

# On JEM Binary Arithmetic Engine Design

## JVET-E0064

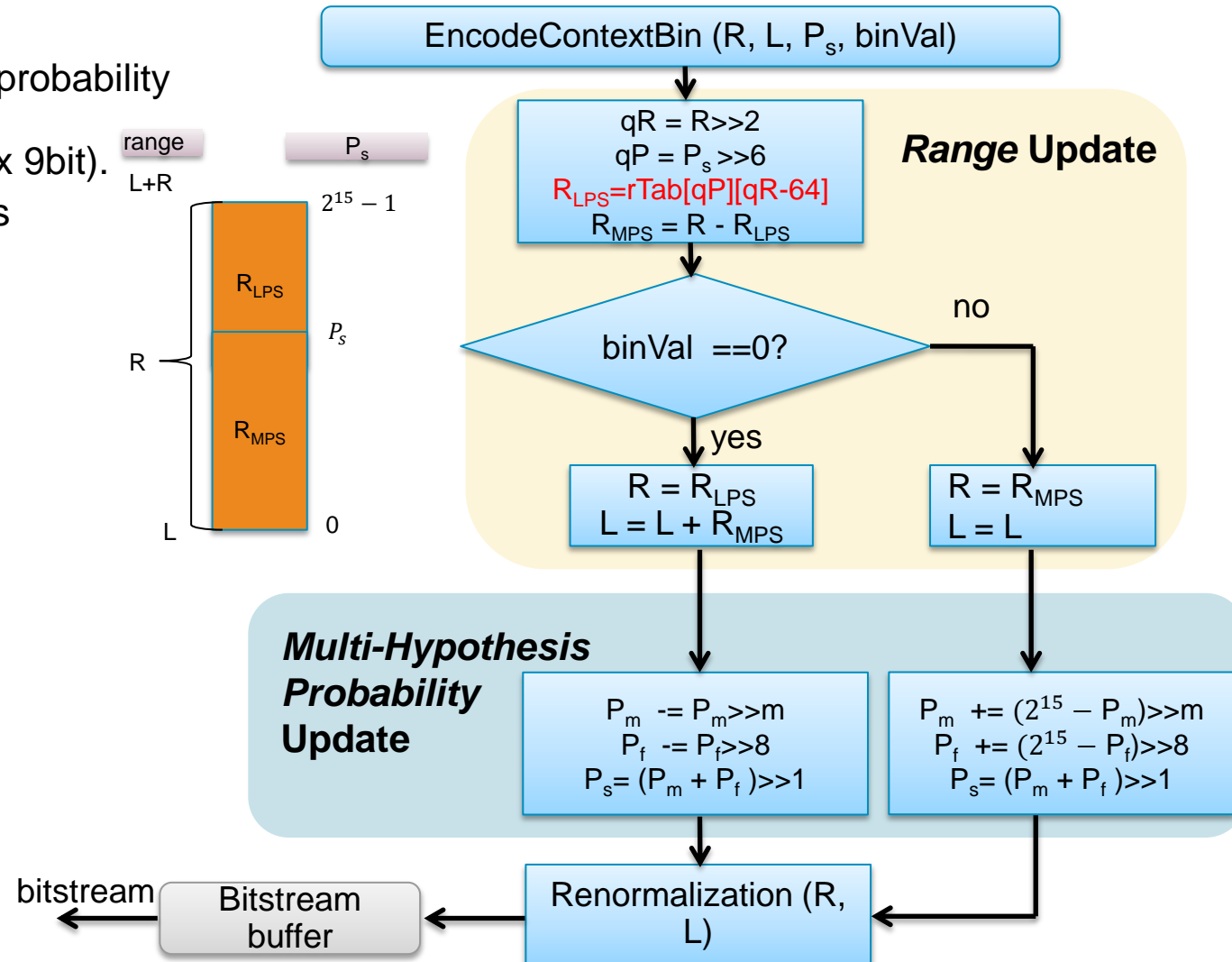
Minhua Zhou and Yi Hu



# Diagram of JEM4.0 Binary Arithmetic Engine

- JEM CABAC design changes:

- Increased precision for range (in 9-bit) and (MPS) probability state (in 15-bit), resulting in a LPS range table (i.e.  $rTab[512][64]$ ) size of 36,384 bytes (i.e.  $512 \times 64 \times 9\text{bit}$ ).
- Probability update with a so-called multi-hypothesis probability update (not a topic of this contribution).



# Experimental Results (1)

- Results of disabling (in JEM4.0)
  - VCEG\_AZ07\_BAC\_ADAPT\_WDOW  
(Multi-hypothesis probability estimation)
  - VCEG\_AZ05\_MULTI\_PARAM\_CABAC  
(CABAC probability estimation with 2 windows)

All Intra Main10					
Over HM-16.6-JEM-4.0 (parallel)					
	Y	U	V	EncT	DecT
Class A1	0.97%	0.98%	1.14%	99%	123%
Class A2	1.00%	1.06%	1.17%	99%	119%
Class B	0.85%	0.76%	0.72%	103%	120%
Class C	0.80%	0.37%	0.45%	96%	110%
Class D	0.60%	-0.07%	-0.07%	95%	105%
Class E	0.64%	0.64%	0.81%	114%	130%
<b>Overall</b>	0.82%	0.63%	0.70%	100%	117%
Class F (optional)	0.69%	0.42%	0.07%	102%	116%
Random Access Main 10					
Over HM-16.6-JEM-4.0 (parallel)					
	Y	U	V	EncT	DecT
Class A1	0.93%	0.22%	0.78%	100%	106%
Class A2	0.83%	0.70%	0.76%	103%	106%
Class B	0.73%	0.42%	0.55%	100%	104%
Class C	0.81%	0.64%	0.64%	99%	101%
Class D	0.60%	0.22%	0.54%	102%	104%
Class E					
<b>Overall (Ref)</b>	0.78%	0.44%	0.65%	101%	104%
Class F (optional)	0.42%	0.45%	0.14%	100%	101%
Low delay B Main10					
Over HM-16.6-JEM-4.0 (parallel)					
	Y	U	V	EncT	DecT
Class A1					
Class A2					
Class B	0.81%	0.50%	0.09%	99%	106%
Class C	1.07%	1.28%	0.90%	109%	113%
Class D	1.08%	-0.06%	0.00%	100%	103%
Class E	0.68%	-0.53%	-0.38%	104%	108%
<b>Overall (Ref)</b>	0.92%	0.36%	0.18%	103%	107%
Class F (optional)	0.64%	0.27%	0.15%	99%	107%
Low delay P Main10					
Over HM-16.6-JEM-4.0 (parallel)					
	Y	U	V	EncT	DecT
Class A1					
Class A2					
Class B	0.84%	-0.15%	-0.41%	97%	107%
Class C	1.03%	0.93%	0.63%	96%	101%
Class D	1.08%	-0.56%	-0.91%	102%	107%
Class E	0.66%	-1.93%	-0.78%	105%	113%
<b>Overall (Ref)</b>	0.91%	-0.31%	-0.34%	100%	106%
Class F (optional)	0.42%	0.36%	-0.32%	101%	107%

# Proposed LPS Range Update Table Design

- Architecture flexible LPS range update table design

- quantize range  $R$  and probability state  $P_s$  by 2 and 7 bits, respectively, and by

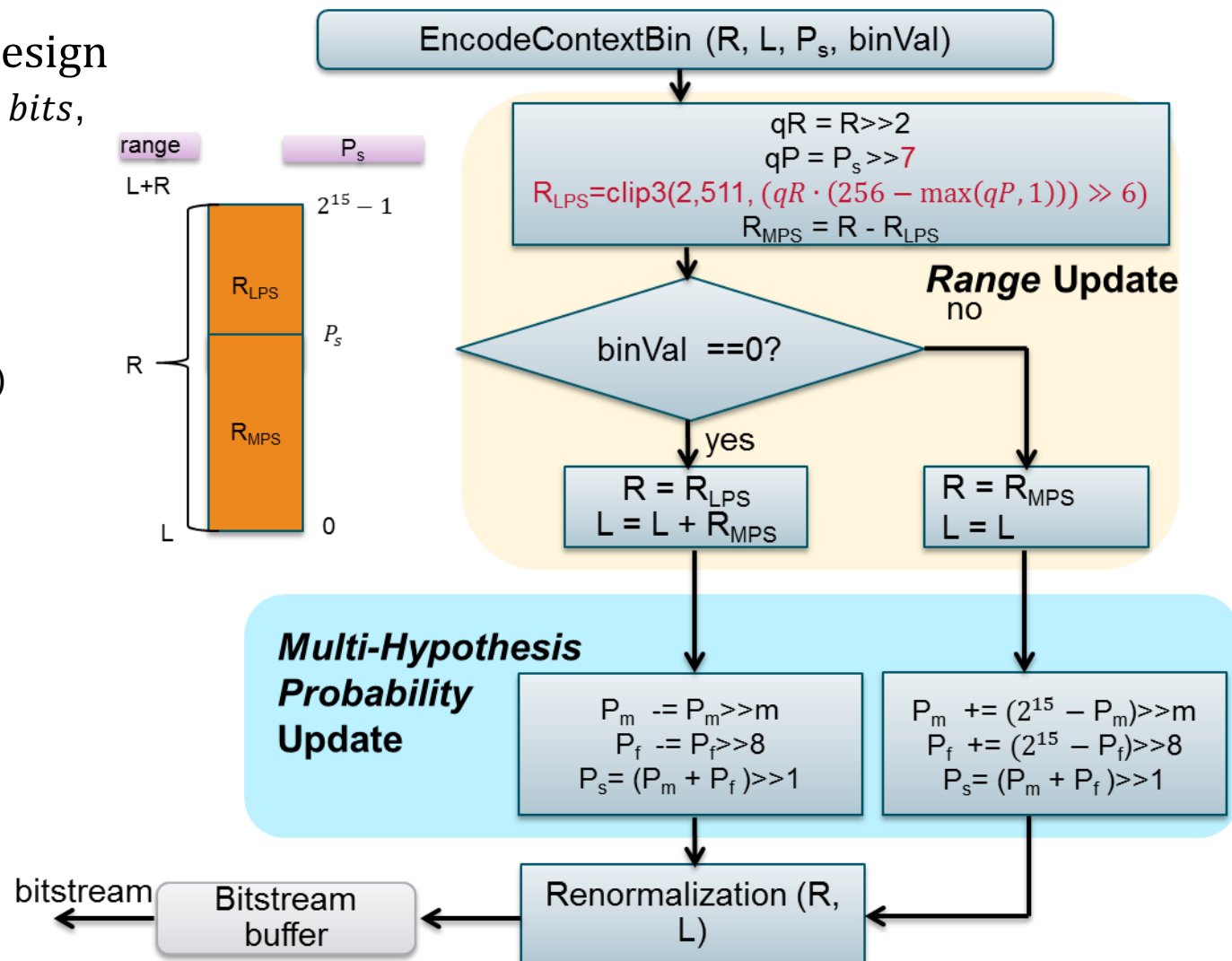
$$\begin{cases} qR = R \gg 2 \\ qP = P_s \gg 7 \end{cases}$$

- Compute the LPS on-the-fly by

$$R_{LPS} = \text{Clip3}(2, 511, (qR \cdot (256 - \max(qP, 1))) \gg 6)$$

- Or table look up with the half of table size

$$R_{LPS} = rTab[qP][qR - 64]$$



# Experimental Results (2)

- Results of the proposed LPS range update

	All Intra Main10				
	Over HM-16.6-JEM-4.0 (parallel)				
	Y	U	V	EncT	DecT
Class A1	0.00%	0.00%	0.00%	105%	123%
Class A2	0.00%	0.00%	0.00%	113%	127%
Class B	0.00%	0.00%	0.00%	105%	118%
Class C	0.00%	0.00%	0.00%	99%	110%
Class D	0.00%	0.00%	0.00%	104%	112%
Class E	0.00%	0.00%	0.00%	109%	121%
<b>Overall</b>	0.00%	0.00%	0.00%	106%	118%
Class F (optional)	0.00%	0.00%	0.00%	97%	109%
	Random Access Main 10				
	Over HM-16.6-JEM-4.0 (parallel)				
	Y	U	V	EncT	DecT
Class A1	0.00%	0.00%	0.00%	103%	107%
Class A2	0.00%	0.00%	0.00%	102%	105%
Class B	0.00%	0.00%	0.00%	105%	108%
Class C	0.00%	0.00%	0.00%	104%	106%
Class D	0.00%	0.00%	0.00%	105%	106%
Class E					
<b>Overall (Ref)</b>	0.00%	0.00%	0.00%	104%	106%
Class F (optional)	0.00%	0.00%	0.00%	102%	103%
	Low delay B Main10				
	Over HM-16.6-JEM-4.0 (parallel)				
	Y	U	V	EncT	DecT
Class A1					
Class A2					
Class B	-0.01%	-0.01%	-0.01%	101%	106%
Class C	0.00%	0.00%	0.00%	105%	106%
Class D	-0.01%	-0.01%	-0.01%	105%	105%
Class E	-0.01%	-0.01%	-0.01%	106%	104%
<b>Overall (Ref)</b>	-0.01%	-0.01%	-0.01%	104%	105%
Class F (optional)	0.00%	0.00%	0.00%	105%	108%
	Low delay P Main10				
	Over HM-16.6-JEM-4.0 (parallel)				
	Y	U	V	EncT	DecT
Class A1					
Class A2					
Class B	0.00%	0.00%	0.00%	105%	111%
Class C	0.00%	0.00%	0.00%	103%	107%
Class D	0.00%	0.00%	0.00%	99%	97%
Class E	-0.01%	-0.01%	-0.01%	97%	102%
<b>Overall (Ref)</b>	0.00%	0.00%	0.00%	102%	104%
Class F (optional)	0.00%	0.00%	0.00%	106%	109%

# Summary

- The proposed LPS range update preserves compression efficiency of the JEM4.0 CABAC design.
- Recommend to offer the option of computing LPS range update on-the-fly in the future video coding if the LPS range update table is disproportionally large.