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Chapter XIV

Multicast: Concept, Problems, Routing Protocols, Algorithms and QoS Extensions

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The advancement in optical fiber and switching technologies has resulted in new generation high-speed networks that can achieve speeds of up to a few gigabits per second. Also, the progress in audio, video and data storage technologies has given rise to new distributed real-time applications. These applications may involve multimedia, which require low end-to-end delay. The applications' requirements, such as the end-to-end delay, delay jitter, and loss rate, are expressed as QoS parameters that must be guaranteed. In addition, many of these new applications may involve multiple users, and hence the importance of multicast communication. In this chapter we discuss the basics of multicasting, its routing protocols and algorithms, along with different QoS-based multicast routing.

INTRODUCTION

Multimedia applications are becoming increasingly important as networks are now capable of carrying continuous media traffic, such as voice and video, to the end user. When there is a lot of information to transmit to a subset of hosts, multicast is the best possible way to facilitate it.

The simplest solution to the multicast problem is to replicate the sender's transmission and send a copy to each recipient. This method is referred to as the N-Unicast technique. The Internet, for example, uses this technique for sending a single electronic mail message to

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multiple recipients via the Simple Mail Transfer Protocol (SMTP). The telephone industry handles a very similar problem in conducting conference calls by having a dedicated conference bridge serve as centralized location where conference group members dial and interconnect. But as we will soon find out, this is not an efficient way of using network resources. In most of the multimedia applications, where only a subset of users are to be connected, we need multicast support for efficient resource utilization. For real-time applications, satisfying the Quality of Service (QoS) requirement is important. Without such a guarantee, a real-time application would be meaningless.

The objective of this chapter is to address multicasting and its applications, including IP and ATM multicast, and the related topics about routing problems. Later we will talk about the QoS requirement in multimedia communication and VoD.

BACKGROUND

What is Multicast?

Multicast consists of concurrently sending the same information to a group of destinations such that exactly one copy of the packet traverses each link in the delivery tree. There are numerous examples of multicast applications. Interactive multicast applications include video conferencing, computer-supported cooperative work, and virtual whiteboard applications. Other multicast applications such as remote education require a lesser amount of interaction. A third group of multicast applications are noninteractive, e.g., mailing lists and some real-time control applications.

In a true multicasting, the following method is used :

1. The least-cost path from the source to each network that includes members of the multicast group is determined. This results in a spanning tree of the required configuration. This is not a full spanning tree, but includes at least those networks containing group members.
2. The source transmits a single packet along the spanning tree.
3. The packet is replicated by routers only at branch points of the spanning tree.

Further detail can be found in Huitema (1999) and Stalling (1997).

Why Multicast?

To give the answer let us start with the problems of unicast and broadcast transmission necessary for some particular applications.

In Unicast, a separate copy of the data is sent from the source to each client that requests it. Networks also support broadcasting. In broadcast, a single copy of the data is sent to all clients on the network. When the same data needs to be sent to only a subset of the clients on the network, both of these methods waste network bandwidth. Unicast wastes bandwidth by sending multiple copies of the data. Broadcast wastes bandwidth by sending the data to the whole network, whether the data is wanted or not. Broadcast also needlessly slows the performance of client machines. Each client must process the broadcast data, whether the client is interested or not.

Multicast falls between these two extremes. It is useful for building distributed pseudo-real-time applications, such as videoconferencing and audioconferencing. However, its use is not restricted to these kinds of applications only. Any application that involves sending copies of data to multiple places can benefit. For instance, one could distribute