

# Context selection complexity in HEVC CABAC

(JCTV-D244/m19005)

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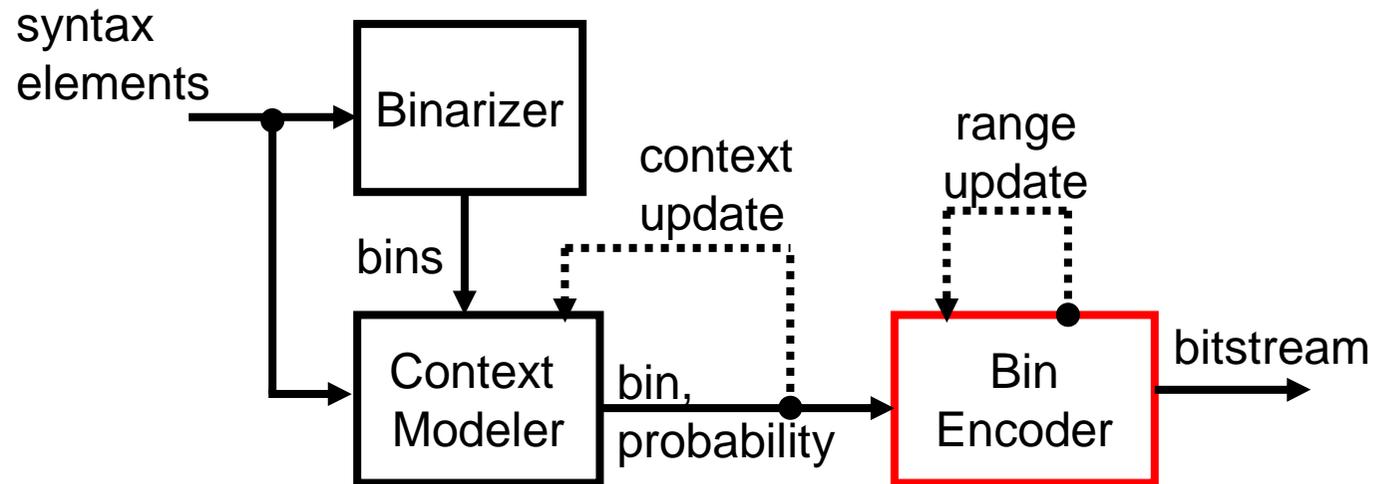
**Joint Collaborative Team on Video Coding (JCT-VC)  
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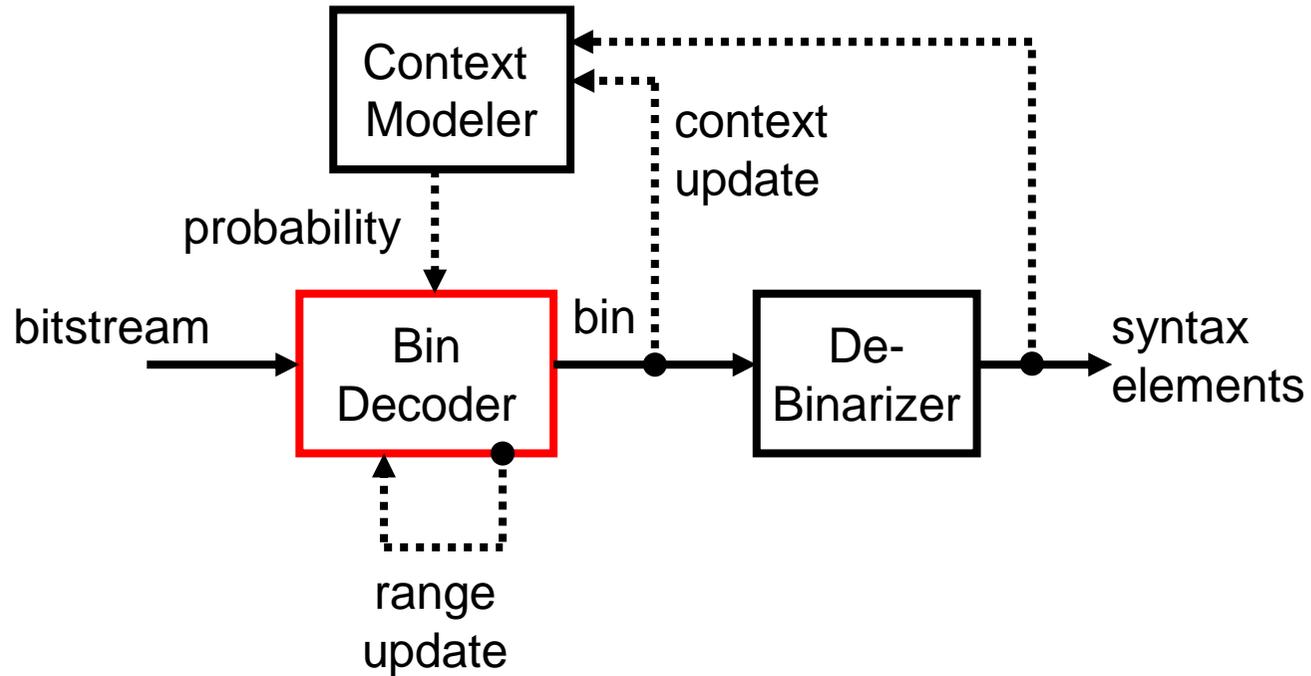
# Serial Dependencies in CABAC

- CABAC is a key bottleneck in video codec implementations
- Difficult to increase throughput due to serial dependencies from multiple feedback loops
- Impact of feedback loops on implementation
  - Parallelism and pipelining common techniques used to increase throughput
    - Parallelism (increase bins per cycle)
    - Pipelining (reduce cycle time)
  - Speculative computations required due to feedback loops

# Feedback Loops at Encoder



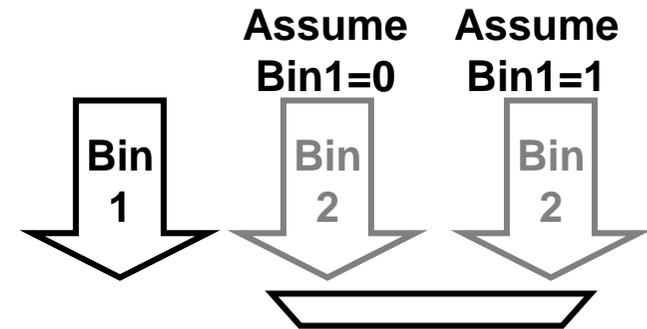
# Feedback Loops in Decoder



**Note that loops pass through multiple modules (e.g. context update loop goes through context modeler *and* bin decoder)**

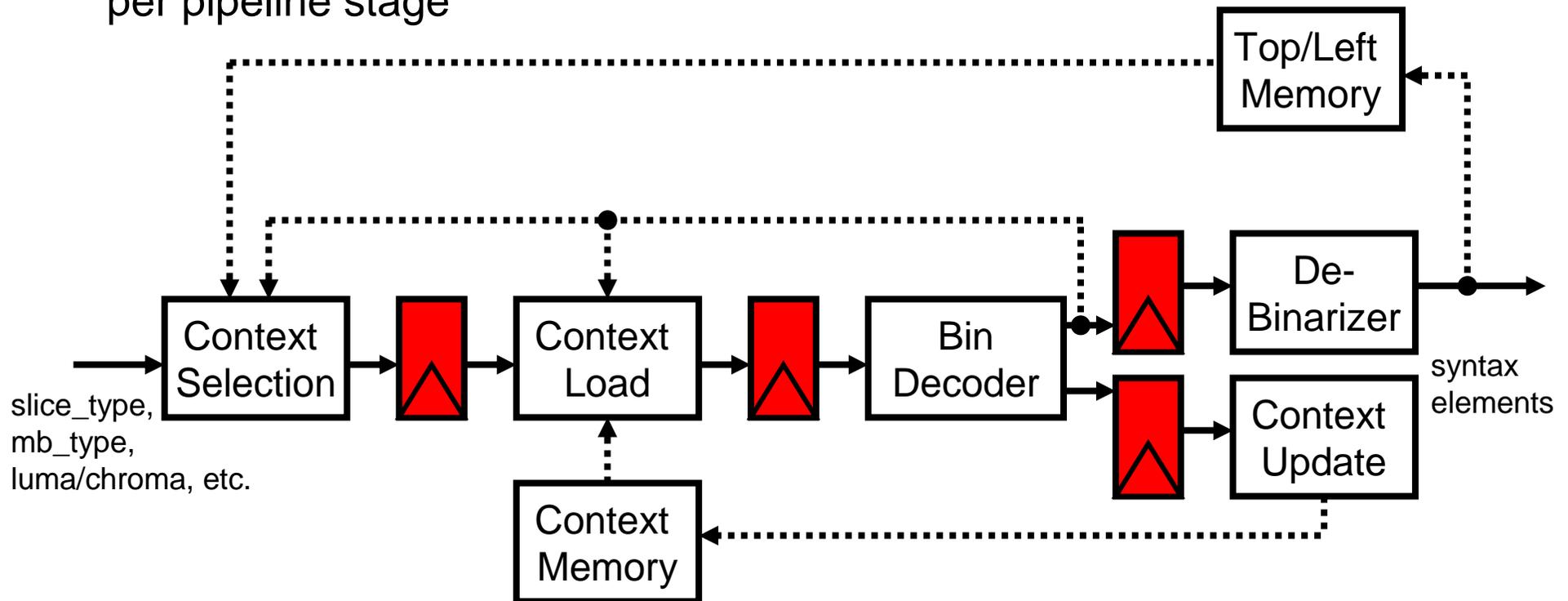
# Speculative Computations for multi-bin

- If want to decode multiple bins in a cycle, need to perform speculative computations due to feedback loops
- Example: Decode two bins in parallel
- To decode bin2 before bin1 is resolved
  - Candidate0: compute bin2 assuming bin1=0
  - Candidate1: compute bin2 assuming bin1=1
  - Once bin1 is resolved, select either Candidate0 and Candidate1
- Overhead
  - Additional computations: for N bins parallel decoder requires  $1+2+\dots+2^{(N-1)}$   
**Number of operations increases exponentially!**
  - Additional delay due to selecting candidates



# Pipelined CABAC

- To reduce critical path delay, CABAC is typically pipelined
- Due to feedback loops, number of speculative computations increase per pipeline stage

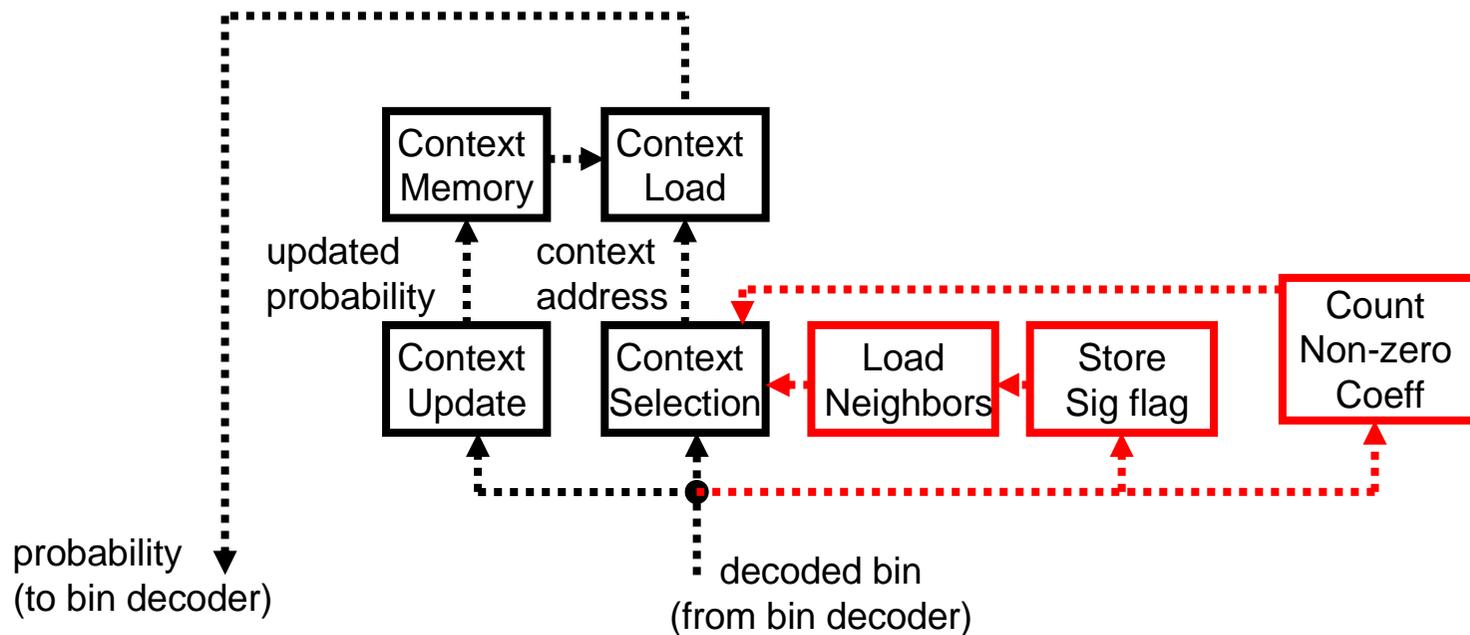


**Pipelined 2 bin per cycle CABAC implementation can require up to 12 context selection calculations**

For 4 bin per cycle in future video codecs, need up to 60 context selections

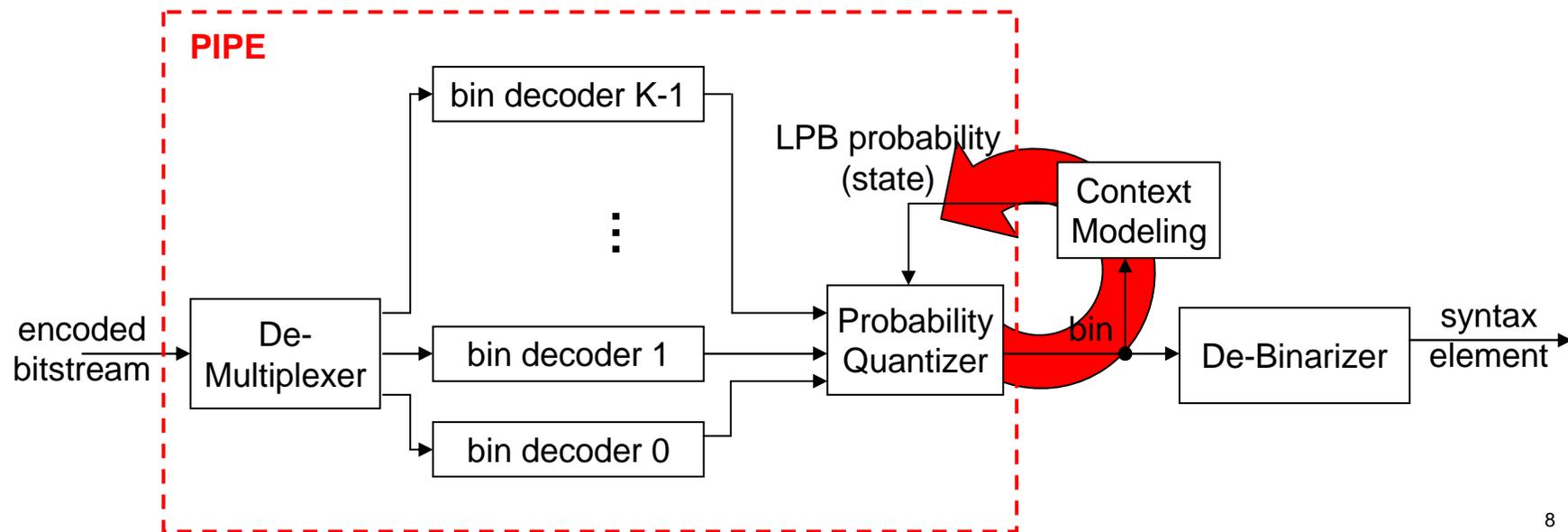
# Additional Dependencies in HEVC

- In AVC, optimizations done to reduce number of speculative computations
- Additional dependencies in HEVC
  - Increases operations per context selection
  - Makes operation reduction difficult
  - potentially increase critical path delay



# Speculative Computations with PIPE/V2V

- Decode N bins in parallel using  $1+2+\dots+2^{(N-1)}$  probabilities (state, MPS)
- In PIPE, read bin from bin decoder based on probabilities
- Speculatively read  $1+2+\dots+2^{(N-1)}$  bins from multiple bin decoders
- Multiple bins can be read from same bin decoder
  - Need to keep track of which bins were speculatively read and which bins were actually read once bin resolved



# Conclusions

- Multiple feedback loops in CABAC cause serial dependencies
- Important to look at **both** encoder and decoder
  - Loops are more complex at the decoder
- Techniques that increase implementation throughput require speculative calculations
- Additional dependencies introduced in HEVC increase number of speculative computations
- For alternative entropy coding methods, important to evaluate end-to-end throughput and decoder complexities