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Optimizing multimedia transcoding multicast trees

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Abstract

In this paper, network hosted transcoding is studied for the optimization of resources in multicast applications. The configuration is as follows: one source node is sending a signal (e.g. a video stream) and several destinations request that signal but at a bit rate adjusted to their access link. Instead of transcoding at the source node, the nodes inside the network will take care of the reduction in bit rate. The advantages are that the source load and overall bandwidth usage are reduced while end-users get the service at a customized quality. The focus of this paper is on the calculation of the optimal multicast tree, including transcoding location optimization and estimation of the resource usage gain.

Keywords: Multicast trees; Transcoding; Active networks; Optimization

1. Introduction

The current internet is very heterogeneous: Users are connected to the net in different ways with a wide variety in access capabilities. Nevertheless they all want the best quality possible and in case of multimedia streams, each user expects to receive the stream at the best quality possible. If the provider sends out only one multicast stream, there are currently two possibilities: either a high quality stream is sent and consequently users with a slow connection will not be able to receive the stream or either a low quality stream is transmitted, resulting in displeased broadband access users.

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A solution to this problem consists of sending multiple formats of the same stream towards the requesting users (simulcasting [1]). This implies that the provider is responsible for all necessary transcodings and should send out all different formats in separate multicast trees.

Another possibility is to use layered media streams and let the users subscribe to multiple layers to get better quality as proposed by McCanne in [2]. This method can only be used with formats supporting this layering of data.

The solution discussed in this paper consists of extending (some of) the network nodes with transcoding capabilities making them 'active nodes' ([3–6]). In this way, only one multicast tree has to be set up and the transcodings can be done inside the network, at optimal locations i.e. at nodes that have enough processing power to do the transcoding and chosen such that the overall bandwidth usage is minimized. As a result, the provider only needs to inject a single format into the active (overlay) network while the users still get a customized service.

Fig. 1 illustrates this solution: a video multicast server sends a video stream at 6 Mbps into the network. Three users request the video: user A requests high quality and asks for the video at full rate. User B also has a cable modem but requires only a 3 Mbps signal. User C has a T1 connection and requests the video at 1.2 Mbps. The active solution presented in Fig. 1 shows that the 6 Mbps signal is injected in the tree and that in two nodes a transcoding takes place, thereby optimizing the overall bandwidth usage.

The problem at hand has been described by Parnes [7] and the 'active' approach has been studied in a.o. [8,9,1,10,11]. Pasquale et al. [8] use the concept of the 'relocatable continuous media filter': filters propagate upstream towards the source to decrease bandwidth consumption. In [9], a video gateway is used to perform bandwidth adaptation to match the transmission quality to the heterogeneous bandwidth constraints of distinct regions of a single logical multicast session. In [1], Kouvelas et al. propose a scheme that uses self-organization to form groups out of co-located receivers with bad reception and that provides local repair through the use of transcoders. In [10], a centralized algorithm is proposed that builds a hierarchy of multicast groups to tackle the problem. Singh et al. [11] propose the use of proxies that can cache and transcode Web content.

In the work proposed here we focus on finding the optimal transcoding locations, which has not been addressed yet. The Transcoding Multicast Tree problem calculates the minimum cost multicast tree from source to all destinations and it determines the optimal transcoding locations in this multicast tree. The cost is related to the bandwidth usage on the edges and the resource usage in the nodes. An optimal solution and two heuristics

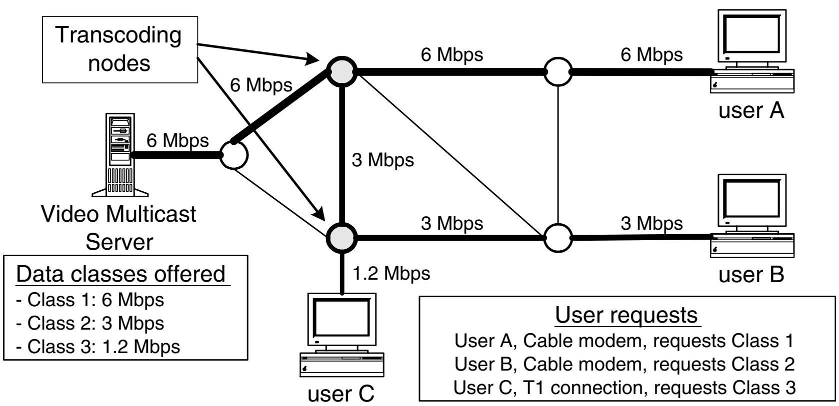

Fig. 1. Example of a Transcoding Multicast Tree.