Pulse Code Modulation for HEVC
(JCTVC-D044/ M18791)

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Summary

- PCM coding

- PCM integration in TMuC

- Simulation results
  - Intra: HE 0.07% and LC 1.43%
  - Random access: HE 0.01 % and LC 0.43%
  - Low delay: HE 0.01% and LC 0.15%
  - Significant decode time saving (up to 82.6%)

- Recommendations
  - Adopt the concept of I_PCM in HM ver.2
  - Study and improve its specification

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Pulse Code Modulation Coding

- A 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

- HM1 does not have such a means; having the same means is desirable.

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PCM integration in HM

- Concept is identical to I_PCM in H.264/ MPEG-4 AVC
  - No prediction, no transform, and no entropy-coding

- Minor modifications for handling CU and IBDI

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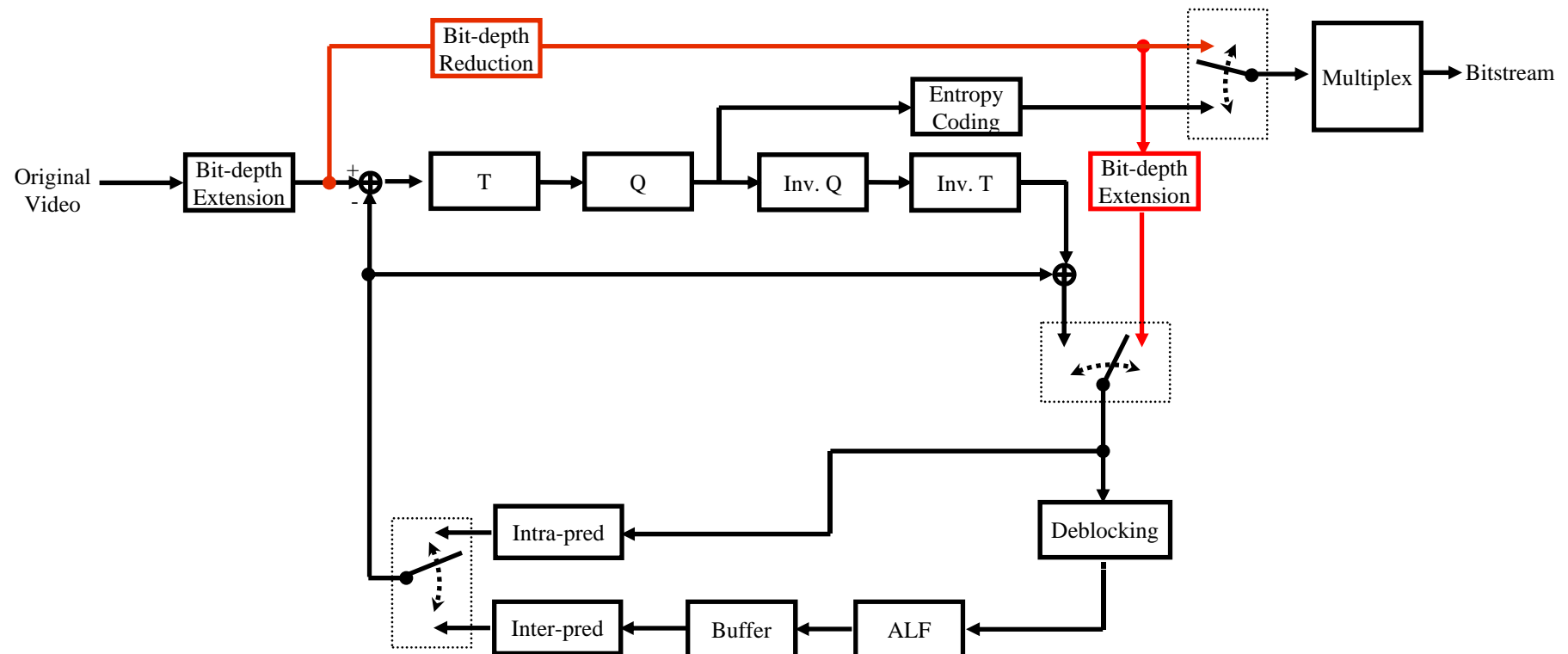
Minor modifications

• Single-bit syntax "pcm_flag" in PU header when CU is intra-coded
  - For CABAC, pcm_flag is transmitted in the same way as end_of_slice_flag
  - For LCEC, fixed-length one bit is transmitted.

• Local bit-depth reduction and extension when IBDI is used

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Simulation

- Two tests
  - Common test sequences with JCTVC-C500
  - Synthesized test sequence with additional low QPs

- Computing platform
  - Windows 7 64-bit on Xeon 3.33GHz and Mem. 32GB

Synthesized sequence, *Sandstorms*, (416x240 30Hz 30frames)

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Common test sequence results

- Marginal BD-rate increase in LC All intra case
- Negligible BD-rate increase in other cases

| | Luma BD-rates [%] | | | | | |
| | All intra | | Random access | | Low delay | |
	HE	LC	HE	LC	HE	LC
Class A	0.01	1.35	0.00	0.57		
Class B	0.01	1.35	-0.01	0.47	0.01	0.16
Class C	0.01	1.45	0.01	0.40	0.01	0.18
Class D	0.01	1.26	0.05	0.34	0.05	0.02
Class E	0.01	1.85			-0.04	0.26
All	0.01	1.43	0.01	0.43	0.01	0.15
Enc Time[%]	101%	107%	101%	102%	101%	101%
Dec Time[%]	100%	101%	102%	105%	100%	104%

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Synthesized test sequence results

> • Proposal avoids yielding # of bits far exceeding input data size
> • Proposal saves decoding time significantly

	QP	HE all intra										Relative dec. [%]
		TMuC0.9					Proposal					
		kbps	Y psnr	Enc T [s]	Dec T [s]	Comp. Ratio	kbps	Y psnr	Enc T [s]	Dec T [s]	Comp. Ratio	
Sandstorms WVGA	12	43548	53.13	151.39	N/A	1.21	36847	99.99	149.63	0.25	1.03	N/A
	17	35986	49.65	142.42	1.44	1.00	36854	99.99	139.27	0.25	1.03	17.40
	22	29217	43.42	130.05	1.20	0.81	29025	43.04	129.70	1.17	0.81	97.34
	27	24110	38.93	117.97	1.05	0.67	24110	38.93	118.41	1.05	0.67	100.00
	32	20232	33.68	108.47	0.94	0.56	20234	33.68	110.17	0.95	0.56	101.71
	37	17000	28.96	103.09	0.88	0.47	16999	28.97	107.17	0.89	0.47	101.71

	QP	LC all intra										Relative dec. [%]
		TMuC0.9					Proposal					
		kbps	Y psnr	Enc T [s]	Dec T [s]	Comp. Ratio	kbps	Y psnr	Enc T [s]	Dec T [s]	Comp. Ratio	
Sandstorms WVGA	12	42365	52.70	22.77	0.53	1.18	36758	99.99	22.81	0.23	1.02	44.07
	17	36730	48.25	22.75	0.48	1.02	36684	99.99	22.69	0.23	1.02	48.35
	22	32408	43.56	22.69	0.47	0.90	32521	43.69	22.77	0.47	0.90	100.00
	27	27476	38.56	22.44	0.44	0.76	27489	38.56	22.47	0.44	0.76	100.00
	32	22889	33.12	22.00	0.41	0.64	22904	33.12	22.03	0.41	0.64	100.00
Page 8	37	19318	28.19	21.47	0.38	0.54	19331	28.18	21.48	0.39	0.54	104.00

Synthesized test sequence results (Cont.)

> • Local bit-depth reduction and extension avoids yielding # of bits far exceeding input data size

| | QP | HE intra | | | | | | | | | | Relative dec. [%] |
| | | Proposal w/o quantization | | | | | Proposal | | | | | |
		kbps	Y psnr	Enc T [s]	Dec T [s]	Comp. Ratio	kbps	Y psnr	Enc T [s]	Dec T [s]	Comp. Ratio	
	12	57804	99.99	149.52	0.38	1.61	36847	99.99	149.63	0.25	1.03	66.67
Sandstorms	17	40192	49.63	138.77	1.16	1.12	36854	99.99	139.27	0.25	1.03	21.63
WVGA	22	29048	43.10	129.27	1.17	0.81	29025	43.04	129.70	1.17	0.81	100.00
	27	24110	38.93	118.45	1.03	0.67	24110	38.93	118.41	1.05	0.67	101.45
	32	20234	33.68	109.08	0.94	0.56	20234	33.68	110.17	0.95	0.56	101.71
	37	16999	28.97	103.70	0.89	0.47	16999	28.97	107.17	0.89	0.47	100.00

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Discussion

- Simulation results show the benefits of PCM with local bit-depth reduction and extension
    - Avoid yielding # of bits far exceeding input data size
    - Save decoding time (up to 82.6%)

- Current pcm_flag signaling method is simple but its coding-efficiency is not high for LCEC
    - pcm_flag may be conditinally signaled in a CU-size dependent way
    - pcm_flag may be jointly signaled with other syntax such as pred_mode, partition size, etc

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Conclusions and recommendations

- PCM coding

- PCM integration in TMuC

- Simulation results
  - BD-rates, and encode and decode times
  - Benefits of PCM coding in improving coding efficiency and performance

- Recommendations
  - Adopt the concept of I_PCM in HM ver.2
  - Study and improve its specification

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