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A QoE-Aware P2P Streaming System using Scalable Video Coding

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***Abstract*—P2P streaming has attracted much attention recently with promises for higher revenues and better load distribution. Still, the majority of P2P video streaming systems today employ the one-size-fits-all concept where the same video bit-rate is offered to all users. Here the promising H.264/Scalable Video Coding (SVC) standard is seen as a necessity in not only supporting heterogeneous resources, but also in reducing the impact of P2P dynamics on the perceived Quality-of-Experience (QoE). In this demonstration we present our streaming application that uses SVC to adapt to different user requirements and resources. The application employs a novel QoE-aware layer selection algorithm that maximizes flexibility through SVC while taking impact on QoE into consideration.**

I. Introduction

P2P techniques for streaming are becoming more popular since they allow for higher revenues for content providers and better load distribution and scalability.

On the other hand, Internet devices that are joining P2P streaming systems are becoming more heterogeneous. Such devices range from smart phones to net-books and PCs, and even network-enabled television sets. In addition, the extra level of mobility allows for many possible network connections that have different connection characteristics, like GPRS/EDGE, UMTS, and WiMAX, while fixed networks, like ADSL and optical networks, provide high data-rates that enable High Definition (HD) streaming. All of this poses stringent requirements on any streaming system to provide support for many kinds of devices and connection characteristics.

A natural method to support these requirements is through the usage of Scalable Video Coding (SVC). SVC refers to the ability of having a flexible video bit stream in which can be adapted to system dynamics.

This demonstration aims at providing an insight on how SVC can be used in a P2P context to provide quality adaptation to network and device dynamics. Additionally, we use a layer decision controlled by a Quality-of-Experience (QoE)-aware algorithm, which assures the best possible user experience.

Our initial design and simulative studies have been conducted to proof the feasibility of our approach, cf. [2], [5]. There are also other projects, such as P2P-Next, working on SVC support for their streaming system [6].

II. Scalable Video Coding and QoE Control

The video codec H.264/SVC, cf. [7], [4], is based on H.264/AVC, a video codec used widely in the Internet, for instance by video platforms (e.g., YouTube, GoogleVideo) or video streaming applications (e.g., Zattoo). The SVC extension enables the encoding of a video file at different qualities within the same layered bit stream. This includes besides different resolutions also different frequencies (frames displayed per second) and different image qualities w.r.t. Signal-to-Noise Ratio (SNR). These three dimensions are denoted to as spatial, temporal and quality scalability. Figure 1 gives an example of different possible scalabilities for a video file. The left bottom ”subcube” is the base layer which is necessary to play the video file, here with CIF resolution, 15 Hz frame-rate, and quality Q0. Based on this layer, different additional enhancement layers permit a better video experience with a higher resolution, better SNR or higher frame rate, respectively.

Since SVC provides three different scalabilities, the question arises which layers should be downloaded if the overlay can not provide enough capacity for the complete video file. At least a minimum resolution, quality and frame rate, which also depends on the user's context, has to be provided. Otherwise the user will not accept the video service. Higher layers will increase the QoE further, but also require a higher bandwidth.

The impact of the different scalabilities on the QoE is depicted in Figure 2. In general, spatial-/quality scalability enables bandwidth reduction by having a minor impact on the QoE, while temporal scalability enables only a minor bandwidth reduction as discussed in [8].

III. Quality Adaptive P2P Streaming

The prototype we are demonstrating is based on our P2P streaming appraoch presented in [2] whose architecture is

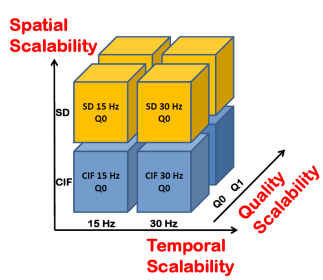

Fig. 1. SVC cube, illustrating the possible scalability dimensions for a

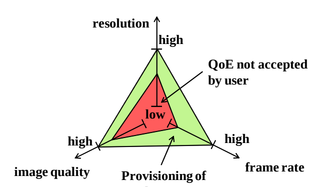

Fig. 2. Acceptable area of QoE control settings.

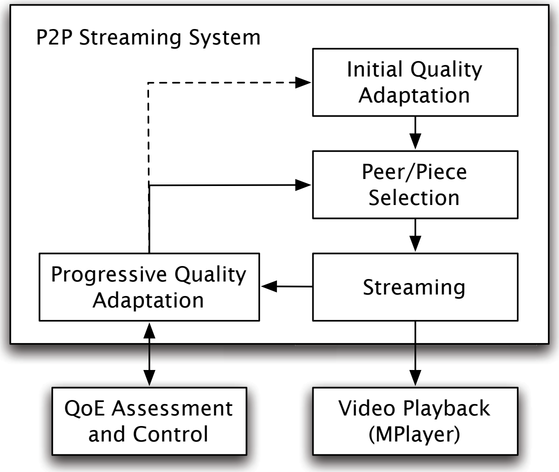

Fig. 3. Quality adaptive P2P streaming system architecture.

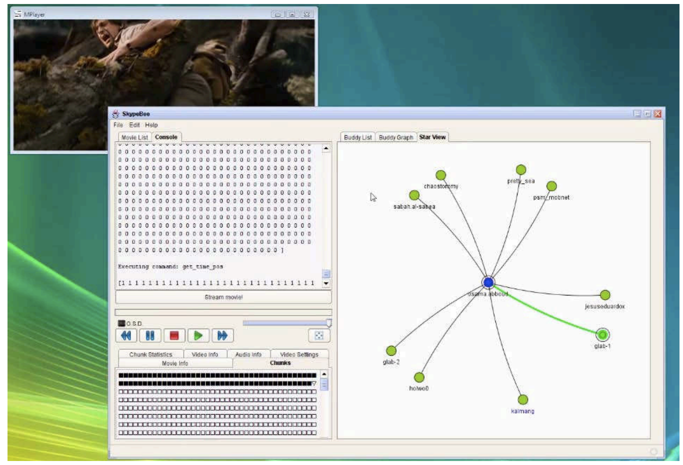

Fig. 4. A screen shot of the streaming application in action with various real time statistics.

depicted in Figure 3.

This system is based on the idea of dividing quality adaptation, or layer selection, into two stages. The first stage, called *Initial Quality Adaptation*, allows to adapt to static resources at the peers, e.g. screen resolution, bandwidth, and processing power. After the initial layer has been selected, peers that can provide the selected layer are contacted and required pieces are requested. Our system further employs a closed loop adaptation algorithm, called *Progressive Quality Adaptation*, that constantly monitors playback performance and throughput and will change the selected layer accordingly. Here this module relies heavily on the *QoE Assessment and Control* module that, based on investigations in [8], takes QoE into consideration. For example, this module gives indications on best layer combinations and layer switching frequency that do not deteriorate QoE. For the actual playback, we use a modified version of the MPlayer [1], which supports SVC encoding [3].

IV. Demonstration Scenario

In the demonstration, we use one layer for the temporal and SNR domains and focus on adaptation based on different spatial layers.

The demonstration will start by presenting how the basic streaming system works. After streaming of a certain SVC movie is initiated, the system visualizes all peers that are streaming this movie. The streaming session starts by performing initial quality adaptation where an initial layer is selected, and pieces belonging to the selected layer are fetched from the connected peers. Then data transmission starts and, after some startup time, MPlayer is launched and playback starts. At this point progressive quality adaptation control is performed in order to ensure that playback is smooth with no excessive stallings. Therefore, this module might decide on decreasing or increasing the spatial layer to cope with any dynamics. We will induce this effect by manually killing a seeder peer. It will be visualized to the audience how the application is adapting to these dynamics by reducing the streamed resolution. Later on, we re-launch this seeder peer, and the application will detect the availability of more resources and will switch to a higher layer automatically.

During the whole demonstration, the application offers various real time statistics and graphs to get a feel of its performance. These statistics include a live SVC buffer-map that shows the chunks that have already been downloaded and their layers. Additionally, the audience can see achievable throughputs, list of all peers in the streaming overlay, and information about the video stream. A screenshot of the prototype is presented in Figure 4.

V. Acknowledgments

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