Reliability Issues of the Multicast-Based Mediacommunication

Gábor Hosszú
Budapest University of Technology and Economics, Turkey

INTRODUCTION

Multimedia applications generally support the one-to-many group communication way. Multicasting decreases communication costs for applications that send the same data to multiple receivers. Table 1 summarizes the types of communication among hosts.

Currently, there is a fast increasing need for scalable and efficient group communication. The multicast theoretically is optimal for such purposes. Therefore, multicast technology is an emerging media dissemination technology instead of the traditional unicast communication. It has two important types: the network-level, namely IP-multicast, and the application-layer host-multicast. In the former, data packets are delivered by the IP protocol from one host to many hosts that are members of a multicast group. The routers run an IP-multicast routing protocol to construct a multicast tree. Along this tree, the data is forwarded to each host. Special IP addresses (224.0.0.0-239.255.255.255 address range) that define multicast channels and do not belong to given hosts are used. In case of Application-Layer Multicast (ALM), the hosts use unicast IP delivery, and the routers do not play any special role.

Reliability is one of the most important features of all multimedia applications, independent from the used multicast technology. This requirement is especially critical in the case of multicast, where, because of the large volume of data to be transferred, the correction or resending of lost data will be even more difficult in time.

In multicast technology, the maintenance of group membership information is also an important question from the point of view of the robustness of the so-called multicast delivery tree. In the case of an IP-multicast, the root of the tree is the sender, the leaves are the receivers and the intermediate nodes are the routers. In the following, the reliability properties of different multicast technologies will be reviewed.

RELIABLE IP-MULTICAST

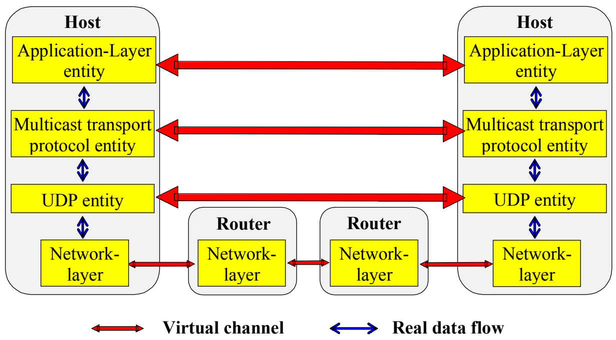
The IP-multicast itself cannot guarantee any reliability, according to the well-known best-effort delivery of the IP network. To increase the reliability for the data distribution or interactive media applications, reliable transport protocols are necessary. However, unicast TCP does not support multicast, and the UDP does not provide any reliability. For this reason, additional multicast transport protocols are used to achieve the required level of reliability (Hosszú, 2001). The protocol stack of the reliable IP-multicast is presented in Figure 1.

The various media applications, as the distributed collaborative multimedia systems, data dissemination tools and real-time media streaming software, require

Table 1. Possible types of communication among hosts

Type	Name	Description
point-to-point	**unicast**	One host communicates with another.
point-to-multipoint	**multicast**	One host (sender) sends data to a group of hosts; the sender sends data only once and every member of the group will receive the data.
multipoint-to-multipoint	**multipoint multicast**	In a communication session more than one sender exists, which independently sends data to every member of the group.
multipoint-to-point	**concast**	Every member of the group sends data to only one host.
point-to-everypoint	**broadcast**	One host sends data to every host.

Figure 1. Location of the multicast transport in the protocol stack



different multicast transport protocols for optimal performance. The multicast transport protocols have many different property attributes of data delivery, such as flow control, congestion control, data and time reliability, packet ordering, state control, acknowledgement control, scalability of the repair requests and so forth. These attributes can be represented by a selected set of protocol parameters. Each protocol parameter describes different reliability mechanisms for the same delivery attribute. Such a protocol parameter is, for instance, the repair method, which can get such values as the retransmission, forward-error correction, interleaving or different ways of the local receiver-based repairs. Another parameter is the acknowledgement type, the possible values of which may be tree-based, ring-based or a simple direct form.

To improve multicast reliability, the optimization of these protocol parameters is necessary. However, to apply any appropriate mathematical optimization method at the selection of the protocol parameters mentioned above, a linearly independent (or *orthogonal*) set of parameters must be applied. To do this, a hyperspace of the parameters is created where all transport protocol corresponds to one point of this space. The optimization procedure means finding the most suitable point on this space to provide the best performances of multicast. The modeling procedure based on the introduced protocol parameter set is presented on some examples. The strengthness of this orthogonality may be weakened, as discussed later.

The possible values of protocol parameters (which are the types of various mechanisms as the components of the transport protocols) are the realizations of the protocol functionalities. Table 2 shows a possible set of 31 different protocol parameters and their classification into categories. These parameters represent the well-known reliable mechanisms of transport protocols. The details of these mechanisms are described in the pertinent literature (e.g., Adamson et al., 2004).

For an individual application, protocol parameters get actual values. To optimize a transport protocol, the optimal point should be found in the 31-dimensional *hyperspace of the protocol parameters*. The optimization procedure can be executed easily if the applied protocol parameters are orthogonal to each other. Orthogonality means that any of them can be changed independently from the others. Since the selection of the applied protocol parameters is very important, the task is to obtain a complete set of protocol parameters that can be taken as orthogonal. For the current set of 31 protocol parameters, orthogonality is not completely satisfied, but because the importance of different protocol parameters are

Table 2. The 31 protocol parameters

Category	Protocol parameters
Data traffic control	Transmission way, transmission direction, congestion prevention, flow control
Delivery control	Data accuracy, time limitation, scheduling, updating, ordering
Feedback management	Acknowledgement types, feedback addressee, election of the designated host, state control, feedback control, way of providing feedback
Repair management	Request way, repair method, repair source, repair selection, way of sending repair, repair scoping, repair control
Session management	Session control, floor control, session membership control, locus of control, scalability, group stability
Network demand	Bandwidth demand, network heterogeneity, direction dependency

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