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| *Title:* | **Core Experiment 6: Intra Prediction Improvement** | |
| *Status:* | Output Document to JCT-VC | |
| *Purpose:* | CE Description | |
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# Abstract

This output document provides a list and description of Core Experiment 6 (CE6) on Intra Prediction Improvements.

# Introduction

Intra prediction improvement core experiments are divided into 5 categories

1. CE6.a: Block based Intra Prediction
2. CE6.b: Short Distance Intra Prediction (SDIP) Harmonization
3. CE6.c: Differential Coding of Intra Mode (DCIM)
4. CE6.d: Parallel Intra Coding
5. CE6.e: Intra Smoothing

# Experimental Conditions

## Software

CE will be implemented into the HM3.0 software that is recommended by the TM software group at the end of Geneva meeting. In addition, SDIP related subtests will be implemented into HM-SDIP software; in those subtest, cross-checkers will have to allocate additional resources for generating HM-SDIP based anchors.

## Test Sequences, Bit Rates and Coding Conditions

In this CE, the recommended Test conditions of Intra-only configuration and Test sequences as defined in the document JCTVC-E700 and provided in the reference config files by the TM software group will be used for all sub-CE tests. The participants could consider either Intra High Efficiency or Intra Low Complexity or both. In addition, the AIS flag needs to be set to “ON” (default HM3.0). AIS related CEs can be done independently.

## Evaluation of CE Results

Results of the CE will be evaluated on the basis of BD-measures. In addition subjective evaluation to support the advantage of the proposed tools is highly desirable.

## Evaluation of Complexity

For the complexity measurement, the anchor, the reference software and the reference software with the tool implemented will be executed on the same machine and the computational time will be measured for each software. Then, a time factor is calculated which compares the reference software including the sub-CE test tool and the reference software without the tool.

# Timelines

|  |  |
| --- | --- |
| **April 15, 2011** | **HM3.0** software available |
| **Geneva + 2Wks** | Deadline for sending email to coordinator expressing interest to participate in core experiment. |
| **June 22, 2011** | Distribution of SW for Cross Check |
| **June 29, 2011** | Cross-verification completed CE. |
| **July 1, 2011** | Report the verification results uploading |

# 

# Description of Tool Experiment

## CE6.a: Block Based Intra Prediction

### Bi-predictive Uni-Directional Intra (BUDI) Mode

JCTVC-E286 & JCTVC-D300 proposed Bi-predictive UDI Intra mode (BUDI) by using linear interpolation between two corresponding reference samples from main and side reference arrays, respectively. The purpose of this CE subset is to study the trade-off between coding performance and complexity. In addition, combination of BUDI with the adopted planar prediction will be considered.

The followings items will be investigated in this CE: (1) to study the performance of LUT-based and LUT-free implementations of BUDI; (2) To investigate signal method of BUDI modes as additional intra mode, instead of replacing the existing Intra mode 6; (3) To investigate on the interaction between BUDI and the planar prediction adopted in this meeting.

### Software

BUDI will be implemented into HM3.0 and the HM-SDIP branch.

### Test plan

1. Evaluate LUT-based and LUT-free BUDI implementations by replacing the existing Intra mode 6 with BUDI. (Note: Anchors are HM3.0 and HM-SDIP branch.)
2. Evaluate BUDI mode signaling as an additional mode. (Note: Anchors are the results of the test (1).)
3. Evaluate harmonized BUDI and Planar prediction mode signaling. (Note: Anchors are the results of either the test (1) or test (2).)
4. Test BUDI on top of both HM3.0 and HM-SDIP branch.

### Timelines

|  |  |
| --- | --- |
| **April 15, 2011** | HM3.0 software available |
| **May 4** | HM-SDIP software available |
| **June 1, 2011** | HM3.0 with BUDI software is available. Start its cross verification  tests. |
| **June 15, 2011** | HM-SDIP with BUDI software is available. Start its cross verification tests. |
| **June 29, 2011** | Complete the tasks of cross-check, and report the results to CE coordinators |
| **July 1, 2011** | Report the verification results and upload input document |

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### Cross-verification assignment

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Cross-checker** | **Test item** | | | | | |
| **HM3.0 based test** | | | **HM-SDIP based test** | | |
| **(1)** | **(2)** | **(3)** | **(1)** | **(2)** | **(3)** |
| I2R | X | X | X |  |  |  |
| Microsoft | X | X | X | X | X | X |
| NEC | X | X | X | X | X | X |
| Qualcomm | X | X | X | X | X | X |

## CE6.b: Short Distance Intra Prediction (SDIP) Harmonization (JCTVC-E278)

This CE subset is to complete and provide the harmonization solution that unifies the adopted SDIP features together with the remaining and existing HM tools from the conclusion of the 5th JCTVC meeting; test and confirm the SDIP performance in the harmonized software; revise and verify and confirm the potential WD text document matches the resulting new HM-SDIP software. In this subtest, cross-checkers shall test Intra-only configurations and can test other configurations optionally. If cross-checkers test other configurations, proponents shall offer their simulation results to them in a timely manner.

### Tests to be performed

1. Interaction between SDIP and RQT  
   In E278, 2-level TU was applied only to some of the SDIP modes such as those in the 16x16 CUs, and the other SDIP modes were further processed by 1-level TU. In this test, harmonization between RQT and SDIP will be done by extending RQT to non-square partitions in SDIP, and up to 3 levels of RQT will be tested for the SDIP modes.

|  |  |
| --- | --- |
| Tests | SDIP with different RQT depth |
| Test 1.1 | 1 |
| Test 1.2 | 2 |
| Test 1.3 | 3 |

1. Interaction between SDIP and Mode-Dependent DCT/DST

To test coding gains from SDIP only, MDDT only, and harmonization of SDIP and MDDT.

|  |  |  |
| --- | --- | --- |
| Tests | SDIP | MDDT |
| Test 2.1 | 0 | 0 |
| Test 2.2 | 0 | 1 |
| Test 2.3 | 1 | 0 |
| Test 2.4 | 1 | 1 |

1. Interaction between SDIP and MDCS

To test coding gains from SDIP only, MDCS only, and harmonization of SDIP and MDCS.

|  |  |  |
| --- | --- | --- |
| Tests | SDIP | MDCS |
| Test 3.1 | 0 | 0 |
| Test 3.2 | 0 | 1 |
| Test 3.3 | 1 | 0 |
| Test 3.4 | 1 | 1 |

1. Harmonization of LM mode and the chroma prediction in SDIP

In the SDIP modes, chroma block was traditionally square block based coded, all four luma prediction modes in the current CU and the four modes 0-3 are tested in mode decision, among which the four luma modes are mapped to low indices and modes 0-3 are mapped to high ones. Only the first five modes by the new indices are searched in mode decision. The new index is then transmitted in the bitstream instead of the original modes. So the current SDIP defines its own chroma prediction based on HM2.0. However, at Geneva meeting, the LM mode (chroma prediction using luma reconstruction) was adopted from E266. In this method, LM mode should have the first index in chroma prediction modes. Accordingly, there is a conflict in mode order when both SDIP and LM are used. Therefore, the harmonization of LM mode and the chroma prediction in SDIP will be investigated in this test.

1. Consistency verification between potential WD and HM software

### Software

CE will be implemented into the HM-SDIP branch.

### Timelines

|  |  |
| --- | --- |
| **Geneva +6 Wks (May 4)** | HM-SDIP software as well as potential WD Text with SDIP available |
| **Geneva + 8Wks (May 18)** | Final CE-description, deadline for expressing interests in joining CE |
| **June 22, 2011** | Start cross verification tests |
| **June 29, 2011** | Complete the tasks of cross-check, and report the results to CE coordinators |
| **July 1, 2011** | Report the verification results and upload input document |

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### Cross-verification assignment

#### Test1: Interaction between SDIP and RQT

|  |  |  |  |
| --- | --- | --- | --- |
| **Cross-checker** | **SDIP with different RQT depth** | | |
| **Depth=1** | **Depth=2** | **Depth=3** |
| Sony | X | X |  |
| HHI |  |  |  |
| TI |  |  |  |
| Nokia |  |  |  |
| NEC | X | X |  |
| Qualcomm | X | X |  |
| I2R |  |  |  |
| Motorola | X | X |  |

Note: Anchor results are HM-SDIP with RQTdepth=3, SDIP=1, MDDT=1, and MDCS=1 with minimum 2D transform size of 16 pixels. Participants shall generate the Anchor results.

#### Test2: Interaction between SDIP and Mode-Dependent DCT/DST

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Cross-checker** | **SDIP = 0** | | **SDIP = 1** | |
| **MDDT=0** | **MDDT=1** | **MDDT=0** | **MDDT=1** |
| Canon |  |  | X |  |
| HHI |  |  |  |  |
| TI |  |  |  |  |
| Nokia |  |  |  |  |
| BBC |  |  | X |  |
| Samsung |  | X |  |  |
| Inria |  | X |  |  |
| NEC |  |  | X |  |
| Sharp |  |  |  |  |
| Orange Labs. | X | X |  |  |
| I2R |  |  |  |  |

Note: Anchor results are HM-SDIP with RQTdepth=3, SDIP=1, MDDT=1, and MDCS=1 with minimum 2D transform size of 16 pixels. Participants shall generate the Anchor results.

Note: SDIP=0 and MDDT=1 in Test2 and SDIP=0 and MDCS=1 in Test3 are the same configuration.

#### Test3: Interaction between SDIP and MDCS

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Cross-checker** | **SDIP=0** | | **SDIP = 1** | |
| **MDCS=0** | **MDCS=1** | **MDCS=0** | **MDCS=1** |
| Sony | X | X | X |  |
| HHI |  |  |  |  |
| TI |  |  |  |  |
| Nokia |  |  |  |  |
| BBC |  |  | X |  |
| Samsung | X | X | X |  |
| Inria | X | X | X |  |
| NEC |  |  | X |  |
| Sharp |  |  |  |  |
| Orange Labs. |  | X |  |  |
| I2R |  |  |  |  |

Note: Anchor results are HM-SDIP with RQTdepth=3, SDIP=1, MDDT=1, and MDCS=1 with minimum 2D transform size of 16 pixels. Participants shall generate the Anchor results.

Note: SDIP=0 and MDDT=1 in Test2 and SDIP=0 and MDCS=1 in Test3 are the same configuration.

#### Test4: Harmonization of LM mode and the chroma prediction in SDIP

|  |  |  |
| --- | --- | --- |
| **Cross-checker** | **SDIP=1** | |
| **proposed=0** | **proposed=1** |
| Canon |  |  |
| HHI |  |  |
| TI |  |  |
| Nokia |  |  |
| BBC |  |  |
| Samsung |  |  |
| Inria |  |  |
| NEC |  |  |
| Qualcomm |  |  |
| Sharp |  | X |
| Orange Labs. |  |  |
| I2R |  |  |
| Motorola |  |  |

Note: Anchor results are HM-SDIP with RQTdepth=3, SDIP=1, MDDT=1, and MDCS=1 with minimum 2D transform size of 16 pixels. Participants shall generate the Anchor results.

Note: proposed = 1 represents the harmonized intra chroma prediction method in SDIP

## CE6.c: Differential Coding of Intra Modes (DCIM) JCTVC-E318

DCIM (Differential Coding of Intra Modes) is a method categorized as Edge based Intra Prediction, which has been evaluated in the past CE [1]. The latest DCIM results are summarized in JCTVC-E318 [2]. In this experiment, the performance of DCIM on the latest reference software i.e., HM3.0 is evaluated. In addition, as listed in the following section, some variations of the component of DCIM and combination with other intra coding tools will be tested, as well.

### List of configuration and combinations to be evaluated

The following configurations and combinations with other intra tools will be evaluated.

a) Interpolation filter for prediction (bilinear vs. 4-tap):

a1. DCIM with bilinear compared to UI with bilinear

a2. DCIM with 4-tap compared to UI with 4-tap

a3. DCIM with 4-tap compared to UI with bilinear

a4. DCIM with bilinear compared to UI with 4-tap

b) Number of intra modes (both UI modes and DCIM modes)

b1. Number of UI modes is same as HM 3.0, Number of DCIM modes is same as JCTVC-E318

b2. Reduced number of intra modes compared to b.1 (Tentatively, 17 modes for UI. It shall be clarified if other configuration will be tested.)

c) Biprediction mode for DCIM

c1. Biprediction mode is used

c2. Biprediction mode is not used

d) Interaction with SDIP

d1. DCIM on, SDIP off

d2. DCIM on, SDIP on

(d3. DCIM off, SDIP on)

(d4. DCIM off, SDIP off)

Note: Since d3 and d4 will be tested in CE6.b, they are not needed to be tested in CE6.c.

The configuration a1+b1+c1+d1 will be used as reference, thus 7 combinations (1 as reference, 3 in set a, 1 in set b, and 1 in set c, and 1 in set d) will be tested.

The interaction with the following intra coding tools might be evaluated:

1. Mode-Dependent DCT/DST [JCTVC-E125, HM 3.0]
   1. DCIM4x4 + DCT4x4, DCIM8x8 + DCT8x8
   2. DCIM4x4 + MDDT4x4, DCIM8x8 + DCT8x8
   3. DCIM4x4 + MDDT4x4, DCIM8x8 + MDDT8x8
2. MDCS: Mode-Dependent Coefficient Scan [HM 3.0]
3. Chroma Intra Prediction by Reconstructed Luma Samples [JCTVC-E266]
4. MDIS with edge directed smoothing [JCTVC-E437]

The interaction should be evaluated by testing combination of DCIM on/off and the target intra tool on/off. The harmonization could be done if necessary and the details of such harmonization shall be reported.

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### Reference

[1] “Description of Core Experiment 6 (CE6): Intra Prediction Improvement”, JCTVC-D606, Daegu, January 2011.

[2] “Differential Coding of Intra Modes”, JCTVC-E318, Geneva, March 2011.

## CE6.d: Parallel Intra Coding

In contribution (JCTVC-E315), the concept of parallel intra-prediction unit (PPU) is introduced. The PPU defines the size of a block that can be coded using parallelization. The motivation is to increase the degree of parallelism for small blocks sizes. The blocks within the PPU are divided into two sets, and blocks within each set are predicted in parallel. The second set of blocks depend on the first set of blocks. For more information, see JCTVC-E315.

In this sub-CE, we will test the coding efficiency degradation of the JCTVC-E315 with different definitions for the first and second set blocks. (Including, a checker board assignment and a vertical assignment.) Additionally, we will consider the case of disabling 4x4 predictions completely as a second point of reference.

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## CE6.e: Intra Smoothing

### JCTVC-D282:”Adaptive intra smoothing”, Qualcomm

In this proposal, an adaptive intra smoothing method is proposed. Multiple filters are introduced and investigated in order to improve the performance of the current intra smoothing method in HM3.0. Filter modes are explicitly and implicitly signaled.

### JCTVC-E437: “On intra coding and MDIS”, Sharp

This proposal seeks to improve the mode dependent intra smoothing (MDIS) technique that was adopted in the previous meeting. MDIS filters the source pixels used for intra prediction with different degrees of smoothing, with the degree determined by the intra prediction direction. The document reports that using edge directed smoothing in the construction of the neighborhood mitigates these issues. For a detailed description of the method see JCTVC-E437.

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