Current Multicast Technology

Gabor Hosszu
Budapest University of Technology and Economics, Hungary

INTRODUCTION

Multicast technology is one-to-many communication, oppositely from the usual one-to-one (unicast) communication, which provides an efficient solution to create multiparty collaborative software by delivering the data flows on an appropriate distribution tree. The root of the distribution tree is the sender and its leaves are the receivers. Many Internet applications, such as distributed simulation, remote education, and videoconference require the underlayer network to support multicast communication.

The main problem of the multicasting is, however, how to construct and maintain the path, called delivery or distribution tree. There are solutions in different levels of the protocol stack, including datalink-layer, network-layer, and application-layer. Only the second and the third level multicast have practical importance; therefore we focus on these in the following.

The network-layer multicast is based on the Internet protocol (IP), which is why this kind of multicasting is called IP multicast. This technology is bandwidth conserving and reduces traffic by simultaneously disseminating a single stream of information to potentially thousands of corporate recipients. Multicast packets are replicated in the network at the point where paths are multiplied by multicast routing protocols, resulting in the most efficient delivery of data to multiple receivers. The main advantage of the multicasting is the smaller bandwidth usage than a normal unicast-based transmission.

The application-layer multicast (ALM) uses a different approach. In this technology, the multiplying nodes are host and the transmission is based on unicast. However, even the application-layer multicast has serious advantages over the pure unicast transmission, since in case of the traditional unicast, the sender has to create as many parallel data streams as receivers joined to the session. However, in case of ALM the sender has to serve a limited number of data streams, since the other group members as nodes also act as multiplication points. In such a way, they create a distribution tree.

BACKGROUND

The traditional unicast require the source to send more than one copy of the data, since there are point-to-point connections between the sender and each of the receivers. Even low-bandwidth applications can benefit from using multicast when there are thousands of receivers. High-bandwidth applications, such as video streaming, may require a large portion of the available network bandwidth for a single stream. In these applications, multicast is the only way to send to more than one receiver simultaneously.

The current Internet applications manage a large and widely distributed set of users, have multiple data streams that vary in content and media type, and make use of multiple unicast and multicast streams in a single session. Examples of these distributed, interactive applications include corporate communications, distance learning, video conferencing, stock quotes, software distribution, network news, collaborative visualization, distributed interactive simulations, and multiplayer games.

Table 1. The IP address ranges

Name	Purpose	Address Range
Class A	Unicast addresses for large networks	1.0.0.0 - 127.255.255.255
Class B	Unicast addresses for medium networks	128.0.0.0 - 191.255.255.255
Class C	Unicast addresses for small networks	192.0.0.0 - 223.255.255.255
Class D	Multicast addresses	224.0.0.0 - 239.255.255.255
Class E	Reserved	240.0.0.0 - 255.255.255.254

THE IP MULTICAST APPROACH

Special IP-addresses are used in the IP-multicast, which do not belong to certain hosts, but define multicast channels. Table 1 presents the address ranges of the IP address space. The Class A, B and C are used for the traditional unicast communication; the Class D addresses are applicable for multicasting.

The first model of the IP-multicasting was proposed by Steve Deering in 1988 in his PhD dissertation, and its first standard was published in the RFC 1112 (Deering, 1989). The most important idea in Deering's model for the multicasting is the so-called multicast group concept. Table 2 summarizes the main factors of this concept.

THE IP MULTICAST ROUTING

The first issue of multicast delivery is the communication between the host and the local router. The host does not have routing functionality; it uses a special signaling protocol, the Internet Group Management Protocol (IGMP), to let the local router know that the host became interested in the traffic of a certain multicast group.

The multicast delivery in the inter-router area is based on the multicast-enable routers, which have multicast routing protocols in their protocol stack. The multicast routing protocols differ from each other according to the underlying unicast routing protocols used. Table 3 presents the most popular multicast routing protocols and their most important properties (Hosszú, 2001).

An important step in creating the delivery tree is to discover all the routers interested in the given multicast session. In case of the DVMRP (Waitzman, 1988), MOSPF (Moy, 1994) and dense mode version of the PIM multicast routing protocols, the routers periodically flood the whole network with a multicast data packet, forwarding it to every router (Adams et al., 2003). Routers not interested in that session send a prune message back to the source of the packet and so the following packets will not be forwarded to these. The flooding step generates a huge amount of unnecessary packets, which is acceptable in dense mode situation, where the majority of the routers

are interested in a multicast delivery. This routing method is called flood-and-prune model, and its operation is demonstrated in Figure 1.

In the sparse mode case, where only a small fraction of the routers are interested in a multicast session, the periodically executed flooding means an unacceptable load in the inter-routing area. In such a situation that multicast routing protocols can efficiently operate, rendezvous points (RP) are used to join to a multicast session and in such a way that the periodical flooding phase is avoided. In case of the PIM-SM routing protocol (Fenner et al., 2004), if a host wants to send multicast traffic, it will send the data packets to its local router, and then it forwards the data to the RP, which is now a designated remote router. The other host interested in that multicast traffic will send an IGMP join message to its local router, in order to become a receiver. Then the local router will send a PIM-SM joint message to the RP. Figure 2 shows this mechanism, where two receivers join to the multicast session.

After completing the join phase, the RP continuously forwards the multicast traffic toward the local router of the receiver. The data from the source to the RP is an encapsulated unicast PIM-SM control message. Figure 3 demonstrates this phase.

The root of such a delivery tree is the RP. A more optimized tree can be obtained, if the routers realize that a shorter path can be created between the source and the receiver. In this case the PIM-SM routers can switch over from the RP-rooted tree to the source-rooted tree. Figure 4 shows the created source-rooted tree.

Besides constructing the tree, its stability is also an important problem, since the routing protocol must upgrade at least a part of the tree whenever a member joins or leaves the multicast session (Van Mieghem & Janic, 2002).

Another serious routing problem of the IP-multicast is the inter-AS (autonomous system) multicast routing, since transmitting multicast traffic is not easy among the peering ASs. To overcome this limitation, different wide-area protocols are developed. The current practice is the usage of the protocol set MBGP/PIM-SM/MSDP; however, it has scalability problems, since it uses flooding to inform

Table 2. Components of the multicast group concept

- **IP-style semantics:** Similarly to the traditional (unicast) IP communication, a source can send data at any time; for this it does not have to join to the group of hosts.
- **Open groups:** The source does not have to know the members of the groups for sending data and the receivers (members of the group) do not have to know the source.
- **Variable groups:** The hosts can create, join to or leave any group at any time. The communication does not need any control center to coordinate the activity of the hosts.

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