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| Question: | 6/21 (VCEG) |
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| Title: | **Unification of lossless coding methods in H.BWC** |
| Purpose: | Proposal  |

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# Abstract

In the current version of H.BWC, multiple tools are supported which can be used for lossless coding. Some of these tools, such as the linear mean squared error (LMS) predictor, operate in the DCT-II domain and can only be activated when the syntax element lms\_lpc\_flag is equal to 1. On the other hand, for example the block-matching predictor, is only accessible when the syntax element lms\_lpc\_flag equals 0. There are even coding tools, such as linear predictive coding (LPC) tool, that are duplicates, meaning that there is a variant of it available when the syntax element lms\_lpc\_flag is set to 0 or 1. Finally, when the syntax element lms\_lpc\_flag equals 1, Huffman entropy coding is used, while the tools accessible with the syntax element lms\_lpc\_flag equals 0 are operating in combination with Context Based Adaptive Binary Arithmetic Coding (CABAC).

It is asserted that with the technology proposed in CE 4 and CE 5, some of the abovementioned coding tools are combined and unified: It is proposed in CE-4 and CE-5 that the LMS prediction mode can be combined with all other prediction modes of the current H.BWC and that a single entropy coding path for the coding of the DCT-II transform coefficients is supported.

In this input contribution, it is proposed to strive for similar unifications also in the case of the coding tools of the current H.BWC that were primarily designed to be applied for lossless compression. Specifically, it is firstly proposed to replace Huffman coding by CABAC entropy coding throughout the codec. Thus, besides from what is proposed in CE 4 and CE 5, it is proposed to remove the Huffman coding also for transform skip (which means no trigonometric transform) coefficient coding and to replace it by CABAC coding. Secondly, it is proposed to support only a single variant of LPC.

Furthermore, as an independent aspect, it is observed that, for lossless compression, the current H.BWC lacks a proper functionality to efficiently handle input data which are integral multiples of an integral power of two greater than one (and thus have zero least significant bits). Consequently, it is proposed to study solutions that address this problem in the next round of CEs.

It is asserted that the targeted lossless codec would be conceptually leaner compared to the current version of H.BWC. Preliminary experimental results for a software that incorporates a first variant of the envisioned unification scheme show significant reduction in bitrate for some of the CTC datasets. Additionally, the encoder runtimes indicate results that are favorable to the proposed lossless coding scheme.

It is proposed to investigate the outlined changes in a Core Experiment.

# Preliminary experimental results

The experimental results presented below were generated by using the software SW-v2 from CE-4 and CE-5 as a starting point. On top of this, the software was further modified as follows:

* Huffman.Coding for transform skip coefficients was replaced by the CABAC entropy coding for transform skip coefficients supported in the current H.BWC.
* For LPC prediction, only the variant associated to lms\_lpc\_flag=1 was invoked.
* On each block, the number of zero least significant bits was detected and transmitted. If this number was greater than zero, the input signal was down-shifted at the encoder before coding and the reconstructed signal was up-shifted at the decoder as the last step to generate the final reconstruction.

The following experimental results are reported over H.BWC, version 2:

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|  | **Lossless Compression** |
|  | **Over BWC-2.1** |
|  | BR-R | EncT | DecT |
| MIT (ECG) | 0,05% | 58% | 71% |
| INCART (ECG) | -20,04% | 40% | 53% |
| CHBMIT (EEG) | -3,28% | 55% | 116% |
| NMR55 (EEG) | -3,83% | 33% | 68% |
| NMR57 (EEG) | -7,15% | 30% | 144% |
| Ozdemir (EMG) | 0,20% | 72% | 121% |
| **Overall**  | -5,68% | 48% | 95% |

The software to generate these results can be found as a zip file attached to this document.

# Proposed core experiments

The following core experiments are proposed, where more details are expected to be contained in the final CE description.

## Unifying LPC coding

It is proposed to support a single variant of linear predictive coding. From a decoder perspective, this means that there should only be one syntax and semantics to decode the LPC weights and to perform the LPC prediction. The LPC process associated to lms\_lpc\_flag equal to one is proposed to be the starting point, were further refinements to it that are potentially beneficial within the new harmonized design shall be investigated.

## Replacing Huffman coding with CABAC entropy coding for transform skip coefficient coding

For the coding of transform skip (no trigonometric transform) coefficients, it is proposed to always use the CABAC entropy coding version supported for transform skip coefficient coding in the current H.BWC and to entirely remove the Huffman coding version. It is proposed to test modifications of the current CABAC entropy coding for transform skip coefficients that might potentially be beneficial due to potential changes of the H.BWC design that might occur as an outcoume of this meeting.

## Bypassing zero LSBs

It is proposed to test technologies that incorporate a down-shifting of the input at the encoder coupled with an up-shifting of the final output at the decoder for suitable input signals on a suitable granularity.

# Conclusion

This document outlines a design for a unification of lossless coding in H.BWC. The preliminary results indicate that the proposed modifications bring significant benefit in terms of bitrate savings and are favorable in terms of encoding runtimes. Hence, it is proposed to further investigate these ideas and potential further improvements in a Core Experiment.

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