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| **Joint Collaborative Team on Video Coding (JCT-VC)**  **of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11**  8th Meeting: San Jose, 1-10 Feb, 2012 | Document: JCTVC-H0437  WG11 Number: m23313 |

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| *Title:* | **CE6.b: Rectangular (2NxN and Nx2N) PU for Intra Prediction** | | | |
| *Status:* | Input Document to JCT-VC | | | |
| *Purpose:* | Proposal | | | |
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# Abstract

This contribution reports the results of the method previously proposed in JCTVC-G135 [1] and its harmonization with NSQT on HM5. In JCTVC-G135, it was proposed to add two prediction unit (PU) types (i.e. 2NxN and Nx2N) to Intra coding units (CU) in addition to the existing PU types (i.e. 2Nx2N and NxN) in current HM. Experimental results report average 1.7% BD-rate reduction for All Intra HE with G135 proposed method. With the current implementation, encoder runtime is increased by 33% and decoding runtime is increased 2%. With 8x2/2x8 transform, experimental results on the harmonization with NSQT reports average 1.54 BD-rate reduction for All Intra HE with 33% encoding time and 2% decoding time increase respectively. Without 8x2/2x8 transform, experimental results on the harmonization with NSQT reports average 1.0 BD-rate reduction for All Intra HE with 25% encoding time and 1% decoding time increase respectively. Experimental results of methods G135 on Random Access HE report average 0.8 BD-rate reduction with 6% encoding time and 1% decoding time increase respectively, Low Delay B HE report average 0.3 BD-rate reduction with 4% encoding time and 1% decoding time increase respectively.

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.

# Proposed Methods

In JCTVC-G135[1], it is proposed to add two rectangular shape partition types to Intra prediction, i.e. 2NxN and Nx2N Intra prediction, to current HEVC/HM. Consequently, in the proposed scheme, an Intra 2Nx2N CU may consist of one 2Nx2N PU, two 2NxN or Nx2N PUs, or four NxN PUs if it is an SCU. The proposed partition types are shown in Figure 2, with 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 Geneva meeting in Nov, 2011, the experts expressed the desire of harmonization between NSQT and the non-square intra PU/TU. In this contribution, the harmonization between NSQT and the G135 proposed PU/TU are proposed. The experimental results are reported.

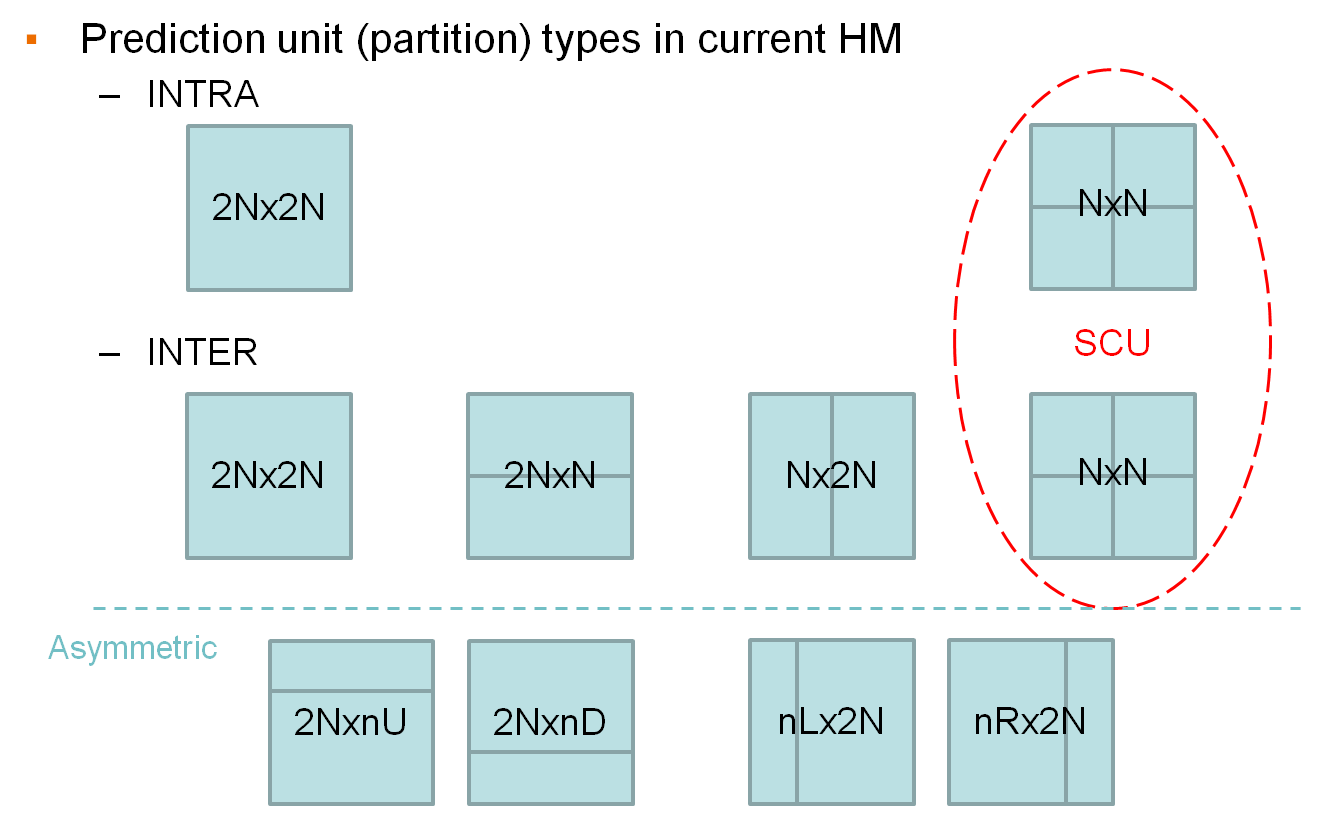


Figure 1 PU (partition) types for a 2Nx2N CU in HM5.0.

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 |

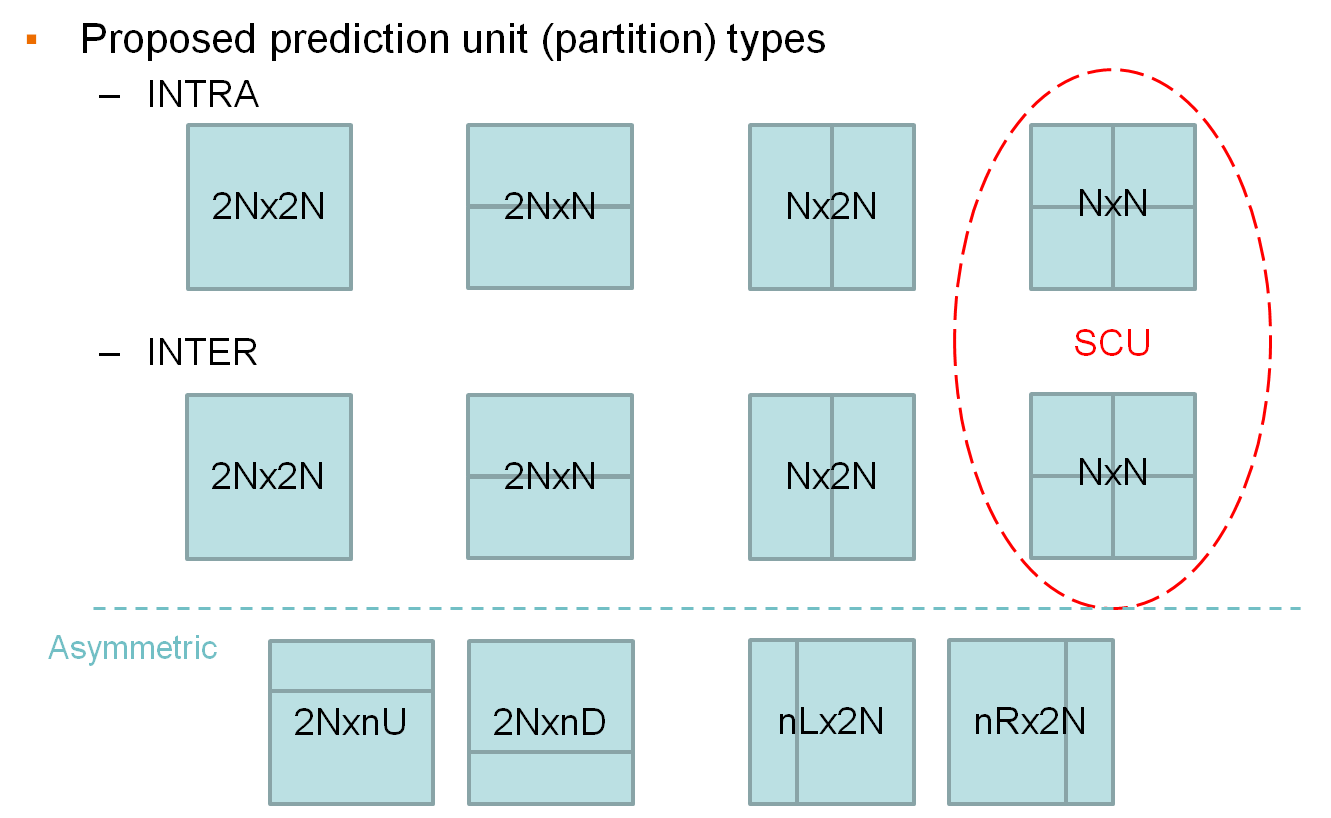


Figure 2 Proposed PU (partition) types for a 2Nx2N CU.

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 current G135 based implementation are shown in Figure 3 and Table 3. They are the same as those have been used in the previously proposed SDIP (Short Distance Intra Prediction) method [4]. The transforms used in the proposed NSQT harmonization implementation is shown in Table 4.

Figure 3 Transform for the proposed rectangular Intra PUs.

Table 3 Transform for G135.

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

Table 4 Transform for the proposed Harmonization

|  |  |
| --- | --- |
| **PU Size** | **TU size** |
| 32x16 | 32x8, 16x4 |
| 16x32 | 8x32, 4x16 |
| 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 proposed by JCTVC-G556[4].

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 three most probable modes by calculate the real RD cost. In the current implementation, we set the M as 2 for 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 implementation, the G135 based results are obtained by only checking the following modes in the HAD loop: K candidate modes selected in 2Nx2N and the modes whose number is smaller than 19. K is 8 for 8x8 CU and 3 for 16x16 and 32x32 CU.

The G135 & NSQT harmonization results are obtained by only checking the following modes in the HAD loop: the K candidate modes selected in 2Nx2N and the modes whose number is smaller than 4. The three most probable modes for second stage RD mode decision in the above is fall back to the original HM5.0.

# Experimental Results

Simulations were conducted following common test conditions defined in JCTVC-1000 [2]. Anchor data was generated using HM5.0 software [3].

## G135method

The results for the proposed G135 method are reported in table 5.

Table 5 Results for G135 proposed 2NxN/Nx2N PU based Intra prediction.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra HE** | | | **All Intra HE-10** | | |
|  | Y | U | V | Y | U | V |
| Class A (8bit) | -1.0% | -2.1% | -2.7% | -0.7% | -1.5% | -1.7% |
| Class B | -1.4% | -2.3% | -2.4% | -1.4% | -2.2% | -2.3% |
| Class C | -1.8% | -1.9% | -2.0% | -1.8% | -1.8% | -2.0% |
| Class D | -1.8% | -1.6% | -1.6% | -1.8% | -1.6% | -1.6% |
| Class E | -2.4% | -5.5% | -4.8% | -2.4% | -5.3% | -4.8% |
| **Overall** | -1.7% | -2.5% | -2.6% | -2.1% | -2.6% | -2.6% |
|  | -1.7% | -2.5% | -2.5% | -2.1% | -2.6% | -2.6% |
| Class F | -5.1% | -4.4% | -4.2% | -5.0% | -4.2% | -4.1% |
| Enc Time[%] | 133% | | | 132% | | |
| Dec Time[%] | 102% | | | 102% | | |
|  |  |  |  |  |  |  |
|  | **Random Access HE** | | | **Random Access HE-10** | | |
|  | Y | U | V | Y | U | V |
| Class A (8bit) | -0.6% | -1.6% | -2.1% | -0.5% | -0.9% | -0.5% |
| Class B | -0.7% | -1.3% | -1.3% | -0.7% | -1.1% | -1.2% |
| Class C | -0.9% | -1.1% | -1.1% |  |  |  |
| Class D | -0.7% | -0.9% | -0.7% |  |  |  |
| Class E |  |  |  |  |  |  |
| **Overall** | -0.8% | -1.2% | -1.2% | -0.6% | -1.0% | -0.9% |
|  | -0.8% | -1.2% | -1.2% | -0.6% | -1.0% | -0.9% |
| Class F | -3.7% | -3.3% | -3.1% |  |  |  |
| Enc Time[%] | 106% | | | 106% | | |
| Dec Time[%] | 101% | | | 101% | | |
|  |  |  |  |  |  |  |
|  | **Low delay B HE** | | |
|  | Y | U | V |
| Class A |  |  |  |
| Class B | -0.2% | -0.4% | -0.3% |
| Class C | -0.3% | -0.6% | -0.3% |
| Class D | -0.2% | -0.8% | -0.5% |
| Class E | -0.6% | -0.9% | -3.4% |
| **Overall** | -0.3% | -0.6% | -0.9% |
|  | -0.3% | -0.6% | -0.9% |
| Class F | -2.2% | -2.2% | -2.4% |
| Enc Time[%] | 104% | | |
| Dec Time[%] | 101% | | |

## G135 Harmonization with NSQT

The results for the proposed harmonization are reported in table 6 and table 7.

Table 6 Results for proposed NSQT harmonization without 8x2/2x8 transform.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **All Intra HE** | | |
|  | Y | U | V |
| Class A (8bit) | -0.8% | -2.0% | -2.6% |
| Class B | -0.9% | -2.1% | -2.2% |
| Class C | -0.9% | -1.6% | -1.7% |
| Class D | -0.8% | -1.1% | -1.1% |
| Class E | -1.6% | -4.6% | -4.0% |
| **Overall** | -1.0% | -2.2% | -2.2% |
|  | -1.0% | -2.1% | -2.2% |
| Class F | -0.9% | -1.2% | -1.0% |
| Enc Time[%] | 125% | | |
| Dec Time[%] | 101% | | |

Table 7 Results for proposed NSQT harmonization with 8x2/2x8 transform.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **All Intra HE** | | |
|  | Y | U | V |
| Class A (8bit) | -0.91% | -2.00% | -2.57% |
| Class B | -1.25% | -2.07% | -2.21% |
| Class C | -1.74% | -1.82% | -1.97% |
| Class D | -1.73% | -1.52% | -1.51% |
| Class E | -1.90% | -4.76% | -4.09% |
| **Overall** | -1.54% | -2.33% | -2.35% |
|  | -1.54% | -2.32% | -2.33% |
| Class F | -5.0% | -4.1% | -4.1% |
| Enc Time[%] | 133% | | |
| Dec Time[%] | 102% | | |

# Conclusions

This contribution reports the method and results of CE6.b subsets which includes JCTVC-G135 proposed method and its harmonization with the NSQT. The coding efficiency and run-time of the proposed methods on HM5.0 software are reported. Experimental results report average 1.7% BD-rate reduction for All Intra HE with G135 proposed method. With the current implementation, encoder runtime is increased by 33% and decoding runtime is increased 2%. With 8x2/2x8 transform, experimental results on the harmonization with NSQT reports average 1.54 BD-rate reduction for All Intra HE with 33% encoding time and 2% decoding time increase respectively. Without 8x2/2x8 transform, experimental results on the harmonization with NSQT reports average 1.0 BD-rate reduction for All Intra HE with 25% encoding time and 1% decoding time increase respectively. Experimental results of G135 methods on Random Access HE report average 0.8 BD-rate reduction with 6% encoding time and 1% decoding time increase respectively, Low Delay B HE report average 0.3 BD-rate reduction with 4% encoding time and 1% decoding time increase respectively. It is recommended to include the proposed 2NxN/Nx2N PU 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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