# 멀티캐스트 라우팅 트리의 비교

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# Comparison of Multicast Routing Trees

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요 약

일반적인 멀티캐스트 라우팅 트리 구성 방식들은 크게 3가지로 분류된다. 즉, 소스기반 트리, 집중화된 공유 트리와 집중화되지 않은 공유 트리 방식이다. 이 논문에서는 이런 멀티캐스트 트리들의 링크 비용과 트리상의 최대 딜레이를 비교하고 평가하고자 한다.

ABSTRACT

The multicast routing trees that have recently been proposed can be classified into three types: source-based trees, center-based shared trees and non-center based shared trees. In this paper, those multicast trees are compared and evaluated in term of the link costs and the maximum delay on the tree by experiments.

## I. Introduction

Recent studies related to IP multicast routing trees can be categorized into three approaches; source based tree (SBT), center based shared tree and non-center based shared tree.

SBT is composed of the shortest paths from a source to all receivers. Thus a different tree is built and managed for each source. The SBT is currently employed by the Distance Vector Multicast Routing Protocol (DVMRP) [14], the Protocol Independent Multicast-Dense Mode (PIM-DM) protocol [5] and the Multicast extension to OSPF (MOSPF) protocol [11]. It is known that SBT is not scalable since a routing entry is required per source per group [10].

In contrast, center based shared tree is a single delivery tree that is shared by all users of a group. In this tree, a single router acts as 'center' of a multicast tree for a group. Such a center router is called the "core" in Core Based Tree (CBT) protocol [1, 2] or the "rendezvous point" in the Protocol Independent Multicast-Sparse Mode (PIM-SM) [6]. This center-based shared tree can also be found in the Simple Multicast Protocol (SMP) [12] and Border Gateway Multicast Protocol (BGMP) [9, 13].

In non-center based trees, any center node is not used. Instead, each incoming user may be connected to a different node among the existing tree nodes such that the tree link costs or the maximum delay on the resulting tree is minimized. These trees can be found in the Quality of Service sensitive Multicast Internet protoCol (QoSMIC) [7] and the Non-Core Based Share Tree (NCBST) [8] approach. The QoSMIC constructs a tree such that the tree link costs on the tree are minimized [3]. Each incoming user is connected to the closest branch of the existing tree. Thus QoSMIC leads to lower tree costs than center-based trees. In NCBST approach, on the other hand, each incoming user is connected to the existing tree such that the maximum delay as well as tree link costs are jointly minimized.

In this paper, those multicast routing trees are compared and evaluated in the viewpoint of the optimization of tree link costs and maximum delay on the tree.

## II. Comparison by Experiments

To evaluate the performance of these multicast routing trees, we employ a real network topology [4], which is the map of the major MBONE routers. We eliminate routers with only one incident link, since such routers do not affect routing. The final graph has 32 routers, 80 links, and average degree of 2.5. In test networks, we assume that group users randomly arrive at the network. The link cost is randomly assigned as an integer number ranged from 1 to 10. In particular, in the implementations of CBT algorithms, a center node is randomly selected in the network. To compare the performance of test multicast trees, we measured the following two metrics; tree cost and maximum end-to-end delay. Tree cost represents the sum of link costs on the tree, and the maximum end-to-end delay represents the maximum length of the end-to-end routing paths on the tree for all pairs of two nodes. We run every experiment 100 times, and the results are averaged. In our experiments, it is not easy to reasonably define the worst-case result for the performance metrics employed. Thus we present only average results.

Figure 1 and 2 illustrate the performance of shared trees. In Figure 1, QoSMIC and NCBST give better performance than CBT in terms of tree cost. Both QoSMIC and NCBST provide nearly the same performance. In the figure, it is also shown that the gap between CBT and NCBST gets larger, as the number of users increases. Figure 2 shows the maximum delay of shared trees. From the figure, it is clear that QoSMIC gives the worst performance, and both CBT and NCBST provide nearly the same performance. Thus it seems that NCBST produces more cost-effective trees than QoSMIC and CBT.

## III. Conclusion

In this paper, the multicast routing trees that have beer. proposed so far are compared and evaluated by experimental simulations. From the experimental results, it is shown that the source-based trees give better performance than shared trees in terms of the maximum delay, while shared trees are more efficient in terms of tree costs. In the shared trees, non-center based trees are better than center-based trees in terms of tree link costs, while those two approaches provide nearly the same performance in terms of maximum delay. It is known that non-center based tree requires more computational overhead than center-based tree. However, non-center based tree seems to provide a significant gain in terms of tree resource utilization, compared to center-based tree.

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Figure 1 Tree Cost of Shared Trees

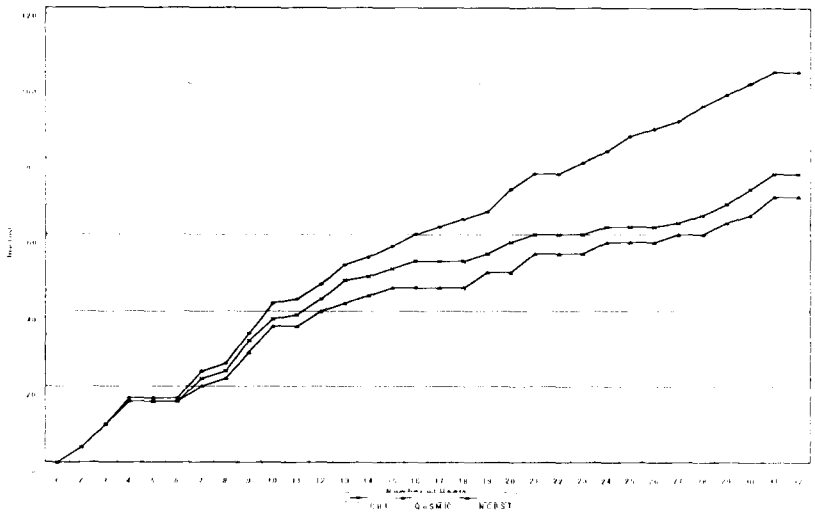

Figure 2 Maximum Delay of Shared Trees