



# CE9: 4.4 Evaluation of Partial (CU) Merge And Proposed Method for Improvements

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# Outline

- CE9: 4.4 Evaluation of partial merge
- Proposed method for improvements
- Results
- Conclusions

# CE9: 4.4 Evaluation of Partial Merge

Test	Which PU is restricted	CU level	Inferred / Encoder-only
<b>Anchor</b>	<b>1<sup>st</sup> 2NxN PU, 1<sup>st</sup> Nx2N PU</b>	<b>16x16 and larger CU sizes</b>	<b>Inferred</b>
PART01	1 <sup>st</sup> 2NxN PU, 1 <sup>st</sup> Nx2N PU	All CU sizes	Inferred
PART02	1 <sup>st</sup> 2NxN PU, 1 <sup>st</sup> Nx2N PU	16x16 and larger CU sizes	Encoder-only
PART03	1 <sup>st</sup> 2NxN PU, 1 <sup>st</sup> Nx2N PU	All CU sizes	Encoder-only
PART04	Both two 2NxN PUs, both two Nx2N PUs	16x16 and larger CU sizes	Inferred
PART05	Both two 2NxN PUs, both two Nx2N PUs	All CU sizes	Inferred
PART06	Both two 2NxN PUs, both two Nx2N PUs	16x16 and larger CU sizes	Encoder-only
PART07 (withdrawn)	Both two 2NxN PUs, both two Nx2N PUs	All CU sizes	Encoder-only
PART08 (withdrawn)	2 <sup>nd</sup> 2NxN PU, 2 <sup>nd</sup> Nx2N PU	16x16 and larger CU sizes	Inferred
PART09 (withdrawn)	2 <sup>nd</sup> 2NxN PU, 2 <sup>nd</sup> Nx2N PU	All CU sizes	Inferred
PART10 (withdrawn)	2 <sup>nd</sup> 2NxN PU, 2 <sup>nd</sup> Nx2N PU	16x16 and larger CU sizes	Encoder-only
PART11 (withdrawn)	2 <sup>nd</sup> 2NxN PU, 2 <sup>nd</sup> Nx2N PU	All CU sizes	Encoder-only
PART12	None (PU merge)	N/A	N/A
PART13	1 <sup>st</sup> 2NxN PU, 1 <sup>st</sup> Nx2N PU	16x16 and larger CU sizes	Encoder-only (RCME)
PART14	1 <sup>st</sup> 2NxN PU, 1 <sup>st</sup> Nx2N PU	16x16 and larger CU sizes	Inferred
	All four NxN PUs	8x8	
PART15	1 <sup>st</sup> 2NxN PU, 1 <sup>st</sup> Nx2N PU	16x16 and larger CU sizes	Encoder-only
	All four NxN PUs	8x8	
PART16	All four NxN PUs	8x8 for NxN	Inferred
PART17	1 <sup>st</sup> 2NxN PU, 1 <sup>st</sup> Nx2N PU	All CU sizes	Inferred
	All four NxN PUs	8x8	
PART18	Disable partial merge and NxN inter predictions		Inferred

# CE9: 4.4 Summary of Test Results

Test	Avg. BD-rate	Avg. Enc. Time
<i>Anchor: Force merge 1<sup>st</sup> 2NxN PU, 1<sup>st</sup> Nx2N PU, Inferred, 16x16 and larger CU sizes</i>	0.000%	100%
<b>PART01:</b> Force merge 1 <sup>st</sup> 2NxN PU, 1 <sup>st</sup> Nx2N PU, Inferred, all CU sizes	0.105%	92.5%
<b>PART02:</b> Encoder-only of Anchor	0.260%	100%
<b>PART03:</b> Encoder-only of PART01	0.602%	92.3%
<b>PART04:</b> Force merge both 2NxN and Nx2N PUs, Inferred, 16x16 and larger CU sizes	0.457%	86.5%
<b>PART05:</b> Force merge both 2NxN and Nx2N PUs, Inferred, all CU sizes	0.847%	70.2%
<b>PART06:</b> Encoder-only of PART04	0.755%	92.3%
<b>PART12:</b> No PU merge	-0.417%	114.2%
<b>PART13:</b> Anchor + RCME, Encoder-only	-0.127%	106.5%
<b>PART14:</b> Anchor + Force merge all four NxN PUs, Inferred	0.030%	89.2%
<b>PART15:</b> Encoder-only of PART14	0.400%	89.8%
<b>PART16:</b> PART12 + Force merge all four NxN PUs, Inferred	-0.380%	102.7%
<b>PART17:</b> PART01 + Force merge all four NxN PUs, Inferred	0.317%	81.2%
<b>PART18:</b> Anchor – Part_mrg – NxN inter predictions	-0.239%	101.6%

# Proposed Method for Improvements

- Force merge inter NxN partitions
  - Applies to SCU (i.e. 4x4 PUs in current anchor condition)

coding_unit( x0, y0, log2CUSize ) {	Descriptor
.....	
if( PartMode == PART_2Nx2N ) {	
prediction_unit( x0, y0, log2CUSize, log2CUSize, 0 , 0 )	
} else if( PartMode == PART_2NxN ) {	
prediction_unit( x0, y0, log2CUSize, log2CUSize - 1, 0 ,	
log2CUSize > Log2MinCUSize )	
prediction_unit( x0, y1, log2CUSize, log2CUSize - 1, 1, 0 )	
} else if( PartMode == PART_Nx2N ) {	
prediction_unit( x0, y0, log2CUSize - 1, log2CUSize, 0 ,	
log2CUSize > Log2MinCUSize )	
prediction_unit( x1, y0, log2CUSize - 1, log2CUSize, 1, 0 )	
} else { /* PART_NxN */	
prediction_unit( x0, y0, log2CUSize - 1, log2CUSize - 1, 0 , 1 )	
prediction_unit( x1, y0, log2CUSize - 1, log2CUSize - 1, 1 , 1 )	
prediction_unit( x0, y1, log2CUSize - 1, log2CUSize - 1, 2 , 1 )	
prediction_unit( x1, y1, log2CUSize - 1, log2CUSize - 1, 3 , 1 )	
}	
.....	
}	

# CE9: 4.4 PART14 Results

	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	0.00	-0.03	0.02	0.04	0.15	-0.01
Class B	-0.01	-0.08	-0.12	0.02	0.01	0.02
Class C	0.00	0.07	0.04	0.12	0.15	0.31
Class D	0.17	0.25	0.16	0.20	0.25	0.25
Class E						
All	0.04	0.04	0.02	0.09	0.13	0.14
Enc Time[%]	91%			89%		
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	-0.03	0.00	-0.11	-0.04	-0.18	-0.21
Class C	-0.02	0.08	0.03	0.03	-0.03	-0.07
Class D	0.00	-0.13	0.72	0.13	0.07	0.03
Class E	0.05	0.18	0.17	-0.17	-0.26	0.57
All	-0.01	0.02	0.18	0.00	-0.09	0.03
Enc Time[%]	90%			87%		
Dec Time[%]	100%			100%		

# CE9: 4.4 PART15 Results

	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	0.21	0.30	0.06	0.28	0.21	0.04
Class B	0.22	0.22	0.15	0.32	0.24	0.28
Class C	0.34	0.41	0.48	0.46	0.41	0.50
Class D	0.49	0.40	0.41	0.51	0.45	0.44
Class E						
All	0.31	0.33	0.27	0.39	0.32	0.31
Enc Time[%]	91%			89%		
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	0.26	0.40	0.02	0.40	0.29	0.47
Class C	0.34	0.51	0.37	0.43	0.44	0.33
Class D	0.42	0.46	1.17	0.57	0.69	0.79
Class E	0.71	1.29	0.43	0.67	0.59	1.09
All	0.40	0.61	0.47	0.50	0.48	0.63
Enc Time[%]	91%			88%		
Dec Time[%]	100%			100%		

# CE9: 4.4 PART16 Results

	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	-0.58	-0.84	-0.99	-0.71	-0.68	-0.67
Class B	-0.39	-0.48	-0.50	-0.44	-0.35	-0.29
Class C	-0.61	-0.56	-0.63	-0.54	-0.39	-0.34
Class D	-0.38	-0.43	-0.36	-0.32	-0.23	-0.49
Class E						
All	-0.48	-0.57	-0.61	-0.50	-0.41	-0.44
Enc Time[%]	102%			104%		
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	-0.19	-0.46	-0.38	-0.29	-0.24	-0.10
Class C	-0.31	-0.39	-0.40	-0.47	-0.41	-0.37
Class D	-0.34	-0.31	0.26	-0.19	-0.13	-0.20
Class E	-0.05	0.24	-0.39	-0.28	0.25	0.37
All	-0.23	-0.27	-0.23	-0.31	-0.16	-0.10
Enc Time[%]	102%			103%		
Dec Time[%]	100%			100%		



# CE9: 4.4 PART17 Results

	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	0.04	0.39	0.18	0.12	0.37	0.16
Class B	0.10	0.10	0.10	0.18	0.19	0.23
Class C	0.45	0.46	0.65	0.67	0.73	0.93
Class D	0.87	1.10	1.17	1.08	1.23	1.25
Class E						
All	0.35	0.49	0.50	0.49	0.60	0.62
Enc Time[%]	85%			80%		
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	-0.03	0.03	-0.09	0.02	-0.08	-0.17
Class C	0.33	0.30	0.34	0.43	0.39	0.36
Class D	0.53	0.82	1.13	0.79	0.56	0.57
Class E	-0.22	-0.21	0.02	-0.22	-0.34	0.25
All	0.16	0.25	0.34	0.27	0.15	0.23
Enc Time[%]	83%			77%		
Dec Time[%]	100%			100%		

# CE9: 4.4 PART 14, 16, 18 Results

	Random access			Random access LoCo		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
All – PART14	<b>0.04</b>	0.04	0.02	<b>0.09</b>	0.13	0.14
Enc Time[%]	91%			89%		
All – PART16	<b>-0.48</b>	-0.57	-0.61	<b>-0.50</b>	-0.41	-0.44
Enc Time[%]	102%			104%		
All – PART18	<b>-0.40</b>	-0.46	-0.51	<b>-0.36</b>	-0.28	-0.30
Enc Time[%]	101%			102%		

	Low delay			Low delay LoCo		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
All – PART14	<b>-0.01</b>	0.02	0.18	<b>0.00</b>	-0.09	0.03
Enc Time[%]	90%			87%		
All – PART16	<b>-0.23</b>	-0.27	-0.23	<b>-0.31</b>	-0.16	-0.10
Enc Time[%]	102%			103%		
All – PART18	<b>-0.10</b>	-0.10	-0.13	<b>-0.10</b>	0.06	-0.02
Enc Time[%]	101%			102%		

# Conclusions

- Reported results for CE9 4.4 PART series
- Proposed a method for improving partial CU merge
  - Force merge Inter NxN partitions
  - Averagely 11% encoding time savings; 0.03% BD-rate increase
- Recommend to include the proposed method in HM.

# Supplementary Results – PART01

	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	-0.09	0.16	0.16	0.03	0.21	-0.04
Class B	0.03	0.02	-0.02	0.08	0.08	0.07
Class C	0.21	0.19	0.27	0.30	0.28	0.35
Class D	0.49	0.49	0.46	0.44	0.33	0.26
Class E						
All	0.15	0.20	0.20	0.20	0.22	0.15
Enc Time[%]	93%			92%		
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	-0.03	0.12	-0.34	-0.02	-0.08	-0.08
Class C	0.14	0.27	0.25	0.12	0.05	-0.01
Class D	0.16	-0.10	0.35	0.27	-0.03	-0.01
Class E	-0.25	-0.65	-0.04	-0.23	-0.09	0.18
All	0.02	-0.04	0.04	0.05	-0.04	0.00
Enc Time[%]	93%			91%		
Dec Time[%]	100%			101%		

# Supplementary Results – PART02

	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	0.20	0.31	0.18	0.29	0.21	0.18
Class B	0.18	0.19	0.11	0.25	0.19	0.17
Class C	0.22	0.25	0.32	0.22	0.16	0.23
Class D	0.27	0.20	0.16	0.18	0.06	0.08
Class E						
All	0.22	0.23	0.19	0.24	0.16	0.17
Enc Time[%]	99%			100%		
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	0.25	0.38	0.19	0.34	0.24	0.29
Class C	0.25	0.26	0.31	0.18	0.28	0.10
Class D	0.13	0.42	0.75	0.20	0.06	0.34
Class E	0.50	0.53	0.68	0.58	0.40	1.12
All	0.27	0.39	0.45	0.31	0.23	0.41
Enc Time[%]	100%			100%		
Dec Time[%]	100%			100%		

# Supplementary Results – PART03

	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	0.37	0.57	0.42	0.46	0.36	0.28
Class B	0.37	0.36	0.35	0.43	0.31	0.32
Class C	0.68	0.69	0.81	0.69	0.59	0.66
Class D	0.99	0.95	0.94	0.84	0.63	0.63
Class E						
All	0.59	0.63	0.61	0.59	0.46	0.46
Enc Time[%]	94%			92%		
Dec Time[%]	101%			101%		

	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	0.35	0.54	0.35	0.52	0.40	0.41
Class C	0.61	0.65	0.65	0.58	0.47	0.38
Class D	0.78	0.66	1.33	0.87	0.76	0.48
Class E	0.55	0.51	0.92	0.76	0.15	0.69
All	0.56	0.59	0.77	0.67	0.46	0.48
Enc Time[%]	93%			91%		
Dec Time[%]	100%			100%		

# Supplementary Results – PART04

	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	0.39	0.65	0.47	0.51	0.48	0.35
Class B	0.46	0.44	0.44	0.55	0.44	0.45
Class C	0.51	0.59	0.65	0.57	0.54	0.55
Class D	0.47	0.50	0.41	0.41	0.22	0.19
Class E						
All	0.45	0.54	0.49	0.51	0.42	0.39
Enc Time[%]	89%			85%		
Dec Time[%]	100%			101%		

	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	0.33	0.40	0.22	0.49	0.36	0.33
Class C	0.43	0.46	0.56	0.46	0.32	0.25
Class D	0.35	0.75	0.88	0.46	0.16	0.30
Class E	0.44	1.04	0.68	0.56	0.32	0.70
All	0.38	0.62	0.56	0.49	0.29	0.37
Enc Time[%]	88%			84%		
Dec Time[%]	100%			101%		

# Supplementary Results – PART05

	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	0.51	1.16	0.87	0.69	0.82	0.54
Class B	0.64	0.61	0.57	0.78	0.66	0.75
Class C	1.13	1.24	1.39	1.26	1.19	1.39
Class D	1.48	1.54	1.70	1.45	1.29	1.33
Class E						
All	0.92	1.11	1.10	1.03	0.97	0.99
Enc Time[%]	76%			68%		
Dec Time[%]	100%			101%		

	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	0.40	0.53	0.42	0.62	0.32	0.40
Class C	0.87	0.89	1.07	0.95	0.80	0.79
Class D	1.06	1.08	1.64	1.19	1.18	0.73
Class E	0.21	0.40	0.26	0.33	0.35	0.32
All	0.65	0.73	0.86	0.79	0.66	0.57
Enc Time[%]	73%			64%		
Dec Time[%]	100%			101%		



# Supplementary Results – PART06

	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	0.57	0.87	0.70	0.79	0.71	0.56
Class B	0.61	0.62	0.63	0.84	0.66	0.65
Class C	0.68	0.76	0.80	0.81	0.66	0.86
Class D	0.67	0.69	0.56	0.59	0.44	0.52
Class E						
All	0.63	0.73	0.67	0.76	0.62	0.65
Enc Time[%]	89%			85%		
Dec Time[%]	101%			101%		

	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	0.59	0.90	1.06	0.97	0.56	0.61
Class C	0.65	1.02	0.93	0.72	0.49	0.55
Class D	0.57	0.42	1.27	0.67	0.64	0.51
Class E	0.99	1.93	1.29	1.57	1.20	1.60
All	0.68	1.00	1.12	0.95	0.68	0.75
Enc Time[%]	87%			84%		
Dec Time[%]	100%			101%		

# Supplementary Results – PART12

	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	-0.61	-1.11	-0.98	-0.69	-0.74	-0.66
Class B	-0.40	-0.50	-0.49	-0.44	-0.32	-0.30
Class C	-0.62	-0.64	-0.76	-0.65	-0.62	-0.63
Class D	-0.48	-0.46	-0.51	-0.53	-0.62	-0.61
Class E						
All	-0.52	-0.67	-0.67	-0.57	-0.56	-0.54
Enc Time[%]	110%			116%		
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	-0.19	-0.31	-0.56	-0.26	-0.17	-0.18
Class C	-0.35	-0.43	-0.58	-0.49	-0.26	-0.41
Class D	-0.39	-0.44	0.22	-0.31	-0.18	-0.25
Class E	-0.10	0.22	-0.06	-0.15	0.48	0.41
All	-0.27	-0.28	-0.27	-0.31	-0.07	-0.14
Enc Time[%]	112%			116%		
Dec Time[%]	100%			100%		

# Supplementary Results – PART13

	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	-0.17	-0.21	-0.09	-0.10	0.17	0.12
Class B	-0.08	-0.12	-0.08	-0.07	0.05	0.06
Class C	-0.19	-0.17	-0.18	-0.20	-0.06	-0.13
Class D	-0.14	-0.14	-0.14	-0.20	-0.32	-0.31
Class E						
All	-0.14	-0.16	-0.12	-0.14	-0.03	-0.06
Enc Time[%]	105%			108%		
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	-0.02	0.02	-0.06	-0.03	-0.02	0.20
Class C	-0.15	0.14	-0.21	-0.23	-0.14	-0.13
Class D	-0.17	-0.29	0.62	-0.19	-0.38	-0.33
Class E	-0.11	-0.44	-0.17	-0.02	0.60	0.56
All	-0.11	-0.11	0.05	-0.12	-0.02	0.05
Enc Time[%]	105%			108%		
Dec Time[%]	99%			100%		

# Supplementary Results – PART18

	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	-0.54	-0.83	-0.94	-0.61	-0.54	-0.61
Class B	-0.35	-0.46	-0.48	-0.38	-0.29	-0.26
Class C	-0.49	-0.37	-0.48	-0.37	-0.21	-0.21
Class D	-0.22	-0.17	-0.14	-0.08	-0.08	-0.11
Class E						
All	-0.40	-0.46	-0.51	-0.36	-0.28	-0.30
Enc Time[%]	101%			102%		
Dec Time[%]	101%			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	-0.11	-0.16	-0.55	-0.20	-0.09	-0.14
Class C	-0.15	-0.02	-0.25	-0.16	-0.04	-0.06
Class D	0.00	0.14	0.55	0.12	0.27	-0.06
Class E	-0.13	-0.41	-0.16	-0.16	0.18	0.27
All	-0.10	-0.10	-0.13	-0.10	0.06	-0.02
Enc Time[%]	101%			102%		
Dec Time[%]	99%			99%		