A Scalable routing scheme for the Overlay Multicast Approach

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Abstract. To provide Multimedia broadcasting services on the Internet or wireless network requires more system resources and network bandwidth. We propose a routing algorithm for the overlay multicast that can efficiently exploit the system resources and network bandwidth. Our proposed algorithm uses minimum traffic overhead to get the routing information, and it is simplifies calculating the optimal route.

Keywords: Multimedia Service, Overlay Multicast, Routing Protocol.

1 Introduction

There have been several studies for providing Multimedia service through the Internet and wireless Network. IP multicast has been proposed to support the exchange of efficient inter-group data over the Internet [1, 2]. The overlay multicast has been introduced for IP multicast, but it still has some drawbacks when deployed over the Internet [3, 4]. In this paper, we propose a scalable routing scheme that is suitable for providing multimedia services over the Internet and wireless network. In our proposed scheme, each host that participates in data relay uses a shared buffer for supporting overlay multicast. Our proposed scheme also builds up a data delivery tree based on the bandwidth and the delay parameters for addressing the network bottleneck problem at the multimedia server.

2 Routing algorithms for Multicast

To find a suitable path, it is required to have the status information among a group of nodes. In the graph theory, finding a suitable path is finding a good tree for routing from a graph. SPT(Shortest Path Tree) routing algorithms find the shortest paths from a source to the destinations from a graph. Thus, they are suitable for situations when a single source generates most of the packets and the other nodes in a group receive these packets. MST(Minimum Spanning Tree) routing algorithms find a tree from a graph with the minimum cost. Thus, MST routing algorithms are suitable when all the nodes in are group generating packets[5, 6].
3 Overlay multicast for the Multimedia Services

For providing overlay multicast for a Multimedia service, SPT routing algorithms can be used for building up the overlay multicast tree.

3.1 Using SPT Routing (SPT)

The SPT algorithm exploits to prepare the shortest routing path for overlay multicast. The source node, which is a rendezvous point, sends a response message that contains the list of nodes in the current tree. To build $G_n$, it is a requirement to gather the delay information between new node $V_n$ and all other nodes in set $V_{n-1}$.

This first step for building an SPT tree will take which is the sum of the round trip delay. We assume that the delay between the nodes is not affected by a direction such as $d(i, j) = d(j, i)$. Among Source node and Client, $2(n-1)$ packets are required to determine the delay between the nodes based on the round trip delay. A new routing tree $T_n$ is built by applying Dijkstra’s algorithm on $G_n$. The second step will take time that has a time complexity of $O(n^2)$ or $O(n + n \log(n))$ based on the data structure. Thus, the time delay $D_{SPT,n}$ for building multicast tree $T_n$ is

$$D_{SPT,n} = 3d(s,n) + \sum_{i=1}^{n-1} 2d(i,n) + D_{2SPT,n} + \sum_{i=1}^{n-1} d(s,i),$$

(1)

The number of control packets $N_{SPT,n}$, which is required for routing in all multicast nodes, is

$$N_{SPT,n} = N_{2SPT,n} + N_{3SPT,n} = 3n + 1,$$

(2)

3.2 The Shortest path detection with Current Tree (SCT)

Since using SPT generates a new shortest path for the joining operation, the structure of the current tree can be changed by the previous tree in the middle of data delivery. If the routing tree is changed in the middle of delivery, then it will be very difficult to prevent packet loss. Thus, we need to provide a mechanism to recover the lost packets, which is a complicated procedure and it requires several retransmissions. The SCT algorithm does not change tree $T_{n-1}$ to build new tree $T_n$. It finds a parent node from tree $T_{n-1}$ and adds the new node. The new node will be attached to a parent node, which offers the shortest path from tree $T_{n-1}$.

4 Designing a Scalable scheme to build a multicast routing tree

Our goal is to offer a design that will further reduce delay, and will generate less control packets for building a multicast tree. We named this new method the shortest path detection by ACK Flooding (SAF) algorithm. When a new node tries to join the group, it sends a join request packet to a source node of tree $T_{n-1}$. The source node adds ACK information in the departing video packet, which will be delivered through multicast tree $T_{n-1}$. Thus, the ACK will be delivered to all nodes in tree $T_{n-1}$ without generating new control packets. When each node in the tree receives the video packet
with the ACK information, it creates a response packet and sends the response packet to the new node. The new node will receive these response packets from all nodes in tree $T_{n-1}$. The response packet that takes the shortest path arrives first at the destination. The node that sends the first response packet, becomes the parent node of the new node. The advantage of using the SAF algorithm is that the new node discards all other response packets that are received later, and it is not required to calculate the shortest path.

Thus, time delay $D_{SAF,n}$ for building the multicast tree $T_n$ is

$$D_{SAF,n} = D_{1SAF,n} + D_{2SAF,n} = 2d(s,n) + \min_{i=1,n-1}(d(s,i) + d(i,n)) + d(i,n),$$  (3)

The number of control packets $N_{saf,n}$ to prepare routing in all multicast nodes is

$$N_{SAF,n} = n + 3,$$  (4)

5 Performance evaluation of algorithms

We can generate network topologies with using random distance values between nodes, but the performance evaluation is very difficult and time consuming when the number of nodes increases. Thus we assume several factors to simplify the process of comparing three algorithms. First, we assume that the average delay between the nodes is $d$, which is used for all values of $i$ and $j$ such as $d(i,j)=d$. Time delays that occur by preparing all multicast nodes’ routing can be simply approximated as

$$D_{SPT,n} \cong (3n + 1)d + D_{2SPT,n}$$

$$D_{SCT,n} \cong (2n + 3)d + D_{2SCT,n}$$

$$D_{SAF,n} \cong 5d$$  (5)

The time complexity to find the shortest path is $O(n^2)$ for $D_{s,n}$, and it is $O(n)$ for $SD_{s,n}$. We assume single operation $O(1)$ is $d/\alpha$ and $\alpha >> 10$. Then,

$$D_{SPT,n} \cong (3n + 1)d + n^2 d/ \alpha$$

$$D_{SCT,n} \cong (2n + 3)d + nd/ \alpha$$

$$D_{SAF,n} \cong 5d$$  (6)

Fig. 1 show the time delays from preparing routing in all multicast nodes when the number of nodes grows from 10 to 1000. The value of $\alpha$ changes from 10 to 1000. The delay quickly grows as the number of nodes increases by applying the SPT scheme or the SCT scheme. However, when the SAF scheme is applied, the delay is very short and it doesn’t proportionally increase to the number of nodes.
6 Conclusion

We proposed an SAF scheme which can be used to build an overlay multicast routing tree for the Multimedia services. Our scheme provides seamless Multimedia services without advance knowledge of the number of clients and their locations. Performance evaluation shows that our proposed scheme provides better performance than the existing schemes in terms of time delays when preparing routing in all multicast nodes and the total network traffic.

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