



REDEFINING MOBILITY



# JCTVC-B095

## Encoder complexity analysis and performance report on adaptive loop filter

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# Summary

- Encoder issues
  - Multiple passes to obtain filter coefficients & filtered/not filtered map
  - High HW complexity
    - On-chip memory (OCMEM) size increase or
    - Memory bandwidth and power increase
- Analyze complexity vs. performance of different adaptive in-loop filter (ALF) algorithm
- Performance report according to ALF method categories
  - Separate quad tree (QT) vs. coding unit (CU) synchronized
  - Filter shapes and types

# Complexity of different ALF

- In current TMuC software implementation,
- Non-separable (diamond/rectangular) ALF
  - 18 passes
    - 1 pass: initial filter decision
    - 15 passes: CU adaptive filter decision
    - 2 passes: filter tap decision
- Separable ALF
  - 34 passes
    - 4 passes: filter tap decision
    - 30 passes: CU adaptive filter decision
- Complexity analysis of each pass is in JCTVC-B110.

# Complexity issues in HW implementation

- 2 set of frame buffers needed
  - Input
  - Reconstructed
- Using full size OCMEM
  - Significant additional OCMEM needed
    - Conventional size of OCMEM is ~512KB
- Partial OCMEM and read/write to DDR (in DPB)
  - Memory BW increase
  - Power consumption increase
    - Power consumption of DDR >> OCMEM

# Alternatives

- Non-separable diamond simplified ALF (2 passes)
  - Encoding pass. Deriving filter coefficients after the end of the encoding pass.
  - Filtering Pass. Apply the filter & CU level filtering decision
    - w/o redesigning the filters
- Post filter (only encoding pass), T09-SG16-C-0128

# Results IPPP

	ALF off	Diamond	Diamond 2-pass 9x9 tap	Post Filter
WQVGA	RaceHorses	-3.42	-3.29	-3.08
	BasketballPass	-2.87	-2.16	-1.96
	BlowingBubbles	-1.9	-1.55	-0.93
	BQSquare	-4.68	-4.32	-3.67
	<b>WQVGA_AVG</b>	<b>-3.22</b>	<b>-2.83</b>	<b>-2.41</b>
WVGA	RaceHorses	-4.56	-4.37	-3.88
	BasketballDrill	-9.72	-6.89	-4.34
	PartyScene	-2.67	-2.2	-2.42
	BQMall	-4.2	-3.14	-3.07
	<b>WVGA_AVG</b>	<b>-5.29</b>	<b>-4.15</b>	<b>-3.43</b>
720p	Vidyo1	-4.39	-1.3	-3.78
	Vidyo3	-11.27	-4.69	-3.65
	Vidyo4	-5.86	-2.26	-4.82
	<b>720p_AVG</b>	<b>-7.17</b>	<b>-2.75</b>	<b>-4.08</b>
1080p	ParkScene	-2.92	-3.18	-2.89
	Kimono	-5.17	-4.85	-4.48
	BasketballDrive	-5.70	-4.90	-3.44
	Cactus	-3.21	-1.33	-3.7
	BQTerrace	-9.46	-8.22	-4.94
	<b>1080p_AVG</b>	<b>-5.29</b>	<b>-4.49</b>	<b>-3.89</b>
	<b>AVG</b>	<b>-5.13</b>	<b>-3.67</b>	<b>-3.44</b>

# Results, HierB

	ALF off	Diamond	Diamond 2-pass 9x9 tap	Post Filter
WQVGA	RaceHorses	-2.85	-2.89	-3.83
	BasketballPass	-1.43	-1.23	-2.18
	BlowingBubbles	-1.3	-0.95	-1.07
	BQSquare	-4.49	-4.2	-3.98
	<b>WQVGA_AVG</b>	<b>-2.52</b>	<b>-2.32</b>	<b>-2.77</b>
WVGA	RaceHorses	-4.72	-4.7	-4.75
	BasketballDrill	-4.62	-3.23	-2.8
	PartyScene	-2.37	-2.09	-2.04
	BQMall	-3.16	-2.85	-2.85
	<b>WVGA_AVG</b>	<b>-3.72</b>	<b>-3.22</b>	<b>-3.11</b>
720p	Vidyo1	-3.96	-2.28	-4.08
	Vidyo3	-8.59	-4.52	-6.19
	Vidyo4	-4.92	-3.12	-4.9
	<b>720p_AVG</b>	<b>-5.82</b>	<b>-3.31</b>	<b>-5.06</b>
1080p	ParkScene	-3.41	-3.34	-3.09
	Kimono	-4.53	-4.48	-4.18
	BasketballDrive	-5.71	-5.65	-5.1
	Cactus	-4.59	-3.66	-5.15
	BQTerrace	-13.68	-13.21	-9.52
	<b>1080p_AVG</b>	<b>-6.38</b>	<b>-6.07</b>	<b>-5.41</b>
	<b>AVG</b>	<b>-4.65</b>	<b>-3.9</b>	<b>-4.11</b>

# Performance report on different ALF methods in TMuC

- Separate Quadtree vs. CU synchronized

- Complexity of separate QT > CU synchronized

- Additional processing for determining of QT structures

- Pruning/merging quad tree based on RD cost

0	0	0	0
1	0	1	0
1	0	0	
1	1		

Separate Quadtree

0	0	0
	1	0
1	0	

CU Synchronized

- Filter shapes and types

- 7x7 separable filters

- 7-tap symmetric filter: 4 multiplications/pixel for each (vertical/horizontal) direction
    - Total of 8 multiplications/pixel

- 5x5 diamond shaped filters (point symmetric)

- Total of 7 multiplications/pixel



# Results- QT vs. CU, IPPP

	ALF off	Separable QT	Separable CU
WQVGA	RaceHorses	-3.05	-3.29
	BasketballPass	-1.35	-1.41
	BlowingBubbles	-1.80	-1.80
	BQSquare	-4.58	-4.69
	<b>WQVGA_AVG</b>	<b>-2.69</b>	<b>-2.79</b>
WVGA	RaceHorses	-3.75	-3.66
	BasketballDrill	-6.29	-6.21
	PartyScene	-2.26	-2.23
	BQMall	-3.43	-3.54
	<b>WVGA_AVG</b>	<b>-3.93</b>	<b>-3.91</b>
720p	Vidyo1	-3.28	-3.43
	Vidyo3	-8.91	-9.17
	Vidyo4	-4.71	-4.59
	<b>720p_AVG</b>	<b>-5.63</b>	<b>-5.73</b>
1080p	ParkScene	-3.51	-3.51
	Kimono	-4.52	-4.51
	BasketballDrive	-3.12	-3.07
	Cactus	-2.92	-2.82
	BQTerrace	-5.99	-5.9
	<b>1080p_AVG</b>	<b>-4.01</b>	<b>-3.96</b>
	<b>AVG</b>	<b>-3.97</b>	<b>-3.99</b>

# Results- QT vs. CU, HierB

	ALF off	Separable QT	Separable CU
WQVGA	RaceHorses	-2.72	-2.72
	BasketballPass	-0.75	-0.75
	BlowingBubbles	-1.03	-1.2
	BQSquare	-3.92	-4.09
	<b>WQVGA_AVG</b>	<b>-2.11</b>	<b>-2.19</b>
WVGA	RaceHorses	-3.6	-3.47
	BasketballDrill	-2.21	-2.24
	PartyScene	-1.89	-1.9
	BQMall	-2.03	-2.15
	<b>WVGA_AVG</b>	<b>-2.43</b>	<b>-2.44</b>
720p	Vidyo1	-2.46	-2.47
	Vidyo3	-6.52	-6.42
	Vidyo4	-3.57	-3.28
	<b>720p_AVG</b>	<b>-4.18</b>	<b>-4.07</b>
1080p	ParkScene	-2.91	-2.87
	Kimono	-3.83	-3.81
	BasketballDrive	-3.13	-2.99
	Cactus	-3.25	-3.21
	BQTerrace	-6.69	-6.48
	<b>1080p_AVG</b>	<b>-3.96</b>	<b>-3.87</b>
	<b>AVG</b>	<b>-3.16</b>	<b>-3.13</b>

# Results- filter shape, IPPP

	ALF off	Diamond 5x5 tap CU	Separable 7 tap CU
WQVGA	RaceHorses	-1.87	-1.62
	BasketballPass	-2.29	-0.96
	BlowingBubbles	-1.32	-1.11
	BQSquare	-2.79	-2.68
	<b>WQVGA_AVG</b>	<b>-2.07</b>	<b>-1.59</b>
WVGA	RaceHorses	-2.67	-2.25
	BasketballDrill	-6.34	-5.07
	PartyScene	-1.93	-1.71
	BQMall	-3.2	-2.43
	<b>WVGA_AVG</b>	<b>-3.54</b>	<b>-2.87</b>
720p	Vidyo1	-3.1	-2.26
	Vidyo3	-7.63	-6.15
	Vidyo4	-4.71	-3.56
	<b>720p_AVG</b>	<b>-5.15</b>	<b>-3.99</b>
1080p	ParkScene	-2.00	-1.5
	Kimono	-3.67	-3.54
	BasketballDrive	-4.01	-2.01
	Cactus	-2.46	-1.68
	BQTerrace	-5.01	-2.69
	<b>1080p_AVG</b>	<b>-3.43</b>	<b>-2.28</b>
	<b>AVG</b>	<b>-3.44</b>	<b>-2.58</b>

# Results- filter shape, HierB

	ALF off	Diamond 5x5 tap CU	Separable 7 tap CU
WQVGA	RaceHorses	-1.7	-1.98
	BasketballPass	-0.97	-0.55
	BlowingBubbles	-0.92	-0.93
	BQSquare	-3.53	-3.25
	<b>WQVGA_AVG</b>	<b>-1.78</b>	<b>-1.67</b>
WVGA	RaceHorses	-2.76	-2.69
	BasketballDrill	-2.66	-1.72
	PartyScene	-1.84	-1.59
	BQMall	-2.59	-1.52
	<b>WVGA_AVG</b>	<b>-2.46</b>	<b>-1.88</b>
720p	Vidyo1	-2.65	-1.73
	Vidyo3	-6.66	-4.34
	Vidyo4	-3.88	-2.41
	<b>720p_AVG</b>	<b>-4.40</b>	<b>-2.83</b>
1080p	ParkScene	-2.51	-2.07
	Kimono	-3.05	-3.02
	BasketballDrive	-3.91	-2.13
	Cactus	-3.25	-2.29
	BQTerrace	-8.62	-4.24
	<b>1080p_AVG</b>	<b>-4.27</b>	<b>-2.75</b>
	<b>AVG</b>	<b>-3.22</b>	<b>-2.28</b>

# Conclusion

- Trade off between complexity and performance of different ALF
- We suggest
  - the proponents to provide performance analysis for limited encoding passes in Loop Filtering TE.
  - to include post filter in Loop Filtering TE.

Thank you