Source Limited Inclusive Routing: A New Paradigm for Multicast Communication

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Abstract

In this paper, we study a combination of the multicast communication problem and the maximum disjoint paths problem. Specifically, we are given a directed tree T rooted at r, and we want to send a message from r to a subset of nodes in T. We accomplish this via a *multicast schedule* which consists of a number of time steps in which informed nodes deliver the message to uninformed nodes until all destinations have received the message. In each time step, any informed node s may forward the message to one of its uninformed descendant nodes d via the unique directed path, or dipath, p from s to d in ditree T. A multicast schedule is called *edge-disjoint* if the dipaths used in any time step do not share any edges. We call a multicast schedule a *node-disjoint* schedule if the dipaths used in any time step are node-disjoint.

We show that directed trees can be used to represent source limited inclusive routing, a realistic class of routing schemes used in popular direct network systems. We then show that node-disjoint multicast schedules in directed trees can be used to closely approximate optimal edge-disjoint multicast schedules. In addition, we show that node-disjoint multicast in directed trees can be reduced to an equivalent broadcast problem in directed trees. We describe an $O(n^2)$ greedy algorithm (GA) for performing node-disjoint broadcast in directed trees. The greatest advantages of the GA algorithm are its simplicity and its optimal performance in popular topologies such as meshes, tori, and hypercubes. We also describe an $O(n^3)$ algorithm that always produces minimum length node- disjoint broadcast schedules for directed tree topologies, which can be easily transformed into an algorithm that produces edge-disjoint multicast schedules that are no more than twice the length of an optimal edge-disjoint multicast schedule for an arbitrary topology.

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