A Survey of Multicast Inter-Domain Routing Protocol (Geo-Assisted) for MANETS

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Abstract- Large military ad hoc networks are often characterized by the interconnection of heterogeneous domains. The same trend is emerging in civilian MANETs (e.g., search and rescue, vehicular networks). In these networks it is important to be able to efficiently propagate information across domains in multicast mode (e.g., situation awareness dissemination, commands, streams). Several multicast protocols have been developed for single domain MANET. However, few can be extended to inter-domain operation. In fact, multicast routing across different MANET domains faces the challenges of node motion, topology changes, dynamic gateway election and, possibly, connectivity interruption. To overcome these challenges, especially to achieve routing scalability and at the same time maintains efficient routing, this paper proposes the Geo-assisted Multicast Inter-domain Routing (GMIDR) protocol based on geographical assistance and cluster technology. Intensive simulation results show that the GMIDR protocol is scalable and stable with various numbers of multicast group members, and it outperforms other multicast protocols. Geocast by applying GMIDR shows the flexibility of the protocol.

Keywords-MANETs, Multicast mode, Clustering, Inter-domain routing.

I.   INTRODUCTION

The mobile ad-hoc network (MANET) inter-domain multicasting comes out as an efficient communication paradigm for the emerging multicast communications across multiple domains, e.g., large military operations, emergency and rescue missions. For instance, a commander-in-general would send the order to the army, navy and air forces to cooperate each other to finish an overall military mission. Also, a remote rescue surgery may need cooperation from multiple doctors physically located in different regions. These above mentioned missions cover several areas and need fast response. Therefore, it is very important to define a network routing policy to disseminate data to different domains. Some civilian MANET applications would also require an inter-domain multicast routing protocol. For example, a vehicle driver may wish to send a traffic situation message to a group of cars in different domains. Multicast TV on public transportation such as buses requires scalable transmission to provide the multimedia.

The Differential Destination Multicast (DDM) protocol [1] which aims to adapt to small multicast groups. SENCAST [2] is a routing protocol designed for large ad hoc emergency network. However, these protocols are hard to meet the inter-domain multicast routing requirements. To the best of our knowledge, very few multicast protocols are designed to inter-domain environment. There is one feasible solution to extend the intra domain routing protocol to the inter-domain routing protocol is adding inter-domain functions into the intra-domain protocol. However, the revision may introduce additional control overhead and decrease the packet delivery ratio. To build an efficient and scalable multicast routing, we introduce the geographical assisted multicast inter-domain routing (GMIDR) protocol. The main goal of our protocol is to achieve a scalable and efficient multicast routing in inter-domain networks. Also, it is important to minimize the control overhead and provide ways to handle inter-domain policy compliance and heterogeneity. We utilize geo-routing protocol and cluster techniques to achieve these goals. The proposed GMIDR applies the geo-routing strategy to reduce network overhead. Namely, each node is aware of its own geographical location, and the geo-routing protocol looks for the node in the multicast group based on the location information, which consumes much less control overhead. To enable scalable and efficient routing, cluster techniques is introduced. Clusters as the basic structure in GMIDR in each domain help the protocol to obtain efficient communication among different domains. Furthermore, multicast group cluster heads (GCHs) are elected within the multicast group covering the entire multicast group. A multicast tree is established from source to each GCH instead of each member in the multicast group. The GCH acts as the stronghold in its group cluster. It obtains the data from outside the group cluster, and delivers to all its children within the group cluster. By taking advantage of GCH, our proposed protocol consumes very low control overhead on the group management.

II.   RELATED WORK

A. GEO-BASED INTER-DOMAIN ROUTING (GIDR)
Geo-based inter-domain routing (GIDR) [3] protocol for MANET is an efficient unicast protocol to apply the clustering technique and geo-routing protocol to obtain the efficient communication and achieve the scalability. Clusters are assigned by the affinity among nodes in each domain of the network. The cluster head (CH) is elected to take the role

of local DNS for its cluster subnet and its neighbour subnets. The CH advertises to its neighbours and connective members its known information such as connectivity, members, and domain information to other domains. When a source node wants to transmit the data packet, it looks up the source's local routing table to find the destination node. If the destination node locates in the local domain, the source can deliver the data via local routing protocol. However, if no information is found in the local routing table, the data will be transmitted to a cluster head. Then the cluster head forwards the packet until it reaches to the destination. The GIDR protocol uses geographical direction forwarding routing as the routing mechanism to transmit the package to the destination. Specifically, it exploits greedy forwarding as its basic mode of operation to tackle the routing issue in MANET. Whereas, the selected next hop may be not satisfied with the greedy forwarding condition due to the presence of holes or obstacles. Instead of perimeter routing, GIDR switches to the direction forwarding. The packet is "direction" forwarded to the "most promising" node in the indicated direction.

GIDR works well in unicast inter-domain routing applications, but it is inefficient to send messages to a large group of receivers. Therefore, we propose the GMIDR multicast inter domain protocol to adapt to new situations transmitting data to large group members [4].

B. ON DEMAND MULTICAST ROUTING PROTOCOL (ODMRP)

ODMRP [5] is an on demand multicast routing protocol for multi hop wireless network. It reduces the network traffic by creating routes on demand. Each source and receiver keeps broadcast join query and join reply to construct the routes. It maintains a forwarding group between sources and receivers to forward multicast packet via scoped flooding. However, ODMRP suffers from a route acquisition. Meanwhile, it has a problem of excessive flooding when numbers of multicast senders are more. Besides, ODMRP is designed for one domain multicasting. It cannot work directly on the inter domain multicast directly.

III. PROTOCOL DESIGN

The proposed Geo-assisted Multicast Inter Domain Routing (GMIDR) Protocol provides a scalable multicast routing mechanism for Mobile Adhoc Networks (MANETs). Geo-based Inter Domain Routing (GIDR) works well in only unicast inter domain routing applications and On Demand Multicast Routing Protocol (ODMRP) is designed for only one domain multicasting. So GMIDR Protocol is used to transmit data to large group members between different domains.

A. OVERVIEW OF GMIDR

The general architecture of GMIDR is represented in the following Fig. 1. CHs are elected in each domain and multicast group cluster heads (GCHs) are elected in the multicast group. Each GCH finds routes to the source node. Then the source uses Reversed Path Forwarding (RPF) [6] technique to build multicast trees. Following the established multicast tree, multicast data packets can be delivered from the source to every GCH. Upon a GCH receiving the data packet, it distinguishes its children from members in the multicast group, and then forwards the packets to its children.
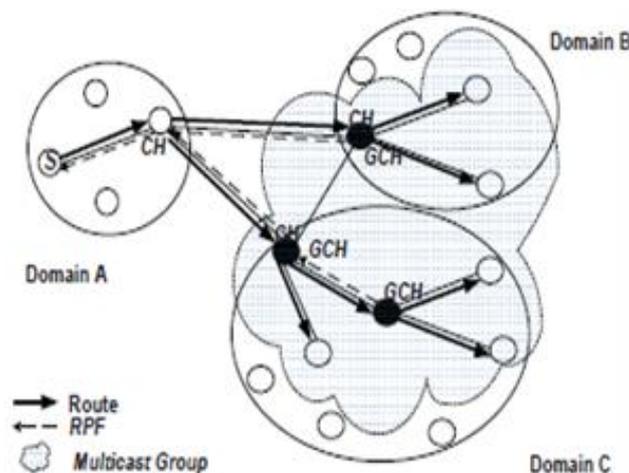

Fig. 1. Overview of GMIDR

B. MULTICAST GROUP CLUSTER HEAD (GCH)

We introduce the multicast group cluster head (GCH) to achieve the scalability of the multicast routing. As we have already indicated, multicast GCH is the node elected in the multicast group to assist the accomplishment of the multicast data delivery. It would be a great complicated multicast tree if the data packet were transmitted to every multicast group member directly. Instead, the multicast tree is built only between the source and GCHs. There are several GCHs chosen in the multicast session to cover the entire group. The most efficient GCHs are the dominating set of the multicast group. However, the construction of a dominating set is a complicated question and costs very much computation resources. By relaxing the selection condition, we propose a distributed GCH election algorithm.

IV. IMPLEMENTATION

GMIDR Protocol propose a Distributed Group Cluster Head (GCH) Election algorithm to choose multicast session to cover the entire group. The dominating set of efficient GCHs is constructed by using this algorithm. GCH play a vital role in Packet transmission in multicast group. Multicast groups are managed without explicit control messages.

A. DISTRIBUTED GROUP CLUSTER HEAD ELECTION ALGORITHM

The construction of a dominating set is a complicated question and costs very much computation resources. By relaxing the selection condition, we propose a distributed GCH election algorithm.

Our strategy of GCH election is described as following:

a. The first step is to find nodes with maximal number of neighbours in the multicast group.

b. If existing GCHs cannot cover the whole group, the protocol will continuously choose the GCH in the rest of the group until every node in the multicast group can be reached in one hop by some GCH.

c. Multicast group clusters may overlap each other during the election using this algorithm. To balance the work load of each GCH, it is better to make the overlapping nodes distribute evenly into clusters. Our scheme is to partition overlapping nodes based on parity of the node ID. Namely, if the overlapping node ID is odd, we consider it as a member of the old multicast group cluster. While if the overlapping node ID is even, we put it to the new multicast group cluster.

Algorithm:

GCH ID ← 1
while1 **do**
foreach node k in multicast group **do**
ifNode[k].numneighbor> Node[GCH ID] **then**
GCH ID ← k
end if
end for
ifGCH ID = −1 **then**
break
end if
foreach node i in multicast group **do**
ifi is the neighbor of GCH ID **then**
Node[i].GCH ← GCH ID
end if
end for
ifoverlap **then**
foreach node j in overlap **do**
ifNode[i].ID is even **then**
Node[j].GCH ← GCH ID
end if
end for
end if
end while

B. PACKET TRANSMISSION IN MULTICAST GROUP

If multicast group members did not undertake the mission of forwarding packets, every GCH can simply finish the last step by forwarding data packet to its members in its own cluster in Internet based network. However, the case in MANET is a little bit complicated. Every node in MANET can be taken as a router. Therefore, GCH has the duty to distinguish multicast group members who does not participate the packet forwarding and needs their GCHs send data to them. We call this kind of members as the children of the GCH. The challenge is how GCHs find out who are their children. Intuitively, multicast group members who do not participate in the multicast.

We use the multicast routing table to figure out these nodes. It is clear that if a node participates the routing for a specific source and multicast data packet, there will be one entry in the multicast routing table of that node. Therefore, the children are nodes that do not have an entry in their multicast routing table for them specific source node. Unfortunately, it is impossible that the GCH has all routing tables of its cluster member and only the node itself has its own routing table. Hence, the node needs to detect its own identity when they check their subjection relationship. Then, it send a message to the GCH to confirm its subjection and report its status.

C. MULTICAST GROUP MANAGEMENT

In GMIDR, there is no explicit control message for joining or leaving the multicast group [7]. If a multicast GCH is going to leave group, it simply stops sending the routing messages, thus the reversed path for the node cannot be established. Meanwhile, members of that GCH starts to switch to other GCHs or elect themselves as temporary GCHs if no GCHs in its range. If a child wants to leave the group, it stops sending subjection messages to its GCH to terminate its membership of the multicast group. If a group member node neither a GCH nor a child intends to leave the group, the

protocol changes its membership to a normal node. On the other hand, if a node wants to join the multicast group, it changes its membership to that multicast group and elect itself as a temporary GCH until a GCH re-election across the entire multicast group [8].

V.   PERFORMANCE EVALUATION

The GMIDR simulation can be implemented on the platform of Qualnet 3.9.5, or ns2. Simulation models can be run on the 1500m * 1500m network area. The PHY/MAC protocol is IEEE 802.11b, which has CSMA/CA with RTS/CTS. The channel capability is 2 Mbps and the radio propagation range of each node is 375 meters. Each simulation executes 900 seconds of simulation.

GMIDR Protocol is evaluated by following typical metrics:
1. **Packet delivery ratio:** The number of data packets delivered to multicast receivers over the number of data packets supposed to be delivered to multicast receivers. The range of the delivery ratio is from 0 to 1. The higher delivery ratio indicates the more efficient packets transmission.
2. **Control overhead:** The total bytes of control packets needed to accomplish the entire multicast routing procedure. In the design of routing protocols, we pursuit a lower control overhead.

To study the scalability and stability of GMIDR, the experiment results of comparison of variety number of multicast members and dynamic multicast group in subsection A. We compare our protocol with ODMRP in subsection B to exhibit the outstanding performance of GMIDR.

A. COMPARISON OF VARIETY NUMBER OF MULTICAST MEMBERS

We consider the multicast group as the receiver in our experiments. There are four different multicast group sizes are designed in experiments which are 5 nodes, 10 nodes, 15 nodes and 20 nodes respectively. There are 5 senders and 20% of nodes are CHs in this group of experiment scenarios.
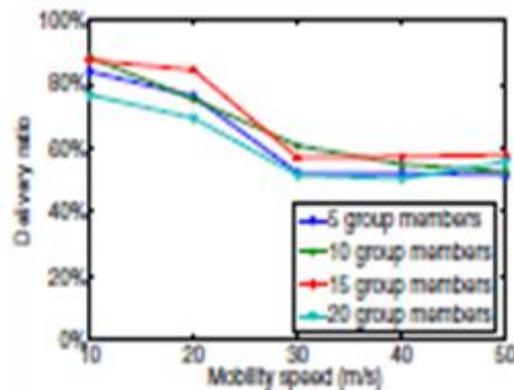

Fig. 2. Delivery ratio

The delivery ratio of different multicast groups as a function of mobility speed is shown in the above Fig. 2. The tendency of each curve decrease as the increasing of mobility speed. When nodes move faster, the radio links among nodes are frequently changed, which causes weaker node connectivity and thus reduces the packet delivery ratio. Additionally, as the change of multicast group size, the difference of delivery ratio is less than 10%, which shows the relative consistence. The multicast tree is built from source to GCH. Due to the distribution of nodes is even which means that no matter large or small group, almost the same number of GCH are elected in the group and thus will not affect the delivery ratio. Hence, the GMIDR protocol has stable delivery ratio in case of different multicast group sizes as a function of mobility speed.
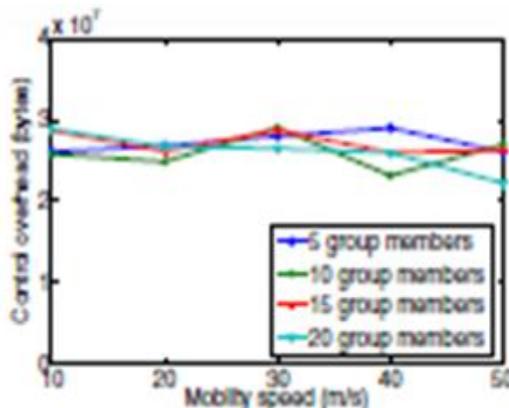

Fig. 3. Control Overhead

The above Fig. 3. represents the presentation of control overhead for different multicast groups as a function of mobility speed. From the perspective of single curve, the fluctuation of the curve is unobserving. This is because that each updates is driven by a event (e.g., forwarding packet, periodical updates), which are not affected by the mobility speed of nodes. These four curves show the consistence of control overhead for different scenarios. Different numbers of multicast group members have little impact on the control overhead. This consistence shows the advantage of GCH. It reduces the complexity to build the multicast tree and therefore the control overhead remains stable as the change of multicast group size.

B. COMPARISON OF DYNAMIC AND CONSTANT MULTICAST GROUP

In this group of experiments, we will show the results comparison between the dynamic multicast group and the network with constant multicast group members. There are two groups of simulation scenarios set up. One contains 10 constant multicast group members. The other one starts with 10 multicast group members, 5 new nodes join in and 5 nodes leave the group during the time of the simulation. 10% of nodes are CHs and there are 5 senders in the experiments.
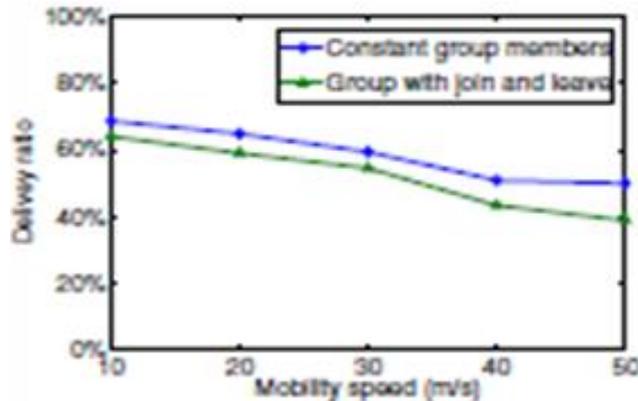

Fig. 4. Delivery ratio

The above Fig. 4 represents the comparison of delivery ratio between constant multicast group and dynamic multicast group as a function of mobility speed. The constant multicast group shows a little bit better performance than the dynamic multicast group in terms of delivery ratio. This is group dynamic change affects the construction of the multicast tree and some data packets may be lost in the process of the reestablishment of the multicast tree. However, we see that the difference of delivery ratio is subtle. The reestablishment of the multicast tree is completed with changing very limited numbers of branches. The pruning operation on the multicast tree only involves the GCH to add or remove nodes. Thus the multicast tree still keeps the stability.
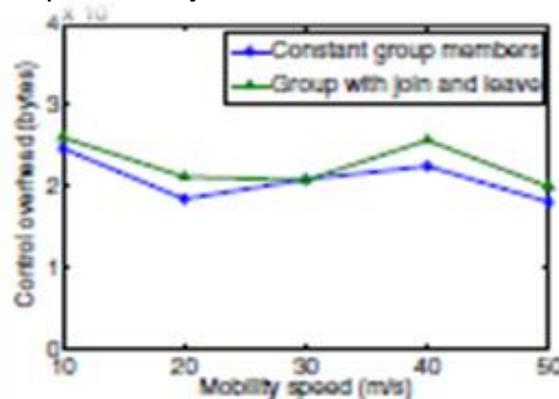

Fig. 5. Control Overhead

The comparison of control overhead as a function of mobility speed is illustrated in the above Fig. 5. The control overhead of constant multicast group is less than the control overhead of dynamic multicast group. The dynamic change of multicast group members will trigger multicast tree to be pruned, which costs more control messages than the constant group members. However, the difference of control overhead between constant group members and group members with join and leave is slight. In the section of multicast group management, both joining and leaving process do not need explicit messages and thus there is no distinguished difference on control overhead.

VI. CONCLUSION

The proposed GMIDR protocol provides a scalable multicast routing mechanism for mobile ad-hoc networks. We introduce multicast GCHs to manage the multicast group. To overcome the challenges caused by network mobility, the GMIDR protocol sends periodical beacons to guarantee the connectivity of the multicast routes. We also introduce

the GCH-reelection mechanism to ensure the efficiency of the GCHs and the stability of the multicast tree. In our protocol, joining and leaving multicast group have little impact on delivery ratio and control overhead. The experimental comparison results shows the scalability of the protocol with different number of multicast group members. We also compared GMIDR with other multiple protocol in the inter-domain mode. It shows GMIDR outperformed than ODMRP in terms of delivery ratio. In addition, by taking advantage of geo-routing protocol, the Geo-assisted Multicast Inter Domain Routing (GMIDR) protocol can be exploited to the Geocast.

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