Chapter 11
Scalable P2P Video Streaming

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ABSTRACT

P2P networks are a technology able to deliver real time and video-on-demand services over IP networks. Layered video coding techniques are being introduced due to their ability to deliver streams at different scales (temporal, spatial and SNR) that solve the heterogeneity problem. This eases transmission in the case of limited bandwidth, as the devices can pick and decode the minimum bit rate base layer. Existing work examines layered video in client-server scenarios. In contrast, this paper analyzes scalable coding H.264/SVC over P2P networks based on an SNR-temporal Codec. Due to the interdependency between the different SVC layers, issues of reliability and quality of experience arise unless proper measures are taken to protect the base layer. The authors explore the effectiveness of a combination of P2P strategies, for example, hybrid P2P architecture, P2P locality, and P2P redundancy, to assess the viability and benefits of scalable video coding over P2P. The resulting performance is compared with a state-of-the-art P2P TV platform.

INTRODUCTION

Streaming of video over Peer-to-Peer (P2P) networks is a potential approach to the ever-growing problem of distributing video over the Internet. In this system, each terminal relays the stream as soon as it becomes available, for the benefit of the other users, acting in fact as a stream-distribution hub for any incoming data. This will significantly reduce the bottlenecks normally generated by the traditional server-based video distribution (Liu et al., 2008). The most striking strength of P2P based streaming over conventional IPTV, is its ability to better adjust to the number and distribution of users over the network. In turn, this leads to higher resource utilization and, more importantly, contributes to a better overall quality of experience. Thus, in contrast to the conventional shared
media applications, where the network resources (e.g., bandwidth) are shared among the users and more users exhaust the network degrading the quality, here it is the content that is shared. This creates a fascinating dilemma for Internet video. With P2P streaming, as more users want to consume content, the very same users will act as distribution relays, contributing to increasing the overall throughput. When more users buffer the same streaming video content, the distribution process can happen in parallel and redundant video feeds lead to an immediate increase in video quality and, with it, to the overall user’s quality of experience.

In this evolution, overlay networks play a vital role. The users’ terminals (or peers) interconnect with each other, forming an overlay network where the intercommunications are virtual, transient and dynamic. As peers join or leave the network, the distribution overlay re-adjusts in order to maintain video feeds, despite the churn of users. Because peers (terminals) work as clients and servers simultaneously the stream is relayed efficiently, despite increasing the number of receivers.

On the other hand, different architectures have been proposed in order to create and manage overlay networks, such as Tree-based (Diot et al., 2000) and Mesh-based (Qiu & Srikant, 2004). These approaches have been studied and each approach has its own advantages and disadvantages (Marfia et al., 2007). In this paper, a mesh-based approach is considered. Many hosts can be supported by a P2P multimedia system, possibly in excess of hundreds or even millions, with miscellaneous heterogeneity in bandwidth, capability, storage, network and mobility. It is desirable that, once the stream is injected into the overlay network and starts circulating, different types of devices (i.e., Mobile Phones and PDAs) are able to access and relay the stream.

Another important factor of the media distribution process is the video encoding technique. In a normal media production system, the stream is encoded before the transmission and then decoded and played back at the destination client. Different video coding schemes are available, including those based on single layer and multi layer coding. However, it appears that a P2P strategy well correlates with the principles of scalable video coding (SVC). In this method, video is coded into a scalable bit stream, where users use the portion of the stream that suits their needs best. In a heterogeneous network, where link capacity and terminal capability may vary considerably, more users have the potential to connect. Having more users in the network makes P2P streaming more efficient; but it is also essential to properly manage the heterogeneity of the distribution overlay. Most of conventional P2P systems are based on single-layer video, which makes them limited when it comes to optimizing the distribution process over heterogeneous systems.

To overcome such limitations, in this paper we explore the combination of P2P streaming with scalable video coding. In our system, those peers that can only handle the lowest video quality (i.e., the base layer) will feed each other in the same way as in conventional single-layer P2P streaming. This of course occurs at a much reduced transmission cost, since base layer rates are at a fraction of the single layer stream, albeit the video quality is lower.

On the other hand, peers demanding higher video quality will get the extra data from the enhancement layers of other peers. In this case with a fraction of extra data, those users having sufficient network and computational resources to render video at higher quality will be able to achieve a higher quality through the necessary enhancement layers. As for the base-layer overlay, when more high-capacity users will be present, the enhancement-layer overlay will become more effective too.

For the sake of our experimental-based evaluation, in this article we focus on H.264/SVC (scalable video coding), which has the ability to be decoded at different levels of granularity, hence satisfying our heterogeneity requirement.