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| *Title:* | **AHG 16: Harmonization of 2NxN/Nx2N Intra PU with SDIP and NSQT** | | | |
| *Status:* | Input Document to JCT-VC | | | |
| *Purpose:* | Proposal | | | |
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# Abstract

This contribution proposes a set of methods for harmonization of 2NxN/Nx2N PU with SDIP and NSQT. The coding efficiency and run-time of the proposed methods built on top of AHG 16 software are reported. Experimental results report average 1.8% BD-rate reduction for All Intra HE with encoding runtime increased by 32%1 and decoding runtime increased by 3% with 8x2/2x8 transform enabled. Experimental results report average 1.4% BD-rate reduction for All Intra HE with encoding runtime increased by 31% and decoding runtime increased by 2% when 8x2/2x8 transform disabled. With further encoder complexity reduction, experimental results report average 1.2% BD-rate reduction for All Intra HE with encoding runtime increased by 23%2 and decoding runtime increased by 2%. By applying the proposed PU type signaling method on 2Nx0.5N/0.5Nx2N intra prediction unit, experimental results report average 0.0% BD-rate difference for All Intra HE with negligible encoding and decoding runtime change compared to AHG16 software. Two context models are removed.

Note: 1 The encoder runtime reported by AhG16 using the same software is 128%.

2 The encoder runtime reported by AhG16 using the same software is 120%.

1. Introduction

The current HEVC (High Efficiency Video Coding) defines coding unit (CU) and prediction unit (PU), where a CU may consist of one or multiple PUs. An Intra 2Nx2N CU should consist of one 2Nx2N PU if it is greater than smallest coding unit (SCU); or it may consist of either one 2Nx2N PU or four NxN PUs if it is an SCU. An Inter 2Nx2N CU may consist of one 2Nx2N PU, two rectangular shape (e.g. 2NxN, Nx2N, 2NxnU, 2NxnD, nLx2N, nRx2N) PUs, or four NxN PUs if it is an SCU. Various PU types for a 2Nx2N CU are shown in Figure 1. Partition types and binarization for Intra Prediction is illustrated in Table 1.

As the discussion in Geneva meeting, Ad-Hoc group (AHG) 16 was set up to investigate the unification of short distance intra prediction (SDIP) with the Inter prediction, especially NSQT. The mandates for AHG16 are as following.

* Implement and harmonize the non-square partitioning techniques in SDIP with the NSQT in HM5.
* Study and investigate combinations of PU and TU sizes that lead to the best coding efficiency and complexity tradeoff.
* Provide the WD text that is entirely consistent with the unified software.

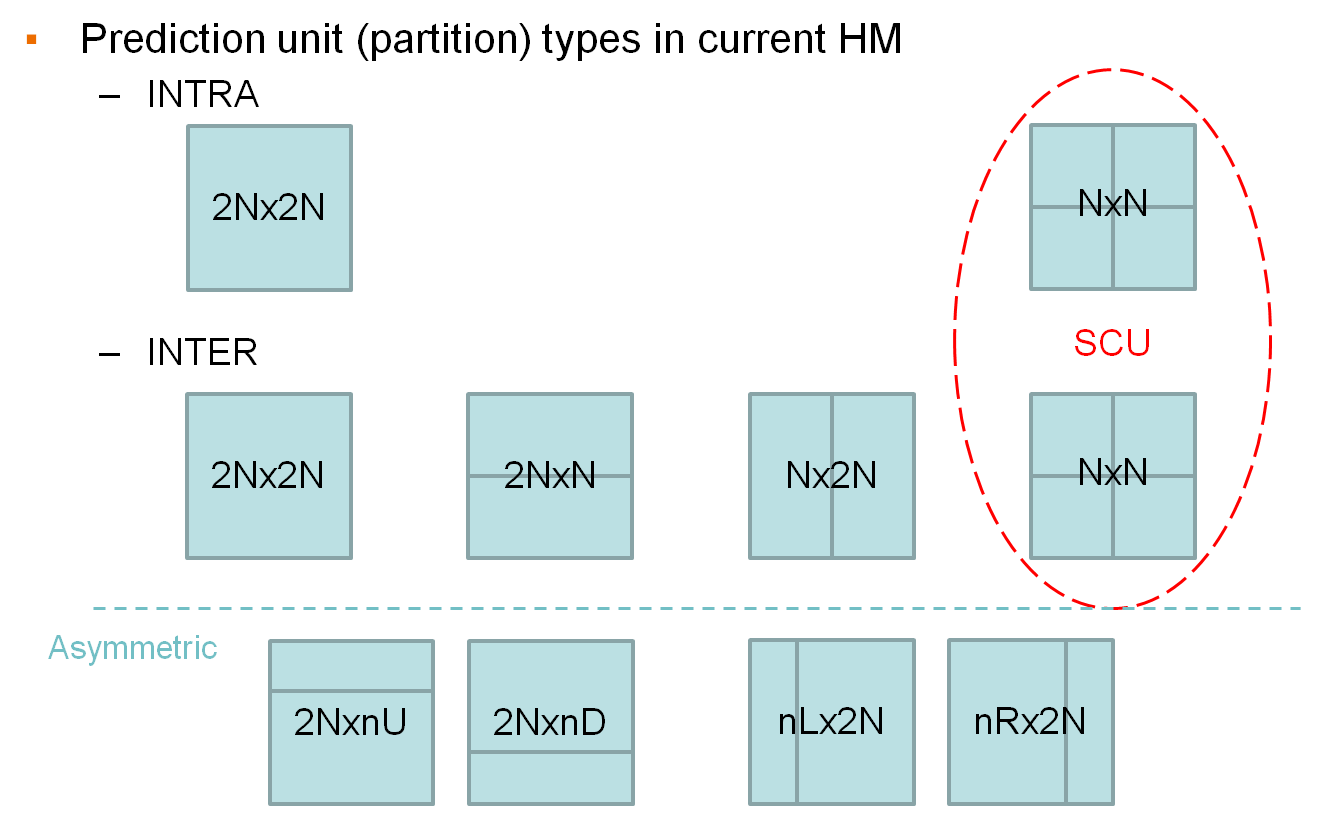


Figure 1 PU (partition) types for a 2Nx2N CU in HM4.0.

Table 1 Partition types and binarization for Intra prediction in HM5.0.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Slice type** | **Value of pred\_type** | **PredMode** | **PartMode** | **Bin string** | |
| log2CUSize > 3 | log2CUSize ==3 |
| I | 0 | MODE\_INTRA | PART\_2Nx2N | - | 1 |
| 1 | MODE\_INTRA | PART\_NxN | - | 0 |

# Proposed Methods

Based on the AHG16 software, this contribution proposes methods to harmonize 2NxN/Nx2N Intra PU with SDIP and NSQT. The proposed partition types are shown in Figure 2, with PU syntax binarization shown in Table 2. For each proposed rectangular shape (i.e. 2NxN and Nx2N) partition, 35 prediction modes are allowed, the same as those are used for 8x8, 16x16 and 32x32 Intra predictions in HM5.0.

In AHG16 software, two additional context models are used if 2Nx0.5N/0.5Nx2N PU are used. In this contribution, the JCTVC-G135 PU syntax coding is tested for all non-square intra PU coding. The corresponding PU syntax binarization is shown in Table 2. The experimental results are reported.

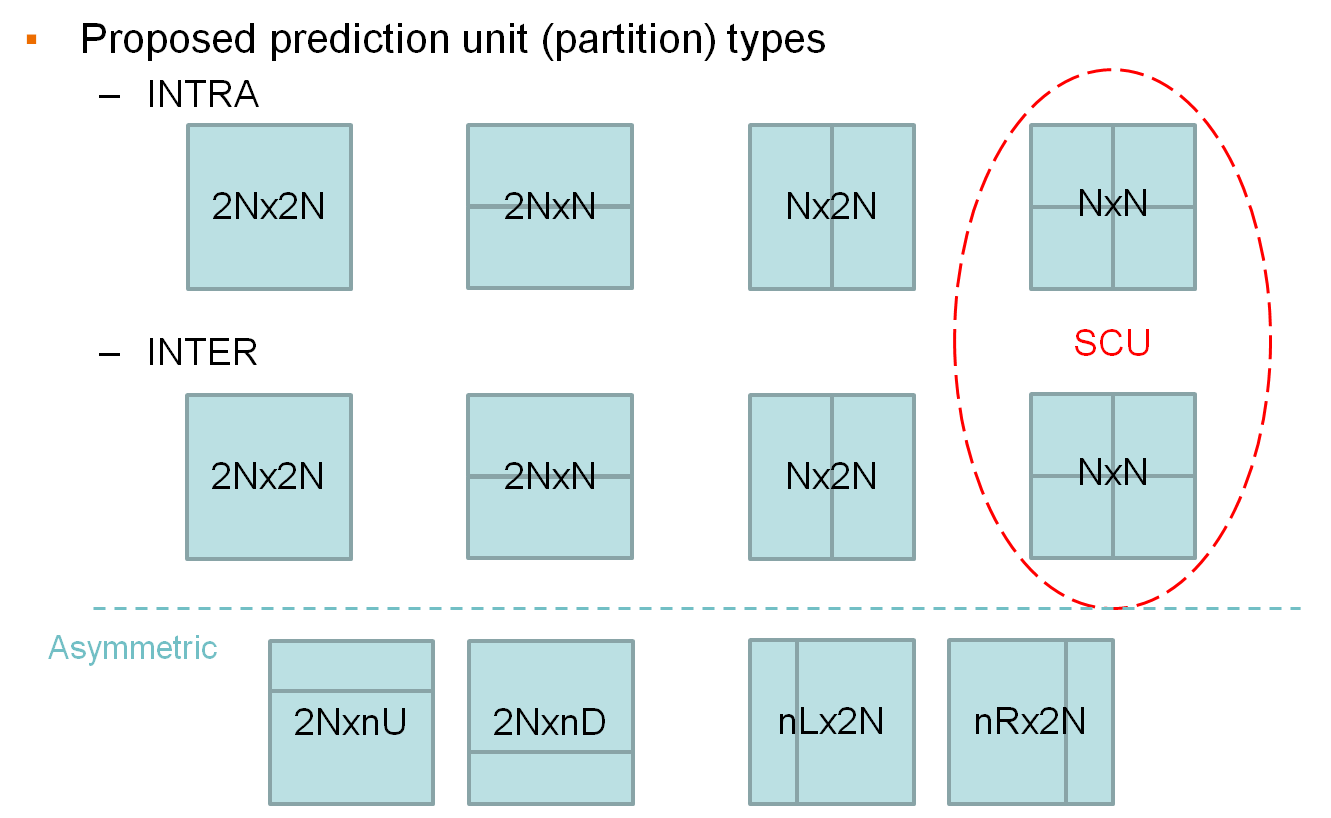


Figure 2 Proposed PU (partition) types for a 2Nx2N CU.

Table 2 Proposed partition types and binarization for Intra prediction.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Slice type** | **Value of pred\_type** | **PredMode** | **PartMode** | **Bin string** | |
| log2CUSize > 3 | log2CUSize ==3 |
| I | 0 | MODE\_INTRA | PART\_2Nx2N | 1 | 1 |
| 1 | MODE\_INTRA | PART\_2NxN | 01 | 001 |
| 2 | MODE\_INTRA | PART\_Nx2N | 00 | 000 |
| 3 | MODE\_INTRA | PART\_NxN | - | 01 |

The transforms used in the proposed harmonization are shown in Table 4.

Table 4 Transform for the proposed Harmonization

|  |  |
| --- | --- |
| **PU Size** | **TU size** |
| 32x16 | 32x8 |
| 16x32 | 8x32 |
| 16x8 | 16x4 |
| 8x16 | 4x16 |
| 8x4 | 8x2/4x4 |
| 4x8 | 2x8/4x4 |

# Encoder complexity reduction

The encoder complexity reduction oriented optimization has been done to achieve better tradeoff between the compression efficiency and the encoding complexity. The optimization is built on the early skip based simplification procedure in AHG16 software.

The complexity reduction consists of two steps. In the first step, the information of coded 2Nx2N PU is used to determine if the non square PU search should be skipped. In the implementation, the number of bits of coding 2Nx2N PU is compared to a content adaptive threshold. The threshold T is calculated as formula (1) when QP is not equal to 0:

T = a \*(64.0 / ((QP < 32)? QP: 64)) (1)

Where variable a set as 5, 10 and 300 for 8x8, 16x16 and 32x32 CU respectively.

The following procedure is used to determine the early skip. If the current CU is 32x32 and the number of bits used by 2Nx2N PU is less than the threshold, the non-square PU will be checked. Otherwise, the non-square PU will be skipped. If the current CU is 16x16 or 8x8 and the number of bits used by 2Nx2N PU is larger than the threshold, the non-square PU will be checked. Otherwise, the non-square PU will be skipped.

In the current HM, the intra prediction mode decision is done by two steps. In the first step, a set of M candidate modes were selected from total N modes (M<= N) by minimize the HAD based RD cost, where N is the intra mode number in Table 1, then the final mode was selected from the M candidate modes and the most probable modes by calculate the real rate distortion cost. In the current implementation, we set the M as 3 for 8x4/4x8 PU and 2 for other non square PUs. In addition, not all of the N modes will be checked by HAD based RD cost for each non-square PU. In the AHG software, only the following modes in the HAD loop are checked: K candidate modes selected in 2Nx2N and the modes whose number is smaller than 10. K is 8 for 8x8 CU and 3 for 16x16 and 32x32 CU.

When 4x4 TU is used for 8x4/4x8 PU, new optimization is added for the encoder complexity reduction. The following early skip procedure is used. If the current CU is 8x8 and the RD cost of NxN is larger than the RD cost of 2Nx2N, the 8x4/4x8 PU checking will be skipped. In the HAD loop, only the following modes in the HAD loop are checked: K candidate modes selected in 2Nx2N and the modes whose number is smaller than 4. Besides that, the number of selected candidate modes M (from HAD loop) is set as 2 for all non-square PUs. During the final real RDO mode decision, the modes that are selected by Intra NxN search are added as the additional candidates.

# Experimental Results

Simulations were conducted following common test conditions defined in JCTVC-1000 [1]. Anchor data was generated using HM5.0 software [2]. Results produced by current software implementation are reported in the following tables.

## Results with 8x2/2x8 transform

Table 5 reports the results of using 4x4 TU for 8x4/4x8 PU in 8x8 CU intra prediction.

Table 5. Results with 8x2/2x8 transform (AhG16 case 1)

|  |  |  |  |
| --- | --- | --- | --- |
|  | **All Intra HE** | | |
|  | Y | U | V |
| Class A (8bit) | -1.3% | -3.6% | -4.1% |
| Class B | -1.5% | -3.6% | -3.7% |
| Class C | -1.9% | -2.7% | -2.9% |
| Class D | -1.8% | -2.5% | -2.5% |
| Class E | -2.3% | -6.7% | -6.4% |
| **Overall** | -1.8% | -3.6% | -3.7% |
|  | -1.8% | -3.7% | -3.7% |
| Class F | -4.84% | -5.19% | -5.21% |
| Enc Time[%] | 132%+ | | |
| Dec Time[%] | 103% | | |

+ The encoder runtime reported by AhG16 using the same software is 128%.

## Results without 8x2/2x8 transform

Table 6 and table 7 report the results of using 4x4 TU for 8x4/4x8 PU in 8x8 CU intra prediction. The processing for 16x4/4x16, 32x8/8x32 intra PU remain the same as AHG16 software. Table 6 results are based on the same encoder optimization as AHG16 software. Table 7 results are based on the combined encoder optimization with further complexity reduction described in Section 3.

Table 6. Results with 8x2/2x8 transform.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **All Intra HE** | | |
|  | Y | U | V |
| Class A (8bit) | -1.4% | -3.7% | -4.2% |
| Class B | -1.3% | -3.4% | -3.5% |
| Class C | -1.3% | -2.4% | -2.5% |
| Class D | -1.2% | -1.9% | -1.9% |
| Class E | -2.2% | -7.2% | -6.7% |
| **Overall** | -1.4% | -3.5% | -3.6% |
|  | -1.4% | -3.5% | -3.5% |
| Class F | -1.2% | -1.7% | -1.7% |
| Enc Time[%] | 131% | | |
| Dec Time[%] | 102% | | |

Table 7. Results without 8x2/2x8 transform (AhG16 case 3b).

|  |  |  |  |
| --- | --- | --- | --- |
|  | **All Intra HE** | | |
|  | Y | U | V |
| Class A (8bit) | -1.1% | -3.4% | -4.0% |
| Class B | -1.1% | -3.3% | -3.4% |
| Class C | -1.0% | -2.2% | -2.3% |
| Class D | -0.9% | -1.8% | -1.7% |
| Class E | -2.0% | -6.9% | -6.4% |
| **Overall** | -1.2% | -3.3% | -3.4% |
|  | -1.2% | -3.3% | -3.4% |
| Class F | -1.0% | -1.6% | -1.7% |
| Enc Time[%] | 123%+ | | |
| Dec Time[%] | 102% | | |

+ The encoder runtime reported by AhG16 using the same software is 120%.

## Results of using proposed signaling

Table 8 reports the results produced by using the proposed PU type signaling on 2Nx0.5N/0.5Nx2N PU on AHG16 software.

Table 8. Results with proposed PU type signaling on 2Nx0.5N/0.5Nx2N PU.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra HE (AHG16 case2)** | | | **All Intra HE (AHG16+proposed signaling)** | | |
|  | Y | U | V | Y | U | V |
| Class A (8bit) | -1.4% | -3.8% | -4.3% | -1.4% | -3.7% | -4.3% |
| Class B | -1.4% | -3.6% | -3.8% | -1.4% | -3.5% | -3.8% |
| Class C | -1.8% | -2.5% | -2.7% | -1.8% | -2.5% | -2.7% |
| Class D | -1.7% | -2.3% | -2.2% | -1.8% | -2.2% | -2.2% |
| Class E | -2.2% | -6.8% | -6.4% | -2.2% | -6.7% | -6.4% |
| **Overall** | -1.7% | -3.6% | -3.7% | -1.7% | -3.6% | -3.7% |
|  | -1.7% | -3.6% | -3.7% | -1.7% | -3.6% | -3.7% |
| Class F | -5.9% | -6.0% | -6.2% | -5.8% | -5.8% | -6.1% |
| Enc Time[%] | 132% | | | 132% | | |
| Dec Time[%] | 103% | | | 103% | | |

# Conclusions

This contribution reports methods and results for harmonization of 2NxN/Nx2N PU with SDIP and NSQT. Experimental results report average 1.8% BD-rate reduction for All Intra HE with encoding runtime increased by 32%1 and decoding runtime increased by 3% with 8x2/2x8 transform enabled. Experimental results report average 1.4% BD-rate reduction for All Intra HE with encoding runtime increased by 31% and decoding runtime increased by 2% when 8x2/2x8 transform disabled. With further encoder complexity reduction, experimental results report average 1.2% BD-rate reduction for All Intra HE with encoding runtime increased by 23%2 and decoding runtime increased by 2%. By applying the proposed PU type signaling on 2Nx0.5N/0.5Nx2N intra prediction unit, experimental results report average 0.0% BD-rate difference for All Intra HE with negligible encoding and decoding runtime change compared to AHG16 software. Two context models can be removed. It is recommended to include the proposed methods in HM.

# Patent rights declaration(s)

**MediaTek Inc. may have current or pending patent rights relating to the technology described in this contribution and, conditioned on reciprocity, is prepared to grant licenses under reasonable and non-discriminatory terms as necessary for implementation of the resulting ITU-T Recommendation | ISO/IEC International Standard (per box 2 of the ITU-T/ITU-R/ISO/IEC patent statement and licensing declaration form).**

# References

1. Frank Bossen, “Common test conditions and software reference configurations”, JCTVC-G1000, Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T VCEG and ISO/IEC MPEG, Geneva, Switzerland, Nov 2011.
2. HM 5.0 Software, <http://hevc.kw.bbc.co.uk/trac/browser/tags/HM-5.0>.