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Efficient IPTV Services Delivery using SVC Adaptation and Cooperative Prefetching

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1. Introduction

As the demand for Internet-based applications grows around the world, Internet Protocol Television (IPTV) has been becoming very popular. Mobile IPTV allows the users to receive multimedia contents over mobile IP networks using unicast, multicast or peer-to-peer (P2P) communications whenever they want and wherever they are.

Common Mobile IPTV services include Live TV and Video-on-Demand (VoD) streaming. The delivery of such services requires addressing the following two issues related to user Quality of Experience (QoE): (1) ensuring minimum start-up delay during channel switching for Live TV, and (2) guaranteeing minimum delay for seek operations in VoD streaming.

Solving the above-mentioned issues is crucial for the successful deployment of mobile IPTV services. In Live TV, users perform frequent channel switching to discover interesting programs. Similarly, in VoD streaming, the freedom of choosing content leads to a large number of seek operations. In both cases, delay reduction is more important than providing the full quality of the video.

In the other hand, to support clients with diverse capabilities and requirements, the MPEG is defining a scalable extension of H.264 AVC namely Scalable Video Coding (SVC) that is able to simultaneously support multiple spatial, temporal and SNR resolutions with minimum processing and transmission overhead. The SVC is being attracting great interests in the research community.

An SVC video stream is a collection of atomic data units namely NALU (Network Abstraction Layer Unit). It consists of a single base layer and one or multiple enhancement layers. The base layer is the most important layer and is essential for decoding the other layers while the exclusion of some or all of the enhancement layers still allows a reasonable quality.

The adoption of SVC in streaming services faces two key design challenges: (1) *layer selection*: how

many layers each user should receive; and (2) *layer delivery*: how to efficiently deliver those layers.

2. Efficient IPTV Services Delivery

It has been noticed that mobile users nowadays have enough bandwidth to satisfy the reception of desired service as well as other services simultaneously. Based on this assumption, we propose, in this letter, the use of SVC adaptation to mitigate the problem of delay for the two IPTV services (Live and VoD). We propose an architecture that ensures fast channel switching (zap-delay) using SVC for live streaming and fast seek operations using cooperative prefetching of SVC NALUs for VoD streaming.

2.1 Enhancing channel zap-delay for live services

In traditional architectures, the content of each live TV channel is sent through a single multicast group. This way, a user has to subscribe to this multicast group to view this channel. When switching to a different channel, the user has to wait a certain amount of time (ranging from hundreds of milliseconds to seconds) before he can start watching. This delay is required for IGMP *leave* and *join* operations but also needed to fill the buffer with the full quality content of the selected channel. However, in our architecture, a TV channel, as it is encoded into a base layer and several enhancement layers, is sent through at least two different multicast groups. The first group provides the transmission of the SVC base layer, while the second group will be used for all the enhancement layers. According to the remaining download bandwidth, we propose that users prefetch base layer content for fast channel switching while acquiring the full quality content once a channel is selected. Thus, in order to view a channel, the user terminal has to subscribe to the two multicast groups (base layer and enhancement layers). While viewing a channel, the remaining bandwidth is utilized to acquire the base layer NALUs of the popular channels. The popular channel information can be provided by the central entity (the streaming server) or discovered using gossip signaling. When a user performs a channel switching (i.e. zap), the user starts viewing the content with minimum delay due to the advance acquisition of the corresponding base layer (see

Figure 1). Once a channel is selected by a user, the maximum bandwidth is assigned for acquiring the NALUs of this channel (base layer as well as enhancement layers) to enhance the quality of the selected channel.

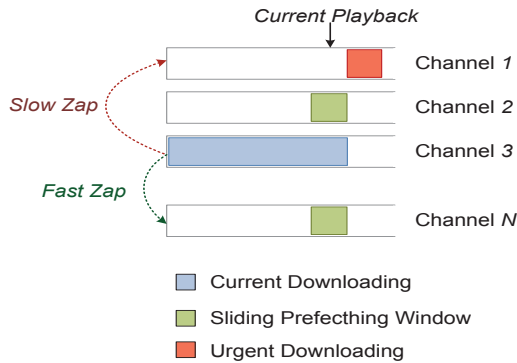


Figure 1. User behavior with respect to Buffer Window for Live TV Streaming

Due to the limited \square_{extra} bandwidth used for prefetching the base layer of the other channels, all the channels cannot be prefetched simultaneously and the fast channel switching is only possible for a small number of channels. To enhance this mechanism, a history-based prediction scheme can be used in order to forecast the user zaps. This dynamic scheme aims to prefetch the appropriate channels to meet the dynamicity of the available \square_{extra} bandwidth and the user behavior.

Consequently, this mechanism allows a fast channel switching trading video quality for reduced start-up delay while considering user behavior.

2.2 Enhancing seeks operation for VoD services

One of the existing scenarios for providing VoD streaming in mobile IPTV is based on P2P network. The users are organized into different sessions according to their preferences and their play head positions. Every x minutes the server starts a new session to broadcast the video from beginning, where x is the predefined session length. This service is also known as near VoD. Initially, when a new user selects a video, it joins a certain streaming session on the basis of its arrival time. A central entity called *tracker* estimates the user available bandwidth and decides whether this user can become the child of the server or a child of another user. Parent peers push the desired content to their child peers. To support VCR operations, the tracker provides the user two lists: *session neighbor list* and *shortcut neighbor list*. The former consists of peers within the same session. This list is used to support a continuous playback of video.

The latter contains peers in different sessions and is used to support the playback leap, which occurs due to VCR operations. In order to support fast seek operations, we propose the use of cooperative prefetching \square among the peers within a VoD session.

In the proposed cooperative prefetching, each peer in a session maintains a buffer map having the state information of available NALUs of different layers (base layer as well as enhancement layers). The peers within a session exchange this state information and create a table of available NALUs within that session. Each peer performs the necessary computation to remove redundancy and creates a list of available non redundant NALUs in the session. The peer then prefetches the desired base layer NALUs (which do not exist in the session) from other peers in other sessions. If it receives no response, these NALUs are requested from the original streaming server. The main advantage of this policy is to reduce the seeking delay by acquiring the maximum NALUs of the base layer. Whenever a peer performs a seek operation (see Figure 2), it can quickly acquire the requested NALUs of the base layer from peers within its session and starts requesting the NALUs of the enhancement layers. As a result, the seeking delay is reduced significantly.

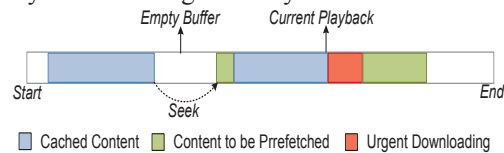


Figure 2. User behavior with respect to Buffer Window for VoD Streaming

3. Conclusion

The use of SVC adaptation allows the support for heterogeneous terminals while overcoming the bandwidth fluctuations which is very common in Internet. Based on SVC, the proposed architecture achieves efficient delivery of mobile IPTV services. In this letter, we proposed the use of SVC adaptation with multicast groups for fast channel switching in Live TV streaming. Moreover, we utilized the cooperative prefetching along with SVC to provide smooth seek operations by minimizing the seek delay in VoD streaming while providing continuous service delivery.

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