

Companion to article 4.10 of Block 4. Print on A4.

1. Entropy coder per codec

Codec	Coder	Alphabet	Contexts	Adaptation	Saving vs prior
MPEG-2 (1995)	Static Huffman	per-symbol VLC	none	none	baseline
H.264 Baseline	CAVLC	per-symbol VLC	5 tables	table choice	~5% over MPEG-2
H.264 High	CABAC	binary bins	~460	64-state per-slice	~10-15% over CAVLC
HEVC (2013)	CABAC only	binary bins	~500	64-state per-slice	~6-8% over H.264 CABAC
AV1 (2018)	Range coder	up to 16/symbol	~1000	per-symbol	~3-5% over HEVC
VVC (2020)	CABAC	binary bins	~700	multi-rate	~2% over HEVC

2. CAVLC vs CABAC at a glance

CAVLC - five short steps: coeff_token, trailing-ones signs, levels, total_zeros, run_before.

- Whole-bit codewords, table choice depends on what was just coded.
- Cheap to parse: a few cycles per coefficient block. Parallelises well.

CABAC - three stages: binarisation, context modelling, binary arithmetic coding.

- Fractional bits per symbol; within 1% of the entropy limit.
- Serial throughput: one bin per 10-20 cycles; main bottleneck in 4K hardware decoders.

3. AV1 range coder - what changed after CABAC

Coder borrowed from Daala (Mozilla/xiph), arxiv.org/abs/1608.01947.

Multi-symbol: up to 16 alphabet values coded in one engine call (no binarisation).

Per-symbol probability adaptation - the table updates after every coded symbol.

Multiple frame_context_idx tables in memory; pick one per frame to track scene shifts.

Equivalent to ~4 binary bins per call. Hardware: fewer cycles per pixel than CABAC.

Trade-off: more on-chip memory for context tables. Slower hardware AV1 rollout.

4. VVC - the small but real CABAC tweaks

Multi-rate probability estimator - two parallel rate tracks per context.

Estimator weights adapted to the current QP; tighter probability tracking at high bitrate.

Context modelling for transform coefficients coupled to dependent quantization state.

Net entropy-stage saving over HEVC: roughly 2% bitrate at the same quality.

5. Live-stream debugging quick reference

Blocky garbage from random tune-in point to slice end (HEVC): CABAC re-init missing at slice.

First few frames after seek decode wrong (H.264 High): cabac_init_idc not honoured.

AV1 stream OK in dav1d, broken in software X: frame_context_idx tables not all implemented.

Slow decode under VVC at low QP: dependent-Q forces sequential context updates.

Encoder reports 5% larger files than spec budget: check that High profile (CABAC) is on, not Baseline.