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| *Title:* | **Update of JCTVC-O0115 on a pipeline and parallel architecture of an SHVC decoder** | | |
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# Abstract

This contribution provides an update of contribution JCTVC-O0115 that provides a complete implementation of the SHVC decoder under the *GPAC* player. The SHVC decoder is based on the open source software *OpenHEVC*, which implements a conforming HEVC decoder. A parallel processing architecture is proposed to reduce both the decoding time and the latency of the SHVC decoder. The proposed solution combines the high level parallel processing solutions defined in the HEVC standard with an extension of the frame-based parallelism. The latter solution enables the decoding of several spatial and temporal SHVC frames in parallel to enhance both decoding frame rate and latency. The wavefront parallel processing solution is used for more coarse level of granularity..

The proposed hybrid parallel processing approach achieves a near optimal speedup and provides a good trade-off between decoding time, latency and memory usage. On a 6 cores Xeon processor, the parallel SHVC decoder performs a real time decoding of 1600p60 video resolution.

# Introduction

The scalable extension of the High Efficiency Video Coding (HEVC) is currently being defined jointly by the ITU-T Video Coding Experts Group and the ISO/IEC Moving Picture Experts Group [1]. At the 13th Meeting in Incheon, only the “reference index based” method was selected and implemented in the SHVC test model (SHM-3) [2]. In this contribution we provide a pipeline and parallel architecture for the “reference index based” SHVC decoder. The proposed real time SHVC decoder is based on the *OpenHEVC* software, which implements a conforming HEVC decoder.

In the case of spatial scalability with two layers (base layer and enhancement layer), the SHVC decoder uses two instances of the *OpenHEVC* decoder [3], one for each layer. The first *OpenHEVC* instance decodes the base layer frame and feeds the second instance with the decoded base layer (BL) frame and its motion vectors (MVs). The second *OpenHEVC* decoder decodes the enhancement layer (EL) frame with using the up-sampled base layer picture as an additional reference picture for inter-layer prediction.

The OpenHEVC decoder performing the decoding of each SHVC layer was extended to support the high level parallel processing solutions, including the wavefront solution. Therefore, each layer can be decoded in parallel with the wavefront approach to improve both the decoding frame rate and the frame latency. To overcome with the wavefront solution limitations and increase the parallelization efficiency, a second level of parallelism (frame-based) is introduced to the SHVC decoder. The idea behind this hybrid approach is to decode several spatial and temporal frames in parallel (frame-based solution) and decode each frame in wavefront associated with a low number of threads. This enables to take advantage of the wavefront approach at its near optimal configuration (ie. number of threads is below 4). Moreover, the inactive threads waiting for both WPP and motion compensation dependencies can be used to decode other frames waiting for available threads. Figure 1 illustrates the frame-based parallelism approach in the SHVC decoder decoding two spatial scalability layers. Indeed, several spatial and temporal frames are decoded in parallel under the restriction that the motion compensation dependencies are satisfied. The BL and the EL frames of the same temporal representation are simultaneously processed, which enhances both decoding frame rate and the SHVC frame latency. Since the inter-layer prediction is performed at the PU level, the BL and the EL frame can be simultaneously decoded with a control process to ensure that the PU used for inter-layer prediction is decoded at the BL decoder. The same communication process is used to decode two frames belonging to the same quality layer and different temporal representation to increase only the frame rate. This hybrid parallel processing solution combining the wavefront and the frame-based solutions in the SHVC decoder takes advantage of both solutions to improve the parallelism efficiency and reduce the decoding latency.

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Figure 1 – Frame-based parallelism for a real time SHVC decoder

# Experimental results

To assess the performance of the SHVC decoder, the HEVC test video sequences were encoded with SHVC reference software [4] in two spatial scalability configurations: x2 and x1.5. To show the decoder performance for larger video resolution, we added to the test sequences two 3840x2160 video sequences from the STV High Definition Multi Format Test Set. The SHVC video sequences were coded in low delay coding configuration, which is widely adopted in video streaming applications. The quantization parameter (QP) of the base layer was set to 27 and 32, while the QP of the enhancement layer is equal to the base layer QP minus 2. We consider n the number of decoding threads used for the wavefront solution, and m the number of thread used for the frame-based parallelism at each layer. To assess the performance of the hybrid parallel processing solution, we compare the performance of three decoding configurations: (n, m) {(6, 1), (1, 3), (2, 2)}. Table 1 gives the average bitrate of the BL and EL for the considered video sequences. Table 1 gives the average bitrate of the BL and EL for the considered video sequences.

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| Configurations | | BL bitrate (Kbps) | EL bitrate (Kbps) |
| QP | EL resolutions |
| 32 | 1920x1080 | 1645 | 3318 |
| 2560x1600 | 4908 | 11788 |
| 3840x2160 | 13615 | 34162 |
| 27 | 1920x1080 | 2961 | 9539 |
| 2560x1600 | 9249 | 24196 |
| 3840x2160 | 29754 | 80262 |

Table 1 – Average bitrate of the SHVC bitstream of the considered video sequences

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| --- | --- | --- | --- | --- |
| Configurations | | Decoding configurations (n, m) | | |
| (6,1) | (1,3) | (2,2) |
| Speedup | x2 | 3.33 | 2.95 | 4.8 |
| x1,5 | 3.6 | 2.75 | 5 |
| Decoding frame rate (fps) | x2 | 48 | 44 | 70 |
| x1,5 | 48 | 40 | 69 |

Table 2 – Average bitrate of the SHVC bitstream of the considered video sequences

Table 2 illustrates the performance of the three considered decoding configurations in terms of speedup, decoding frame rate. The hybrid parallel processing solution achieves the highest speedup of 4.8 and 5 for x2 and x1 scalable configurations, respectively. The speedup of the wavefront parallelism ((n,m) =(6, 1) ) is decreased by the wavefront limitations, especially for small video resolutions. The high speedup performance of the hybrid parallel processing solution considerably increases the decoding frame rate, which is in average around 70 frames per second (fps), instead of 48 fps and 40 fps for the wavefront and the frame-based parallelism configurations, respectively.

# Conclusion

In this contribution we provided an update of JCTVC-O0115 of a pipeline and parallel architecture of an SHVC decoder. This implementation enables two levels of parallelism by decoding the BL and EL frames on separate threads and the decoding of each layer in performed in parallel through the wavefront parallel processing solution.

The real time SHVC decoder is being integrated in the GPAC player [5] witch parses the MP4 fileformat and enabling to switch between tracks corresponding to the base layer and the enhancement layer. GPAC allows also to separate video tracks into separate PIDs, one for each layer.

# Acknowledgement

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# References

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# Patent rights declaration(s)

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