Chapter 6

Video Broadcasting Protocol for Streaming Applications with Cooperative Clients

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ABSTRACT

Video broadcasting is one of the efficient methods in implementing large-scale video-on-demand (VoD) systems. Managing large number of concurrent channels in a video server is the main barrier to implement Harmonic Broadcast (HB) in VoD applications. In this chapter, we propose a new transmission protocol denoted as Harmonic-Based Peer-to-Peer Broadcasting (HPB) to release the burden of HB by dispersing a large portion of workload over a number of clients denoted peer servers. As the bandwidth requirement of each segment in HB is different, we first develop a segment placement algorithm to balance the workload among peer servers. We then study the dynamic nature of peer-to-peer (P2P) paradigm on the design of the system. An analytical model is developed to determine the optimal number of peer servers required for the system under certain level of availability such that the workload of the central server can reach a target level. The results show that the workload of central server can be significantly reduced.

INTRODUCTION

In recent years, one of the cost-effective solutions to provide video-on-demand (VoD) services for a large community is *periodic broadcast*. Existing periodic broadcast protocols first partition a video into a number of segments and transmit them into different logical channels periodically. Clients then listen and fetch the desired segments from the appropriate channels according to a specified download policy. Based on the transmission nature of various schemes, the broadcasting protocols can be categorized into two groups (Hu et al., 1999): *equal bandwidth* (EB) and *equal segment* (ES). In the EB group, the

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bandwidth allocation for each channel is identical while the size of each segment of the video is different. On the contrary, in the ES group, the bandwidth of each channel is different but the size of all the segments is the same. *Pyramid Broadcasting* (PB) (Viswanathan & Imielinski, 1996) and *Harmonic Broadcasting* (HB) (Juhn & Tseng, 1997) are the pioneers of EB and ES respectively.

Compared with the EB group, the ES scheme can achieve better bandwidth efficiency. The HB approach can greatly reduce the start-up delay and at the same time slowly increase the bandwidth requirement when the number of segments of the video is increased. However, it is found that managing large number of concurrent channels in a video server is the main barrier to implement HB in real applications. For example, a video with a length of 7200 seconds should be divided into 240 segments so as to limit the waiting time to about 30 seconds. Thus, if the system provides 100 videos with the same waiting time, the server is required to handle 24000 channels simultaneously.

In order to reduce the workload and the complexity of the video server when using HB, in this work, we propose a new scheme called Harmonic-based Peer-to-Peer Broadcasting (HPB) protocol to distribute the partitioned segments to a number of clients called peer servers. Based on the proposed data distribution schemes, each peer server is only responsible for broadcasting one or tens segments simultaneously. Nevertheless, in a dynamic peer-to-peer (P2P) environment, the peer server may enter and leave the system at arbitrary time. In order to provide continuous video playback for the clients, more than one peer server has to support for each segment in order to increase the degree of reliability. Therefore, it is crucial to determine how many peer servers are required for each segment such that the service will not be disrupted during the video session. The main objective of this work is to find out the optimal number of peer servers under certain level of availability such that the workload of the central server can be reduced to a target level. Since the bandwidth requirement of each segment in HB is different, a segment placement algorithm is also developed to balance the workload among peers. In addition, the fault recovery procedure and synchronization issue are discussed in the chapter.

The remaining of the chapter is organized as follows: We first review the recent related works. Next, we describe the system architecture and the data transmission scheme. To balance the workload among peer servers and determine the optimal number of peer servers required for the system, a segment placement algorithm and an analytical model will be developed in Section titled "System modeling". Results will be presented to demonstrate the efficacy of the proposed system. Finally, the conclusion is given in the last section.

RELATED WORK

With the explosive growth of the Internet, the demand for various multimedia applications is rapidly increasing in recent years. Among different multimedia applications, Video-on-Demand (VoD) is playing a very important role. The VoD systems proposed in the last decade typically can be classified into four main architectures (Thouin & Coates, 2007): centralized, proxy-based, content distribution network (CDN) and peer-to-peer (P2P) architecture. The diagrams for different architectures are shown in Fig. 1.

In a centralized architecture, the system consists of two main components: the central server and client (Fig. 1a). The central server has a large storage space to store all the available videos for clients connected via a wide area network (WAN) or local area network (LAN). In such framework, all the requests from clients are handled at the central server. The request process starts with generating a request message from clients to the central server. In response to the client's request, the central server serves

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