

EXHIBIT 2005



Title: JCT-VC AHG report: Reference picture buffering and list construction (AHG21)

Status: Input Document to JCT-VC

Purpose: Report

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Source: AHG

Abstract

This report summarizes the Reference picture buffering and list construction ad-hoc activities between the 6th and the 7th JCT-VC meeting and the input documents to this meeting related to this ad-hoc group.

1 Mandate

Table 1 - AHG mandates

AHG Title and Email Reflector	Chairs
Reference picture buffering and list construction (AHG21) (jct-vc@lists.rwth-aachen.de) - Study possible improvements to the reference picture list construction processes - Examine the behavior of unified lists with the F493 proposed default list construction processes and identify any robustness issues.	D. Flynn, R. Sjöberg (co-chairs), Y. Chen, T. K. Tan, W. Wan, Y. K. Wang (vice chairs)

▪ Examine the merits of the list 0/1, combined and unified lists ▪ Discuss and identify solutions for support of weighted prediction methods	
• Produce a single candidate WD text specification for picture buffer management based on F493 for review at the next meeting	
• Produce software supporting picture marking including the following features: ▪ Flexible support for cyclic picture structures and temporal layering ▪ Decoder support to decode a subset of temporal layers ▪ Rudimentary error concealment for lost reference picture slices (frame copy of closest picture based on POC, set all MVs of lost reference picture to zero)	

2 The reference picture set (RPS) concept

The reference picture set concept was first described in JCTVC-F493. It includes describing the reference pictures in the decoded picture buffer (DPB) in an absolute manner in each slice header of a picture instead of in a relative manner (through MMCO and sliding window process). The concept can be described in the following example:

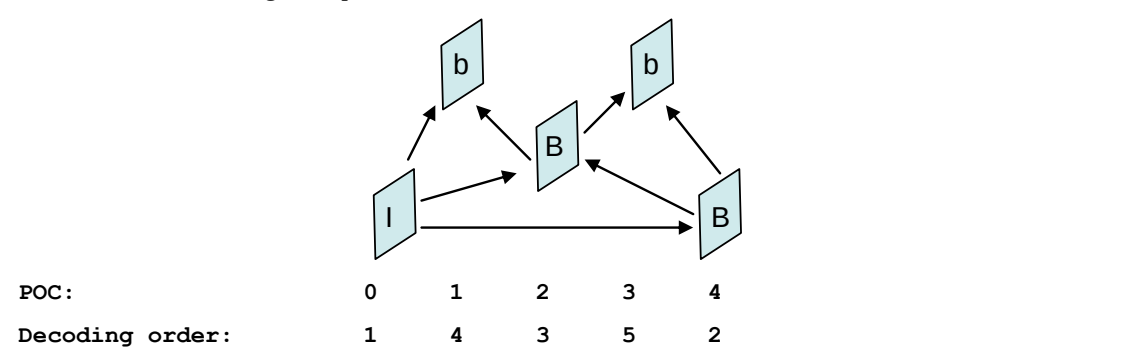


Figure 1 . Example coding structure.

The reference picture set contains a list of deltaPOC information of all reference pictures that the decoder shall keep. The deltaPOC is used to calculate the POC of a reference picture as $POC_{reference} = POC_{current} + \text{deltaPOC}$. POC is used by the decoder to deliver the pictures in the correct order for display but also for identification of reference pictures during reference picture list construction and decoded reference picture marking. All pictures in the DPB that are not a part of the Buffer Description reference picture set shall be marked as “unused for prediction reference”.

In the example in Figure 1Figure 1, the second picture in decoding order will include POC 0 in the RPS while the third picture in decoding order will include POC 0 and POC 4 in its RPS. The fourth picture in decoding order must include not only POC 0 and POC 2 in its RPS but also POC 4 since that picture will be used for reference in the future. The fifth picture in decoding order does not need to include POC 0 in its RPS unless it is going to be used for reference in the future. If POC 0 is not included in the RPS of the fifth picture in decoding order it will be marked as "unused for reference".

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3 WD text for picture buffer management

The WD text was extensively discussed on the JCT-VC reflector. Several candidate WD documents were produced and uploaded to ftp://ftp.hhi.de/ahg21/. The final candidate WD text is attached together with this document as document JCTVC-F803_d5_RPS_r2.doc. This document uses change-bars to show the text changes relative JCTVC-F803_d5.doc.

3.1 Open issues

Besides the open issues listed below, there were a few proposals that were discussed on the e-mail reflector. One example is a proposal on more compact reference picture set syntax including bit savings for reference picture sets following IDR and CRA pictures, JCTVC-G198. Another example is a proposal on signaling a counter for each picture that specifies when in the future a picture should be removed from the DPB, JCTVC-G166.

3.1.1 Long-term pictures

The first WD candidate did provide combined signaling to support long-term pictures. This included syntax for adding explicitly coded long-term pictures to a referenced RPS. The initial feedback was that long-term picture support was a weakness of the AHG WD.

An updated WD version contained more extensive long-term picture syntax but now some people started to question the long-term picture use-cases altogether.

For the final version, long-term picture syntax and combined signaling was removed in order to keep the WD short and concise. There was no agreement on how to signal long-term pictures, this is still an open issue to be discussed at the Geneva JCT-VC meeting.

3.1.2 Reference picture list construction

Whether to always fill the initial lists with num_ref_idx_lX_active_minus1+1 picture using a while loop as it is currently specified in 8.2.3.1 of the AHG21 WD or use AVC type initialization ~~where the number of available reference pictures must be larger than or equal to ref_idx_lX_active_minus1+1~~ is still open.

3.1.3 CRA picture issue

Whether to allow a reference picture set for a picture following a CRA in display order to include pictures preceding the CRA in display order needs to be decided.

3.2 WD Changes

A summary of the WD text changes are shown below. Blue underline text means additions and red strikethrough means deletions. Note that this is just a summary, please read the attached complete WD text for all details.

3.2.1 Definitions

3.88 reference picture set: A set of reference pictures associated with a picture, consisting of all reference pictures that are prior to the associated picture in decoding order, that may be used for inter prediction of the associated picture or any picture following the associated picture in decoding order.

3.2.2 SPS syntax

seq_parameter_set_rbsp() {	Descriptor
profile_idc	u(8)
...	
~~log2_max_frame_num_minus4~~	~~ue(v)~~
~~pic_order_cnt_type~~	~~ue(v)~~
~~if(pic_order_cnt_type == 0)~~	
log2_max_pic_order_cnt_lsb_minus4	ue(v)
~~else if(pic_order_cnt_type == 1) {~~	
~~delta_pic_order_always_zero_flag~~	~~u(1)~~
~~offset_for_non_ref_pic~~	~~se(v)~~
~~num_ref_frames_in_pic_order_cnt_cycle~~	~~ue(v)~~
~~for(i = 0; i < num_ref_frames_in_pic_order_cnt_cycle; i++)~~	
~~offset_for_ref_frame[i]~~	~~se(v)~~
~~}~~	
max_num_ref_frames	ue(v)
~~gaps_in_frame_num_value_allowed_flag~~	~~u(1)~~
...	
}	

The POC types have been removed as well as frame_num and gaps_in_frame_num.

3.2.3 PPS syntax

pic_parameter_set_rbsp() {	Descriptor
pic_parameter_set_id	ue(v)
seq_parameter_set_id	ue(v)
entropy_coding_mode_flag	u(1)
<u>num_ref_pic_sets</u>	<u>ue(v)</u>
<u>for(idx = 0; idx < num_ref_pic_sets; idx++)</u>	
<u>ref_pic_set(idx)</u>	
...	
}	

Signaling of a number of reference picture sets has been added to the PPS.

3.2.4 Slice header syntax

slice_header() {	Descriptor
lightweight_slice_flag	u(1)
if(!lightweight_slice_flag) {	
slice_type	ue(v)
pic_parameter_set_id	ue(v)
~~frame_num~~	~~u(v)~~
if(IdrPicFlag) {	
idr_pic_id	ue(v)
<u>no_output_of_prior_pics_flag</u>	<u>u(1)</u>
}	
else {	
~~if(pic_order_cnt_type == 0)~~	
pic_order_cnt_lsb	u(v)
<u>ref_pic_set_pps_flag</u>	<u>u(1)</u>
<u>if(!ref_pic_set_pps_flag)</u>	
<u>ref_pic_set(num_ref_pic_sets)</u>	
<u>else</u>	
<u>ref_pic_set_idx</u>	<u>u(v)</u>
if(slice_type == P slice_type == B) {	
num_ref_idx_active_override_flag	u(1)
if(num_ref_idx_active_override_flag) {	
num_ref_idx_l0_active_minus1	ue(v)
if(slice_type == B)	
num_ref_idx_l1_active_minus1	ue(v)
}	
}	
ref_pic_list_modification()	
ref_pic_list_combination()	
~~if(nal_ref_idc != 0)~~	
~~dec_ref_pic_marking()~~	
}	
...	
}	

frame_num has been removed. no_output_of_prior_pics_flags has been moved from dec_ref_pic_marking to the slice header since dec_ref_pic_marking (a.k.a. MMCO commands) has been removed.

Signaling of a reference picture sets has been added, either as a reference to the PPS or through explicit signaling. Both methods uses the same ref_pic_set() syntax.

3.2.5 Reference picture set syntax

<u>ref_pic_set(idx) {</u>	<u>Descriptor</u>
<u> num_negative_pics</u>	<u>ue(v)</u>
<u> num_positive_pics</u>	<u>ue(v)</u>
<u> for(i = 0; i < num_negative_pics; i++) {</u>	
<u> delta_poc_s0_minus1[i]</u>	<u>ue(v)</u>
<u> used_by_curr_pic_s0_flag[i]</u>	<u>u(1)</u>
<u> }</u>	
<u> for(i = 0; i < num_positive_pics; i++) {</u>	
<u> delta_poc_s1_minus1[i]</u>	<u>ue(v)</u>
<u> used_by_curr_pic_s1_flag[i]</u>	<u>u(1)</u>
<u> }</u>	
<u>}</u>	

Syntax to signal a reference picture set is added.

Identification of reference pictures is done through delta POC values relative the POC of previously signaled reference pictures. For example, assume that the POC of the current picture is 10 and that the encoder wants to include two reference pictures with POC = {9, 7}. Then the encoder signals num_negative_pics=2 and num_positive_pics=0. The value of delta_poc_s0_minus1[0] is 0 since POC 10 minus POC 9 is 1. delta_poc_s0_minus1[1] becomes 1 since POC 9 minus POC 7 is 2.

The used_by_curr_pic_sX_flag is used to indicate to the decoder whether the reference picture is to be included into the reference picture lists or not. This replaces the method in F493 where temporal_id was sent for each picture in the reference picture set.

3.2.6 Reference picture list modification

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)
<del>if(modification_of_pic_nums_idc == 0 </del>	
~~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)~~	
<u>list modification_idc</u>	<u>ue(v)</u>
<u>if(list modification_idc != 2)</u>	
<u>ref_pic_set_idx</u>	<u>ue(v)</u>
<u>} while(list modification_idc != 2)</u>	
}	
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)
<del>if(modification_of_pic_nums_idc == 0 </del>	
~~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)~~	
<u>list modification_idc</u>	<u>ue(v)</u>
<u>if(list modification_idc != 2)</u>	
<u>ref_pic_set_idx</u>	<u>ue(v)</u>
<u>} while(list modification_idc != 2)</u>	
}	
}	

4 Source code

The first version of the AHG21 source code was made available on October 28 in the HM-4.0-dev-ahg21-picbuffer branch. The following features were implemented:

1. Flexible support for cyclic picture structures and temporal layering.
The code supports very flexible configuration of cyclic picture structures that can be set through the config files. The config files in the cfg directory were updated accordingly such that no editing of them is needed in order to run the encoder according to the common conditions.
2. Decoder support to decode a subset of temporal layers
A new decoder flag was added to support decoding of a subset of temporal layers. Using "-t 0" will

make the decoder only decode the base layer, "-t 1" decodes the two lowest layers and so on. If the parameter is omitted, all layers will be decoded.

3. Rudimentary error concealment for lost reference picture slices
The decoder does not crash on picture losses. Instead, frame copy concealment is done.
4. Calculation of the lambda factor used for each frame was changed, and it now relies on a factor QPfactor supplied in the config file. As above, the default config files were given values of QPfactor that correspond to the common conditions.

The following issues with the code were reported:

1. The source code syntax is not fully aligned with the latest AHG21 WD candidate syntax
2. Loss of the first IDR picture is not working properly
3. Only loss of complete pictures is supported, slice partitioning and loss is not

A description of the config file changes is attached to this report as AHG_HM_configfile_description_r0.doc.

The encoder will parse the config file and generate signaling of all reference picture sets in the PPS. This means that no reference picture set will be signaled in the slice header explicitly except for coding the pictures after the last complete GOP.

5 List of AHG related input documents

The following contributions related to this AHG were submitted to the current JCT-VC meeting:

JCTVC-G0157 [Hendry, S. Park, B. Jeon (LG)] "Reference List Construction for Random Access Settings"

JCTVC-G0166 [Hendry, S. Park, B. Jeon (LG)] "AHG21: Explicit Reference Pictures Signaling with Output Latency Count Scheme"

JCTVC-G0198 [T.K. Tan, C.S. Boon (NTT Docomo)] "AHG21: Inter reference picture set prediction syntax and semantics."

JCTVC-G0314 [Y. -K. Wang, Y. Chen (Qualcomm)] "AHG21: On DPB management"

JCTVC-G0526 [Y. Park, I.-K. Kim, C. Kim (Samsung)] "AHG21: Combined signaling for reference picture set"

JCTVC-G0548 [V. Wahadaniah, C. S. Lim, S. M. T. Naing (Panasonic)] "AHG21: Construction and modification of predefined reference picture sets and reference picture lists"

JCTVC-G0549 [Y. Park, S. Jeong, C. Kim (Samsung)] "Syntax rearrangement for list combination"

JCTVC-G0635 [M. Naccari (BBC), G. Van Wallendael (Ghent University), M. Mrak (BBC), D. Flynn (BBC)] "Coding with a unified reference picture list"

JCTVC-G0637 [R. Sjöberg, J. Samuelsson (Ericsson)] "AHG21: Long-term pictures and pruning of reference picture sets"

JCTVC-G0643 [M. M. Hannuksela, S. M. Gopalakrishna (Nokia)] "AHG21: On reference picture list construction and reference picture marking"

JCTVC-G0713 [K. Misra, S. Deshpande, A. Segall (Sharp)] "AHG21: Long term picture referencing using wrapped POC"

JCTVC-G0714 [K. Misra, S. Deshpande, A. Segall (Sharp)] "AHG21: On picture referencing"

JCTVC-G0715 [K. Misra, S. Deshpande, L. Kerofsky, A. Segall (Sharp)] "AHG18/21: Absolute signaling for resolution switching"

JCTVC-G0717 [Y. Yu, K. Panusopone, X. Fang, L. Wang (Motorola Mobility)] "The Reference Picture Construction of Combined List for HEVC"

JCTVC-G0788 [G. J. Sullivan, Y. Wu, J. Xu (Microsoft), B. Li (USTC)] "AHG21: Proposal on Decoded Picture Buffer Description Syntax Relating to JCTVC-F493"

6 Recommendation

The Reference picture buffering and list construction AHG recommends:

- JCT-VC to review the candidate WD text on picture buffer management and consider it for adoption
- To use the HM-4.0-dev-ahg21-picbuffer source code for comparisons in picture buffer management proposals
- JCT-VC to review all picture buffer management and list construction related input document.