A Novel Ring-based Multicast Framework for Wireless Mobile Ad hoc Network

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Abstract

Multicasting is an efficient means of one to many (or many to many) communications. Due to the frequent and unpredictable topology changes, multicast still remains as challenge and no one-size-fits-all protocol could serve all kinds of needs in ad hoc network. Protocols and approaches currently proposed on this issue could be classified mainly into four categories, tree-based, meshed-based, statelessness and hybrid. In this article, we borrow the concept of Eulerian ring in graph theory and propose a novel ring-based multicast framework--Hierarchical Eulerian Ring-Oriented Multicast Architecture (HEROMA) over wireless mobile Ad hoc network. It is familiar with hybrid protocol based on mesh and tree who concentrates on efficiency and robustness simultaneously. Architecture and recovery algorithm of HEROMA are investigated in details. Simulation result is also presented, which show different level of improvements on end-to-end delay in scenario of small scale.

Keywords: Multicast, Ring-based, Ad hoc network.

I. Introduction

Multicasting is an efficient means of one to many (or many to many) communications. Due to the frequent and unpredictable topology changes, multicast still remains as challenge and no one-size-fits-all protocol could serve all kinds of needs in ad hoc network. Many efforts are being made to provide efficient multicast protocol over mobile ad hoc network. For simplicity, four categories could be classified as, tree-based, meshed-based, statelessness and hybrid multicast protocol [1]. Due to the complexity of ad hoc network, GPS-based or zone-based approaches are also proposed recently to deal with network of large scale, among which are VGA [3][4] and MZR [5]. In [2] a hybrid multicast routing scheme based on Eulerian ring was proposed and it tries to address efficiency and robustness simultaneously.

In this paper, some improvements on recovery algorithm for [2] have been proposed to improve performance.

The rest of this article is organized as follows. In section 2, Architecture of HEROMA and Multicast Agent (MA) are reviewed. In section 3, improvements on recovery algorithm are proposed in detail. In section 4, we present the performance simulation by comparing with AMRIS [6] and CAMP [7]. Our conclusion and future work are presented in section 5.

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2. Architecture of HEROMA

The Hierarchical Eulerian Ring-Oriented Multicast Architecture (HEROMA) contains three main features, hierarchy, Eulerian ring and multicast agent. The reason we prefer hierarchy and Eulerian ring topology have already been discussed by detail in [2]. Terminology to be discussed herein should also be correlated with [2].

2.1 Review of Eulerian ring

In graphs theory, if there is a closed trail that includes every edge one and only, such a trail is called a Eulerian trail. If it forms a ring, it is called a Eulerian ring. After searching algorithms in [2], a topology of Eulerian rings and branches could be obtained. An example is shown in Fig 1.

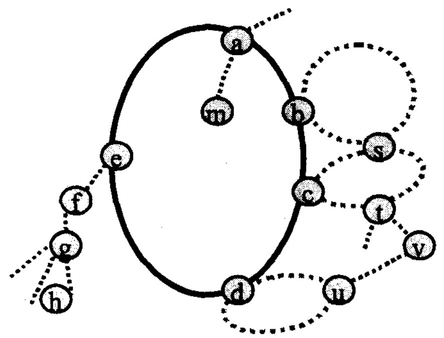

Fig. 1. Eulerian ring topology

Among these rings one will get multicast packets earlier than others and it is defined as main ring; others that may receive multicast packets later are named as sub-rings, thus hierarchy is formed.

2.2 Review of Multicast Agent (MA)

Each master and diverge node would maintain a Multicast Agent (MA). MA has two important elements: status table (ST) and token demon. For a master, ST keeps the information of its member nodes including diverge nodes; Token demon manages token that flows along the ring. Ordinary nodes will also have simple MA.

3. Improvements On Recovery Algorithm

In HEROMA, adding or pruning a node will not affect the multicast service because the ring topology is fault-tolerance for single node failure or single link breakage. But it does destroy integrality and might fragment Eulerian ring into pieces. Therefore improvements on recovery algorithm are proposed herein.

After locating the position of failure, we define nearest-neighbors in the ring who locate nearest to failure, say node B and D (refer to Fig.1). We also define nearer-neighbors, say node A and E. The key idea of recovery algorithm is to search a bridge to recovery the ring.

```
Node B and D flood recovery-REQ message and
start the timer
If (time-out expired and bridge not found)
   { Report recovery-fail to master;
    The master ask node A and E repeat
    Recovery algorithm;
      B and D degraded as leaf node;}
If (time-out not expired, bridge not found)
    {Continue flood recovery-REQ;
     At each node hop-counter++;
    Hop-Counter's value is contained by
    recovery-REQ transmitted along flood
    path;}
If (time-out not expired and bridge found)
    {if (number of bridges>=2)
       {Select one as bridge if it has a min
       value of counter1+counter2}
     else{
Case1 (it is not a member of any ring)
    {Send back recovery-ACK along the
    coming path to B, D;
    B, D relay this report to master;
    Master re-computers routing and inform
    each node belongs to the new main-ring;}
    break;
Case2 (it is a member of sub-ring)
    {honor it a member of main-ring, do
    case1;
    It will still play the original role in
    the sub-ring;}
     break;
Case3 (it belongs to a trail but not a leaf)
    {honor it a member of main-ring, do
    case1;
    It turns into the master of its
    trail;}
     break;
Case4 (it is a leaf node of trail)
    {honor it a member of main-ring, do
    case1;
    it will still play the original role in
    the trail;}
     break;
          }

    }
```

Analysis: we must recovery the ring as fast as we could after the breakage occurs. The recovery algorithm must find the bridge quickly to ensure ring's integrality.

In case of new join-request, any multicast receiver nearby could reply such requests and forward multicast packets.

4. Performance Simulation

This section presents the simulation utilizing OPNET Modeler v8.0. The performance is evaluated in terms of traffic sink end-to-end delay by comparing with Ad hoc Multicast Routing Protocol (AMRIS) [6] and Core-Assisted Mesh Protocol (CAMP) [7]. In this simulation (Fig.2) Y-axis stands for time and its unit is second and it shows that our proposal outperforms AMRIS and CAMP in fields of traffic sink end-to-end delay.

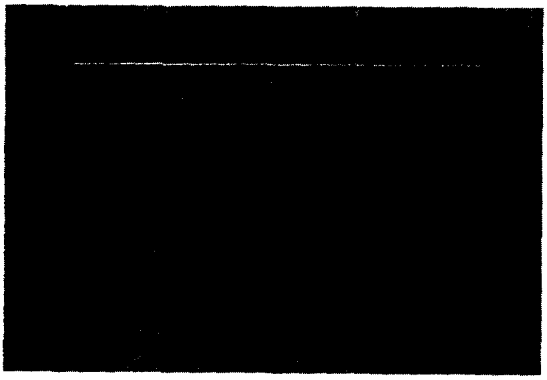

Fig. 2. Traffic Sink End-to-End Delay

There are two possible reasons. One reason is that control traffics are restricted locally in our scheme; the other reason lies in that multicast receivers save much time by registering to a near master rather than remote multicast source.

It should be noted that the aforementioned result was arrived at a small multicast population, 16 mobile hosts at last participate multicast group in this scenario, the HEROMA employs only 2-level hierarchy and the Eulerian ring-searching algorithm is started by multicast source. If the multicast group size increases, the hierarchical level will increase, algorithm in a distributed fashion will be better. Since a big Eulerian ring could be divided into smaller Eulerian rings, our further investigation will focus on how to execute searching algorithm in a distributed manner for large multicast group size.

5. Conclusion

In this paper, an improvement on recovery algorithm for HEROMA is proposed. Graph-oriented multicast architecture and improvements on recovery algorithm are discussed. Simulation shows our multicast routing scheme outperforms than AMRIS and CAMP in terms of sink traffic end-to-end delay. We believe the scheme is promising for signaling cost and end-to-end delay. In the future our work will focus on optimizing algorithms and other simulations.

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