Joint Collaborative Team on Video Coding (JCT-VC)
of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11
6th Meeting: Torino, IT, 14-22 July, 2011

Document: JCTVC-F744

Title: **BoG Report on MV Coding and Throughput/Parsing Robustness**

Status: Input Document to JCT-VC

Purpose: Report

Author(s) or Contact(s): B. Bross

Tel:
Email:

Source: BoG on MV Coding and Parsing Throughput/Robustness

This contribution summarizes the activities of the Break out Group (BoG) on MV Coding and Parsing Throughput/Robustness.

1 Attendees

Minhua Zhou	zhou@ti.com	(TI)
Yu-Wen Huang Shan Liu	yuwen.huang@mediatek.com shan.liu@mediatek.com	(MediaTek)
Tim Hellman Yong Yu Wade Wan	timhellman@broadcom.com yongyu@broadcom.com wadewan@broadcom.com	(Broadcom)
Kimihiko Kazui	kazui.kimihiko@jp.fujitsu.com	(Fujitsu)
Jianle Chen Il-Koo Kim	jianle.chen@samsung.com ilkoo.kim@samsung.com	(Samsung)
Hiroya Nakamura Shigeru Fukushima	nakamura.hiroya@jk-holdings.com fukushima.shigeru@jk-holdings.com	(JVC KENWOOD)
Toshiyasu Sugio	sugio.toshiyasu@jp.panasonic.com	(Panasonic)
Patrice Onno Guillaume Laroche	patrice.onno@crf.canon.fr guillaume.laroche@crf.canon.fr	(Canon)
Yunfei Zheng Wei-Jung Chien Shawn Wang	zhengy@qualcomm.com wchien@qualcomm.com xianglin@qualcomm.com	(Qualcomm)
Yoshinori Suzuki	suzukiyos@rd.nttdocomo.co.jp	(NTT DOCOMO)
Joel Jung	joelb.jung@orange-ftgroup.com	(Orange Labs)
Yongjoon Jeon Seungwook Park Joonyoung Park	yongjoon.jeon@lge.com seungwook.park@lge.com jy.park@lge.com	(LGE)
Kazushi Sato	kazushi.sato@jp.sony.com	(Sony)
Krit Panusopone	krit@motorola.com	(Motorola Mobility)
Shun-ichi Sekiguchi	sekiguchi.shunichi@eb.mitsubishielectric.co.jp	(Mitsubishi Electric)

Nokia Exhibit 2009, p. 1
Amazon.com v. Nokia
IPR2024-01505

2 Anchor

During the presentation of the CE9 report JCTVC-F029 it was agreed to adopt

1. Disabling inferred merge
2. A SPS flag disabling 4x4 inter partitions which is disabled in default configuration

Furthermore, in track A it was agreed to adopt

3. The modified motion vector rounding from JCTVC-F142.

It was agreed to integrate this in the anchor because this may have an impact on the proposals tested within this BoG.

2.1 Software

Fujitsu provides JCTVC-F142 code (3.) to MediaTek. MediaTek provides anchor software (1.+2.) based on HM3.0 with bug #146 affecting the spatial motion vector scaling process fixed (http://hevc.kw.bbc.co.uk/trac/ticket/146).

2.2 Tests

The following tests are performed.

Test	**Tester1**	**Tester2**
Anchor: 1. + 2. + 3.	TI	Qualcomm
Anchor without modified MV rounding: 1. + 2.	MediaTek	Fujitsu

Testing the anchor without the modified MV rounding was suggested to show the performance without inferred merge and 4x4 inter partition.

2.3 Results

Reference: HM3.0 with bugfix #146

Tested: Anchor

	Random access			Random access LC		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A	-0.7	-1.2	-0.8	-0.8	-0.7	-0.7
Class B	-0.6	-0.6	-0.6	-0.6	-0.3	-0.3
Class C	-0.9	-0.7	-0.6	-0.9	-0.5	-0.5
Class D	-1.0	-0.5	-0.5	-1.0	-0.4	-0.6
Class E						
All	-0.8	-0.7	-0.6	-0.8	-0.5	-0.5
Enc Time[%]	99%			103%		
Dec Time[%]	101%			106%		

	Low delay			Low delay LC		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A						
Class B	-0.2	-0.1	-0.3	-0.2	-0.2	-0.2
Class C	-0.2	-0.1	-0.3	-0.3	0.0	-0.1
Class D	-0.1	-0.1	0.4	0.0	0.2	0.0
Class E	-0.2	-0.8	0.0	-0.2	0.1	0.6
All	-0.2	-0.3	-0.1	-0.2	0.0	0.0
Enc Time[%]	102%			102%		
Dec Time[%]	97%			98%		

(TI)

	Random Access HE			Random Access LC		
	Y	U	V	Y	U	V
Class A	-0.7	-1.2	-0.8	-0.8	-0.7	-0.7
Class B	-0.6	-0.6	-0.6	-0.6	-0.3	-0.3
Class C	-0.9	-0.7	-0.6	-0.9	-0.5	-0.5
Class D	-1.0	-0.5	-0.5	-1.0	-0.4	-0.6
Class E						
Overall	**-0.8**	**-0.7**	**-0.6**	**-0.8**	**-0.5**	**-0.5**
Enc Time[%]	97%			99%		
Dec Time[%]	93%			95%		

	Low delay B HE			Low delay B LC		
	Y	U	V	Y	U	V
Class A						
Class B	-0.2	-0.1	-0.3	-0.2	-0.2	-0.2
Class C	-0.2	-0.1	-0.3	-0.3	0.0	-0.1
Class D	-0.1	-0.1	0.4	0.0	0.2	0.0
Class E	-0.2	-0.8	0.0	-0.2	0.1	0.6
Overall	**-0.2**	**-0.3**	**-0.1**	**-0.2**	**0.0**	**0.0**
Enc Time[%]	94%			98%		
Dec Time[%]	98%			96%		

(Qualcomm)

Reference: Anchor

Tested: Anchor without modified MV rounding

	Random access			Random access LoCo		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A	0.1	0.2	-0.1	0.1	0.1	0.1
Class B	0.3	0.1	0.2	0.2	0.0	0.0
Class C	0.4	0.3	0.2	0.4	0.2	0.2
Class D	0.7	0.5	0.3	0.7	0.2	0.4
Class E						
All	0.4	0.3	0.2	0.4	0.1	0.1
Enc Time[%]	101%			102%		
Dec Time[%]	100%			100%		

	Low delay			Low delay LoCo		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A						
Class B	0.0	0.0	-0.2	0.0	0.2	0.4
Class C	0.1	-0.1	0.0	0.0	-0.1	-0.1
Class D	0.0	0.1	-0.5	0.0	-0.1	0.1
Class E	0.2	0.8	-0.2	0.0	0.2	-0.3
All	0.1	0.2	-0.2	0.0	0.1	0.1
Enc Time[%]	101%			103%		
Dec Time[%]	99%			99%		

(MediaTek)

	Random access			Random access LoCo		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A	0.1	0.2	-0.1	0.1	0.1	0.1
Class B	0.3	0.1	0.2	0.2	0.0	0.0
Class C	0.4	0.3	0.2	0.4	0.2	0.2
Class D	0.7	0.5	0.3	0.7	0.2	0.4
Class E						
All	0.4	0.3	0.2	0.4	0.1	0.1
Enc Time[%]	93%			100%		
Dec Time[%]	83%			80%		

	Low delay			Low delay LoCo		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A						
Class B	0.0	0.0	-0.2	0.0	0.2	0.4
Class C	0.1	-0.1	0.0	0.0	-0.1	-0.1
Class D	0.0	0.1	-0.5	0.0	-0.1	0.1
Class E	0.2	0.8	-0.2	0.0	0.2	-0.3
All	0.1	0.2	-0.2	0.0	0.1	0.1
Enc Time[%]	105%			107%		
Dec Time[%]	88%			80%		

(Fujitsu)

3 Simplification of AMVP candidate list construction (SP)

3.1 Related Proposals

JCTVC-F050 "CE9: Results of Experiment SP04" (MediaTek)

1. SP04 is on removing the redundancy checking procedure during the derivation of top MVP in Inter mode.

JCTVC-F088 "CE9: Simplified AMVP design (SP06S1, SP06S2)" (TI and LGE)

2. SP06S2 is in reducing the number of spatial MVP scaling from four to one.

The proposed simplifications SP01 and SP07 are not evaluated because they only apply on 4x4 inter partitions.

It was agreed not to integrate SP01 and SP07 in case that 4x4 inter prediction is enabled because these are minor changes that can be easily reintegrated.

JCTVC-F575 "Simplification of MVP Design for HEVC" (Motorola Mobility)

This contribution proposes a simplification of MVP design for HEVC (High Efficiency Video Coding). Simulation results show that there is very minor loss or no loss compared to original AMVP while the complexity of the proposed method is reduced by half as compared to the MVP selection procedure of AMVP.

Results only shown for LowDelay.

If further studied in a CE a precise description of the Random Access case should be provided in a timely manner (2 weeks after the meeting).

Concerns were raised that inferring MVP for list1can restrict the encoder flexibility.

Further study on top of a robust solution is recommended.

Recommendation: Further study in a CE

JCTVC-F587 "Reduction of reference picture list checking for temporal motion vector prediction" (Samsung)

In this contribution, reduction of reference picture list checking for temporal motion vector prediction is proposed. Current HM-3.0 always checks two reference picture lists to select the best picture list of collocated PU for temporal motion vector prediction. In this contribution, only one picture list is tested for collocated PU, but only when the first picture list doesn't exist, the other list is examined instead of checking two picture lists. This simplification shows no loss without encoding and decoding time changes. It is recommended to adopt this simplification in the next HM.

Cross-checker (TI) has checked the code, confirms that the code reflects what is proposed.

Recommendation: Adopt method 3 in the HM

JCTVC-F593 uses the same method to detect the uni-directional case.

It was proposed that the POC check at slice level can be replaced by a "low delay" flag in the slice header. Further study of this in high-level syntax AHG was recommended.

3.2 Software

TI provides the code for SP04 and SP06S2 and MediaTek integrates it in the anchor software.

3.3 Tests

The following test is performed.

Simplification test	Tester1	Tester2
BOG_SP: Anchor + SP04 + SP06S2	TI	MediaTek

3.4 Results

Reference: Anchor

Tested: BOG_SP

	Random access			Random access LC		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A	0.0	0.2	-0.1	0.0	0.2	0.3
Class B	0.0	0.0	0.0	0.0	0.1	0.0
Class C	0.0	0.1	0.0	0.0	0.0	0.0
Class D	0.0	-0.1	-0.1	0.0	-0.1	0.1
Class E						
All	0.0	0.0	0.0	0.0	0.0	0.1
Enc Time[%]	104%			102%		
Dec Time[%]	107%			110%		

	Low delay			Low delay LC		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A						
Class B	0.0	-0.2	-0.3	0.0	0.0	0.1
Class C	0.0	-0.2	0.0	0.0	0.0	0.2
Class D	0.0	-0.1	0.0	0.0	0.0	0.0
Class E	0.0	0.5	-0.1	0.0	-0.2	-0.1
All	0.0	0.0	-0.1	0.0	0.0	0.0
Enc Time[%]	101%			100%		
Dec Time[%]	106%			106%		

(TI)

	Random access			Random access LoCo		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A	0.0	0.2	-0.1	0.0	0.2	0.3
Class B	0.0	0.0	0.0	0.0	0.1	0.0
Class C	0.0	0.1	0.0	0.0	0.0	0.0
Class D	0.0	-0.1	-0.1	0.0	-0.1	0.1
Class E						
All	0.0	0.0	0.0	0.0	0.0	0.1
Enc Time[%]	99%			101%		
Dec Time[%]	99%			99%		

	Low delay			Low delay LoCo		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A						
Class B	0.0	-0.2	-0.3	0.0	0.0	0.1
Class C	0.0	-0.2	0.0	0.0	0.0	0.2
Class D	0.0	-0.1	0.0	0.0	0.0	0.0
Class E	0.0	0.5	-0.1	0.0	-0.2	-0.1
All	0.0	0.0	-0.1	0.0	0.0	0.0
Enc Time[%]	100%			102%		
Dec Time[%]	100%			99%		

(MediatTek)

Recommendation: Adopt SP04 and SP06S2 in the HM

4 Unification of merge and AMVP candidate positions (UNI)

4.1 Related Proposals

JCTVC-F297 "CE9: Results of Experiments UNI03, SP10, and SP11" (Qualcomm)

1. UNI03

JCTVC-F419 "Unification of derivation process for merge mode and MVP" (JVC KENWOOD)

2. Proposal (1)

UNI03 and JCTVC-F419(1) search the same 5 spatial merge candidate positions.

UNI03 choose 4 spatial candidates to be used in merge mode.

JCTVC-F419(1) choose 2 spatial candidates to be used in merge mode.

UNI03 and JCTVC-F419(1) apply different search orders.

It was requested to test UNI03 without CAVLC modifications.

It was requested to test JCTVC-F419(1) using 4 spatial candidates for merge as in JCTVC-F297 instead of 2.

The following comments on the motivation of this unification have been made.

- No benefit in logic
- Memory access benefits

4.2 Software

JVC KENWOOD provides the code for JCTVC-F419(1). Qualcomm integrates it together with UNI03 on top of BOG_SP software.

The code for UNI03 should not change CABAC.

After release of the software was noted that:

- F419(1) derives the TMVP refidx using the unified merge candidate positions
- UNI03 derives the TMVP refidx using the HM3.0 merge candidate positions

UNI03 is also tested with deriving the TMVP refidx using the unified merge candidate positions. This is included in the released software.

4.3 Tests

The following tests are performed.

Unification test	**Tester1**	**Tester2**
BOG_UNI01: BOG_SP + UNI03 + unified TMVP refidx derivation without CAVLC modifications	Qualcomm	
BOG_UNI02: BOG_SP + UNI03 + unified TMVP refidx derivation	Qualcomm	
BOG_UNI03: BOG_SP + JCTVC-F419(1) using 4 merge candidates as in JCTVC-F297	JVC KENWOOD	MediaTek

4.4 Results

Reference: Anchor

Tested: BOG_UNI01

	Random Access HE			Random Access LC		
	Y	U	V	Y	U	V
Class A	-0.1	0.0	-0.3	-0.1	0.1	0.0
Class B	-0.1	-0.1	-0.1	-0.1	0.0	-0.1
Class C	-0.1	0.0	-0.2	0.0	-0.1	-0.1
Class D	-0.1	-0.1	0.0	0.0	-0.1	0.1
Class E						
Overall	**-0.1**	**0.0**	**-0.2**	**-0.1**	**0.0**	**0.0**
Enc Time[%]	101%			98%		
Dec Time[%]	#NUM!			#NUM!		

	Low delay B HE			Low delay B LC		
	Y	U	V	Y	U	V
Class A						
Class B	-0.2	-0.3	-0.3	-0.2	-0.1	0.2
Class C	-0.1	-0.3	-0.3	0.0	-0.1	-0.2
Class D	-0.1	-0.3	-0.4	-0.1	-0.1	0.0
Class E	0.0	1.2	-0.1	0.0	0.0	-0.1
Overall	**-0.1**	**0.0**	**-0.3**	**-0.1**	**-0.1**	**0.0**
Enc Time[%]	103%			105%		
Dec Time[%]	#NUM!			#NUM!		

BOG_UNI02

Random Access LC		
Y	U	V
0.0	0.1	0.0
-0.1	0.0	-0.1
-0.1	-0.2	-0.2
-0.1	-0.3	0.0
-0.1	**-0.1**	**-0.1**
98%		
#NUM!		

Low delay B LC		
Y	U	V
-0.1	0.0	0.2
-0.1	-0.2	-0.3
-0.2	-0.3	-0.2
-0.1	0.2	-0.4
-0.1	**-0.1**	**-0.1**
103%		
#NUM!		

(Qualcomm)

Reference: Anchor

Tested: BOG_UNI03

	Random Access HE			Random Access LC		
	Y	U	V	Y	U	V
Class A	-0.1	-0.1	-0.4	-0.1	0.1	0.0
Class B	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1
Class C	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
Class D	0.0	0.0	-0.2	-0.1	-0.1	0.0
Class E						
Overall	**-0.1**	**-0.1**	**-0.2**	**-0.1**	**0.0**	**-0.1**
Enc Time[%]	68%			94%		
Dec Time[%]	#NUM!			#NUM!		

	Low delay B HE			Low delay B LC		
	Y	U	V	Y	U	V
Class A						
Class B	-0.2	-0.2	-0.3	-0.2	0.1	-0.1
Class C	-0.1	-0.1	-0.1	-0.1	-0.2	-0.1
Class D	-0.1	0.0	-0.3	-0.1	-0.2	0.3
Class E	-0.1	1.1	-0.1	-0.1	0.3	-0.4
Overall	**-0.1**	**0.1**	**-0.2**	**-0.1**	**0.0**	**-0.1**
Enc Time[%]	69%			98%		
Dec Time[%]	#NUM!			#NUM!		

(JVC KENWOOD)

	Random Access HE			Random Access LC		
	Y	U	V	Y	U	V
Class A	-0.1	-0.1	-0.4	-0.1	0.1	0.0
Class B	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1
Class C	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
Class D	0.0	0.0	-0.2	-0.1	-0.1	0.0
Class E						
Overall	**-0.1**	**-0.1**	**-0.2**	**-0.1**	**0.0**	**-0.1**
Enc Time[%]	68%			94%		
Dec Time[%]	#NUM!			#NUM!		

	Low delay B HE			Low delay B LC		
	Y	U	V	Y	U	V
Class A						
Class B	-0.2	-0.2	-0.3	-0.2	0.1	-0.1
Class C	-0.1	-0.1	-0.1	-0.1	-0.2	-0.1
Class D	-0.1	0.0	-0.3	-0.1	-0.2	0.3
Class E	-0.1	1.1	-0.1	-0.1	0.3	-0.4
Overall	**-0.1**	**0.1**	**-0.2**	**-0.1**	**0.0**	**-0.1**
Enc Time[%]	69%			98%		
Dec Time[%]	#NUM!			#NUM!		

(MediaTek)

Recommendation: Adopt merge candidate search order and TMVP refidx derivation from JCTVC-F419(1), adopt using 4 spatial merge candidates from 5 positions in JCTVC-F297 in the HM.

5 Improvements of merge and AMVP modes

5.1 Related Proposals

JCTVC-F105 "On MVP list pruning process" (LGE)

In the AMVP process, 'identical' MVP (Motion Vector Predictor) candidates are removed from the MVP list. This contribution proposes to allow 'different' MVP candidates to be removed from the MVP list if the difference between motion vectors is smaller than or equal to a threshold value. Various threshold values are tested and the threshold value is determined to 5 considering overall coding efficiency. The proposed technique changes only one condition in the AMVP process and this minor change results in 0.2% BD-rate reduction for the random access and low delay high efficiency configurations and 0.1% BD-rate reduction for the random access and low delay low complexity configurations.

Concerns were raised on the complexity of the threshold approach.

Gain may come from a shorter candidate list that is beneficial in current list size depending index coding.

Recommendation: Further study in a CE

JCTVC-F373 "Merge based mvd transmission" (JVC KENWOOD)

In the HM3.0, merge based skip mode is adopted since skip mode has same characteristic with merge that motion vector difference (mvd) is not transmitted. In the case of transmitting mvd, AMVP (Advanced Motion Vector Prediction) is used to reduce motion information.

In this proposal, it is described to improve coding efficiency by extending merge motion information derivation process based on merge mode to mvd transmission case.

The simulation results report that the proposed technique provides 0.6% BD-rate gain for random access settings and 1.3% gain for low delay settings with 14% encoder runtime and 1% decoder runtime increase.

It should be investigated how much the overhead of not using this mode will be.

Recommendation: Further study in a CE

JCTVC-F372 "Bi-derivative merge candidate" (JVC KENWOOD)

This proposal was already presented in track A. From the meeting notes (JCTVC-F_Notes_d5.doc):

> "Should be studied in relation to the MVP candidate list construction discussion. (BoG ongoing B. Bross)"

Recommendation: Further study in a CE

6 Parsing throughput/robustness (ROB)

6.1 Related Proposals

JCTVC-F341 "Decoder Performance Restrictions due to Merge/MVP Index Parsing" (Broadcom)

Previous contributions have asserted that the present method of decoding Merge Index and MVP Index have significant negative impacts on CABAC and CAVLC performance and implementation in high-performance decoder applications. This contribution quantifies some of this impact. It suggests that the present method of Merge/MVP Index encoding will severely limit achievable CABAC decoder bit rates and CAVLC decoder performance. It proposes one solution to this problem, and recommends accepting one of several possible encoding solutions, even if they have a small negative impact on coding efficiency.

The presentation was just informative to show that besides robustness, throughput is a serious issue.

It was pointed out that the impact on throughput could be evaluated by taking the portion of merge and amvp idx bits in the bitstream into account.

JCTVC-F474 "CE9: Description of experiments ROB01 and ROB02" (Canon)

This contribution reports the results of ROB01 and ROB02 experiments for section 4.5 of CE 9 as described in JCTVC-E709. Both experiments deal with the parsing robustness related to the use of the temporal predictor in Inter and Merge modes. The ROB01 experiment fully solves this parsing issue by determining the number of predictors in the set according to the availability of the spatial predictor positions. The ROB02 experiment uses the same scheme to fix parsing issue. The difference comes from the use of a specific derivation process which produces non-redundant predictors. ROB02 experiment obtains 0.5% coding loss compared to the CE9 anchor with 95% decoding runtime variation.

A slice header flag is added to disable the temporal MVP. That was also proposed in JCTVC-F427.

A simplification is presented that reduces the number of scaling operations for AMVP from 10 to 6 compared to HM3.0.

A robustness check as performed in the contribution should be performed for every method.

Several companies expressed support for the simplified ROB02 solution.

BD rate loss of this solution is 0.6% RA HE, 0.4 RA LC, 0.7% LDB HE, 0.4% LDB LC.

Recommendation: Further study in a CE

JCTVC-F052 "CE9: Results of Experiment ROB04" (MediaTek)

This contribution reported the performance results of CE9 ROB04 experiment on parsing robustness. In this experiment, a basic scheme with parsing robustness by skipping the process of removing redundant motion vector predictors (MVPs) and forcing the availability of the temporal MVP was firstly provided. The experiment results reported that this basic scheme resulted in average 1.3%, 1.3%, 1.9%, and 2.0% bit rate increases for high HE-RA, LC-RA, HE-LD, and LC-LD, respectively. To reduce the bit rate

increases, two approaches were tested in ROB04. The first approach was replacing the redundant MVPs by other substitutes, and the second approach was reducing redundant MVPs without comparing motion vector values. It was reported that combing both approaches caused 0.3%, 0.4%, 0.3%, and 0.5% bit rate increases for HE-RA, LC-RA, HE-LD, and LC-LD, respectively, while providing the ability to prevent all parsing errors caused by any data loss of reference pictures.

Concerns are raised about that memory needs for storing motion id. The motion id is incremented if no merge is used (max 10 no 4x4 / 12bits 4x4).

The motion id concept gives BD rate loss of 0.9% RA HE, 0.9% RA LC, 1.4% LDB HE, 1.3% LDB LC

Recommendation: Further study in a CE.

JCTVC-F713 "CE9: Result about the combination of experiments ROB02 and ROB04" (Canon, MediaTek)

This contribution reports the results of the combination of two experiments ROB02 and ROB04 presented in the scope of CE9. It is reported that this combination leads to an average loss of 0.2% in RA-HE, 0.1% in RA-LC, 0.2% in LB-HE and 0.1% in LB-LC, respectively. Compared to ROB02 only, the combination brings an average coding gain of 0.4% in RA-HE, 0.2% in RA-LC, 0.6% in LB-HE and 0.3% in LB-LC, respectively. Compared to ROB04 only, the combination brings an average coding gain of 0.2% in RA-HE, 0.3% in RA-LC, 0.2% in LB-HE and 0.4% in LB-LC, respectively.

It is also reported that the encoding time is 102% in RA-HE, 103% in RA-LC, 103% in LB-HE and 104% in LB-LC, respectively. The decoding time is reportedly 96% in RA-HE, 97% in RA-LC, 96% in LB-HE and 97% in LB-LC, respectively.

Combination uses not simplified ROB02.

Recommendation: Further study in a CE.

JCTVC-F470 "Parsing Robustness for Merge/AMVP" (Panasonic)

In this contribution, an approach to solve the parsing problem related to Merge/AMVP in HM3.0 was proposed. The proposed approach uses fixed list length of Merge/AMVP candidates to decouple Merge/AMVP candidate list derivation and Merge/AMVP indices parsing. Moreover, in order to compensate the coding performance loss caused by the fixed list length, additional Merge/AMVP candidates are assigned to the empty positions in the list, Relative to the HM3.0+bugfix146, experimental results reportedly showed 0.1% BR saving for HE and 0.3% BR saving in the RA scenarios, and 0.2% BR saving for HE and 0.7% BR saving for LC on average in the LD scenarios while achieving the parsing robustness for Merge/AMVP.

JCTVC-F090 "Cross-verification of Panasonic's proposal JCTVC-F470 on parsing robustness for merge/AMVP" (TI)

To avoid the parsing problem, following two adaptive switching methods are disabled in this proposal.

- Adaptive context selection method for inter_pred_flag and ref_idx_lx (CABAC)
  → It is changed such that ctxIdx is fixed to 0
- Adaptive combined coding method for inter_pred_flag and ref_idx_lx (CAVLC)
  → It is changed such that use_combined_inter_pred_ref is fixed to true in B slice

The context derivation for inter_pred_flag was also discussed in the BoG on context reduction for CABAC (JCTVC-F746). In this BoG it was decided to derive the inter_pred_flag context depending on the CU depth. It was noted that using that method instead of setting the ctxIdx to 0 would not have an impact on F470.

A Table showing the number of scaling to be performed in the worst case was requested.

It was mentioned that the method would pass a robustness check.

It was asked what the gains are for applying only adding candidates and not fixing the list size.

A simplification based on comment in the cross check report F090 was presented.

Several companies expressed support because gains are reported.

WD text can be further improved. An improved version of the WD text describing the simplifications was made available in JCTVC-F470_r3.doc.

JCTVC-F402 "MVP index parsing with fixed number of candidates" (Samsung)

In this contribution, truncated unary coding with fixed number of MVP candidates to solve the robust parsing issue related to AMVP and Merge. With the fixed number of candidates, parsing merge index and AMVP index doesn't require any information regarding available candidates. At motion data reconstruction stage, to make the fixed number of MVP candidates always, the first existing candidate is modified and added to candidates list if initial existing candidates' number is less than the fixed number. The proposed method achieves robust parsing of motion information as well as parsing throughput improvement with 0.3%, 0.2%, 0.6%, 0.7% BD-rate loss, respectively in HE-RA, LC-RA, HE-LD and LC-LD configurations.

The proponent referred to F347 as to be further discussed instead of F402.

Recommendation: Further study in a CE.

JCTVC-F068 "A study on HM3.0 parsing throughput issue" (TI)

It has been reported that the current HM3.0 design has parsing throughput issue due to interdependency between the motion data reconstruction and entropy decoding. This contribution reports throughput study results and proposes a solution to the reported issue. Throughput study reveals that the entropy decoding throughput would need to be improved by roughly 2x to achieve the same decoding throughput as AVC if such interdependency remains unchanged. It is proposed to use truncated unary coding with fixed maximum code length signaled in the slice header for the MVP index coding to completely remove the interdependency between the motion data reconstruction and entropy decoding. Compared to HM3.0 the proposed algorithm leads to an average loss of 0.6% in RA-HE, 0.7% in RA-LC, 1.0% in LB-HE and 1.1% in LB-LC, respectively. A study on combined solution with JCTVC-F470 shows that average gain of 0.0% in RA-HE, 0.1% in RA-LC, 0.1% in LB-HE and 0.5% in LB-LC can be achieved. The combined solution has considered practical implementation by limiting the maximum number of additional scales to ONE and maximum number of MVP candidates for the final pruning process to 10.

Recommendation: Further study in a CE

JCTVC-F347 "A method of decoupling motion data reconstruction from entropy decoding" (TI, Panasonic, Broadcom, Samsung)

A simple solution is preferred to have in HM4.0 as a baseline for upcoming CEs. This will result in a loss that has to be justified to the group by emphasizing that the parsing throughput/robustness issue is critical und has to be resolved. An outlook can be given of how much the loss can be reduced.

New slice header syntax elements are proposed. It was raised that since they would be fixed, introducing new slice header syntax elements is not a good starting point.

It was claimed that only minimal changes to the current design are introduced.

Recommendation: Further study in a CE

JCTVC-F427 "Consideration on Temporal Predictor" (Sony)

HEVC employs temporal predictor as well as spatial predictors both for AMVP and Merge. As of the former motion information of surrounding PUs is stored in line buffer, but as of the latter all motion

information in the reference frames should be stored in memory so increase of the size of the storage and bandwidth is concern. Especially for encoder manufacturers solution to develop low-cost encoders without the temporal predictor will be needed. In TMuC there use to be "mv_competition_temporal_flag" in the slice header and by setting the value as 0, it is possible to develop encoder without the temporal predictor. However it is no longer contained in the latest HEVC specification. The problem is that if all of the spatial predictors are unavailable and the temporal predictor is available in a PU, it cannot be avoided to apply the temporal predictor. This problem will happen both with AMVP and Merge cases. To solve this problem we propose either of the following solutions:

(a) Insert "amvp_temporal_flag" (formerly known as "mv_competition_temporal_flag") and "merge_temporal_flag" in a slice header

(b) If all of the spatial predictors unavailable, set (0,0) as a spatial predictor regardless of the availability of the temporal predictor

As shown in the rest of this document, solution (b) does not cause loss in coding efficiency.

Missmatch between software and WD for zero MV candidate in AMVP if no candidates are available.

Inserting a slice header flag to disable the temporal candidate for merge and AMVP (a) was also proposed by JCTVC-F051(ROB03), JCTVC-F052(ROB04) and JCTVC-F474(ROB02).

Recommendation: Put a flag in PPS to disable temporal MV predictor

Problem addressed by solution (b) is solved by F470 with simplifications.

JCTVC-F083 "CE9: Evaluation results on disabling TMVP from AMVP list construction (ROB05)" (TI)

Recommendation: Further study in a CE

6.2 Software

Panasonic provides the code for F470 with simplifications and integrates it on top of BOG_UNI03 software.

Canon provides the code for ROB02 with simplifications and integrates it on top of BOG_UNI03 software.

6.3 Tests

The following tests are performed.

Robustness test	**Tester1**	**Tester2**
BOG_ROB01: BOG_SP + BOG_UNI03 + F470 with simplifications	Panasonic	TI
BOG_ROB02: BOG_SP + BOG_UNI03 + ROB02 with simplifications	Canon	MediaTek

6.4 Results

Reference: Anchor

Tested: BOG_ROB01

	Random Access HE			Random Access LC		
	Y	U	V	Y	U	V
Class A	-0.2	-0.3	-0.6	-0.4	-0.1	-0.3
Class B	-0.1	-0.3	-0.3	-0.1	-0.2	-0.2
Class C	0.0	0.0	-0.3	-0.1	-0.2	-0.3
Class D	0.1	-0.1	-0.1	0.1	-0.2	0.0
Class E						
Overall	**-0.1**	**-0.2**	**-0.3**	**-0.1**	**-0.2**	**-0.2**
Enc Time[%]	113%			111%		
Dec Time[%]	101%			100%		

	Low delay B HE			Low delay B LC		
	Y	U	V	Y	U	V
Class A						
Class B	-0.6	-1.4	-1.1	-1.3	-1.2	-1.1
Class C	-0.6	-1.0	-1.1	-0.9	-0.9	-0.9
Class D	-0.5	-0.6	-0.7	-0.6	-0.7	-0.6
Class E	0.4	0.3	-0.7	-0.1	-0.4	-0.4
Overall	**-0.4**	**-0.7**	**-0.9**	**-0.8**	**-0.9**	**-0.8**
Enc Time[%]	109%			108%		
Dec Time[%]	100%			100%		

(Panasonic)

	Random access			Random access LC		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A	-0.2	-0.3	-0.6	-0.4	-0.1	-0.3
Class B	-0.1	-0.3	-0.3	-0.1	-0.2	-0.2
Class C	0.0	0.0	-0.3	-0.1	-0.2	-0.3
Class D	0.1	-0.1	-0.1	0.1	-0.2	0.0
Class E						
All	-0.1	-0.2	-0.3	-0.1	-0.2	-0.2
Enc Time[%]	119%			110%		
Dec Time[%]	103%			98%		

	Low delay			Low delay LC		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A						
Class B	-0.6	-1.4	-1.1	-1.3	-1.2	-1.1
Class C	-0.6	-1.0	-1.1	-0.9	-0.9	-0.9
Class D	-0.5	-0.6	-0.7	-0.6	-0.7	-0.6
Class E	0.4	0.3	-0.7	-0.1	-0.4	-0.4
All	-0.4	-0.7	-0.9	-0.8	-0.9	-0.8
Enc Time[%]	111%			109%		
Dec Time[%]	102%			103%		

(TI)

Reference: Anchor

Tested: BOG_ROB02

	Random Access HE			Random Access LC		
	Y	U	V	Y	U	V
Class A	0.4	0.4	0.3	0.2	0.2	0.0
Class B	0.6	0.4	0.3	0.5	0.3	0.2
Class C	0.7	0.6	0.5	0.6	0.3	0.3
Class D	0.8	0.4	0.4	0.7	0.3	0.4
Class E						
Overall	**0.6**	**0.4**	**0.4**	**0.5**	**0.3**	**0.2**
Enc Time[%]	115%			115%		
Dec Time[%]	96%			100%		

	Low delay B HE			Low delay B LC		
	Y	U	V	Y	U	V
Class A						
Class B	0.1	-0.4	-0.7	-0.4	-0.5	-0.5
Class C	0.3	-0.1	-0.1	0.1	-0.2	-0.3
Class D	0.5	0.2	-0.2	0.2	-0.2	-0.5
Class E	2.0	2.6	1.3	1.7	1.9	2.5
Overall	**0.6**	**0.4**	**0.0**	**0.3**	**0.1**	**0.1**
Overall wo Cl	**0.3**	**-0.1**	**-0.3**	**-0.1**	**-0.3**	**-0.4**
Enc Time[%]	113%			112%		
Dec Time[%]	94%			100%		

(Canon)

	Random access			Random access LoCo		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A	0.4	0.4	0.3	0.2	0.2	0.0
Class B	0.6	0.4	0.3	0.5	0.3	0.2
Class C	0.7	0.6	0.5	0.6	0.3	0.3
Class D	0.8	0.4	0.4	0.7	0.3	0.4
Class E						
All	0.6	0.4	0.4	0.5	0.3	0.2
Enc Time[%]	115%			114%		
Dec Time[%]	96%			99%		

	Low delay			Low delay LoCo		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A						
Class B	0.1	-0.4	-0.7	-0.4	-0.5	-0.5
Class C	0.3	-0.1	-0.1	0.1	-0.2	-0.3
Class D	0.5	0.2	-0.2	0.2	-0.2	-0.5
Class E	2.0	2.6	1.3	1.7	1.9	2.5
All	0.6	0.4	0.0	0.3	0.1	0.1
Enc Time[%]	114%			113%		
Dec Time[%]	99%			99%		

(MediaTek)

Recommendation: Adopt F470 with simplifications in the HM and the CABAC context derivation depending on CU depth for inter_pred_flag from JCTVC-F746.

7 Additional Tests

7.1 Proposals

It was requested to test the following proposals on top of agreed solution.

JCTVC-F060 "Reducing Line Buffers for Motion Data and CABAC" (MediaTek)

Motion data line buffer reduction variant using 2:1 compression

JCTVC-F465 "Experiments on tools in Working Daft (WD) and HEVC Test Mode (HM-3.0)" (Samsung, TI)

Item 1 (Center position of TMVP candidates)

JCTVC-F587 "Reduction of reference picture list checking for temporal motion vector prediction" (Samsung)

7.2 Software

MediaTek provides the code for F460 and integrates it on top of BOG_ROB01 software.

F465/Item 1 can be tested by disabling the following macros in the BOG_ROB01 software.

```
#define FT_TCTR_MRG     0           ///< central colocated in MERGE
#define FT_TCTR_AMVP    0           ///< central colocated in AMV
```

7.3 Tests

The following tests are performed.

Additional test	Tester1	Tester2
BOG_ADD01: BOG_ROB01 + F060	MediaTek	Qualcomm
BOG_ADD02: BOG_ROB01 + F465 Item1	TI	Orange Labs
BOG_ADD03: BOG_ROB01 + F587 Method 3	Samsung	TI

7.4 Results

Reference: Anchor

Tested: BOG_ADD01

	Random access			Random access LoCo		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A	-0.2	-0.2	-0.5	-0.4	-0.1	-0.3
Class B	-0.1	-0.3	-0.3	-0.1	-0.2	-0.1
Class C	0.0	-0.1	-0.3	-0.1	-0.2	-0.3
Class D	0.1	-0.1	-0.2	0.1	-0.3	0.0
Class E						
All	-0.1	-0.2	-0.3	-0.1	-0.2	-0.2
Enc Time[%]	#NUM!			#NUM!		
Dec Time[%]	#NUM!			#NUM!		

	Low delay			Low delay LoCo		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A						
Class B	-0.6	-1.3	-1.3	-1.3	-1.3	-1.2
Class C	-0.6	-1.1	-1.0	-0.9	-0.8	-0.9
Class D	-0.5	-0.7	-0.6	-0.6	-0.8	-0.4
Class E	0.5	0.0	-0.5	-0.2	0.0	-0.4
All	-0.4	-0.8	-0.9	-0.8	-0.8	-0.8
Enc Time[%]	#NUM!			#NUM!		
Dec Time[%]	#NUM!			#NUM!		

(MediaTek)

	Random Access HE			Random Access LC		
	Y	U	V	Y	U	V
Class A	-0.2	-0.2	-0.5	-0.4	-0.1	-0.3
Class B	-0.1	-0.3	-0.3	-0.1	-0.2	-0.1
Class C	0.0	-0.1	-0.3	-0.1	-0.2	-0.3
Class D	0.1	-0.1	-0.2	0.1	-0.3	0.0
Class E						
Overall	**-0.1**	**-0.2**	**-0.3**	**-0.1**	**-0.2**	**-0.2**
Enc Time[%]	114%			109%		
Dec Time[%]	106%			102%		

	Low delay B HE			Low delay B LC		
	Y	U	V	Y	U	V
Class A						
Class B	-0.6	-1.3	-1.3	-1.3	-1.3	-1.2
Class C	-0.6	-1.1	-1.0	-0.9	-0.8	-0.9
Class D	-0.5	-0.7	-0.6	-0.6	-0.8	-0.4
Class E	0.5	0.0	-0.5	-0.2	0.0	-0.4
Overall	**-0.4**	**-0.8**	**-0.9**	**-0.8**	**-0.8**	**-0.8**
Enc Time[%]	112%			110%		
Dec Time[%]	102%			102%		

(Qualcomm)

Recommendation: Adopt F060 motion data line buffer reduction with 2:1 compression

Reference: Anchor

Tested: BOG_ADD02

	Random access			Random access LC		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A	-0.2	-0.3	-0.6	-0.4	0.1	-0.2
Class B	0.0	-0.3	-0.3	-0.1	-0.1	-0.1
Class C	0.1	0.0	-0.2	0.0	-0.1	-0.2
Class D	0.2	-0.1	0.0	0.2	-0.1	0.1
Class E						
All	0.0	-0.2	-0.3	0.0	-0.1	-0.1
Enc Time[%]	117%			113%		
Dec Time[%]	103%			105%		

	Low delay			Low delay LC		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A						
Class B	-0.5	-1.1	-1.4	-1.2	-1.1	-1.1
Class C	-0.5	-0.9	-0.7	-0.7	-0.7	-0.9
Class D	-0.3	-0.6	-0.2	-0.5	-0.4	-0.4
Class E	0.6	0.7	-0.5	-0.1	0.0	-0.1
All	-0.3	-0.6	-0.8	-0.7	-0.6	-0.7
Enc Time[%]	110%			111%		
Dec Time[%]	101%			106%		

(TI)

	Random access			Random access LC		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A	-0.2	-0.3	-0.6	-0.4	0.1	-0.2
Class B	0.0	-0.3	-0.3	-0.1	-0.1	-0.1
Class C	0.1	0.0	-0.2	0.0	-0.1	-0.2
Class D	0.2	-0.1	0.0	0.2	-0.1	0.1
Class E						
All	0.0	-0.2	-0.3	0.0	-0.1	-0.1
Enc Time[%]	117%			113%		
Dec Time[%]	103%			105%		

	Low delay			Low delay LC		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A						
Class B	-0.5	-1.1	-1.4	-1.2	-1.1	-1.1
Class C	-0.5	-0.9	-0.7	-0.7	-0.7	-0.9
Class D	-0.3	-0.6	-0.2	-0.5	-0.4	-0.4
Class E	0.6	0.7	-0.5	-0.1	0.0	-0.1
All	-0.3	-0.6	-0.8	-0.7	-0.6	-0.7
Enc Time[%]	110%			111%		
Dec Time[%]	101%			106%		

(Orange Labs)

Recommendation: Further study disabling the centered temporal motion vector predictor in a CE

Reference: Anchor

Tested: BOG_ADD03

	Random Access HE			Random Access LC		
	Y	U	V	Y	U	V
Class A	-0.2	-0.4	-0.7	-0.4	-0.1	-0.4
Class B	-0.1	-0.3	-0.3	-0.1	-0.2	-0.2
Class C	0.0	0.0	-0.2	-0.1	-0.2	-0.3
Class D	0.0	-0.2	-0.2	0.1	-0.2	0.0
Class E						
Overall	**-0.1**	**-0.2**	**-0.3**	**-0.2**	**-0.2**	**-0.2**
Enc Time[%]	#NUM!			#NUM!		
Dec Time[%]	#NUM!			#NUM!		

	Low delay B HE			Low delay B LC		
	Y	U	V	Y	U	V
Class A						
Class B	-0.6	-1.4	-1.1	-1.3	-1.2	-1.1
Class C	-0.6	-1.0	-1.1	-0.9	-0.9	-0.9
Class D	-0.5	-0.6	-0.7	-0.6	-0.7	-0.6
Class E	0.4	0.3	-0.7	-0.1	-0.4	-0.4
Overall	**-0.4**	**-0.7**	**-0.9**	**-0.8**	**-0.9**	**-0.8**
Enc Time[%]	#NUM!			#NUM!		
Dec Time[%]	#NUM!			#NUM!		

(Samsung)

	Random access			Random access LC		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A	-0.2	-0.4	-0.7	-0.4	-0.1	-0.4
Class B	-0.1	-0.3	-0.3	-0.1	-0.2	-0.2
Class C	0.0	0.0	-0.2	-0.1	-0.2	-0.3
Class D	0.0	-0.2	-0.2	0.1	-0.2	0.0
Class E						
All	-0.1	-0.2	-0.3	-0.2	-0.2	-0.2
Enc Time[%]	116%			112%		
Dec Time[%]	99%			100%		

	Low delay			Low delay LC		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A						
Class B	-0.6	-1.4	-1.1	-1.3	-1.2	-1.1
Class C	-0.6	-1.0	-1.1	-0.9	-0.9	-0.9
Class D	-0.5	-0.6	-0.7	-0.6	-0.7	-0.6
Class E	0.4	0.3	-0.7	-0.1	-0.4	-0.4
All	-0.4	-0.7	-0.9	-0.8	-0.9	-0.8
Enc Time[%]	109%			110%		
Dec Time[%]	99%			107%		

(TI)

8 Timeline

Sat. July 16, evening

- Anchor + simplification code release
- Start of anchor tests
- Start of simplifications tests

Sun, July 17 morning

- Anchor + simplification + unification code release
    - Start of unification tests

Mon, July 18

- Review the available results
- Review proposals not tested in this BoG
- Review parsing throughput/robustness proposals and try to agree on a simple robust solution

- Prepare testing this solution together with anchor, simplifications and unifications
    - Anchor + SP04 + SP06S2 + F419(1) + simplified F474
    - Anchor + SP04 + SP06S2 + F419(1) + F470

  JVC will proved software and macro settings for Anchor + SP04 + SP06S2 + F419(1)
- WD text and software should be provided for both tests

Wednesday morning the participants have the possibility to study the code and the WD text.

Wed, July 20

- Review software and WD text for simplified F474 and simplified F470
- Discuss to continue/establish CE(s)
- Prepare and start additional tests

Thu, July 21

- Review additional tests
- Present and finalize report