



# AHG4: Wavefront tile parallel processing

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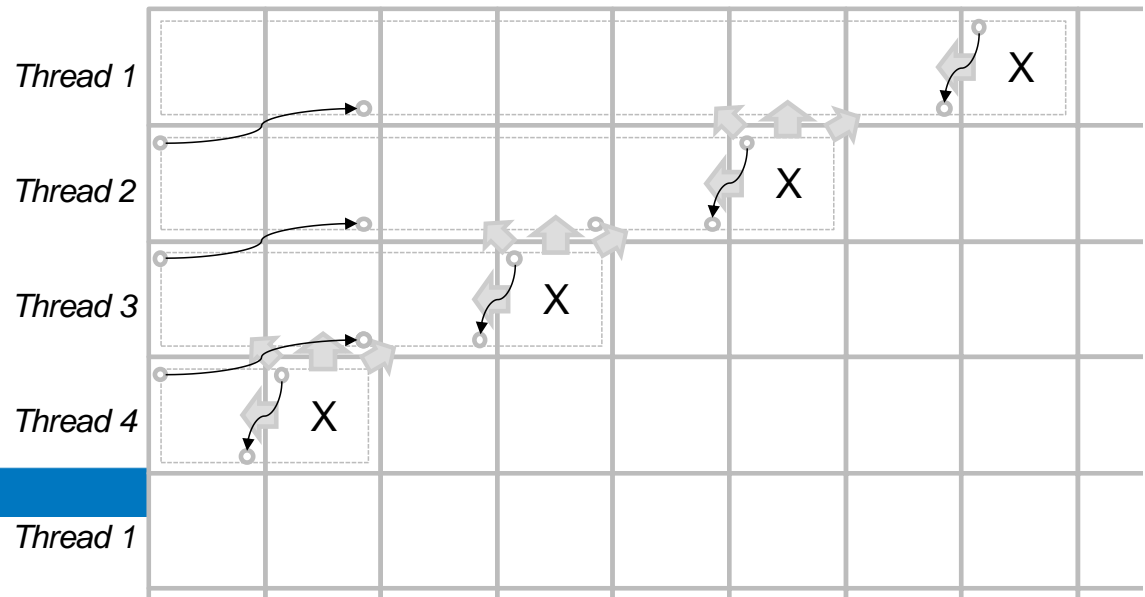
# Overall Summary

- “Wavefront Tile Parallel Processing (WTPP)” is proposed
  - It has been proposed in F063
  - Combine WPP and dependent tiles for parallel processing
  - Get the advantages of both WPP and tiles
- The proposed WTPP scheme has following advantages
  - In comparison with tiles, better coding efficiency is achieved under the same parallelism conditions
    - 0.3% better than tiles for 2 threads/tiles
    - 0.6% better than tiles for 4 threads/tiles
  - In comparison with WPP, 80% causality checks (interaction between threads) can be reduced
  - Support computation scalability and heterogeneity for practical applications

# Wavefront Parallel Processing [JCTVC-E196]

- Wavefront processing order maintains spatial dependency
- Quick learning of CABAC probabilities
  - The first LCU of each row is initialized with the probabilities obtained after the second LCU of the upper row is processed
- **WPP causality check:**
  - Check if the upper right LCU has been processed
- For multi-core systems to perform WPP
  - Takes more interactions among cores to preserve the correct processing order between threads

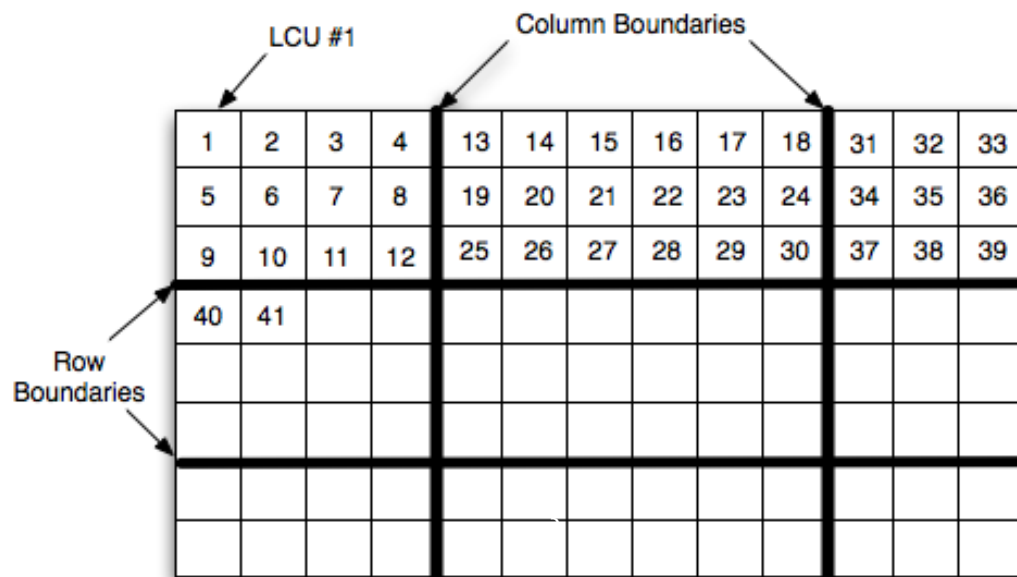
## WPP with 4 threads



# Tiles [JCTVC-D227]

- Partition picture into rectangular segments for parallel processing
  - LCUs are processed in raster scan order within each tile
  - Tiles are processed in raster scan order within the picture
- Tile boundaries break dependency for independent tiles
  - Suffer coding efficiency loss

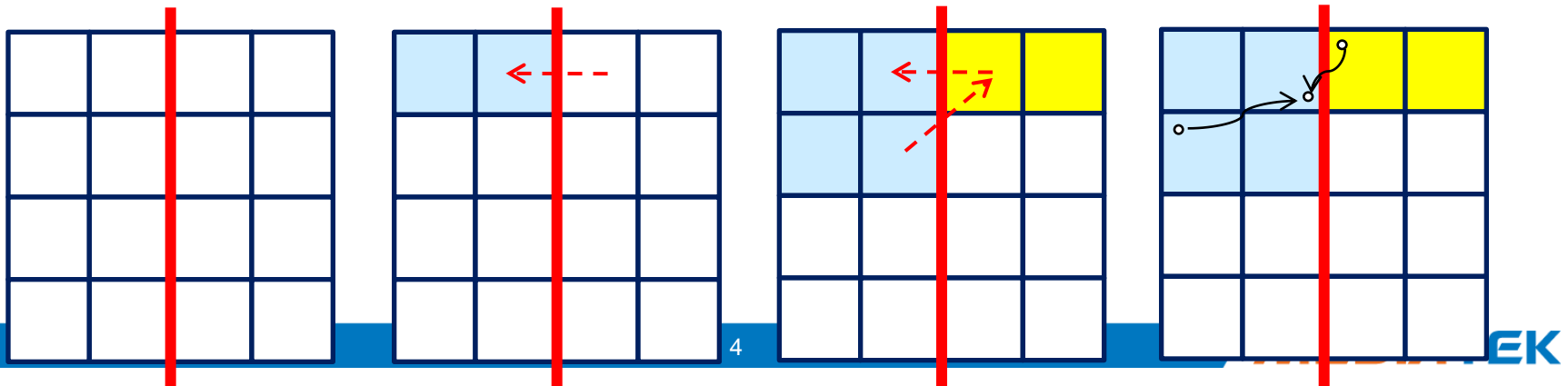
## Tiles partitioning using 3 columns and 3 rows



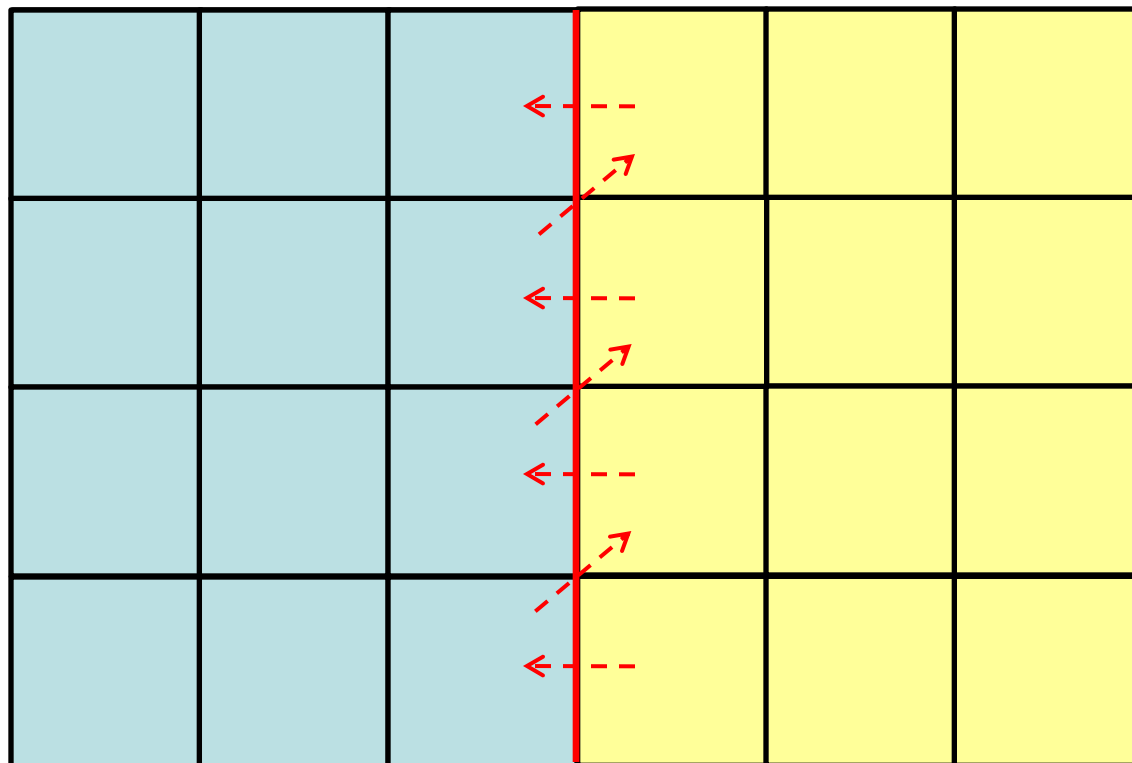
# Proposed WTPP

- WPP concept is extended and applied to tiles with columns of LCUs
- Causality checks only happen on the LCUs at tile boundaries
  - For tile boundary LCU at right tile: check left LCU
  - For tile boundary LCU at left tile: check upper-right LCU
- CABAC probabilities inheritance
  - Inner tile: raster-scan order
  - Inter tile: only the first LCU row; left to right

WTPP with 2 tiles <--- : Causality check



# WTPP with 2 Tiles

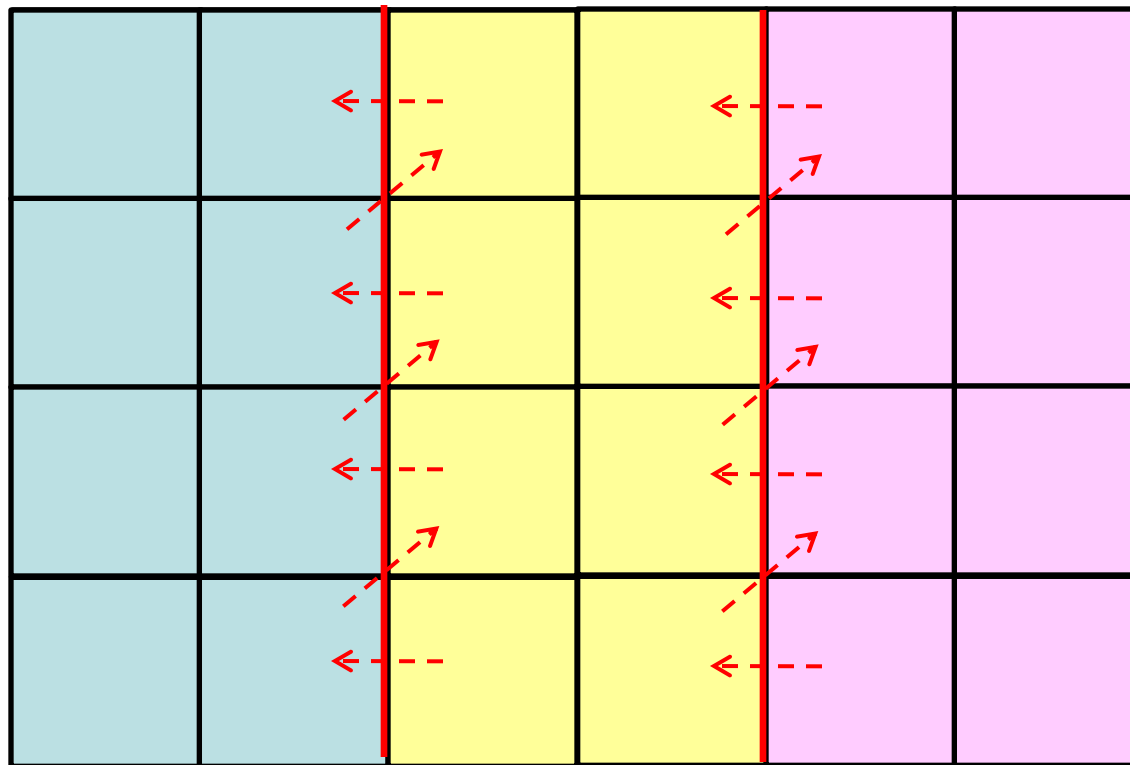


← --- Causality check

Tile boundary

# WTPP with 3 Tiles

← --- Causality check



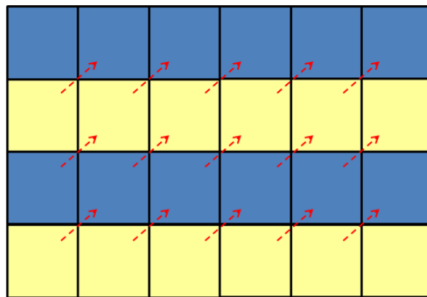
Tile boundary

Tile boundary

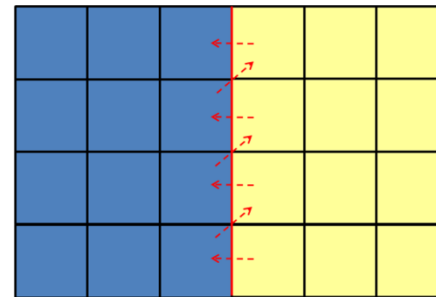
# Number of Causality Checks (1/2)

- WPP
  - Depends on number of LCUs of entire picture
  - **5x3=15** in the 2-thread example
- WTPP
  - Depends on number of LCUs of picture height & number of tiles
  - **(3+4)x1=7** in the 2-thread example

2-thread WPP



2-thread WTPP



 : Causality check



# Number of Causality Checks (2/2)

- WTPP can save 80% of causality checks
- When the picture size increases, the reduction is more significant

	WPP	WTPP		
Threads	2, 3, 4	2	3	4
Class A	936	49 (5.2%)	98 (10.5%)	147 (15.7%)
Class B	464	33 (7.1%)	66 (14.22%)	99 (21.3%)
Class E	209	23 (11.0%)	46 (22.0%)	69 (33.0%)

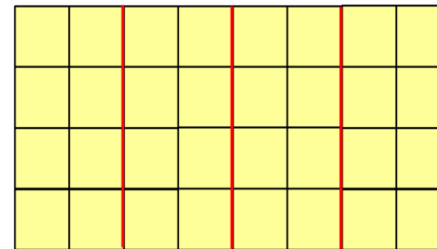
# Support of Computation Scalability

- For practical applications, encoders and decoders may have asymmetrical computational power
  - WTPP can easily provide computation scalability to adapt to the asymmetry

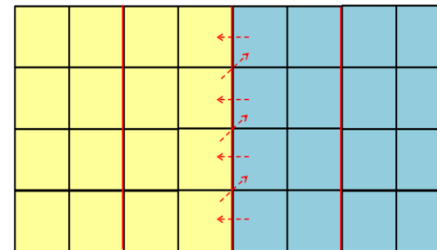
Encoder with 4-parallel WTPP



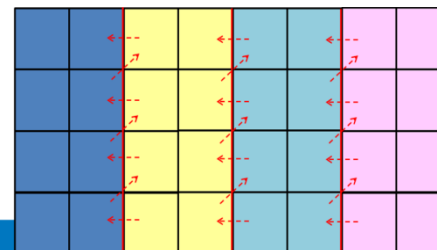
WTPP bitstream



Decoder with  
1-parallel  
WTPP



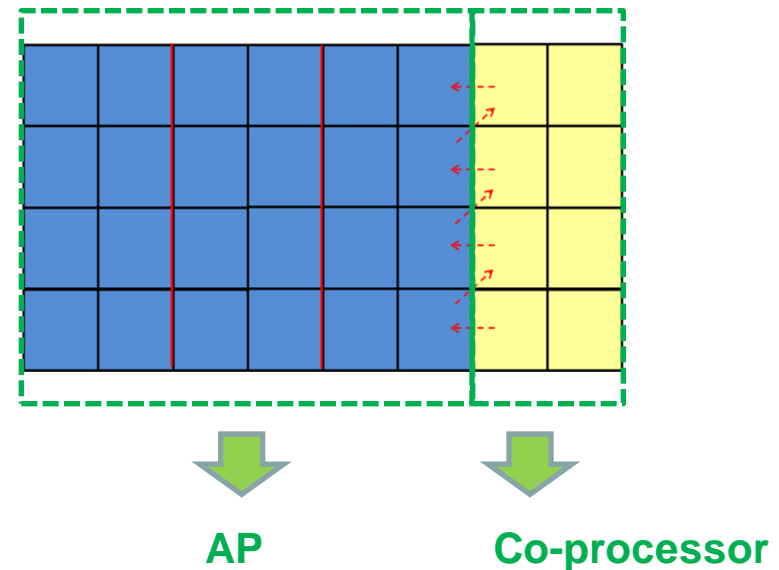
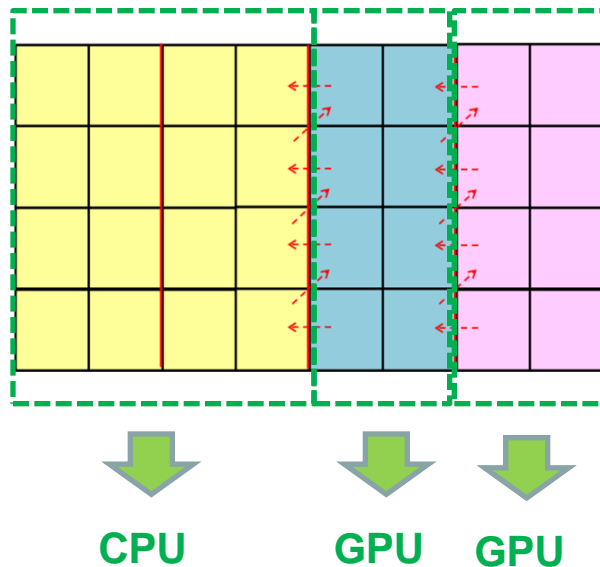
Decoder with  
2-parallel  
WTPP



Decoder with  
4-parallel  
WTPP

# Support of heterogeneity

- For multi-core applications, parallel processing may be fulfilled among heterogeneous cores
  - CPU and GPU, or application processor (AP) and co-processor
  - Each core has different computational power
  - WTPP can easily provide computation adaptation to the heterogeneity



# Simulation Results: 2 Threads/Tiles

- Anchor
  - HM-4.0 ( no tiles & WPP)
  - HE cases are tested
- Results
  - The proposed scheme is 0.3% better than tiles
  - No tile marker inserted (will degrade more)

BD-rate	HE-All Intra	HE-Random Access	HE-Low Delay
Tiles	0.2%	0.7%	1.0%
WTPP	0%	0.4%	0.8%

# Simulation Results: 4 Threads/Tiles

- Anchor
  - HM-4.0 ( no tiles & WPP)
  - HE cases are tested
- Results
  - The proposed scheme is 0.6% better than tiles
  - No tile marker inserted (will degrade more)

BD-rate	HE-All Intra	HE-Random Access	HE-Low Delay
Tiles	0.6%	1.3%	1.8%
WTPP	0%	0.7%	1.2%

# Conclusions

- In this contribution, WTPP was proposed to combine WPP and dependent tiles for parallel processing
- WTPP was compared with both WPP and tiles
  - 0.3% better than tiles for 2 threads/tiles
  - 0.6% better than tiles for 4 threads/tiles
  - The number of causality checks of WTPP is significantly less than that of WPP
    - < 16% for class A (2560x1600)
    - < 22% for class B (1920x1080)
    - < 33% for class E (1280x720)
- WTPP could support computation scalability and heterogeneity for practical applications
- We recommend to adopt WTPP as a combined mode for WPP and tiles
  - To get advantages of both WPP and tiles