



# Alliance for Open Media

Next Generation, Open-Source Digital Media Technology for  
Everyone

## HardWare SubGroup reports

*In Suk Chong, Google*

On behalf of AOM Codec Working Group

AOM Workshop @ ICIP 2024, Abu Dhabi, UAE, October 30, 2024

# Alliance for Open Media (AOM)

## Founding Members



Apple



Google



Meta



NETFLIX



SAMSUNG

Tencent

- Organized the efforts to develop state of the art video codec
  - Weekly Codec Working Group (CWG)
  - Sub Groups: **HW SubGroup**, SW SubGroup
  - Focus Groups: ML, Partitioning, Transform, Entropy, etc
  - Every 4 months, new anchor generated based on adopted proposals

# Initiation of HW SubGroup

- Google proposed to start HW SubGroup (Dec 2023)
- Motivations
  - Concerns on the complexity of AVM
    - 3x decoder, 13x encoder vs. AV1 (in CPU run time)
  - Hardware implementations has unique constraints in implementing the proposed algorithms
- Initiatives
  - Evaluate current AVM HW complexity
  - Systematically assess new AVM tools
  - Address any HW issues before spec is frozen
  - Collaborative efforts to make AVM HW friendly



# Hardware SubGroup activity - summary

- Organization
  - Chaired by 4 co-chairs (Google, Broadcom, Apple, Intel)
  - Starting from Jan 2024, weekly meeting with AOM members
  - Multiple HW vendors participating
    - Google, Apple, Broadcom, Intel, AMD, Arm, NVIDIA, Samsung, LG, RealTek, VeriSilicon
    - Xilinx, NetInt, Chips&Media, BlueDot
- Define the mandates (Jan 2024)
  - Study draft and proposed coding tools (including candidate tools) to identify implementation issues relating to decoder pipelines, decoder throughput, and other aspects of implementation difficulty.
  - Solicit hardware analysis of complex tools.
  - Provide feedback on potential solutions to address identified issues.
  - Study the feasibility of assessing encoder HW complexity for selected tools

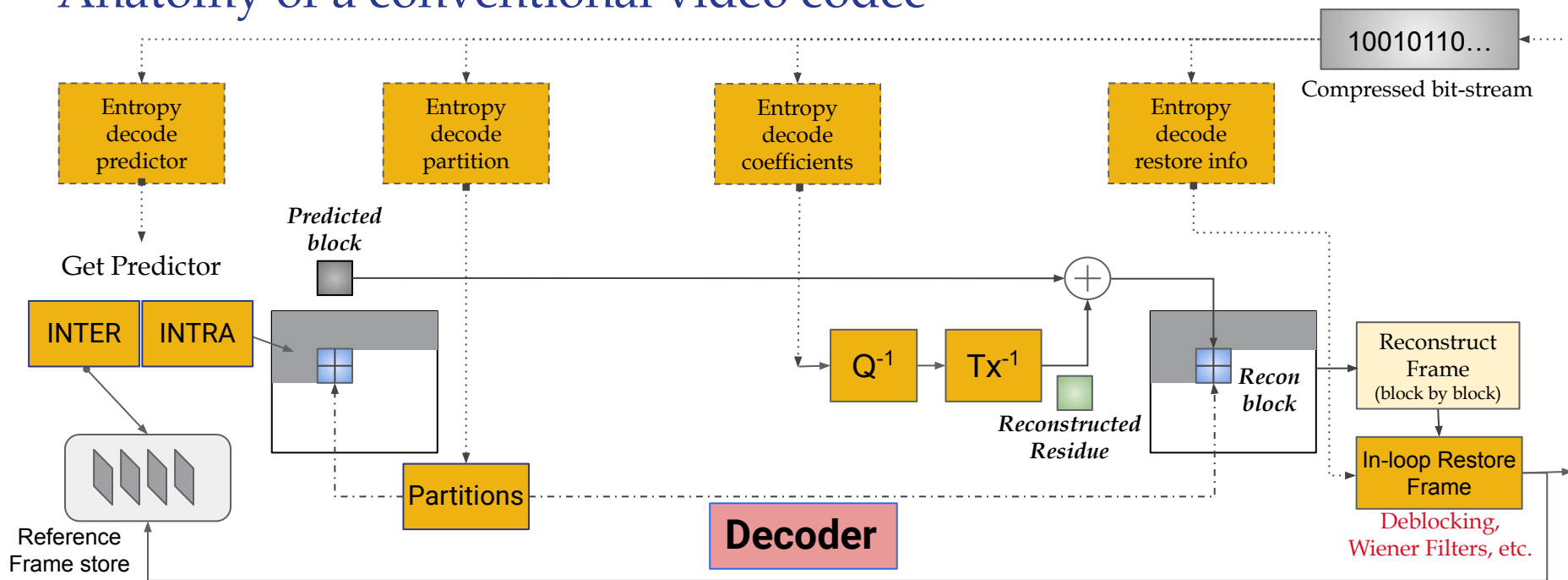
# Hardware SubGroup activity - summary

- Analyze all major tools in AVM (Feb-July 2024)
  - Design/analysis documents are provided from multiple proponents and volunteers
  - 17 design/analysis documents were reviewed
  - 35 tools were provided with recommended changes
- Summary reports are generated (Aug- 2024)
  - Action items are defined and closely followed up
  - Selective new proposals are analyzed and simplification ideas are recommended




# Hardware SubGroup activity - Tool analysis

## Anatomy of a conventional video codec



Framework has not changed much in the last 35 years !

# Hardware SubGroup activity - Tool analysis

- **Intra Predictor**
    - Multiple Reference Line Selection(MRLS)
    - Adaptive Intra Mode Coding (AIMC)
    - Intra Bi-Prediction (IBP)
    - Local Intra Block Copy (IBC)
    - Improved CfL Prediction (CFL)
  - **Inter Predictor**
    - Reference Framework
    - Temporal Interpolated Picture (TIP)
    - Optical Flow MV Refinement (OPFL)
    - Temporal MV Prediction (TMVP)
    - Spatial MV Prediction (SMVP)
    - MV Coding
    - Warp Reference list (WRL)
    - Extended Wedge Compound Mode
    - Block Adaptive Weighted Prediction (BAWP)
    - Skip Mode Enhancement
  - **Quantization**
    - Extended Quantization
  - **Partitioning**
    - Extended Recursive Partitioning (ERP)
    - Semi-Decoupled Partitioning (SDP)
  - **Transform Coding**
    - New Transform Partitioning (NTP)
    - Primary Transforms
    - Intra Secondary Transforms (IST)
    - Cross Component Transform (CCTX)
  - **Entropy Coding**
    - Parity Hiding & Forward Skip Coding (FSC)
    - Probability Adjustment Rate Adaptation (PARA)
    - Coefficient Coding Improvements
    - Arithmetic Coding Improvements
  - **In-Loop Filtering**
    - Improved Deblocking Filters
    - Cross Component Sample Offset (CCSO)
    - Extended Loop Restoration Filters
- 

# Hardware SubGroup activity - Tool analysis

- Proponents/volunteers generated design/analysis documentation
  - 17 design/analysis documents were reviewed
    - ERP, SB256, TMVP, WRL, DRL, IST, OPFL, TIP, Inter BAWP, Wedge, MHCCP, CFL, IBC, Intra BAWP, CCSO, LR, Entropy coding
  - 35 tools were provided with recommended changes

1	A	B	C	D	E	F	G	H	I	J	K
	Tool Name	Status	Design Doc	Date	Company	Analysis Doc	Date	Company	Comments	Recommended Actions	
2	Block Partition	ERP+SB256	Recommendation open	Presented	03/13	Google, E041	Not needed		No major HW concerns in the decoder side Update the design doc with followings: 1. Description and ROM requirements for additional scanning pattern for 1:8/1:16 2. Frame boundary handling logic 3. Chroma block handling 4. Condition for inferred bits in partition signaling 5. (optionally) coding gain of each added partition types	1. Reduce # of CDFs added for new partition types -> E136 reduced # of CDFs by 30% 2. Enable 256x256 for keyframes	
3	SDP		Recommendation open	Presented					Requires whole SB luma, <b>not compatible with 64x64 sized decoder pipeline</b> The dual tree introduces chroma reconstruction latency larger than 1024 luma samples, which makes the reconstruction of luma and chroma blocks of a 64x64 region fully sequential. <b>Interaction with CFL (1024 pixel requirements)</b>	1. Interleave syntax elements in 64x64 level to make it 64x64 decoder pipeline compatible. 2. Analyze the interaction with CFL (1024 pixel latency requirements) -> E066 SDP starting point to 64x64	
4	NTP		Recommendation open	Presented					Is the TU partitioning tree still needed given the ERP?	Revisit the coding gain of TU partitioning to see TU partitioning tree still needed given the ERP.	
5	WEDGE extension		Recommendation open	Presented					16 modes -> 68 modes	1. Check how much complexity is needed for additional wedge mask (16 modes -> 68 modes). Max ROM size increased from 32x32 to 64x64 (2kbytes -> 32kbytes). 2. Need to check the break down # of coding gain.	
6	Entropy Coding	PARA	Recommendation open	Presented						Better utilization of the parameter storage (9 bits => 6 bits), <b>(done, E123)</b> 9bits (8modes x 3) -> 6 bits (4modes x 3) Need to support separate path for coefficient coding Evaluate the coding gain for SCC and natural contents.	



# Hardware SubGroup activity - Follow up

- Follow up on recommendations
  - AOM members actively addressed the issues
  - Regular progress reports are generated
- Current status
  - Stable stages
    - ERP, SB256, DRL, SDP, NTP
    - ADST, CCTX, Palette, PARA
    - Parity Hiding, TIP, OBMC
    - MC filters, PEF, IBP, MRLS, CCSO
  - Close to stable stages
    - AIMC, IST, OPFL, DMVR, FSC
    - BAWP, CFL, Intra BAWP
  - Still need further working
    - TMVP, WRL, DAMR, Wedge
    - MHCCP,IBC, LR, Deblocking
    - Throughput/BW improvements



Alliance for Open Media  
Codec Working Group

Document: **CWG-E131**

## HW SG summary reports


July 10, 2024

<b>Status:</b>	Input document
<b>Purpose:</b>	Proposal
<b>Author(s):</b>	In Suk Chong, Minhua Zhou, Aki Kuusela, Iole Moccagatta
<b>Email(s):</b>	<a href="mailto:insukchong@google.com">insukchong@google.com</a> , <a href="mailto:minhua.zhou@broadcom.com">minhua.zhou@broadcom.com</a> , <a href="mailto:a_kuusela@apple.com">a_kuusela@apple.com</a> , <a href="mailto:iole.moccagatta@intel.com">iole.moccagatta@intel.com</a>
<b>Source:</b>	Google, Broadcom, Apple, Intel

### Abstract

In this report, we summarized all the activities during HW SubGroup starting from Jan 2024. In the beginning, mandates are defined, and initial analysis of major tools are provided by Google and Broadcom in [CWG-E020](#). Based on that initial list, chairs asked multiple participants to generate design/analysis documents for the tools which have multiple adoptions. Those documents are presented and various comments are collected from the participants. Also HW SubGroup and FG8 jointly generated a list of things to be checked in the entropy coding engine ([CWG-E090](#)). Furthermore, HW Subgroup chairs compiled initial action items(AIs) for the tools that do not have design/analysis documents [3], and those are also presented and comments are collected. Based on those comments, final AIs are generated for each tool. In summary, 17 Design/Analysis documents were reviewed, 35 tools were provided with recommended changes. All activities were recorded in the [summary sheets](#) [1] and HW SG [meeting notes](#) [2].

# Hardware SubGroup activity - more details

- Partition
    - ERP: reduced the # of contexts in partition signaling
    - SDP: fixing the issues related to CFL
  - List derivations
    - TMVP: simplifying MV trajectory approach
    - DRL: addressed major complexity issues in AV1
    - WRL: 3 new WRL modes needs to be cleaned up
    - AIMC: simplified the derivation of smaller PU size
  - Transform/Quant
    - IST: ROM size & MACs/pixel reduced
    - ADST (matrix based): improved coding gain vs. complexity trade off using data-driven tx (DDT)
    - CCTX: no major issues
    - Parity Hiding: no major issues
- 

# Hardware SubGroup activity - more details

- Inter tools
  - OPFL: BW issues are being addressed
  - DMVR: working on BW restrictions
  - BAWP: simplified the derivation of parameters
  - DAMR: working on parameter estimation simplification
  - Wedge: working on mask simplification
  - TIP: fixed and simplified motion vector derivation, hole-filling logic
  - PEF: moved to deblocking stage
  - MC filters: dual filters are removed
  - OBMC: evaluating coding gain



# Hardware SubGroup activity - more details

- Intra tools
  - MHCCP: active simplifications are on-going
  - CFL: line buffer/ downsampling filter issues are addressed
  - IBC: evaluation of local vs. global IBC
  - Intra BAWP: simplified parameter estimation
  - IBP: simplified the table size and DC prediction
  - MRLS: no major issues
  - ORIP: evaluating coding gain vs. complexity
  - Palette: fixed parsing dependency issues
- Loop filters
  - CCSO: simplifying filter shapes
  - LR: addressing unification of multiple modes
  - Deblocking: simplification is on-going



# References

- Initiation proposal:  
<https://groups.aomedia.org/g/wg-codec/files/InputDocuments/D2023/CWG-D180>
- Initial tool list:  
<https://groups.aomedia.org/g/wg-codec/files/InputDocuments/E2024/CWG-E020>
- Summary sheets:  
[https://docs.google.com/spreadsheets/d/1Utoi6-YgN7tT\\_IlniSgpvSLzcOPaDgGOhawy2xSgGkA/edit?gid=941005279#gid=941005279](https://docs.google.com/spreadsheets/d/1Utoi6-YgN7tT_IlniSgpvSLzcOPaDgGOhawy2xSgGkA/edit?gid=941005279#gid=941005279)
- Summary reports:  
<https://groups.aomedia.org/g/wg-codec/files/InputDocuments/E2024/CWG-E131>



Back Up