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| *Title:* | **Results for Non-Square Intra Prediction with NSQT** | | | |
| *Status:* | Input Document to JCT-VC | | | |
| *Purpose:* | Proposal | | | |
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# Abstract

This contribution reports methods and results for utilizing non-square intra prediction with NSQT. The fundamentals are same as the methods proposed in AHG16 in the 8th JCT-VC meeting. The coding efficiency and run-time of the proposed methods built on top of HM6.0 software are reported. Experimental results report average 1.3% BD-rate reduction for All Intra HE10 with encoding runtime increase of 31%. For Random access HE10, experimental results report average 0.6% BD-rate reduction with encoding runtime increase of 4%. For Low delay HE10, experimental results report average 0.3% BD-rate reduction with encoding runtime increase of 3%. The average decoding runtime variation is negligible. With further encoder complexity reduction, experimental results report average 1.1% BD-rate reduction for All Intra HE10 with encoding runtime increase of 22% and negligible decoding runtime variation.

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.

In the 8th JCTVC meeting, Ad-Hoc group (AHG) 16 [1,2] investigated the unification of non-square intra prediction with the Inter prediction, especially NSQT [3]. Based on experts’ comments, we integrated non-square intra prediction with NSQT on HM6.0 [4] software.

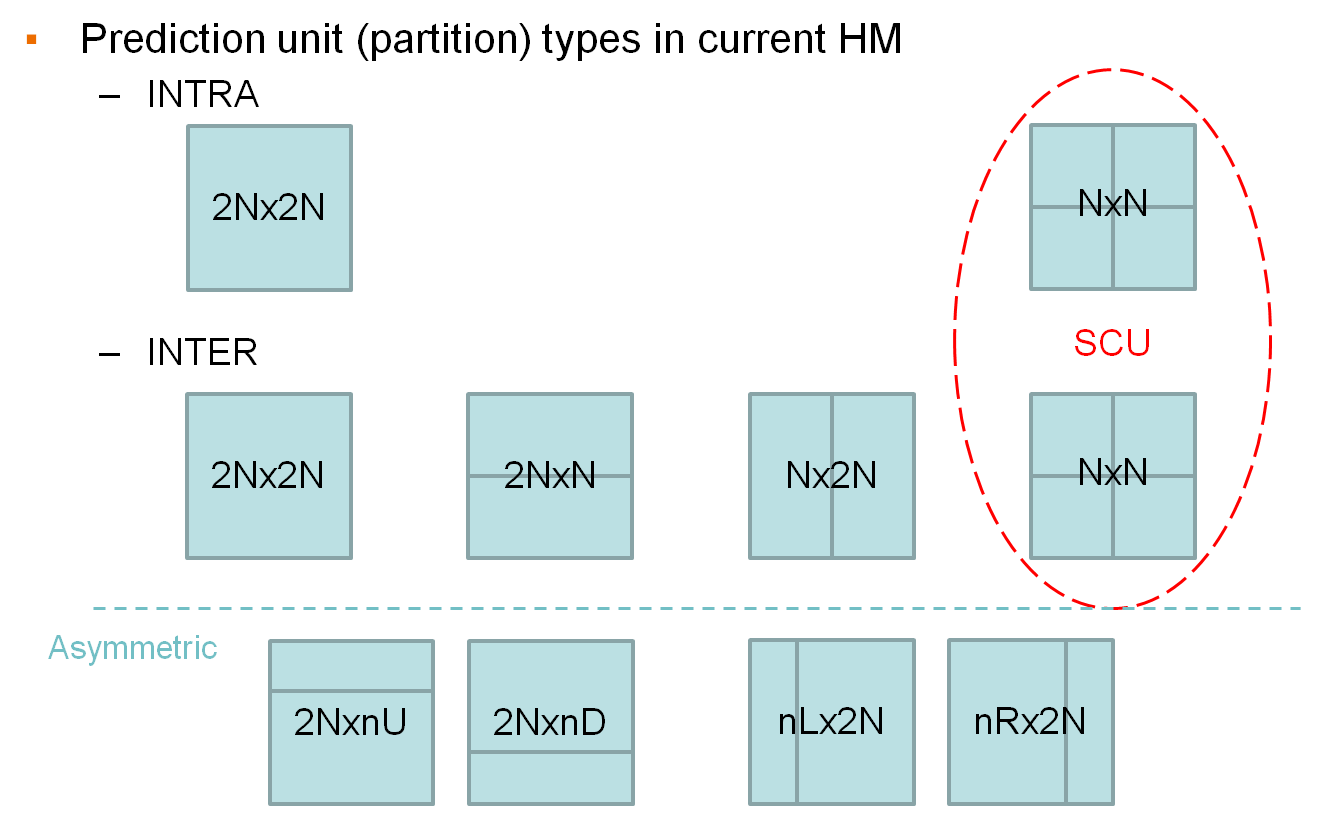


Figure 1. PU (partition) types for a 2Nx2N CU in HM6.0.

Table 1. Partition modes and binarization for Intra prediction in HM6.0.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| PredMode | Value of PartMode | PartMode | Bin string | |
| log2CUSize > 3 | log2CUSize == 3 |
| INTRA | 0 | PART\_2Nx2N | - | 1 |
| 1 | PART\_NxN | - | 0 |

# Proposed Methods

Based on the HM6.0 software, this contribution proposes to include 2NxN and Nx2N partition modes for Intra prediction and apply NSQT to them. 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 HM6.0.

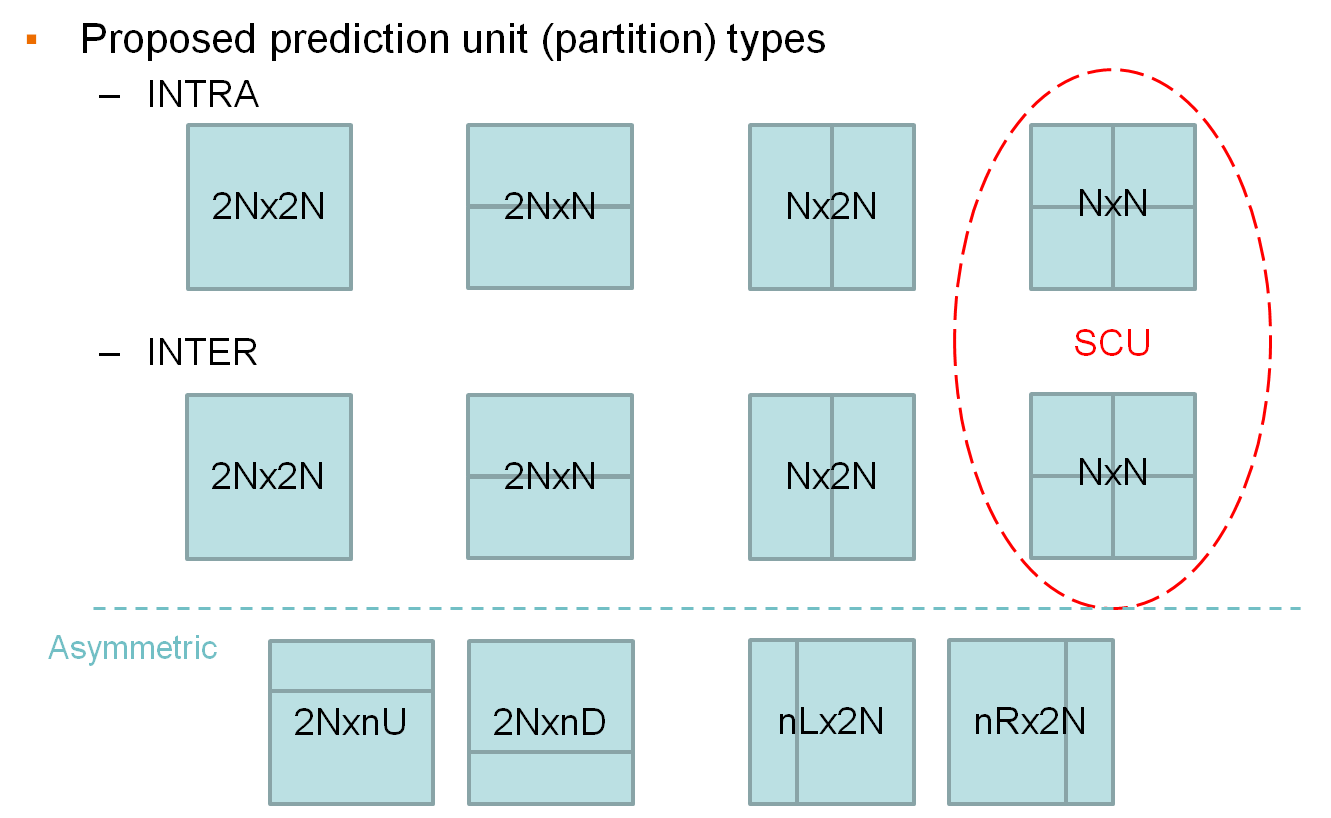


Figure 2. Proposed PU (partition) types for a 2Nx2N CU.

Table 2. Proposed partition modes and binarization for Intra prediction.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| PredMode | Value of PartMode | PartMode | Bin string | |
| log2CUSize > 3 | log2CUSize == 3 |
| INTRA | 0 | PART\_2Nx2N | 1 | 1 |
| 1 | PART\_NxN | - | 01 |
| 2 | PART\_2NxN | 01 | 001 |
| 3 | PART\_Nx2N | 00 | 000 |

A set of non-square transforms as defined in NSQT [3] that have been adopted for Inter prediction are applied to non-square the proposed Intra prediction. The corresponding CU, PU and TU block sizes in Luma samples are shown in Table 3. TU depth is set as zero for Chroma.

Table 3. CU, PU and TU relationship for the proposed scheme.

|  |  |  |
| --- | --- | --- |
| CU | Proposed non-square PU | TU |
| 32x32 | 32x16 | 32x8 |
| 16x32 | 8x32 |
| 16x16 | 16x8 | 16x4 |
| 8x16 | 4x16 |
| 8x8 | 8x4 | 4x4 |
| 4x8 | 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 10, 15 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 total number of intra modes 35, 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 2 for 32x16/16x32 and 16x8/8x16 PUs. In addition, not all of the N modes will be checked by HAD based RD cost for each non-square PU. Only the following modes in the HAD loop are checked: K candidate modes selected in 2Nx2N and 11 modes that evenly sampled from the 35 modes (0, 1, 2, 6, 10, 14, 18, 22, 26, 30, 34). K is 3 for 16x16 and 32x32 CU.

For 8x4/4x8 PU, the HAD loop is skipped. Up to five candidate modes are checked to calculate the true rate-distortion (R-D) cost: The first two most probable modes from 3 MPM, up to two modes that are selected by Intra NxN search and Planar mode.

Besides above optimizations, additional optimization can be added for further 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 Planar, DC, Vertical and Horizontal mode. Besides that, the number of selected candidate modes M for calculating true R-D cost is set as 2 for non-square PUs when CU is 32x32 and 16x16.

# Experimental Results

Simulations were conducted following common test conditions defined in JCTVC-H1100 [5]. Anchor data was generated using HM6.0 software [4]. Results produced by current software implementation are reported in the following tables.

Table 4 reports the results of All Intra HE10 configuration.

Table 4. Results for All Intra HE10 configuration

|  |  |  |  |
| --- | --- | --- | --- |
|  | **All Intra HE10** | | |
|  | Y | U | V |
| Class A | -0.9% | -2.5% | -2.7% |
| Class B | -1.3% | -3.0% | -3.3% |
| Class C | -1.3% | -2.5% | -2.8% |
| Class D | -1.2% | -1.9% | -1.8% |
| Class E | -2.0% | -3.5% | -4.4% |
| **Overall** | -1.3% | -2.7% | -3.0% |
|  | -1.3% | -2.7% | -3.0% |
| Class F | -1.3% | -1.6% | -1.4% |
| Enc Time[%] | 131% | | |
| Dec Time[%] | 101% | | |

Table 5 reports the results of Random Access HE10 configuration.

Table 5. Results for Random Access HE10 configuration.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Random Access HE10** | | |
|  | Y | U | V |
| Class A | -0.6% | -1.1% | -2.0% |
| Class B | -0.7% | -1.5% | -1.6% |
| Class C | -0.6% | -1.4% | -1.6% |
| Class D | -0.5% | -0.8% | -0.8% |
| Class E |  |  |  |
| **Overall** | -0.6% | -1.2% | -1.5% |
|  | -0.6% | -1.2% | -1.5% |
| Class F | -0.9% | -1.2% | -1.1% |
| Enc Time[%] | 104% | | |
| Dec Time[%] | 100% | | |

Table 6 reports the results of Low Delay configuration.

Table 6. Results for Low Delay configuration.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Low delay B HE10** | | |
|  | Y | U | V |
| Class A |  |  |  |
| Class B | -0.2% | -1.0% | -0.4% |
| Class C | -0.3% | -0.5% | -0.7% |
| Class D | -0.2% | -1.1% | -0.2% |
| Class E | -0.4% | -1.1% | -1.7% |
| **Overall** | -0.3% | -0.9% | -0.6% |
|  | -0.3% | -0.8% | -0.6% |
| Class F | -0.5% | -1.0% | 0.8% |
| Enc Time[%] | 103% | | |
| Dec Time[%] | 100% | | |

Table 7 reports the results of All Intra HE10 configuration with additional encoding complexity reduction.

Table 7. Results for All Intra HE10 configuration with additional encoding complexity reduction.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **All Intra HE10** | | |
|  | Y | U | V |
| Class A | -0.7% | -2.4% | -2.5% |
| Class B | -1.1% | -3.0% | -3.3% |
| Class C | -1.0% | -2.4% | -2.6% |
| Class D | -0.9% | -1.8% | -1.8% |
| Class E | -1.8% | -3.4% | -4.4% |
| **Overall** | -1.1% | -2.6% | -2.9% |
|  | -1.1% | -2.6% | -2.9% |
| Class F | -1.1% | -1.5% | -1.5% |
| Enc Time[%] | 122% | | |
| Dec Time[%] | 101% | | |

# Conclusions

This contribution reports methods and results for applying non-square intra prediction with NSQT. The fundamentals are same as the methods proposed in AHG16 in the 8th JCTVC meeting. The coding efficiency and run-time of the proposed methods built on top of HM6.0 software are reported. Experimental results report average 1.3% BD-rate reduction for All Intra HE10 with encoding runtime increased by 31% and minor decoding runtime variation. For Random access HE10, Experimental results report average 0.6% BD-rate reduction with encoding runtime increased by 4% and minor decoding runtime variation. For Low delay HE10, Experimental results report average 0.3% BD-rate reduction with encoding runtime increased by 3% and minor decoding runtime variation. With further encoder complexity reduction, experimental results report average 1.1% BD-rate reduction for All Intra HE10 with encoding runtime increased by 22% and minor decoding runtime variation. Compared to AHG16 in 8th meeting, the working draft change is significantly reduced. 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).**

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