

Pulse Code Modulation for HEVC (JCTVC-E057/ M19565)

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Summary

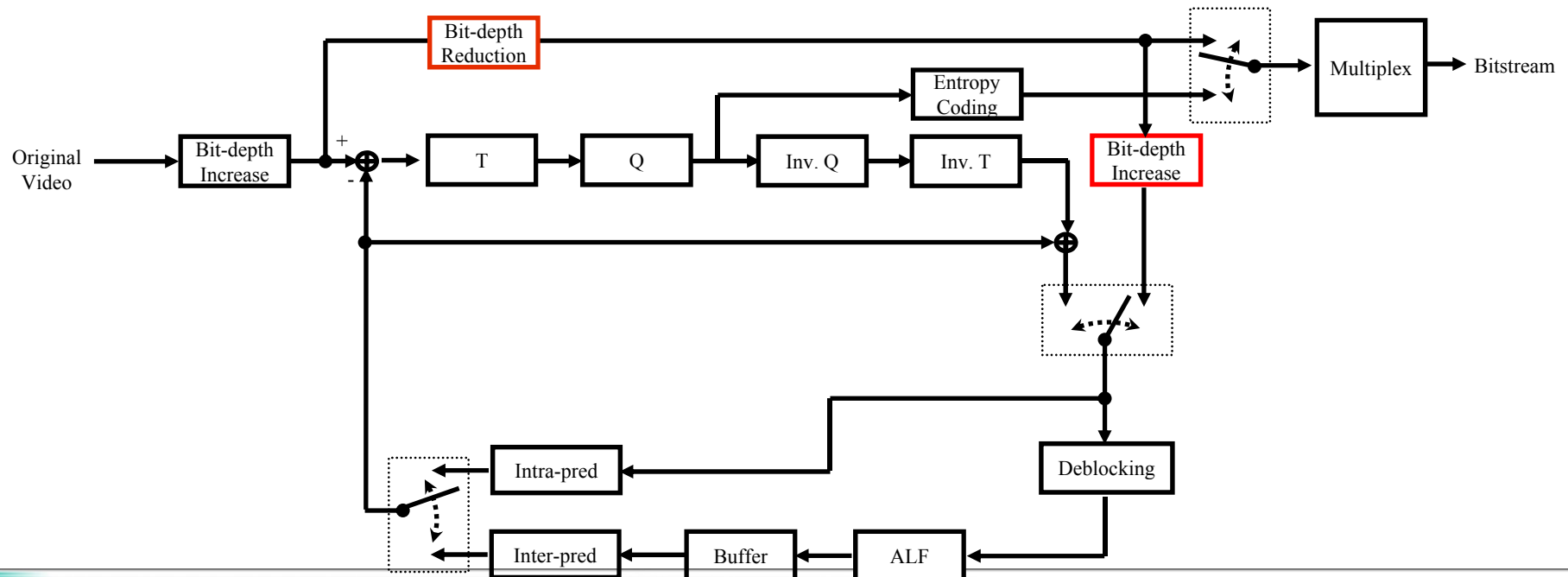
- PCM coding
- PCM integration in HM
- Simulation results
 - Intra: HE 0.00% and LC 0.08%
 - Random access: HE -0.01 % and LC 0.04%
 - Low delay: HE -0.04% and LC 0.02%
 - Significant decode time saving (up to 77%)
- Recommendations
 - Adopt I_PCM in HM ver.3

Pulse Code Modulation Coding

- Simple coding means: No prediction, no transform, and no entropy-coding
- Allow encoders to adjust the number of bits of CU to a predetermined value or less
- Used in H.264/MPEG-4 AVC as I_PCM
- HM2 does not have such a means; having the same means is desirable.

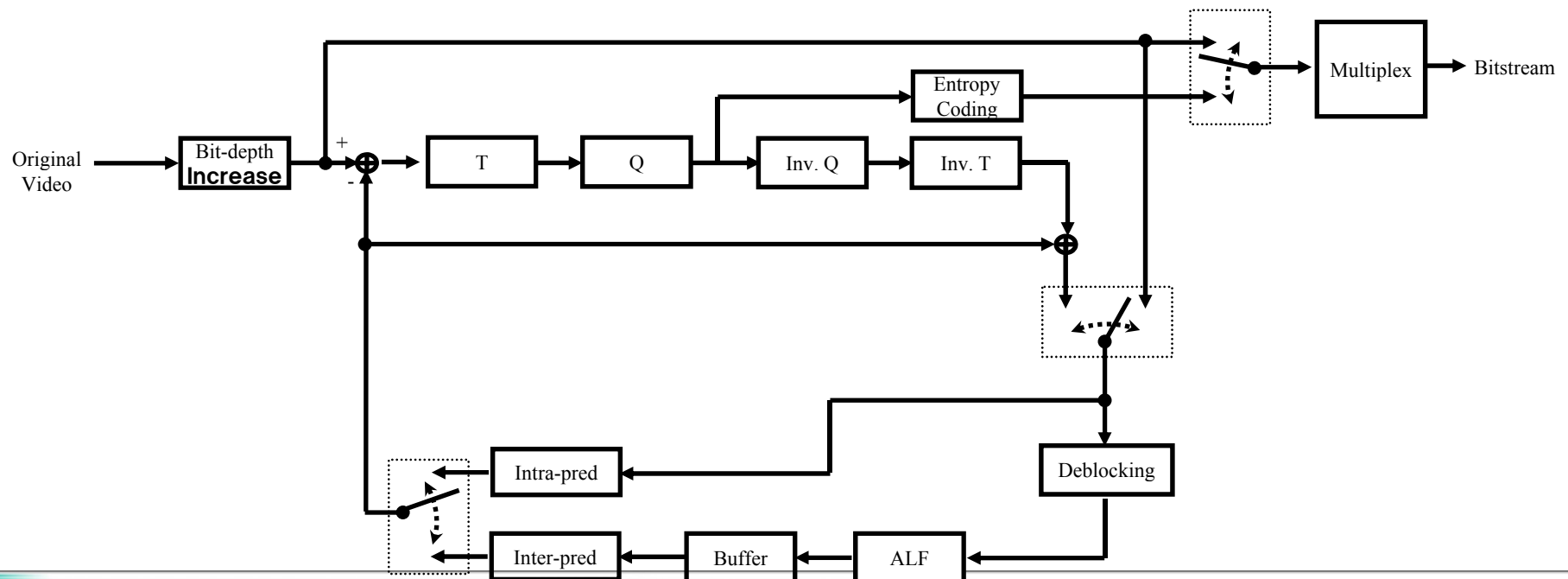
JCTVC-D044 PCM coding

- Concept is identical to AVC's I_PCM
- Minor modifications:
 - Local bit-depth reduction and extension when BDI is used
 - Transmit single-bit syntax “pcm_flag” in PU header when PU is intra



Proposed PCM coding

- Modified version of JCTVC-D044:
 - **No** local bit-depth reduction and extension even when BDI is used
 - **Conditionally** transmit single-bit syntax “pcm_flag” in PU header when PU is **2Nx2N** intra



Conditional signaling of I_PCM flag

PCM operation mode 1

- All $2N \times 2N$ intra PU

PCM operation mode 2

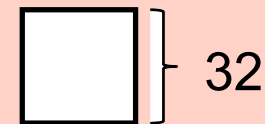
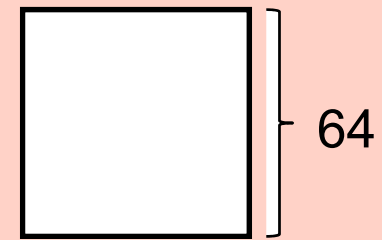
- $2N \times 2N$ intra PUs \geq minPCM size indicated by SPS

PCM operation mode 3

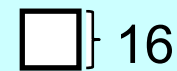
- $2N \times 2N$ intra PUs \leq maxPCM size indicated by SPS

Mode 1

Mode 2 (MinPCM=32)



Mode 3 (MaxPCM=16)



Simulation

- Two tests
 - Common test sequences with JCTVC-D600
 - Synthesized test sequence with additional low QPs
- Computing platform
 - Windows 7 64-bit on Xeon 3.33GHz and Mem. 32GB



Synthesized sequence, *Sandstorms* (CIF 30Hz)

Common test sequence results

	PCM operation mode 1 Luma BD-rates [%]					
	All intra		Random access		Low delay	
	HE	LC	HE	LC	HE	LC
Class A	0.01	1.39	0.08	0.77		
Class B	0.01	1.57	-0.02	0.71	0.01	0.37
Class C	0.01	1.20	-0.02	0.52	-0.01	0.31
Class D	0.01	0.89	0.00	0.38	-0.09	0.26
Class E	0.02	2.37			-0.23	0.39
All	0.01	1.44	0.01	0.60	-0.06	0.33
Enc Time[%]	100%	102%	100%	100%	100%	100%
Dec Time[%]	102%	101%	103%	104%	103%	104%
	PCM operation mode 2 Luma BD-rates [%]					
	All intra		Random access		Low delay	
	HE	LC	HE	LC	HE	LC
Class A	0.00	0.08	0.02	0.07		
Class B	0.00	0.11	-0.01	0.06	-0.01	0.05
Class C	0.00	0.03	-0.02	0.02	0.00	-0.04
Class D	0.00	0.01	-0.01	0.00	-0.03	0.06
Class E	-0.01	0.16			-0.16	0.00
All	0.00	0.08	-0.01	0.04	-0.04	0.02
Enc Time[%]	101%	101%	101%	100%	100%	100%
Dec Time[%]	102%	102%	102%	104%	102%	104%
	PCM operation mode 3 Luma BD-rates [%]					
	All intra		Random access		Low delay	
	HE	LC	HE	LC	HE	LC
Class A	0.01	1.31	-0.03	0.54		
Class B	0.01	1.46	0.00	0.66	0.00	0.35
Class C	0.01	1.17	-0.04	0.52	-0.02	0.25
Class D	0.01	0.88	0.01	0.37	-0.08	0.24
Class E	0.01	2.18			-0.15	0.27
All	0.01	1.37	-0.01	0.53	-0.05	0.28
Enc Time[%]	101%	101%	100%	100%	100%	100%
Dec Time[%]	101%	101%	103%	103%	102%	103%

- PCM operation mode 2 has the least impact on BD-rates. (less than 0.1% on average.)

Synthesized test sequence results

- Proposal avoids yielding # of bits far exceeding input data size
 - Current HM produces about 1.80 times more bits than that of input data.
- Proposal saves decoding time significantly

		HE Intra										
	QP	HM2.0					Proposal (Operation mode 1)					Relative dec.
		kbps	PSNR Y	Enc T [s]	Dec T [s]	Com. Ratio	kbps	PSNR Y	Enc T [s]	Dec T [s]	Com. Ratio	[%]
Sandstorms	0	64549	63.06	118.68	2.11	1.77	47400	99.99	118.47	0.48	1.30	22.93
	2	60989	61.30	117.75	2.03	1.67	47399	99.99	116.75	0.48	1.30	23.82
	7	52679	57.02	112.59	1.89	1.44	47400	99.99	111.40	0.47	1.30	24.80
	12	44121	52.69	104.15	1.70	1.21	47401	99.99	104.84	0.48	1.30	28.41
	17	36427	49.17	97.59	1.68	1.00	37283	47.18	98.14	1.51	1.02	89.85

		LC Intra										
	QP	HM2.0					Proposal (Operation mode 1)					Relative dec.
		kbps	PSNR Y	Enc T [s]	Dec T [s]	Com. Ratio	kbps	PSNR Y	Enc T [s]	Dec T [s]	Com. Ratio	[%]
Sandstorms	0	67019	71.41	23.20	1.01	1.84	37792	99.99	23.06	0.41	1.05	39.94
	2	62313	64.93	22.87	0.97	1.71	37792	99.99	22.71	0.39	1.05	40.33
	7	52071	57.51	21.95	0.86	1.43	37792	99.99	21.81	0.39	1.05	45.45
	12	42990	52.88	20.81	0.75	1.18	37792	99.99	20.73	0.39	1.05	52.14
	17	37204	48.40	20.61	0.69	1.02	37792	99.99	20.39	0.39	1.05	56.85

Discussion

- Simulation results show the benefits of PCM
 - Avoid yielding # of bits far exceeding input data size
 - Save decoding time (up to 77%)
- Proposed PCM methods are cross-checked by E066, E199, and E214
- The PCM operation mode 2 is recommended for HM 3.0 adoption by three companies, by considering its small impact on BD-rates and current HM design

Conclusions and recommendations

- PCM coding
- PCM integration in HM
- Simulation results
 - BD-rates, and encode and decode times
 - Benefits of PCM coding in improving coding efficiency and performance
- Recommendations
 - Adopt the PCM operation mode 2 in HM ver.3

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