

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



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- 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 **samples** 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 picture 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 samples 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  $(\text{Max}(\text{PicSizeLuma}, \text{fR} * \text{MaxLumaPR}) + \text{MaxLumaPR} * (\text{tr}(0) - \text{tr}_n(0))) \div \text{SliceRate}$ , 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  $(\text{Max}(\text{PicSizeInMbs}, \text{fR} * \text{MaxMBPS}) + \text{MaxMBPS} * (\text{tr}(0) - \text{tr}_n(0))) \div \text{SliceRate}$ , 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)

# Using samples not macroblocks!

- 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  $\text{MaxLumaPR} * (\text{tr}(n) - \text{tr}(n - 1)) \div \text{SliceRate}$ , where  $\text{MaxLumaPR}$  and  $\text{SliceRate}$  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  $\text{MaxMBPS} * (\text{tr}(n) - \text{tr}(n - 1)) \div \text{SliceRate}$ , where  $\text{MaxMBPS}$  and  $\text{SliceRate}$  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 samples 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)

# Max slices proportional to sample resolution

- $\text{MaxSliceNum} = \text{MaxLumaPR} * (\text{tr}(n) - \text{tr}(n-1)) \div \text{SliceRate}$

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 sample rate

363 slices for 1080p60  
1451 slices for 4Kp60  
5440 slices for 8Kp60

# Modify SliceRate parameter

- $\text{MaxSliceNum} = \text{MaxLumaPR} * (\text{tr}(n) - \text{tr}(n-1)) \div (256 * \text{SliceRate})$

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



- $\text{MaxSliceNum} = \text{MaxLumaPR} * ( \text{tr}(n) - \text{tr}(n-1) ) \div (256 * \text{SliceRate})$
- 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:

$$\text{MaxSliceNum} = \text{MaxLumaPR} \div (15360 * \text{SliceRate})$$



# Summary of Proposed Changes



- In bitstreams conforming to the Main profile, the number of slices in a picture is less than or equal to  $\text{MaxLumaPR} \div (15360 * \text{SliceRate})$ , 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!



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# Proposal Refinement

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- Preliminary decision after initial presentation
  - Suggested to adopt in concept
  - Revisit on exact formula and numbers
- Updates after discussion with other experts (S. Wenger, T.K. Tan, M. Zhou)
- Suggestion #1: Use MaxLumaFS (max luma picture size in samples) instead of MaxLumaPR (max luma pixel rate in samples/sec) from Table A-1
  - Generally accepted that removal of frame rate from formula is OK
  - Avoids problem of compensating for frame rate and previous 1/60 factor
- Suggestion #2: Apply constraints to levels 1 and 2
  - No constraint on levels 1 and 2 in H.264/AVC
  - Assists scenario of multiple decodes of lower resolution video

- Proposed text in Section A.4.2:

In bitstreams conforming to the Main profile, the number of slices in a picture is less than or equal to  $\text{MaxLumaFS} \div (256 * \text{SliceRate})$ , where MaxLumaFS and SliceRate are the values specified in Table A-1 and Table A-3, respectively

- Proposed text in Table A.3S:

Level number	SliceRate
1	60
2	60
3	60
3.1	120
4	120
4.1	120
4.2	120
4.3	120
5	180
5.1	180
5.2	180
6	240
6.1	240
6.2	240

- Revised proposal with maximum number of slices per level and intermediate calculations (for information and not for inclusion in text)

Level number	Max luma picture size MaxLumaFS (samples)	SliceRate	Max Number Of Slices Per Picture = MaxLumaFS÷ (256*SliceRate)
1	36,864	60	2.4
2	122,880	60	8.0
3	458,752	60	29.9
3.1	983,040	120	32.0
4	2,088,960	120	68.0
4.1	2,088,960	120	68.0
4.2	2,228,224	120	72.5
4.3	2,228,224	120	72.5
5	8,912,896	180	193.4
5.1	8,912,896	180	193.4
5.2	8,912,896	180	193.4
6	33,423,360	240	544.0
6.1	33,423,360	240	544.0
6.2	33,423,360	240	544.0