Joint Video Experts Team (JVET)
of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29/WG 11
13th Meeting: Marrakech, MA, 9–18 Jan. 2019

Document: JVET-M0092-v1

Title:	**CE11: Very strong deblocking with conditional activation signaling (Test 11.1.1)**
Status:	Input document to JVET
Purpose:	Proposal

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Abstract

This contribution describes the configuration of the authors' conditionally signaled very strong deblocking approach, as previously presented in JVET-L0523, in the VTM software for the Core Experiment (CE) on improved deblocking filtering for the Versatile Video Coding (VVC) standard. The integration of this proposal into VTM 3.0 reportedly results in negligible luma BD-rate changes while providing subjective gains. It is kindly requested to adopt one of the proposed two variants (differing in algorithmic complexity) of the very strong deblocking method in the next revision of the VVC specification and VTM reference software.

1 Introduction

Following previous iterations of CE11 on improved deblocking methods for the VVC standard, as described in JVET-L1031 [1], a low-complexity "superstrong" deblocking design was presented by the current authors in JVET-L0523 [2] and subsequently accepted as Test 11.1.1 in the current CE11 phase [3]. A characteristic feature of this very strong deblocking scheme is the conditional signaling of a filter control parameter (FCP) for specific CTUs in the bit-stream, allowing said very strong deblocking to be disabled in the given CTU, in combination with the use of a simple strong deblocking algorithm with relatively low hardware requirements, yielding further gains in visual coding quality. In this way, the proposal offers a means to control the application of a superstrong deblocking design from the encoder side on a CTU level, thus providing hardware or software encoder developers with a previously unavailable level of control over the use of this tool.

For this round of CE11 tests, the basic operation of the very strong deblocking procedure remained identical to that described in L0523, so a complete description of the conditional signaling process and syntax or the actual deblocking algorithm is omitted here for the sake of brevity. Please refer to [2] for details. However, some minor modifications to the algorithmic steps of the deblocking post-processor and conditional signaling and have been devised for CE test 11.1.1, and these will be described in detail in the following section.

2 Modifications to Algorithm

The following three modifications to the very strong deblocking solution in [2] have been made for this CE.

2.1 Signaling of Filter Control Parameter in Slightly More CTUs

In [2], the authors proposed the selective signaling of an in-loop filter control parameter (FCP) only in CTUs which are partitioned into fewer than $A = 9$ coding units (CUs) and in which residual coefficient coding, as indicated by a non-zero coded block flag (CBF), is employed in at least $B = 1$ of its transform units (TUs).

For this revision of the superstrong deblocking algorithm, the abovementioned A+B condition for signaling of the FCPs was extended to cover slightly more CTUs while keeping the signaling rate at roughly the same level of less than about 0.4% of the mean bit-rate (see also Section 3). Specifically, the FCP is now written to, and read from, the bit-stream **(1)** for all CTUs partitioned into fewer than $A = 10$ CUs and at least $B = 1$ coded TUs **or**, if no TU is coded with a non-zero CBF, **(2)** for CTUs partitioned into c CUs with $3 < c < A$.

2.2 Improved Superstrong Deblocking Adaptivity for Large TUs

In [2], the use of four boundary offset$_d$ values, with d = {left, right, top, bottom}, was suggested to parameterize the superstrong deblocking process within each TU. Moreover, the superstrong deblocking algorithm was executed only in TU areas with a size of 32×32 luma (16×16 downsampled chroma) samples or larger.

For this revision of the conditional very strong deblocking, the number and spatial location of the boundary offset$_d$ values was modified for large TUs. Specifically, the offset$_d$ parametrization of Fig. 1 is used, namely,

- for TUs sized between 16×16 and (excl.) 32×32 samples, the offset$_d$ locations were relocated to the TU block corners, i. e., d = {top-left, top-right, bottom-left, bottom-right}, and N = 8, see Fig. 1(a),
- for TUs sized between 32×32 and (excl.) 64×64 samples, 8 instead of 4 offset$_d$ values are used, i.e., d = {left, top-left, top, top-right, right, bottom-left, bottom, bottom-right}, and N = 16, see Fig. 1(b),
- for (luma) TUs sized 64×64 samples or larger, 16 offset$_d$ values are computed (i. e., two intermediate offsets are added along each block side, e. g., mid-top-left, mid-top-right), and N = 16, see Fig. 1(c).

For non-square TUs, the horizontal and vertical block dimensions are treated accordingly and individually. Value N denotes the parameter support and deblocking filter length in picture samples, see also Section 3. This modification over L0523 was found to allow slightly better input adaptivity – and, hence, visual coding quality – by the superstrong deblocking method on some sequences highly susceptible to blocking artifacts. Note that, as in L0523, the very strong deblocking is performed on the luma as well as chroma components.

2.3 Combination of CE 11.1.1 with Strong Chroma Deblocking

The configuration described above, with encoder-side distortion threshold x = 0.1 dB according to [2], was submitted for visual evaluation at the 13th JVET meeting in Marrakech and may serve as a benchmark with regard to "algorithmic complexity vs. visual quality" tradeoffs. Nonetheless, a more *quality*-centric tradeoff may be achievable by combining the conditional superstrong deblocking design with conventional decoder-side improved "blind" deblocking for the chroma channels, activated unconditionally when the superstrong deblocking is disabled (FCP = 0). As an example, the very strong deblocking of CE test 11.1.1 was combined with the improved chroma deblocking of L0072 [6] previously tested as CE11.1.9 at the 12th JVET meeting, which was configured to apply the HEVC-style luma deblocking on the chromatic channels when the very strong deblocking according to this document is disabled in a CTU or when the processed picture region is covered by a chroma TU whose width and/or height is smaller than 8 samples. Given that L0072 claims to improve subjective quality at low bit-rates [6], which was verified by the cross-checker [3], such combined luma-chroma deblocking is expected to yield slightly better chromatic visual coding quality than the more *low-complexity*-centric configuration discussed earlier, which does not integrate approaches such as L0072.

3 Experimental Results

Estimates of the required computational complexity as well as the expected coding efficiency were derived. Table 1 lists the number of algorithmic operations needed by the different parts of the very strong deblocking process in the VTM decoder. The tabulated values are for the worst-case condition where the TU width and height is twice as long as the superstrong filter length N (4, 8, or 16, color and TU size dependent, see Sec. 2.2). The counted comparisons enforce the value range limit via the bit-depth dependent *ClipBD*( ) function.

Bjøntegaard delta (BD) rate gains on the sequences in the SDR-category Common Test Conditions (CTC) [7], [8] were measured to verify the absence of notable losses in coding efficiency or increases in either encoder or decoder runtime due to CE11.1.1. VTM software version 3 with default configuration is used [5].

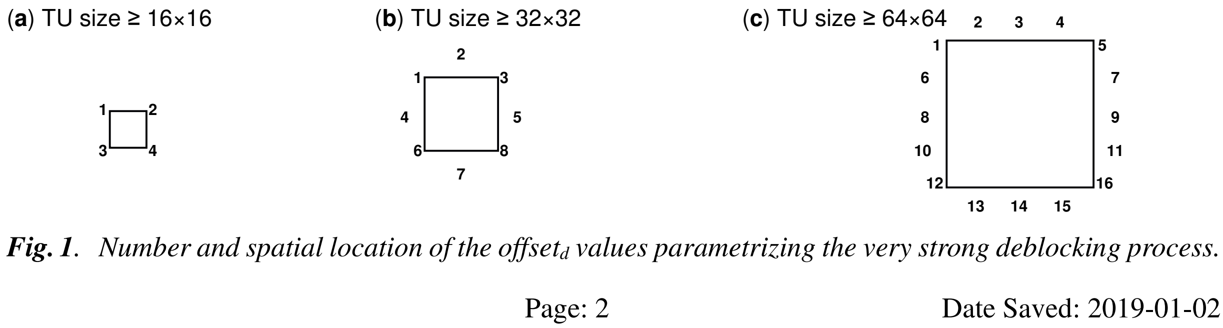

Fig. 1. *Number and spatial location of the offset$_d$ values parametrizing the very strong deblocking process.*

Table 1. *Number of operations used by CE11.1.1. N: number of filtered samples on each side of a boundary. Note that a multiply-accumulate operation is considered as only one multiplication but no addition.*

Functional Part	**Multiplies**	**Additions**	**Right-Shifts**	**Comparisons**	**Sum**
Calculation of filter parameters for a TU	0	$4(W{+}H)+32$	8	0	$4(W{+}H)+40$
Appl. of very strong deblock. per sample	$3N$	$2N$	N	$2N$	$8N$

Tables 2–3 list the BD-rate data for very strong deblocking variant **1** (only CE11.1.1), while Tables 4–5 hold the BD-rate values for very strong deblocking variant **2** (CE11.1.1+L0072). More detailed results are provided in separate Excel files included in the Zip file containing this document. Overall, it can be stated that

- both variants yield very similar overall luma BD-rate results (and variant 2 provides chroma gains),
- the luma BD-rate losses are negligible for both deblocking variants (and a bit lower for variant 2),
- no significant runtime increases are noticed for variant 1 (variant 2 slows down decoding by 2–3%).

These observations confirm the expectation that variant 1 represents a *low-complexity* configuration of the proposal while variant 2 can serve as a *highest-quality* configuration (to be confirmed by subjective testing).

Table 2. *BD-rate [7] data for VTM 3 with vs. without variant **1**, CE11.1.1 proposal, ALF **on**, SDR CTC [8].*

All Intra	**Gain Y** (%)	**Gain Cb** (%)	**Gain Cr** (%)	**Time Enc.** (%)	**Time Dec.** (%)
Class A1	0.17	–0.17	0.03	100	101
Class A2	0.03	0.10	0.12	100	100
Class B	0.03	0.02	0.00	100	100
Class C	0.00	0.04	0.01	100	101
Class E	0.03	0.06	0.04	100	100
Overall	0.05	0.01	0.03	100	100
Random Access	**Gain Y** (%)	**Gain Cb** (%)	**Gain Cr** (%)	**Time Enc.** (%)	**Time Dec.** (%)
Class A1	0.72	0.12	0.29	101	103
Class A2	0.46	0.19	0.19	100	100
Class B	0.28	0.10	0.04	100	103
Class C	0.10	0.09	0.06	100	100
Class E					
Overall	0.35	0.12	0.12	100	101

Table 3. *BD-rate [7] data for VTM 3 with vs. without variant **1**, CE11.1.1 proposal, ALF **off**, SDR CTC [8].*

All Intra	**Gain Y** (%)	**Gain Cb** (%)	**Gain Cr** (%)	**Time Enc.** (%)	**Time Dec.** (%)
Class A1	0.16	–0.41	–0.18	100	104
Class A2	0.03	0.09	0.11	100	104
Class B	0.03	0.02	–0.01	100	99
Class C	0.00	0.04	0.01	100	100
Class E	0.03	0.03	0.00	100	100
Overall	0.04	–0.03	–0.01	100	101
Random Access	**Gain Y** (%)	**Gain Cb** (%)	**Gain Cr** (%)	**Time Enc.** (%)	**Time Dec.** (%)
Class A1	0.73	0.15	0.22	101	102
Class A2	0.52	0.02	0.08	100	100
Class B	0.29	0.11	–0.03	101	106
Class C	0.07	0.07	0.08	101	102
Class E					
Overall	0.36	0.09	0.07	101	103

*Table 4. BD-rate [7] data for VTM 3 with vs. without variant **2**, CE11.1.1 + [6]-chroma, ALF **on**, SDR CTC.*

All Intra	**Gain Y** (%)	**Gain Cb** (%)	**Gain Cr** (%)	**Time Enc.** (%)	**Time Dec.** (%)
Class A1	0.02	–1.17	–1.03	101	103
Class A2	–0.07	–0.68	–0.41	100	104
Class B	–0.01	–0.77	–1.09	100	104
Class C	–0.05	–0.76	–1.00	101	102
Class E	0.00	–0.69	–0.73	100	103
Overall	–0.02	–0.81	–0.89	100	103
Random Access	**Gain Y** (%)	**Gain Cb** (%)	**Gain Cr** (%)	**Time Enc.** (%)	**Time Dec.** (%)
Class A1	0.56	**–2.60**	**–3.45**	100	104
Class A2	0.40	–1.67	–1.26	99	102
Class B	0.23	–1.91	**–2.45**	100	107
Class C	0.04	–1.70	–1.76	99	103
Class E					
Overall	0.28	–1.94	**–2.23**	99	104

*Table 5. BD-rate [7] data for VTM 3 with vs. without variant **2**, CE11.1.1 + [6]-chroma, ALF **off**, SDR CTC.*

All Intra	**Gain Y** (%)	**Gain Cb** (%)	**Gain Cr** (%)	**Time Enc.** (%)	**Time Dec.** (%)
Class A1	0.02	–1.71	–1.45	100	104
Class A2	–0.07	–0.63	–0.28	100	102
Class B	–0.01	–0.72	–1.02	100	101
Class C	–0.04	–0.52	–0.70	101	100
Class E	–0.01	–0.78	–0.92	100	101
Overall	–0.02	–0.84	–0.88	100	101
Random Access	**Gain Y** (%)	**Gain Cb** (%)	**Gain Cr** (%)	**Time Enc.** (%)	**Time Dec.** (%)
Class A1	0.54	**–3.30**	**–3.98**	99	101
Class A2	0.42	–1.70	–1.31	98	101
Class B	0.26	**–2.06**	**–2.62**	99	105
Class C	0.07	**–2.02**	**–2.11**	100	103
Class E					
Overall	0.30	**–2.23**	**–2.49**	99	103

The authors thank Kenneth Andersson for cross-checking of the BD-rate measurements of Tables 2 and 3.

4 Summary and Conclusion

This document described the integration of the conditionally signaled very strong deblocking method, previously proposed in JVET-L0523 and currently evaluated as CE11 test 11.1.1, into version 3.0 of the VTM reference software. All recent modifications to the deblocking process devised after the 12th JVET meeting, namely, the signaling of the filter control parameter in slightly more CTUs, an increase in the signal adaptivity of the deblocking algorithm, and the optional combination of the proposal with conventionally designed improved "blind" deblocking for the chroma channels, were discussed. Two basic configuration variants of the proposal, having different complexity-quality tradeoffs, were presented: variant **1** as currently evaluated in CE11.1.1 (aiming for *low-complexity* and undergoing visual assessment) and variant **2** realizing a combination of CE11.1.1 of the current 13th JVET meeting and the chromatic part of the former CE11.1.9 of the previous 12th JVET meeting (aiming for *highest visual quality* at the cost of slightly increased complexity).

With $x = 0.1$ dB [2], the two proposed variants exhibit negligible luma BD-rate losses of 0.05%/0.35%/0.4% (variant 1) and 0.0%/0.3%/0.35% (variant 2) in All-Intra/Random-Access/Low-Delay B and P (rounded to ±0.05%). Given these results, it is requested to adopt one of the variants in the next version of the VTM and VVC draft. An updated, completed syntax and decoding process specification text is provided upon request.

5 References

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[5] JVET/Fraunhofer, "jvet/VVCSoftware_VTM," https://vcgit.hhi.fraunhofer.de/jvet/VVCSoftware_VTM

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6 Patent Rights Declaration(s)

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