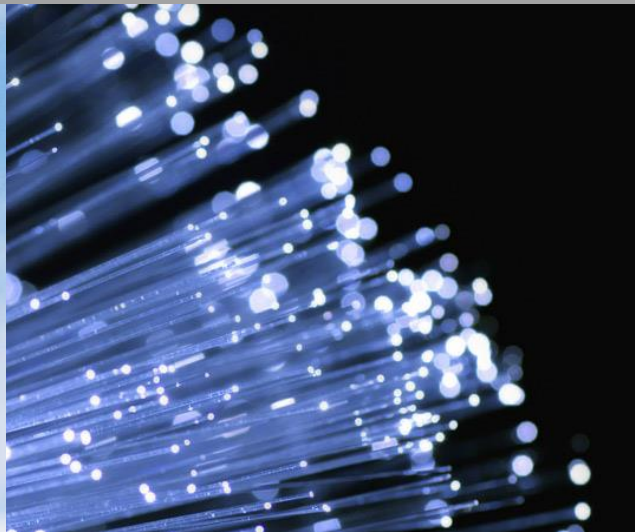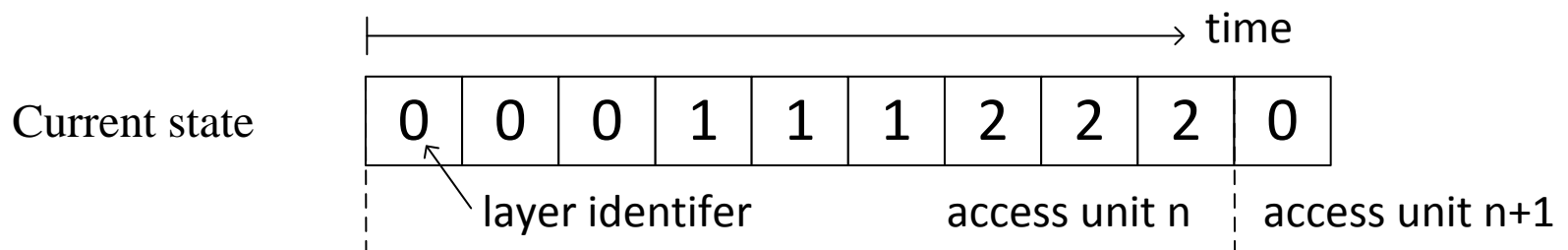# MV-HEVC/SHVC HLS: Ultra-low delay with SHVC, MV-HEVC and 3D-HEVC
JCTVC-N0290/JCT3V-E0098

Robert Skupin, Karsten Sühring, Yago Sanchez, Thomas Schierl

Problem Statement

- Ultra-low delay (ULD) operation of base HEVC based on spatial segmentation and DU based HRD operation.

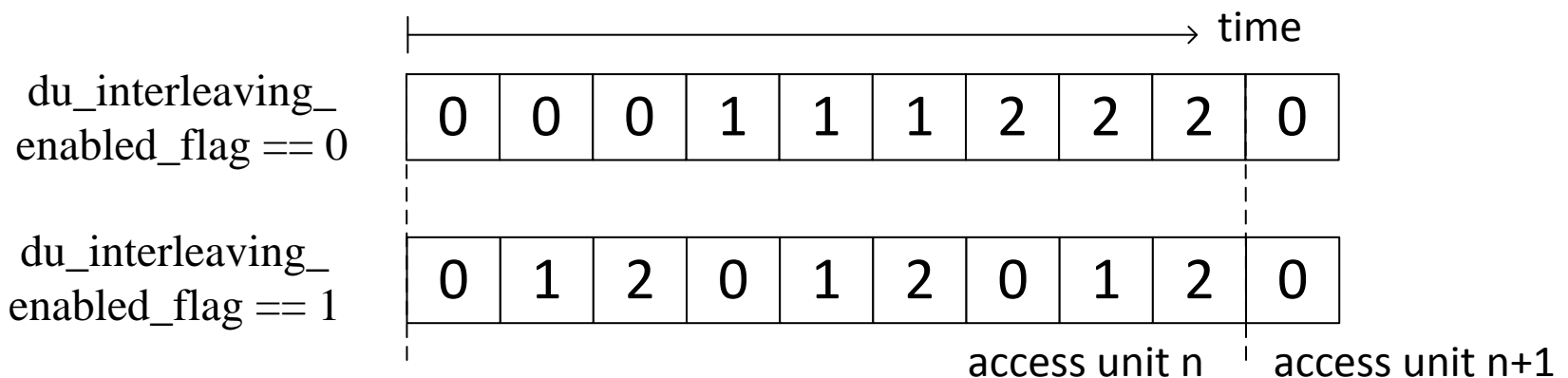- Current HEVC extension drafts disallow ULD operation: all DUs of layer n precede all DUs of layer (n+1)

Exemplary order of DUs within a 3 layer AU:

Current state → time

| 0 | 0 | 0 | 1 | 1 | 1 | 2 | 2 | 2 | 0 |

layer identifer   access unit n   access unit n+1

Proposal

- ULD operation with HEVC extensions requires appropriate

  - NAL unit bitstream order
  - HRD operation

  Control ULD mode through VPS extension flag:
  du_interleaving_enabled_flag

time →

| du_interleaving_enabled_flag == 0 | 0 | 0 | 0 | 1 | 1 | 1 | 2 | 2 | 2 | 0 |

| du_interleaving_enabled_flag == 1 | 0 | 1 | 2 | 0 | 1 | 2 | 0 | 1 | 2 | 0 |

access unit n   access unit n+1

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Proposal – NALU bitstream order

Complement current extension drafts

A coded picture with nuh_layer_id equal to nuhLayerIdA shall precede in decoding order all coded pictures with nuh_layer_id greater than nuhLayerIdA in the same access unit.
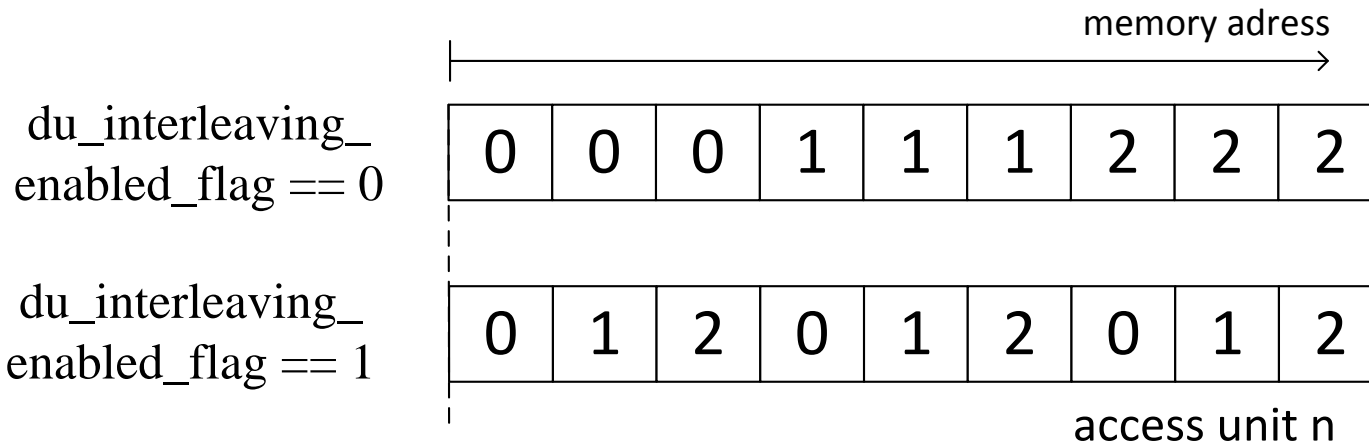
with highlighted text:

If du_interleaving_enabled_flag is equal to 0, all VCL NAL units of a ~~A~~ coded picture with nuh_layer_id equal to nuhLayerIdA shall precede in decoding order the VCL NAL units of all coded pictures with nuh_layer_id greater than nuhLayerIdA in the same access unit.

Otherwise (du_interleaving_enabled_flag is equal to 1), all VCL NAL units of decoding unit m with nuh_layer_id equal to nuhLayerIdA shall precede in decoding order all VCL NAL units of decoding unit n with nuh_layer_id greater than nuhLayerIdA in the same access unit for which the decoding process depends on syntax elements or decoded sample values that belong to the decoding unit m.
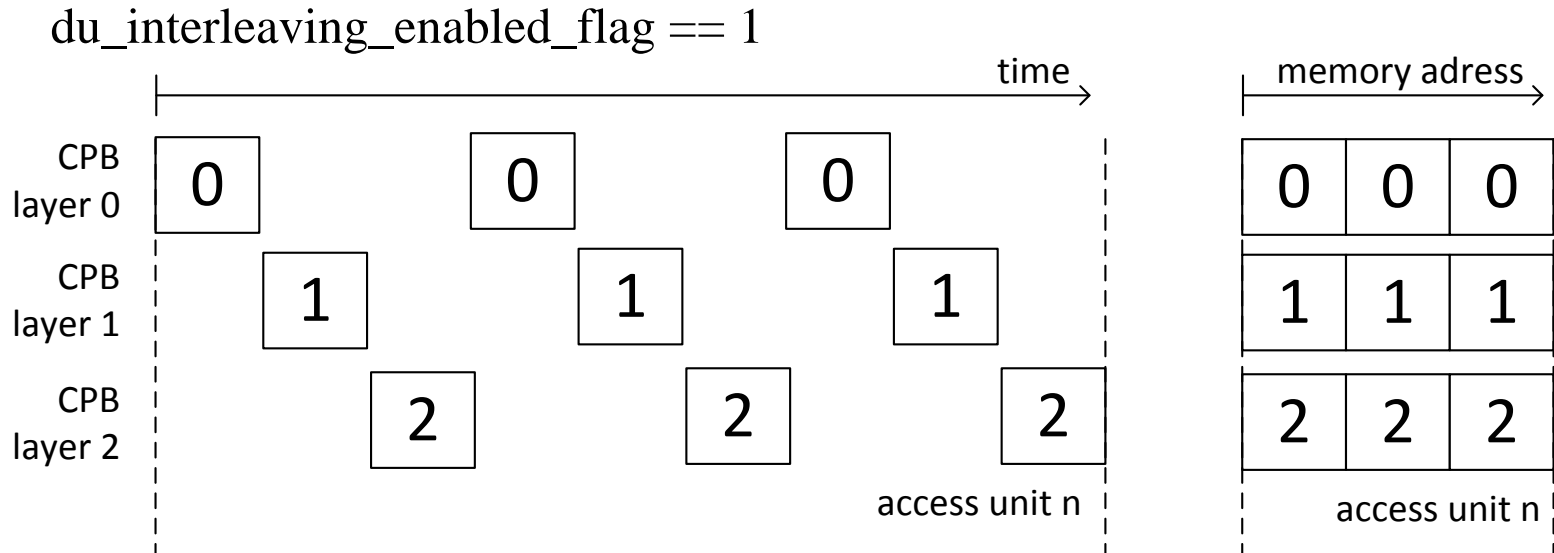
Proposal – HRD operation

In ULD mode:

- Decoding unit information SEI conveys DU CPB removal timings (du_interleaving_enabled_flag equal to 1)

- Incapable devices fall back to AU based operation.

- AU recombination with nuh_layer_id and NALU order as ordering constraint:
  - Single CPB: Non-consecutive memory access
  - Per-layer CPB: Consecutive layer-wise recombination

CPB layouts

Single CPB

du_interleaving_enabled_flag == 0

| 0 | 0 | 0 | 1 | 1 | 1 | 2 | 2 | 2 |

du_interleaving_enabled_flag == 1

| 0 | 1 | 2 | 0 | 1 | 2 | 0 | 1 | 2 |

memory adress

access unit n

Multiple CPBs

du_interleaving_enabled_flag == 1

time

CPB layer 0: 0 0 0
CPB layer 1: 1 1 1
CPB layer 2: 2 2 2

access unit n

memory adress

0	0	0
1	1	1
2	2	2

access unit n

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Summary

- Current HEVC extension drafts disallow ULD operation

- **Proposed modifications:**

  - Add ULD control flag du_interleaving_enabled_flag
  - Adjust bitstream order of DUs in ULD mode
  - AU based HRD operation as fall back
  - AU recombination based on nuh_layer_id and NALU order

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