<8th JCT-VC meeting @San Jose, February 2012>

<JCTVC-H0247>
AHG10: Unified design on parallel merge/skip

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1 February 2012

Summary

- **Proposal: a unified design for high-throughput merge/skip estimation.**
  - JCTVC-H092, JCTVC-H0090, and JCTVC-H0240
  - 1) removal of inter-PU dependency by default,
  - 2) further removal of inter-CU dependency in a configurable manner,
  - 3) reduction of the worst-case # of MCL constructions roughly by half.
- **Results**
  - roughly 0.2%, 0.4%, 1.1%, and 2.1% for PME (Parallel Merge Estimation) region sizes of 8x8, 16x16, 32x32, and 64x64, respectively.

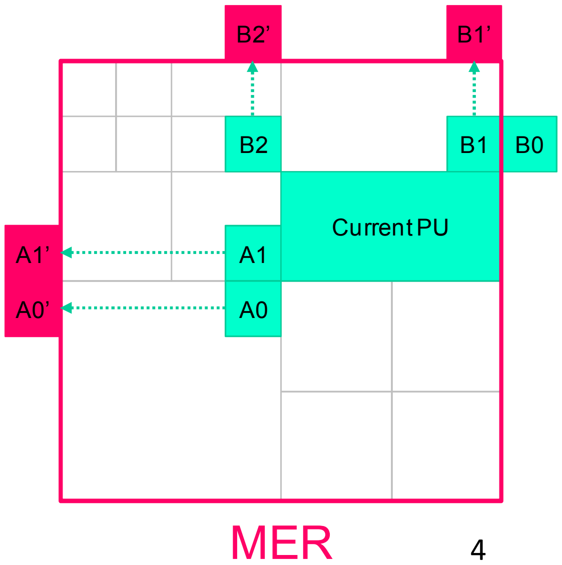
Unified PME Solution

- **Combination of :**
  - TMVP refIdx is derived independent of PUs of a same CU, removing the inter-PU dependency by default. (JCTVC-H0092)
  - Each 8x8 CU is limited to have a single MCL at all parallel merge/skip levels, reducing the worst-case number of MCLs roughly by half. (JCTVC-H0240 CU-level MCL, but only limited to 8x8 CUs.)
  - The MCL (Merge Candidate List) construction and merge/skip motion estimation processes are decoupled from the regular motion estimation at CU-group level, removing both the inter-PU dependency and the inter-CU dependency within a parallel merge estimation (PME) region. (JCTVC-H0082 and JCTVC-H0090)
  - The second and third features are configurable by a high-level parameter as follows:

parallel merge level	description
log2_parallel_merge_level_minus2 = 0	1) Within each CU, all TMVPs share the refIdx of 2Nx2N PU.
log2_parallel_merge_level_minus2 = 1	1) Within each CU, all TMVPs share the refIdx of 2Nx2N PU. 2) Within a 8x8 CU, all PUs share the MCL of 2Nx2N PU. 3) Parallel merge/skip is enabled for every 8x8 region.
log2_parallel_merge_level_minus2 = 2	1) Within each CU, all TMVPs share the refIdx of 2Nx2N PU. If the refIdx positio n is inside PME region, use '0' instead. 2) Within a 8x8 CU, all PUs share the MCL of 2Nx2N PU. 3) Parallel merge/skip is enabled for every 16x16 region.
log2_parallel_merge_level_minus2 = 3	1) Within each CU, all TMVPs share the refIdx of 2Nx2N PU. If the refIdx positio n is inside PME region, use '0' instead. 2) Within a 8x8 CU, all PUs share the MCL of 2Nx2N PU. 3) Parallel merge/skip is enabled for every 32x32 region.
log2_parallel_merge_level_minus2 = 4	1) Within each CU, all TMVPs share the refIdx of 2Nx2N PU. If the refIdx positio n is inside PME region, use '0' instead. 2) Within a 8x8 CU, all PUs share the MCL of 2Nx2N PU. 3) Parallel merge/skip is enabled for every 64x64 region.

Unified PME Solution (cont'd)

- **Modifications to HM5:**
  - High-level signaling of PME (Parallel Merge Estimation) level
    - all CUs and PUs inside a PME region could be processed in parallel.
  - If the current CU size is 8x8, the MCL of 2Nx2N PU is used for all the other PUs.
  - When deriving spatial MVPs,
    - if a neighbouring PU and the current PU belong to a same PME region, the MVP candidate is treated as unavailable.
  - When deriving the reference index for TMVP,
    - if the left neighbouring PU and the current PU belong to a same MER, the reference index for TMVP is set to 0.
    - Otherwise, the TMVP reference index for 2Nx2N PU is used for the TMVP reference index for the current PU.
  - After the TMVP reference index derivation process (before the first pruning stage),
    - the MVPs made unavailable by the second rule are replaced by the MVPs located outside the PME region.
    - The closest one to each original MVP position is used.
    - If the PU is available and not intra-coded, the MVP is added to the list.



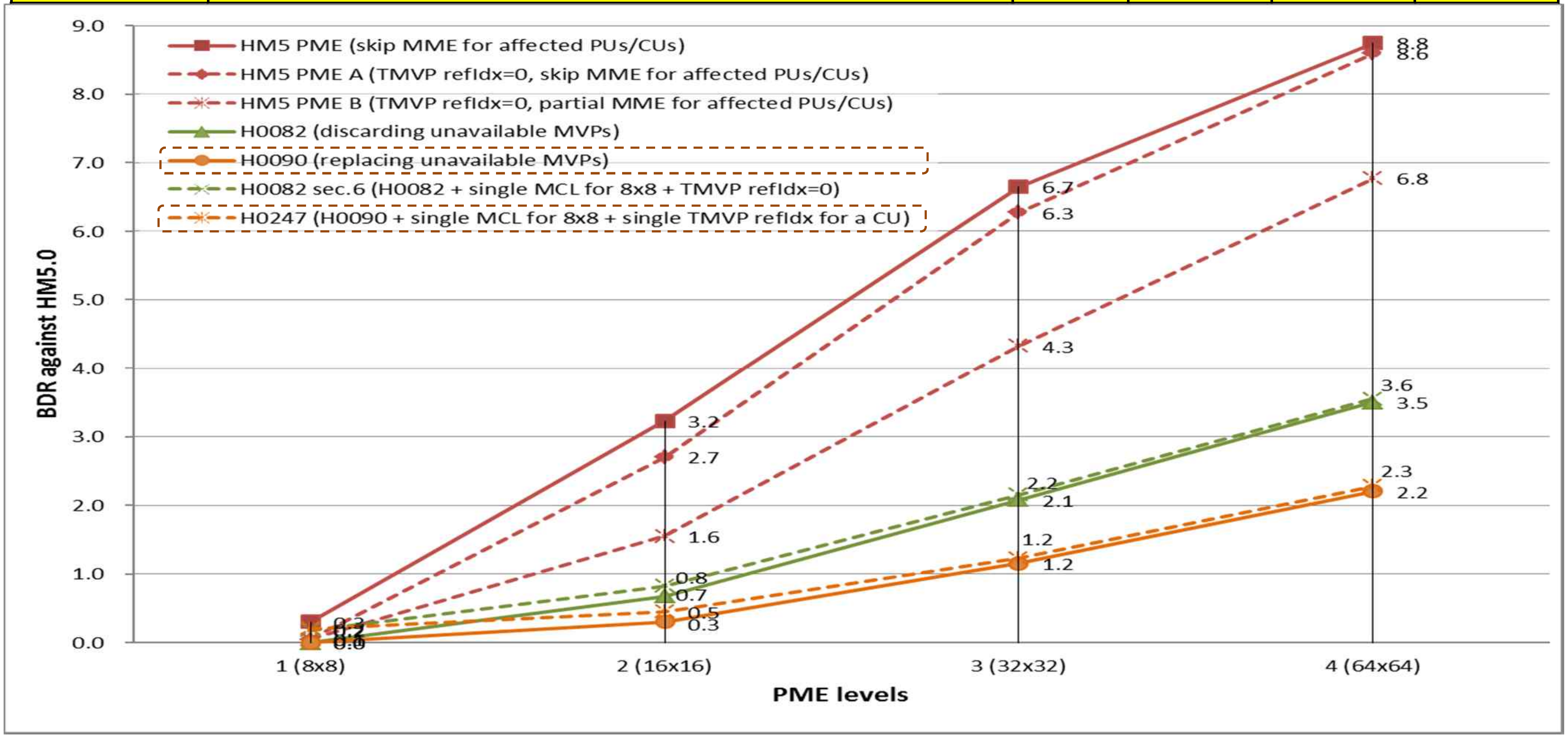
Unified PME Solution (cont'd)

❑ Achieved design goals

- ❖ decouples the MCL construction and merge/skip motion estimation from the regular motion estimation at any CU-group levels and CU levels (this decoupling basically enables a HEVC encoder to fully leverage HEVC quality potential at a same motion estimation throughput of AVC)
- ❖ reduces the worst case number of MCLs by limiting each 8x8 CU to have a single MCL at all parallel merge/skip levels
- ❖ and is configurable to provide coding efficiency and throughput trade-offs on the encoder side.

Experimental Results: Summary

Category	Tool	PME level			
		1 (8x8)	2 (16x16)	3 (32x32)	4 (64x64)
HM5 PMEs	**HM5 PME** (skip MME for affected PUs/CUs)	0.3	3.2	6.7	8.8
	HM5 PME A (TMVP refIdx=0, skip MME for affected PUs/CUs)	0.1	2.7	6.3	8.6
	HM5 PME B (TMVP refIdx=0, partial MME for affected PUs/CUs)	0.1	1.6	4.3	6.8
CU-Group level PMEs	**H0082** (discarding unavailable MVPs)	0.0	0.7	2.1	3.5
	H0090 (replacing unavailable MVPs)	0.0	0.3	1.2	2.2
Combined with H0240 and H0092	**H0082 sec.6** (H0082 + single MCL for 8x8 + TMVP refIdx=0)	0.2	0.8	2.2	3.6
	H0247 (H0090 + single MCL for 8x8 + single TMVP refIdx for a CU)	0.2	0.5	1.2	2.3



Results for PME level 0

- ❑ **log2_parallel_merge_level_minus2 = 0 (identical to JCTVC-H0092.)**

	Random Access HE			Random Access LC			Random Access HE-10		
	Y	U	V	Y	U	V	Y	U	V
Class A (8bit)	0.02%	0.07%	-0.06%	0.01%	0.06%	0.05%	0.05%	-0.02%	0.02%
Class B	0.01%	0.00%	0.01%	0.01%	0.02%	-0.02%	0.01%	-0.01%	-0.01%
Class C	-0.01%	0.04%	0.07%	0.02%	0.01%	-0.02%			
Class D	0.00%	-0.02%	-0.01%	0.01%	0.07%	-0.05%			
Class E									
Overall	0.01%	0.02%	0.01%	0.01%	0.04%	-0.02%	0.03%	-0.02%	0.00%
	0.01%	0.00%	0.02%	0.01%	0.03%	-0.03%	0.03%	-0.02%	0.02%
Class F	-0.06%	0.00%	0.00%	0.00%	0.02%	0.01%			
Enc Time[%]	105%			107%			100%		
Dec Time[%]	99%			100%			105%		

	Low delay B HE			Low delay B LC			Low delay B HE-10		
	Y	U	V	Y	U	V	Y	U	V
Class A									
Class B	0.02%	0.05%	0.22%	-0.01%	-0.01%	-0.02%			
Class C	0.01%	-0.16%	0.07%	0.03%	0.25%	-0.05%			
Class D	0.00%	0.06%	0.21%	0.00%	0.34%	0.02%			
Class E	0.06%	-0.16%	-0.29%	0.02%	-0.26%	-0.10%			
Overall	0.02%	-0.04%	0.08%	0.01%	0.10%	-0.03%			
	0.02%	-0.03%	0.02%	0.01%	0.13%	-0.06%			
Class F	-0.09%	-0.15%	-0.51%	-0.16%	-0.46%	-0.66%			
Enc Time[%]	108%			105%					
Dec Time[%]	94%			91%					

Results for PME level 1

❑ **log2_parallel_merge_level_minus2 = 1 (8x8)**

	Random Access HE			Random Access LC			Random Access HE-10		
	Y	U	V	Y	U	V	Y	U	V
Class A (8bit)	0.1%	0.1%	0.1%	0.2%	0.1%	0.1%	0.1%	0.1%	0.2%
Class B	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	0.0%	0.0%
Class C	0.1%	0.1%	0.1%	0.2%	0.2%	0.1%			
Class D	0.2%	-0.2%	0.1%	0.3%	0.3%	0.2%			
Class E									
Overall	0.1%	0.0%	0.1%	0.2%	0.2%	0.1%	0.1%	0.1%	0.1%
	0.1%	0.0%	0.1%	0.2%	0.2%	0.1%	0.1%	0.0%	0.1%
Class F	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%			
Enc Time[%]	102%			104%			96%		
Dec Time[%]	100%			100%			100%		

	Low delay B HE			Low delay B LC			Low delay B HE-10		
	Y	U	V	Y	U	V	Y	U	V
Class A									
Class B	0.1%	0.1%	0.2%	0.1%	0.0%	0.5%			
Class C	0.2%	0.1%	0.0%	0.3%	0.3%	0.3%			
Class D	0.2%	-0.5%	0.2%	0.3%	0.4%	0.3%			
Class E	0.2%	0.1%	0.0%	0.3%	-0.1%	0.2%			
Overall	0.2%	-0.1%	0.1%	0.3%	0.1%	0.3%			
	0.2%	-0.1%	0.1%	0.3%	0.1%	0.2%			
Class F	0.0%	0.3%	-0.1%	0.2%	-0.1%	-0.4%			
Enc Time[%]	92%			113%					
Dec Time[%]	99%			99%					

Results for PME level 2

❑ **log2_parallel_merge_level_minus2 = 2 (16x16)**

	Random Access HE			Random Access LC			Random Access HE-10		
	Y	U	V	Y	U	V	Y	U	V
Class A (8bit)	0.3%	0.3%	0.2%	0.5%	0.5%	0.5%	0.2%	0.2%	0.2%
Class B	0.1%	0.2%	0.2%	0.3%	0.4%	0.3%	0.2%	0.1%	0.2%
Class C	0.4%	0.5%	0.6%	0.6%	0.7%	0.7%			
Class D	0.5%	0.5%	0.6%	0.7%	0.7%	0.7%			
Class E									
Overall	0.3%	0.3%	0.4%	0.5%	0.6%	0.5%	0.2%	0.2%	0.2%
	0.3%	0.4%	0.4%	0.5%	0.6%	0.5%	0.2%	0.1%	0.2%
Class F	0.2%	0.3%	0.2%	0.4%	0.4%	0.5%			
Enc Time[%]	100%			100%			100%		
Dec Time[%]	100%			100%			100%		

	Low delay B HE			Low delay B LC			Low delay B HE-10		
	Y	U	V	Y	U	V	Y	U	V
Class A									
Class B	0.2%	0.3%	0.4%	0.3%	0.2%	0.6%			
Class C	0.5%	0.3%	0.6%	0.8%	1.1%	0.8%			
Class D	0.7%	0.4%	0.8%	0.9%	1.8%	1.3%			
Class E	0.3%	-0.4%	0.2%	0.4%	0.5%	0.7%			
Overall	0.4%	0.2%	0.5%	0.6%	0.9%	0.8%			
	0.4%	0.2%	0.5%	0.6%	0.9%	0.8%			
Class F	0.3%	0.3%	-0.1%	0.6%	-0.1%	0.7%			
Enc Time[%]	90%			100%					
Dec Time[%]	100%			99%					

Results for PME level 3

❑ log2_parallel_merge_level_minus2 = 3 (32x32)

	Random Access HE			Random Access LC			Random Access HE-10		
	Y	U	V	Y	U	V	Y	U	V
Class A (8bit)	0.9%	0.9%	0.9%	1.1%	1.2%	1.3%	0.6%	0.6%	0.6%
Class B	0.6%	0.6%	0.6%	0.8%	1.0%	1.0%	0.6%	0.6%	0.7%
Class C	1.1%	1.2%	1.3%	1.4%	1.7%	1.8%			
Class D	1.1%	0.9%	1.2%	1.4%	1.7%	1.6%			
Class E									
Overall	0.9%	0.9%	1.0%	1.2%	1.4%	1.4%	0.6%	0.6%	0.7%
	0.9%	0.9%	1.0%	1.2%	1.4%	1.4%	0.6%	0.6%	0.7%
Class F	0.7%	0.7%	0.8%	0.9%	1.0%	1.0%			
Enc Time[%]	101%			100%			101%		
Dec Time[%]	100%			100%			100%		

	Low delay B HE			Low delay B LC			Low delay B HE-10		
	Y	U	V	Y	U	V	Y	U	V
Class A									
Class B	0.8%	0.9%	0.9%	1.2%	1.2%	1.9%			
Class C	1.4%	1.3%	1.7%	1.9%	2.1%	2.1%			
Class D	1.7%	1.6%	2.2%	2.1%	2.8%	2.7%			
Class E	0.7%	0.1%	0.5%	1.2%	1.4%	1.7%			
Overall	1.2%	1.0%	1.3%	1.6%	1.9%	2.1%			
	1.2%	1.1%	1.4%	1.6%	1.9%	2.1%			
Class F	1.0%	1.1%	0.8%	1.4%	0.6%	1.4%			
Enc Time[%]	90%			100%					
Dec Time[%]	100%			100%					

Results for PME level 4

- log2_parallel_merge_level_minus2 = 4 (64x64)

	Random Access HE			Random Access LC			Random Access HE-10		
	Y	U	V	Y	U	V	Y	U	V
Class A (8bit)	1.6%	1.6%	1.6%	1.9%	2.2%	2.2%	1.0%	0.9%	1.0%
Class B	1.3%	1.3%	1.3%	1.6%	2.0%	1.8%	1.3%	1.4%	1.3%
Class C	1.9%	2.2%	2.3%	2.3%	2.7%	2.9%			
Class D	1.9%	2.1%	2.1%	2.3%	2.7%	2.6%			
Class E									
Overall	1.7%	1.8%	1.8%	2.0%	2.4%	2.4%	1.2%	1.2%	1.2%
	1.7%	1.8%	1.9%	2.0%	2.4%	2.3%	1.2%	1.2%	1.2%
Class F	1.2%	1.3%	1.3%	1.5%	1.7%	1.7%			
Enc Time[%]	103%			105%			99%		
Dec Time[%]	100%			100%			101%		

	Low delay B HE			Low delay B LC			Low delay B HE-10		
	Y	U	V	Y	U	V	Y	U	V
Class A									
Class B	1.9%	2.0%	2.2%	2.6%	2.4%	2.8%			
Class C	2.5%	2.2%	2.7%	3.2%	3.3%	3.2%			
Class D	2.9%	2.8%	3.3%	3.5%	4.7%	4.3%			
Class E	2.0%	1.9%	1.8%	3.0%	3.2%	3.5%			
Overall	2.3%	2.2%	2.5%	3.1%	3.3%	3.4%			
	2.3%	2.2%	2.5%	3.1%	3.4%	3.4%			
Class F	1.8%	2.0%	2.0%	2.1%	2.2%	2.0%			
Enc Time[%]	100%			105%					
Dec Time[%]	100%			99%					

Conclusion

- **A unified design for high-throughput merge/skip estimation.**
  - JCTVC-H092, JCTVC-H0090, and JCTVC-H0240
  - 1) removal of inter-PU dependency by default,
  - 2) further removal of inter-CU dependency in a configurable manner,
  - 3) reduction of the worst-case # of MCL constructions roughly by half.

- **Results**
  - roughly 0.2%, 0.4%, 1.1%, and 2.1% for PME region sizes of 8x8, 16x16, 32x32, and 64x64, respectively.
  - Cross-checked by Samsung (JCTVC-H0635)

- **Recommendation**
  - Adopt this solution into the next version of HM.

Thank You Very Much !

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