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| *Title:* | **MV-HEVC/SHVC HLS: On sharing parameter sets across layers** | | |
| *Status:* | Input Document to JCT-VC and JCT-3V | | |
| *Purpose:* | Proposal | | |
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# Abstract

This contribution presents three proposals regarding sharing parameter sets:

1. Restrict that sharing parameter sets (SPS/PPS) shall be used in the condition the parameter sets is direct or indirect reference layer of the layer.
2. Add a new direct\_dependency\_type to show sharing parameter set dependency in VPS.
3. Signal scaled reference layer offsets for multiple layers which refer the same SPS or Move scaled reference layer offsets into VPS like JCTVC-N0089.

It is asserted that the proposed changes can benefit on the following issues;

1. Avoid the improper removal of sharing parameter set in bitstream extraction.
2. Enable parameter sharing in case of pixel, motion or any other dependency is not utilized.
3. Enhance SPS sharing capability for Extended Spatial Scalability.

Revision r2 revised some typos on proposal 2.

# Introduction

Current high level syntax design allows multiple layers to refer to the same SPS or PPS. Omitting representation data in SPS by signalling representation format in VPS also enhances SPS sharing capability. However, there exists two issue regarding sharing parameter sets:

1. In sub bitstrem extraction, when NAL unit with the target nuh\_layer\_id or NAL unit with nuh\_layer\_id of direct or indirect reference of the the target layer, sharing SPS or PPS could be removed. It is because SPS or PPS can also be shared in case of no dependency between the layers of shared SPS and the referring layer.
2. In SPS extension, scaled reference layer offsets for only one layer with nuh\_layer\_id equal to the nuh\_layer\_id value of SPS are signalled so that when scaled reference layer offsets are present in SPS, different layers cannot refer the SPS. It restricts SPS sharing capability.

The situation on the first issue can be illustrated in Figure 1.

* 1. Layer0 is direct reference layer of Layer2.
  2. Parameter sets of Layer1 are shared among Layer1 and Layer2, but Layer 1 is not direct reference layer of Layer2.
  3. When extracting Layer2, parameter sets of Layer1 could be discarded.



Figure 1: Example case that the coded pictures with nuh\_layer\_id equal to LayerId2 are un-decodable since shared parameter sets with nuh\_layer\_id equal to LayerId1 are discarded through bitstream extraction process.

The first issue can be solved by Proposal 1 (adding a restriction that sharing parameter sets (SPS/PPS) shall be used in the condition the parameter sets is direct or indirect reference layer of the layer).

With the Proposal 1 change, it is not allowed to share the parameter sets if there are no direct dependency in sample dependency or motion dependency. Therefore, we additionally suggest to use Proposal 2, that is, to add new direct\_dependency\_type to show sharing parameter set dependency in VPS.

To solve the second issue, we also suggest to signal scaled reference layer offsets for multiple layers which refer the same SPS or move scaled reference layer offsets into VPS, which can enhance the SPS sharing capability for Extended Spatial Scalability.

# Proposal

## Proposal 1

The proposal adds the following restriction.

F.7.4.2.4 Order of VPS, SPS and PPS RBSPs and their activation

It is a requirement of bitstream conformance that, when an SPS with nuh\_layer\_id equal to nuhLayerIdA is active for a layer with nuh\_layer\_id equal to nuhLayerIdB, the layer with nuh\_layer\_id equal to nuhLayerIdA shall be a direct or indirect reference layer of the layer with nuh\_layer\_id equal to nuhLayerIdB.

It is a requirement of bitstream conformance that, when a PPS with nuh\_layer\_id equal to nuhLayerIdA is active for a layer with nuh\_layer\_id equal to nuhLayerIdB, the layer with nuh\_layer\_id equal to nuhLayerIdA shall be a direct or indirect reference layer of the layer with nuh\_layer\_id equal to nuhLayerIdB.

## Proposal 2

It is proposed to add new direct\_dependent\_type to indicate Non-VCL dependency which is mainly (currently only) used for parameter set dependency, including some editorial improvements.

If applies proposal2, proposal1 is modified as follows:

It is a requirement of bitstream conformance that, when an SPS with nuh\_layer\_id equal to nuhLayerIdA is active for a layer with nuh\_layer\_id equal to nuhLayerIdB, the layer with nuh\_layer\_id equal to nuhLayerIdA shall be a direct reference layer of the layer with nuh\_layer\_id equal to nuhLayerIdB and the direct dependency type between the two layers indicates non-VCL dependency.

It is a requirement of bitstream conformance that, when a PPS with nuh\_layer\_id equal to nuhLayerIdA is active for a layer with nuh\_layer\_id equal to nuhLayerIdB, the layer with nuh\_layer\_id equal to nuhLayerIdA shall be a direct reference layer of the layer with nuh\_layer\_id equal to nuhLayerIdB and the direct dependency type between the two layers indicates non-VCL dependency type.

Let the layer with nuh\_layer\_id equal to nuhLayerIdA have an index j. The direct dependency type between the two layers NonVCLDepEnabledFlag[ nuhLayerIdB ][ j ] shall be equal to 1.

Changes are highlighted in yellow, and both of removals and typos are stroke through in red.

**F.7.3.2.1.1 Video parameter set extension syntax**

|  |  |
| --- | --- |
| vps\_extension( ) { | Descriptor |
| …snipped…  // signal dependency type indicating that SPS/PPS having nuh\_layer\_id equal to layer\_id\_nuh[j] for the layer with layer\_id\_nuh[j] is directly referred by the layer with nuh\_layer\_id equal to layer\_id\_nuh[i] |  |
| **direct\_dep\_type\_len\_minus3** | ue(v) |
| for( i = 1; i <= vps\_max\_layers\_minus1; i++ ) |  |
| for( j = 0; j < i; j++ ) |  |
| if( direct\_dependency\_flag[ i ][ j ] ) |  |
| **direct\_dependency\_type**[ i ][ j ] | u(v) |
| …snipped… |  |
| } |  |

**F.7.4.3.1.1 Video parameter set extension semantics**

**direct\_dependency\_flag**[ i ][ j ] equal to 0 specifies that the layer with index j is not a direct reference layer for the layer with index i. direct\_dependency\_flag[ i ][ j ] equal to 1 specifies that the layer with index j may be a direct reference layer for the layer with index i. When direct\_dependency\_flag[ i ][ j ] is not present for i and j in the range of 0 to vps\_max\_layers\_minus1, it is inferred to be equal to 0.

…snipped…

**direct\_dep\_type\_len\_minus3~~2~~** plus 3~~2~~ specifies the number of bits of the direct\_dependency\_type[ i ][ j ] syntax element. In bitstreams conforming to this version of this Specification the value of direct\_dep\_type\_len\_minus3~~2~~ shall be equal 0. Although the value of direct\_dep\_type\_len\_minus3~~2~~ shall be equal to 0 in this version of this Specification, decoders shall allow other values of direct\_dep\_type\_len\_minus3~~2~~ in the range of 0 to 29~~30~~, inclusive, to appear in the syntax.

**direct\_dependency\_type**[ i ][ j ] indicates the type of dependency between the layer with nuh\_layer\_id equal layer\_id\_in\_nuh[ i ] and the layer with nuh\_layer\_id equal to layer\_id\_in\_nuh[ j ].

~~direct\_dependency\_type[ i ][ j ] equal to 0 indicates that the layer with nuh\_layer\_id equal to layer\_id\_in\_nuh[ j ] is used for inter-layer sample prediction but not for inter-layer motion prediction of the layer with nuh\_layer\_id equal layer\_id\_in\_nuh[ i ].   
direct\_dependency\_type[ i ][ j ] equal to 1 indicates that the layer with nuh\_layer\_id equal to layer\_id\_in\_nuh[ j ] is used for inter-layer motion prediction but not for inter-layer sample prediction of the layer with nuh\_layer\_id equal layer\_id\_in\_nuh[ i ].   
direct\_dependency\_type[ i ][ j ] equal to 2 indicates that the layer with nuh\_layer\_id equal to layer\_id\_in\_nuh[ j ] is used for both inter-layer sample motion prediction and inter-layer motion prediction of the layer with nuh\_layer\_id equal layer\_id\_in\_nuh[ i ].~~((direct\_dependency\_type[ i ][ j ] + 1) & 1) equal to 1 indicates that the layer with nuh\_layer\_id equal to layer\_id\_in\_nuh[ j ] is used for inter-layer sample prediction of the layer with nuh\_layer\_id equal layer\_id\_in\_nuh[ i ].   
(((direct\_dependency\_type[ i ][ j ] + 1) & 2) >> 1) equal to 1 indicates that the layer with nuh\_layer\_id equal to layer\_id\_in\_nuh[ j ] is used for inter-layer motion prediction of the layer with nuh\_layer\_id equal layer\_id\_in\_nuh[ i ].  
(((direct\_dependency\_type[ i ][ j ] + 1) & 4) >> 2) equal to 1 indicates that any parameter sets having nuh\_layer\_id with layer\_id\_in\_nuh[ j ] for the layer with nuh\_layer\_id equal to layer\_id\_in\_nuh[ j ] may be used as the parameter sets for the layer with nuh\_layer\_id equal to layer\_id\_in\_nuh[ i ].

Although the value of direct\_dependency\_type[ i ][ j ] shall be in the range of 0 to 6~~2~~, inclusive, in this version of this Specification, decoders shall allow values of direct\_dependency\_type[ i ][ j ] in the range of 7~~3~~ to 232 − 2, inclusive, to appear in the syntax.

[Ed. (GT/JB):May need to define semantic constraints associated with values of direct\_dependency\_type.]

The variables NumDirectRefLayers[ i ], RefLayerId[ i ][ j ] SamplePredEnabledFlag[ i ][ j ], MotionPredEnabledFlag[ i ][ j ], NonVCLDepEnabledFlag[ i ][ j ] and DirectRefLayerIdx[ i ][ j ] are derived as follows:

for( i = 0; i <= vps\_max\_layers\_minus1; i++ ) {  
 iNuhLId = layer\_id\_in\_nuh[ i ]  
 NumDirectRefLayers[ iNuhLId ] = 0  
 for( j = 0; j < i; j++ )  
 if( direct\_dependency\_flag[ i ][ j ] ) {  
 RefLayerId[ iNuhLId ][ NumDirectRefLayers[ iNuhLId ]++ ] = layer\_id\_in\_nuh[ j ]  
 SamplePredEnabledFlag[ iNuhLId ][ j ] = ( ( direct\_dependency\_type[ i ][ j ] + 1 ) & 1 )  
 MotionPredEnabledFlag[ iNuhLId ][ j ] = ( ( ( direct\_dependency\_type[ i ][ j ] + 1 ) & 2 ) >> 1 )  
 NonVCLDepEnabledFlag[ iNuhLId ][ j ] = ( ( ( direct\_dependecy\_type[ i ][ j ] + 1 ) & 4 ) >>2 )

DirectRefLayerIdx[ iNuhLid ][ layer\_id\_in\_nuh[ j ] ] = NumDirectRefLayers[ iNuhLId ] – 1 }  
}

## Proposal 3

It is proposed to signal scaled reference layer offsets for multiple layers which refer the same SPS.

Changes are highlighted in yellow.

F.7.3.2.2.1 Sequence parameter set extension syntax

|  |  |
| --- | --- |
| sps\_extension( ) { | **Descriptor** |
| … |  |
| **num\_layer\_id\_refering\_sps\_minus1** | ue(v) |
| for( k = 0; k < num\_layer\_id\_refering\_sps\_minus1; k++) { |  |
| if( k > 0 ){ | se(v) |
| **layer\_id\_refering\_sps[ k ]** | u(6) |
| LIdtoIdx[ layer\_id\_refering\_sps[ k ] ] = k |  |
| else{ |  |
| layer\_id\_refering\_sps[ 0 ] = nuh\_layer\_id |  |
| LIdtoIdx[ layer\_id\_refering\_sps[ k ] ] = 0 |  |
| } |  |
| **num\_scaled\_ref\_layer\_offsets**[ k ] | ue(v) |
| for( i = 0; i < num\_scaled\_ref\_layer\_offsets[ k ]; i++) { |  |
| **scaled\_ref\_layer\_left\_offset**[ k ][ i ] | se(v) |
| **scaled\_ref\_layer\_top\_offset**[ k ][ i ] | se(v) |
| **scaled\_ref\_layer\_right\_offset**[ k ][ i ] | se(v) |
| **scaled\_ref\_layer\_bottom\_offset**[ k ][ i ] | se(v) |
| **}** |  |
| **}** |  |
| **}** |  |

F.7.4.3.2.1 Sequence parameter set extension semantics

**num\_layer\_id\_refering\_sps\_minus1** plus 1 specifies the number of layers which refer the SPS.

**layer\_id\_refering\_sps[ k ]** specifies the nuh\_layer\_id of the layer which refers the SPS. When k is equal to 0, layer\_id\_refering\_sps[ 0 ] is equal to the nuh\_layer\_id value of the SPS.

**num\_scaled\_ref\_layer\_offsets**[ k ] specifies the number of sets of scaled reference layer offset parameters that are present in the SPS. The value of num\_scaled\_ref\_layer\_offsets[ k ] shall be in the range of 0 to 63, inclusive.

**scaled\_ref\_layer\_left\_offset**[ k ][ i ] specifies the horizontal offset between the top-left luma sample of the resampled i-th direct reference layer picture used for inter-layer prediction and the top-left luma sample of the current picture with nuh\_layer\_id equal to layer\_id\_refering\_sps[ k ] in units of two luma samples. When not present, the value of scaled\_ref\_layer\_left\_offset[ k ][ i ]is inferred to be equal to 0.

**scaled\_ref\_layer\_top\_offset**[ k ][ i ] specifies the vertical offset between the top-left luma sample of the resampled i-th direct reference layer picture used for inter-layer prediction and the top-left luma sample of the current picture with nuh\_layer\_id equal to layer\_id\_refering\_sps[ k ] in units of two luma samples. When not present, the value of scaled\_ref\_layer\_top\_offset[ k ][ i ] is inferred to be equal to 0.

**scaled\_ref\_layer\_right\_offset**[ k ][ i ] specifies the horizontal offset between the bottom-right luma sample of the resampled i-th direct reference layer picture used for inter-layer prediction and the bottom-right luma sample of the current picture with nuh\_layer\_id equal to layer\_id\_refering\_sps[ k ] in units of two luma samples. When not present, the value of scaled\_ref\_layer\_right\_offset[ k ][ i ] is inferred to be equal to 0.

**scaled\_ref\_layer\_bottom\_offset**[ k ][ i ] specifies the vertical offset between the bottom-right luma sample of the resampled i-th direct reference layer picture used for inter-layer prediction and the bottom-right luma sample of the current picture with nuh\_layer\_id equal to layer\_id\_refering\_sps[ k ] in units of two luma samples. When not present, the value of scaled\_ref\_layer\_bottom\_offset[ k ][ i ] is inferred to be equal to 0.

H.8.1.4 Resampling process for inter layer reference pictures

…

The variable currLayerId is set equal to nuh\_layer\_id of the current picture. The variable dRlIdx is set equal to DirectRefLayerIdx[ currLayerId ][ rLId ].

The variables ScaledRefLayerLeftOffset, ScaledRefLayerTopOffset, ScaledRefLayerRightOffset and ScaledRefLayerBottomOffset are derived as follows:

ScaledRefLayerLeftOffset = scaled\_ref\_layer\_left\_offset[ LIdtoIdx[ currLayerId ] ][ dRlIdx ] << 1 (H‑13)  
ScaledRefLayerTopOffset = scaled\_ref\_layer\_top\_offset[ LIdtoIdx[ currLayerId ] ][ dRlIdx] << 1 (H‑14)  
ScaledRefLayerRightOffset = scaled\_ref\_layer\_right\_offset[ LIdtoIdx[ currLayerId ] ][ dRlIdx ] << 1 (H‑15)  
ScaledRefLayerBottomOffset = scaled\_ref\_layer\_bottom\_offset[ LIdRtoIdx[ currLayerId ] ][ dRlIdx ] << 1 (H‑16)

…

# Conclusion

This contribution proposes two proposals.

1. Restrict sharing parameter sets (SPS/PPS) for direct or indirect reference layer.
2. Add new direct\_dependency\_type to show sharing parameter set dependency.
3. Signal scaled reference layer offsets for multiple layers which refer the same SPS or Move scaled reference layer offsets into VPS like JCTVC-N0089.

We think the first proposal is necessary for efficient bitstream extraction, and we also think the new direct dependency type is useful to accomplish sharing parameter set in case that any other dependency is not applied. We also suggest to signal scaled reference layer offsets for multiple layers which refer the same SPS or move scaled reference layer offsets into VPS, which can enhance the SPS sharing capability for Extended Spatial Scalability.

Therefore, it is recommended to adopt both of proposals to the next SHVC and MV-HEVC.

# Reference

1. J. Chen, et.al, “SHVC Draft 3”, JCTVC-N1008, Vienna, AT, 25 July–2 Aug. 2013.
2. G. Tech, et.al, “MV-HEVC Draft Text 5”, JCT3V-E1004, Vienna, AT, 27 July–2 Aug. 2013.
3. Y.-K. Wang, et.al, “MV-HEVC/SHVC HLS: On signalling of scaled reference layer offset”, JCTVC-N0089, Vienna, AT, 25 July-2 Aug. 2013.

# Patent rights declaration(s)

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