|  |  |
| --- | --- |
| **Joint Collaborative Team on Video Coding (JCT-VC)**  **of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11**  7th Meeting: Geneva, 21-30 November, 2011 | Document: JCTVC-G384 |

|  |  |  |  |
| --- | --- | --- | --- |
| *Title:* | **Varying QP Deblocking** | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Proposal | | |
| *Author(s) or Contact(s):* | Geert Van der Auwera, Xianglin Wang, Marta Karczewicz  5775 Morehouse Dr San Diego, CA 92121 USA | Email: | geertv@qualcomm.com  xianglin@qualcomm.com  martak@qualcomm.com |
| *Source:* | Qualcomm Inc. | | |

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

# Abstract

This contribution proposes changes to the deblocking filter to support the varying QP capability enabled by delta-QP signaling. It is proposed to use the maximum of the QP values on both sides of the edge to lookup Beta and tC threshold parameters. In case of the weak filter decision for modifying one or two samples, the proposal is to use the QP value of the respective edge side to lookup a Beta parameter.

# Introduction

The HM4 in-loop deblocking filter [1] processes certain TU and PU edges based on the result from the boundary strength computation and deblocking decisions (on/off, weak/strong, weak filter strength) that are dependent on threshold parameters tC and beta [1]. The tC and β thresholds depend on the parameter Q, which is derived from QP and the boundary strength (Bs), as follows:

* + TcOffset = ( Bs > 2 ) ? 2 : 0
  + **tC:** Q = Clip3(0, MAX\_QP+4, QP + TcOffset ) (MAX\_QP = 51)
  + **β:** Q = Clip3(0, MAX\_QP, QP )

Recently, the sub-LCU-level delta quantization parameter (dQP) method has been adopted in HEVC (JCTVC-E051/220/391/436/217/D038/D258) and allows dQP signaling for CUs smaller than the LCU size. The purpose is to allow finer granularity rate and visual quality control. The dQpMinCuSize parameter is defined as the minimum CU quantization group size that can signal dQP. All leaf CUs within a dQpMinCuSize quantization group share the same dQP. A dQP is also signaled for a leaf CU of the LCU quadtree, if the leaf CU is larger than or equal to the dQpMinCuSize. dQP is sent only when at least one nonzero coefficient exists. The dQP value is added to the predicted QP value from the neighboring quantization group (left or last in decoding order) to produce the QP value for the present CU.

The HM4 deblocking filter obtains the QP value from the CU that contains the current edge to be deblocked (luma-QP for luma edge; chroma-QP for chroma edge). This QP value is appropriate only for processing internal edges of the CU, because the sub-LCU-level dQP signaling may result in different QP values on both sides of the CU boundary (left or top boundary), as is the case in Figure 1 where the LCU contains four quantization groups (QG1…QG4) which may have different QP values. The HM4 deblocking filter does not take different QP values for both edge sides into account when processing an edge and, therefore, the applied deblocking filtering may be too weak or too strong for those CU boundary edges. Assume a shared edge between two neighboring CUs, CU-P and CU-Q, with CU-P either on the left or above CU-Q and with QP values QP-P and QP-Q, respectively. If the current CU is CU-Q, then the deblocking filter will only employ QP-Q to lookup the β and tC parameters.

QG1

QG2

QG3

QG4

CU-P

QP-P

CU-Q

QP-Q

Figure Quantization groups QG1-4

# Deblocking Modifications for Varying QP

In case of CU boundary edges that belong to two quantization groups with potentially different QP values, QPP and QPQ, the proposal is to use the maximum of QPP and QPQ for the luma QP value, QPL, that is employed to lookup the β and tC thresholds for the current edge to be processed (on/off decision, strong/weak decision, tC based clipping):

QPL = Max( QPP, QPQ )

In case of the weak filter, it is proposed to use the QP values on both sides of the edge to look up β thresholds to decide between modifying one or two samples, as follows:

Δ =  ( 9\*(q0-p0) - 3\*(q1-p1) + 8 )/16

Δ = Clip( -tC, tC, Δ )

p0’ = p0 + Δ

q0’ = q0 - Δ

dp = |p22 – 2\*p12 – p02| + |p25 – 2\*p15 + p05|

Δp = Clip( - tC/2, tC/2, ( (p2 + p0 + 1)/2 - p1 + Δ)/2 )

ThrP = ( β(QPP) + (β(QPP)>>1) )>>3

IF ( dp < ThrP ) THEN p1’ = p1 + Δp

dq = |q22 – 2\*q12 – q02| + |q25 – 2\*q15 + q05|

Δq = Clip( - tC/2, tC/2, ( (q2 + q0 + 1)/2 - q1 - Δ)/2 )

ThrQ = ( β(QPQ) + (β(QPQ)>>1) )>>3

IF ( dq < ThrQ ) THEN q1’ = q1 + Δq

# Objective Results

Since the proposed changes do not influence the BD-rates under HM4 common test conditions [2], the CE4 [3] anchor software is used (HM4-CE4) to demonstrate the BD-rate of the proposed changes. The CE4 anchor software is used in the CE4 QP prediction experiments with MaxQPAdaptationRange=12, with dQpMinCuSize=8, and with QP adaptation based on the psycho-visual model “TM5Step3”. For this proposal, the MaxQPAdaptationRange is set to 6. The encoding times are measured in a variable computing environment and the decoding times on a single CPU.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra HE** | | | **All Intra LC** | | |
|  | Y | U | V | Y | U | V |
| Class A | 0.1% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Class B | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Class C | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Class D | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Class E | 0.1% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| **Overall** | 0.1% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
|  | 0.1% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 97% | | | 98% | | |
| Dec Time[%] | 101% | | | 100% | | |
|  |  |  |  |  |  |  |
|  | **Random Access HE** | | | **Random Access LC** | | |
|  | Y | U | V | Y | U | V |
| Class A | 0.0% | 0.1% | 0.1% | 0.0% | -0.1% | -0.1% |
| Class B | 0.0% | 0.0% | -0.1% | 0.0% | 0.0% | 0.0% |
| Class C | 0.0% | 0.0% | 0.0% | 0.0% | -0.1% | -0.1% |
| Class D | 0.0% | 0.0% | -0.1% | 0.0% | -0.2% | 0.1% |
| Class E |  |  |  |  |  |  |
| **Overall** | 0.0% | 0.0% | -0.1% | 0.0% | -0.1% | 0.0% |
|  | 0.0% | 0.0% | 0.0% | 0.0% | -0.1% | 0.0% |
| Enc Time[%] | 99% | | | 99% | | |
| Dec Time[%] | 100% | | | 101% | | |
|  |  |  |  |  |  |  |
|  | **Low delay B HE** | | | **Low delay B LC** | | |
|  | Y | U | V | Y | U | V |
| Class A |  |  |  |  |  |  |
| Class B | 0.0% | 0.0% | 0.2% | 0.0% | 0.1% | 0.1% |
| Class C | 0.0% | 0.0% | -0.1% | -0.1% | -0.1% | 0.1% |
| Class D | 0.1% | 0.7% | -0.2% | 0.0% | 0.5% | 0.2% |
| Class E | 0.0% | 0.3% | -0.3% | 0.0% | -0.2% | -0.8% |
| **Overall** | 0.0% | 0.2% | -0.1% | 0.0% | 0.1% | 0.0% |
|  | 0.0% | 0.2% | -0.1% | 0.0% | 0.0% | -0.1% |
| Enc Time[%] | 97% | | | 99% | | |
| Dec Time[%] | 101% | | | 100% | | |
|  |  |  |  |  |  |  |
|  | **Low delay P HE** | | | **Low delay P LC** | | |
|  | Y | U | V | Y | U | V |
| Class A |  |  |  |  |  |  |
| Class B | 0.0% | 0.1% | 0.3% | -0.1% | 0.0% | 0.1% |
| Class C | 0.0% | -0.1% | 0.0% | -0.1% | 0.2% | 0.1% |
| Class D | -0.1% | 0.2% | 0.1% | -0.1% | -0.1% | 0.1% |
| Class E | -0.1% | 0.4% | -0.5% | -0.1% | 0.2% | 0.2% |
| **Overall** | 0.0% | 0.1% | 0.0% | -0.1% | 0.1% | 0.1% |
|  | 0.0% | 0.1% | 0.1% | -0.1% | 0.0% | 0.1% |
| Enc Time[%] | 102% | | | 99% | | |
| Dec Time[%] | 101% | | | 101% | | |

# Subjective Results

Figures 2 and 3 depict examples of the quality improvement of the proposal compared with HM4-CE4.

|  |  |
| --- | --- |
| 1. HM4-CE4 | 1. Proposal |

Figure 2 Frame 30 of the “Vidyo3” sequence coded with low delay test conditions and QP=37.

|  |  |
| --- | --- |
| 1. HM4-CE4 | 1. Proposal |

Figure 3 Frame 492 of the “Vidyo3” sequence coded with low delay test conditions and QP=37.



# Conclusion

It was proposed to adapt the deblocking filter behavior to the delta-QP signaling capability, which may vary QP values on the sub-LCU level. The BD-rate results are obtained using the CE4 anchor software, which includes a psycho-visual model to assign QP values. There is no significant BD-rate change observed and execution times are comparable to the anchor. The goal of this proposal is subjective quality improvement of the deblocking filter.

# References

1. B. Bross, W.-J. Han, J.-R. Ohm, G. J. Sullivan, T. Wiegand, “WD4: Working Draft 4 of High-Efficiency Video Coding,” 6th JCT-VC Meeting, Turin, Italy, July 2011, Doc. JCTVC-F803
2. F. Bossen, “Common test conditions and software reference configurations,” 6th JCT-VC Meeting, Turin, Italy, July 2011, Doc. JCTVC-F900.
3. K. Sato, M. Budagavi, M. Coban, H. Aoki, X. Li, “Description of Core Experiment 4: Quantization,” 6th JCT-VC Meeting, Turin, Italy, July 2011, Doc. JCTVC-F904.

# Working Draft

**8.6.1.4.1 Decision process for luma block edge**

Inputs of this process are:

– a luma location ( xC, yC ) specifying the top-left luma sample of the current coding unit relative to the top left luma sample of the current picture,

– a luma location ( xB, yB ) specifying the top-left luma sample of the current block relative to the top left luma sample of the current coding unit,

– a variable verticalEdgeFlag,

– a variable bS specifying the boundary filtering strength,

Output of this process is:

– variables dE, dEp1 and dEq1 containing decisions,

– one-dimensional array of size (8), dS containing decisions.

Let s’ represent the luma sample array recPictureL of the current picture.

Depending on verticalEdgeFlag, the following applies:

– If verticalEdgeFlag is equal to 1, the following ordered steps apply:

1. The sample values pi,k and qi,k with i = 0..3 and k = 2,5 are derived as follows:

qi,k = s’[ xC + xB +i, yC + yB + k ] (8‑447)

pi,k = s’[ xC + xB – i – 1, yC + yB + k ] (8‑448)

1. The quantization parameter QPP of the neighboring block is assigned the QPY value of the coding unit containing sample p0,0
2. The loop filter quantization parameter QPL is derived as follows:

QPL = Max( QPY, QPP )

1. A variable β is specified as Table 8‑13 with loop filter quantization parameter QPL as input.
2. A variable βP is specified as Table 8‑13 with quantization parameter QPP as input.
3. A variable βQ is specified as Table 8‑13 with luma quantization parameter QPY as input.
4. A variable tC is specified as follows:
   1. If bS is greater than 2, the variable tC is specified as with quantization parameter Clip3(0, 55, QPL + 2 ) as input,
   2. Otherwise (bS is equal or less than 2), the variable tC is specified as Table 8‑13 with quantization parameter QPL as input.
5. The variables dp, dq and d are derived as follows:

dp = | p2,2 – 2\*p1,2 + p0,2 | + | p2,5 – 2\*p1,5 + p0,5 | (8‑449)

dq = | q2,2 – 2\*q1,2 + q0,2 | + | q2,5 – 2\*q1,5 + q0,5 | (8‑449)

d = dp + dq (8‑449)

1. The variables dE, dEp1 and dEq1 are set equal to 0.
2. If bS is not equal to 0 and d is less than β, the following ordered steps apply:
3. for each sample location ( xC + xB, yC + yB + k ), k = 0..7, the following ordered steps apply:
   1. The decision process for a luma sample specified in subclause 8.6.1.4.4 is invoked with sample values pi,k, qi,k with i = 0..3, the boundary filtering strength bS and the variables d, β and tC as inputs and a decision dSam as output.
   2. The variable dS[k] is set equal to dSam
4. The variable dE is set equal to 1.
5. If dp is less than ( βP + ( βP >> 1 ) ) >> 3, the variable dEp1 is set equal to 1.
6. If dq is less than ( βQ + ( βQ >> 1 ) ) >> 3, the variable dEq1 is set equal to 1.

– Otherwise (verticalEdgeFlag is equal to 0), the following ordered steps apply:

1. The sample values pi,k and qi,k with i = 0..3 and k = 2,5 are derived as follows:

qi,k = s’[ xC + xB +k, yC + yB + i ] (8‑435)

pi,k = s’[ xC + xB +k, yC + yB – i – 1 ] (8‑436)

1. The quantization parameter QPP of the neighboring block is assigned the QPY value of the coding unit containing sample p0,0
2. The loop filter quantization parameter QPL is derived as follows:

QPL = Max( QPY, QPP )

1. A variable β is specified as with loop filter quantization parameter QPL as input.
2. A variable βP is specified as with quantization parameter QPP as input.
3. A variable βQ is specified as with quantization parameter QPY as input.
4. A variable tC is specified as follows:
   1. If bS is greater than 2, the variable tC is specified as with quantization parameter Clip3(0, 55, QPL + 2 ) as input,
   2. Otherwise (bS is equal or less than 2), the variable tC is specified as Table 8‑13 with loop filter quantization parameter QPL as input.
5. The variables dp, dq and d are derived as follows:

dp = | p2,2 – 2\*p1,2 + p0,2 | + | p2,5 – 2\*p1,5 + p0,5 | (8‑437)

dq = | q2,2 – 2\*q1,2 + q0,2 | + | q2,5 – 2\*q1,5 + q0,5 | (8‑437)

d = dp + dq (8‑437)

1. The variables dE, dEp1 and dEq1 are set equal to 0.
2. If bS is not equal to 0 and d is less than β, the following ordered steps apply:
3. For each sample location ( xC + xB + k, yC + yB ), k = 0..7, the following ordered steps apply:
   1. The decision process for a luma sample specified in subclause 8.6.1.4.4 is invoked with sample values pi,k, qi,k with i = 0..3, the boundary filtering strength bS and the variables d, β and tC as inputs and a decision dSam as output.
   2. The variable dS[k] is set equal to dSam.
4. The variable dE is set equal to 1.
5. If dp is less than ( βP + ( βP >> 1 ) ) >> 3, the variable dEp1 is set equal to 1.
6. If dq is less than ( βQ + ( βQ >> 1 ) ) >> 3, the variable dEq1 is set equal to 1.

# Patent rights declaration

**Qualcomm Inc. may have IPR relating to the technology described in this contribution and, conditioned on reciprocity, is prepared to grant licenses under reasonable and non-discriminatory terms as necessary for implementation of the resulting ITU-T Recommendation | ISO/IEC International Standard (per box 2 of the ITU-T/ITU-R/ISO/IEC patent statement and licensing declaration form).**