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Efficient Multicasting In Manet Using RSGM Technique

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Abstract

The challenges in designing a scalable and robust multicast routing protocol in a mobile ad hoc network (MANET) due to the difficulty in group membership management, multicast packet forwarding, and the maintenance of multicast structure over the dynamic network topology for a large group size or network size. To use a novel Robust and Scalable Geographic Multicast Protocol (RSGM) which exhibit several virtual architectures. Specially, scalable and efficient group membership management is performed through a virtual-zone-based structure, and the location service for group members is integrated with the membership management. The stateless virtual-tree-based structures significantly reduce the tree management overhead, support more efficient transmissions, and make the transmissions much more robust to dynamics. Geographic forwarding is used to achieve further scalability and robustness. To overcome flooding of the source information throughout the network, an efficient source tracking mechanism is designed. Furthermore, we handle the empty-zone problem faced by most zone-based routing protocols. We have studied the protocol performance by performing both quantitative analysis and extensive simulations. Our results demonstrate that RSGM can scale to a large group size and a large network size, and can more efficiently support multiple multicast groups in the network. Compared to other protocols ODMRP and SPBM, RSGM achieves a significantly higher delivery ratio under all circumstances, with different moving speeds, node densities, group sizes, number of groups, and network sizes. RSGM also has the minimum control overhead and joining delay.

Keywords— Multicast routing, geographic multicast, mobile computing, wireless networks, mobile ad hoc networks, geographic routing, location, scalable, robust

1. INTRODUCTION

An ad-hoc network is a local area network (LAN) that is built spontaneously as devices connect. Instead of relying on a base station to coordinate the flow of messages to each node in the network, the individual network nodes forward packets to and from each other. Ad-hoc network does not contain any access point, instead each node acts as access points. Wireless communication enables information transfer among a network of disconnected, and often mobile, users. Popular wireless networks such as mobile phone networks and wireless LANs are traditionally infrastructure-based, i.e. base stations, access points and servers are deployed before the network can be used. In contrast, ad hoc networks are dynamically formed amongst a group of wireless users and require no existing infrastructure or pre-configuration.ad hoc networks makes them particular useful in situations where rapid network deployments are required or it is prohibitively costly to deploy and manage network infrastructure. Some example applications include, Attendees in a conference room sharing documents and other information via their laptops and handheld computer; Armed forces creating a tactical network in unfamiliar territory for communications and distribution of situational awareness information; Small sensor devices located in animals and other strategic locations that collectively, monitor habitats and environmental conditions; Emergency services communicating in a disaster area and sharing video updates of specific locations among workers in the field, and back to headquarters.

Unfortunately, the ad hoc nature that makes these networks attractive also introduces many complex communication problems. Although some of the first ad hoc networks were deployed in the early 1970's, significant research problems remain unanswered.

A mobile ad-hoc network (MANET) is a self-configuring network of mobile routers (and associated hosts) connected by wireless links the union of which form an arbitrary topology. The routers are free to move randomly and organize themselves arbitrarily; thus, the network's wireless topology may change rapidly and unpredictably. Such a network may operate in a standalone fashion, or may be connected to the larger Internet. Minimal configuration and quick deployment make ad hoc networks suitable for emergency situations like natural or human-induced disasters, military conflicts, emergency medical situations etc.

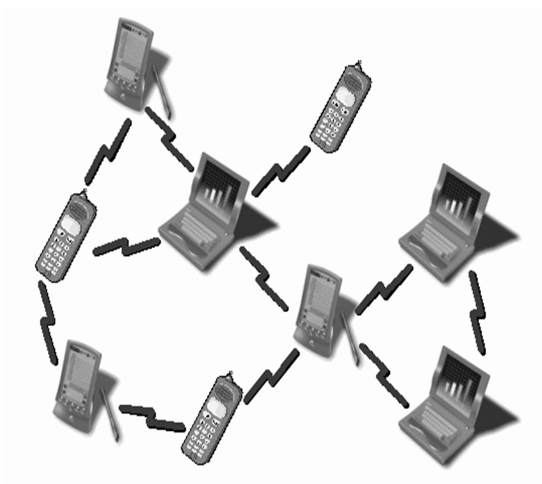

Fig 1 Ad hoc Network

The earliest MANETs were called "packet radio" networks, and were sponsored by DARPA in the early 1970s. BBN Technologies and SRI International designed, built, and experimented with these earliest systems. Experimenters included Jerry Burchfiel, Robert Kahn, and Ray Tomlinson of later TENEX, Internet and email fame. It is interesting to note that these early packet radio systems predated the Internet, and indeed were part of the motivation of the original Internet Protocol suite. Later DARPA experiments included the Survivable Radio Network (SURAN) project, which took place in the 1980s. Another third wave of academic activity started in the mid 1990s with the advent of inexpensive 802.11 radio cards for personal computers. Current MANETs are designed primarily for military utility; examples include JTRS and NTDR

A mobile ad-hoc network (MANET) consists of mobile hosts equipped with wireless communication devices. The transmission of a mobile host is received by all hosts within its transmission range due to the broadcast nature of wireless communication and Omni-directional antennae. If two wireless hosts are out of their transmission ranges in the ad hoc networks, other mobile hosts located between them can forward their messages, which effectively build connected networks among the mobile hosts in the deployed area. Due to the mobility of wireless hosts, each host needs to be equipped with the capability of an autonomous system, or a routing function without any statically established infrastructure or centralized administration. The mobility and autonomy introduces a dynamic topology of the networks not only because end-hosts are transient but also because intermediate hosts on a communication path are transient. A typical MANET network is shown in the figure

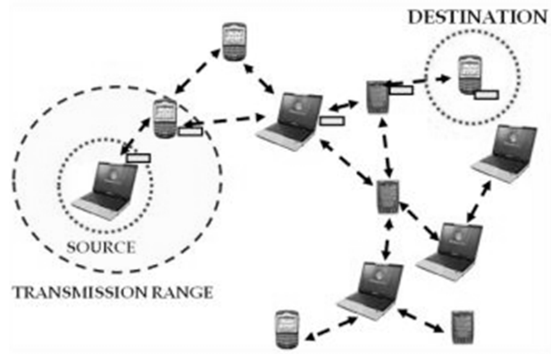

Fig 2 Mobile Ad-Hoc Networks

In the figure 2, mobile nodes are connected via wireless links. It has no infrastructure and dynamic i.e. free to move.

The Characteristics of MANETs are Operating without a central coordinator, Multi-hop radio relaying, Frequent link breakage due to mobile nodes, Constraint resources (bandwidth, computing power, battery lifetime, etc.), Instant deployment.

Wireless mobile ad hoc networks (MANETs) are self configuring, dynamic networks in which nodes are free to move. A major performance constraint comes from path loss and multipath fading. Many MANET routing protocols exploit multihop paths to route packets. The probability of successful packet transmission on a path is dependent on the reliability of the wireless channel on each hop. Rapid node movements also affect link stability, introducing a large Doppler spread, resulting in rapid channel variations.

In a MANET, wireless devices could self-configure and form network with an arbitrary topology. 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. Although it is important to support multicast in a MANET, which is often required by military and emergency applications, there is a big challenge to design a reliable and scalable multicast routing protocol in the presence of frequent topology changes and channel dynamics. Many efforts have been made to develop multicast protocols for MANETs. These include conventional tree-based protocols and mesh-based protocols. The tree-based protocols (e.g., MZRP) construct a tree structure for more efficient multicast packet delivery, and the tree structure is known for its efficiency in utilizing network resources. However, it is very difficult to maintain the tree structure in mobile ad hoc networks, and the tree connection is easy to break and the transmission is not reliable.

The mesh-based protocols (e.g., Core-Assisted Mesh protocol) are proposed to enhance the robustness with the use of redundant paths between the source and the set of multicast group members, which incurs a higher forwarding overhead. There is a big challenge to support reliable and scalable multicast in a MANET with these topology-based schemes, as it is difficult to manage group membership, find and maintain multicast paths with constant network topology changes. In order to support more reliable and scalable communications, it is critical to reduce the states to be maintained by the network, and make the routing not significantly impacted by topology changes. Recently, several location-based multicast protocols have been proposed, for MANET.

These protocols assume that mobile nodes are aware of their own positions through certain positioning system (e.g., GPS), and make use of geographic routing to transmit packets along the multicast trees. In these protocols, a multicast packet carries the information of the entire tree or all the destinations into the packet headers. Thus, there is no need to distribute the routing states in the network. Although these protocols are more robust than the conventional topology-based multicast schemes, the header overhead increases significantly as the group size increases, which prevents the scaling of these protocols and constrains these protocols to be used only for small multicast groups.

Additionally, there is a need to efficiently manage the membership of a potentially large group, obtain the positions of the members, and transmit packets to member nodes that may be located in a large network domain and in the presence of node movements. The existing small-group-based geographic multicast protocols normally address only part of these problems.

2. RELATED WORK

In this section, we first summarize the basic procedures assumed in conventional multicast protocols, and then discuss a few geographic multicast algorithms proposed in the literature.

As introduced in Section 1, 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 that can be used to forward multicast data packets when some of the links break. A topology-based multicast protocol generally has the following three inherent components that make them difficult to scale:

Group membership management: The group membership changes frequently as each node may join or leave a multicast group randomly, and the management becomes harder as the group size or network size increases.

Creation and maintenance of a tree- or mesh-based multicast structure: The tree-based structures are difficult to maintain in the presence of the movement of nodes and the change of multicast group membership, while the mesh-based schemes achieve the robustness at the cost of extra network resource consumption.

Multicast packet forwarding: The multicast packets are forwarded along the prebuilt tree or mesh structures, which are vulnerable to breakage over the dynamic topology, especially in a large network with potentially longer paths.

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. In contrast, RSGM uses a location-aware approach for more reliable membership management and packet transmissions. 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 setup, RSGM has a much higher packet delivery ratio than that of .Besides the three components included in conventional topology-based multicast protocols, a geographic multicast protocol also requires a location service to obtain the positions of the members. The geographic multicast protocols presented in, and need to put the information of the entire tree or all the destinations into packet headers, which would create a big header overhead when the group size is large and constrain these protocols to be used only for small groups. In DSM, each node floods its location in the network. A source constructs a Steiner tree and encodes the multicast tree into each packet, and delivers the packet by using source routing. LGT requires each group member to know the locations of all other members, and proposes two overlay multicast trees: a bandwidth minimizing LGS tree and a delay-minimizing LGK tree. In PBM, a multicast source node finds a set of neighboring, next-hop nodes and assigns each packet destination to one next-hop node. The next-hop nodes, in turn, repeat the process. In GMP, which proposed for sensor networks, a node needs to perform a centralized calculation for more efficient tree construction. Therefore, it is more applicable for a smaller group in a static network.

The conventional topology-based multicast protocols are usually composed of the following three components that generally cannot scale to large network size: 1) Group membership management. The management becomes harder for a large group. 2) Creation and maintenance of a tree or mesh-based multicast structure.

These will cause significant control overhead over the dynamic topology of MANET.3) Multicast packet forwarding. The multicast packets are forwarded along the pre-built tree or mesh structure, which is vulnerable to be broken over the dynamic topology, especially in a large network with potentially longer paths. Besides these, a geographic multicast protocol also needs location service to obtain the members' positions. The geographic multicast protocols are need to put the information of all the group members into the packet header, which is only applicable for the small group case. The network terrain is divided into a quad-tree with L levels. The top level is the whole network and the bottom level is constructed by basic squares. A node periodically broadcasts its membership and position in basic square. And at each level of the quad-tree, every square needs to periodically flood its membership into its upper level square. Such periodical flooding are repeated for every two neighboring levels until the upmost level which is the whole network. Significant control overhead will be generated when the network size increases. With this proactive periodic membership updating scheme, a node's membership change may need to go through L levels' membership updates to make it known to the whole network, which leads to a long joining time.

3. ROBUST AND SCALABLE GEOGRAPHIC MULTICAST PROTOCOL

RSGM supports a two-tier membership management and forwarding structure. At the lower tier, a zone structure is built based on position information and a leader is elected on demand when a zone has group members. A leader manages the group membership and collects the member nodes' positions in its zone. At the upper tier, the leaders of the member zones report the zone memberships to the sources directly along a virtual reverse-tree-based structure or through the home zone. With the knowledge of the member zones, the source forwards data packets to the zones that have group members along a virtual tree rooted at the source. After the packets arrive at the member zones, they will be further forwarded to local members through the leaders. In RSGM, we assume every node is aware of its own position (e.g., through GPS). The forwarding of data packets and most control messages follows the geographic forwarding strategy described.

A. Notations and Definitions

pos: A mobile node's position coordinates (x, y).
zone: The network terrain is divided into square zones as shown in Fig. 1.*mZone* (*non mZone*): Member (Non member) zone, a zone with (without) group members in it. *zLdr*: Zone leader. *hZone*: Home zone. A zone in the network is elected as home zone to keep track of the addresses and locations of all the sources. *groupID*: The address of a multicast group. *G, S, M*: Representing a ulticast group, a source of G and a member of G respectively.
mcastTable: Multicast table. A node records the multicast information in its mcastTable. A mcastTable contains a list of group entries and hZone information (including its identification and seqNo) to be introduced later. Each group entry saves the information of a group: groupID, source list, member list and mZone list. Source list is a list of source records, which is used by group members and zLdrs to keep the sources.

The member list is used by a zLdr to save the information of multicast group members within its local zone, and a source will record mZones in its zone list.

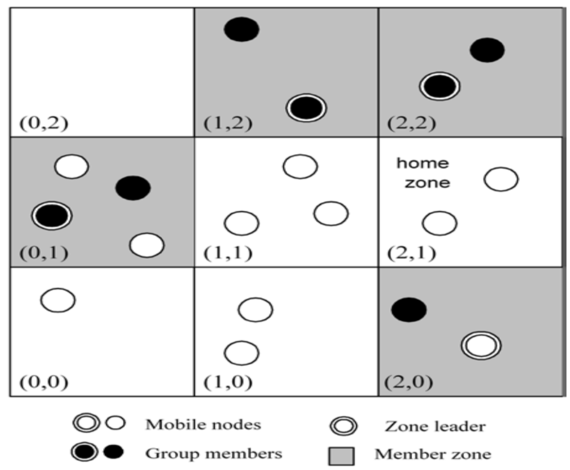

Fig 3 Zone structure

B. Zone Construction and Maintenance

1) Zone construction*:* The length of a side of the zone square is defined as *zone size*. Each zone is identified by a zone ID (zID). A node can calculate its zID (a, b) from its *pos* (x, y) as: $a = [\ x-x0\ /zone\ size\ ]$ and $b = [\ y-y0/zone\ size\ ]$, where $(x0, y0)$ is the position of the virtual origin. For simplicity, we assume all the zone IDs are positive. zID will also help locate a zone. In our scheme, a packet destined to a zone will be forwarded towards its center. The center position (xc, yc) of a zone with zID (a,b) can be calculated as: $xc = x0+(a+0.5)\times zone\ size$, $yc = y0 + (b + 0.5) \times zone\ size$.

2) On-demand leader election: A leader will be elected in a zone only when the zone has group members in it. When a multicast group member M just moves into a new zone, if the zone leader (zLdr) is unknown, M queries a neighbor node in the zone for zLdr. When failing to get zLdr information, M will announce itself as zLdr by flooding a LEADER message into the zone. In the case that two leaders exist in a zone, e.g., due to the slight time difference of leader queries and announcements, the one with larger ID will win as zLdr.

A zLdr floods a LEADER in its zone every time interval *Intvalrefresh* to announce its leadership until the zone no longer has any members. If no LEADER message is received longer than 2 × *Intvalrefresh*, a member node will wait a random period and then announce itself as zLdr when no other node announces the leadership.

C. Group Membership Management

1) Local group membership management: The group membership is first aggregated in the local zone. When joining or leaving a group, a member M sends a message REFRESH (groupIDs, *posM*) immediately to its zLdr to notify its membership change, where *posM* is its position and groupIDs are the addresses of the groups that M is a member. M also needs to unicast a REFRESH message to its zLdr every time interval *Intvalrefresh* to update its position and membership information. And a member record will be removed by the zLdr if not refreshed for longer than 2 × *Intvalrefresh*. When M moves to a new zone, its next periodic REFRESH will be sent to the zLdr in the new zone. Fig. 2. The aggregation of REPORT messages.as zLdr if the new zone has no zLdr. The moving node will still receive the multicast data packets from the old zone before its information is timed out at the old zLdr, which reduces the packet loss during the moving. For a zLdr, if its distance to the zone border is shorter than a distance threshold and the zone is still a member zone, it will handover its leadership by unicasting a LEADER to the neighbor node in its zone which is closest to the zone center. The LEADER message will continue being forwarded towards zone center until reaching a node which has no neighbor closer to the zone center than itself, and the node will take over the leadership and flood a LEADER within the zone to announce its leadership.

***2) Membership management at network range**:* After the membership information is aggregated in the local zone, a source only needs to track the member zones (mZones).

a) Zone membership reporting by zone leaders

When a zone changes from mZone to non mZone of G or vice versa, zLdr sends a REPORT immediately to S to notify the change. zLdr can get S's address and *posS* using methods described in Section III-D. A zLdr needs to send REPORT every time interval *Intvalzone* to S to refresh its zone membership information. S will remove a mZone record if not refreshed longer than 2 × *Intvalzone*.

b) Empty zone handling

A zone may become empty when all the nodes move away.When a mZone of G is becoming empty, the moving out zLdr will notify S immediately to stop sending packets to the empty zone. If the moving out zLdr fails to notify S (e.g., zLdr suddenly dies), the packet forwarded to the

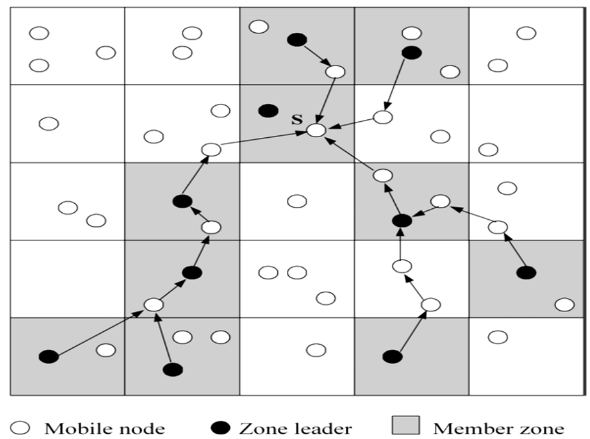

Fig 4 The aggregation of REPORT messages.

empty zone will finally be dropped without being able to be delivered. The node which drops the packet will notify S to delete the zone from its zone list. A false deletion will be corrected when S receives the periodic membership reporting from the corresponding zone.

c) Message aggregation

As compared to local messages, the control messages sent at network tier would generally traverse a longer path. We consider a *reverse-tree-based* aggregation scheme, with which all the control messages sent towards the same destination (e.g., the source S) will be aggregated to further reduce control overhead. Different from other tree-based multicast protocols, no explicit tree-structure needs to be maintained, which avoids the overhead and improves the robustness. Specifically, the periodic REPORT messages sent to the source can be aggregated. To facilitate the message aggregation, S schedules the periodic REPORT sending for the mZones. S inserts the next reporting time *t* into the data packets sent out. The zLdr of a mZone schedules its next periodic REPORT to S at the time *t* + _*t*, where _*t* is inversely proportional to its distance to S. The zLdrs will form an upstream and downstream relationship according to their distances to S. Generally the zLdrs farther away from S have a shorter _*t* and will send the REPORTs earlier than the upstream zLdrs, but strict timing is not needed. When a REPORT message reaches a mZone, it is forwarded to zLdr first. When an upstream zLdr receives REPORTs from downstream zLdrs, if it hasn't sent out its REPORT, it will aggregate these REPORTs with its own REPORT, and send out the REPORT at its scheduled time. As a result, the forwarding of the REPORT messages follows a tree structure as shown in Fig. 2.

D. Multicast Packet Delivery

With the membership management, the mZones are recorded by the source S and the local group members and their positions are recorded by zLdrs. The multicast packets are first delivered by S to mZones towards their zone centers. S sends each multicast packet to all the mZones, and to the member nodes in its own zone through zLdr. For each destination, it decides the next hop by using the geographic forwarding strategy ([3]). After all the next hops are decided, S unicasts to each next hop a copy of the packet which carries the list of destinations that must be reached through this hop. So the packets are forwarded along a tree-shape path although there is no need to build the tree. For robust transmissions, geographic unicast is used in packet forwarding. The packets can also be sent through broadcast to further reduce forwarding bandwidth, at the cost of reliability. When an intermediate node receives the packet, if its zone ID is not in the destination list, it will take similar action as S to continue forwarding the packet. If its zone is in the list, it will replace its zID in the destination list with the local members if it is a zLdr, or replace the zID with its zLdr otherwise, and then aggregate the sending according to the destination list as S.

4. PERFORMANCE EVALUATION

A. Simulation Overview

We implemented RSGM within the Global Mobile Simulation (GloMoSim) [10] library. We implemented he geographic unicast forwarding strategy described in with the beaconing interval set as 4s. We set RSGM's *Intvalrefresh* as 4s and *Intvalzone* as 6s. The zone size was set as 400m according to our experience. For performance reference, we choose to compare with the classic mesh-based, on-demand topology based multicast protocol ODMRP, and geographic multicast protocol SPBM. The simulations were run with 400 nodes randomly distributed in the area of 2400*m*× 2400*m*. One multicast group was simulated with 100 group members and one source. We set the network size and group size to relatively large values to study the scalability of the protocols. The nodes moved following the *random waypoint* mobility model. The minimum moving speed was set as 1 m/s. IEEE 802.11b was used as the MAC layer protocol and the nominal transmission range was 250m. Each simulation lasted 500 simulation seconds. Each source sends CBR data packets at 8 Kbps with packet length 512 bytes. The CBR flows start at around 30s so that the group membership management has time to initialize and stop at 480s. A simulation result was gained by averaging over six runs with different seeds. The following metrics were studied:

1) *Packet delivery ratio*: The ratio of the number of packets received and the number of packets expected to be received. So the ratio is the total number of receivedpackets over the multiplication of the group size and the number of originated packets.

2) *Normalized control overhead*: The total number of control message transmissions divided by the total number of received data packets.

3) *Average path length*: The average number of hops traversed by each delivered data packet.

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 the group after the source began sending data packets.

5. CONCLUSION

We have designed a robust, scalable and efficient geographic multicast protocol RSGM for MANET in this paper. In RSGM, both the data packets and control messages will be transmitted along efficient tree-shape paths without the need of explicitly creating and maintaining a tree structure. Scalable membership management is achieved through a zone structure. A home zone is defined to provide location and address service for the sources to avoid the periodic network-range flooding of source information, and the location service for group members is combined with the membership management to avoid the overhead of searching for addresses and positions of all group members through an outside location server. The position information is used in RSGM to guide the zone structure building, membership management and packet forwarding, which reduces the maintenance overhead and leads to more robust multicast forwarding upon the topology changes. We also handle the empty zone problem which is challenging for the zone-based protocols. Our simulation results show that our protocol not only outperforms the existing geographic multicast protocol and conventional multicast protocol but can also scale to a large group size and large network size. Specifically, our protocol is more robust to network dynamics.

7. FUTURE ENHANCEMENT

The enhancement of our project is to reduce the transmission delay in MANET. In every group, we create one proxy buffer for store the data at the transmission time. In the transmission time if any data loss will occur; the request passes to the previous group of nodes from packet losses group .after that, the data retransmit to the next node from the proxy buffer and node get the information, if the loss is occur again, the process comes to again. In this sending data packet from one group to another group is successfully done, the data is removed from the previous proxy buffer.

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