Neural Video Compression with Context Modulation

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1. Contributions

1. Proposing **context modulation** in the conditional coding-based framework to generate high-quality temporal context exploiting the reference information in both pixel and feature domain.
2. Proposing **flow orientation** to mine inter-frame correlation between the reference frame and prediction frame.
3. Proposing **context compensation** to modulate the propagated temporal context with oriented context.
4. **SOTA compression performance** compared with both H.266/VVC (**22.7%**) and previous SOTA neural video codec DCVC-FM (**10.1%**).

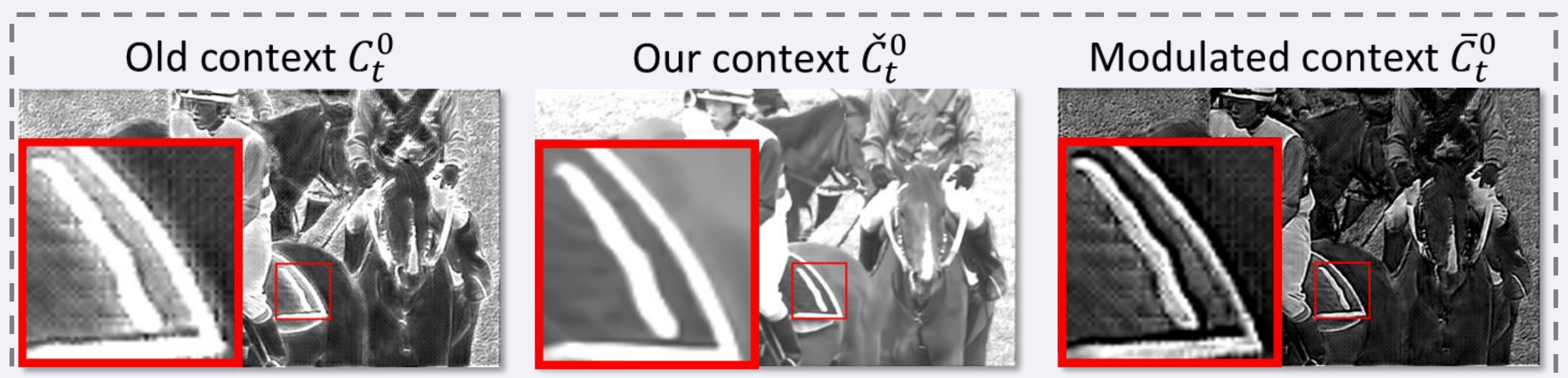
2. Motivation and Analysis

I. Motivation

1. Previous conditional coding-based neural video codecs (NVCs) adopted the inherent reference propagation structure mechanism in temporal context generation with input of propagated adjacent reference feature F_{t-1} and reconstructed MV $\hat{v}_t$.
2. DCVC-FM has mitigated the error propagation in NVCs by manually switching the input of context generation from the propagated reference feature F_{t-1} to reference frame $\hat{x}_{t-1}$.

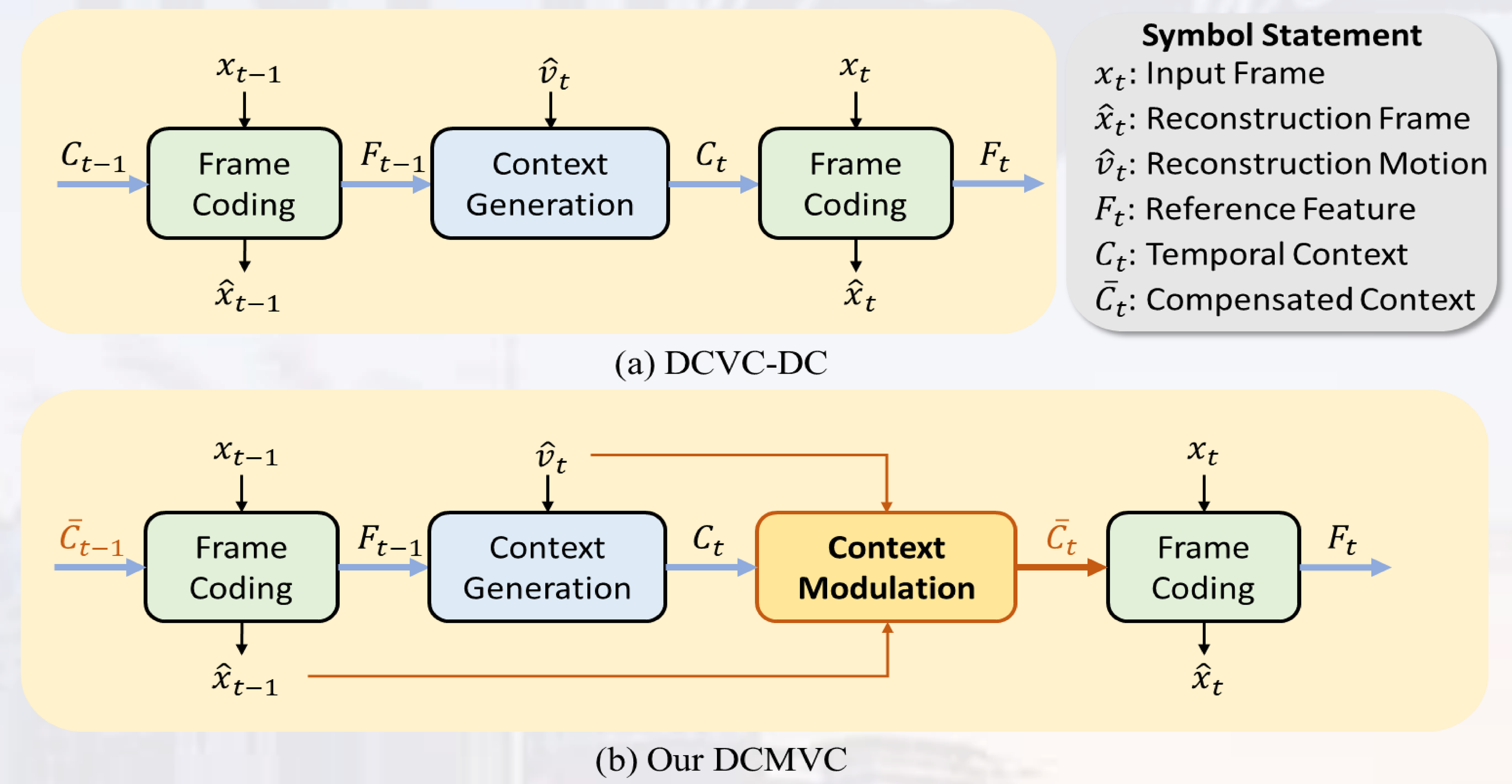
II. Analysis

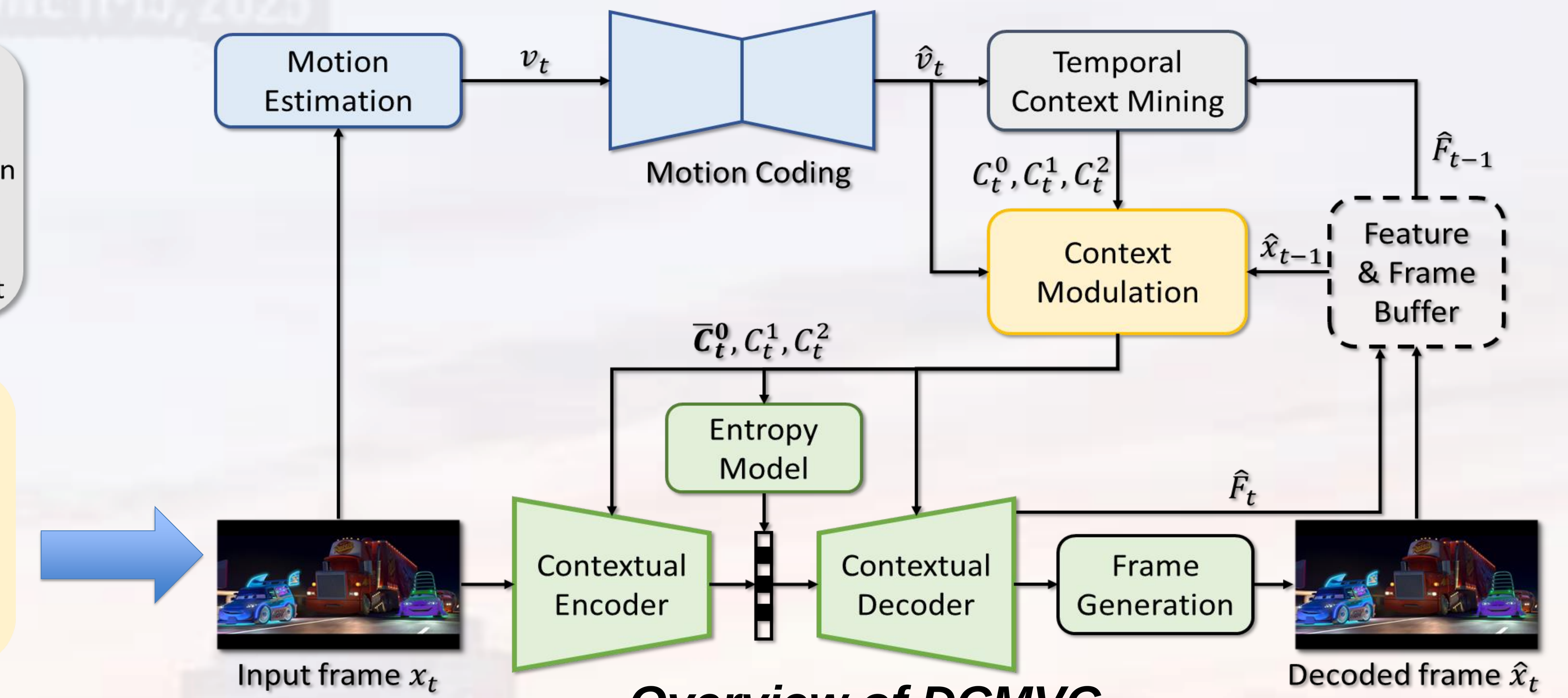
1. **Reference frame** $\hat{x}_{t-1}$, constrained by the distortion loss in the rate-distortion (RD) loss function, though contains less information than propagated reference feature F_{t-1}, yet conveys less irrelevant information in the prediction chain.
2. Further exploiting the potential of reference frame $\hat{x}_{t-1}$ in context generation can enhance the reference mechanism, enabling better temporal context modeling.



Visualization of Different temporal contexts

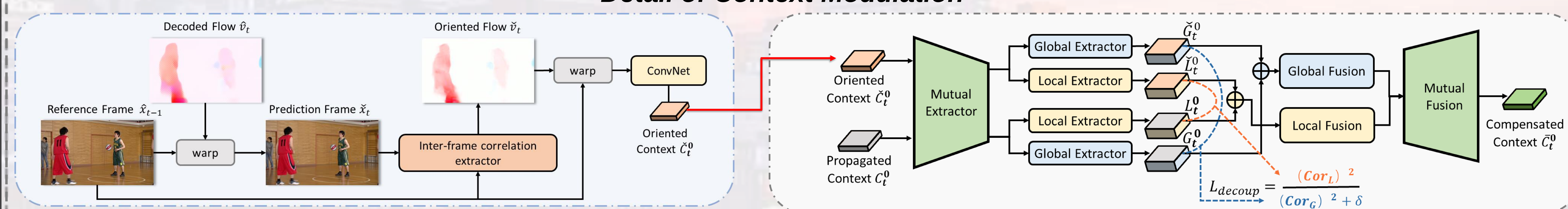
3. Framework (*Proposed DCMVC*)





Overview of DCMVC

Detail of Context Modulation



Flow Orientation ***Context Compensation***

4. Experiment Results of *Proposed DCMVC*

Comparison with SOTA Methods (BD-Rate(%) for RGB-PSNR)

IP32

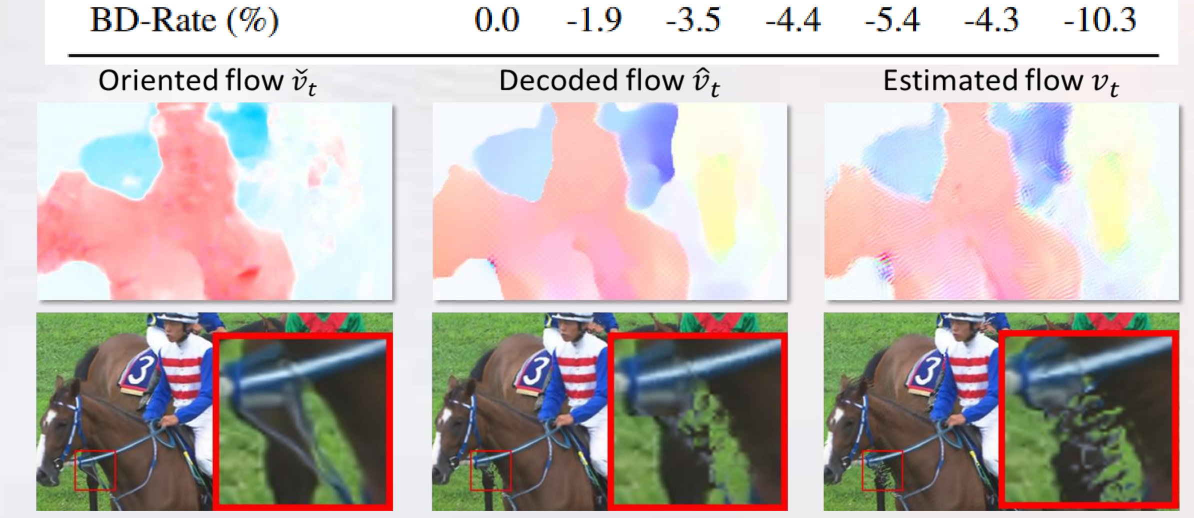
	UVG	MCL-JCV	HEVC B	HEVC C	HEVC D	HEVC E	USTC-TD	Average
VTM	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0.0
DCVC [25]	133.9	106.6	119.6	152.5	110.9	274.8	139.6	148.3
DCVC-TCM [47]	23.1	38.2	32.8	62.1	29.0	75.8	75.3	48.0
DCVC-HEM [26]	–17.2	–1.6	–0.7	16.1	–7.1	20.7	20.6	4.4
SDD [48]	–19.7	–7.1	–13.7	–2.3	–24.9	–8.4	7.7	–9.8
DCVC-DC [27]	–25.9	–14.4	–13.9	–8.8	–27.7	–19.1	10.8	–14.1
DCVC-FM [28]	–20.4	–8.1	–10.3	–8.4	–25.8	–21.9	25.4	–9.9
Our DCMVC	**–30.6**	**–17.3**	**–14.5**	**–14.4**	**–31.6**	**–28.1**	0.4	**–19.4**

IP-1

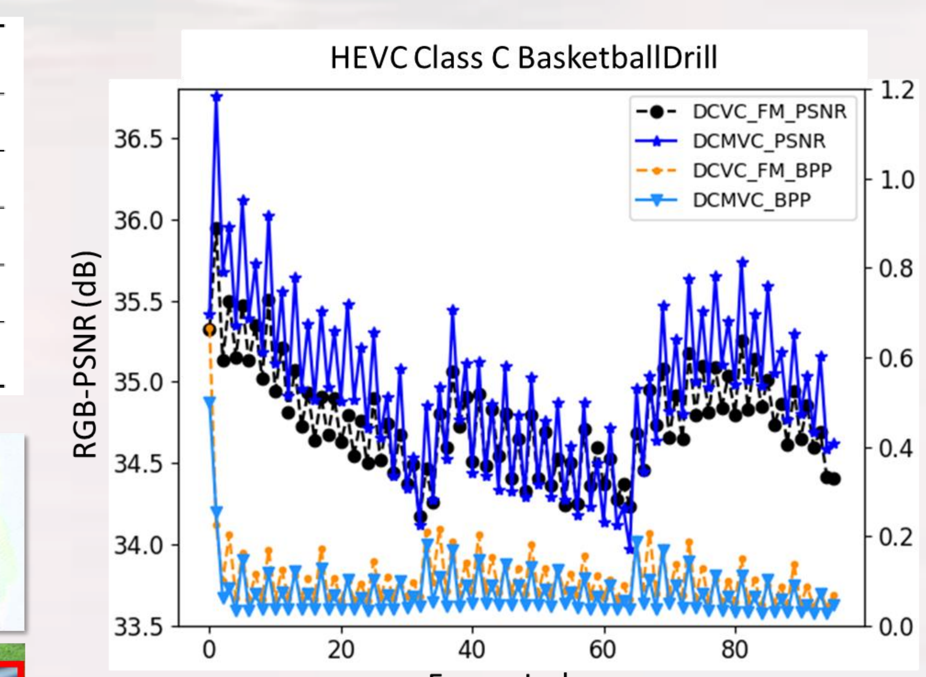
	UVG	MCL-JCV	HEVC B	HEVC C	HEVC D	HEVC E	USTC-TD	Average
VTM	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0.0
DCVC [25]	259.5	160.0	212.2	254.8	180.6	858.4	168.2	276.2
DCVC-TCM [47]	61.6	55.5	61.7	99.6	50.4	213.9	90.2	90.4
DCVC-HEM [26]	1.2	4.9	10.0	30.0	-1.1	68.6	27.2	20.1
SDD [48]	–5.5	–0.3	–2.2	16.9	–18.2	46.4	12.3	7.1
DCVC-DC [27]	–21.2	–13.0	–10.8	–0.1	–24.2	–7.7	11.9	–9.3
DCVC-FM [28]	–24.3	–12.5	–11.7	–8.2	–28.5	–26.6	23.9	–12.6
Our DCMVC	**–35.6**	**–22.8**	**–16.8**	**–14.8**	**–34.6**	**–36.5**	1.9	**-22.7**

Ablation Study

	M_a	M_b	M_c	M_d	M_e	M_f	M_g
Flow orientation		✓		✓	✓		✓
Context compensation			✓	✓	✓		✓
Decoupling loss					✓		✓
Long-sequence training						✓	✓
BD-Rate (%)	0.0	-1.9	-3.5	-4.4	-5.4	-4.3	-10.3



Visualization of Different flows



Quality and bitrate cost comparison