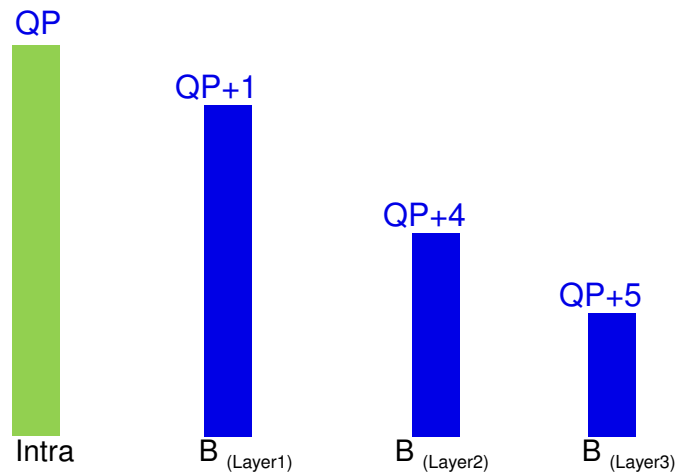


Reference Lists for B Pictures under Low Delay Constraints

*Chong Soon Lim
Sue Mon Thet Naing
Viktor Wahadaniah
Xuan Jing*

Panasonic Corporation

- JCTVC-A204 reports that Call for Proposals (CfP) beta anchor performed subjectively better than the gamma anchor for most cases in low delay constraints
- This contribution evaluates the effect of picture QP fluctuation and investigates further coding efficiency improvements introduced by different constructions of B-picture reference picture lists in low delay constraints
- HM 0.9 supports QP fluctuation for low delay condition by setting $\text{RateGOPSize} = 4$
 - QP Scaling



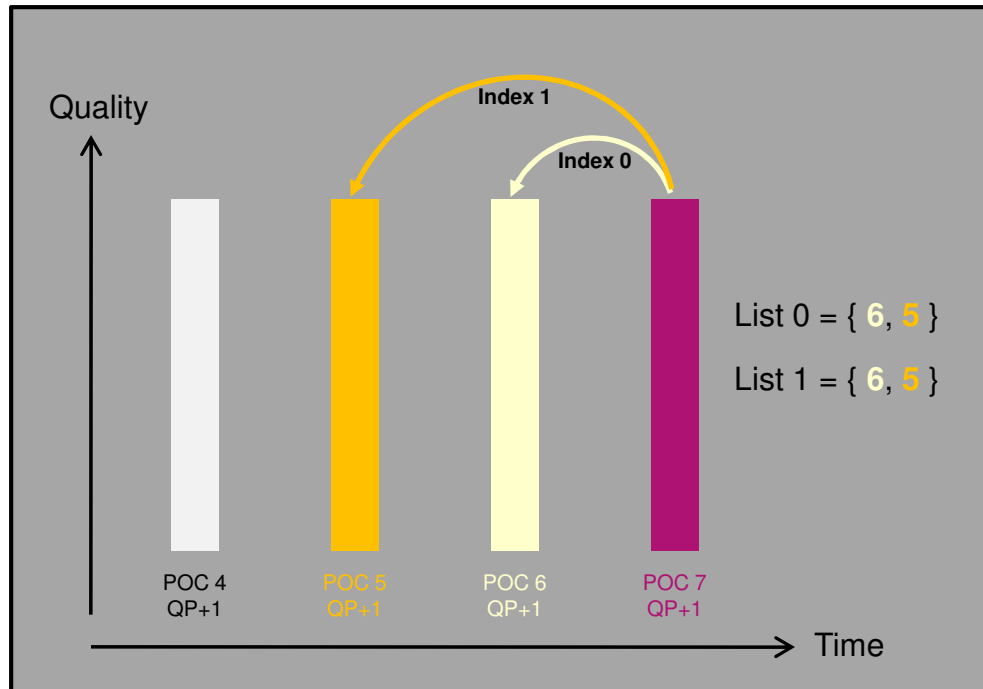
Summary of Different Reference Lists

	QP Assignment	List 0 Ref Picture	List 1 Ref Picture	No. Ref Index	Reference Lists
Case 1	No QP fluctuation (RateGOPSize = 1)	Nearest	Nearest	2 reference indexes (Default)	
Case 2	QP fluctuation (RateGOPSize = 4)	High Quality	High Quality	1 reference index (Default)	
Case 3	QP fluctuation (RateGOPSize = 4)	Nearest	Nearest	Same as Case 2	
Case 4	QP fluctuation (RateGOPSize = 4)	High Quality	Nearest	Same as Case 2	
Case 5	QP fluctuation (RateGOPSize = 4)	High Quality	High Quality	2 reference indexes (Same as Case 1)	
Case 6	QP fluctuation (RateGOPSize = 4)	Nearest	Nearest	2 reference indexes (Same as Case 1)	

Reference Lists Construction in HM

Case 1: No QP Fluctuation (RateGOPSize = 1) (Default)

- Same QP used for all B pictures
- Uses 2 nearest reference pictures for both List 0 and List 1



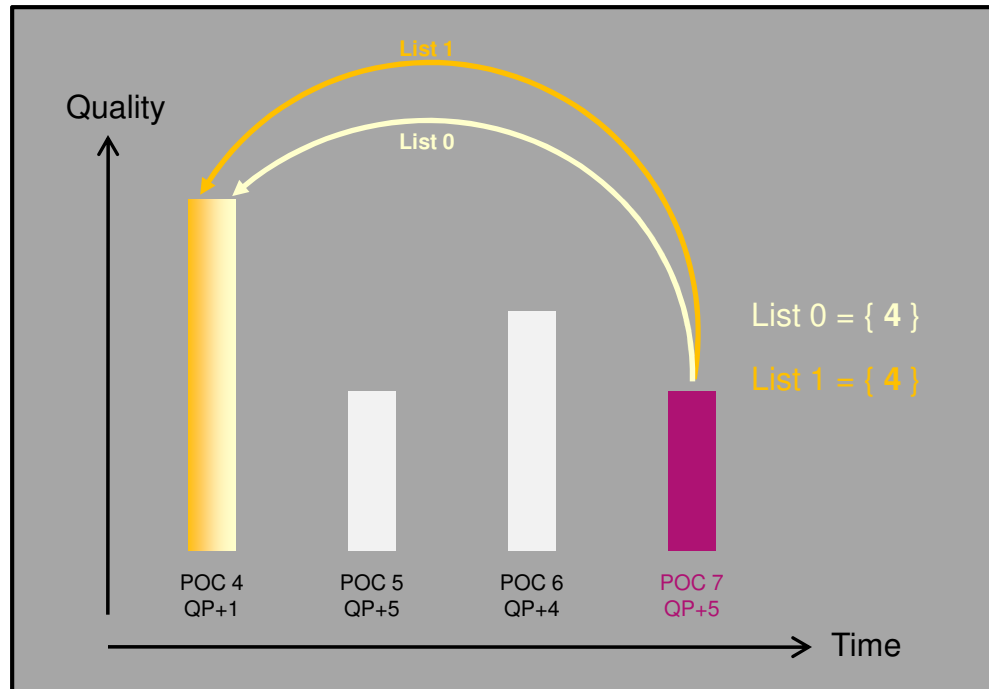
RateGOPSize = 4
Reference Lists Setting

POC 0	[L0]	[L1]
POC 1	[L0 0]	[L1 0]
POC 2	[L0 1 0]	[L1 1 0]
POC 3	[L0 2 1]	[L1 2 1]
POC 4	[L0 3 2]	[L1 3 2]
POC 5	[L0 4 3]	[L1 4 3]
POC 6	[L0 5 4]	[L1 5 4]
POC 7	[L0 6 5]	[L1 6 5]
POC 8	[L0 7 6]	[L1 7 6]
POC 9	[L0 8 7]	[L1 8 7]

Reference Lists Construction in HM

Case 2: Low delay default reference lists (RateGOPSize=4)

- QP fluctuation
- Higher quality pictures as reference pictures for both list 0 and list 1



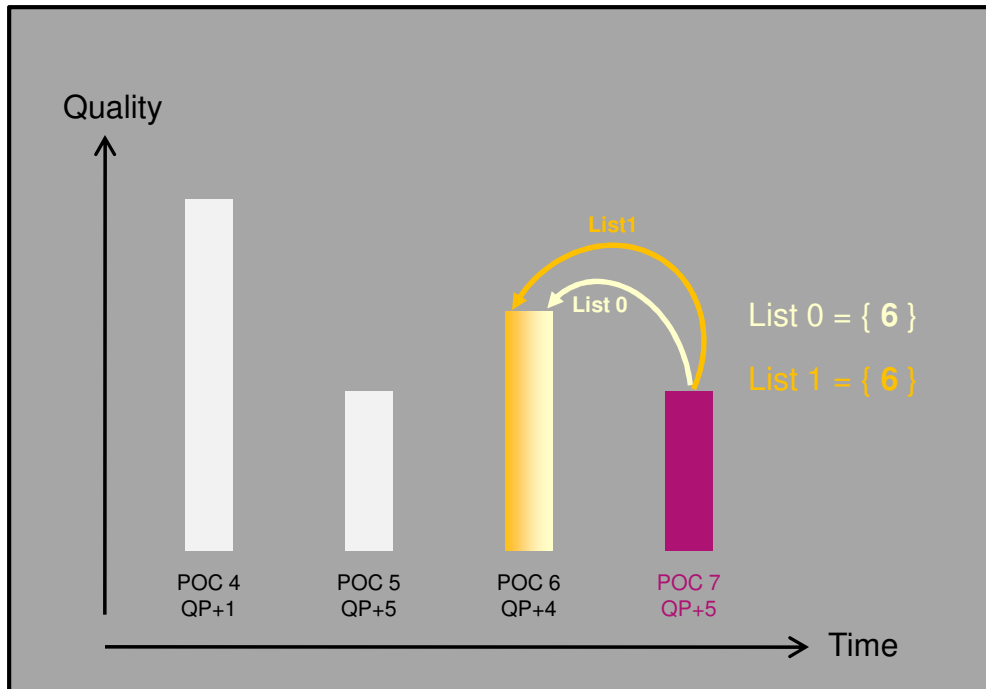
RateGOPSize = 4
Reference Lists Setting

POC 0	[L0] [L1]
POC 1	[L0 0] [L1 0]
POC 2	[L0 0] [L1 0]
POC 3	[L0 0] [L1 0]
POC 4	[L0 0] [L1 0]
POC 5	[L0 4 0] [L1 4 0]
POC 6	[L0 4] [L1 4]
POC 7	[L0 4] [L1 4]
POC 8	[L0 4] [L1 4]
POC 9	[L0 8 4] [L1 8 4]

Reference Lists Construction in HM

Case 3: Nearest POC reference picture lists

- RateGOPSize = 4
- Nearest pictures as reference pictures for both list 0 and list 1
- Same number of reference indexes as case 2



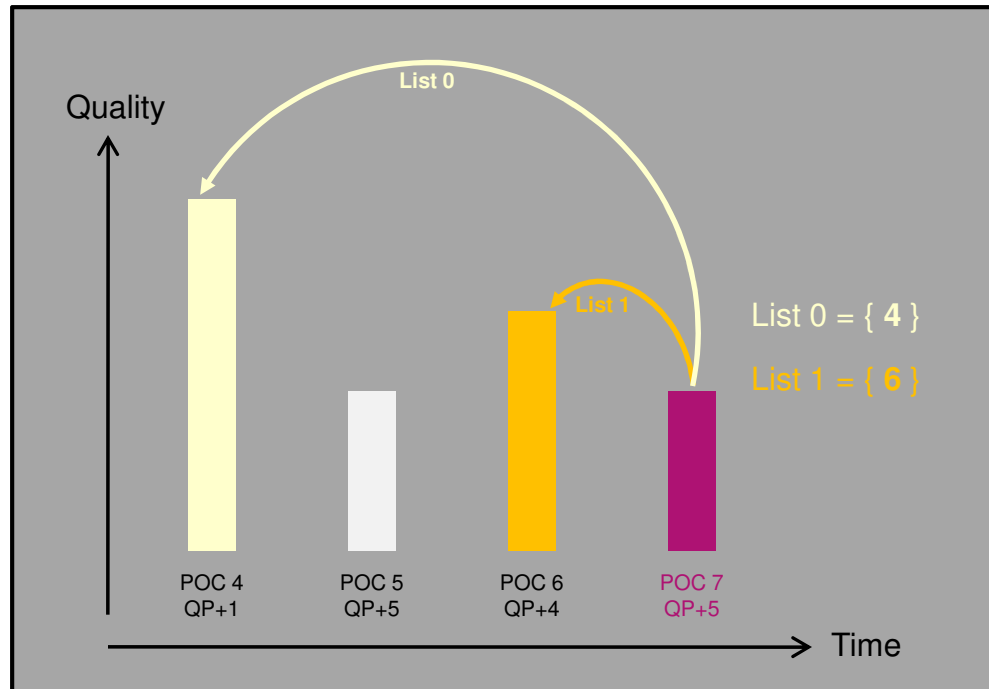
RateGOPSize = 4
Reference Lists Setting

POC 0	[L0]	[L1]
POC 1	[L0 0]	[L1 0]
POC 2	[L0 1]	[L1 1]
POC 3	[L0 2]	[L1 2]
POC 4	[L0 3]	[L1 3]
POC 5	[L0 4 3]	[L1 4 3]
POC 6	[L0 5]	[L1 5]
POC 7	[L0 6]	[L1 6]
POC 8	[L0 7]	[L1 7]
POC 9	[L0 8 7]	[L1 8 7]

Reference Lists Construction in HM

Case 4: Proposed reference picture lists

- RateGOPSize = 4
- Higher quality picture as reference picture for list 0 and
- Nearest picture as reference picture for list 1
- Same number of reference indexes as case 2 and 3



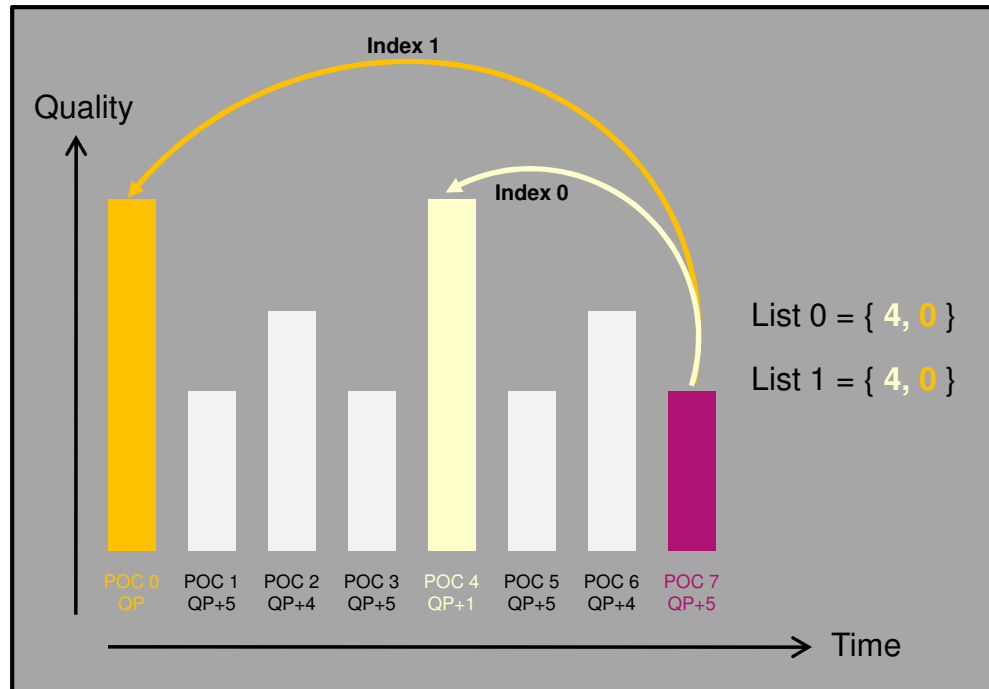
RateGOPSize = 1
Reference Lists Setting

POC 0	[L0] [L1]
POC 1	[L0 0] [L1 0]
POC 2	[L0 0] [L1 1]
POC 3	[L0 0] [L1 2]
POC 4	[L0 0] [L1 3]
POC 5	[L0 4 3] [L1 4 3]
POC 6	[L0 4] [L1 5]
POC 7	[L0 4] [L1 6]
POC 8	[L0 4] [L1 7]
POC 9	[L0 8 7] [L1 8 7]

Reference Lists Construction in HM

Case 5: Default reference picture lists with 2 reference pictures

- RateGOPSize = 4
- 2 Higher quality pictures as reference pictures for each list 0 and list 1



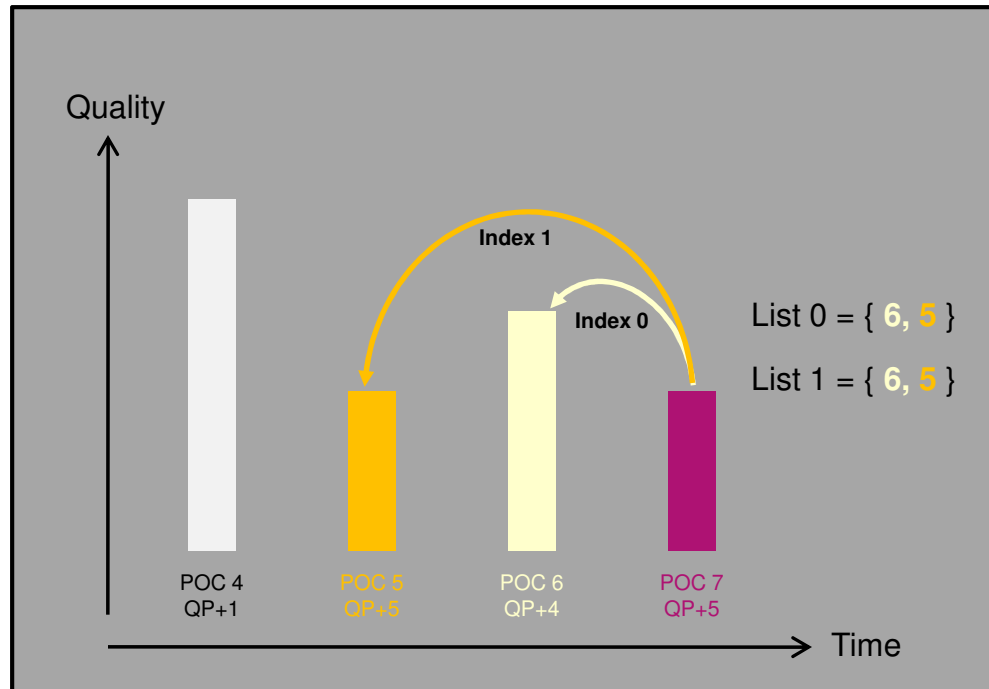
RateGOPSize = 4
Reference Lists Setting

POC 0	[L0] [L1]
POC 1	[L0 0] [L1 0]
POC 2	[L0 0] [L1 0]
POC 3	[L0 0] [L1 0]
POC 4	[L0 0] [L1 0]
POC 5	[L0 4 0] [L1 4 0]
POC 6	[L0 4 0] [L1 4 0]
POC 7	[L0 4 0] [L1 4 0]
POC 8	[L0 4 0] [L1 4 0]
POC 9	[L0 8 4] [L1 8 4]

Reference Lists Construction in HM

Case 6: Nearest POC reference picture lists with 2 reference pictures

- RateGOPSize = 4
- 2 Nearest pictures as reference pictures for each list 0 and list 1



RateGOPSize = 4
Reference Lists Setting

POC 0	[L0]	[L1]
POC 1	[L0 0]	[L1 0]
POC 2	[L0 1 0]	[L1 1 0]
POC 3	[L0 2 1]	[L1 2 1]
POC 4	[L0 3 2]	[L1 3 2]
POC 5	[L0 4 3]	[L1 4 3]
POC 6	[L0 5 4]	[L1 5 4]
POC 7	[L0 6 5]	[L1 6 5]
POC 8	[L0 7 6]	[L1 7 6]
POC 9	[L0 8 7]	[L1 8 7]

Experimental Details

Experiments were conducted using 0.9-hm low delay setting:

Case 1: Anchor: 0.9-hm low delay setting

- RateGOPSize = 1
- Nearest pictures as reference pictures for each list 0 and list 1
- 2 reference indexes for each list

Case 2: Low delay setting default reference lists (QP fluctuation)

- RateGOPSize = 4
- Higher quality pictures as reference pictures for both list 0 and list 1
- Default number of reference indexes

Case 3: Nearest POC reference picture lists

- RateGOPSize = 4
- Nearest pictures as reference pictures for both list 0 and list 1
- Same number of reference indexes as case 2

Case 4: Proposed reference picture lists

- RateGOPSize = 4
- Higher quality picture as reference picture for list 0 and
- Nearest picture as reference picture for list 1
- Same number of reference indexes as case 2 and 3

Case 5: Default reference picture lists with 2 reference pictures

- RateGOPSize = 4
- Same reference pictures list as case 2 (Higher quality pictures as reference pictures for each list 0 and list 1)
- 2 reference indexes for each list

Case 6: Nearest POC reference picture lists with 2 reference pictures

- RateGOPSize = 4
- Same reference pictures list as case 3 (Nearest pictures as reference pictures for each list 0 and list 1)
- 2 reference indexes for each list

Default number of reference indexes :

POC 0	[L0]	[L1]
POC 1	[L0 x]	[L1 x]
POC 2	[L0 x]	[L1 x]
POC 3	[L0 x]	[L1 x]
POC 4	[L0 x]	[L1 x]
POC 5	[L0 x x]	[L1 x x]
POC 6	[L0 x]	[L1 x]
POC 7	[L0 x]	[L1 x]
POC 8	[L0 x]	[L1 x]
POC 9	[L0 x x]	[L1 x x]

Experimental Results

High Efficiency :

High Efficiency Low Delay	Case 2: RateGOPSize=4 (Default) (H-quality Frame)			Case 3: RateGOPSize=4 (Nearest POC)			Case 4: RateGOPSize=4 (Proposed)			Case 5: RateGOPSize=4 (H-quality 2 Ref Frames)			Case 6: RateGOPSize=4 (Nearest POC 2 Ref Frames)		
	Y	U	V	Y	U	V	Y	U	V	Y	U	V	Y	U	V
Class B	5.3%	-23.1%	-24.6%	-2.7%	-26.0%	-25.4%	-7.2%	-30.6%	-31.0%	0.3%	-26.0%	-27.3%	-6.0%	-28.8%	-28.6%
Class C	2.6%	-17.6%	-17.1%	-5.0%	-21.9%	-21.0%	-10.9%	-26.8%	-26.1%	-2.0%	-20.9%	-20.8%	-8.7%	-24.9%	-24.1%
Class D	-2.6%	-23.8%	-21.2%	-1.2%	-21.5%	-19.2%	-12.5%	-30.9%	-28.6%	-6.5%	-26.3%	-23.8%	-8.2%	-27.3%	-24.4%
Class E	-5.1%	-26.8%	-27.9%	-9.2%	-25.0%	-23.6%	-15.6%	-33.4%	-33.3%	-7.4%	-29.3%	-30.0%	-12.3%	-29.4%	-28.1%
All	0.7%	-22.6%	-22.5%	-4.1%	-23.7%	-22.4%	-11.0%	-30.3%	-29.6%	-3.4%	-25.4%	-25.3%	-8.4%	-27.5%	-26.3%
Enc Time	74%			76%			86%			91%			95%		
Dec Time	100%			91%			88%			95%			94%		

Low Complexity:

Low Complexity Low Delay	Case 2: RateGOPSize=4 (Default) (H-quality Frame)			Case 3: RateGOPSize=4 (Nearest POC)			Case 4: RateGOPSize=4 (Proposed)			Case 5: RateGOPSize=4 (H-quality 2 Ref Frames)			Case 6: RateGOPSize=4 (Nearest POC 2 Ref Frames)		
	Y	U	V	Y	U	V	Y	U	V	Y	U	V	Y	U	V
Class B	4.4%	-20.3%	-21.3%	2.5%	-16.2%	-14.8%	-8.1%	-27.3%	-27.2%	-0.3%	-23.7%	-24.9%	-4.4%	-22.7%	-22.4%
Class C	3.5%	-18.1%	-16.7%	0.7%	-15.9%	-14.3%	-10.9%	-27.4%	-25.9%	-2.6%	-22.4%	-21.2%	-6.2%	-22.2%	-20.8%
Class D	-0.9%	-24.4%	-21.2%	6.9%	-13.9%	-11.0%	-12.7%	-31.8%	-28.8%	-6.9%	-28.1%	-25.2%	-5.8%	-24.7%	-21.7%
Class E	-5.7%	-18.2%	-16.7%	-6.1%	-16.5%	-14.9%	-16.2%	-25.9%	-24.9%	-9.0%	-20.1%	-19.3%	-11.9%	-22.6%	-21.3%
All	0.9%	-20.4%	-19.3%	1.5%	-15.6%	-13.8%	-11.5%	-28.2%	-26.8%	-4.2%	-23.8%	-23.0%	-6.6%	-23.1%	-21.6%
Enc Time	71%			73%			84%			101%			97%		
Dec Time	100%			83%			60%			64%			79%		

Experimental Results

**High Efficiency: Per Sequence BD-Rate gain
QP fluctuation (RateGOPSize=4) with different reference lists settings**

Sequence Name	BD-Rate Luma (High Efficiency)				
	Case 2: Default Ref List	Case 3: Nearest Ref List	Case 4: Proposed Ref List	Case 5: Default (2 Ref) Ref List	Case 6: Nearest (2 Ref) Ref List
Kimono	11.5%	-1.5%	-3.2%	10.9%	-2.5%
ParkScene	-6.4%	-9.8%	-14.4%	-8.5%	-11.8%
Cactus	6.5%	-3.3%	-8.2%	0.0%	-6.3%
BasketballDrive	14.7%	1.6%	-0.8%	13.1%	-1.1%
BQTerrace	0.0%	-0.6%	-9.6%	-13.9%	-8.1%
BasketballDrill	-0.2%	-10.8%	-15.0%	-7.0%	-13.7%
BQMall	4.6%	-6.1%	-9.6%	3.7%	-8.9%
PartyScene	-17.8%	-11.2%	-24.3%	-23.3%	-17.7%
RaceHorses	23.7%	8.2%	5.3%	18.7%	5.7%
BasketballPass	13.1%	-2.5%	-3.4%	12.0%	-3.6%
BQSquare	-27.8%	7.3%	-26.4%	-35.1%	-15.0%
BlowingBubbles	-13.6%	-12.6%	-20.4%	-17.9%	-15.4%
RaceHorses	17.9%	3.0%	0.2%	15.2%	1.1%
Vidyo1	-5.4%	-9.7%	-14.3%	-6.8%	-12.0%
Vidyo3	-3.6%	-7.1%	-15.6%	-5.7%	-10.2%
Vidyo4	-6.4%	-10.8%	-17.0%	-9.7%	-14.7%
Average (All Seq)	0.7%	-4.1%	-11.0%	-3.4%	-8.4%
Enc Time [%]	74%	76%	86%	91%	95%
Dec Time [%]	100%	91%	88%	95%	94%

Experimental Results

Low Complexity: Per Sequence BD-Rate gain
QP fluctuation (RateGOPSize=4) with different reference lists settings

Sequence Name	BD-Rate Luma (Low Complexity)				
	Case 2: Default Ref List	Case 3: Nearest Ref List	Case 4: Proposed Ref List	Case 5: Default (2 Ref) Ref List	Case 6: Nearest (2 Ref) Ref List
Kimono	14.4%	1.9%	-1.1%	13.4%	-0.4%
ParkScene	-6.6%	-4.7%	-15.3%	-9.3%	-10.3%
Cactus	7.5%	-1.0%	-7.9%	0.3%	-6.2%
BasketballDrive	15.5%	5.8%	-0.6%	13.5%	0.4%
BQTerrace	-8.8%	10.4%	-15.6%	-19.6%	-5.7%
BasketballDrill	0.3%	-7.8%	-15.6%	-7.1%	-13.0%
BQMall	3.8%	-1.9%	-10.5%	2.1%	-7.7%
PartyScene	-17.3%	-2.1%	-25.0%	-26.8%	-12.9%
RaceHorses	27.4%	14.5%	7.4%	21.3%	8.7%
BasketballPass	17.2%	0.9%	-1.4%	15.4%	-1.5%
BQSquare	-29.8%	25.6%	-31.0%	-42.0%	-12.5%
BlowingBubbles	-13.6%	-7.7%	-20.9%	-19.3%	-12.7%
RaceHorses	22.5%	9.0%	2.3%	18.4%	3.4%
Vidyo1	-6.1%	-6.1%	-15.1%	-8.3%	-11.3%
Vidyo3	-5.1%	-5.8%	-17.0%	-9.0%	-11.1%
Vidyo4	-6.0%	-6.6%	-16.6%	-9.8%	-13.2%
Average (All Seq)	0.9%	1.5%	-11.5%	-4.2%	-6.6%
Enc Time [%]	71%	73%	84%	101%	97%
Dec Time [%]	100%	83%	60%	64%	79%

- This contribution investigates the coding efficiency improvement of low delay setting by using RateGOPSize = 4 with different B-picture reference list construction schemes.
- Among all tested schemes, the best overall coding gain is achieved when reference list 0 is ordered based on quality and reference list 1 is ordered based on POC.
- As compared to current TMuC v0.9 anchor low delay setting, 11.0% average coding gain for high efficiency (max 26.4%), 11.5% average coding gain low complexity (max 31.0%) .
- We recommend JCT-VC to consider supporting the proposed reference list construction functionality in HM software when RateGOPSize is set to >1 under low delay constraints.

Questions?