



# CE8.c.2: Single-source SAO and ALF virtual boundary processing

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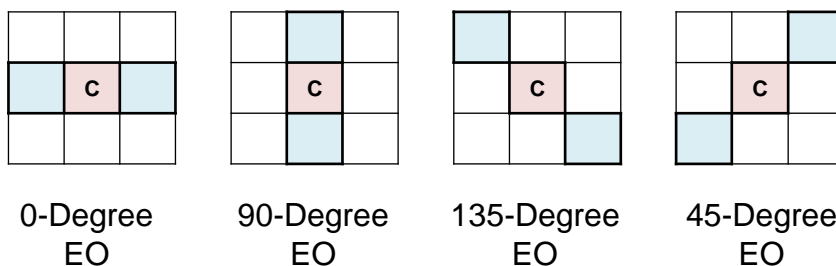
Presented by Yu-Wen Huang  
7<sup>th</sup> JCT-VC Meeting in Geneva  
21-30 November, 2011

# Overall Summary

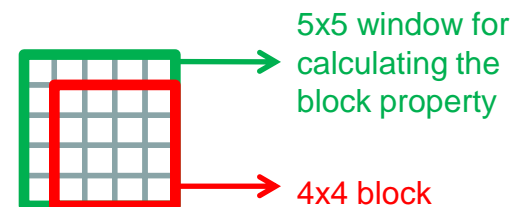
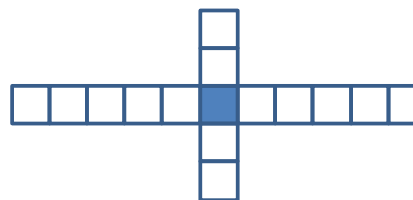
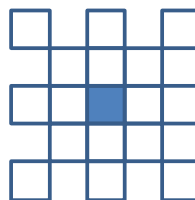
- In HM-4.0
  - SAO: 0.2 luma line, 0.2 chroma line
  - ALF: 4.1 luma lines, 4 chroma lines
- In the proposed virtual boundary (VB) processing
  - Luma VB: 4 pixels above the horizontal LCU boundary
  - Chroma VB: 2 pixels above the horizontal LCU boundary
  - Processing a pixel on one side of a VB does not use any pixel on the other side of the VB
  - Does not change SAO and ALF input pixels (single-source)
  - All SAO and ALF line buffers can be saved
  - 0.1-0.4% bit rate increase
  - No noticeable run time change
  - Slightly degraded visual quality

# Background Information

- Deblocking filter (DF)
  - Luma: read 4 pixels and write 3 pixels
  - Chroma: read 2 pixels and write 1 pixel
- Sample adaptive offset (SAO)
  - Edge offset (EO): need a 3x3 window for pixel classification

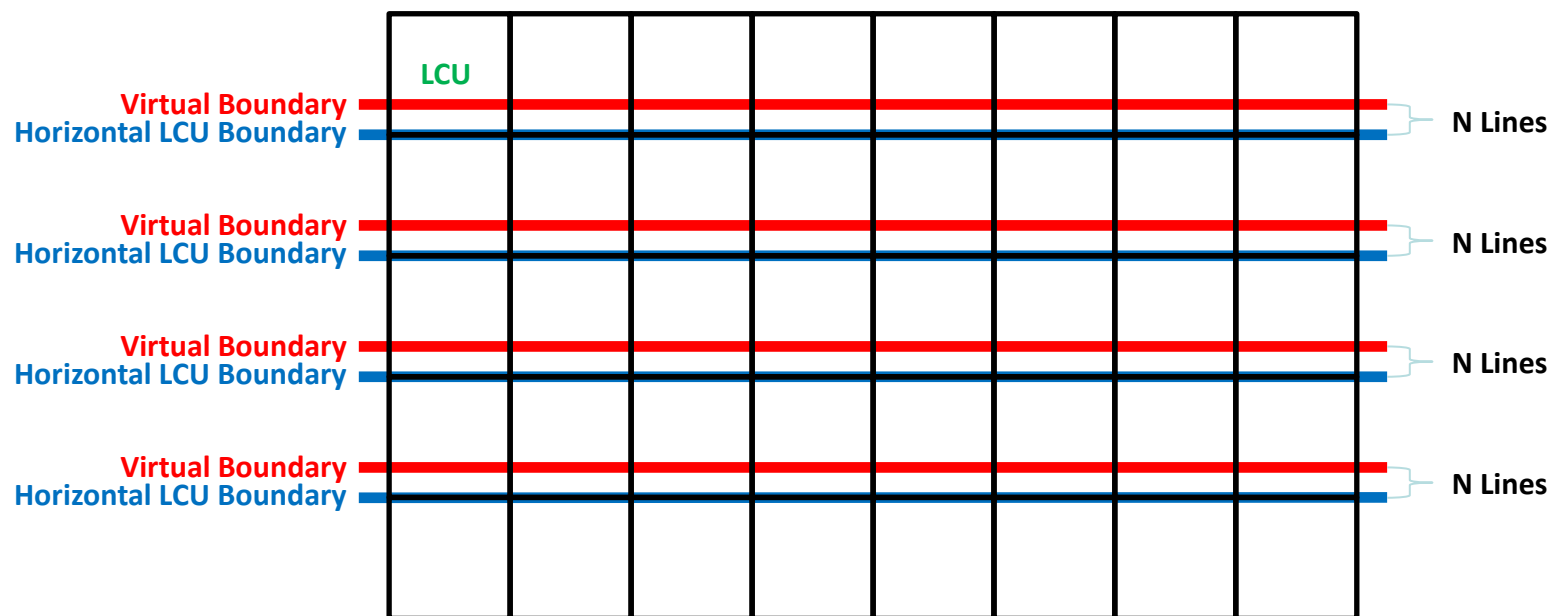


- Adaptive loop filter (ALF)
  - Calculate 4x4 block property for luma
  - Snowflake5x5
  - Cross11x5

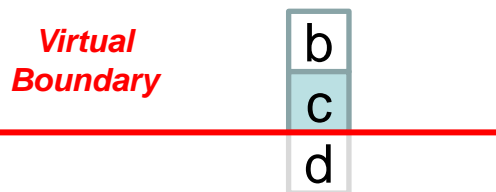


# Virtual Boundary (VB)

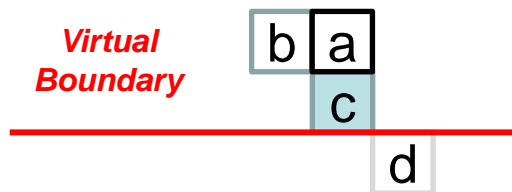
- $N=4$  for luma,  $N=2$  for chroma
- Processing a pixel on one side of a VB does not use any pixel on the other side of the VB



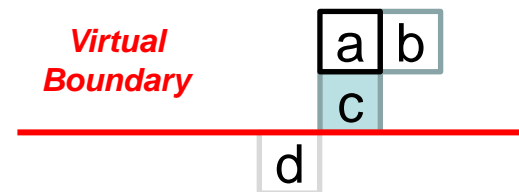
# SAO VB Processing



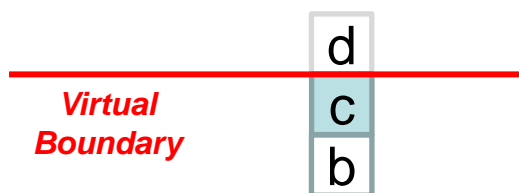
90-degree EO



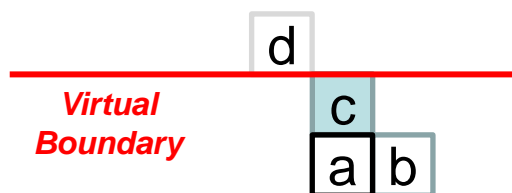
135-degree EO



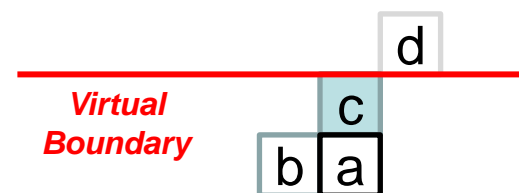
45-degree EO



90-degree EO



135-degree EO



45-degree EO

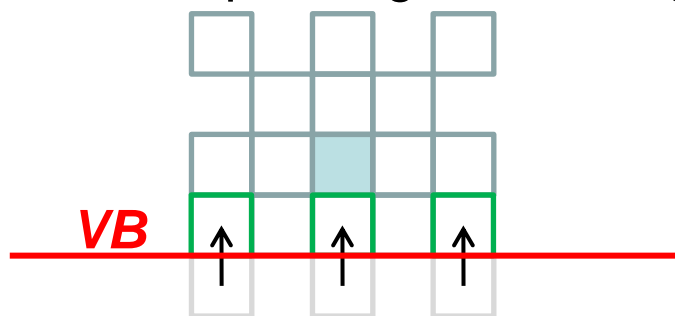
```

if ( ( |c-a| < TH ) && (sanity check is passed) )
    c uses b's offset
else
    c uses zero offset
  
```

# ALF VB Processing for Above-VB Pixels

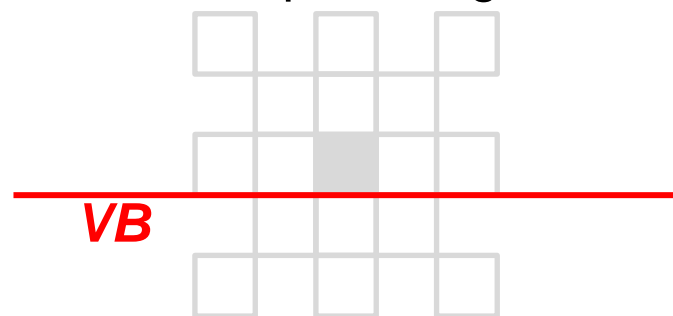
Snowflake5x5

2<sup>nd</sup> line: padding and averaging



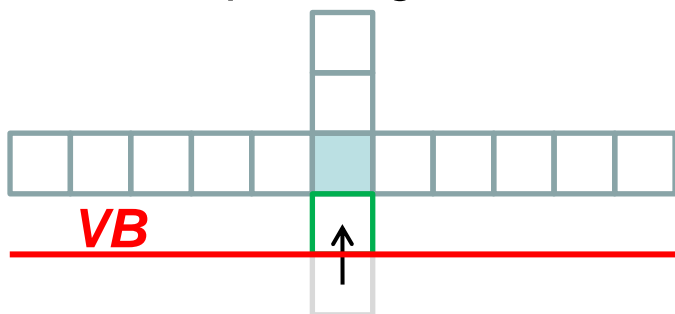
Snowflake5x5

1<sup>st</sup> line: skip filtering



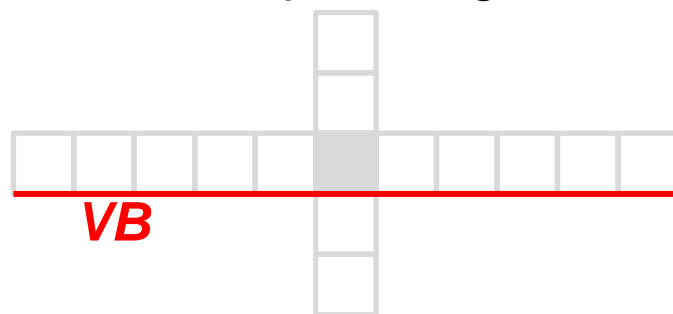
Cross11x5

2<sup>nd</sup> line: padding and averaging



Cross11x5

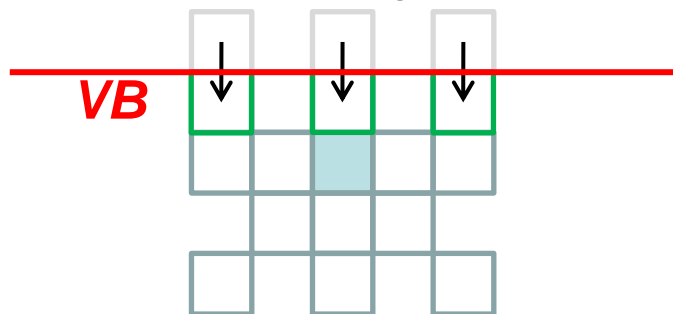
1<sup>st</sup> line: skip filtering



# ALF VB Processing for Below-VB Pixels

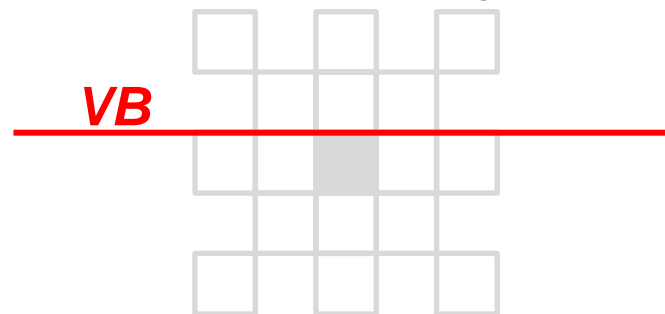
Snowflake5x5

2<sup>nd</sup> line: padding and averaging



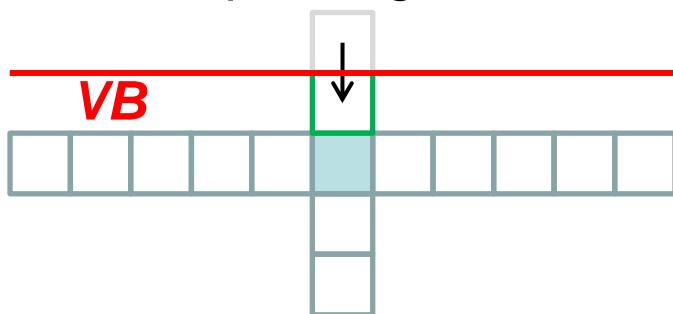
Snowflake5x5

1<sup>st</sup> line: skip filtering



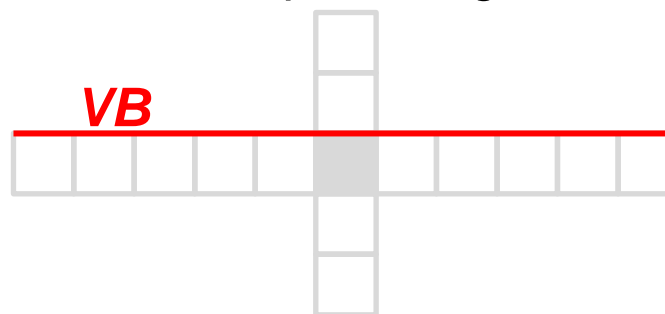
Cross11x5

2<sup>nd</sup> line: padding and averaging



Cross11x5

1<sup>st</sup> line: skip filtering



# Simulation Results

- Anchor: JCTVC-F900
- 0.1-0.4% loss in HE
- 0.0-0.1% loss in LC
- Similar run times
- Slightly degraded visual quality in HE
- Same visual quality in LC

|             | All Intra HE |      |      | All Intra LC |      |      |
|-------------|--------------|------|------|--------------|------|------|
|             | Y            | U    | V    | Y            | U    | V    |
| Class A     | 0.1%         | 0.2% | 0.2% | 0.0%         | 0.1% | 0.2% |
| Class B     | 0.1%         | 0.2% | 0.2% | 0.0%         | 0.1% | 0.1% |
| Class C     | 0.1%         | 0.3% | 0.3% | 0.0%         | 0.1% | 0.1% |
| Class D     | 0.0%         | 0.2% | 0.3% | 0.0%         | 0.1% | 0.1% |
| Class E     | 0.2%         | 0.4% | 0.5% | 0.0%         | 0.2% | 0.1% |
| Overall     | 0.1%         | 0.3% | 0.3% | 0.0%         | 0.1% | 0.1% |
|             | 0.1%         | 0.3% | 0.3% | 0.0%         | 0.1% | 0.1% |
| Enc Time[%] | 101%         |      |      | 99%          |      |      |
| Dec Time[%] | 100%         |      |      | 100%         |      |      |

|             | Random Access HE |      |      | Random Access LC |       |       |
|-------------|------------------|------|------|------------------|-------|-------|
|             | Y                | U    | V    | Y                | U     | V     |
| Class A     | 0.3%             | 0.6% | 0.5% | 0.1%             | 0.3%  | 0.3%  |
| Class B     | 0.2%             | 0.5% | 0.3% | 0.0%             | 0.1%  | 0.2%  |
| Class C     | 0.2%             | 0.3% | 0.4% | 0.1%             | 0.1%  | 0.1%  |
| Class D     | 0.1%             | 0.3% | 0.3% | 0.0%             | -0.1% | -0.1% |
| Class E     |                  |      |      |                  |       |       |
| Overall     | 0.2%             | 0.4% | 0.4% | 0.0%             | 0.1%  | 0.1%  |
|             | 0.2%             | 0.4% | 0.4% | 0.0%             | 0.1%  | 0.1%  |
| Enc Time[%] | 101%             |      |      | 100%             |       |       |
| Dec Time[%] | 100%             |      |      | 99%              |       |       |

|             | Low Delay B HE |      |      | Low Delay B LC |      |      |
|-------------|----------------|------|------|----------------|------|------|
|             | Y              | U    | V    | Y              | U    | V    |
| Class A     |                |      |      |                |      |      |
| Class B     | 0.2%           | 0.5% | 0.4% | 0.0%           | 0.3% | 0.4% |
| Class C     | 0.2%           | 0.7% | 0.5% | 0.0%           | 0.4% | 0.2% |
| Class D     | 0.1%           | 0.2% | 0.8% | 0.0%           | 0.0% | 0.0% |
| Class E     | 0.7%           | 0.8% | 1.8% | 0.1%           | 1.5% | 1.1% |
| Overall     | 0.3%           | 0.6% | 0.8% | 0.0%           | 0.5% | 0.3% |
|             | 0.3%           | 0.5% | 0.7% | 0.0%           | 0.4% | 0.3% |
| Enc Time[%] | 98%            |      |      | 101%           |      |      |
| Dec Time[%] | 98%            |      |      | 100%           |      |      |

|             | Low Delay P HE |      |      | Low Delay P LC |      |      |
|-------------|----------------|------|------|----------------|------|------|
|             | Y              | U    | V    | Y              | U    | V    |
| Class A     |                |      |      |                |      |      |
| Class B     | 0.4%           | 0.7% | 0.7% | 0.1%           | 0.4% | 0.4% |
| Class C     | 0.2%           | 0.7% | 0.6% | 0.1%           | 0.3% | 0.2% |
| Class D     | 0.2%           | 0.2% | 0.5% | 0.1%           | 0.1% | 0.1% |
| Class E     | 0.9%           | 1.9% | 1.3% | 0.3%           | 0.6% | 0.7% |
| Overall     | 0.4%           | 0.8% | 0.7% | 0.1%           | 0.3% | 0.3% |
|             | 0.4%           | 0.8% | 0.7% | 0.1%           | 0.3% | 0.3% |
| Enc Time[%] | 99%            |      |      | 99%            |      |      |
| Dec Time[%] | 99%            |      |      | 101%           |      |      |



# Conclusion

- Proposed virtual boundary processing for SAO and ALF
  - Remove all line buffers
  - 0.1-0.4% coding efficiency loss
  - Slightly degraded visual quality