Robust Overlay Multicast On-demand Protocol in Mobile Ad-hoc Network

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***Abstract*— Multicast is an efficient transport mechanism for group communications and to support a lot of applications that require mobile nodes work as a group several multicast mechanisms have been proposed. However, due to the mobility of nodes, many control messages are required for these protocols and then overlay data paths in overlay can remain static. In this paper, we propose a robust overlay multicast on-demand protocol (ROMOP) using unicast routing stream table. Therefore, multicast data packets between group members are delivered through the shortest paths in physical networks and the data path in ROMOP can be managed without periodic control messages in the dynamic situation. Simulation results show that our mechanisms reduce the control overhead and thus the overall latency compared to existing multicast protocols proposed for MANETs.**

Keywords-Overlay Multicast; Mobile Ad-hoc Network; Unicast routing; overlay data path

I. INTRODUCTION

Multicast is an efficient transport mechanism for group communications. Recently a lot of applications require that the mobile nodes work as a group. To support these applications, many issues have been researched for group communications in Mobile Ad hoc Network (MANET [1]). However, MANET is envisioned to have dynamic, sometimes rapidly changing, multi-hop topologies that are likely composed of relatively bandwidth constrained wireless links. Even whole networks of nodes may continuously move, or disappear. Due to these dynamic topology properties of MANET, many control messages are required for maintaining group statement. In overlay multicast, non-group members do not need to maintain group statement and only member nodes perform multicast operations. The overlay data path connection is established through a unicast tunnel between group nodes. As a result, overlay multicast has more stable protocol operation, robustness and low control overhead even in a highly dynamic environment unlike network multicast. Several overlay multicast routing approaches in MANET have been proposed [2][3][4]. PAST-DM [2] optimizes the cost of the tree and can use efficient resources based on a source based Steiner-Tree algorithm. Therefore it can easily respond to changes in network topology. Location guided tree (LGT) [3] builds an overlay multicast packet distribution tree on top of the unicast routing protocol using a geometric distance between group members. On-Demand Overlay Multicast Protocol (ODOMP) [4] is on-demand multicast protocol. It only creates an overlay topology using delayed forwarding when it is needed. However, data paths in the overlay multicast protocol can remain static despite changing the physical topology. In this paper, we propose a robust overlay multicast on-demand protocol (ROMOP) using unicast routing stream table. This protocol has the shortest data path and low control overhead using unicast routing table. First, the data path setting in ROMOP is based on the next node and number of hop. When the source chooses the next receiver nodes, multicast data packets between group members are delivered through the shortest paths. Also, the data path in ROMOP manages statement without periodic control messages in the dynamic environment. ROMOP contributes two problems of existing overlay multicast which are too many control messages and creation of the unnecessary data path. Therefore, ROMOP has the high packet delivery ratio, low end-to-end latency and low control overhead. The remainder of this paper is organized as follows. In Section 2, the proposed protocol is explained in detail. In section 3, simulations evaluation will be discussed. Finally, we draw conclusions in Section 4.

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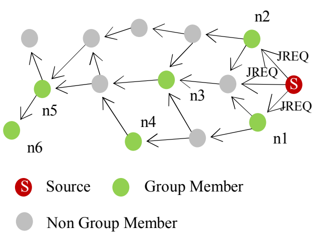
II. PROTOCOL DESCRIPTION

In this section, we describe the Robust Overlay Multicast On-demand Protocol (ROMOP).

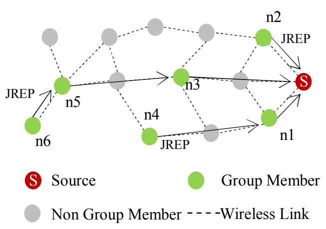


(a)

Node	Source Address	Source Distance	Upstream Node
n1	S	1	S
n2	S	1	S
n3	S	2	S
n4	S	3	n1
n5	S	4	n3
n6	S	5	n5

(b)

Figure 1. (a) Broadcasting the JREQ messages and (b) Upstream table of each group member node



(a)

Node	Downstream Node	Number of hop	Next Node
S	n1	1	n1
	n4	3	n1
	n2	1	n2
	n3	2	n3
	n5	4	n3
	n6	5	n3
n1	n4	2	n4
n3	n5	2	n5
	n6	3	n5
n5	n6	1	n6

(b)

Figure 2. (a) Sending the JREP messages and (b) Downstream table of each group member node

A. *Initial Path Setting*

In order to set an initial path for group communications, first, the multicast source broadcasts JOIN_REQUEST (JREQ) message to its neighbors. This JREQ message contains Source address, Source distance and the last address information. The Source distance is the number of group members which exists between the source and each group member. The last address contains the address of the last group member. If a node receiving JREQ message is non-group member, it rebroadcasts the JREQ message after increasing source distance by 1. However, if the node is a group member, it stores information of the JREQ message in an upstream table. The upstream table is consisted of Source address, Source distance and upstream node. Therefore, every group member node stores information in the upstream table. After storing the JREQ message, the group member modifies the JREQ message by increasing the Source distance by one and sets the address of itself to the last address. And the group member rebroadcasts the modified JREQ message. Fig. 1(b) shows the upstream table of each group member node after receiving the JREQ message. If the group member receives the several JREQ messages, it chooses the JREQ message with the lowest Source distance value. After all group members construct the upstream table, the group members send a JOIN_REPLY (JREP) to its upstream node by unicast routing protocol. Fig. 2(a) shows sending the JREP messages to the multicast source. The JREP message contains Sender address, Hop distance, the last member address. The Sender Address is set to the address of the group member which sends the first JREP message. The hop distance denotes the number of hop from a sender to the upstream node of the sender. And the last member address contains the address of the last group member which sends this JREP message. When the upstream node receives the JREP message, it stores information of the JREP message in a downstream table. The downstream table is consisted of downstream node, number of hop and next node. The downstream node stores the address of the member node from which the JREP message was received. The number of hop is a value which adds the hop distance to hop distance of the last member address in unicast routing table of the upstream node. The next node is a next node of the last member address in unicast routing table of the upstream node. After storing JREP message in the downstream table, the upstream node sends the modified JREP message to the high upstream node. The hop distance adds current hop distance value to number of hop of Sender address and the last member address is changed. This process stops when the source receives the JREP message.

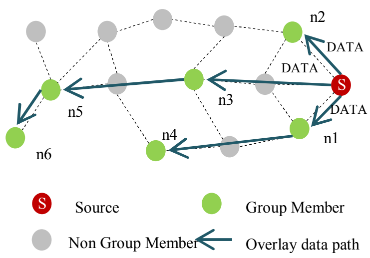


Figure 3. Overlay data paths among group members

B. *Data transmission*

Fig 3 shows an overlay data paths among group members. To send a data packet first, the source node S assorts the list of downstream table according to the same next node. Secondly, the sender selects group members which have the shortest number of hop among the assorted next nodes in the list. For example, node n1, n2 and n3 are selected because they are the shortest number of hop in each assorted list. Finally, the original data packet is replicated into three packets and then forwarded via unicast tunnel to node n1, n2 and n3. After receiving the data packet, node n1, n2 and n3 each repeats the packet forwarding to other down destination. This process stops when the downstream table of group member has an empty.

C. *Path Recovery*

When connections between group members are changed due to mobility of nodes, the group members can easily detect this by looking at its unicast routing table. The group member initiates the data path reconstruction process when the connection to its upstream node and downstream node changed. If there is the new data path which is better than the previous one, the group members sets the new data path. And the previous data path is deleted. For example, when the unicast routing table about the n5 in upstream table of node n6 was changed due to movement of node n6, node n6 first sends a GROUP_REQ (GREQ) message to all its neighbor group members using the expanding ring search mechanism. If neighbor group members receive the GREQ message of node n6, there reply to node n6 with a GROUP_REP (GREP) message. This GREP message contains the address of neighbor group member and the source distance value. If node n6 receives the GREP messages from node n2 and n3, it selects a new upstream node by the source distance value in the GREP messages. The neighbor group member which has the smallest source distance value is selected as new upstream node. Node n6 sends a GROUP_CONFIRM (GCON) message to node n2 as new upstream node. Node n6, before replying with the GCON message updates information about node n2 to the upstream table. Node n2 receives the GCON message and adds information of node 6 in the downstream table. After the new data path construction process is end, the previous data path is deleted.

III. Performance Evaluation

In this section, we evaluate a performance of ROMOP. For comparing performances our proposed algorithm, we implement and compare ODMRP, LGT and PAST-DM which is existing representative multicast protocol in MANET.

A. Simulation Model

Our simulation modeled a network of 200 mobile nodes placed randomly within a 2000m * 2000m space. Each node has a radio transmission range of 300m and channel capacity of 2Mbps. The mobility model follows a random waypoint model with speed extent of 0 m/s to 20 m/s and pause time of 5 seconds to create a moderately dynamic network. A simulation time is 500 seconds and a group size is 30 group members which are fixed. Traffic is generated as a constant bit rate of 5 packets per second. MAC protocol is 802.11 DCF and AODV protocol is used as unicast routing protocol. The following metric are used for comparing protocol performances.

- Packet Delivery Ratio: The ratio of the number of multicast data packets received by all multicast receivers and the number of multicast data packets which should be received by all multicast receivers. This metric reflects the effectiveness of a multicast protocol.
- Average End-to-End Latency: Defined as the average delay of transmitted packets form the source node to each destination.
- Forwarding Efficiency: The ratio of the number of transmitted multicast data packets and the number of multicast data packets delivered to the application. This metric reflects the efficiency of the created multicast delivery structure, the lower the value the higher the efficiency.
- Control Overhead: The ratio of the number of control packets transmitted and the number of delivered multicast data packets.

B. Simulation Results

Fig 4 shows a result of variable evaluation factors under the node mobility. The result in each group shows an average value after 500 simulation seconds.

To evaluate the effects of performance of the various protocols, we varied the mobility speed from 0 m/s to 20 m/s. As shown in Fig 4(a), the fixed group size in the simulations is 30. The packet delivery ratio of ODMRP is the highest. Multicast packets in ODMRP are delivered through the multiple paths, because ODMRP is the mesh-based protocol. ROMOP has better performance of the packet delivery ratio than LGT and PAST-DM. ODMRP has lower latency than the other protocols because ODMRP always tries to include the shortest path within the forwarding group. The latency of ROMOP and PAST-DM are a little bit higher than that of ODMRP. Since LGT periodically exchanges the location information, the average end-to-end latency rapidly increases with increasing mobility speed. Fig 4(c) show the forwarding efficiency with increasing mobility speed.

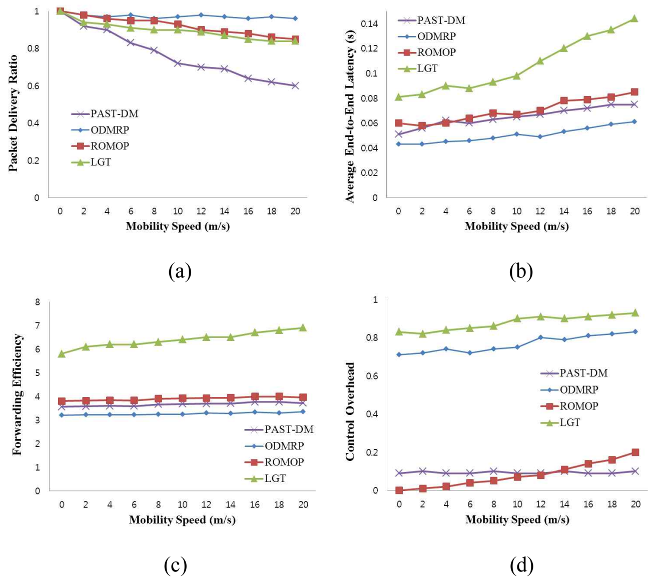


Figure 4. Performance versus mobility (Group size is 30)

It shows similar result with the average end-to-end latency. The control overhead of ODMRP and LGT is very independent of the mobility, because it does not reflect the link break. It recreates the delivery path periodically. The other hand, when unicast routing table of group member in ROMOP is changed, the data path is recreated by transmitting control messages to neighbor group members. Therefore it shows low control overhead.

IV. Conclusions

We proposed a robust overlay multicast on-demand protocol for MANET. ROMOP has shortest overlay data path and low control overhead by using streaming routing table information. Therefore, multicast data packets between group members are transmitted more quickly and efficiently than the existing overlay multicast protocols. Also, the overlay data path in ROMOP is managed without periodic control messages in the dynamic environment. When the group member moves, overlay data path is reconstructed by updated stream routing table. Therefore, ROMOP has low control overhead because periodic control messages do not need. Simulation results show that ROMOP achieves the overall high performance compared to existing overlay multicast protocols in terms of packet delivery ratio, average end-to-end latency, Forwarding efficiency and control overhead.

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