

Chapter XI

HSM:

A Hybrid Streaming Mechanism for Delay-Tolerant Multimedia Applications

Annanda Thavymony Rath

Institute of Technology of Cambodia, Cambodia

Saraswathi Krithivasan

India Institute of Technology, Bombay

Sridhar Iyer

India Institute of Technology, Bombay

ABSTRACT

Traditionally, Content Delivery Networks (CDNs) deploy proxy servers at strategic locations at the edge of the network to efficiently serve client requests. With the tremendous growth in multimedia applications and the number of clients accessing such applications, an edge proxy server may serve clients connected to it through a multihop network of heterogeneous links. Further, a special class of multimedia applications that can tolerate startup delays is emerging. In such applications, clients require a minimum acceptable quality (loss-free transmission at a minimum encoded rate r_i) and the start of playback at a specific time $(t + d_i)$ where t is the current time and d_i is the delay tolerance acceptable to client i . Our work deals with enhancing performance of such networks through a Hybrid Streaming Mechanism (HSM). In HSM, a client's request triggers the selection of an intermediate node as a streaming point to which multimedia contents are dynamically transferred from the proxy/source, and this streaming point streams the contents to the client. Transferred contents are temporarily cached at the streaming point to service future requests for the same content. HSM helps a Content Service Provider's objective of satisfying as many client requests as possible and providing enhanced quality to clients given their delay tolerance. Simulation results demonstrate that by leveraging the delay tolerance of clients and by combining the dynamic download and streaming mechanisms, HSM performs better than directly streaming from edge servers, serving on average 40% more client requests.

INTRODUCTION

For large-scale multimedia data dissemination, Content Delivery Networks (CDNs) are used to overcome the limitation of streaming server capacity and link bandwidth constraints in the network. The main objectives of CDNs are to (i) minimize the startup latency (the time it takes for a client to start the playback), (ii) reduce network congestion, and (iii) reduce the load on the central server (Frossard & Verscheure, 2002; Qian Zhang & Zhang, 2001; Shen, Lee & Basu, 2000; Yang-Sao, 2003). CDNs achieve these objectives through strategic deployment of proxy servers where contents are cached in anticipation of future requests. Each proxy server serves as a source for clients connected to it through a multihop network of heterogeneous links.

In addition, streaming media applications are emerging where multiple clients access the contents at specific times according to their convenience. In these special classes of multimedia applications, termed *delay-tolerant* applications (Krithivasan & Iyer, 2006), clients request the multimedia content, specifying their requirements: (i) *stream quality*: a minimum rate at which they want to receive the stream, and (ii) *delay tolerance*: the time they will wait for the play out of the stream. Universities offering their courses to a set of global subscribers and multinational corporations providing training to employees across cities are some examples. Note that mechanisms proposed in the literature to efficiently serve requests for multimedia content, including CDNs, propose ways to *minimize* the startup delay (Hua, Cai & Sheu, 1998; Jiangchuan, Chu & Xu, 2003; Sen, 2000; Shen et al., 2000; Su & Wu, 2005), whereas we deal with applications that may *require* startup delay.

In this chapter, we present a Hybrid Streaming Mechanism (HSM) to increase the efficiency of Content Service Providers (CSPs) by using a combination of dynamic download and streaming mechanisms. In HSM, a client's request triggers the selection of an intermediate node to which multimedia contents are *dynamically* transferred from the source, and this *streaming point* streams the contents to the client. Transferred contents are temporarily cached at the streaming point to service future requests for the same content until the contents need to be evicted.

Simulation results of HSM show that by leveraging the delay tolerance of clients and by combining the dynamic download and streaming mechanisms intelligently, HSM performs better than direct streaming from edge servers, serving on average 40% more client requests. In the next section, we present a motivating example. We present the HSM algorithm in Section 3 and present our experimental analysis in Section 4. Related works in the area are presented in Section 5. Section 6 presents the conclusions of our work.

MOTIVATING EXAMPLE

We consider a network modeled as a tree, with source S at the *root* and clients C_1, C_2, \dots, C_{14} at the *leaves*, as shown in Figure 1.

All other intermediate nodes serve as *relay nodes*. A relay node that directly serves a group of clients is termed a *region node*. We use the term *region* to refer to the subtree that contains the region node and the clients it serves. For example, in Figure 1, the network has five regions with nodes 7, 9, 10, 11, and 12 serving as region nodes. We refer to the network from S to the region nodes as the *backbone* of the content dissemination network. While most existing research focuses on the Internet (best effort

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