



# CABAC with a Reduced LPS Range Table

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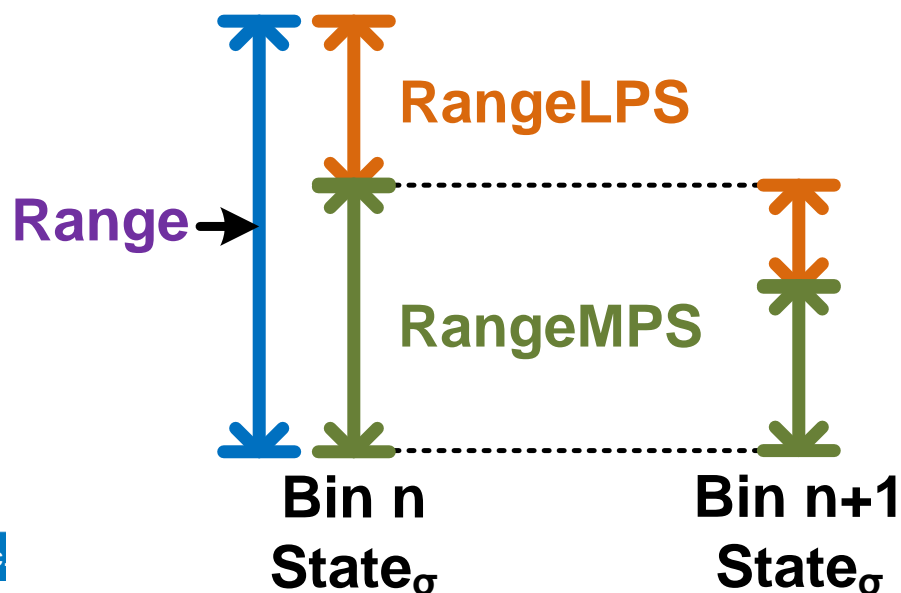
# Overall Summary

- A new least probable symbol (LPS) range derivation method
  - A 3-column table is used instead of the 4-column table in HM 3.0
  - Two columns of LPS ranges and one column of refinement values
  - Emulate an 8-column LPS range table on the fly to reduce the quantization error of the pre-calculated LPS range
- 0.1% of bit rate reduction and 34% of the overall LPS range table size reduction

	AI-HE Y BD-rate	RA-HE Y BD-rate	LD-HE Y BD-rate
<b>Class A</b>	-0.1	-0.2	
<b>Class B</b>	-0.1	-0.1	-0.1
<b>Class C</b>	-0.1	-0.1	-0.1
<b>Class D</b>	-0.1	0.0	-0.1
<b>Class E</b>	-0.1		-0.2
<b>All</b>	<b>-0.1</b>	<b>-0.1</b>	<b>-0.1</b>
<b>Enc Time[%]</b>	99%	100%	100%
<b>Dec Time[%]</b>	100%	100%	100%

# Range in CABAC

- Depending on the corresponding context with probability state <sub>$\sigma$</sub> , with probability value  $p_{\sigma}$ , the range is divided into  $rangeMPS_{\sigma}$  and  $rangeLPS_{\sigma}$ 
  - $rangeLPS_{\sigma} = range \times p_{\sigma}$
  - $rangeMPS_{\sigma} = range - rangeLPS_{\sigma}$
- In HM 3.0, it has 64 probability states for  $p_{\sigma}$



# LPS Range Derivation in HM 3.0

- Range is quantized into four values
- The LPS range of each probability state $_{\sigma}$  of each range value is obtained from pre-calculated look-up table
- The range quantization results in the quantization error of the LPS range
  - The table with more columns results in smaller quantization errors

Range		256 - 319	320 - 383	384 - 447	448 - 511
Quant. Range		287	351	415	479
(Range>>6)&3		0	1	2	3
state $_{\sigma}$	$p_{\sigma}$	Range LPS			
...	...	...	...	...	...
9	0.313	90	110	130	150
10	0.297	85	104	123	142
11	0.282	81	99	117	135
12	0.268	77	94	111	128
13	0.254	73	89	105	122
...	...	...	...	...	...

# Proposed Method

- A 2-column LPS range table and a 1-column refinement values ( $\Delta$ ) table are used to generate an 8-column LPS range table on the fly
- Only need one addition and one shift operation

(Range>>5)&7	0	1	2	3	4	5	6	7	refinement value $\Delta$
Quan. Range	271	303	335	367	399	431	463	495	
State	Range LPS								
...	...	...	...	...	...	...	...	...	...
9	- $\Delta$	95	+ $\Delta$	+ $2\Delta$	- $\Delta$	135	+ $\Delta$	+ $2\Delta$	10
10	- $\Delta$	90	+ $\Delta$	+ $2\Delta$	- $\Delta$	128	+ $\Delta$	+ $2\Delta$	10
11	- $\Delta$	86	+ $\Delta$	+ $2\Delta$	- $\Delta$	122	+ $\Delta$	+ $2\Delta$	9
12	- $\Delta$	81	+ $\Delta$	+ $2\Delta$	- $\Delta$	115	+ $\Delta$	+ $2\Delta$	9
13	- $\Delta$	77	+ $\Delta$	+ $2\Delta$	- $\Delta$	110	+ $\Delta$	+ $2\Delta$	8
14	- $\Delta$	73	+ $\Delta$	+ $2\Delta$	- $\Delta$	104	+ $\Delta$	+ $2\Delta$	8
15	- $\Delta$	69	+ $\Delta$	+ $2\Delta$	- $\Delta$	99	+ $\Delta$	+ $2\Delta$	7
16	- $\Delta$	66	+ $\Delta$	+ $2\Delta$	- $\Delta$	94	+ $\Delta$	+ $2\Delta$	7
...	...	...	...	...	...	...	...	...	...

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- Only need one addition and one shift operation

(Range>>5)&7	0	1	2	3	4	5	6	7	refinement value $\Delta$
Quan. Range	271	303	335	367	399	431	463	495	
State	Range LPS								
...	...	...	...	...	...	...	...	...	...
9	85	95	105	115	125	135	145	155	10
10	80	90	100	110	118	128	138	148	10
11	77	86	95	104	113	122	131	140	9
12	72	81	90	99	106	115	124	133	9
13	69	77	85	93	102	110	118	126	8
14	65	73	81	89	96	104	112	120	8
15	62	69	76	83	92	99	106	113	7
16	59	66	73	80	87	94	101	108	7
...	...	...	...	...	...	...	...	...	...

# Simulation Results

- JCTVC-E700 anchor
- 0.1% bit rate reduction without run time increase
- Overall table size is reduced by 34%
  - HM 3.0: 4 col. of LPS range ( $64 \times 4 \times 8 = 2048$  bits)
  - Proposed : 2 col. of LPS range + 1 col. of  $\Delta$  ( $64 \times 2 \times 8 + 64 \times 1 \times 5 = 1344$ )

	Intra			Random access			Low delay		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A	-0.1	-0.1	0.0	-0.2	-0.3	-0.4			
Class B	-0.1	0.0	0.0	-0.1	-0.1	0.0	-0.1	0.1	0.2
Class C	-0.1	0.0	0.0	-0.1	0.1	0.0	-0.1	-0.2	0.1
Class D	-0.1	0.0	0.0	0.0	-0.1	-0.2	-0.1	0.2	1.2
Class E	-0.1	-0.1	-0.1				-0.2	0.3	0.0
<b>All</b>	<b>-0.1</b>	<b>0.0</b>	<b>0.0</b>	<b>-0.1</b>	<b>-0.1</b>	<b>-0.1</b>	<b>-0.1</b>	<b>0.1</b>	<b>0.4</b>
Enc Time[%]	99%			100%			100%		
Dec Time[%]	100%			100%			100%		

# Cross Verification

- We thank HHI for crosschecking our proposal
  - JCTVC-F453
- BD-rates and run times are confirmed



# Conclusions

- Proposed a new LPS range derivation method
  - A 2-column LPS range table and a 1-column refinement value table are used to generate an 8-column LPS range table on the fly
  - Reduce the quantization error of pre-calculated LPS range
- 0.1% of bit rate reduction and 34% of the overall LPS range table size reduction
  - No encoding or decoding time increase