Specifying a maximum bound on slices per picture
(JCTVC-I0238)

Wade Wan, Tim Hellman and Brian Heng

Broadcom Corporation

Introduction

- Recommend reducing maximum number of slices allowed per picture
  - Problematic to handle worst-case number of slice headers
  - Very high number of slices not used in practice for many applications

- Current formula similar to H.264/AVC but HEVC calculation using pixels instead of H.264/AVC macroblocks!
  - Significantly higher number of slices now possible!
  - Can be corrected by introducing scale factor

- Current formula directly proportional to pixel resolution
  - Scales too quickly for resolutions like 4K and 8K video
  - Can be corrected by modifying SliceRate parameter

- Current formula depends on frame rate
  - Remove dependency on frame rate
  - Have formula depend only on picture size

Using pixels not macroblocks!

- HEVC Section A.4.2:

a) In bitstreams conforming to the Main profile, the removal time of access unit 0 shall satisfy the constraint that the number of slices in picture 0 is less than or equal to (Max(PicSizeLuma, fR * MaxLumaPR) + MaxLumaPR * (tr(0) − tr,n(0))) ÷ SliceRate, where MaxLumaPR and SliceRate are the values specified in Table A-1 and Table A-3, respectively, that apply to picture 0 and PicSizeLuma is the number of pic_width_in_luma_samples * pic_height_in_luma_samples in picture 0.

- H.264/AVC Section A.3.3:

a) In bitstreams conforming to the Main, High, High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, or CAVLC 4:4:4 Intra profiles, the removal time of access unit 0 shall satisfy the constraint that the number of slices in picture 0 is less than or equal to (Max(PicSizeInMbs, fR * MaxMBPS) + MaxMBPS * (tr(0) − tr,n(0))) ÷ SliceRate, where MaxMBPS and SliceRate are the values specified in Tables A-1 and A-4, respectively, that apply to picture 0 and PicSizeInMbs is the number of macroblocks in picture 0.

(For access unit 0)

- HEVC Section A.4.2:

b) In bitstreams conforming to the Main profile, the difference between consecutive removal time of access units n and n − 1 with n > 0 shall satisfy the constraint that the number of slices in picture n is less than or equal to MaxLumaPR * (tr(n) − tr(n − 1)) ÷ SliceRate, where MaxLumaPR and SliceRate are the values specified in Table A-1 and Table A-3, respectively, that apply to picture n.

- H.264/AVC Section A.3.3:

b) In bitstreams conforming to the Main, High, High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, or CAVLC 4:4:4 Intra profiles, the difference between consecutive removal time of access units n and n − 1 with n > 0 shall satisfy the constraint that the number of slices in picture n is less than or equal to MaxMBPS * (tr(n) − tr(n − 1)) ÷ SliceRate, where MaxMBPS and SliceRate are the values specified in Tables A-1 and A-4, respectively, that apply to picture n.

(For access unit n with n>0)

Using pixels not macroblocks!

- HEVC using PicSizeLuma and maxLumaPR

- H.264 using PicSizeInMbs and MaxMBPS

- Example for access unit n>0 for fixed frame-rate 720p60 using 16x16 CTBs:
  - HEVC Maximum number of slices per picture = 17,408
  - H.264/AVC Maximum number of slices per picture = 68

- Proposal:
  - Introduce scale factor because HEVC does not have consistent fixed block size definition as H.264/AVC
  - Can use 1/256 (resembles 16x16 H.264/AVC macroblock)

- MaxSliceNum = MaxLumaPR * (tr(n) - tr(n-1)) ÷ SliceRate

Column A	Column B	Column C	Column D	Column E
Level number	SliceRate	MaxLumaPR	MaxSliceNum for 60 fps	MaxSliceNum for 60 fps video (divided by 256)
1	-	552,960	n/a	n/a
2	-	3,686,400	n/a	n/a
3	22	13,762,560	10,426	41
3.1	60	33,177,600	9,216	36
4	60	62,668,800	17,408	68
4.1	24	62,668,800	43,520	170
4.2 / 4.3	24	133,693,440	92,843	363
5 / 5.1	24	267,386,880	185,685	725
5.2	24	534,773,760	371,371	1,451
6	24	1,002,700,800	696,320	2,720
6.1	24	2,005,401,600	1,392,640	5,440
6.2	24	4,010,803,200	2,785,280	10,880

Maximum slice rate scales too quickly if proportional to pixel rate

363 slices for 1080p60

1451 slices for 4Kp60

5440 slices for 8Kp60

Modify SliceRate parameter

- MaxSliceNum = MaxLumaPR * (tr(n) - tr(n-1)) ÷ (256*SliceRate)

Column A	Column B	Column C	Column D	Column E	Column F	Column G
Level number	SliceRate	MaxLumaPR	MaxSliceNum for 60 fps	MaxSliceNum for 60 fps video (divided by 256)	Proposed SliceRate	MaxSliceNum for 60 fps video (divided by 256 and using Proposed SliceRate)
1	-	552,960	n/a	n/a	-	-
2	-	3,686,400	n/a	n/a	-	-
3	22	13,762,560	10,426	41	30	30
3.1	60	33,177,600	9,216	36	60	36
4	60	62,668,800	17,408	68	60	68
4.1	24	62,668,800	43,520	170	60	68
4.2 / 4.3	24	133,693,440	92,843	363	90	97
5 / 5.1	24	267,386,880	185,685	725	150	116
5.2	24	534,773,760	371,371	1,451	210	166
6	24	1,002,700,800	696,320	2,720	300	218
6.1	24	2,005,401,600	1,392,640	5,440	480	272
6.2	24	4,010,803,200	2,785,280	10,880	640	408

MaxSliceNum depends on frame rate

- MaxSliceNum = MaxLumaPR * (tr(n) - tr(n-1)) ÷ (256*SliceRate)

- With earlier recommendations:
  - Fixed-frame rate 720p60 has a maximum of 68 slices
  - Fixed-frame rate 720p @ 1 frame/sec has a maximum of 4080 slices!

- Also difficult for variable frame-rate conformance

- Suggest removal of frame rate and replaced by 1/60 factor

- New formula:

    MaxSliceNum = MaxLumaPR ÷ (15360*SliceRate)

Summary of Proposed Changes

- In bitstreams conforming to the Main profile, the number of slices in a picture is less than or equal to MaxLumaPR ÷ (15360*SliceRate), where MaxLumaPR and SliceRate are the values specified in Table A-1 and Table A-3, respectively.

- Table A-1 (MaxLumaPR) remains the same

- Changes to Table A-3 (SliceRate)

Thank you!

Wade Wan, Tim Hellman and Brian Heng

Broadcom Corporation