NETRIC: A Proposed System for Synthesis of Multicast Transport Protocols

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INTRODUCTION

The article presents a proposed method to select an optimal set of the multicast protocol parameters, which are linearly independent from each other. A multidimensional hyperspace, as a mathematical model, is stated where every transport protocol parameter is represented with an individual point. A determined novel protocol parameter set is shown and the modeling procedure is presented on some examples. A multicast transport simulator has been applied to describe the performance of the transport protocols and for optimization of the parameters, providing the most reliable multicasting operation.

BACKGROUND

Reliability is one of the most important features of all multimedia applications. This requirement may be 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 (Hosszú, 2005).

The multimedia applications generally support the one-to-many group communication way. For this purpose, the IP-multicast transport mechanism is preferable (McCanne, 1997). However, the IP-multicast itself cannot guarantee any reliability because of 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 multicast transport protocols are necessary. However, the unicast TCP does not support the multicast and, on the other hand, the UDP does not provide any reliability (Yu, 2001). For this reason, additional multicast transport protocols are used to achieve the required level of reliability (Obraczka, 1998).

The various media applications, as the distributed collaborative multimedia systems, data dissemination tools, and real-time media streaming software require various multicast transport protocols to obtain optimal performance. The transport protocols have a lot of different property attributes of the data delivery. Such properties are the *flow control*, the *congestion control*, the *data- and the time-reliability*, the *packet ordering*, the *state control*, the *acknowledgment control*, the *scalability of the repair requests*, and so forth. These attributes can be represented by a selected set of the now introduced so called *protocol parameters* (Hosszú, 2005). Each protocol parameter describes different reliability mechanisms for the same delivery attribute. A protocol parameter is, for instance, the repair method, which can get the values such as the retransmission, the forward-error correction, the interleaving or the different ways of the local receiver-based repairs. Another parameter is the acknowledgment type, the possible values of which may be tree-based, ring-based, or a simple direct form (Levine & Garcia-Luna-Aceves, 1998).

An attempt to classify these protocol attributes was published by the IETF Reliable Multicast Transport Working Group (RMTWG) in Handley, Whetten, Kermode, Floyd, Vicisano, and Luby (2000) and Whetten, Vicisano, Kermode, Handley, Floyd, and Luby (2001), introducing the "*building blocks*" for multicast protocols, where these building blocks can be considered mostly equivalent with the protocol parameters. The use of building blocks is reasonable because of the intention to make the work of a protocol-designer easier. Our approach shows that the idea of partitioning protocols based on their parameters is good and can serve the base of further research.

In the transport area, the RMTWG defines some design criteria for the building blocks connected to topics like the data content model, the group membership dynamics, the sender/receiver relationship, the group size, the data delivery performance, and the network topology with or without router level intermediate system assistance. The protocols are divided into three families, on the grounds of their realization-bases: NACK based protocols, Tree-based ACK protocols, and an "Asynchronous Layered Coding Protocol" that uses Forward Error Correction. All building blocks can be used to develop a new protocol belonging to these three protocol families, so the work of a protocol-designer gets easier.

However, all work described above has been made in only one direction, especially based on the requirements of such applications that use one-to-many bulk data transfer. This could mean a limit for the usability of this approach, just as for defining all of the protocol parameters. In the novel NETRIC protocol analyzer and synthesizer system, a most universal interpretation of these protocol parameters was applied, constructing an *orthogonal hyperspace* of these. This assembly of parameters allows applying well known mathematical methods for optimization in order to select an individual point on this space providing the optimum set of multicast protocol parameters. However, the specification of the parameters can be done with compatibility to the building blocks.

The design process of the building blocks was done from a functionality based point of view, but the NETRIC system uses the mechanism-based approach. The aim of the building blocks is creating a development framework in order to help the developers. In the NETRIC system, we use existing mechanisms and try to select the best collection of mechanisms to implement. The building block-based approach is focused on development and needs human assistance during the process; however, we concentrate on simulation and selection. We try to create an automated process, which can automatically determine the right solution. Their productivity differs in the various using areas. For example, a building block-based development is more productive for new types of services, but NETRIC is better for fine tuning existing, well known protocols in different environments.

METHOD

The main goal of the NETRIC project is, as mentioned, the optimization of the protocol parameters in order to improve multicast reliability. However, applying any appropriate mathematical optimization method, the selection of the protocol parameters mentioned above must be carried out to provide a *linearly independent* (in other words, orthogonal) set of parameters. Selecting these protocol parameters, basically a hyperspace of the parameters is created where all transport protocol corresponds to one point of this space (Hosszú, 2005). The optimization procedure means to find 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 (Handley et al., 2000). The strangeness of this orthogonality may be weakened, as discussed later.

To carry out a correct optimization procedure on the appropriately selected protocol parameters, a well usable simulation program should be applied in order to present statistically acceptable results for multicast data transfer. This problem has been solved by the multicast simulator SimCast (Orosz & Tegze, 2001), which describes the performance of the transport protocols (Whetten et al., 2001). The simulator has a modular architecture, which makes it possible to choose from the alternative mechanisms of each protocol parameter.

The system presented does iteration loops with the multicast transport protocol parameters in order to satisfy the requirements of the upper layer media applications. The synthesis is done by designating the protocol parameters and determining the range of them, based on the results of the simulation loops. Using