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| *Title:* | **HEVC/MV-HEVC/SHVC HLS: Redundant picture SEI message** | | |
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| *Author(s) or Contact(s):* | *Sychev Maxim*  *Stepin Victor*  *Ikonin Sergey* | *Email:* | [*Sychev.Maxim@huawei.com*](mailto:Sychev.Maxim@huawei.com)  [*Stepin.Victor@huawei.com*](mailto:Stepin.Victor@huawei.com)  [*Sergey.Ikonin@huawei.com*](mailto:Sergey.Ikonin@huawei.com) |
| *Source:* | Huawei | | |

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# Abstract

This contribution presents the support for redundant pictures in HEVC/SHVC/MV-HEVC via SEI message. The proposed solution describes the syntax and semantics of how to support redundant pictures. In opposite to H.263/H.264 redundant pictures the proposed approach allows to separate in time the protected primary picture with associated redundant picture. This increases probability of delivering one of them.

# Introduction

Most of the media transmission systems work in unmanaged and partial management networks with packet loss and other network impairments. This may result in the frame loss and in the temporal error propagation, because predictive coding extensively used in video coding to achieve high compression efficiency. Not only part of the frame can be lost but several dependent frames can be lost during the transmission which can result to the big frame freezing interval in displaying video.

Interactive methods refer to feedback based techniques where the recipient transmits information about corrupted decoded areas and/or transport packets to the transmitter. The intra refresh, periodic intra refresh and reference picture selection are the most known feedback based methods. Feedback based algorithm are efficient in channel with low round-trip delay and low packet loss, but in unmanaged and partial managed networks these methods are not efficient because long delay

The opposite approach is non-interactive methods which do not involve interaction between the transmitter and the receiver. It is really useful to prevent temporal error propagation for systems where feedback information cannot be used. Non-interactive methods include forward error correction (FEC) [3], which is done in transport layer. This approach doesn’t require feedback, but it has very big redundancy for short code length or it has very long algorithmic delay for efficient longs codes especially when channel interleaving is used for protection from group packet loss. The source coding layer methods include intra refresh (with the granularity of either macroblock (MB) or picture), which can prevent some error propagation [5], but this approach significantly decrease coding efficiency.

The multiple description video coding (MDC) is also the well known non-interactive technique often used for error resilience [3], but for decoder state recovering the IDR or PIR is still needed.

The previous standards (H.263, H.264 [5, 6]) allow using redundant frames for error resilience in error prone channels [7]. The redundant picture is an additional representation of protected primary picture. In H.264/AVC each primary coded picture may have up to 127 redundant pictures. The reconstructed region represented by a redundant picture after decoding should be similar in quality to the same region in associated primary picture. The redundant frames specified in H.264/AVC are included in the same access unit (AU) as the primary coded picture. This is not a good solution when the bursts (grouped packet loss) appears in a stream.

# Problem Statement

As described in [2, 3] for networks with different quality level described in Table 1 the sequential packet loss for well-managed network is just random loss, but for partially-managed network and for un-managed network the sequential packet loss achieve up to 200 and 10000 ms respectively as showed in Table 2. The one way latency leads to the long delay especially for case of using negative acknowledgment channel (NAC) (backward channel to signal lost pockets). The jitter also has a big influence to the latency.

Table 1. Different test profiles for network impairment [2, 3]

|  |  |  |  |
| --- | --- | --- | --- |
| **Service Test Profiles** | **Applications (Examples)** | **Node Mechanisms** | **Network Techniques** |
| Well-Managed IP Network | High quality video and VoIP, VTC (Real-time applications, loss sensitive, jitter sensitive, high interaction) | Strict QoS, guaranteed no over subscription on links | Constrained routing and distance |
| Partially-Managed IP Network | VoIP, VTC  (Real-time applications, jitter sensitive, interactive) | Separate queue with preferential servicing, traffic grooming | Less constrained routing and distances |
| Unmanaged IP Network, Internet | Lower quality video and VoIP, signaling, transaction data (highly interactive) | Separate queue, drop priority | Constrained routing and distance |
| Transaction data, interactive |  | Less constrained routing and distances |
| Short transactions, bulk data (low loss) | Long queue, drop priority | Any route/path |
| Traditional Internet applications (default IP networks) | Separate queue (lowest priority) | Any route/path |

Table 2. Network impairment ranges for different service level agreements [2, 3]

|  |  |  |  |
| --- | --- | --- | --- |
| Impairment Type | well-managed | partially-managed | un-managed |
| One Way Latency, ms | 20 to 100 (regional)  20 to 300 (intercontinental) | 50 to 200 (regional) 50 to 400 (intercontinental) | 50 to 800 |
| Jitter (peak to peak), ms | 0 to 50 | 0 to 150 | 0 to 500 |
| Sequential Packet Loss, ms | Random loss only (except when link failure occurs) | 40 to 200 | 40 to 10000 |
| Rate of Sequential Loss, sec-1 | Random loss only (except when link failure occurs) | ≤ 10-3 | ≤ 10-1 |
| Random Packet Loss, % | 0 to 0.05 | 0 to 2 | 0 to 20 |
| Reordered Packets, % | 0 to 0.001 | 0 to 0.01 | 0 to 0.1 |

# Relation to prior work

The previously standardized redundant frames in H.263, H.264 [5, 6] was not helpful for increasing robustness of video transmission through error prone channels. It was contained within the same access unit (AU) as a primary frame. During previous JCT-VC meeting another style of redundant frames was introduced in JCTVC-P0062 [1]. The main advantage of proposed approach was the distance in coding order between primary frames and redundant ones. It allows to significantly reduce the probability of simultaneous primary and redundant frames loss in the same group/sequence of lost packets. During the presentation of JCTVC-P0062 there are several aspects was discussed:

1. It was asked whether a decoder would be expected to wait several frame periods for a redundant picture to arrive and then decode that picture for use as a reference picture for the prediction of other dependent pictures that have arrived in the meantime.
2. It was noted that the proposal is entirely new as a concept for HEVC, and has arrived at a late stage of the development of the current phase of extensions development.
3. It was asked whether, assuming we like the proposed functionality, it could be added in a later extension rather than being done within the current phase of work. This seemed possible in principle…
4. Further study was encouraged…

# Redundant pictures SEI message

The following spec text changes are proposed, in relative to JCTVC-P1003v1 (additions are highlighted in yellow).

## Definitions

**primary coded picture**: The *coded representation* of a *picture* to be used by the *decoding process* for a bitstream conforming to this Recommendation | International Standard. The *primary coded picture* contains all *coding tree units* of the *picture*. The only *pictures* that have a normative effect on the *decoding process* are *primary coded pictures*. See also *redundant coded picture*.

**redundant coded picture**: A *coded representation* of a *picture* or a part of a *picture*. The content of a *redundant coded picture* shall not be used by the *decoding process* for a bitstream conforming to this Recommendation | International Standard. A *redundant coded picture* is not required to contain all *coding tree units* in the *primary coded picture*. *Redundant coded pictures* have no normative effect on the *decoding process*. See also *primary coded picture*.

## Syntax

To avoid the “entirely new as a concept for HEVC” approach for redundant pictures the SEI message approach is introduced in this proposal. The redundant picture SEI message determines the position of redundant picture in CVS and the POC of associated primary picture for recovering during decoding process. The same SEI message indicates the primary picture by using SEI payloadType. Does not allowed to have two SEI messages within one AU with both redundant and primary payload types. The delay for waiting (or POC) the associated redundant picture signalled in primary\_pic\_info.

|  |  |
| --- | --- |
| sei\_payload( payloadType, payloadSize ) { | Descriptor |
| if( nal\_unit\_type = = PREFIX\_SEI\_NUT ) |  |
| … |  |
| else if( payloadType = = 141 ) |  |
| redundant\_pic\_info( payloadSize ) |  |
| else if( payloadType = = 142 ) |  |
| primary\_pic\_info( payloadSize ) |  |
| … |  |
| } |  |

* + 1. Redundant picture SEI message syntax

|  |  |
| --- | --- |
| redundant\_pic\_info( payloadSize ) { | Descriptor |
| **rpi\_pic\_order\_cnt\_delta\_sign\_flag** | u(1) |
| **rpi\_pic\_order\_cnt\_delta\_minus1** | ue(v) |
| **prm\_poc\_reset\_flag** | u(1) |
| } |  |

* + 1. Primary picture SEI message syntax

|  |  |
| --- | --- |
| primary\_pic\_info( payloadSize ) { | Descriptor |
| **num\_redundant\_pics\_minus1** | ue(v) |
| for( i = 0; i <= num\_redundant\_pics\_minus1; i++ ) { |  |
| **ppi\_pic\_order\_cnt\_delta\_sign\_flag**[ i ] | u(1) |
| **ppi\_pic\_order\_cnt\_delta\_minus1**[ i ] | ue(v) |
| } |  |
| } |  |

## Redundant picture SEI message semantics

The redundant picture SEI message indicates that the current picture is a redundant coded picture and contains information about the associated primary coded picture. Information carried in the redundant picture SEI message can be used for recovery from transmission errors.

**rpi\_pic\_order\_cnt\_delta\_sign\_flag** equal to 0 specifies that the picture order count delta indicated by rpi\_pic\_order\_cnt\_delta\_minus1 is positive. rpi\_pic\_order\_cnt\_delta\_sign\_flag equal to 1 specifies that the picture order count delta indicated by rpi\_pic\_order\_cnt\_delta\_minus1 is negative.

**rpi\_pic\_order\_cnt\_delta\_minus1** plus 1 specifies the absolute difference between the PicOrderCntVal of the associated primary coded picture (as specified below) and the PicOrderCntVal of the current picture.

The associated primary coded picture is the picture that has PicOrderCntVal equal to prmPicOrderCntVal, which is derived as follows, where currPicOrderCntVal is the PicOrderCntVal of the current picture:

prmPicOrderCntDelta = ( 1 – 2 \* rpi\_pic\_order\_cnt\_delta\_sign ) \* ( rpi\_pic\_order\_cnt\_delta\_minus1 + 1 )

prmPicOrderCntVal = currPicOrderCntVal – prmPicOrderCntDelta

The value of rpi\_pic\_order\_cnt\_delta\_minus1 shall be in the range of 0 to 255, inclusive.

**prm\_poc\_reset\_flag** equal to 1 indicates that the associated primary coded picture is an IRAP picture with NoRaslOutputFlag equal to 1 and the PicOrderCntVal of the associated primary coded picture is equal to 0. prm\_poc\_reset\_flag equal to 0 indicates that the associated primary coded picture is not an IRAP picture with NoRaslOutputFlag equal to 1 and the PicOrderCntVal of the associated primary coded picture may or may not be equal to 0.

NOTE – The following two approaches may be applied for decoder state recovering after a primary coded picture loss:

* When some delay is allowed, the decoder may wait for the arrival of a redundant coded picture, and then take the redundant coded picture as the primary coded picture.
* For real-time, low-delay applications after decoding redundant picture replace the primary picture with redundant picture.

In case of loss both pictures proposed to use the decoding process described in section 8.3.3.

A redundant picture SEI messages shall not be associated with any picture that satisfy any of the following conditions:

* The picture has PicOutputFlag equal to 1.
* The picture is used as a reference picture by any other picture.
* The picture has sps\_temporal\_mvp\_enabled\_flag equal to 1 and uses a primary coded picture as a reference picture.
* The vps\_poc\_proportional\_to\_timing\_flag in the VPS referred to by the picture or vui\_poc\_proportional\_to\_timing\_flag in the SPS referred to by the picture is equal to 1.

## Primary picture SEI message semantics

The primary picture SEI message indicates that the current picture is a primary coded picture and provides information on the redundant coded pictures associated with the current picture.

**num\_redundant\_pics\_minus1** plus 1 specifies the number of redundant coded pictures associated with the current picture that is a primary coded picture. The value of num\_redundant\_pics\_minus1 shall be in the range of 0 to 15, inclusive.

**ppi\_pic\_order\_cnt\_delta\_sign\_flag**[ i ] equal to 0 specifies that the picture order count delta indicated by ppi\_pic\_order\_cnt\_delta\_minus1[ i ] is positive. ppi\_pic\_order\_cnt\_delta\_sign\_flag[ i ] equal to 1 specifies that the picture order count delta indicated by ppi\_pic\_order\_cnt\_delta\_minus1[ i ] is negative.

**ppi\_pic\_order\_cnt\_delta\_minus1**[ i ] plus 1 specifies the absolute difference between the PicOrderCntVal of the current picture and and the PicOrderCntVal of i-th redundant coded picture associated with the current picture.

The i-th redundant coded picture associated with the current picture is the picture that has PicOrderCntVal equal to rdtPicOrderCntVal, which is derived as follows, where currPicOrderCntVal is the PicOrderCntVal of the current picture:

rdtPocDelta[ i ] = ( 1 – 2 \* ppi\_pic\_order\_cnt\_delta\_sign[ i ] ) \* ( ppi\_pic\_order\_cnt\_delta\_minus1[ i ] + 1 )

rdtPicOrderCntVal[ i ] = currPicOrderCntVal[ i ] + rdtPocDelta[ i ]

The value of ppi\_pic\_order\_cnt\_delta\_minus1[ i ] shall be in the range of 0 to 255, inclusive.

## Recovering process for lost pictures

Available two ways for decoder state recovering after primary picture loss.

1. If some delay is allowed then to wait redundant picture and replace primary picture with redundant picture.
2. For realtime and low delay applications after decoding redundant picture replace the primary picture with redundant one if primary picture unavailable.

In case of loss both pictures proposed to use the decoding process described in section 8.3.3.

## Constraints

Some constraints should be activated on encoder side for using redundant frames with POC different from primary frames:

* PicOutputFlag equal to 0 for redundant pictures
* It is not allowed to use redundant pictures as reference picture
* sps\_temporal\_mvp\_enabled\_flag should be equal to 0 for pictures which uses primary picture as reference picture.
* vps\_poc\_proportional\_to\_timing\_flag(vui\_poc\_proportional\_to\_timing\_flag) should be set to 0 to indicate that the picture order count value for each picture in the CVS that is not the first picture in the CVS, in decoding order, may or may not be proportional to the output time of the picture relative to the output time of the first picture in the CVS.
* One of the solution for output timing decoder conformance with redundant picture in CVS with PicOrderCntVal different from primary picture is to use PicOrderCntVal multiplied by 2 and to use odd values of PicOrderCntVal for redundant pictures. In this case the value of vps\_num\_ticks\_poc\_diff\_one\_minus1 (vui\_num\_ticks\_poc\_diff\_one\_minus1) plus 1 should be divided by 2.
* The other way for output timing decoder conformance with redundant picture is to use the picture timing SEI message with variables DpbOutputTime, picDpbOutputDelay and DpbDelayOffset described in C.3.3 for correct output of pictures followed by redundant picture.

# Conclusion

According to comments from previous contribution this proposal uses the SEI message approach for signalling redundant pictures in HEVC. The primary SEI message allows to inform the decoder about waiting period for recovering. It is also duplicate the difference of POC for redundant picture, which increases the robustness in error prone channels. The redundant SEI message have no mandatory influence on HEVC version 1 codec, but have a non normative influence which allows to protect the video stream from packet loss and in unmanaged networks with much more effectiveness than different protection mechanisms. Comparing to channel level protection schemes this method uses the existing memory which allows significantly reduce the memory used by channel level for saving packet for retransmission or for FEC based algorithms.

We suggest the committee adopts the redundant picture SEI message to the standard.

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