographs, sounds, and videos. In this case, although it is

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useful to have the data that other members obtained, it seems difficult for a mobile host to have replicas of all the data.

III. MANET (MOBILE AD HOC NETWORK)

A self-configuring infrastructure less network of mobile devices connected by wireless links. Each device in a MANET is free to move independently in any direction, and will therefore change its links to other devices frequently.

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.

The Fig2 shows the structure of the wireless Ad-hoc networks.

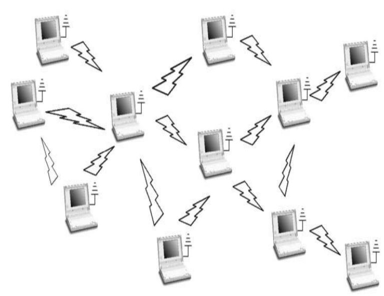

Fig 2 : The structure of the Wireless Ad-hoc Networks

IV. SPBM PROTOCOL

The existing geographic routing protocols generally assume mobile nodes are aware of their own positions through certain positioning system, and a source can obtain the destination position through some types of location service. Basing their forwarding decisions only on the local topology, geographic routing protocols have drawn a lot of attentions.

However, inaccurate local topology knowledge and the outdated destination position information can lead to inefficient geographic forwarding and even routing failure.

Using the Scalable Position Based Multicast (SPBM) geographic routing schemes, the local topology is updated in a timely manner according to network dynamics and traffic demands. SPBM incurs several times of control overhead, redundant packet transmissions and multicast group joining delay.

Instead of using this SPBM we propose a novel Efficient Geographic Multicast Protocol (EGMP). Our simulation studies have shown that the proposed routing protocols EGMP are more robust and outperform the existing geographic routing protocol.

4.1 Protocol Overview

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 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. 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 Intval max period for the beacons from other nodes. Every Intval min a node will check its neighbor table and determine its zone leader under different cases:

- The neighbor table contains no other nodes in the same zone it will announce itself as the leader.
- 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.

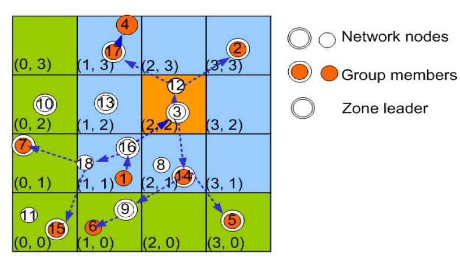

***Fig 3:* Zone structure and multicast session example.**

- More than one node in the same zone have their leader flags set, the one with the highest node ID is elected.
- Only one of the nodes in the zone has its flag set, and then the node with the flag set is the leader. A node

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constructs its neighbor table without extra signaling. When receiving a beacon from a neighbor, a node records the node ID, position, and flag contained in the message in its neighbor table.

In this zone based structure we use the algorithm named as node life time algorithm. In this algorithm we calculate the energy level for all the nodes in the zone based structure.

If there are two nodes that have the same residual energy level, an active node that is used in many data-forwarding paths consumes energy more quickly, and thus, it has a shorter lifetime than the remaining inactive node. The node lifetime that is based on its current residual energy and its past activity solution that does not need to calculate the predicted node lifetime from each data packet. An exponentially weighted moving average method to estimate the energy drain rate evi . Ei represents the current residual energy of node *i*, and evi is the rate of energy depletion. Ei can simply be obtained online from a battery management instrument and evi is the statistical value that is obtained from recent history. The estimated energy drain rate in the nth period, and ev(n−1) i is the estimated energy drain rate in the previous ($n - 1$)th period. α denotes the coefficient that reflects the relation between evn and evn−1 , and it is a constant value with a range of [0, 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 Timeout or the corresponding neighbor is detected unreachable by the MAC layer protocol 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 uncast 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 to M. This forwarding process helps reduce the packet loss and facilitates seamless packet transmissions during zone crossing. When the rejoining process finishes M will send a LEAVE message 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 its 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 introduced 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

- 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 uncast 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.

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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.

Reduce the forwarding overhead and delay, EGMP supports bidirectional 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. Many issues need to be addressed to make the protocol fully functional and scalable. The issues related to zone management include: the schemes for more efficient and robust zone construction and maintenance, the strategies for election and maintenance of a zone leader with minimum overhead, zone partitioning as a result of severe wireless channels or signal blocking, potential packet loss when multicast members move across zones.

The issues related to packet forwarding include: the efficient building of multicast paths with the zone structure, the handling of empty zone problem, the efficient tree structure maintenance during node movements, the reliable transmissions of control and multicast data packets, and obtaining location information to facilitate our geometric design without resorting to an external location server. 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.

4.2 Simulation Results

Simulation results demonstrate that EGMP has the following:

- High packet delivery ratio
- Low control overhead
- Multicast group joining delay
- Scalable to both the group size and network size

V. PERFORMANCE EVALUATION

The performance of the proposed GAR algorithm is evaluated via glomosim simulator. Performance metrics are utilized in the simulations for performance comparison:

- ***Packet arrival rate***. The ratio of the number of received data packets to the number of total data packets sent by the source.
- ***Average end-to-end delay***. The average time elapsed for delivering a data packet within a successful transmission.
- ***Energy consumption***. The energy consumption for the entire network, including transmission energy consumption for both the data and control packets.

VI. CONCLUSION

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 intrazone 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.

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