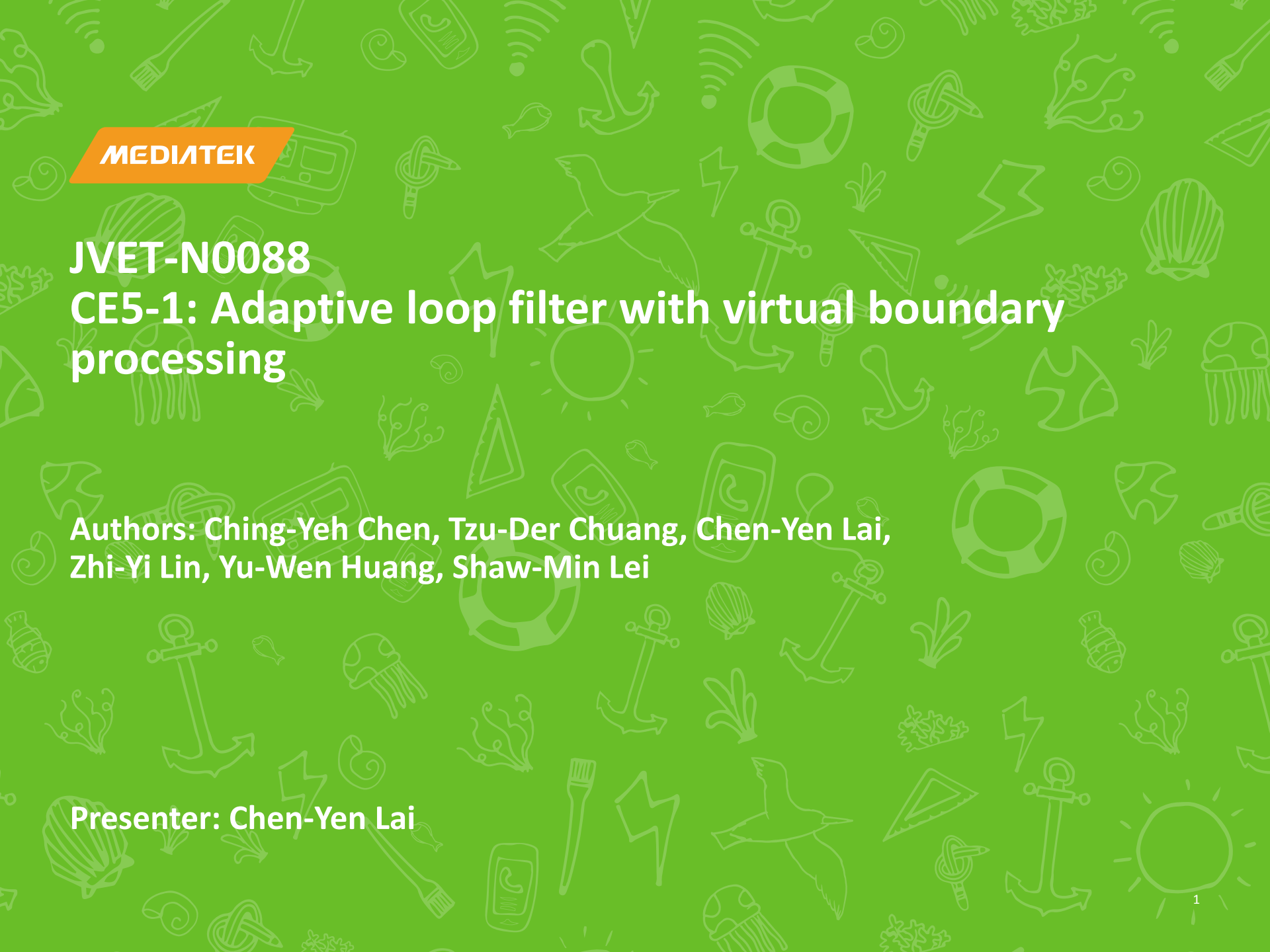


The background is a solid green color with a repeating pattern of white line-art icons. These icons include various nautical items like anchors, lifebuoys, and seashells, as well as outdoor and travel-related items like a compass, a map, a bird, and a lightning bolt.

MEDIATEK

JVET-N0088

CE5-1: Adaptive loop filter with virtual boundary processing

**Authors: Ching-Yeh Chen, Tzu-Der Chuang, Chen-Yen Lai,
Zhi-Yi Lin, Yu-Wen Huang, Shaw-Min Lei**

Presenter: Chen-Yen Lai

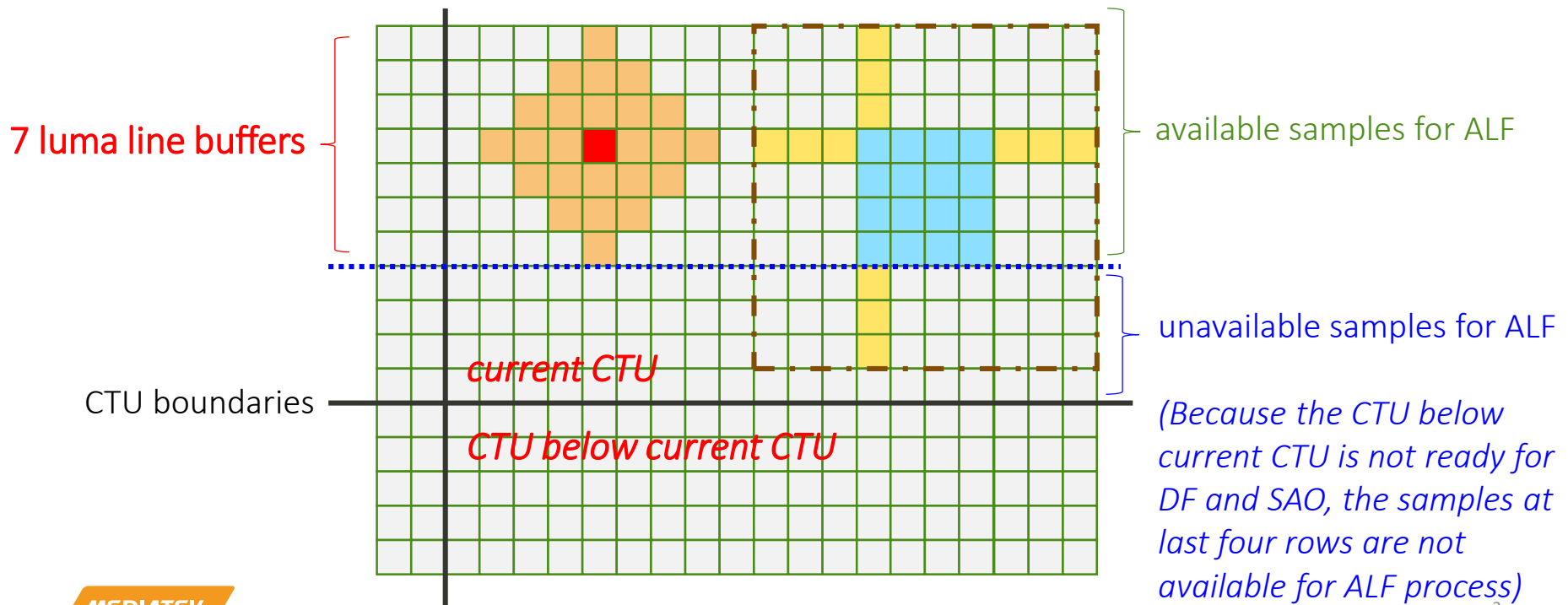
Overall Summary

- VTM4.0 ALF needs 7 luma line buffers and 4 chroma line buffers
 - 7x7 diamond filters with 4x4 block-based classification are used for luma
 - A 5x5 diamond filter without classification is used for chroma
- Apply virtual boundary (VB) processing to remove ALF line buffers
 - The required samples across the VB are replaced with padded samples
- Simulation results:

	Luma BD-rate Over VTM-4.0			EncTime	DecTime
	AI	RA	LB		
Proposed Method	0.07%	0.09%	0.09%	100% 100% 101%	103% 102% 103%

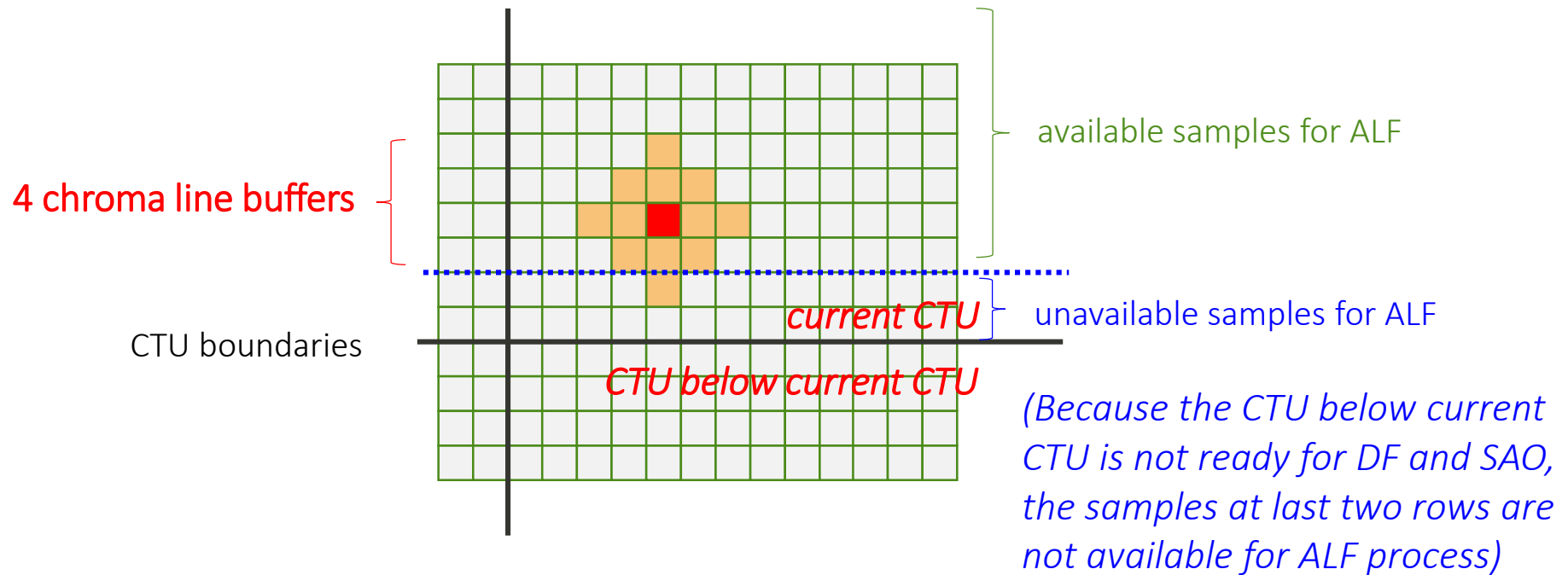
Luma Line Buffer Usage in ALF

- A 10x10 luma window is required for one 4x4 block
 - 7x7 diamond filters
 - 4x4 block-based classification



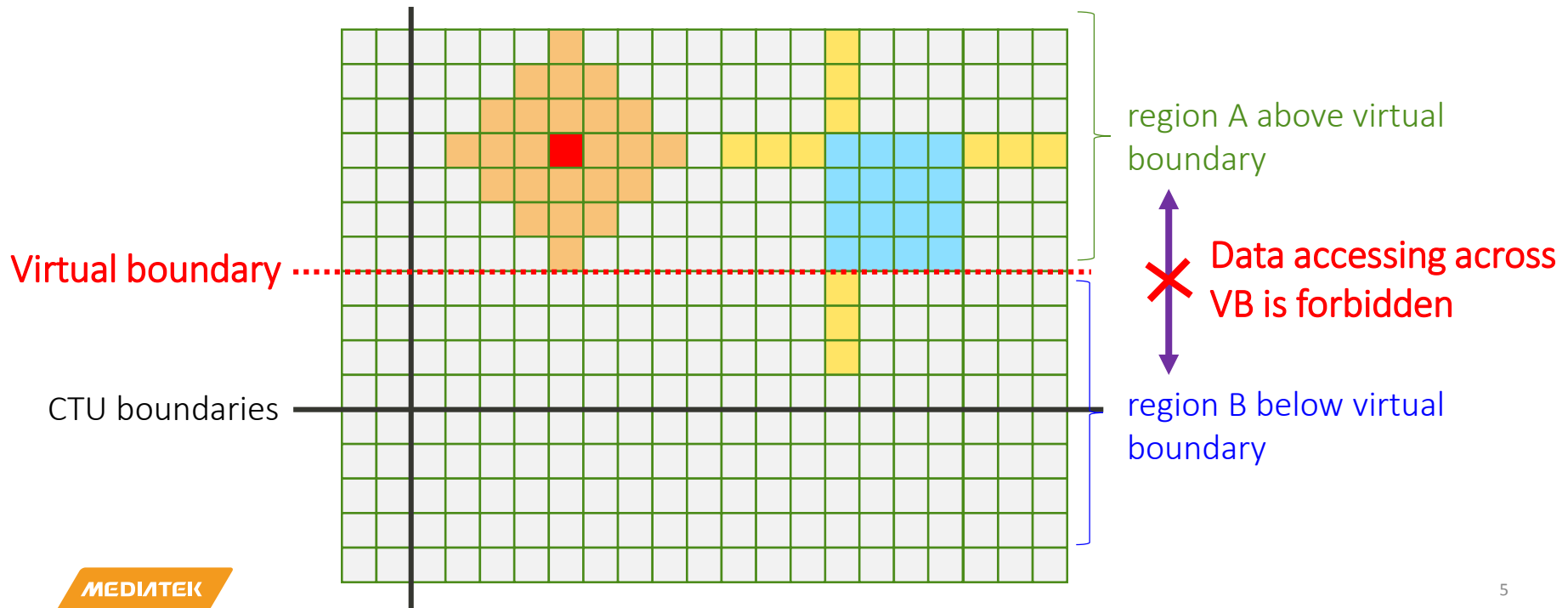
Chroma Line Buffer Usage in ALF

- 5x5 diamond filter is used for chroma



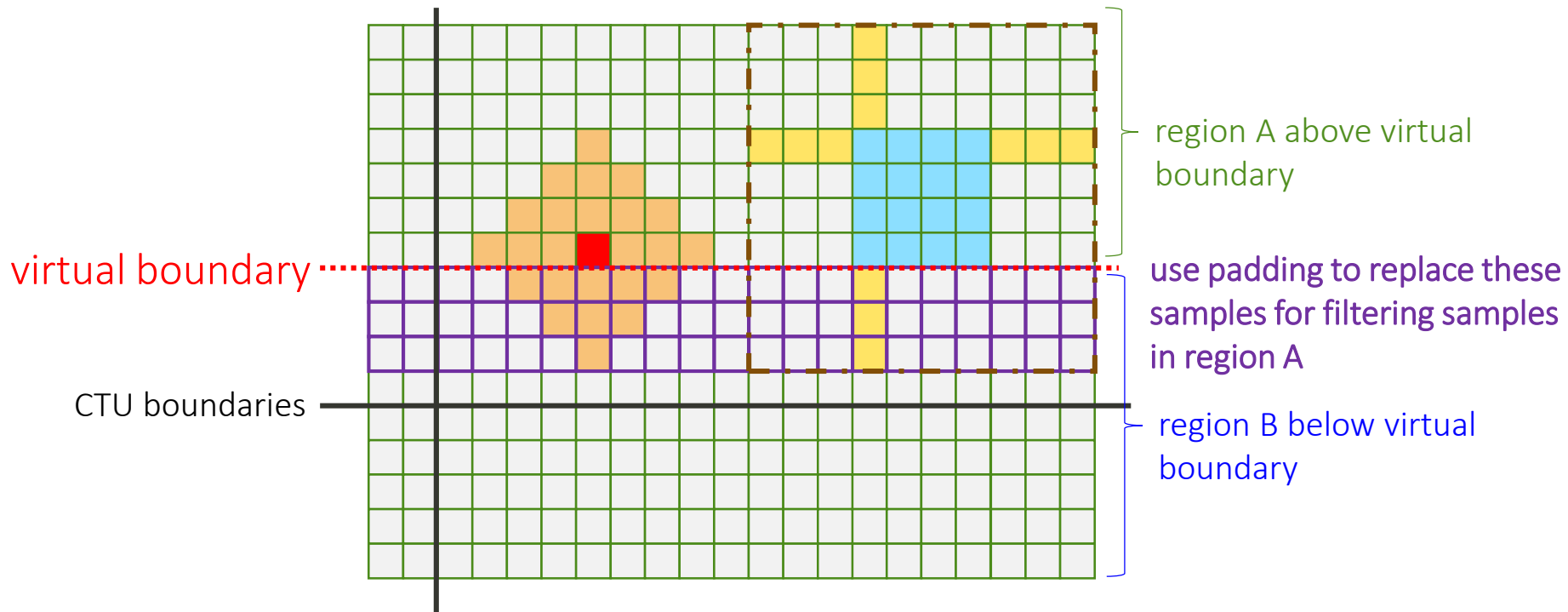
Proposed Method

- Apply virtual boundary processing to break the data dependency when crossing a virtual boundary
 - When one sample located at one side of a VB is filtered, accessing samples located at the other side of the VB is forbidden.



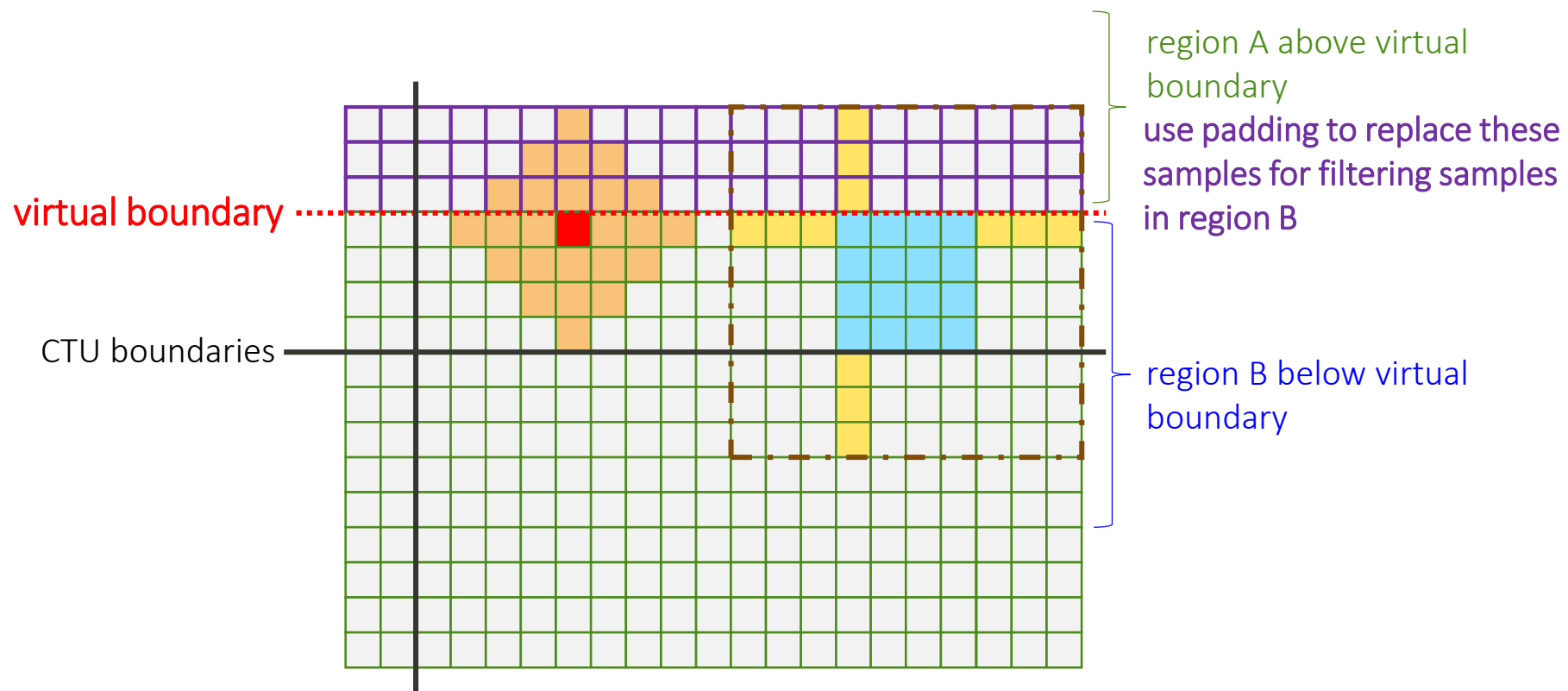
Proposed Method

- Apply ALF to the samples in region A



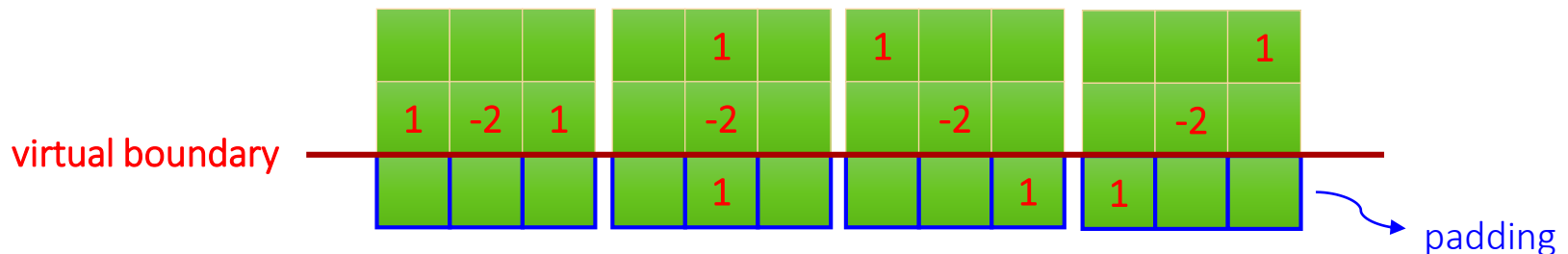
Proposed Method

- Apply ALF to the samples in region B

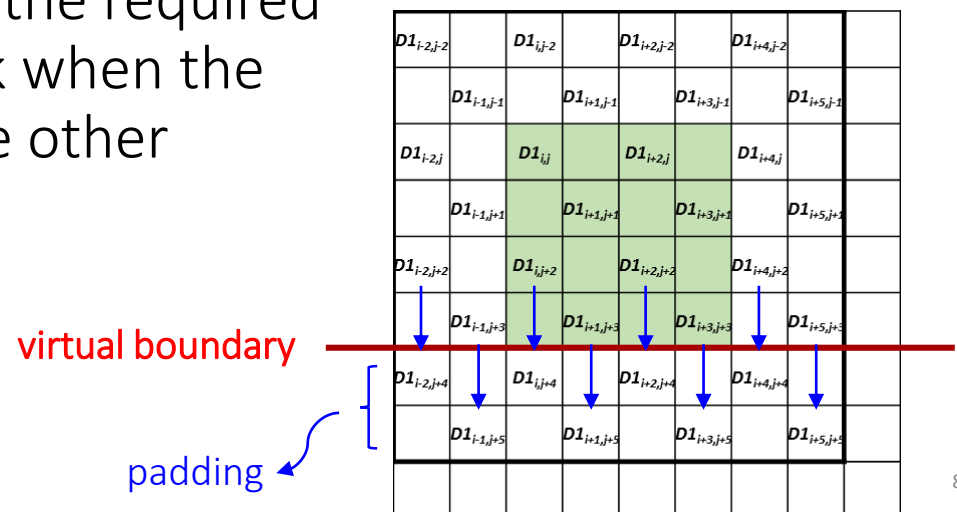


Modification in Classifications

- Using padding to generate the required samples in 3-tap gradient filter when the required samples are located in the other side of virtual boundary

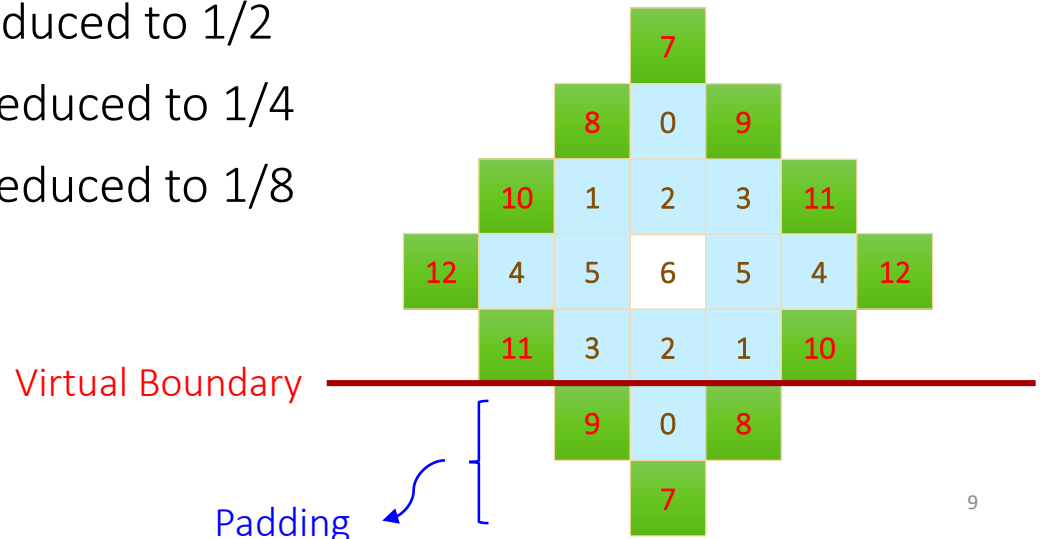


- Using padding to generate the required gradients for one 4x4 block when the gradients are located in the other side of virtual boundary



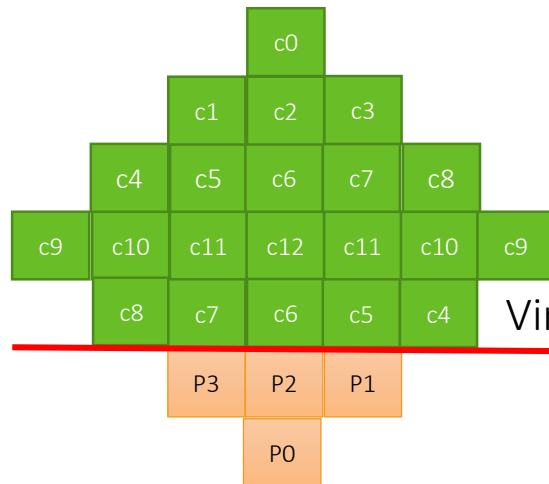
Modification in Filtering Process

- Using padding to generate the required samples in the filter footprint when the required samples are located at the other side of virtual boundary
- A weighted averaging process is introduced
 - $\text{FinalOutput} = (w * \text{filtered sample} + (8-w) * \text{ALF input sample} + 4) \gg 3$.
 - w is dependent on the number of padded lines
 - 1 padded line: weight is reduced to $1/2$
 - 2 padded lines: weight is reduced to $1/4$
 - 3 padded lines: weight is reduced to $1/8$



Implicit Filter On/Off Control

- The implicit filter on/off control is presented in JVET-M0301
- The decision is made according to the ratio between the sum of absolute filter coefficients applied to padded samples and the sum of absolute filter coefficients applied to real samples



Padded samples: $P0 + P1 + P2 + P3$

Real samples: $c0 + c1 + c2 + c3 + 2*(c4 + c5 + c6 + c7 + c8 + c9 + c10 + c11) + c12$

Virtual Boundary

Simulation Results

	All Intra Main10				
	Over VTM-4.0				
	Y	U	V	EncT	DecT
Class A1	0.08%	0.21%	0.16%	100%	102%
Class A2	0.07%	0.13%	0.08%	100%	106%
Class B	0.06%	0.07%	0.07%	100%	102%
Class C	0.05%	0.07%	0.10%	100%	102%
Class E	0.10%	0.11%	0.19%	100%	103%
Overall	0.07%	0.11%	0.11%	100%	103%
Class D	0.03%	0.06%	0.06%	100%	103%
Class F	0.06%	0.06%	0.05%	100%	103%
	Random access Main10				
	Over VTM-4.0				
	Y	U	V	EncT	DecT
Class A1	0.11%	0.06%	0.09%	100%	101%
Class A2	0.11%	-0.07%	0.02%	100%	102%
Class B	0.10%	0.09%	0.12%	100%	101%
Class C	0.07%	-0.04%	-0.17%	100%	103%
Class E					
Overall	0.09%	0.02%	0.02%	100%	102%
Class D	0.03%	-0.02%	-0.02%	100%	105%
Class F	0.04%	0.06%	0.06%	100%	101%
	Low delay B Main10				
	Over VTM-4.0				
	Y	U	V	EncT	DecT
Class A1					
Class A2					
Class B	0.07%	-0.05%	-0.09%	100%	101%
Class C	0.04%	0.29%	0.27%	101%	105%
Class E	0.19%	0.27%	-0.32%	102%	103%
Overall	0.09%	0.14%	-0.03%	101%	103%
Class D	0.02%	0.23%	-0.17%	100%	103%
Class F	-0.02%	-0.25%	-0.31%	102%	106%

Simulation Results

- With filter on/off control

	All Intra Main10				
	Over VTM-4.0				
	Y	U	V	EncT	DecT
Class A1	0.08%	0.21%	0.16%	100%	101%
Class A2	0.07%	0.13%	0.08%	100%	105%
Class B	0.06%	0.07%	0.07%	100%	102%
Class C	0.05%	0.07%	0.10%	100%	102%
Class E	0.10%	0.11%	0.19%	101%	107%
Overall	0.07%	0.11%	0.11%	100%	103%
Class D	0.03%	0.06%	0.06%	100%	102%
Class F	0.06%	0.06%	0.05%	100%	102%
	Random access Main10				
	Over VTM-4.0				
	Y	U	V	EncT	DecT
Class A1	0.11%	0.13%	0.02%	100%	104%
Class A2	0.11%	-0.07%	0.08%	100%	103%
Class B	0.10%	0.13%	0.10%	100%	103%
Class C	0.07%	-0.04%	-0.17%	99%	103%
Class E					
Overall	0.10%	0.04%	0.01%	100%	103%
Class D	0.03%	-0.03%	-0.02%	99%	103%
Class F	0.04%	0.06%	0.06%	100%	101%
	Low delay B Main10				
	Over VTM-4.0				
	Y	U	V	EncT	DecT
Class A1					
Class A2					
Class B	0.08%	-0.06%	0.14%	100%	104%
Class C	0.08%	0.47%	0.20%	100%	105%
Class E	0.20%	0.19%	-0.21%	100%	103%
Overall	0.11%	0.18%	0.07%	100%	104%
Class D	0.03%	0.20%	-0.12%	100%	107%
Class F	-0.04%	0.09%	0.42%	100%	104%

Conclusion

- Virtual boundary (VB) processing to remove ALF line buffers
 - The required samples across the VB are replaced with padded samples
 - Remove seven luma line buffers and four chroma line buffers

- Simulation results

	Luma BD-rate Over VTM-4.0			EncTime	DecTime
	AI	RA	LB		
Proposed Method	0.07%	0.09%	0.09%	100% 100% 101%	103% 102% 103%

- Thank Huawei and Qualcomm for crosschecking

