Thor update

High Efficiency, Moderate Complexity Video Codec using only RF IPR

(https://datatracker.ietf.org/ipr/2636/)

draft-fuldseth-netvc-thor-03

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Thor status

- No updates in the github repository since IETF98
- Alternative single pass CDEF design
- Implementation in progess:
  - CDEF (loop filter)
  - Daala EC
- A tool designed to improve screen content still lacking

Single pass CDEF

- Original CDEF design had a directional filter (Daala dering), then a cross filter (Thor CLPF) applied on top
  - This gave some hw concerns over line buffer requirements
- The two passes can be combined into one:
  - Primary taps (corresponding to the original directional filter)
  - Secondary taps (directional CLPF, 45 degree offset)
- So CDEF becomes a single directional filter, but with the ability to specify the filter strength along the direction and 45 degrees off the direction separately
- No luma BDR impact, slight chroma BDR gain

Primary and secondary taps

index=0:

				$\frac{3}{16}$
			$\frac{4}{16}$	
		x		
	$\frac{4}{16}$			
$\frac{3}{16}$				

index=1:

				$\frac{3}{16}$
	$\frac{4}{16}$	x	$\frac{4}{16}$	
$\frac{3}{16}$				

index=2:

$\frac{3}{16}$	$\frac{4}{16}$	x	$\frac{4}{16}$	$\frac{3}{16}$

index=3:

$\frac{3}{16}$				
	$\frac{4}{16}$	x	$\frac{4}{16}$	
				$\frac{3}{16}$

index=4:

$\frac{3}{16}$				
	$\frac{4}{16}$			
		x		
			$\frac{4}{16}$	
				$\frac{3}{16}$

index=5:

	$\frac{3}{16}$			
		$\frac{4}{16}$		
		x		
		$\frac{4}{16}$		
			$\frac{3}{16}$	

index=6:

		$\frac{3}{16}$		
		$\frac{4}{16}$		
		x		
		$\frac{4}{16}$		
		$\frac{3}{16}$		

index=7:

			$\frac{3}{16}$	
		$\frac{4}{16}$		
		x		
		$\frac{4}{16}$		
	$\frac{3}{16}$			

index=0, 4:

		$\frac{1}{16}$		
		$\frac{2}{16}$		
$\frac{1}{16}$	$\frac{2}{16}$	x	$\frac{2}{16}$	$\frac{1}{16}$
		$\frac{2}{16}$		
		$\frac{1}{16}$		

index=1, 5:

			$\frac{1}{16}$	
$\frac{1}{16}$		$\frac{2}{16}$		
	$\frac{2}{16}$	x	$\frac{2}{16}$	
		$\frac{2}{16}$		$\frac{1}{16}$
	$\frac{1}{16}$			

index=2, 6:

$\frac{1}{16}$				$\frac{1}{16}$
	$\frac{2}{16}$		$\frac{2}{16}$	
		x		
	$\frac{2}{16}$		$\frac{2}{16}$	
$\frac{1}{16}$				$\frac{1}{16}$

index=3, 7:

	$\frac{1}{16}$			
		$\frac{2}{16}$		$\frac{1}{16}$
	$\frac{2}{16}$	x	$\frac{2}{16}$	
$\frac{1}{16}$		$\frac{2}{16}$		
			$\frac{1}{16}$	

Single pass CDEF

AWCY results for AV1, 2017-07-06 (objective-1-fast)

Gains for going from 2-pass to fully directional 1-pass

- Low latency, cpu-used=0:

PSNR	PSNR Cb	PSNR Cr	PSNR HVS	SSIM	MS SSIM	CIEDE 2000
-0.2007	-0.4025	N/A	-0.0952	-0.2461	-0.1490	-0.4277

- High latency, cpu-used=0:

PSNR	PSNR Cb	PSNR Cr	PSNR HVS	SSIM	MS SSIM	CIEDE 2000
-0.1493	-0.5564	-0.1960	-0.0799	-0.2039	-0.0849	-0.4267

- Low latency, cpu-used=4:

PSNR	PSNR Cb	PSNR Cr	PSNR HVS	SSIM	MS SSIM	CIEDE 2000
-0.2937	-0.7250	-0.5186	-0.2046	-0.3201	-0.2195	-0.6042

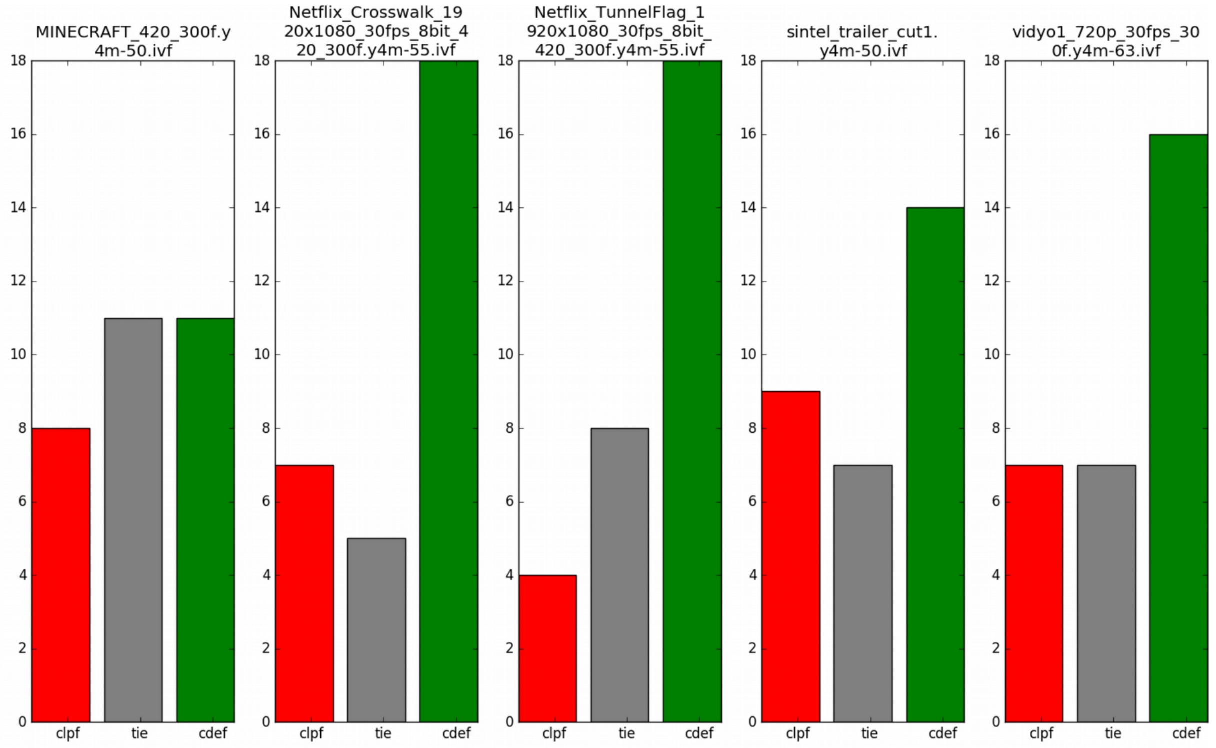
- High latency, cpu-used=4:

PSNR	PSNR Cb	PSNR Cr	PSNR HVS	SSIM	MS SSIM	CIEDE 2000
-0.1575	-0.5135	-0.8489	-0.0942	-0.2632	-0.1418	-0.3871

CLPF vs CDEF subjective test

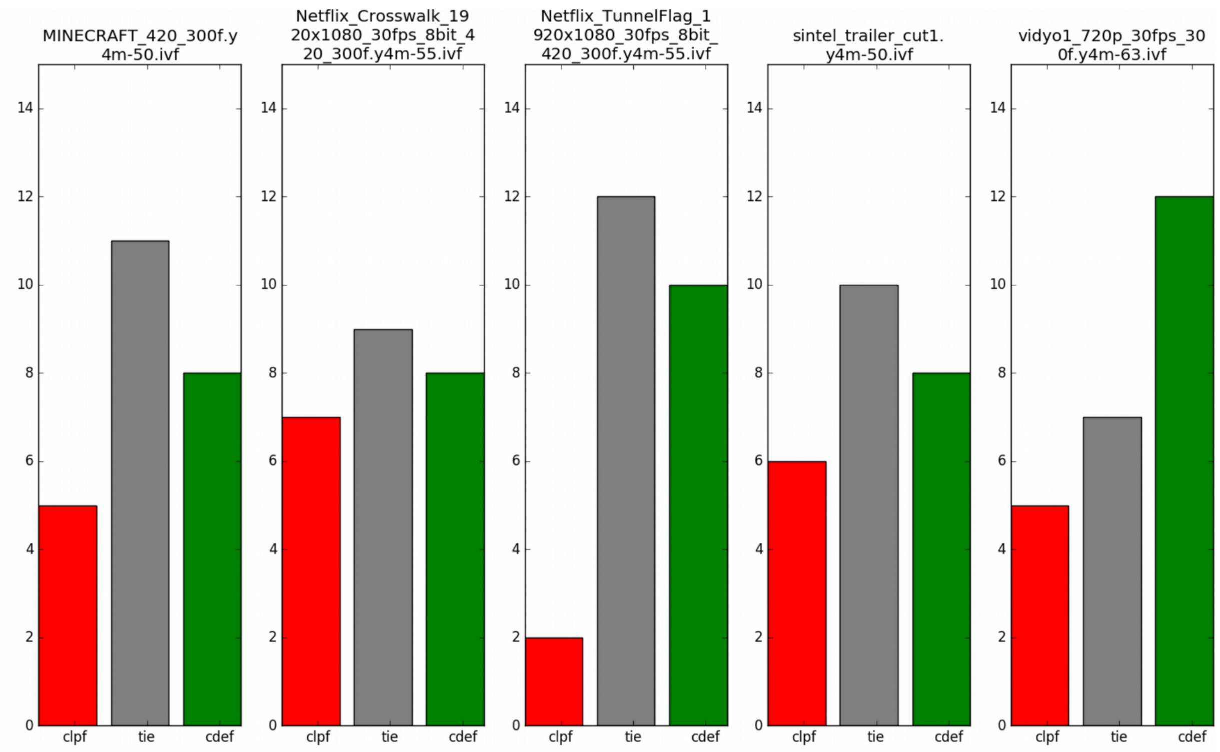
- AWCY test framework used (Thomas Daede)
- CDEF and CLPF were compared in AV1
- In the low latency case there was a significant preference for CDEF on two out of five videos
- No significant preference for high delay
- Yet, CDEF got more votes than CLPF for every sequence both in low delay and high delay.
- So, for some sequences CDEF wins, and for the rest there is no clear subjective advantage, but objective scores for CDEF are slightly better.

Raw low latency results



Video		clpf	Tie	cdef	Total	P-val
subjective-wip/MINECRAFT_420_300f.y4m-50	:	8	11	11	30	0.58466
subjective-wip/Netflix_Crosswalk_1920x10	:	7	5	18	30	0.04277
subjective-wip/Netflix_TunnelFlag_1920x1	:	4	8	18	30	0.01612
subjective-wip/sintel_trailer_cut1.y4m-5	:	9	7	14	30	0.36159
subjective-wip/vidyo1_720p_30fps_300f.y4	:	7	7	16	30	0.09874

Raw high latency results

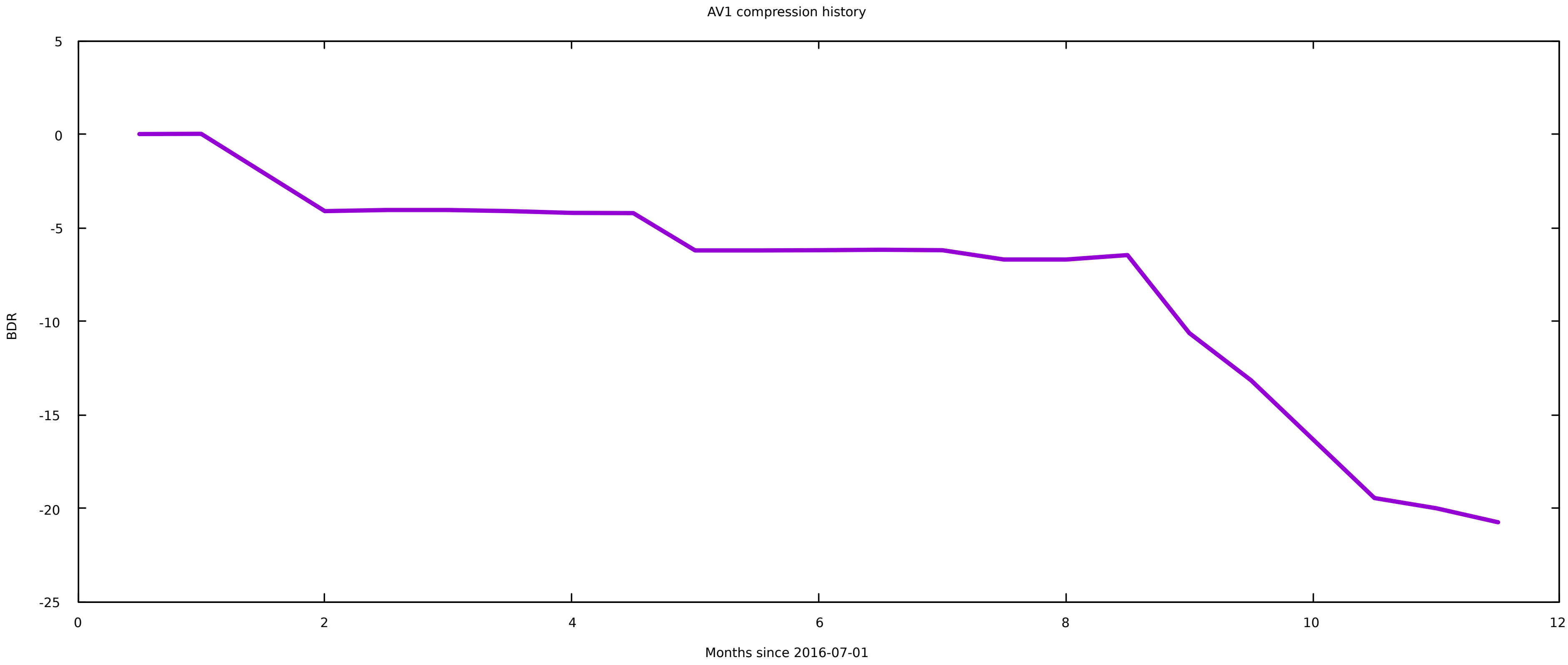


Video		clpf	Tie	cdef	Total	P-val
subjective-wip/MINECRAFT_420_300f.y4m-50	:	5	11	8	24	0.54126
subjective-wip/Netflix_Crosswalk_1920x10	:	7	9	8	24	0.83882
subjective-wip/Netflix_TunnelFlag_1920x1	:	2	12	10	24	0.15159
subjective-wip/sintel_trailer_cut1.y4m-5	:	6	10	8	24	0.83882
subjective-wip/vidyo1_720p_30fps_300f.y4	:	5	7	12	24	0.15159

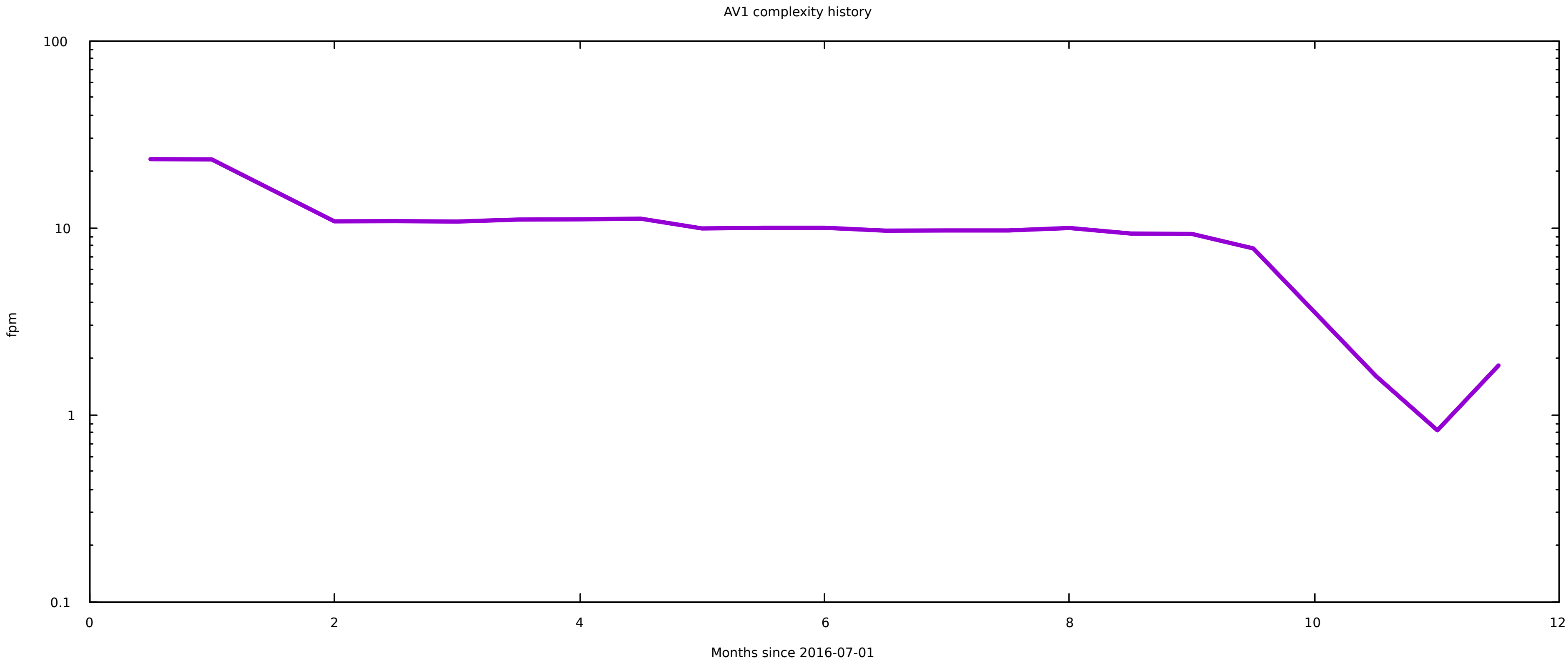
Objective codec comparisons

- Compression/speed relationships measured using AWCY
  - Mixed content: objective-1-fast
  - Videoconferencing content: 720p subset of objective-1-fast
- AV1 compression has significantly improved since IETF98 (for both low and high latency), but the complexity has also increased
- Low delay configuration. VP9 & AV1 run in both error resilient and non-resilient modes. Thor is always resilient.
- BDR anchor is Thor high complexity, low latency

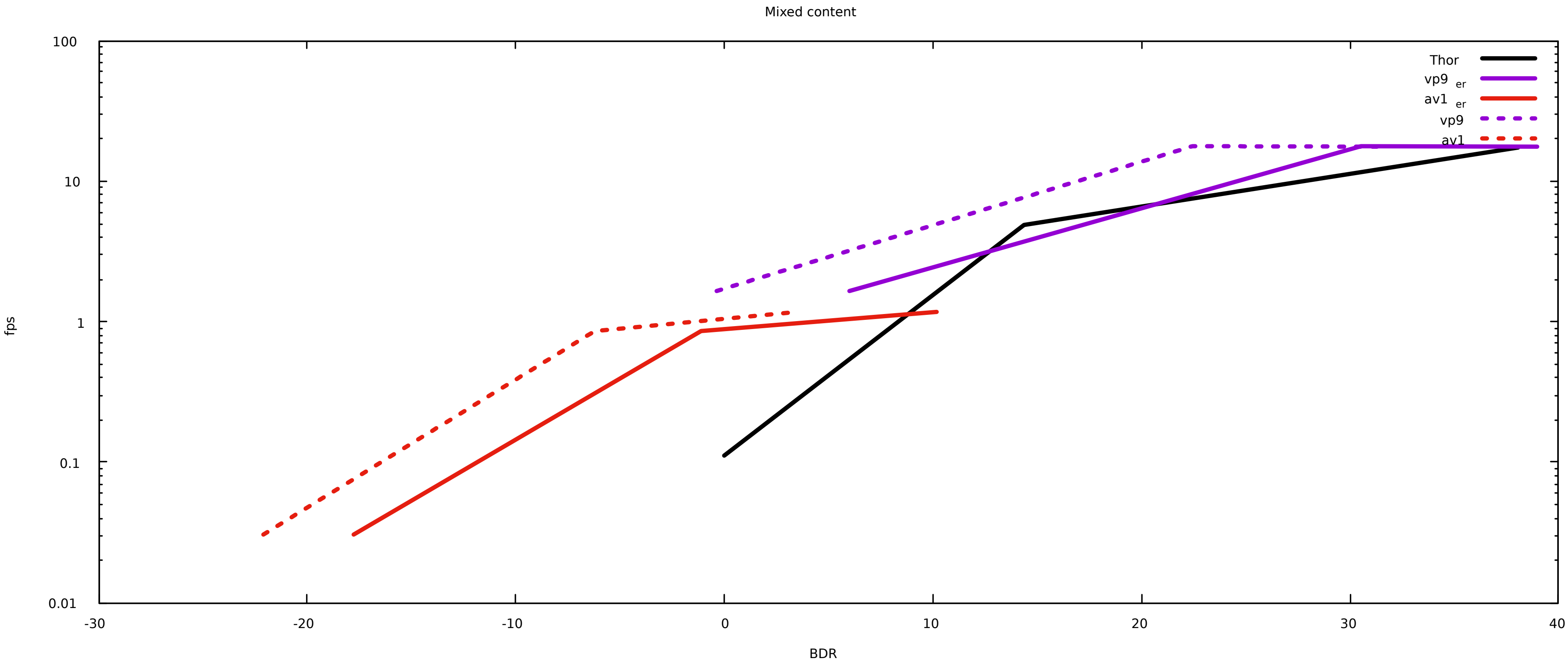
AV1 compression history



AV1 complexity history



Codec comparisons (AWCY)



Codec comparisons (AWCY)