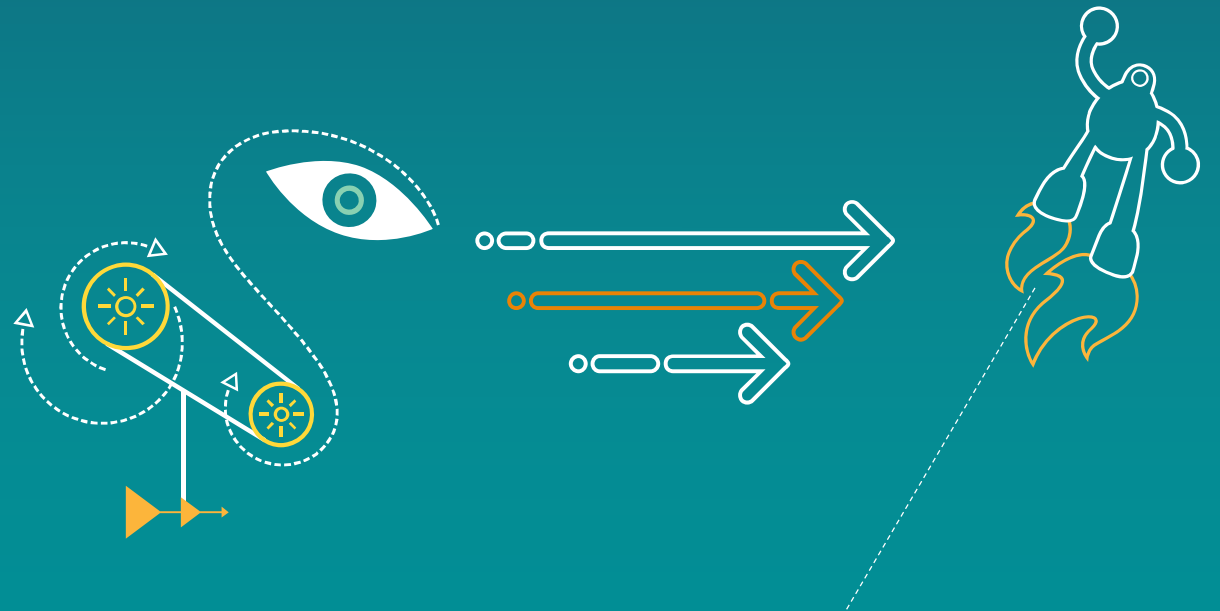


JVET-G0083

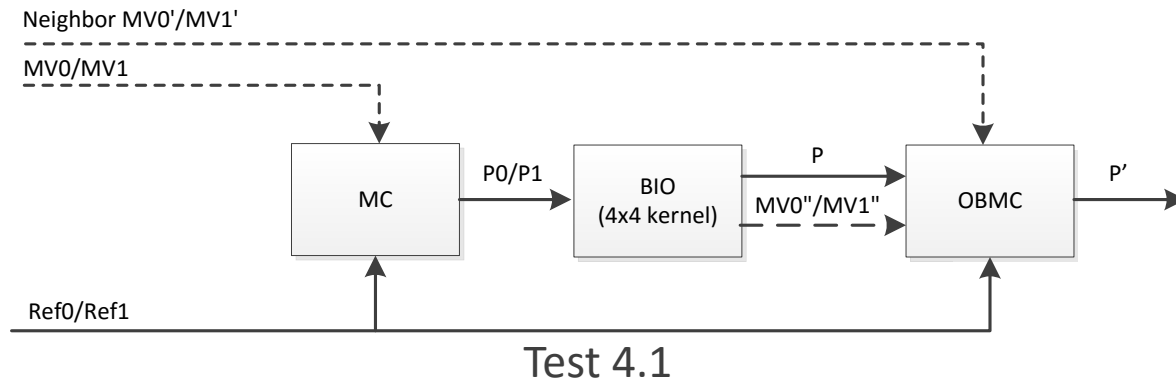
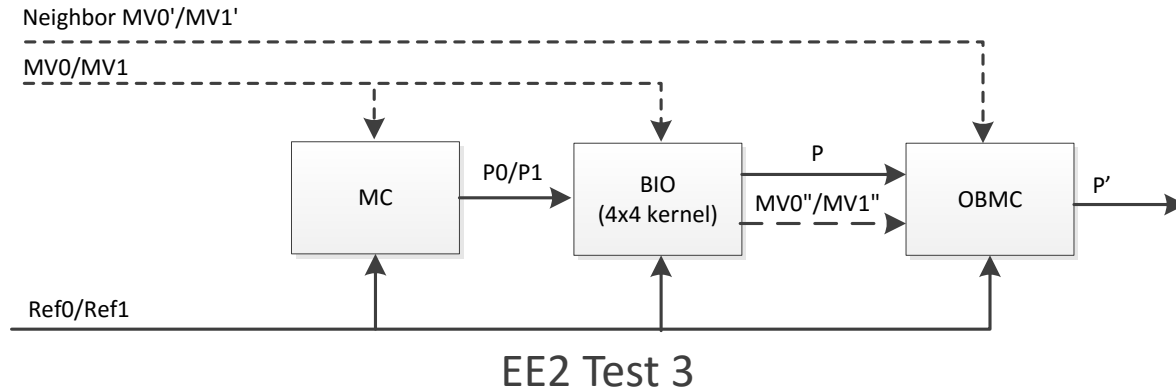
EE2-related : a simplified gradient filter for Bi-directional optical flow (BIO)



Introduction

- In JEM-6.0, gradient values for BIO are calculated using a set of 1/16-phase 6-tap interpolation filter and a set of 1/16-phase 6-tap gradient filter
 - Using reference samples
 - Separately for horizontal direction and vertical direction
- A simplified gradient filter is proposed
 - 4-tap symmetric filter with coefficients {2, -9, 0, 9, -2}
 - Using already interpolated samples by HEVC MC process
 - Memory access is the same as in JEM-6.0 BIO, which is the same as HEVC MC process

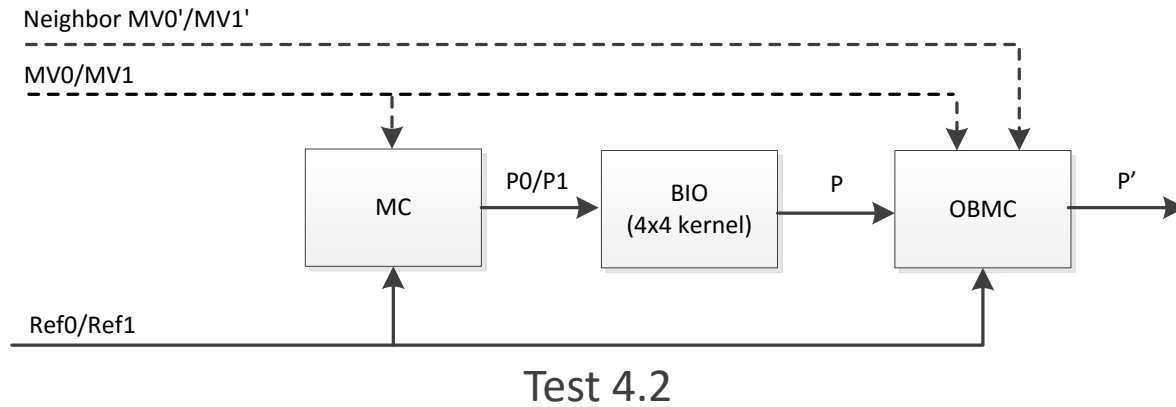
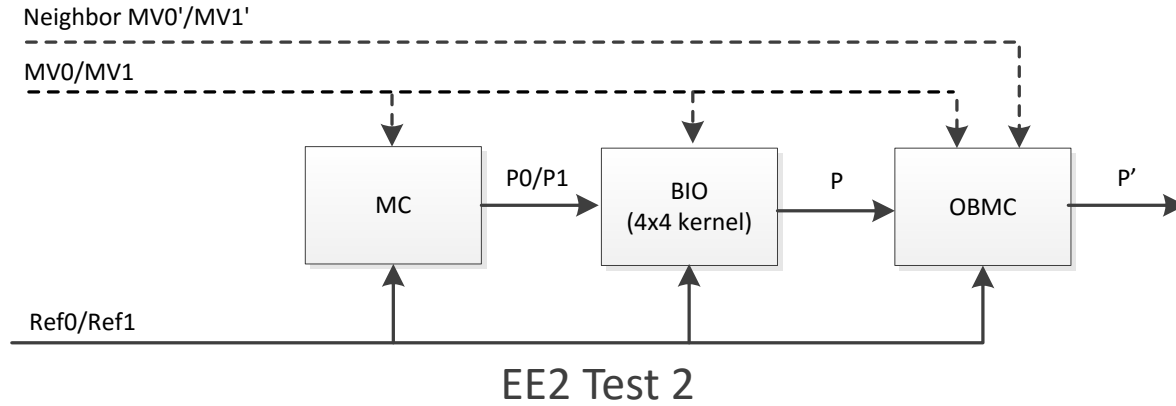
Test 4.1 (EE2 Test 3 + proposed filter)



	Random Access Main 10				
	Over JEM-6.0 (gcc-v6.2, parallel)				
	Y	U	V	EncT	DecT
Class A1	-0.1%	-0.3%	-0.3%	96%	95%
Class A2	-0.1%	-0.3%	-0.3%	93%	90%
Class B	-0.2%	-0.3%	-0.4%	92%	88%
Class C	-0.1%	-0.3%	-0.4%	94%	90%
Class D	0.0%	-0.2%	-0.3%	95%	91%
Class E					
Overall (Ref)	-0.1%	-0.3%	-0.3%	94%	91%
Class F (optional)	0.1%	0.0%	0.0%	98%	88%

	Low delay B Main10				
	Over JEM-6.0 (gcc-v6.2)				
	Y	U	V	EncT	DecT
Class A1					
Class A2					
Class B	0.0%	0.2%	0.0%	97%	94%
Class C	0.0%	-0.2%	-0.2%	98%	96%
Class D	-0.1%	-0.3%	0.1%	99%	96%
Class E	-0.2%	0.0%	-0.7%	97%	94%
Overall (Ref)	-0.1%	-0.1%	-0.1%	98%	95%
Class F (optional)	0.1%	0.3%	0.3%	99%	97%

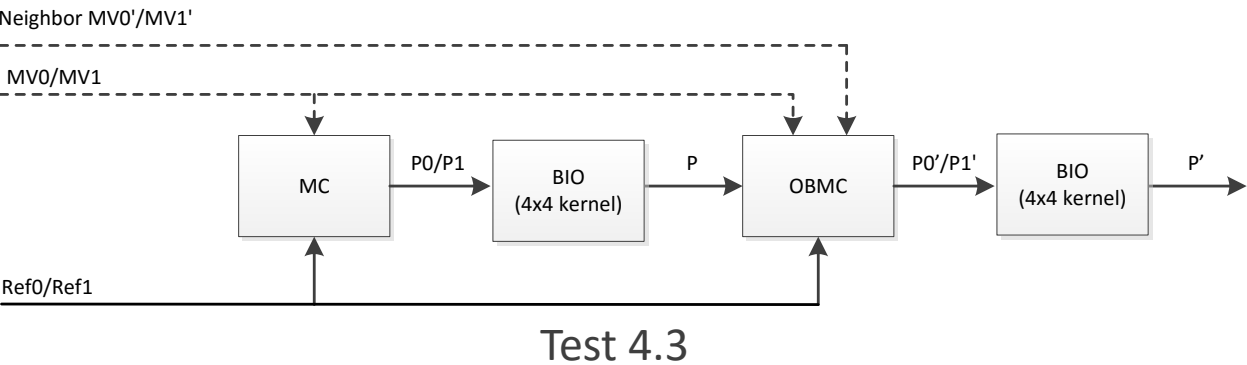
Test 4.2 (EE2 Test 2 + proposed filter)



	Random Access Main 10				
	Over JEM-6.0 (gcc-v6.2, parallel)				
	Y	U	V	EncT	DecT
Class A1	0.0%	0.0%	-0.1%	94%	81%
Class A2	0.1%	-0.1%	-0.1%	91%	76%
Class B	0.0%	-0.1%	-0.1%	90%	74%
Class C	0.2%	0.0%	0.0%	92%	78%
Class D	0.3%	0.1%	0.0%	91%	83%
Class E					
Overall (Ref)	0.1%	-0.1%	-0.1%	91%	78%
Class F (optional)	0.2%	0.1%	0.1%	96%	81%

	Low delay B Main10				
	Over JEM-6.0 (gcc-v6.2)				
	Y	U	V	EncT	DecT
Class A1					
Class A2					
Class B	0.0%	0.2%	0.0%	98%	95%
Class C	0.0%	-0.2%	-0.2%	98%	96%
Class D	-0.1%	-0.3%	0.1%	98%	95%
Class E	-0.2%	0.0%	-0.7%	96%	93%
Overall (Ref)	-0.1%	-0.1%	-0.1%	98%	95%
Class F (optional)	0.1%	0.3%	0.3%	98%	97%

Test 4.3 (4x4 BIO kernel + proposed filter)



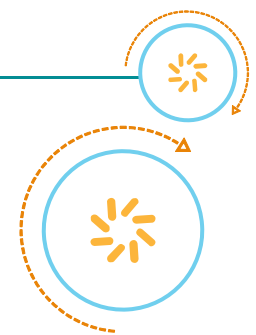
	Random Access Main 10				
	Over JEM-6.0 (gcc-v6.2, parallel)				
	Y	U	V	EncT	DecT
Class A1	0.0%	-0.1%	-0.1%	97%	90%
Class A2	-0.1%	-0.1%	-0.1%	95%	86%
Class B	-0.1%	-0.2%	-0.2%	94%	84%
Class C	0.0%	0.0%	0.0%	95%	88%
Class D	0.0%	0.0%	-0.1%	96%	93%
Class E					
Overall (Ref)	-0.1%	-0.1%	-0.1%	95%	88%
Class F (optional)	0.1%	0.0%	0.1%	98%	87%

	Low delay B Main10				
	Over JEM-6.0 (gcc-v6.2)				
	Y	U	V	EncT	DecT
Class A1					
Class A2					
Class B	0.0%	0.1%	0.3%	99%	99%
Class C	-0.1%	-0.1%	0.0%	100%	99%
Class D	0.0%	0.5%	-0.3%	98%	97%
Class E	-0.3%	0.5%	-0.3%	99%	98%
Overall (Ref)	-0.1%	0.2%	0.0%	99%	98%
Class F (optional)	0.0%	0.1%	0.2%	100%	99%

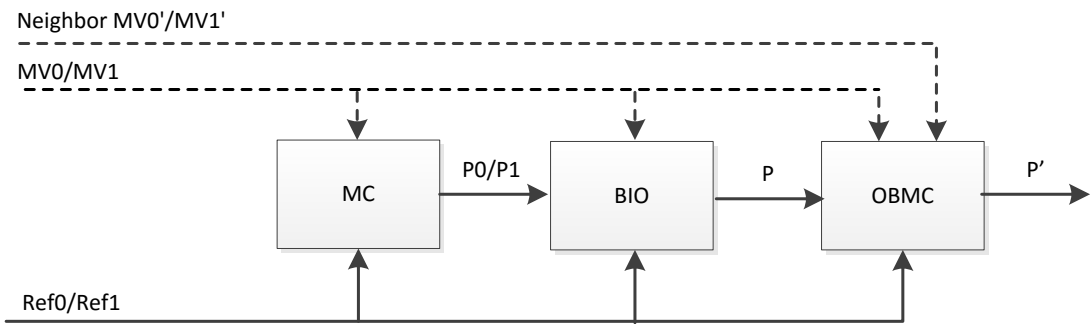
Conclusion

- In this contribution, we propose
 - A simplified gradient filter
- For Test 4.1 (-0.1% BD-rate on both RA (-0.1% BD-rate on classA/B) and LDB)
 - 6% reduction in encoding time and 9% reduction in decoding time for RA
 - 2% reduction in encoding time and 5% reduction in decoding time for LDB
- For Test 4.2 (0.1% BD-rate on RA (0.0% BD-rate on classA/B) and -0.1% BD-rate LDB)
 - 9% reduction in encoding time and 22% reduction in decoding time for RA
 - 2% reduction in encoding time and 5% reduction in decoding time for LDB
- For Test 4.3 (-0.1% BD-rate on both RA (-0.1% BD-rate on classA/B) and LDB)
 - 5% reduction in encoding time and 12% reduction in decoding time for RA
 - 1% reduction in encoding time and 2% reduction in decoding time for LDB
- Thanks Sony and Sharp for crosscheck
- We recommend to include the proposed techniques to the next version of JEM

BACKUP



EE2: Test1 (restrict BIO in OBMC)



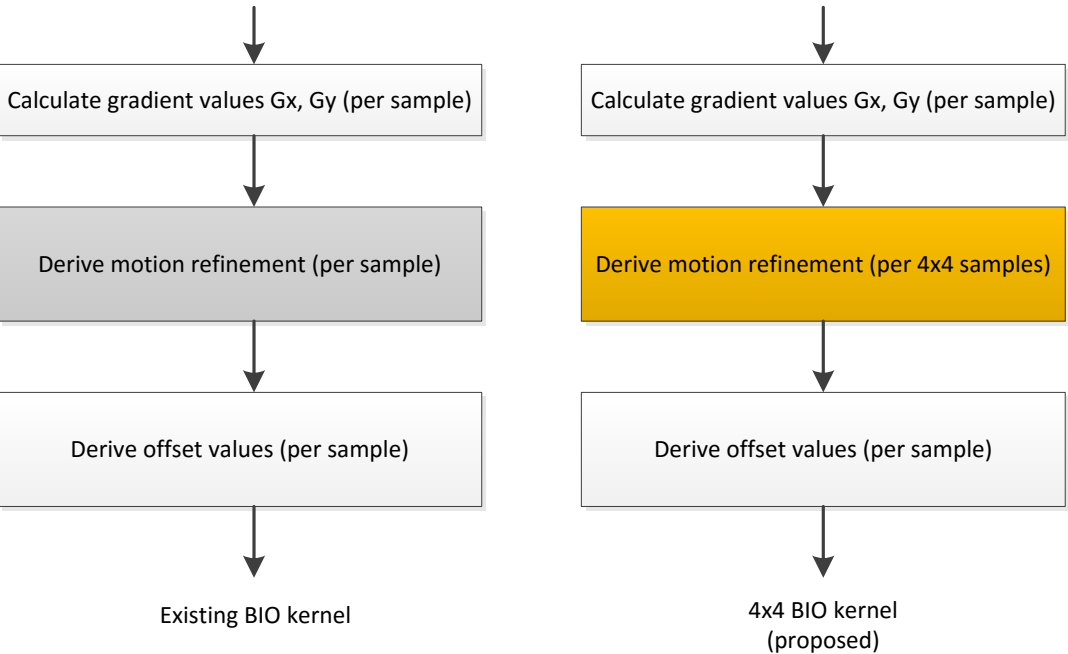
	Random Access Main 10				
	Over JEM-6.0 (gcc-v6.2, parallel)				
	Y	U	V	EncT	DecT
Class A1	0.0%	0.0%	0.0%	95%	88%
Class A2	0.2%	0.0%	0.0%	93%	85%
Class B	0.1%	0.0%	0.1%	92%	84%
Class C	0.2%	0.0%	0.0%	94%	85%
Class D	0.4%	0.1%	-0.1%	95%	89%
Class E					
Overall (Ref)	0.2%	0.0%	0.0%	94%	86%
Class F (optional)	0.1%	0.1%	0.1%	98%	92%
	Low delay B Main10				
	Over JEM-6.0 (gcc-v6.2)				
	Y	U	V	EncT	DecT
Class A1					
Class A2					
Class B	0.1%	0.0%	0.0%	97%	96%
Class C	0.0%	0.1%	-0.1%	96%	94%
Class D	0.0%	0.1%	0.2%	99%	98%
Class E	0.0%	0.8%	-0.7%	98%	95%
Overall (Ref)	0.0%	0.2%	-0.1%	97%	96%
Class F (optional)	0.1%	0.2%	-0.3%	99%	98%

With division

	Random Access Main 10				
	Over JEM-6.0 (gcc-v6.2, parallel)				
	Y	U	V	EncT	DecT
Class A1	0.1%	0.0%	0.0%	98%	91%
Class A2	0.2%	0.0%	0.0%	95%	88%
Class B	0.1%	0.0%	0.0%	94%	87%
Class C	0.2%	0.1%	-0.1%	97%	88%
Class D	0.4%	0.2%	0.0%	95%	91%
Class E					
Overall (Ref)	0.2%	0.1%	0.0%	96%	89%
Class F (optional)	0.1%	0.1%	0.1%	99%	95%
	Low delay B Main10				
	Over JEM-6.0 (gcc-v6.2)				
	Y	U	V	EncT	DecT
Class A1					
Class A2					
Class B	0.1%	0.0%	0.1%	99%	97%
Class C	0.1%	-0.2%	-0.1%	98%	95%
Class D	0.0%	0.4%	0.1%	98%	96%
Class E	0.1%	0.6%	0.3%	99%	96%
Overall (Ref)	0.0%	0.1%	0.1%	98%	96%
Class F (optional)	0.0%	0.2%	-0.4%	98%	97%

Division-free

EE2: Test2 (Test1 + 4x4 BIO kernel)



	Random Access Main 10				
	Over JEM-6.0 (gcc-v6.2, parallel)				
	Y	U	V	EncT	DecT
Class A1	0.0%	0.0%	0.0%	96%	89%
Class A2	0.0%	0.0%	-0.1%	95%	86%
Class B	0.0%	0.0%	0.0%	94%	83%
Class C	0.0%	0.0%	-0.1%	96%	86%
Class D	0.1%	0.0%	-0.1%	94%	91%
Class E					
Overall (Ref)	0.0%	0.0%	-0.1%	95%	87%
Class F (optional)	0.0%	0.1%	0.1%	96%	86%

	Low delay B Main10				
	Over JEM-6.0 (gcc-v6.2)				
	Y	U	V	EncT	DecT
Class A1					
Class A2					
Class B	0.0%	0.1%	0.3%	99%	97%
Class C	0.0%	0.3%	0.0%	100%	98%
Class D	0.0%	0.0%	-0.1%	99%	96%
Class E	0.0%	0.7%	0.0%	98%	94%
Overall (Ref)	0.0%	0.2%	0.1%	99%	96%
Class F (optional)	0.1%	0.3%	0.0%	98%	98%

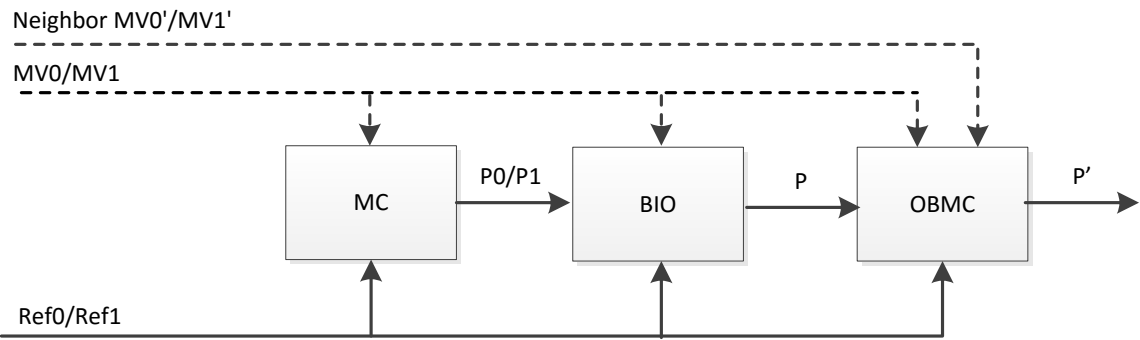
4x4 BIO, division-free

	Random Access Main 10				
	Over JEM-6.0 (gcc-v6.2, parallel)				
	Y	U	V	EncT	DecT
Class A1	0.0%	-0.1%	0.0%	94%	81%
Class A2	0.1%	-0.1%	-0.1%	91%	76%
Class B	0.1%	-0.1%	-0.1%	89%	73%
Class C	0.2%	0.1%	-0.1%	94%	78%
Class D	0.5%	0.1%	-0.2%	92%	83%
Class E					
Overall (Ref)	0.2%	0.0%	-0.1%	92%	78%
Class F (optional)	0.1%	0.1%	0.2%	95%	81%

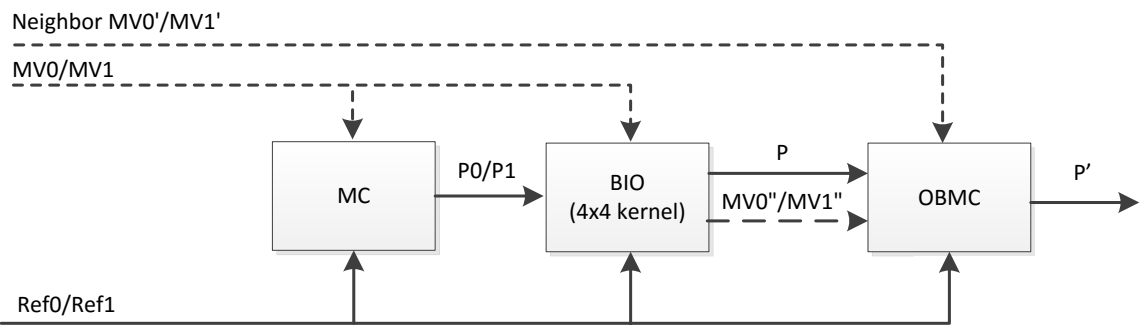
	Low delay B Main10				
	Over JEM-6.0 (gcc-v6.2)				
	Y	U	V	EncT	DecT
Class A1					
Class A2					
Class B	0.0%	0.2%	0.2%	97%	94%
Class C	0.0%	0.1%	-0.1%	98%	95%
Class D	0.0%	0.1%	-0.3%	97%	93%
Class E	0.0%	0.0%	0.3%	97%	93%
Overall (Ref)	0.0%	0.1%	0.0%	97%	94%
Class F (optional)	0.1%	0.3%	-0.1%	98%	97%

Test 2, division-free

EE2: Test3 (Test2 + MV synchronization)



Test 1



Test 3

	Random Access Main 10				
	Over JEM-6.0 (gcc-v6.2, parallel)				
	Y	U	V	EncT	DecT
Class A1	0.0%	-0.1%	-0.2%	96%	95%
Class A2	0.0%	-0.2%	-0.3%	94%	90%
Class B	-0.1%	-0.2%	-0.2%	93%	88%
Class C	0.1%	-0.1%	-0.2%	95%	89%
Class D	0.3%	0.0%	-0.3%	93%	90%
Class E					
Overall (Ref)	0.1%	-0.1%	-0.2%	94%	90%
Class F (optional)	0.1%	0.0%	0.1%	97%	87%

	Low delay B Main10				
	Over JEM-6.0 (gcc-v6.2)				
	Y	U	V	EncT	DecT
Class A1					
Class A2					
Class B	0.0%	0.2%	0.2%	97%	94%
Class C	0.0%	0.1%	-0.1%	98%	95%
Class D	0.0%	0.1%	-0.3%	96%	93%
Class E	0.0%	0.0%	0.3%	97%	92%
Overall (Ref)	0.0%	0.1%	0.0%	97%	94%
Class F (optional)	0.1%	0.3%	-0.1%	98%	97%

Division-free