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| *Title:* | **On reference picture list construction for uni-predicted partitions** | | |
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| *Purpose:* | Proposal | | |
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# Abstract

This document proposes a different design for reference picture list construction for the creation of the combined reference picture list, LC, for uni-predicted partitions. In the proposed design, LC is not created from the final RefPicList0 and RefPicList1, as is the case in the current HEVC WD, but rather from all short-term and long-term reference pictures, by reusing existing steps of the reference picture list construction process.

# AVC reference picture list construction process

In AVC, one reference picture list is used for coding of each P slice, and two reference picture lists are used for coding of each B slice. The AVC reference picture list construction process consists of three steps:

1. Reference picture list initialization, wherein the initial reference picture list(s), RefPicList0 and, for B slices, RefPicList1, are formed.
2. Reference picture list truncation, as specified by the following text copied from subclause 8.2.2.2 of the AVC specification:
   1. When the number of entries in the initial RefPicList0 or RefPicList1 produced as specified in subclauses 8.2.2.2.1 through 8.2.2.2.2 is greater than num\_ref\_idx\_l0\_active\_minus1 + 1 or num\_ref\_idx\_l1\_active\_minus1 + 1, respectively, the extra entries past position num\_ref\_idx\_l0\_active\_minus1 or num\_ref\_idx\_l1\_active\_minus1 are discarded from the initial reference picture list.
   2. When the number of entries in the initial RefPicList0 or RefPicList1 produced as specified in subclauses 8.2.2.2.1 through 8.2.2.2.2 is less than num\_ref\_idx\_l0\_active\_minus1 + 1 or num\_ref\_idx\_l1\_active\_minus1 + 1, respectively, the remaining entries in the initial reference picture list are set equal to "no reference picture".
3. Reference picture list modification, wherein RefPicList0 and, for B slices, RefPicList1, from the above steps are modified according to reference picture modification commands signaled in the slice header, when present.

# Current HEVC reference picture list construction process

HEVC WD2 includes a modified design for reference picture list construction for B slices. Basically, the modification involves combining the two uni-prediction modes, i.e., Pred\_L0 and Pred\_L1, into a collective uni-prediction mode Pred\_LC, and the reference picture list used for Pred\_LC is a combined reference picture list, named LC, obtained by either of two LC creation processes described below.

In the first LC creation process, LC is created by including the union of the entries in the final RefPicList0 and RefPicList1 (after reference picture list modification) in a specified order. In the second LC creation process, LC is created by including a subset of the union of the entries in the final RefPicList0 and RefPicList1 according to 1) an indicated number of the entries in LC, 2) which entries in the final RefPicList0 and RefPicList1 are to be included in LC, and 3) in which order to include those entries.

This way, the possible values of the original inter\_pred\_idc syntax element will be reduced from three to two, BiPred or Pred\_LC, and hence can be coded as a one-bit flag, and thus coding efficiency is improved.

In short, for B slices, a fourth step, reference picture list combination, has been added to the reference picture list construction process in HEVC.

The above reference picture list construction process for B slices has the following shortcomings:

1. Typically, to achieve the optimal compression efficiency for the partitions using the BiPred mode, the final RefPicList0 or RefPicList1 should contain certain reference pictures in certain order. Thus, it is possible that in uni-prediction mode, some of its optimal reference pictures are not present in either RefPicList0 or RefPicList1. This can cause coding efficiency loss in uni-prediction mode.
2. One possible solution to the above problem is to determine the final RefPicList0, the final RefPicList1 and the combined list LC altogether. However, such a process needs to take into account (1) which partitions are coded in BiPred mode and which partitions are coded in uni-predicted mode; (2) which reference pictures are used by each mode and (3) the optimal order of the reference pictures used by each mode. These factors nonetheless cause undesirable increase in encoding complexity. An alternative is to use a less complex encoder implementation and/or encoding process, but at the cost of sub-optimal compression efficiency.
3. At the decoder side, in addition to existing reference picture list modification process that is identical for the creation of list 0 and creation of list 1, two different new optional processes for creating the combined list LC need to be implemented.

# Proposal

To solve the above problems, this document proposes a simpler design for the creation of the combined reference picture list, LC, for uni-predicted partitions. In the proposed design, LC is not created from the final RefPicList0 and RefPicList1, but rather from all the short-term and long-term reference pictures, by reusing the existing steps of the reference picture list construction process, namely initialization, truncation, and modification as they are. Furthermore, the first step, initialization, is skipped, by reusing the initial RefPicList0 or RefPicList1 before the truncation and modification steps. The syntax change, semantics and the process for LC generation are described in the following subsections.

## Syntax change

The proposed syntax changes include addition of one new syntax element in the picture parameter set syntax and two new syntax elements in the reference picture list modification syntax, as shown in the following modified syntax tables (changes are highlighted):

|  |  |
| --- | --- |
| pic\_parameter\_set\_rbsp( ) { | Descriptor |
| **pic\_parameter\_set\_id** | ue(v) |
| **seq\_parameter\_set\_id** | ue(v) |
| **entropy\_coding\_mode\_flag** | u(1) |
| **num\_ref\_idx\_l0\_default\_active\_minus1** | ue(v) |
| **num\_ref\_idx\_l1\_default\_active\_minus1** | ue(v) |
| **num\_ref\_idx\_lc\_default\_active\_minus1** | ue(v) |
| **pic\_init\_qp\_minus26** **/**\* relative to 26 \*/ | se(v) |
| **constrained\_intra\_pred\_flag** | u(1) |
| rbsp\_trailing\_bits( ) |  |
| } |  |

|  |  |
| --- | --- |
| ref\_pic\_list\_modification( ) { | Descriptor |
| if( slice\_type % 5 != 2 && slice\_type % 5 != 4 ) { |  |
| **ref\_pic\_list\_modification\_flag\_l0** | u(1) |
| if( ref\_pic\_list\_modification\_flag\_l0 ) |  |
| do { |  |
| **modification\_of\_pic\_nums\_idc** | ue(v) |
| if( modification\_of\_pic\_nums\_idc = = 0 | |  modification\_of\_pic\_nums\_idc = = 1 ) |  |
| **abs\_diff\_pic\_num\_minus1** | ue(v) |
| else if( modification\_of\_pic\_nums\_idc = = 2 ) |  |
| **long\_term\_pic\_num** | ue(v) |
| } while( modification\_of\_pic\_nums\_idc != 3 ) |  |
| } |  |
| if( slice\_type % 5 = = 1 ) { |  |
| **ref\_pic\_list\_modification\_flag\_l1** | u(1) |
| if( ref\_pic\_list\_modification\_flag\_l1 ) |  |
| do { |  |
| **modification\_of\_pic\_nums\_idc** | ue(v) |
| if( modification\_of\_pic\_nums\_idc = = 0 | |  modification\_of\_pic\_nums\_idc = = 1 ) |  |
| **abs\_diff\_pic\_num\_minus1** | ue(v) |
| else if( modification\_of\_pic\_nums\_idc = = 2 ) |  |
| **long\_term\_pic\_num** | ue(v) |
| } while( modification\_of\_pic\_nums\_idc != 3 ) |  |
| **ref\_pic\_list\_modification\_flag\_lc\_l0** | u(1) |
| **ref\_pic\_list\_modification\_flag\_lc** | u(1) |
| if( ref\_pic\_list\_modification\_flag\_lc ) { |  |
| if( num\_ref\_idx\_active\_override\_flag ) |  |
| **num\_ref\_idx\_lc\_active\_minus1** | ue(v) |
| do { |  |
| **modification\_of\_pic\_nums\_idc** | ue(v) |
| if( modification\_of\_pic\_nums\_idc = = 0 | |  modification\_of\_pic\_nums\_idc = = 1 ) |  |
| **abs\_diff\_pic\_num\_minus1** | ue(v) |
| else if( modification\_of\_pic\_nums\_idc = = 2 ) |  |
| **long\_term\_pic\_num** | ue(v) |
| } while( modification\_of\_pic\_nums\_idc != 3 ) |  |
| } |  |
| } |  |
| } |  |

## Semantics

The semantics of the new syntax elements are as follows.

**num\_ref\_idx\_lc\_default\_active\_minus1** specifies how num\_ref\_idx\_lc\_active\_minus1 is inferred for B slices with num\_ref\_idx\_active\_override\_flag equal to 0. The value of num\_ref\_idx\_lc\_default\_active\_minus1 shall be in the range of 0 to 15, inclusive.

**ref\_pic\_list\_modification\_flag\_lc\_l0** equal to 1 specifies that the final combined reference picture list LC is identical to the final RefPicList0 (when ref\_pic\_list\_modification\_flag\_lc is equal to 0) or the initial combined reference picture list LC (before truncation and modification) is identical to the initial RefPicList0 (when ref\_pic\_list\_modification\_flag\_lc is equal to 1). ref\_pic\_list\_modification\_flag\_lc\_l0 equal to 0 specifies that the final combined reference picture list LC is identical to the final RefPicList1 (when ref\_pic\_list\_modification\_flag\_lc is equal to 0) or the initial combined reference picture list LC (before truncation and modification) is identical to the initial RefPicList1 (when ref\_pic\_list\_modification\_flag\_lc is equal to 1).

**ref\_pic\_list\_modification\_flag\_lc** equal to 1 specifies that the syntax element modification\_of\_pic\_nums\_idc is present for specifying the combined reference picture list LC. ref\_pic\_list\_modification\_flag\_lc equal to 0 specifies that this syntax element is not present. When ref\_pic\_list\_modification\_flag\_lc is equal to 1, the number of times that modification\_of\_pic\_nums\_idc is not equal to 3 following ref\_pic\_list\_modification\_flag\_lc shall not exceed num\_ref\_idx\_lc\_active\_minus1 + 1.

## Decoding process

The decoding process for creation of the final RefPicList0 and RefPicList1 remain unchanged. The final combined reference picture list LC is created as follows.

* When ref\_pic\_list\_modification\_flag\_lc\_l0 is equal to 1 and ref\_pic\_list\_modification\_flag\_lc is equal to 0, LC is derived as identical to the final RefPicList0.
* When ref\_pic\_list\_modification\_flag\_lc\_l0 is equal to 0 and ref\_pic\_list\_modification\_flag\_lc is equal to 0, LC is derived as identical to the final RefPicList1.
* When ref\_pic\_list\_modification\_flag\_lc\_l0 is equal to 0 and ref\_pic\_list\_modification\_flag\_lc is equal to 1, LC is created according to the following three steps:
  1. The initial combined reference picture list LC is derived as identical to the initial RefPicList0;
  2. The initial combined reference picture list LC is truncated according to the value of num\_ref\_idx\_lc\_active\_minus1 + 1, similarly as the initial RefPicList0 was truncated according to the value of num\_ref\_idx\_l0\_active\_minus1 + 1;
  3. The truncated combined reference picture list LC is modified according to reference picture modification commands signaled in the slice header, similarly as the truncated RefPicList0 was modified.
* When ref\_pic\_list\_modification\_flag\_lc\_l0 is equal to 1 and ref\_pic\_list\_modification\_flag\_lc is equal to 1, LC is created according to the following three steps:
  1. The initial combined reference picture list LC is derived as identical to the initial RefPicList1;
  2. The initial combined reference picture list LC is truncated according to the value of num\_ref\_idx\_lc\_active\_minus1 + 1, similarly as the initial RefPicList1 was truncated according to the value of num\_ref\_idx\_l1\_active\_minus1 + 1;
  3. The truncated combined reference picture list LC is modified according to reference picture modification commands signaled in the slice header, similarly as the truncated RefPicList1 was modified.

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