JCTVC-S0137
Non-CE4: Intra Line Copy with Extended Full-frame Search for Test A

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Strasbourg, France, 2014

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Introduction

* In CE4 Test A2 (JCTVC-S0135) and SCM-2.0, the search range for ILC and 4x4/4x8/8x4 IBC is restricted to 2 CTUs

* This contribution reports results in extending their search range to full frame
  - Test A2: **2-CTU** for 4x4/4x8/8x4 IBC, **2-CTU** for ILC
  - Test #1: **2-CTU** for 4x4/4x8/8x4 IBC, **full-frame** for ILC
  - Test #3: **full-frame** for 4x4/4x8/8x4 IBC, **full-frame** for ILC
  - Test #2: **full-frame** for 4x4/4x8/8x4 IBC (i.e. **#2 without ILC**)

* Codebase: JCTVC-S0136 software (incl. CABAC throughput fixes)

Full-frame Configuration

✳ SCM-2.0

CU Size	8x8				16x16			Others
PU Type	-	4x4	4x8/8x4	8x8	-	8x16/16x8	16x16	
SCM	-	2-CTU	2-CTU	FF	-	x	FF	x

✳ This contribution

CU Size	8x8				16x16			Others
PU Type	Line	4x4	4x8/8x4	8x8	Line	8x16/16x8	16x16	
Test A2	2-CTU	2-CTU	2-CTU	FF	x	x	FF	x
Test #1	FF	2-CTU	2-CTU	FF	x	x	FF	x
Test #3	FF	FF	FF	FF	x	x	FF	x
Test #2	-	FF	FF	FF	-	x	FF	x

Summary

* Relative to SCM-2.0:
  - Up to **4.4%** gain w/ **2-CTU** 4x4/4x8/8x4 IBC, **2-CTU** ILC
  - Up to **10.1%** gain w/ **2-CTU** 4x4/4x8/8x4 IBC, **full-frame** ILC
  - Up to **12.9%** gain w/ **full-frame** 4x4/4x8/8x4 IBC, **full-frame** ILC
  - Up to **6.0%** gain w/ **full-frame** 4x4/4x8/8x4 IBC only (**no ILC)**

* Average-case memory access bandwidth
  - 4x2 memory access pattern; (alignment, burst) = (64, 256)
  - w/o cache (AI)
    * Up to **13%** increase with 2-CTU ILC
    * Up to **25%** when extended to full-frame ILC
  - w/ cache (AI)
    * Minor increase with 2-CTU ILC
    * Up to **3.5%** when extended to full-frame ILC
  - For RA/LB, up to **2%** increase (w/o cache), minor increase (w/ cache)

Performance Results

Lossy (G/Y BD-rate)	All Intra				Random Access				Low Delay B			
	(A2) 2-IBC 2-ILC	(#1) 2-IBC F-ILC	(#3) F-IBC F-ILC	(#2) F-IBC X	(A2) 2-IBC 2-ILC	(#1) 2-IBC F-ILC	(#3) F-IBC F-ILC	(#2) F-IBC X	(A2) 2-IBC 2-ILC	(#1) 2-IBC F-ILC	(#3) F-IBC F-ILC	(#2) F-IBC X
RGB, text & graphics with motion, 1080p	-4.4	-10.1	-12.9	-6.0	-2.4	-5.4	-7.0	-3.1	-1.5	-3.6	-4.8	-2.3
RGB, text & graphics with motion, 720p	-1.5	-4.6	-6.2	-3.5	-1.2	-3.2	-4.3	-2.4	-0.5	-1.6	-2.3	-1.2
RGB, mixed content, 1440p	-1.7	-4.0	-5.0	-2.6	-1.1	-2.5	-3.2	-1.7	-0.6	-1.2	-1.7	-1.0
RGB, mixed content, 1080p	-2.5	-7.0	-8.2	-4.7	-1.9	-4.9	-5.7	-3.3	-0.7	-2.1	-2.5	-1.6
YUV, text & graphics with motion, 1080p	-4.4	-9.9	-13.0	-6.1	-2.2	-4.7	-6.3	-2.8	-1.3	-2.9	-4.0	-1.8
YUV, text & graphics with motion, 720p	-1.5	-4.5	-6.3	-3.6	-1.1	-3.2	-4.5	-2.5	-0.7	-1.5	-2.2	-1.3
YUV, mixed content, 1440p	-1.6	-4.1	-5.2	-2.8	-1.1	-2.6	-3.3	-1.5	-0.6	-1.4	-1.5	-0.8
YUV, mixed content, 1080p	-2.5	-7.1	-8.5	-4.9	-1.8	-5.3	-6.2	-3.4	-0.7	-2.0	-2.6	-1.2
Enc Time[%]	117	128	143	114	107	109	116	108	108	108	115	107
Dec Time[%]	102	102	102	100	104	102	102	101	104	103	103	101

Lossless (G/Y BD-rate)	All Intra				Random Access				Low Delay B			
	(A2)	(#1)	(#3)	(#2)	(A2)	(#1)	(#3)	(#2)	(A2)	(#1)	(#3)	(#2)
RGB, text & graphics with motion, 1080p	4.9	11.0	12.8	5.7	3.4	8.0	9.4	4.1	2.8	6.8	8.1	3.6
RGB, text & graphics with motion, 720p	1.0	2.4	2.8	1.2	0.5	1.2	1.4	0.7	0.3	0.8	1.0	0.4
RGB, mixed content, 1440p	0.6	2.2	2.4	0.7	0.1	0.4	0.5	0.2	0.1	0.2	0.3	0.1
RGB, mixed content, 1080p	0.8	2.8	3.1	1.6	0.1	0.5	0.6	0.3	0.1	0.2	0.3	0.1
YUV, text & graphics with motion, 1080p	5.1	11.8	13.7	5.8	3.6	8.6	10.0	4.1	3.0	7.4	8.7	3.6
YUV, text & graphics with motion, 720p	1.2	2.9	3.4	1.4	0.6	1.5	1.8	0.8	0.4	1.0	1.1	0.5
YUV, mixed content, 1440p	0.7	2.3	2.5	0.9	0.1	0.4	0.5	0.2	0.1	0.3	0.4	0.2
YUV, mixed content, 1080p	0.9	3.3	3.6	2.0	0.2	0.6	0.7	0.4	0.1	0.3	0.3	0.2
Enc Time[%]	115	121	141	119	103	104	109	105	102	104	107	104
Dec Time[%]	101	100	100	100	101	100	100	100	100	100	100	100

Average-case Memory Access Bandwidth

Lossy (G/Y BD-rate)	All Intra							
	64-256				64-256 Cache			
	(A2) 2-IBC 2-ILC	(#1) 2-IBC F-ILC	(#3) F-IBC F-ILC	(#2) F-IBC X	(A2) 2-IBC 2-ILC	(#1) 2-IBC F-ILC	(#3) F-IBC F-ILC	(#2) F-IBC X
RGB, text & graphics with motion, 1080p	113.2%	125.1%	121.9%	102.4%	99.5%	103.5%	106.8%	105.4%
RGB, text & graphics with motion, 720p	106.8%	114.0%	112.2%	102.2%	99.8%	102.3%	105.8%	105.0%
RGB, mixed content, 1440p	108.2%	113.7%	112.3%	101.3%	99.7%	101.7%	103.3%	102.8%
RGB, mixed content, 1080p	111.6%	119.2%	116.3%	101.5%	99.5%	102.9%	104.1%	103.5%
RGB, animation, 720p	100.8%	100.8%	100.9%	100.1%	100.0%	100.1%	100.4%	100.3%
RGB, camera captured, 1080p	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.3%	100.3%
YUV, text & graphics with motion, 1080p	111.6%	122.4%	120.4%	102.4%	99.5%	103.4%	106.8%	105.3%
YUV, text & graphics with motion, 720p	106.2%	112.7%	111.4%	102.1%	99.8%	102.3%	105.1%	104.2%
YUV, mixed content, 1440p	107.1%	112.3%	111.1%	101.2%	99.7%	101.6%	103.1%	102.6%
YUV, mixed content, 1080p	110.6%	117.8%	115.3%	101.6%	99.5%	102.6%	103.9%	103.3%
YUV, animation, 720p	100.8%	100.8%	100.9%	100.1%	100.0%	100.1%	100.3%	100.3%
YUV, camera captured, 1080p	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.3%	100.3%
Average	106.4%	**111.6%**	**110.2%**	**101.3%**	99.7%	**101.7%**	**103.4%**	**102.8%**

Average-case Memory Access Bandwidth

Lossy (G/Y BD-rate)	Random Access							
	64-256				64-256 Cache			
	(A2) 2-IBC 2-ILC	(#1) 2-IBC F-ILC	(#3) F-IBC F-ILC	(#2) F-IBC X	(A2) 2-IBC 2-ILC	(#1) 2-IBC F-ILC	(#3) F-IBC F-ILC	(#2) F-IBC X
RGB, text & graphics with motion, 1080p	100.9%	101.8%	101.6%	100.1%	99.9%	100.2%	100.4%	100.3%
RGB, text & graphics with motion, 720p	100.2%	100.4%	100.3%	100.0%	100.0%	100.0%	100.1%	100.1%
RGB, mixed content, 1440p	100.3%	100.2%	100.3%	100.0%	100.1%	100.0%	100.1%	100.0%
RGB, mixed content, 1080p	100.1%	100.3%	100.2%	100.0%	99.9%	100.0%	100.1%	100.0%
RGB, animation, 720p	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
RGB, camera captured, 1080p	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.1%	100.0%
YUV, text & graphics with motion, 1080p	100.8%	101.6%	101.4%	100.2%	100.0%	100.3%	100.5%	100.3%
YUV, text & graphics with motion, 720p	100.2%	100.4%	100.3%	100.0%	100.0%	100.1%	100.1%	100.1%
YUV, mixed content, 1440p	100.2%	100.3%	100.2%	100.1%	100.0%	100.1%	100.1%	100.1%
YUV, mixed content, 1080p	100.2%	100.3%	100.1%	100.0%	100.0%	100.1%	99.9%	100.1%
YUV, animation, 720p	100.1%	100.1%	100.1%	100.0%	100.0%	100.0%	100.0%	100.0%
YUV, camera captured, 1080p	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Average	100.2%	**100.4%**	**100.4%**	**100.0%**	100.0%	**100.1%**	**100.1%**	**100.1%**

Concluding Remarks

* On top of SCM-2.0 with full-frame config., ILC provides (in TGwM class, AI) up to
  – **4.4%** more gains with 2-CTU search
  – **10.1%** when extended to full-frame search
  – **12.9%** when combined with full-frame 4x4/4x8/8x4 IBC
  NOTE -- **6.7%** on top of SCM-2.0 with 4-CTU config. (JCTVC-S0136)

* Encoder-only change (full-frame 4x4/4x8/8x4 IBC **w/o ILC**) incurs 6.9% loss (12.9%->6.0%)

* Modest increase (<3.5%) in average-case memory access bandwidth for AI w/ cache, and negligible (<1%) for RA/LB

* Thank MediaTek and InterDigital for cross-checking this proposal