Scalable, Wavelet-Based Video: From Server to Hardware-Accelerated Client

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***Abstract*—Video source, carrier and client diversification have led the video coding community to develop scalable video codecs supporting efficient decoding at varying resolution, frame rate and quality. Scalable video has several advantages over a nonscalable approach, but a large scale deployment is far from trivial and a lot of open questions remain. To resolve these, we developed a complete video delivery chain for scalable wavelet-based video. This includes a video server, a negotiation framework, a video scaling infrastructure and two scalable video clients, one pure software client and one real-time, hardware accelerated client. This paper describes the complete chain and identifies and quantifies the impact of using scalable video in every link of this chain.**

***Index Terms*—MPEG-21 BSDL, negotiation, reconfigurable hardware, scalable video, wavelets.**

I. Introduction

THE world of (digital) video is in strong transition. Video sources, carriers and clients diversify at a fast pace resulting in the production of cross media content for the publication and distribution in a multichannel environment. In such an environment, content providers want to create the content once, such that the users can consume it on any device and such that it can be transported over all possible network connections. This concept is better known as Universal Multimedia Access (UMA) [1]. One enabling technology in UMA is the use of scalable video coding. The defining characteristic of scalable video coding is that only one version of the coded video stream is required. By simple elimination of dispensable parts in this stream, the video can readily be adapted to suit the needs of clients and/or carrier networks without the need for a costly transcoding step. This truncation operation has to be executed by an adaptation engine which should be reusable for multiple codecs, independent of the specifics of the underlying coding format.

Typically, scalable video supports temporal, spatial and quality scalability. Temporal scalability enables reduction of the frame rate of the video stream by periodically dropping frames from the stream. Spatial scalability allows decoding of the video at different, reduced, resolutions. Finally, quality scalability allows seamless variation of the reconstruction accuracy (the signal-to-noise ratio) of the decoded frames. Employing these dimensions of scalability adapts the bitstream such that all system requirements (available bandwidth, computational power, battery power, etc.) are satisfied.

While the concept of scalable video sounds great in theory, it is unclear what problems an actual large scale deployment would engender. Indeed, the choice of a scalable coding scheme impacts every link in the complete video delivery chain going from server over a network to a client. The main contribution of this paper is to identify and quantify this impact in every link of the chain, based on an actual prototype implementation. In the RESUME project (Reconfigurable Embedded Systems for Use in scalable Multimedia Environments[1]) we have developed a complete video delivery chain including a video server, negotiation framework, video scaling infrastructure and scalable video clients, using a wavelet-based, scalable coding scheme as core technology. Two client implementations were made: one in software and one in reconfigurable hardware. To our knowledge, the RESUME project is the first to realise such a complete chain from server to client using this scheme. The main contribution of this work lies in the quantitative insights it provides into the difficulties associated with composing the various parts of the complete system. The effective detailed implementation indeed unveiled several issues caused by the targeted scalability.

The paper is structured as follows. Section II addresses the motivation to use scalable video formats and elucidates the choices made regarding the use of wavelets and Field Programmable Gate Arrays (FPGAs). In Section III our wavelet-based video codec using a Spatial-Domain MCTF scheme (SD-MCTF) is described focusing primarily on those techniques which enable scalability. In Sections IV–VII we investigate how the scalability in the coding scheme affects crucial steps in the delivery chain. Section IV presents how Quality

[1]http://www.elis.ugent.be/resume

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