Analysis of Scalable Video Coding (SVC) – Architecture, Classification and Application

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Abstract— This paper shows an analysis of the performance of the Scalable Video Coding (SVC) which is an extension of H.264/AVC. It presents SVC’s main functionalities and the issues in encoder control and bit stream extraction. By that, it enables for instance multicast services to clients of heterogeneous capabilities at the same time, while consuming less bit rate compared to simulcasting the services as SVC allows for data rate adaptation without re-encoding just by dropping packets of the bit stream. There are advances established in video compression capability with the help of the H.264/AVC video coding standard, The Joint Video Team of the ITU-T VCEG and the ISO/IEC MPEG has now also standardized a Scalable Video Coding (SVC) extension of the H.264/AVC standard. SVC has been primarily designed for progressive video. However, even if progressive material is becoming the favorite format for production, broadcasting and consumers equipments, and interlaced material is still widely used in the video world and will not disappear in the next few years. Over the last one and a half decades, digital video compression technologies have become a primary part of the way we create, communicate, and consume visual information. The scalable extension of AVC Scalable Video Coding (SVC) is a current standardization project of the Joint Video Team (JVT) of the ITU-T Video Coding Experts Group (VCEG) and the ISO/IEC Moving Picture Experts Group (MPEG). SVC enables the transmission and decoding of partial bit streams which results in providing video services with lower temporal or spatial resolutions or reduced reliability. It also retains a reconstruction quality that is high relative to the rate of the partial bit streams. The required features and performance of the system will increase as technology evolves to address portable and applications. Our study can provide a guideline to the H2.64/SVC for the design of a more secure and practical network.

Keywords- H.264/SVC.

I. INTRODUCTION

There are many applications of Digital video communication, such as:

- Broadcast, subscription, and pay-per-view services over satellite, cable, and terrestrial transmission channels (e.g., using H.222.0 MPEG-2 systems [1]);
- Wire-line and wireless real-time conversational services (e.g., using H.32x [2]–[4] or Session Initiation Protocol (SIP) [5]);
- Internet or local area network (LAN) video streaming (using Real-Time Protocol/Internet Protocol (RTP/IP) [6]);
- Storage formats (e.g., digital versatile disk (DVD), digital camcorders, and personal video recorders).

There are new improvements in video coding technology and standardization [7]–[12] It also has made rapid developments and improvements of network infrastructures, storage capacity, and computing power which enables an rise in number of video applications. Application areas today range from multimedia messaging, video telephony, and video conferencing over mobile TV, wireless and wired Internet video streaming, standard and high-definition TV broadcasting to DVD, Blue-ray Disc, and HD DVD optical storage media. For these applications, a variety of video transmission and storage systems may be engaged.

SVC supports scalability in terms of spatial and temporal resolution as well as the variation of the reconstruction quality.

For multiple older video coding standards [13]–[15] scalable profiles have been urbanized, mainly for quality scalability, the rate-distortion efficiency of these schemes was limited when compared to non scalable single layer coding [16]. The difference in rate-distortion performance between state-of-the-art single-layer coding and scalable coding could be considerably reduced with the Scalable Video Coding (SVC) extension of H.264/AVC. The improved coding efficiency of SVC relative to the scalable profiles of previous standards can be credited to the possibility of using efficient hierarchical prediction structures, the new inter-layer prediction mechanisms, the improved drift control for quality scalable coding with packet-based granularity as well as the efficient coding tools of H.264/AVC such as the variable block size motion-compensated prediction with multiple reference pictures or the efficient entropy coding methods.
Interlaced support was not considered in SVC as it was specifically designed for progressive material. Regarding spatial and temporal prediction, generalization of SVC for interlaced video is direct: single layer AVC picture and macro block frame/field modes [17], [18] can be directly reused in a multilayer approach. To ensure inter-layer bridges between progressive and interlaced data an inter-layer prediction (for spatial and fidelity scalability) must incorporate new conversion mechanisms.

This paper discusses the key concepts of spatial scalability within the SVC extension. Although the earlier designs were mainly not successful in terms of industry adoption, this project is the fourth in a historical series of efforts to standardize spatially SVC schemes (after prior efforts in MPEG-2 [19], [20], H.263 Annex O [21], and MPEG-4 part 2 [22]).

The Scalable Video Coding (SVC) [23], [24] standard as an extension of H.264/AVC [25], [26] provides an efficient, standard-based scalability of temporal, spatial, and quality resolution of a decoded video signal through adaptation of the bit stream.

Since terminals usually vary in display resolution and processing power capabilities according to their evolution state and category. The capability of end-user devices motivates for scalability of the media.

SVC has been an active study and standardization area for at least 20 years. Scalable Video Coding (SVC) is a highly attractive solution to the problems posed by the characteristics of modern video transmission systems. The former international video coding standards H.262 MPEG-2 Video [27], H.263 [28], and MPEG-4 Visual [29] already include several tools by which the most important scalability modes can be supported.

SVC is an extension of the AVC standard [30], [31], adding spatial and fidelity [or signal-to-noise ratio (SNR)] scalability features [32].

Here in this paper, it shows a summary analysis of introduction, architecture, classification of scalability & application of SVC. It also reflects including elements being drafted right now to most current work of the SVC. The rest of this paper is organized as follows. In section II, we focus on SVC architecture, in section III, focus on classifications of scalability. In section IV and V, we conclude with applications and conclusion.

II- Architecture of SVC

SVC compression and adaptation technology was developed for a variety of usage scenarios [33], [34]. These include video broadcast/unicast, video conferencing and surveillance. A single stream can be used to serve all end-users by using scalable video coding as enabled by SVC. Adaptation can be performed at the server but also in the network (e.g., at media gateways) in order to tailor the video stream according to the specific usage requirements.

The architecture comprises of a client, a server and, an adaptation node in between of these two.

• The client collects user context and requests multimedia content to the adaptation node.
• The adaptation node relays the media requests to the server (or another adaptation node), receives and adapts the media units and finally sends them to the client.
• The server fulfills requests from the adaptation node. It reads media packets and metadata from either a storage area or from a live encoder that produces scalable media packets and associated metadata on the fly.

![Figure 1. Architecture for live encoding and transmission of SVC video](image-url)
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Other than the above protocol standards, the architecture also supports a simpler scenario; it consists only in an audio and a video stream, coming from a live source. Here, the task of the adaptation node is simplified and generally includes in relaying, with adaptation, a multicast live session to several unicast sessions.

However, the media of each unicast session are personalized according to each bandwidth and terminal context. Fig. 1 shows the usage of a live encoder integrated with the server. The audiovisual stream is multicast to the adaptation node that relays it with specific adaptation parameters (e.g., lower quality or frame rate) to multiple clients through unicast connections.

The SVC extension of H.264/AVC provides a mechanism for reusing an encoded lower resolution version of an image sequence for the coding of a corresponding higher resolution sequence.

III- Types of Scalable

The provision of scalability is an important feature of SVC is at the bit stream level and the bit streams can be simply obtained by disposing NAL units from a global SVC bitstream. The SVC specification defines three scalable profiles. The Scalable Baseline Profile specifies that the base layer must conform to the restricted Baseline Profile and that only restricted spatial scalability configurations are supported. With the Scalable High Profile, a High Profile compliant base layer and fully ESS are supported. The Scalable High Intra Profile consists of the same tools as Scalable High, but is constrained to the coding of IDR pictures.

For supporting temporal, spatial, and quality scalable coding a brief overview of the basic concepts in SVC is given as under:

A. Temporal Scalability

H.264/AVC provides high litheness in the obligation of reference pictures for motion compensated forecast. Temporal scalable coding can be efficiently provided by using hierarchical coding structures with B- or P-pictures [35], [36]. The pictures of the temporal base layer are only forecasted from previous pictures of this layer. The enhancement layer pictures can be bi-directionally predicted by using the two contiguous pictures of a lower temporal layer as references.

Among the base layer representation and the previous base layer representation a picture of the temporal base layer and all temporal refinement pictures build a group of pictures (GOP). However, it enables temporal scalability, the hierarchical prediction structures usually also provide an improved coding efficiency as compared to classical IBBP coding. One of the ways to control the delay in the coding of the hierarchical structures can be by restricting the motion-compensated prediction from pictures of the future.

In general, the size of the GOP or even the prediction configuration can differ over time if projected, e.g., in order to make the efficiency of the coding to rise. However, this might restrict the degree of temporal scalability supported by the stream.

B. Spatial and Coarse-Grain Quality Scalability

As spatial scalability is achieved by using a multilayer approach. The pictures of different spatial layers are coded with layer-specific prediction information and motion parameters. Switchable inter-layer prediction mechanisms have been developed in order to improve the enhancement layer coding efficiency in comparison to simulcast. Which information of the reference layer is exploited for efficient enhancement layer coding can be freely chosen by an encoder.

Each layer can be decoded with a single motion-compensation loop by using SVC. It is the role of the employed inter-layer prediction to ensure that the computationally complex operations of motion-compensated prediction and de-blocking (with the exception of intra-coded blocks) only have to be applied in the target layer, which then corresponds to the output pictures. With the exception of intra-coded macro block that are used for inter-layer prediction, decoded samples of lower layers do not need to be reconstructed. The single-loop decoding feature of SVC is especially important for the case of successive layers of equal spatial resolution (CGS/MGS).

1) Inter-Layer Motion Prediction: The development of new macro block type is to employ motion data from a lower layer for the coding of spatial enhancement layers. This macro block type is also known as reference layer skip mode and it specifies that the forecasted data are completely derived from the reference layer and that only an enhancement of the left over signal is determined. When the derived prediction mode specifies inter-picture coding, the macro block partitioning is determined by up-
sampling and realigning the partitioning of the reference layer region that covers the same picture area as the macro block to be coded. We can see a simple example of dyadic spatial scalability without cropping, each enhancement layer macro block corresponds to an 8 *8 sub-macro block in the reference layer, and so in this way the enhancement layer partitioning macro block is obtained by scaling the partitioning of the 8* 8 base layer block by a factor of 2 in both vertical and horizontal directions.

2) Inter-Layer Residual Prediction: A flag signals the usage of inter-layer residual prediction which is transmitted on a macro block basis. When this flag is true, the corresponding reference layer residual signal is up-sampled and then it is used as a prediction for the residual signal of the current macro block, so that only the corresponding difference signal is coded. The up-sampling of the reference layer residual is processed on a transform block basis in order to make sure that no filtering is applied across transform block boundaries, which could bring on visually disturbing signal components.

3) Inter-Layer Intra Prediction: The prediction signal is generated by up-sampling the co-located reconstructed intra signal of the reference layer, when a macro block is coded using the reference layer skip mode and the derived prediction mode specifies intra-picture coding. This inter-layer intra prediction is the only prediction mode for spatial scalable coding that was already supported in the earlier standards that supported spatial scalable coding [6]–[9].

C. Medium-Grain Quality Scalability
as described in Section II-B (CGS), the quality scalability based on the dependency identifier, provides only limited granularity, since switching between CGS layers (and spatial layers) is only supported at IDR pictures. SVC provides the chance to use the quality identifier for quality refinements so as to enhance the granularity for quality scalable coding,

This method is known to as medium-grain quality scalability and it also allows bit stream adaptation and a NAL unit basis; but it requires a concept for controlling the associated drift. The main cause for the relatively reduced performance of the fine-granular quality scalability in MPEG-4 Visual is that the motion-compensated prediction is only done in the base layer. However, motion-compensated prediction is always employed using the enhancement layer reconstruction as reference in the quality scalable mode of MPEG-2 Video, This ensures reduced complexity and a increased coding efficiency for the enhancement layer, but introduces significant drift when enhancement layer information gets vanished.

IV- APPLICATIONS
Considering the needs of today’s and future video applications as well as the experiences with scalable profiles in the past, the success of any future SVC standard critically depends on the following essential requirements.
• Similar coding efficiency compared to single-layer coding—for each subset of the scalable bit stream.
• Little increase in decoding complexity compared to single layer decoding that scales with the decoded spatio–temporal resolution and bit rate.
• Support of temporal, spatial, and quality scalability.
• Support of a backward compatible base layer (H.264/AVC in this case).
• Support of simple bit stream adaptations after encoding.

In any case, the coding efficiency of scalable coding should be clearly superior to that of “simulcasting” the supported spatio–temporal resolutions and bit rates in separate bit streams.

In comparison to single-layer coding, bit rate increases of 10% to 50% for the same fidelity might be tolerable depending on the specific needs of an application and the supported degree of scalability.

VII- CONCLUSION
In comparison to the scalable profiles of prior video coding standards, the H.264/AVC extension for SVC provides various tools for reducing the loss in coding efficiency relative to single layer coding.

These new features provide SVC with a competitive rate-distortion performance while only requiring a single motion compensation loop at the decoder side.

Although SVC coding shares the common hybrid video coding structure with previous standards, there are significant differences that provide substantial coding gains. SVC promises some significant advances of the state-of-the-art of standardized video coding in mobile applications.
In addition to excellent coding efficiency, the design of SVC also takes into account network adaptation providing large flexibility for its use in wireless applications.

REFERENCES


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