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| *Title:* | **Parallel AMVP candidate list construction** | | |
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| *Purpose:* | Proposal | | |
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# Abstract

This contribution proposes three solutions for parallel construction of AMVP candidate list (AMVPCL) at different parallel levels. Solution one is a CU-based approach and it constructs AMVPCL of all PUs in the same CU in parallel. Solution two is also a CU-based approach but it generates a single AMVPCL for all PUs inside a CU. Solution three is a region-based approach, in which AMVPCL of all PUs in the same region are constructed in parallel. Solution two and solution three are designed to be compatible with the parallel merge/skip mode in HM6.0. It is reported that average BD-rate loss is roughly 0.2% for the solution 1, 0.1% for the solution 2, and 0.0 % for the solution 3.

# Introduction

In the current HEVC framework, there is dependency among neighboring PUs in all inter modes excluding Merge/Skip mode. This makes parallel processing of multiple PUs difficult for both the encoder and decoder in inter modes.

In HM6.0, the AMVPCL consists of both spatial candidates and temporal candidates. Spatial candidates are classified into 2 categories [1], i.e. top category (T-1, Tn and Tn+1) and left category (Lm and Lm+1), as shown in Figure 1(a). In each category, the first available candidate in the search order is added to the AMVPCL. After the spatial candidates are derived, a temporal candidate is added to the AMVPCL, as shown in Figure 1(b). Therefore, the candidate list contains 2 spatial candidates and 1 temporal candidate at most.

With the current HM6.0 design, when encoding a CU, only the first PU in it can immediately derive its AMVPCL while other PU have to wait until its preceding PUs are encoded, as shown in Figure 2. (In Figure 2, different types of candidates are highlighted in different colors. The top ones are in red, the left ones are in blue, the gray ones indicate candidates that are available until they are coded, and the green ones are candidates that are not encoded yet.) Figure 3 provides an example to describe this problem. As can be seen, the derivation process of the AMVPCL as well as the motion estimation process for different PUs must be carried out sequentially.

To meet parallel motion estimation requirement, this contribution proposes three solutions at different parallel levels.

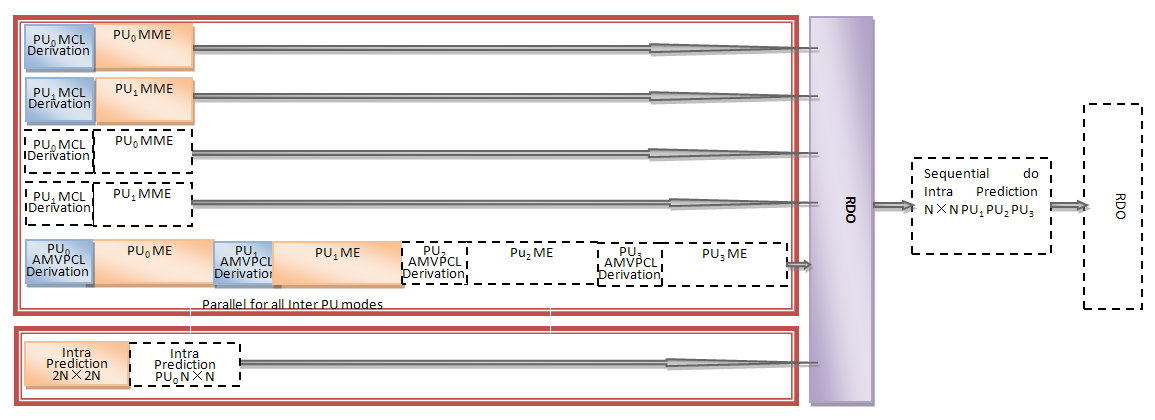


1. Spatial Candidates (b) Temporal Candidates

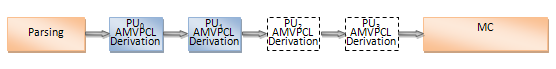
Figure 1. Illustration of the AMVP candidate list construction of HM6.0



**Figure 2.** AMVP candidate list of PUs in a CU



1. Encoder

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(b) Decoder

**Figure 3.** An example of motion estimation in HM6.0

# Algorithm description

## Solution 1

In solution 1, AMVPCL of all PUs in a CU are constructed in parallel. In the parallel AMVPCL construction process, candidates within the CU are unavailable and replaced by corresponding candidates outside the CU. Figure 4 illustrates proposed method for both symmetric motion partition (SMP) cases and asymmetric motion partition (AMP) cases. As can be seen from Figure 4, inner candidates (in gray and green) of the CU are replaced by the corresponding outer candidates pointed by the arrows. Specifically, for above or above right candidate, if it is within the same CU with the current PU, it is replaced by the corresponding candidate of the current PU’s above neighboring PU; for above left, left or below left candidate, if it is within the same CU with the current PU, it is replaced by the corresponding candidate of the current PU’s left neighboring PU.

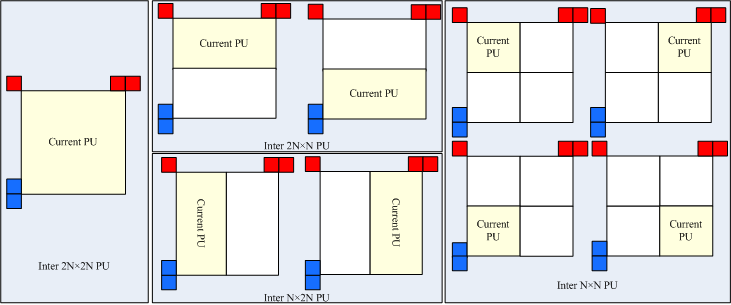




**Figure 4.** Proposed solution: a CU-based approach for AMVP candidate list construction.

## Solution 2

In solution 2, no matter what kind of partition mode a CU uses, all PUs in it uses AMVPCL of the inter 2Nx2N PU. Figure 5 illustrates proposed method for SMP cases, and the same concept also applies to AMP cases. To balance the parallelism and rate-distortion performance, solution 2 is only applied to 8x8 CU. This also makes solution 2 be compatible with the parallel merge/skip MVP mode in HM6.0.



**Figure 5.** Proposed solution: all PUs in the CU share one single AMVPCL.

## Solution 3

Enlightened by [2] which provides a solution for parallel merge/skip MVP list construction, this contribution proposes a parallel AMVPCL construction method. In the proposed method, AMVPCL of all PUs in one motion estimation region (MER) are constructed in parallel. If some involved candidate in AMVPCL construction process is within the current processing MER, it is disabled. To be compatible with parallel merge/skip mode in HM6.0, the syntax element **log2\_parallel\_merge\_level\_minus2** in HM6.0 is used to define the MER.

# Experimental results

The proposed method is implemented on HM6.0 software and compared with it under common test conditions [3].

# Complexity analysis

## Solution 1

From Fig.4, it can be seen that the proposed approach needs 10 additional getting neighboring PU operations for each CU that larger than 8x8 (which have both SMP and AMP partition mode), and 4 additional getting neighboring PU operations for 8x8 CU (which has only SMP partition mode) during the spatial MVP derivation process.

## Solution 2

In the current HM design, every PU has its own AMVPCL for each reference frame in each reference list. On the encoder side, the AMVPCLs to be constructed for motion estimation could reach a very large number. For a 64x64 block, this number is 593xN, in which N is equal to the number of reference frame in all reference lists, as shown in the Table 1. The larger the number, the more occurrence chance of different motion candidates increasing the memory contention possibility. Note that even when the AMVPCLs could be constructed in parallel, the memory can be accessed only in a sequential manner. Thus for high-throughput encoder design, it is desirable to reduce the number of different motion candidates as much as possible. Note that the proposed solution significantly reduces the number of AMVPCLs that should be constructed for motion estimation. Table 5 shows that the AMVPCL number for an 8x8 block is reduced by 80%.

**Table 5. Number of AMVPCLs that should be constructed for 64x64 motion estimation**

|  |  |  |  |
| --- | --- | --- | --- |
| **CU Size** | **AMVPCL construction for a 64x64 block** | | |
| **HM6.0** | **Proposed** | **Ratio to HM6.0** |
| 64x64 | 13\*N | 1\*N | 1 : 13 (7.7%) |
| 32x32 | 13\*4 \*N = 52\*N | 4\*N | 1 : 13 (7.7%) |
| 16x16 | 13\*4\*4\*N = 208\*N | 4\*4 \*N = 16\*N | 1 : 13 (7.7%) |
| 8x8 | 5\*4\*4\*4 \*N = 320\*N | 4\*4\*4\*N = 64\*N | 1 : 5 (20.0%) |
| **Sum** | **593**\*N | **85**\*N | **1 : 7 (14%)** |

## Solution 3

# The proposed parallel AMVPCL construction approach needs to check whether the current PU and its neighboring PU belong to the same MER during the spatial MVP derivation process. However, the complexity increase is negligible compared to the amount of availability checks already needed in the HM6.0 spatial MVP derivation process.

# Conclusion and recommendations

Proposed approaches improve parallelism of all inter modes excluding merge/skip mode hence make the HM design more friendly to high-throughput implementation, at the cost of only small BD-rate increase. It is recommended to review this proposal and adopt proposed approaches into the HEVC test model.

# References

1. Liang Zhao,Xun Guo,Shawmin Lei, Siwei Ma, Debin Zhao, Wen Gao, “Non-CE9: Simplification of AMVP”, JCTVC-H0316, 8th JCT-VC Meeting, San Jose, CA, USA, 1-10 February, 2012.
2. Minhua Zhou, “AHG10: Configurable and CU-group level parallel merge/skip”, JCTVC-H0082, 8th JCT-VC Meeting, San Jose, CA, USA, 1-10 February, 2012.
3. Frank Bossen, “Common test conditions and software reference configurations”, JCTVC-H1100, 8th JCT-VC Meeting, San Jose, CA, USA, 1-10 February, 2012.

# Patent rights declaration(s)

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