DAALA_EC in AV1

AOM Codec WG Face-2-Face
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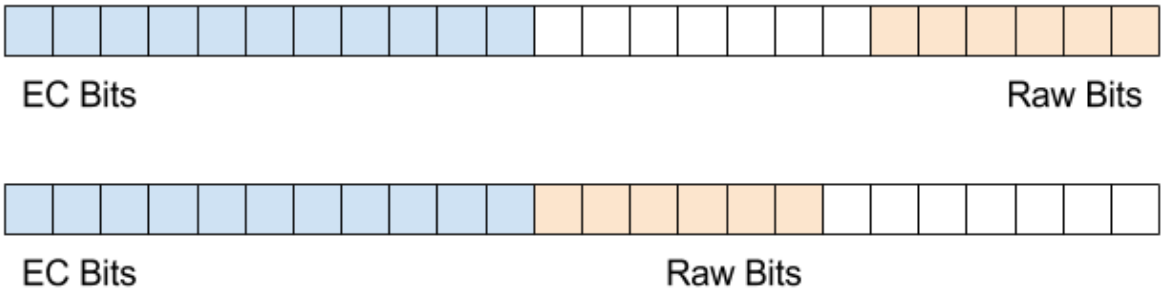
DAALA_EC Overview

- Arithmetic Range Coder
  - Based on Martin [1] and Opus entropy coder
- Code both binary symbols and multi-symbols
  - 15-bit probabilities
  - Alphabet sizes up to 16
- Encoded bits do not get revisited
- Currently enabled by default in AV1

[1] Martin, G.N.N. “Range encoding: an algorithm for removing redundancy from a digitised message”, Video and Data Recording Conference (Jul 1979)

Raw Bits

- Appended to the end of the frame (tile)
- Coded from back to front
  - Simpler than bypass mode
  - Can write many raw bits at once
- Encoder writes to separate buffer and is merged at finalize:



- Purely a throughput optimization
  - Can still code equiprobable symbols

Overhead

ec_multisymbol: off, vpxbool → daala_ec

PSNR	PSNR Cb	PSNR Cr	PSNR HVS	SSIM	MS SSIM	CIEDE 2000
-0.047%	-0.047%	-0.047%	-0.048%	-0.048%	-0.047%	-0.047%

ec_multisymbol: on, ans → daala_ec

PSNR	PSNR Cb	PSNR Cr	PSNR HVS	SSIM	MS SSIM	CIEDE 2000
-0.135%	-0.135%	-0.136%	-0.140%	-0.138%	-0.137%	-0.134%

Software Performance

Method	Decode Time (user sec)	decode_coef (percent)	Total Cycles (estimate)	decode_coef Cycles (prod)	Size (bytes)
vpxbool (bool only)	44.36	12.61%	134962424554	17018761736	1456312
daala_ec (bool only)	45.54 **2.66%**	13.54%	138490640942 **2.61%**	18751632783 **10.18%**	1455816 **-0.034%**
ans (bool only)	42.86 **-3.38%**	10.55%	132044972958 **-2.16%**	13930744647 **-18.14%**	1456057 **-0.018%**
daala_ec (ec multi)	44.93 **1.28%**	12.88%	135885706374 **0.68%**	17502078980 **2.84%**	1455743 **-0.039%**
ans (ec multi)	43.09 **-2.86%**	10.01%	131480579241 **-2.58%**	13161205982 **-22.67%**	1456028 **-0.020%**

- DAALA_EC 2.84% slower than vpxbool (no SIMD)

Hardware Considerations

HW overview

	Latency*	Throughput**	Area %***	Caveats
Daala decoder	1	1	2.7% (54k)	
ANS decoder	1	1	2.45% (49k)	
Daala encoder	1	1	.09% (9k)	Carry compression, buffer combining
ANS encoder	2	2	.25% (25k)	Byte reordering, division operation
Bool coder****		2.13	9k	

* Number of clocks between input and output (1 means the output is produced on the next clock after the input is read).
** Number of clocks between outputs (2 means one symbol is output per 2 clocks).
*** All the blocks have been implemented in HW, the numbers are reported by DC using a 500Mhz clock with 16nm library.
**** Based on the average 2.13 bins per symbol.

Google

- Both DAALA_EC and ANS faster than vpxbool with multi-symbol coding

Future Work

- Optimize the multi-symbol decoder
  - SIMD partition search
  - INLINE more DAALA_EC functions
- Merge adaptation step with entropy code
  - Once finalized, adaptation should also SIMD
- Combine symbols into larger multi-symbols
  - Larger alphabets reduce symbols clocked through EC
  - Benefits both DAALA_EC and ANS backends