Frame Context Selection

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Requirements for Temporal Scalability

- It should be possible to determine and control which previously coded frames are dependencies of the current frame
  - E.g., allow skipping every other frame

Requirements for Error Resilience

- It should be possible to determine if the decoder is missing a frame required for decoding
  - This allows retransmission or dropping of the frame
  - Allows a decoder that never shows a broken frame

VP9

- Reference frame dependencies
  - Implicitly or explicitly signaled with picture IDs in RTP mapping
  - Up to three allowed per frame (from pool of 8)
- Frame contexts (probabilities)
  - Stores probabilities that are backwards-adapted based on data from previous frames
  - Decoder maintains four independent sets
  - Each frame signals which one to use
    - Optionally writes back to the slot it read from
  - Choice uncorrelated with references or picture IDs

Problems with Frame Contexts

- If you lose a frame, you don’t know which slot it updated
  - You no longer know if you can decode any frame
- The last frame to update the slot you’re using might not be one of your reference frames
  - Frame contexts introduce potential hidden fourth frame dependency (this is surprising)
  - RTP mapping only signals three picture IDs (could fix)
- You can’t fork probabilities and evolve them independently
  - Every layer pays cost of re-learning probabilities

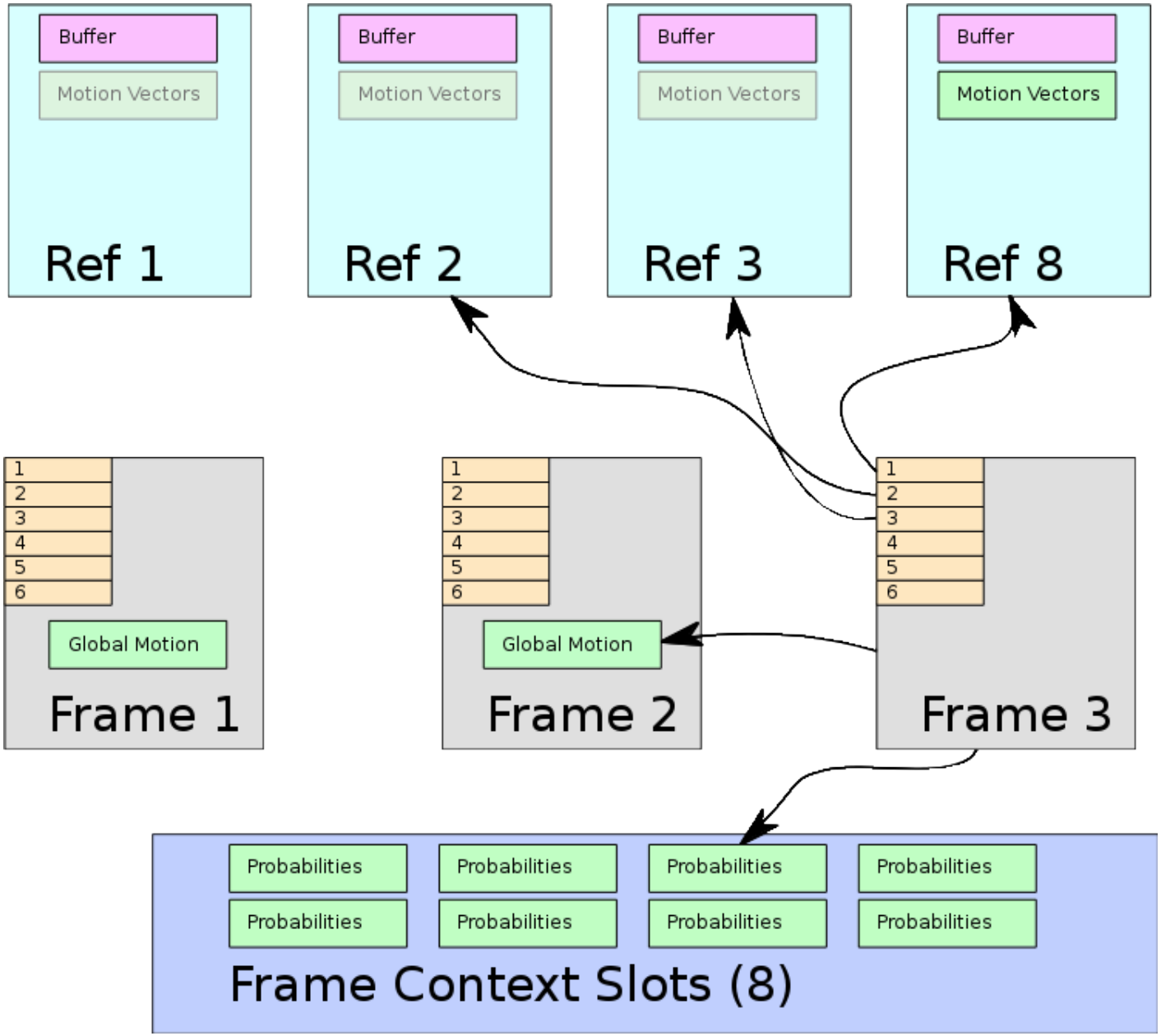
AV1

- Reference frame dependencies
  - Explicitly signaled and coded with frame IDs in codec payload
  - Up to six allowed per frame (from pool of 8)
- Probabilities
  - Currently same as VP9, but expanded to 8 slots
- Motion vectors for temporal MV prediction
  - Always from last coded frame
  - Fixed up by tempmv_signaling proposal
- Global motion data
  - Coded as deltas relative to last coded frame

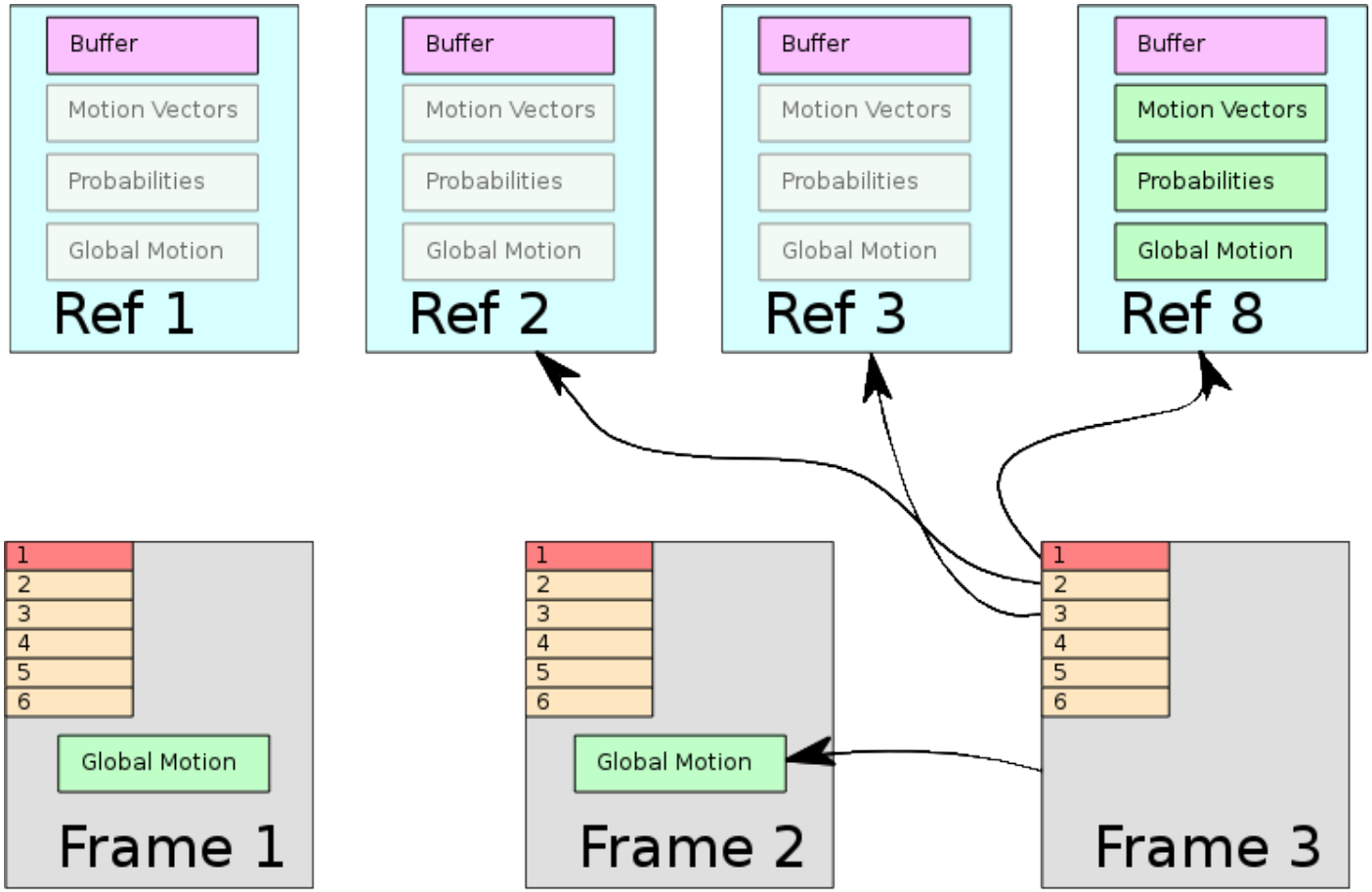
Proposal

- Make all dependencies between frames track with reference frame structure

Before


Buffer
Motion Vectors
Ref 1
Buffer
Motion Vectors
Ref 2
Buffer
Motion Vectors
Ref 3
Buffer
Motion Vectors
Ref 8
1
2
3
4
5
6
Global Motion
Frame 1
1
2
3
4
5
6
Global Motion
Frame 2
1
2
3
4
5
6
Frame 3
Probabilities
Probabilities
Probabilities
Probabilities
Probabilities
Probabilities
Probabilities
Probabilities
Frame Context Slots (8)

After


Buffer
Motion Vectors
Probabilities
Global Motion
Ref 1
Buffer
Motion Vectors
Probabilities
Global Motion
Ref 2
Buffer
Motion Vectors
Probabilities
Global Motion
Ref 3
Buffer
Motion Vectors
Probabilities
Global Motion
Ref 8
1
2
3
4
5
6
Global Motion
Frame 1
1
2
3
4
5
6
Global Motion
Frame 2
1
2
3
4
5
6
Frame 3

Details

- Remove frame context slots
- Remove all syntax elements for saving and restoring frame contexts
- Instead, always save frame context with reference buffers
  - When storing a reference frame, store updated probabilities, temporal MVs, etc., too
- No more syntax to reset frame contexts
  - Implicit on a keyframe

Complexities

- Interaction between reference number and function
  - In current encoder, first reference is always last frame from same layer
  - Need to re-order reference list to use probabilities from long-term reference (golden frame), alt-ref, etc.
- Using a previous frame context for intra-only frames
  - Currently not supported (same as VP9)
- Using probabilities from a non-reference frame
  - No longer supported
  - With up to 6 of 8 references per frame, impact seems low

TODO

- Still some things to move to frame context
  - Global motion
  - Frame size prediction

Chroma from Luma

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New Update to CfL Proposal

- Current evolution of `draft-egge-netvc-cfl`
  - A lot has changed
- Complementary to `draft-midtskogen-netvc-chromapred`

What is Chroma from Luma?

- Exploits *local* correlation between color planes

Original

Reconstructed luma + chroma DC prediction (SSE: 315,364)

Reconstructed luma + CfL linear prediction α = <-0.25, -0.25> (SSE: 116,884)

Adapting CfL for AV1

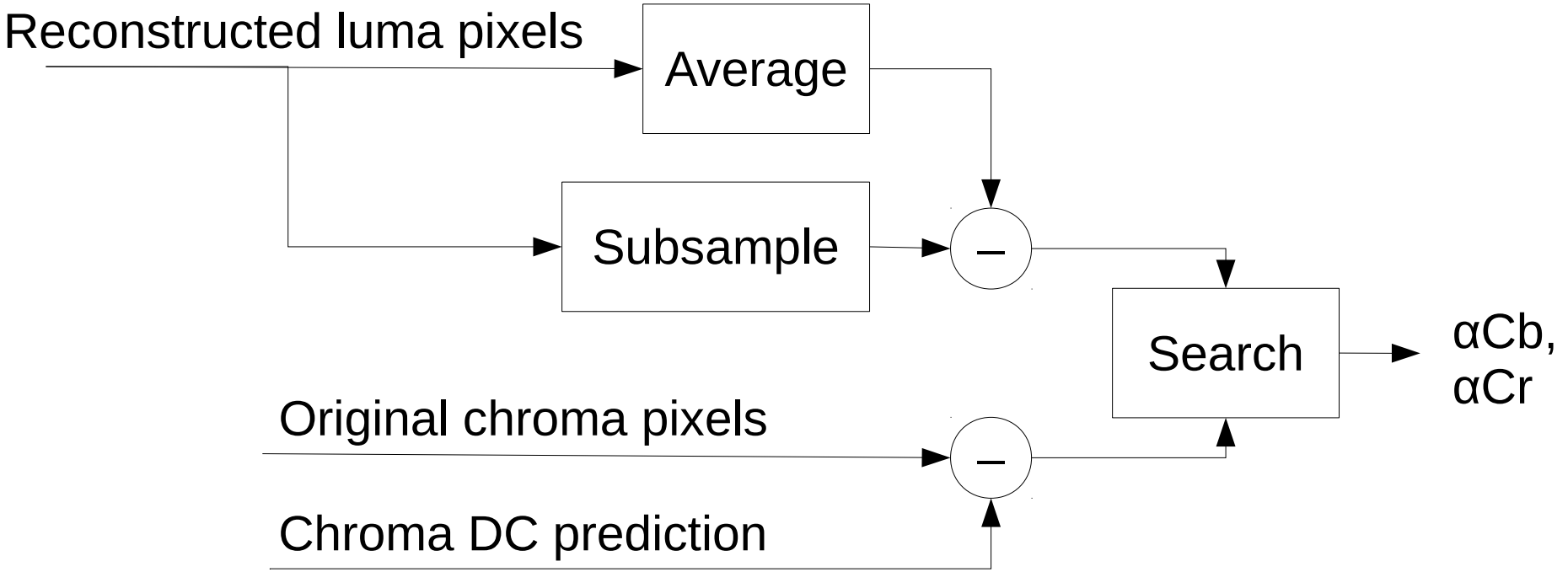
- Daala CfL predicted coefficients directly
- Hard to do frequency-domain processing in AV1
  - Up to 16 different transform types
  - Luma transform type may not match chroma type
  - Luma transform *size* may not match chroma size
    - Could handle this for the DCT
    - Hard to do for all transform type combinations
- Lesson from Daala
  - Implicit model building is not very good
  - Okay when it works, can be very bad when it doesn’t

Proposed vs. Prior CfLs

	LM Mode[1]	Thor CfL[2]	Daala CfL[3]	**Proposed**
Prediction Domain	Spatial	Spatial	Frequency	Spatial
Bitstream Signaling	No	No	Sign bit, PVQ gain	Polar index
Activation Mechanism	LM Mode (4×4 and 8×8)	Threshold	Signaled per band	CFL_PRED (UV-only mode)
Requires PVQ	No	No	Yes	No
Encoder Model Fitting	Yes	Yes	Via PVQ	Search
Decoder Model Fitting	Yes	Yes	No	No

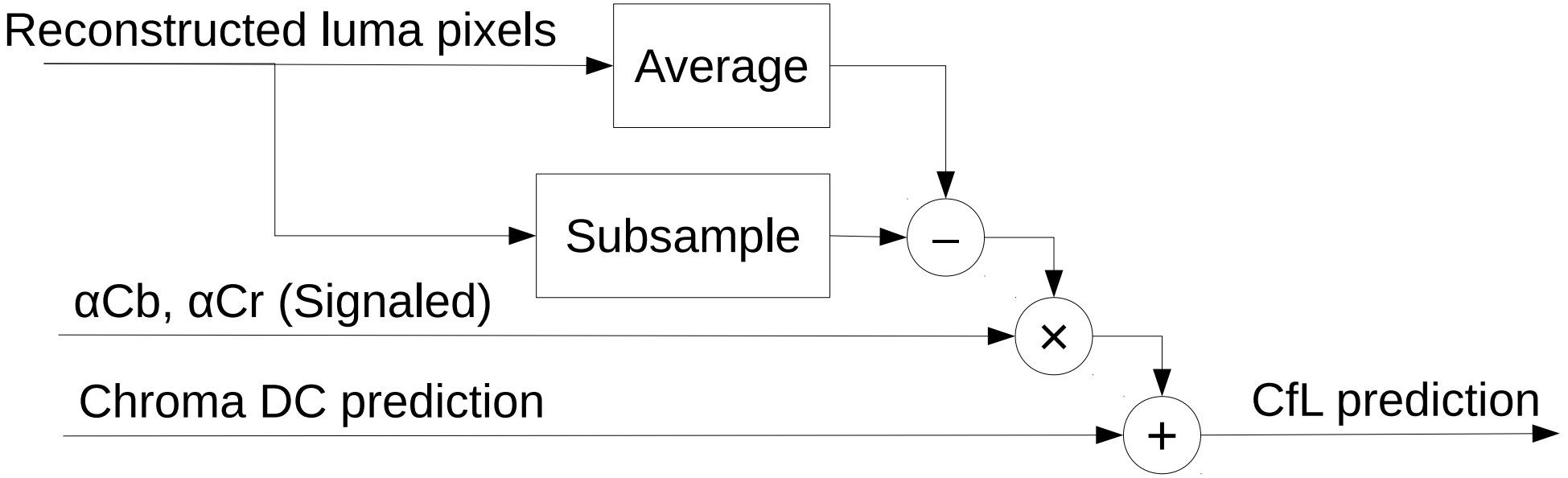
1. JCTVC-E266 (Chen et al.)
2. `draft-midtskogen-netvc-chromapred`
3. `draft-egge-netvc-cfl`

CfL: Encoder Side



- Luma average computed over transform block
  - Minimizes luma buffering in decoder
- Chroma DC computed over whole prediction block
  - Simplifies encoder search

CfL: Decoder Side



- Luma average computed over transform block
  - Minimizes luma buffering in decoder
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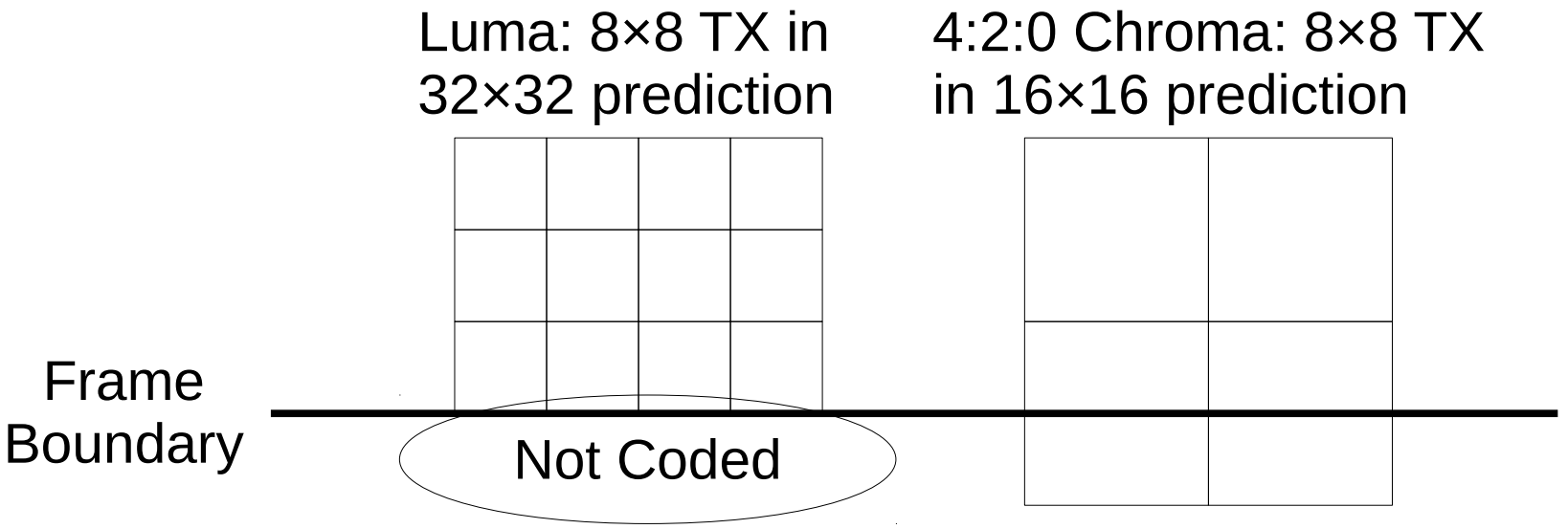
Complications (1)

- Sub-8×8 block sizes for 4:2:0 (and 4:2:2, 4:4:0)
  - Chroma uses one 4×4 transform with mode information from *bottom right*
    - Chroma is intra if bottom-right luma is intra
  - Must buffer luma from *inter* blocks above, left
- Chroma DC prediction for non-square blocks
  - Number of above + left pixels not a power of two
  - Average requires division (can implement with LUT)
  - AV1 adding rectangular transforms with rectangular intra prediction, so not a CfL-specific problem

Complications (2)

- Boundary handling
  - Frame size rounded up to nearest multiple of 8
  - Intra transform blocks completely outside this region are *not coded*
  - Chroma transform blocks may cover larger area than luma

Boundary Handling: Example



- Use simple extrapolation to recover missing luma pixels
- Also complicates DC prediction (not CfL-specific)

Outdated Example: AV1

205_-_Vallée_de_Colca_Panorama_-_Juin_2010_-_5_de_6.y4m (subset1)
QP = 55, PSNR Cr = 37.26 dB
Analyzer link: https://goo.gl/69N6LC

Outdated Example: AV1+CfL

205_-_Vallée_de_Colca_Panorama_-_Juin_2010_-_5_de_6.y4m (subset1)
QP = 55, PSNR Cr = 38.58 dB
Analyzer link: https://goo.gl/69N6LC

Latest Results

- AWCY BD-rate results on subset1 (still images)

PSNR	PSNR Cb	PSNR Cr	PSNR HVS	SSIM	MS SSIM	CIEDE 2000
0.2948	-14.8567	-12.7782	0.5817	0.5682	0.5886	-5.0903

`reorder@2017-07-07T15:41:21.181Z → cfl-mode-uniform-alpha-it1-20@2017-07-13T13:13:50.456Z`

- Working on adjusting encoder's luma-chroma balance
  - Currently different parts of the encoder use different weights

Questions?