Delayed State update for CABAC
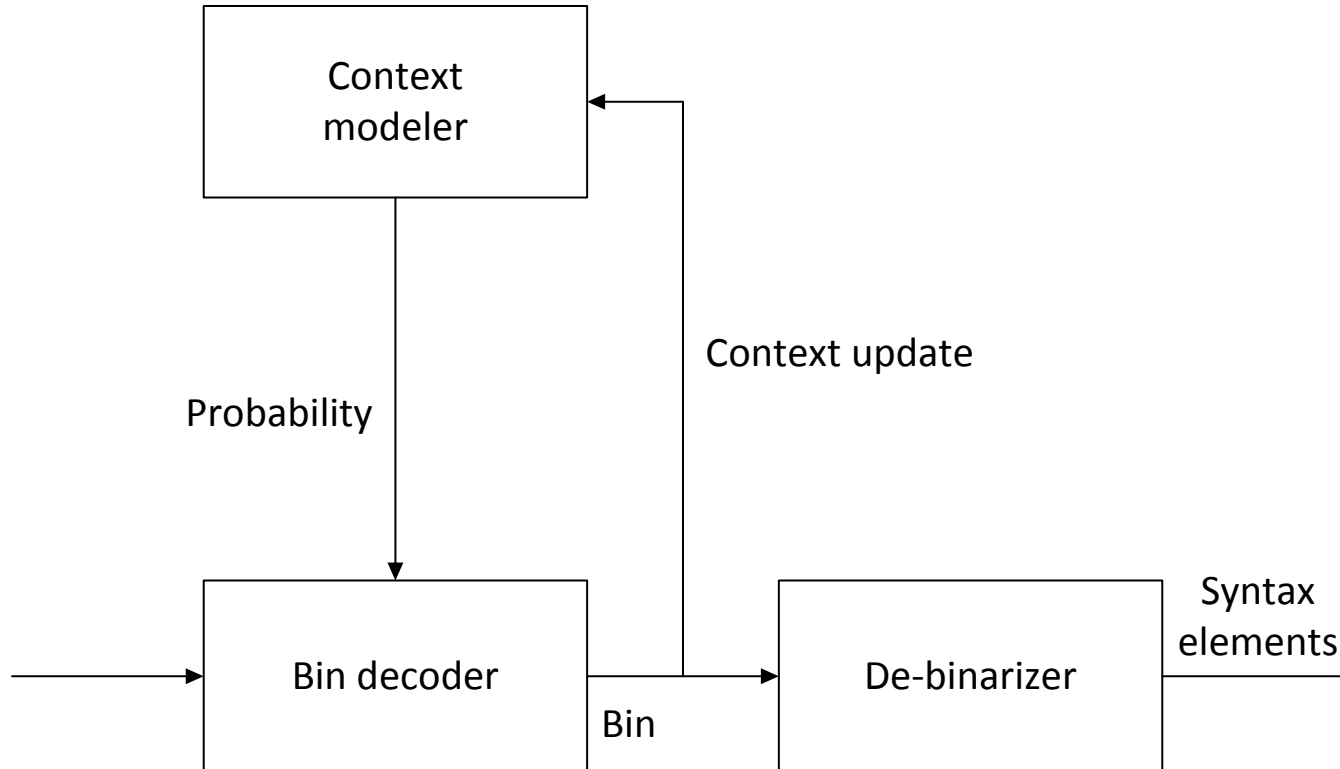
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Qualcomm

Motivation

- Two feedback loops in CABAC
  - Context derivation
    - Already addressed for significance coding
    - A number of non-residual contexts.
  - State update
    - Affects encoding/decoding of the next bin
- Other solutions
  - Disable update completely (G233, G633) or selectively (G349, G440)

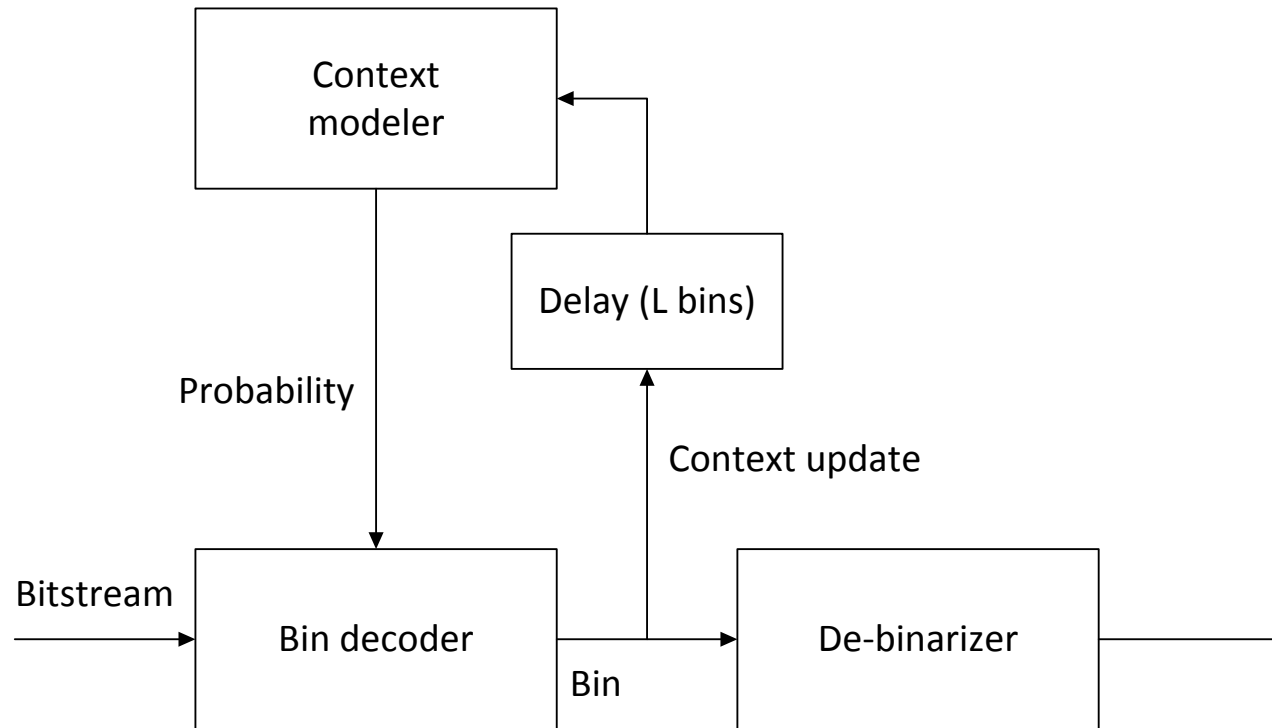# CABAC decoder

Delayed State Update

- Delay state update by L bins
  - Evaluated performance for L = 1, 2, and 3
- Applied across *all* context elements.
  - No need for separate logic for different syntax elements

Modified CABAC decoder

Example: $L = 2$

context

35	33	20	31	33	33	27
LPS	LPS	MPS	LPS	LPS	MPS	LPS

decoded bin

decodeBin (context _35)	
decodeBin (context_33)	
decodeBin (context_20)	updateLPS (context_35)
decodeBin (context_31)	updateLPS (context_33)
decodeBin (context_33)	updateMPS (context_20)
decodeBin (context_33)	updateLPS (context_31)
decodeBin (context_27)	updateLPS (context_33)

Decode and update operations in parallel

Results (delay = 1)

BD-rate	Intra HE			Random access HE			Low delay HE		
	Y	U	V	Y	U	V	Y	U	V
Class A	0.17	0.26	0.35	0.15	0.16	0.12			
Class B	0.13	0.18	0.27	0.09	0.27	0.03	0.07	-0.11	-0.38
Class C	0.10	0.17	0.19	0.11	0.05	0.11	0.11	0.16	0.01
Class D	0.11	0.15	0.10	0.12	0.00	-0.25	0.04	0.13	0.03
Class E	0.14	0.33	0.22				0.04	0.05	1.06
All	0.13	0.21	0.23	0.12	0.13	0.01	0.07	0.05	0.09
Enc T[%]	104%			102%			101%		
Dec T[%]	103%			101%			101%		

Results (delay = 2)

BD-rate	Intra HE			Random access HE			Low delay HE		
	Y	U	V	Y	U	V	Y	U	V
Class A	0.28	0.17	0.14	1.01	0.74	0.07			
Class B	0.20	0.23	0.26	0.87	0.47	0.44	1.01	0.72	0.64
Class C	0.14	0.18	0.17	0.66	0.43	0.59	0.71	0.48	0.53
Class D	0.15	0.17	0.17	0.50	0.58	0.23	0.45	0.24	0.53
Class E	0.28	0.32	0.26				1.77	1.17	2.23
All	0.20	0.21	0.20	0.77	0.55	0.34	0.94	0.62	0.88
Enc T[%]	106%			104%			105%		
Dec T[%]	105%			101%			101%		

Results (delay = 3)

BD-rate	Intra HE			Random access HE			Low delay HE		
	Y	U	V	Y	U	V	Y	U	V
Class A	0.32	0.32	0.64	1.47	0.43	0.53			
Class B	0.22	0.24	0.66	1.32	0.43	0.54	1.56	0.77	0.65
Class C	0.17	0.20	0.34	0.92	0.25	0.74	0.98	0.67	0.49
Class D	0.17	0.17	0.27	0.76	0.44	0.23	0.70	0.17	0.16
Class E	0.31	0.39	0.90				3.23	1.10	2.98
All	0.23	0.26	0.55	1.13	0.39	0.51	1.51	0.65	0.93
Enc T[%]	105%			104%			103%		
Dec T[%]	105%			102%			101%		

Comparison of delayed update (delay=3) with no update

No update

BD-rate	Y	U	V
AI-HE	3.1%	1.5%	0.2%
RA-HE	6.6%	8.8%	8.0%
LB-HE	6.4%	9.8%	9.3%

Delayed update (delay = 3)

BD-rate	Y	U	V
AI-HE	0.2%	0.3%	0.6%
RA-HE	1.1%	0.4%	0.5%
LB-HE	1.5%	0.7%	0.9%

Conclusions

- Delayed update (delay = 1)
  - simplifies hardware implementation of CABAC
  - Small BD-rate effect (0.1% on average)
  - Recommend for adoption into HM5.0
- Delayed update (higher delays)
  - Good alternative to methods which disable updates completely

Results with class F(delay = 1)

	All Intra HE			Random Access HE			Low delay B HE		
	Y	U	V	Y	U	V	Y	U	V
Class A	0.17%	0.25%	0.38%	0.15%	0.28%	0.12%			
Class B	0.13%	0.18%	0.27%	0.08%	0.28%	0.09%	0.07%	-0.14%	-0.24%
Class C	0.10%	0.17%	0.17%	0.11%	0.08%	0.10%	0.12%	0.13%	-0.04%
Class D	0.11%	0.16%	0.11%	0.12%	0.07%	-0.24%	0.04%	0.19%	0.24%
Class E	0.14%	0.31%	0.22%				0.04%	0.11%	1.24%
Class F	0.18%	0.21%	0.34%	0.09%	0.27%	0.08%	0.04%	0.19%	0.58%
Overall	0.14%	0.21%	0.25%	0.11%	0.20%	0.03%	0.06%	0.08%	0.28%
Overall No F	0.13%	0.21%	0.23%	0.12%	0.18%	0.02%	0.07%	0.05%	0.21%