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| --- | --- | --- | --- |
| *Title:* | **Adaptation Parameter Set for SHVC** | | |
| *Status:* | Input Document | | |
| *Purpose:* | Proposal | | |
| *Author(s) or Contact(s):* | Yong He, Jie Dong, Yan Ye 9710 Scranton R-D, #250  San Diego, CA 92121  USA | Tel: Email: | 1-858-210-4807 Yong.He@InterDigital.com |
| *Source:* | InterDigital Communications, Inc. | | |

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# Abstract

This contribution is a follow-up of JCTVC-M0179. It is proposed to use Adaptation Parameter Set (APS) to carry picture level parameter information to support scalable extension of HEVC. The syntax elements of inter-layer processing, such as inter-layer filtering coefficients, sample prediction and motion prediction syntax elements are proposed to be signaled in APS instead of slice header to save bits and keep the existing slice header syntax intact. The APS syntax, semantic and simulation results are provided in this contribution.

# Introduction

At the 13th JCTVC Incheon meeting, SCE3 was established to evaluate inter-layer filtering tools for SHVC. Currently, the parameters of adaptive filters are designed to be signaled in PPS or slice header, depending on individual implementation. Additional syntax elements need to be added to the PPS or slice header to support these tools.

In general, VPS is used to hold the syntax elements shared by multiple layers and/or essential information for the purpose of capability exchange and session negotiation. The SPS carries the information common to all pictures/slices in a coded video sequence. The PPS carries the picture level information which does not need frequent updates and remains unchanged through a relative long duration of pictures. Slice header usually carries the parameters that change on the slice level, while the overhead bit cost is higher, especially when multiple slices are used to code a picture.

Adaptation parameter set (APS) was adopted in early versions of HEVC to carry picture level adaptive data, such as ALF and SAO parameters, that usually change more frequently than those carried in PPS. The characteristic of APS could be a good match to signal the inter-layer processing parameters. In addition, APS is defined as an individual NAL unit with unique NAL unit type assigned. The benefits of carrying the inter-layer processing information and parameters in a separate APS NAL unit are:

1. This allows parsing of the slice header syntax elements and decoding of the slice header to remain substantially similar to those of the single layer codec
2. This allows the BL codec, the ILP unit, and the EL codec to operate in a multi-threaded and parallelized manner.

# Proposed APS Format

Table 1 is the proposed general APS syntax structure. The 4-bit LSB of the picture order count for the picture associated with the current APS is used as the identification of the APS. Such identification is able to detect APS packet loss to improve the error resilience. In addition, it also helps to synchronize the APS with the corresponding picture to which the inter layer processing parameters are applied.

1. Adaptation parameter set RBSP syntax

|  |  |
| --- | --- |
| aps\_rbsp( ) { | Descriptor |
| **aps\_pic\_order\_cnt\_lsb** | u (4) |
| inter\_layer\_information() |  |
| **aps\_extension\_flag** | u (1) |
| if( aps\_extension\_flag ) |  |
| while( more\_rbsp\_data( ) ) |  |
| **aps\_extension\_data\_flag** | u (1) |
| rbsp\_trailing\_bits( ) |  |
| } |  |

**aps\_pic\_order\_cnt\_lsb** identifies the picture to which the inter layer processing information in the current adaptation parameter set is associated.

**aps\_extension\_flag** equal to 0 specifies that no aps\_extension\_data\_flag syntax elements are present in the adaptation parameter set RBSP syntax structure. aps\_extension\_flag shall be equal to 0 in bitstreams conforming to this Recommendation | International Standard. The value of 1 for aps\_extension\_flag is reserved for future use by ITU‑T | ISO/IEC. Decoders shall ignore all data that follow the value 1 for aps\_extension\_flag in an aps\_extension\_flag parameter set NAL unit.

**aps\_extension\_data\_flag** may have any value. Its value does not affect decoder conformance to profiles specified in this Recommendation | International Standard.

# APS Signaling for Chroma Sample Enhancement Filter

Chroma sample enhancement filter is an inter-layer filtering tool to improve the quality of chroma planes by using the information from the luma plane. Currently chroma enhancement filter is being evaluated in SCE3.4. The chroma enhancement filter is performed on a picture basis and the filter coefficients can change for every picture.

1. Chroma enhancement filter parameters syntax

|  |  |
| --- | --- |
| inter\_layer\_information ( ) { | Descriptor |
| **chroma\_cb\_filtering\_flag** | u (1) |
| if (chroma\_cb\_filtering\_flag) { |  |
| for (i = 0; i < number\_of\_coefficents; i++) |  |
| **chroma\_cb \_filter\_coefficients[i]** | u (4) |
| **chroma\_cb\_scaling\_factor\_abs\_minus1** | u (10) |
| **chroma\_cb\_scaling\_factor\_sign** | u (1) |
| **chroma\_cb \_shifting** | u (5) |
| } |  |
| **chroma\_cr\_filtering\_flag** | u (1) |
| if (chroma\_cr\_filtering\_flag) { |  |
| **chroma\_filter\_identical\_flag** |  |
| if (chroma\_filter\_identical\_flag == 0) { |  |
| for (i = 0; i < number\_of\_coefficents; i++) |  |
| **chroma\_cr\_filter\_coefficients[i]** | u (4) |
| **chroma\_cr\_scaling\_factor\_abs\_minus1** | u (10) |
| **chroma\_cr\_scaling\_factor\_sign** | u (1) |
| **chroma\_cr\_shifting** | u (5) |
| } |  |
| } |  |
| } |  |

is the syntax of chroma enhancement filter parameters proposed in SCE3 Test 3.4.1, included in the inter\_layer\_information() section of the proposed APS. The semantics associated with the syntax elements in are specified below.

**chroma\_cb\_filtering\_flag** specifies if the chroma enhancement filter for Cb is presented or not. When chroma\_cb\_filtering\_flag is set to 1, the corresponding chroma enhancement filter for Cb plane is presented.

**chroma\_cb\_scaling\_factor\_abs\_minus1** plus 1 and **chroma\_cb\_scaling\_factor\_sign** together specify the value of the variable CbScalingFactor as follows:

CbScalingFactor = (1–2 \* chroma\_cb\_scaling\_factor\_sign) \* (chroma\_cb\_scaling\_factor\_abs\_minus1+1)

The value of chroma\_cb\_scaling\_factor\_abs\_minus1 shall be in the range of 0 to 1023, inclusive.

**chroma\_cb\_shifting** is 5-bit right shifting factor used by chroma enhancement filter for Cb.

**chroma\_cb\_filter\_coefficients** are the chroma enhancement filter coefficients used for Cb.

**chroma\_cr\_filtering\_flag** specifies if the chroma enhancement filter for Cr is presented or not. When chroma\_cr\_filtering\_flag is set to 1, the corresponding chroma enhancement filter for Cr plane is presented.

**chroma\_filter\_identical\_flag** equal to 1 indicates the same chroma enhancement filter as for Cb is used forCr, and no additional parameters will be presented for Cr in the following bitstream

**chroma\_cr\_scaling\_factor\_abs\_minus1** plus 1 and **chroma\_cr\_scaling\_factor\_sign** together specify the value of the variable CrScalingFactor as follows:

CrScalingFactor = (1 – 2 \* chroma\_cr\_scaling\_factor\_sign) \* (chroma\_cr\_scaling\_factor\_abs\_minus1+1)

The value of chroma\_cr\_scaling\_factor\_abs\_minus1 shall be in the range of 0 to 1023, inclusive.

**chroma\_cr\_shifting** is 5-bit right shifting factor used by chroma enhancement filter for Cr.

**chroma\_cr\_filter\_coefficients** are the chroma enhancement filter coefficients used for Cr.

The number\_of\_coefficents of current chroma enhancement filter is 11.

The APS signaling to support chroma enhancement filters is implemented based on SCE3.4.1 chroma enhancement filter code. The results of chroma enhancement filtering performance using APS signaling are shown in Table 3 and Table 4. The anchor in Table 3 is the corresponding anchor data from SHM2.0, and the anchor in Table 4 is the SCE3.4.1 test results.

1. APS signaled SCE3.4.1 performance (anchor: SHM2.0)

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **AI HEVC 2x** | | | **AI HEVC 1.5x** | | |  |  |  |
|  | Y | U | V | Y | U | V |  |  |  |
| Class A | -0.9% | -7.8% | -6.2% |  |  |  |  |  |  |
| Class B | -0.8% | -6.3% | -8.4% | -0.7% | -8.2% | -10.4% |  |  |  |
| **Overall (Test vs Ref)** | -0.9% | -6.8% | -7.8% | -0.7% | -8.2% | -10.4% |  |  |  |
| **Overall (Test vs single layer)** | 11.8% | 7.3% | 6.1% | 9.7% | 1.1% | -1.1% |  |  |  |
| **Overall (Ref vs single layer)** | 12.8% | 14.9% | 14.6% | 10.5% | 9.8% | 9.3% |  |  |  |
| **EL only (Test vs Ref)** | -1.6% | -8.0% | -8.9% | -2.2% | -11.2% | -13.6% |  |  |  |
| Enc Time[%] | 114.3% | | | 108.8% | | |  |  |  |
| Dec Time[%] | 111.0% | | | 104.5% | | |  |  |  |
| BL Match | Matched | | | Matched | | |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  | **RA HEVC 2x** | | | **RA HEVC 1.5x** | | | **RA HEVC SNR** | | |
|  | Y | U | V | Y | U | V | Y | U | V |
| Class A | -0.5% | -11.3% | -7.7% |  |  |  | -0.4% | -9.0% | -5.2% |
| Class B | -0.3% | -8.1% | -9.7% | -0.3% | -10.4% | -11.9% | -0.3% | -7.6% | -8.2% |
| **Overall (Test vs Ref)** | -0.4% | -9.0% | -9.1% | -0.3% | -10.4% | -11.9% | -0.3% | -8.0% | -7.4% |
| **Overall (Test vs single layer)** | 18.8% | 20.9% | 20.4% | 15.9% | 15.7% | 14.6% | 14.0% | 21.4% | 24.6% |
| **Overall (Ref vs single layer)** | 19.2% | 33.3% | 32.0% | 16.2% | 28.8% | 29.1% | 14.4% | 32.1% | 34.1% |
| **EL only (Test vs Ref)** | -0.6% | -9.7% | -9.7% | -0.7% | -11.8% | -13.3% | -0.6% | -8.9% | -8.1% |
| Enc Time[%] | 118.2% | | | 123.9% | | | 126.3% | | |
| Dec Time[%] | 124.2% | | | 129.5% | | | 132.1% | | |
| BL Match | Matched | | | Matched | | | Matched | | |
|  |  |  |  |  |  |  |  |  |  |
|  | **LD-B HEVC 2x** | | | **LD-B HEVC 1.5x** | | | **LD-B HEVC SNR** | | |
|  | Y | U | V | Y | U | V | Y | U | V |
| Class A | -0.2% | -9.9% | -5.8% |  |  |  | -0.3% | -7.9% | -5.0% |
| Class B | -0.2% | -5.1% | -6.6% | -0.2% | -8.1% | -10.7% | -0.2% | -5.6% | -6.7% |
| **Overall (Test vs Ref)** | -0.2% | -6.5% | -6.4% | -0.2% | -8.1% | -10.7% | -0.3% | -6.3% | -6.2% |
| **Overall (Test vs single layer)** | 28.3% | 29.5% | 30.8% | 24.6% | 22.5% | 21.8% | 24.0% | 26.1% | 30.7% |
| **Overall (Ref vs single layer)** | 28.5% | 39.0% | 39.7% | 24.8% | 33.0% | 35.9% | 24.3% | 34.7% | 39.5% |
| **EL only (Test vs Ref)** | -0.3% | -6.7% | -6.5% | -0.4% | -8.7% | -11.3% | -0.4% | -6.8% | -6.7% |
| Enc Time[%] | 108.1% | | | 105.0% | | | 103.7% | | |
| Dec Time[%] | 109.2% | | | 108.5% | | | 105.3% | | |
| BL Match | Matched | | | Matched | | | Matched | | |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
| **Optional Tests** | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  |
|  | **LD-P HEVC 2x** | | | **LD-P HEVC 1.5x** | | | **LD-P HEVC SNR** | | |
|  | Y | U | V | Y | U | V | Y | U | V |
| Class A | -0.2% | -9.4% | -5.3% |  |  |  | -0.3% | -7.3% | -4.4% |
| Class B | -0.2% | -4.5% | -6.2% | -0.2% | -7.6% | -10.0% | -0.2% | -5.1% | -6.1% |
| **Overall (Test vs Ref)** | -0.2% | -5.9% | -6.0% | -0.2% | -7.6% | -10.0% | -0.2% | -5.7% | -5.6% |
| **Overall (Test vs single layer)** | 26.3% | 29.4% | 30.9% | 22.6% | 22.9% | 22.6% | 23.2% | 26.7% | 31.6% |
| **Overall (Ref vs single layer)** | 26.6% | 38.0% | 39.1% | 22.8% | 32.8% | 35.6% | 23.4% | 34.6% | 39.4% |
| **EL only (Test vs Ref)** | -0.3% | -6.2% | -6.1% | -0.5% | -8.4% | -10.6% | -0.3% | -6.2% | -6.0% |
| Enc Time[%] | 98.7% | | | 102.4% | | | 103.0% | | |
| Dec Time[%] | 97.3% | | | 103.1% | | | 103.3% | | |
| BL Match | Matched | | | Matched | | | Matched | | |

1. APS signaled SCE3.4.1 performance (anchor: SCE3.4.1)

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **AI HEVC 2x** | | | **AI HEVC 1.5x** | | |  |  |  |
|  | Y | U | V | Y | U | V |  |  |  |
| Class A | 0.0% | 0.0% | 0.0% |  |  |  |  |  |  |
| Class B | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |  |  |  |
| **Overall (Test vs Ref)** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |  |  |  |
| **Overall (Test vs single layer)** | 11.8% | 7.3% | 6.1% | 9.7% | 1.1% | -1.1% |  |  |  |
| **Overall (Ref vs single layer)** | 11.8% | 7.3% | 6.1% | 9.7% | 1.1% | -1.1% |  |  |  |
| **EL only (Test vs Ref)** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |  |  |  |
| BL Match | Matched | | | Matched | | |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  | **RA HEVC 2x** | | | **RA HEVC 1.5x** | | | **RA HEVC SNR** | | |
|  | Y | U | V | Y | U | V | Y | U | V |
| Class A | 0.0% | 0.0% | 0.0% |  |  |  | 0.0% | 0.0% | 0.0% |
| Class B | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| **Overall (Test vs Ref)** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| **Overall (Test vs single layer)** | 18.8% | 20.9% | 20.4% | 15.9% | 15.7% | 14.6% | 14.0% | 21.4% | 24.6% |
| **Overall (Ref vs single layer)** | 18.7% | 20.9% | 20.4% | 15.8% | 15.7% | 14.5% | 14.0% | 21.4% | 24.6% |
| **EL only (Test vs Ref)** | 0.1% | 0.0% | 0.0% | 0.1% | 0.1% | 0.1% | 0.0% | 0.0% | 0.0% |
| BL Match | Matched | | | Matched | | | Matched | | |
|  |  |  |  |  |  |  |  |  |  |
|  | **LD-B HEVC 2x** | | | **LD-B HEVC 1.5x** | | | **LD-B HEVC SNR** | | |
|  | Y | U | V | Y | U | V | Y | U | V |
| Class A | 0.0% | 0.0% | 0.0% |  |  |  | 0.0% | 0.0% | 0.0% |
| Class B | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| **Overall (Test vs Ref)** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| **Overall (Test vs single layer)** | 28.3% | 29.5% | 30.8% | 24.6% | 22.5% | 21.8% | 24.0% | 26.1% | 30.7% |
| **Overall (Ref vs single layer)** | 28.2% | 29.4% | 30.8% | 24.5% | 22.4% | 21.7% | 24.0% | 26.1% | 30.7% |
| **EL only (Test vs Ref)** | 0.0% | 0.0% | 0.0% | 0.1% | 0.1% | 0.1% | 0.0% | 0.0% | 0.0% |
| BL Match | Matched | | | Matched | | | Matched | | |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
| **Optional Tests** | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  |
|  | **LD-P HEVC 2x** | | | **LD-P HEVC 1.5x** | | | **LD-P HEVC SNR** | | |
|  | Y | U | V | Y | U | V | Y | U | V |
| Class A | 0.0% | 0.0% | 0.0% |  |  |  | 0.0% | 0.0% | 0.0% |
| Class B | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| **Overall (Test vs Ref)** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| **Overall (Test vs single layer)** | 26.3% | 29.4% | 30.9% | 22.6% | 22.9% | 22.6% | 23.2% | 26.7% | 31.6% |
| **Overall (Ref vs single layer)** | 26.3% | 29.4% | 30.9% | 22.5% | 22.9% | 22.5% | 23.1% | 26.7% | 31.6% |
| **EL only (Test vs Ref)** | 0.0% | 0.0% | 0.0% | 0.1% | 0.1% | 0.1% | 0.0% | 0.0% | 0.0% |
| BL Match | Matched | | | Matched | | | Matched | | |

# APS Signaling for sample and motion prediction syntax elements

For error resilience considerations, slice header is sent for every slice in the picture (unless it is a dependent slice). Because a picture may consist of multiple slices, the bit cost of slice header is more of a concern than the bit cost of other parameter sets such as SPS (Sequence parameter set) or PPS (Picture parameter set), which are usually sent less frequently.

In SHVC WD2 G.7.4.7.1, it specifies that the variables such as *NumActiveRefLayerPics, inter\_layer\_pred\_layer\_idc* and *collocated\_ref\_layer\_idx* shall be the same for all slices of a coded picture. Instead of the slice header, it may be beneficial to signal these syntax elements, such as *inter\_layer\_pred\_enable\_flag, num\_inter\_layer\_ref\_pics\_minus1, inter\_layer\_pred\_layer\_idc, inter\_layer\_sample\_pred\_only\_flag, alt\_collocated\_indicate\_flag* and *collocated\_ref\_layer\_idx*, in APS so that the same syntax won’t be duplicated for each slices within a picture. While at the same time, APS offers the flexibility to change the sample and motion prediction dynamically on the picture level.

Table 5 and Table 6 are the proposed APS syntax table and corresponding slice header syntax.

1. Proposed sample and motion prediction syntax in APS

|  |  |
| --- | --- |
| inter\_layer\_information ( ) { | **Descriptor** |
| NumActiveRefLayerPics = 0 |  |
| **inter\_layer\_pred\_enabled\_flag** | u(1) |
| if( inter\_layer\_pred\_enabled\_flag ) { |  |
| **num\_inter\_layer\_ref\_pics\_minus1** | u(v) |
| NumActiveRefLayerPics = num\_inter\_layer\_ref\_pics\_minus1 + 1 |  |
| for( i = 0; i < NumActiveRefLayerPics; i++ ) |  |
| **inter\_layer\_pred\_layer\_idc[**i ] | u(v) |
| } |  |
| if(NumActiveRefLayerPics > 0 ) |  |
| **inter\_layer\_sample\_pred\_only\_flag** | u(1) |
| if( nuh\_layer\_id > 0 ) |  |
| **alt\_collocated\_indication\_flag** | u(1) |
| if( alt\_collocated\_indication\_flag ) |  |
| **collocated\_ref\_layer\_idx** | ue(v) |
| else { |  |
| if( slice\_type = = B ) |  |
| **collocated\_from\_l0\_flag** | u(1) |
| if( ( collocated\_from\_l0\_flag && num\_ref\_idx\_l0\_active\_minus1 > 0 ) | |  ( !collocated\_from\_l0\_flag && num\_ref\_idx\_l1\_active\_minus1 > 0 ) ) |  |
| **collocated\_ref\_idx** | ue(v) |
| } |  |
| } |  |

1. Proposed slice segment header syntax

|  |  |
| --- | --- |
| slice\_segment\_header( ) { | Descriptor |
| **...** |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
| **...** |  |
| if( nuh\_layer\_id == 0 && slice\_temporal\_mvp\_enabled\_flag ) { |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
| if( slice\_type = = B ) |  |
| **collocated\_from\_l0\_flag** | u(1) |
| if( ( collocated\_from\_l0\_flag && num\_ref\_idx\_l0\_active\_minus1 > 0 ) | |  ( !collocated\_from\_l0\_flag && num\_ref\_idx\_l1\_active\_minus1 > 0 ) ) |  |
| **collocated\_ref\_idx** | ue(v) |
|  |  |
| } |  |
| **...** |  |
| } |  |

# Patent rights declaration(s)

**InterDigital Communications, Inc. may have current or pending patent rights relating to the technology described in this contribution and, conditioned on reciprocity, is prepared to grant licenses under reasonable and non-discriminatory terms as necessary for implementation of the resulting ITU-T Recommendation | ISO/IEC International Standard (per box 2 of the ITU-T/ITU-R/ISO/IEC patent statement and licensing declaration form).**