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| *Title:* | **AHG21: Comments on Signaling of Short-term Reference Pictures** | | |
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# Abstract

In the 7th JCT-VC meeting, method for signaling short-term and long-term reference picture was adopted. This document proposes some changes to the current syntax and semantics elements for signaling short-term reference pictures. The proposed changes are:

* Modification to signaling of number of reference pictures in RPS
* Making signaling of ‘used\_by\_curr\_pic\_sX\_flag’ conditional.

It is suggested that the proposed changes improve signaling efficiency without changing the main concept of the current signaling.

# Introduction

After adoption in the last meeting, short-term reference pictures are now signaled explicitly within so called reference picture set (RPS) which is contained in PPS and/or slice header. RPS contains information such as number of reference pictures (ie.. divided into number of reference pictures with negative and positive delta POC relative to POC of current slice) that should exists in decoded picture buffer (DPB), delta POC of the reference pictures, and whether or not the reference pictures are used by current slice.

While the concept seems stable, the syntax elements within RPS might still be improved by considering other syntax elements. In this document, we propose some changes to the way of signaling short-term reference pictures in RPS without changing the main concept.

# Proposed Changes

## Signalling of Number of Reference Pictures

Currently, the number of reference pictures that are signalled in RPS is described by number of negative and positive pictures and both are coded as ue(v). Considering other adoption syntax element ‘max\_dec\_frame\_buffering’ in the last meeting, it might be better to apply the following changes:

1. Instead of signaling num\_negative\_pics and num\_positive\_pics, it is better to signaled num\_ref\_pics\_minus1, which indicate the number of all reference pictures and num\_positive\_ref\_pics, which indicate the number of positive reference pictures. The syntax element num\_ref\_pics\_minus1 shall be coded with unsigned integer using n bits (i.e., u(n)) or with unsigned integer Exp-Golomb-coded syntax element with the left bit first (i.e., ue(v)), depending on the value of of syntax element max\_dec\_frame\_buffering. The syntax element num\_positive\_ref\_pics shall be coded with unsigned integer Exp-Golomb-coded syntax element with the left bit first (i.e., ue(v)).
2. Making signalling of num\_positive\_ref\_pics conditional depending on the value of ‘num\_reorder\_frames. num\_reorder\_frames == 0 can be interpreted that backward prediction is not used so that num\_positive\_ref\_pics will be always zero. Thus, we can avoid signalling it.

Table 1 – Syntax element after proposed item 2.1

|  |  |
| --- | --- |
| ref\_pic\_set( idx ) { | Descriptor |
| **inter\_ref\_pic\_set\_prediction\_flag** | u(1) |
| if( inter\_ref\_pic\_set\_prediction\_flag) { |  |
| **…** |  |
| } |  |
| else { |  |
| **num\_ref\_pics\_minus1** | u(n) | ue(v) |
| if (num\_reorder\_frame > 0) **num\_positive\_ref\_pics** | ue(v) |
| for( i = 0; i < num\_all\_ref\_pics\_minus1 - num\_positive\_ref\_pics + 1; i++ ) { |  |
| **delta\_poc\_s0\_minus1**[ i ] | ue(v) |
| **used\_by\_curr\_pic\_s0\_flag**[ i ] | u(1) |
| } |  |
| for( i = 0; i < num\_positive\_ref\_pics; i++ ) { |  |
| **delta\_poc\_s1\_minus1**[ i ] | ue(v) |
| **used\_by\_curr\_pic\_s1\_flag**[ i ] | u(1) |
| } |  |
| } |  |
| } |  |

**num\_ref\_pics\_minus1** plus 1 specifies the number of the sum of the following delta\_poc\_s0\_minus1[ i ] and delta\_poc\_s1\_minus1[ i ] syntax elements. When the value of max\_dec\_frame\_buffering is 0, num\_all\_ref\_pics\_minus1 is coded with unsigned integer Exp-Golomb-coded syntax element with the left bit first, otherwise, num\_all\_ref\_buffering is coded with unsigned integer using n bits where n is ceil(log2(max\_dec\_frame\_buffering)).

**num\_positive\_pics** specifies the number of the following delta\_poc\_s1\_minus1[ i ] and used\_by\_curr\_pic\_s1\_flag1[ i ] syntax elements. The value of num\_positive\_pics shall be in the range of 0 to max\_num\_ref\_frames – num\_negative\_pics, inclusive.

The variable NumPositivePics]idx] is derived as follows:

if (num\_reorder\_frames == 0) NumPositivePics[idx] = 0

else NumPositivePics[idx] = num\_positive\_pics

The variable NumNegativePics[ idx ] is derived as follows:

NumNegativePics[ idx ] = num\_ref\_pics\_minus1 + 1 - NumPositivePics[idx]

### Bit-count Analysis

Bit-count analysis for the proposed method of signalling number of reference pictures in RPS is given in file “Bit-count\_Analysis\_For\_Item\_2.1.xlsx”. Note that for case 2.1 ~ 2.7, we use 3 bits to signal the syntax element num\_rf\_pics\_minus1 because the maximum number of required buffer never exceed 8; for case 3.1 and 3.2 we use 2 bits to signal the syntax element since the maximum number of required buffer is 4; and for case 3.4 we use 3 bits.

The analysis shows that the proposed method is more advantageous when RPS is signalled in slice header (e.g., case 3.4). When RPS is signalled in PPS, there is good chance that inter-predicted RPS can be used. Since inter-predicted RPS does not need to signal number of reference pictures, the proposed changes does not have any (significant) effect (i.e., saving only 0 ~ 4 bits per PPS). On the other hand, in the case 3.4, since delta POC of short term reference pictures is irregular so that RPS must be signalled in slice header and it is difficult to use inter-predicted RPS, the proposed changes have more significant effect (i.e., on average 3 bits per slice).

### Error Resilience Analysis

The proposed method of signalling number of reference pictures in RPS does not have any effect on error resiliency feature of the current RPS signalling mechanism.

## Signaling used\_by\_curr\_pic\_sX\_flag conditionally

In some condition (e.g., low delay case in current HM common test condition), all reference pictures that exist in DPB (also carried in RPS) is always used by current slice. Thus, in such condition, there is no need to signal the syntax element used\_by\_curr\_pic\_sX\_flag (X can be replaced by either 0 or 1) since it will be always 1.

In addition to above, when RPS is signaled in slice header and the slice type is intra, then there is no need to signal the syntax element used\_by\_curr\_pic\_sX\_flag (X can be replaced by either 0 or 1) since it will be always 0.

Motivated by possibility saving from the above observation, we propose the following modification:

1. Add a flag in PPS called no\_unused\_ref\_pic\_flag.
2. When no\_unused\_ref\_pic\_flag equals 1, then the syntax element used\_by\_curr\_pic\_sX\_flag shall not be signaled but instead its value is inferred as 1. Otherwise, when no\_unused\_ref\_pic\_flag equals 0, used\_by\_curr\_pic\_sX\_flag shall be signalled.
3. If idx == num\_ref\_pic\_sets, which mean that the RPS is signaled in slice header, and slice type equals intra, then used\_by\_curr\_pic\_sX\_flag shall not be signaled by inferred as 0.

The syntax and semantics of modified / added element in RPS are as follows.

Table 2 – Syntax element in PPS after proposed item 2.2

|  |  |
| --- | --- |
| pic\_parameter\_set\_rbsp( ) { | Descriptor |
| … |  |
| **num\_ref\_pic\_sets** | ue(v) |
| **no\_unused\_ref\_pic\_flag** | u(1) |
| for(idx = 0; idx < num\_ref\_pic\_sets; idx++) |  |
| ref\_pic\_set( idx ) |  |
| … |  |
| } |  |

**no\_unused\_ref\_pics\_flag** equals 1 indicates that the syntax element used\_by\_curr\_pic\_sX\_flag is not present in RPS. Otherwise, when no\_unused\_ref\_pics\_flag equals 0, the syntax element used\_by\_curr\_pic\_sX\_flag is present in RPS.

Table 3 – Syntax element in RPS after proposed item 2.2

|  |  |
| --- | --- |
| ref\_pic\_set( idx ) { | Descriptor |
| **inter\_ref\_pic\_set\_prediction\_flag** | u(1) |
| if( inter\_ref\_pic\_set\_prediction\_flag) { |  |
| **delta\_idx\_minus1** | ue(v) |
| **delta\_rps\_sign** | u(1) |
| **abs\_delta\_rps\_minus1** | ue(v) |
| for( j = 0; j <= NumDeltaPocs[ RIdx ]; j++ ) { |  |
| **ref\_idc0**[ j ] | u(1) |
| if( !ref\_idc0[ j ] && no\_unused\_ref\_pic\_flag == 0 && idx != num\_ref\_pic\_sets &&slice\_type != I) |  |
| **ref\_idc1**[ j ] | u(1) |
| } |  |
| } |  |
| else { |  |
| **num\_negative\_ref\_pics** | ue(v) |
| **num\_positive\_ref\_pics** | ue(v) |
| for( i = 0; i < num\_negative\_ref\_pics; i++ ) { |  |
| **delta\_poc\_s0\_minus1**[ i ] | ue(v) |
| if (no\_unused\_ref\_pic\_flag == 0 || (idx == num\_ref\_pic\_sets &&slice\_type == I)) { |  |
| **used\_by\_curr\_pic\_s0\_flag** [ i ] | u(1) |
| } |  |
| } |  |
| for( i = 0; i < num\_positive\_ref\_pics; i++ ) { |  |
| **delta\_poc\_s1\_minus1**[ i ] | ue(v) |
| if (no\_unused\_ref\_pic\_flag == 0 || (idx == num\_ref\_pic\_sets &&slice\_type == I)) { |  |
| **used\_by\_curr\_pic\_s1\_flag** [ i ] | u(1) |
| } |  |
| } |  |
| } |  |
| } |  |

**used\_by\_curr\_pic\_s0\_flag**[ i ] equal to 0 specifies that the i-th reference picture that has picture order count less than that of the current picture is not used for reference by the current picture.

The variable UsedByCurrPicS0[ idx ][ i ] is derived as follows:

if (no\_unused\_ref\_pic\_flag == 1)

{

UsedByCurrPicS0 [idx][i] = 1

}

else if (idx == num\_ref\_pic\_sets && slice\_type == I)

{

UsedByCurrPicS0 [idx][i] = 0

}

else

{

UsedByCurrPicS0[ idx ][ i ] = used\_by\_curr\_pic\_s0\_flag[ i ]

}

**used\_by\_curr\_pic\_s1\_flag**[ i ] equal to 0 specifies that the i-th reference picture that has picture order count greater than that of the current picture is not used for reference by the current picture.

The variable UsedByCurrPicS1[ idx ][ i ] is derived as follows.

if (no\_unused\_ref\_pic\_flag == 1)

{

UsedByCurrPicS1 [idx][i] = 1

}

else if (idx == num\_ref\_pic\_sets && slice\_type == I)

{

UsedByCurrPicS1 [idx][i] = 0

}

else

{

UsedByCurrPicS1[ idx ][ i ] = used\_by\_curr\_pic\_s1\_flag[ i ]

}

The semantic of ref\_idc0[ j ] shall be updated as follows:

**ref\_idc0[ j ]** and **ref\_idc1[ j ]** together specifies if DeltaPoc[ RIdx ][ j ] is used for prediction of DeltaPoc[ idx ][ i ]and if the i-th reference picture is used for reference by the current picture according to Table 7-xx.

if (no\_unused\_ref\_pic\_flag == 1 || (idx == num\_ref\_pic\_sets &&slice\_type = = I)), then:

|  |  |
| --- | --- |
| ref\_idc0[ j ] | Properties of i-th reference picture |
| 1 | Picture is used for reference by the current picture DeltaPoc[ idx ][ i ] = DeltaPoc[ RIdx ][ j ] + DeltaRPS |
| 0 | There is no corresponding i-th reference picture for DeltaPoc[ RIdx ][ j ]. |

Else,

|  |  |  |
| --- | --- | --- |
| ref\_idc0[ j ] | ref\_idc1[ j ] | Properties of i-th reference picture |
| 1 |  | Picture is used for reference by the current picture DeltaPoc[ idx ][ i ] = DeltaPoc[ RIdx ][ j ] + DeltaRPS |
| 0 | 1 | Picture is not used for reference by the current picture (but used by future pictures) DeltaPoc[ idx ][ i ] = DeltaPoc[ RIdx ][ j ] + DeltaRPS |
| 0 | 0 | There is no corresponding i-th reference picture for DeltaPoc[ RIdx ][ j ]. |

### Bit-count Analysis

Compared to the current system method, the proposed changes will impact the bit-count of signalling method as follow:

* For case 2.1 ~ 2.7: overhead cost 1 bit for signalling no\_unused\_ref\_pic\_flag in PPS
* For case 3.1:
  + overhead cost 1 bit for signalling no\_unused\_ref\_pic\_flag in PPS
  + save 4 bits from RPS #1
  + save 1 bits from each of RPS #2 ~ #4
* For case 3.2: saving total 4 bits.
  + overhead cost 1 bit for signalling no\_unused\_ref\_pic\_flag in PPS
  + save 1 bits from each of RPS #1 ~ #4
* For case 3.4:
  + overhead cost 1 bit for signalling no\_unused\_ref\_pic\_flag in PPS
  + save on average 5 bits per slice.

### Error Resilience Analysis

The proposed method of signalling number of reference pictures in RPS does not have any effect on error resiliency feature of the current RPS signalling mechanism.

# Conclusion

This document proposes some changes to the current syntax and semantics elements for signaling short-term reference pictures. While the proposed changes do not change signaling main concept of signaling, they may improve signaling efficiency. We recommend the group to further discuss the proposed changes can consider adopting them.

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