MEDIATEK

CE7 (Tests 7.1, 7.2, 7.3, and 7.4): Constraints on context-coded bins for coefficient coding

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Overall Summary

- The averaged maximum number of context-coded bins per 16 samples in VVC is 2.56x of that in HEVC.

1. Color components and subblock sizes dependent constraint values to reduce number of context-coded bins
2. Increase the constraints values according to the last significant subblock position to improve the coding efficiency
3. Move the greater than 2 flags to first coding pass to improve the parsing throughput

- Compared with HEVC, the averaged maximum number of context-coded bins per 16 samples is only increased by 1.3%

	AI			RA			LB		
	Y	U	V	Y	U	V	Y	U	V
CE7.1 : M1	0.08%	0.64%	0.44%	0.07%	0.87%	0.69%	0.09%	1.58%	0.89%
CE7.2 : M1 + M2	0.06%	0.19%	0.10%	0.03%	0.35%	0.30%	0.00%	0.57%	0.14%
CE7.3 : M1 + M2 + M3	0.00%	0.09%	0.05%	0.00%	0.30%	0.23%	0.02%	0.58%	-0.12%
CE7.4 : M3	-0.08%	-0.09%	-0.10%	-0.06%	0.03%	-0.06%	-0.04%	0.00%	0.12%

Problem Definition

- In HEVC, for a 4x4 coefficient subblock, the maximum number of context-coded bins per 16 samples is 25
  - Including 16 significant flags, eight greater than 1 (gt1) flags, and one greater than 2 (gt2) flag
- In VVC-3.0, a constraint on the maximum number of context-coded bins is proposed
  - At most 32 context-coded bins can be used in a 4x4 coefficient subblock
  - At most 8 context-coded bins can be used in a 2x2 coefficient subblock
  - Still have 28% more maximum number of context-coded bins than HEVC

Averaged Maximum Number of Context-Coded Bins

Number of maximum context-coded bins per sub-block	4x4 luma sub-block	4x4 chroma sub-block	2x2 chroma sub-block	Maximum number of context-coded bins in one 64-sample luma block and two 16-sample chroma blocks	Averaged maximum number of context-coded bins per 16 samples
HEVC	25	25	N/A	25*4 + 25*2 = 150	25 (1.00x)
VTM2.0.1	64	64	16	64*4 + 64*2 = 384	64 (2.56x)
VVC-3.0	32	32	8	32*4 + 8*8 = 192	32 (1.28x)

Proposed Methods (1/3)

- Different constraints according to color components and subblock sizes
  - Proposed to constrain the maximum number of context-coded bins to 30 for luma 4x4 subblocks, 16 for chroma 4x4 subblocks, and 4 for chroma 2x2 subblocks.
- The averaged maximum number of context-coded bins per 16 samples is only increased by 1.3%

Averaged Maximum Number of Context-Coded Bins

Number of maximum context-coded bins per sub-block	4x4 luma sub-block	4x4 chroma sub-block	2x2 chroma sub-block	Maximum number of context-coded bins in one 64-sample luma block and two 16-sample chroma blocks	Averaged maximum number of context-coded bins per 16 samples
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VVC-3.0	32	32	8	32*4 + 8*8 = 192	32 (1.28x)
Proposed	30	16	4	30*4 + 4*8 = 152	25.33 (1.013x)

Proposed Methods (2/3)

- Last significant subblock position dependent constraint
  - When not all the subblocks in a TB need to be coded, the constraint value can be loosened
  - According to the last significant subblock position, the number of to-be-coded subblocks (NumToBeCodedSb) in a TB can be derived
  - No increase for worst-case number of context-coded bins

```
if (NumToBeCodedSb * 2 <= NumTotalSb)
        ConstraintValue = ConstraintValue * 2
else if (NumToBeCodedSb * 1.25 <= NumTotalSb)
        ConstraintValue = ConstraintValue * 1.25
```

Proposed Methods (3/3)

- In VTM2.0, the gt1 flag is parsed after the parity bit flag
  - The state and the context set selection of significant flag coding depends on the parity bit of the previous parsed coefficient
  - The time of parsing gt1 flag can be used to calculate the state and prepare the context variable set of the next coefficient
- In VTM3.0, the parity bit is moved after the gt1 flag
  - There is no “hidden” time to calculate the state and prepare the context variable set
- In this contribution, the gt2 flag is proposed to be moved to the first coding pass after the parity bit.
  - The time of parsing gt2 flag can be used to calculate the state and prepare the context set of the significant flag of the next coefficient.
  - The number of coding passes can be reduced from 4 to 3

Simulation Results

- Anchor: VTM3.0
- Proposed method
  - M1: Constraint values of 30 for luma 4x4 subblocks, 16 for chroma 4x4 subblocks, and 4 for chroma 2x2 subblocks
  - M2: Last significant sub-block position dependent constraint
  - M3: Move gt2 flag into the first coding pass
  - The averaged maximum number of context-coded bins per 16 samples is only increased by 1.3%

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	Y	U	V	Y	U	V	Y	U	V
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CE7.3 : M1 + M2 + M3	0.00%	0.09%	0.05%	0.00%	0.30%	0.23%	0.02%	0.58%	-0.12%
CE7.4 : M3	-0.08%	-0.09%	-0.10%	-0.06%	0.03%	-0.06%	-0.04%	0.00%	0.12%

Thank Alibaba, LGE, Qualcomm, and HHI for cross-checking

Simulation Results

- Anchor: VTM3.0 in low-complexity setting (no DQ and RDOQ, sigh hiding is enabled)
- Proposed method
  - M1: Constraint values of 30 for luma 4x4 subblocks, 16 for chroma 4x4 subblocks, and 4 for chroma 2x2 subblocks
  - M2: Last significant subblock position dependent constraint
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CE7.1 : M1	0.12%	0.42%	0.47%	0.09%	0.45%	0.58%	-0.02%	1.03%	0.66%
CE7.2 : M1 + M2	0.06%	0.12%	0.14%	0.03%	0.15%	0.22%	-0.01%	0.40%	0.13%
CE7.3 : M1 + M2 + M3	0.00%	0.03%	0.11%	0.02%	0.14%	0.17%	-0.01%	0.50%	0.09%
CE7.4 : M3	-0.05%	-0.08%	-0.08%	-0.02%	-0.12%	-0.02%	0.02%	-0.15%	-0.09%

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Conclusions

- Color components and subblock sizes dependent constraint values to reduce number of context-coded bins
- Increase the constraints values according to the last significant sub-block position to improve coding efficiency
- Move the greater than 2 flags to first coding pass to improve the parsing throughput
- Compared with HEVC, the averaged maximum number of context-coded bins per 16 samples is only increased by 1.3%

	AI			RA			LB		
	Y	U	V	Y	U	V	Y	U	V
CE7.3: combined all methods	0.00%	0.09%	0.05%	0.00%	0.30%	0.23%	0.02%	0.58%	-0.12%

everyday genius