Application Layer Multicast with Proactive Route Maintenance over Redundant Overlay Trees

Yohei Kunichika, Jiro Katto and Sakae Okubo

Department of Computer Science, Waseda University

1 Introduction

Application layer multicast (ALM) or overlay multicast emerges as an alternative to the IP multicasting which has not yet widely spread. It enables packet multicasting delivery in an application layer without changing any network infrastructure of the current Internet. However, previous ALMs had an unavoidable disadvantage that end hosts have to reconstruct the overlay network after a node leaves the sessions or fails. Most researchers had focused on reactive approaches, in which restoration of the tree starts after node departures.

Recently, some researchers proposed proactive approaches that reduced interruption periods caused by node leaving and node failures [3][4]. This paper proposes an extended proactive route maintenance that avoids the degree limitation problem by forcing each node to prepare a redundant route for backup. Computer simulations are carried out and effectiveness of the proposed approach is verified.

2 Previous Work

One of the unavoidable problems of the ALM is that end hosts have to reconstruct the overlay network after a node leaves the multicast session or fails. Although quite a lot of routing protocols are proposed, most researchers focused on reactive restoration of a delivery tree. An example of reactive approach is [1]. That is, end hosts start to search for its new parent after its old parent node departures. When the parent node leaves, the main task is to find a new parent for each affected child as quickly as possible. However, especially in the node failure phase, it takes longer time because each affected node searches for its new parent by contacting to the rooted node in the tree, that might be quite far from the affected node.

On the other hand, end hosts maintenance backup routes in proactive approaches. Yang's approach called in this paper is one of the proactive approaches [3]. In this approach, backup routes are calculated proactively whenever a node leaves or joins. When a node leaves, a backup route previously calculated is immediately applied and next backup routes are updated. When a new node joins, next backup routes are calculated without activating the previous backup route. Calculation of the backup routes is lead by two nodes; the parent node and the grandparent node of the leaving/joining node. A problem of this approach is that, when a node cannot form a backup route due to degree constraints of its children nodes, it employs grandchildren and below until a node without the degree constraint will be found. Another problem is that two nodes have to be involved in the backup route calculation whenever leave/join events happen.

3 Proactive Root Maintenance over Redundant Tree

We therefore propose a new proactive approach in order to solve the problems of Yang's approach. It is most important that we construct an overlay tree without each host maximizing its out-degree. Total out-degree may be calculated by the bandwidth of the connection of an end host divided by the media playback rate. If an end host has total out-degree = n, it can have n children.

However, in our scheme, we force an end host with total out-degree = n to have n-1 children only. This limitation simplifies backup route calculation, in which parent finding operation is completed at the children layer, and contributes to overhead reduction.

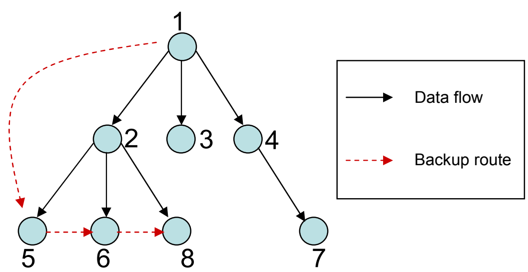

Fig.1. An example of backup route selection

Next, backup route calculation is carried out by the parent node as follows. In Fig.1, it is assumed that each node's out degree is four and node 8 tries to join a tree. When node 8 connects to node 2, node 2 checks its children list. Since node 2 has three children, when node 2 leaves, node 1 cannot accommodate all the children of node 2 due to its degree constraint. Therefore, node 2 sends the children list to node 1. Node 1 then measures a round trip time to each grandchild, and informs the fastest node that node 1 will be its backup parent.

Node 1 also informs the other nodes that faster nodes will be their backup parents. In Fig.1, node 8 is the fastest, node 5 is the second and node 6 is the last. Therefore, node 8 chooses its grandparent, node 1, node 5 chooses node 8, and node 6 chooses node 5, respectively, as their backup parents. This backup route calculation is also carried out whenever the node leaving/failure event happens similar to the node participation case.

4 Performance Evaluation

We carry out computer simulations using ns-2 simulator [2]. We compare our scheme with the effective reactive scheme, called grandfather policy in [1]. We also compare our scheme with Yang's approach.

Our simulation topology has 24 routers, in which four of them are domain-to-domain routers. End hosts randomly connect to one of the 20 routers except the four inter domain routers. The number of hosts varies from 50 to 400. The out-degree of each host is fixed at 4. The overlay tree is constructed at once after each experiment starts. Then end-hosts randomly join and leave the tree every 10 seconds.

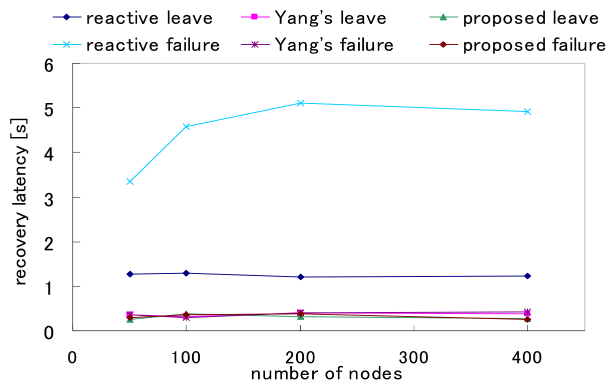

Fig.2. Comparison of recovery latencies when node leave or failure happens

Fig. 2 compares recovery latencies. Recovery latency is the time after an affected node of a leaving node connects to a new parent and receives data packets from the parent. From this figure, we can recognize that the average recovery time of the reactive method is twice or more higher than that of the proactive methods when a node leaves, and 10 times higher when a node fails. This is because the proactive methods enable the affected nodes to connect to their backup parents immediately without any negotiation steps.

Fig.3 compares total number of control packets. Control packets represent all signaling packets except data packets and heartbeat messages. From this figure, we can recognize that Yang's approach generates higher control packets than others. There are two activating nodes and possible iterative searches for finding backup routes. As a result, the quantity of control packets for backup routes is quite large in Yang's approach. Note that our scheme activates a single parent node only due to the route redundancy. This contributes to drastic reduction of control packets for backup routes as shown in the figure.

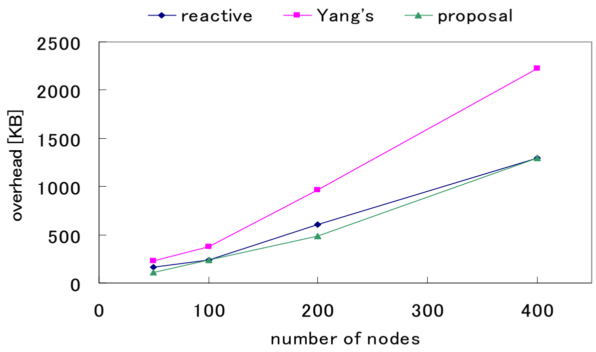

Fig.3 comparison of control overhead

5 Conclusion

This paper proposed proactive backup route maintenance over redundant overlay trees in order to enable smooth tree recovery and to reduce control overheads. Computer simulations were carried out, and it was verified that the recovery latencies were drastically reduced while the overhead of control packets was almost the same as that of the reactive approach. As future work, implementation of the proposed ALM system has to be evaluated over the actual Internet.

Acknowledgments

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Reference

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