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# 〈JCTVC-H0240〉 Throughput improvement for merge/skip mode

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# Summary

## ❑ **Throughput issues with HM5 merge mode**

- ❖ Issue 1: Inter-PU dependency
- ❖ Issue 2: Large # of MCLs (merge candidate lists) to be constructed for merge estimation

## ❑ **Proposal: CU-based construction of merge candidate list (MCL)**

- ❖ 2Nx2N PU's MCL is shared for all the PUs in a CU, regardless of the partition types and indices.
- ❖ Removes inter-PU dependency → improves parallelism (especially in encoder)
- ❖ Uses common MCL logic for a CU size → reduces complexity and improves throughput bound of both encoder and decoder
- ❖ BDR penalty of just 0.3% in average

## ❑ **Two variants**

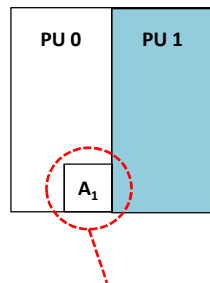
- ❖ Variant 1: CU-based TMVP refIdx (inter-PU dependency removal) → 0.0% BDR penalty
- ❖ Variant 2: CU-based MCL only for 8x8 CUs → 0.1% BDR penalty

# Throughput Issues

## ❑ Throughput issues with HM5 MCL (Merge Candidate List) construction

- ❖ Issue 1: Inter-PU dependency (in TMVP refIdx derivation)
  - *unfriendly to parallel encoder/decoder implementation*
- ❖ Issue 2: Excessive # of MCLs constructed for merge estimation
  - 17 partition variants in a CU, having their own MCL
  - 17 different MCL construction logics are required for a CU size,
  - causes memory contention headache with large chance of occurrence of different motion candidates, unfriendly to high-throughput encoder implementation

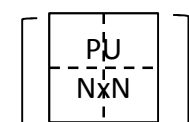
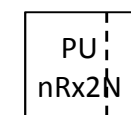
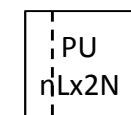
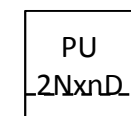
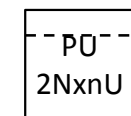
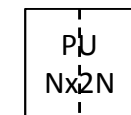
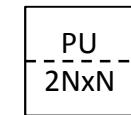
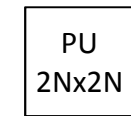
### <Issue 1>



TMVP refIdx position for PU1

### <Issue 2>

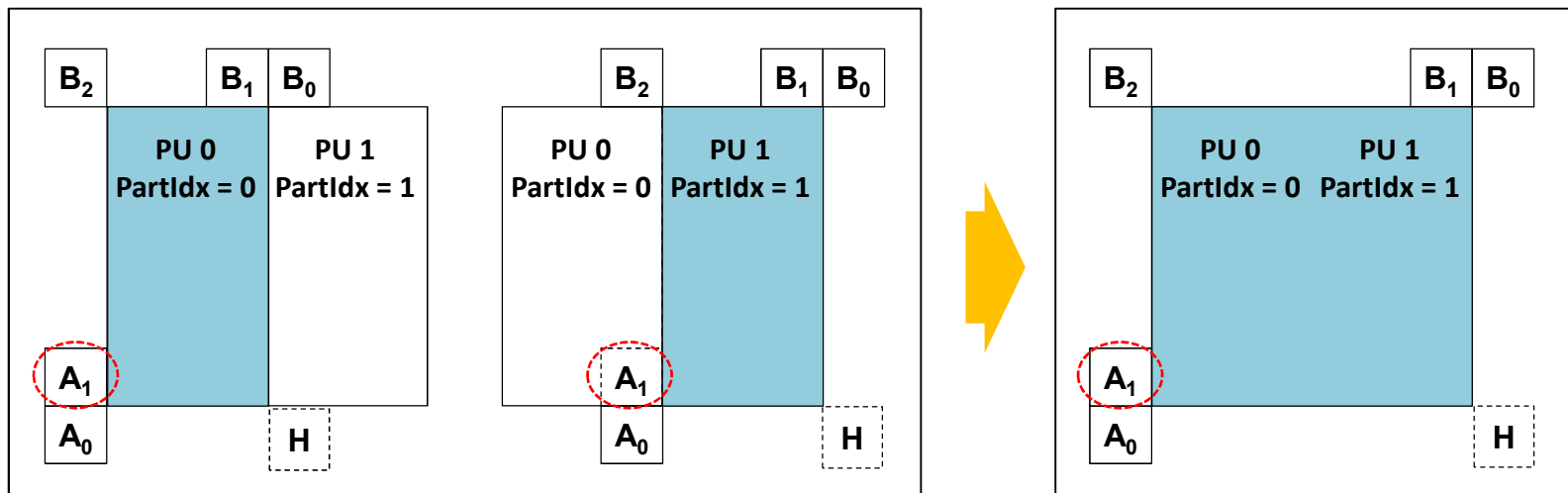
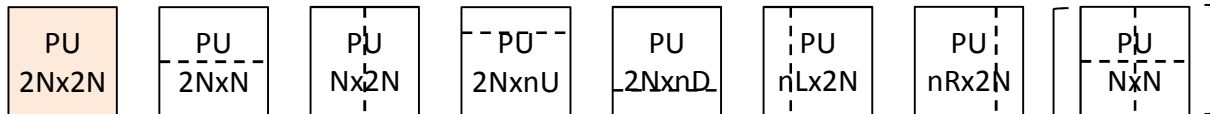
CU Size	# MCL constructions for a 64x64 block
64x64	13
32x32	$13 * 4 = 52$
16x16	$13 * 4 * 4 = 208$
8x8	$5 * 4 * 4 * 4 = 320$
<b>Sum</b>	<b>593</b>




# Proposal

## ❑ Single MCL (Merge Candidate List) construction for a CU

- ❖ The single MCL is shared for all the PUs in a CU, regardless of the partition types and indices.
- ❖ The common MCL is the same one as 2Nx2N PU.



HM5

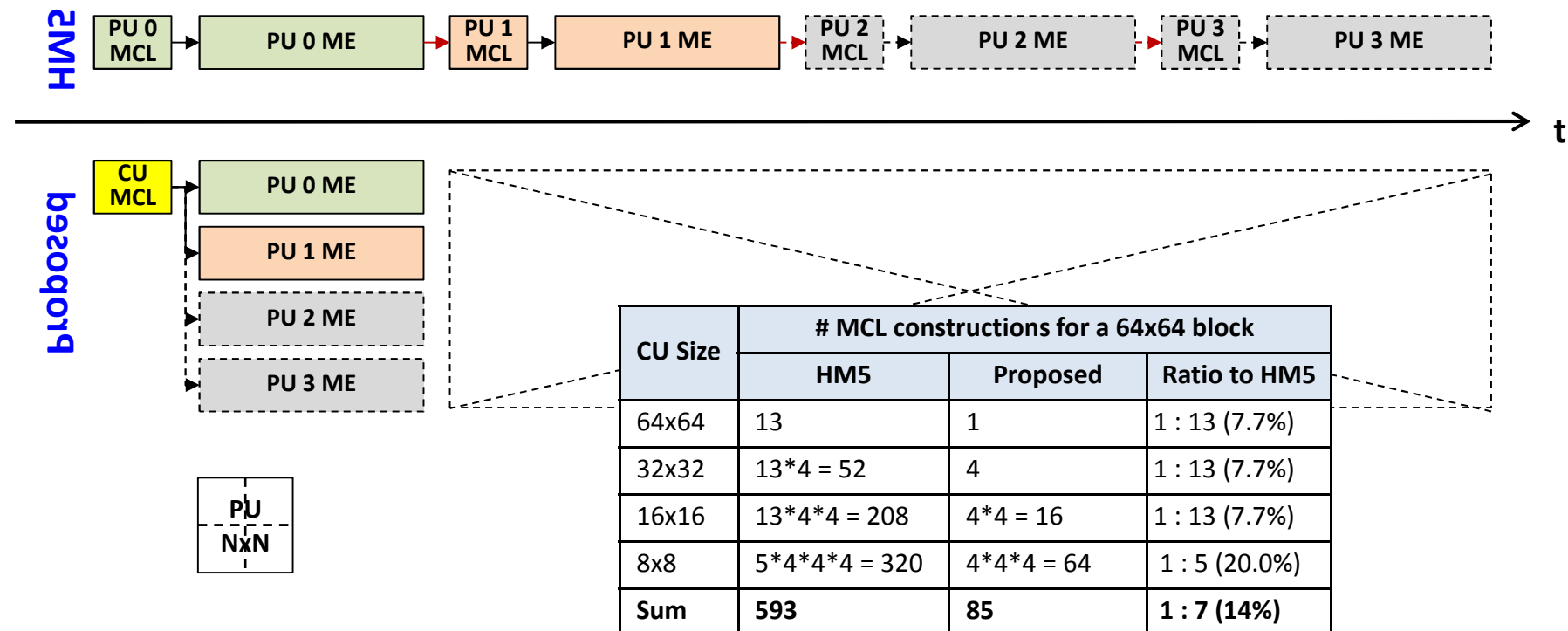
 : TMVP refIdx position

Proposed

# Benefits

## ❑ For encoders:

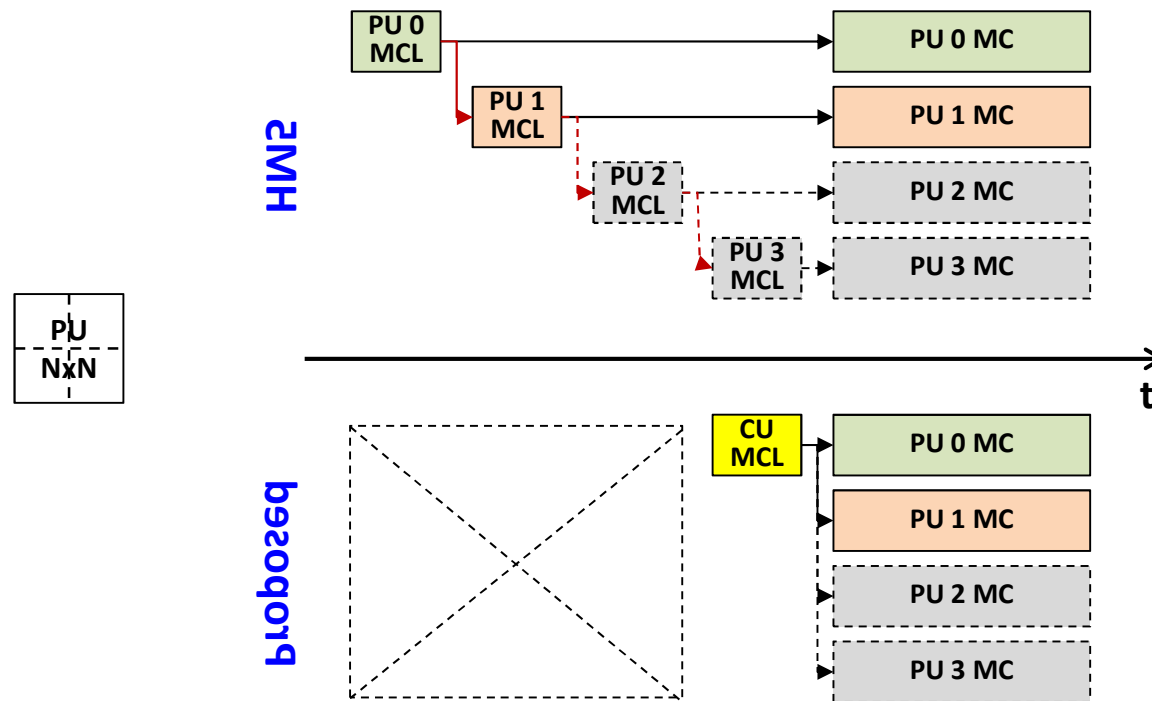
- ❖ Enables parallel merge estimation of all possible PU partitions (up to 17), expanding the throughput bound of the design
- ❖ Reduces the number of MCLs that should be constructed (from 593 to 85 for a 64x64 LCU), reducing the worst case number of different motion candidates and hence alleviating the memory contention problem
- ❖ Improves regularity and maximize commonality, enabling cost-effective hardware design (from up to 17 different MCL construction logics to one logic for a CU size)



# Benefits (cont'd)

## ❑ For decoders:

- ❖ Enables parallel processing of merge mode PUs, expanding the throughput bound of the design
- ❖ Improves regularity and maximize commonality, enabling cost-effective hardware design (from up to 4 different MCL construction logics to one logic for a CU size)



# Experimental Results

## ❑ Original Proposal (CU-based MCL)

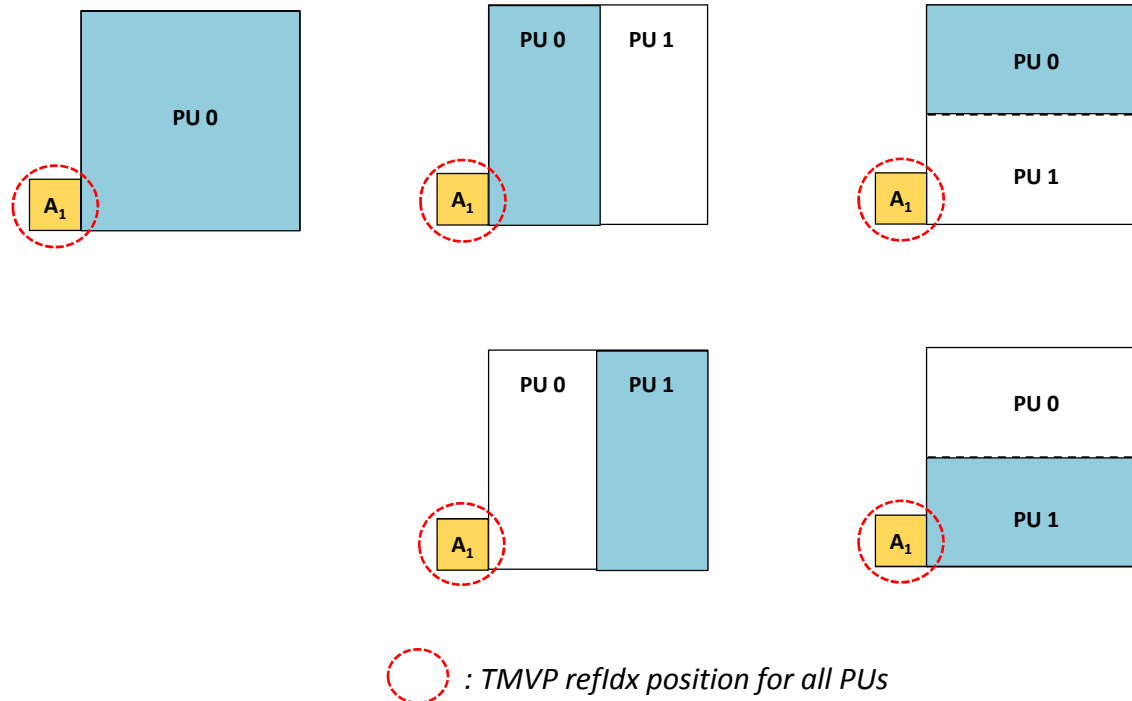
- ❖ Average loss of 0.3%.
- ❖ Cross-checked by Canon (JCTVC-H0629)

	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%	0.3%	0.3%	0.2%	0.2%	0.3%	0.3%	0.2%
Class B	0.2%	0.1%	0.2%	0.1%	0.2%	0.1%	0.2%	0.2%	0.2%
Class C	0.3%	0.2%	0.3%	0.3%	0.2%	0.3%			
Class D	0.3%	0.4%	0.2%	0.3%	0.3%	0.3%			
Class E									
Overall	0.3%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.3%	0.2%
	0.3%	0.2%	0.3%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%
Class F	0.1%	0.1%	0.1%	0.2%	0.1%	0.1%			
Enc Time[%]	100%			100%			97%		
Dec Time[%]	100%			101%			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	0.4%	0.4%	0.5%	0.3%	0.1%	0.2%			
Class C	0.5%	0.1%	0.5%	0.4%	0.6%	0.3%			
Class D	0.5%	0.2%	0.1%	0.4%	0.6%	0.4%			
Class E	1.0%	0.5%	0.5%	0.7%	0.5%	1.2%			
Overall	0.5%	0.3%	0.4%	0.4%	0.4%	0.5%			
	0.5%	0.4%	0.4%	0.4%	0.5%	0.5%			
Class F	0.3%	0.2%	0.0%	0.2%	-0.7%	-0.3%			
Enc Time[%]	90%			100%					
Dec Time[%]	101%			100%					

# Variant 1: CU-based TMVP refIdx

❑ Always use refIdxA1 of 2Nx2N PU for TMVP

❖ Removes inter-PU dependency



(AMPs are omitted in the figure.)

# Variant 1: Experimental Results

## ❑ Variant 1 (CU-based TMVP refIdx)

❖ Average loss of 0.0%.

❖ Cross-checked by Canon (JCTVC-H0629)

	Random Access HE			Random Access LC			Random Access HE-10		
	Y	U	V	Y	U	V	Y	U	V
Class A (8bit)	0.0%	0.1%	-0.1%	0.0%	0.1%	0.0%	0.1%	0.0%	0.0%
Class B	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Class C	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%			
Class D	0.0%	0.0%	0.0%	0.0%	0.1%	-0.1%			
Class E									
Overall	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Class F	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%			
Enc Time[%]	100%			100%			100%		
Dec Time[%]	100%			99%			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	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%			
Class C	0.0%	-0.2%	0.1%	0.0%	0.2%	0.0%			
Class D	0.0%	0.1%	0.2%	0.0%	0.3%	0.0%			
Class E	0.1%	-0.2%	-0.3%	0.0%	-0.3%	-0.1%			
Overall	0.0%	0.0%	0.1%	0.0%	0.1%	0.0%			
	0.0%	0.0%	0.0%	0.0%	0.1%	-0.1%			
Class F	-0.1%	-0.2%	-0.5%	-0.2%	-0.5%	-0.7%			
Enc Time[%]	100%			100%					
Dec Time[%]	99%			100%					



# Variant 2: Experimental Results

## ❑ Variant 2 (CU-based MCL for 8x8 CUs only)

❖ Average loss of 0.1%.

❖ Cross-checked by Canon (JCTVC-H0629)

	Random Access HE			Random Access LC			Random Access HE-10		
	Y	U	V	Y	U	V	Y	U	V
Class A (8bit)	0.1%	0.0%	0.0%	0.2%	0.1%	0.1%	0.1%	0.0%	0.0%
Class B	0.0%	0.0%	0.1%	0.1%	0.2%	0.0%	0.0%	0.0%	0.0%
Class C	0.1%	0.1%	0.1%	0.1%	0.1%	0.2%			
Class D	0.2%	0.0%	0.1%	0.2%	0.2%	0.1%			
Class E									
<b>Overall</b>	0.1%	0.0%	0.1%	0.1%	0.2%	0.1%	0.1%	0.0%	0.0%
	0.1%	0.0%	0.0%	0.1%	0.2%	0.1%	0.1%	0.0%	0.0%
Class F	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%			
Enc Time[%]	100%			100%			100%		
Dec Time[%]	99%			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	0.0%	0.0%	0.2%	0.1%	0.0%	0.0%			
Class C	0.2%	0.1%	0.3%	0.3%	0.5%	0.3%			
Class D	0.2%	0.0%	-0.1%	0.3%	0.6%	0.2%			
Class E	0.2%	-0.4%	0.0%	0.3%	0.0%	0.1%			
<b>Overall</b>	0.2%	0.0%	0.1%	0.2%	0.3%	0.1%			
	0.2%	0.0%	0.0%	0.2%	0.3%	0.2%			
Class F	-0.1%	0.0%	-0.4%	0.1%	-0.3%	-0.3%			
Enc Time[%]	90%			100%					
Dec Time[%]	99%			99%					

# Conclusion

## ❑ CU-based approach for merge candidate list (MCL) construction

- ❖ Proposal:  $2N \times 2N$  PU's MCL is shared for all PUs in a CU, regardless of the partition types and indices.
- ❖ Variant 1: CU-based TMVP refIdx
- ❖ Variant 2: CU-based MCL only for  $8 \times 8$  CUs

## ❑ Benefits

- ❖ Removes inter-PU dependency → improves parallelism (especially in encoder)
- ❖ Uses common MCL logic for a CU size → reduces complexity and improves throughput bound of both encoder and decoder
- ❖ Involves only a small amount of Text/SW modifications.

## ❑ Experimental results

- ❖ Original: 0.3% BDR penalty
- ❖ Variant 1: 0.0 %
- ❖ Variant 2: 0.1%

## ❑ It is recommended to adopt this change into the next version of HM



***Thank You Very Much !***

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