Reliability Issues of the Multicast-Based Mediacommunication

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INTRODUCTION

The multimedia applications generally support one-to-many group communication. Multicasting decreases the communication costs for applications, which send the same data to multiple receivers. *Table 1* summarizes the types of the communication among the hosts.

Currently, there is an increasing need for scalable and efficient group communication. Theoretically, multicasting is optimal for such purposes. Therefore, this 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 one, the data packets are delivered by the IP protocol, from one host to many hosts that are member of a multicast group. The routers run an IP-multicast routing protocol in order 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) are used, which do not belong to hosts, but rather define multicast channels. In the 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, independently from the multicast technology in use. This requirement is especially critical in the case of multicast, where the large volume of data is to be transferred, and correction or resending of lost data is even more difficult in time.

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

RELIABLE IP-MULTICAST

The IP-multicast itself cannot guarantee any reliability, according to the well-known best-effort delivery of the IP network. In order to increase the reliability for the data distribution or interactive media applications, reliable transport protocols are necessary. However, unicast TCP does not support the multicast, and on the other hand, UDP does not provide any reliability. For

Table 1. The possible types of the communication among the hosts

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

this reason, additional multicast transport protocols are used to achieve the required level of reliability (Hosszú, 2001). The protocol stack of reliable IP-multicast is presented in Figure 1.

Various media applications, as distributed collaborative multimedia systems, data dissemination tools, and real-time media streaming software, all require different multicast transport protocols to obtain optimal performance. Multicast transport protocols have many different properties which affect data delivery. Such properties are flow control, congestion control, data- and time-reliability, packet ordering, state control, acknowledgement control, scalability of the repair requests, and so on. These attributes can be represented by a selected set of the now introduced protocol parameters. Each protocol parameter describes a different reliability mechanism for the same delivery attribute. Such a protocol parameter is, for instance, repair method, which can get the values, such as retransmission, error correction, interleaving or different ways of the local receiver-based repairs. Another parameter is acknowledgement type, the possible values of which may be tree-based, ring-based, or a simple direct form.

In order to improve multicast reliability, the optimization of these protocol parameters is necessary. However, applying any appropriate mathematical optimization method, at the selection of the protocol parameters mentioned above, a linearly independent (in other words: *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 aim of the optimization procedure is to find the most suitable point in this space, to provide the best performance of multicast. The modeling procedure based on the introduced protocol parameter set is presented on some examples. The strength 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 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 the transport protocols. The details of these mechanisms are described in (e.g., Adamson et al., 2004).

For an individual application, protocol parameters get actual values. In order 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 the protocol parameters, which can be taken as orthogonal. For the current set of the 31 protocol parameters, the orthogonality is not completely satisfied, but the fact that the importance of different protocol parameters are highly different can be utilized. The parameters

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