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| *Title:* | **Redundant frames for SHVC/MV-HEVC/HEVC** | | |
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# Abstract

This contribution presents the support for redundant frames in SHVC/MV-HEVC (/HEVC if possible). The proposed solution describes the syntax and semantics of how to support redundant frames (in the enhancement layers) by enabling more then one frame in the same layer to have the same POC, and propose the HRD behaviour when processing the frame with duplicated POC. This contribution has two solutions for usage of redundant frames for error resilience and one solution for performing interlayer prediction for redundant frames.

# Sections description (how to read this document)

Section 2 - provide the problem description and introduction.

Section 3 – introduces and describes the redundant frames for SHVC/MV-HEVC/HEVC specification.

Subsection 3.1 – the method of using redundant frames in enhancement layers is explained

Subsection 3.2 – provides description of redundant frames usage without signalling

Subsection 3.3 – provides the new NAL unit type for redundant frames

Subsection 3.4 – describes the technique of introducing redundant frames into HEVC

Subsection 3.5 – describes recovering process for lost frames

Section 4 – The list of references

# Introduction

Most of the media transmission systems are prone to network packet loss or storage data loss. 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.

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) [1], which is done in transport coding layer. The source coding layer methods include intra refresh (with the granularity of either macroblock (MB) or picture), which can prevent some error propagation [2].

The multiple description video coding (MDC) is also the well known non-interactive technique often used for error resilience [3]. All of those techniques have their own disadvantages. Using backward channel for protecting video transmission from errors is the most useful technique in case if backward channel is available. But the delay of backward channel is not small and errors in backward channel can only increase the whole delay. To protect video stream from grouped packet loss the redundancy of FEC codes need to be as much as the (average) size of group of lost packets. It is a very large redundancy especially in case of intra slice protection. Usage of unequal error protection mechanism with FEC for golden/intra frames (or similar highly significant frames) substantially increases the delay because these frames appear rarely in video stream in case of video transmission through the error prone channel. The MDC significantly increase the error resilience of a stream. It allows to output video even in case of some frame loss if the errors appear not in all descriptions but the output frame rate will be significantly reduced (twice or more). The intra refresh approach also has big redundancy because the temporal dependencies between frames are not used. Usage of redundant frames for protection is similar to FEC but implemented in the source coding layer.

Another application for redundant frames is the video server based systems like video broadcasting or multi-point videoconferencing even without errors in transmission channel. The widely used technique which allows for newcomers to join in is the periodic insertion of intra random access point (IRAP), especially for systems without backward channels. This approach increases the bandwidth of the channel significantly and the delay or quality degradation can appear. The redundant frames can significantly improve this situation for the already connected participants, while IRAPs are only used for the new recipients.

The previous standards (H.263, H.264 [4,5]) allow using redundant frames for error resilience in error prone channels [6]. The redundant picture is a redundant coded 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.

# Redundant frames for SHVC

The current specification of SHVC/MV-HEVC and HEVC does not allow having redundant frames in bitstream. This proposal describes introducing redundant frames into SHVC/MV-HEVC/HEVC and several applications and examples of how they can be used. Usage of redundant frames makes no sense for non-reference pictures.

Proposed solutions allow to separate the primary coded picture and the redundant coded pictures, which can increase the error resilience of bitstream in case of grouped packet loss.

For redundant frame introducing proposed to remove constraint on decoding picture order counter and make the following changes to the SHVC WD and Recommendation ITU-T H.265 sections:

**3 Definitions**

…

**coded picture**: A *coded representation* of a *picture* containing all *coding tree units* of the *picture*. Coded picture is a collective term referring to a *primary coded picture* or a *redundant coded picture*, but not to both together.

**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*.

**recovered picture**: A *recovered picture* is derived by decoding a *redundant coded picture*. The content of a *recovered picture* shall not be used by the *decoding process* for a *bitstream* conforming to this Recommendation | International Standard. Recovered pictures have no normative effect on the *decoding process*. See also *primary 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*.

…

**F.8.3.1 Decoding process for picture order count**

…

The value of PicOrderCntVal shall be in the range of −231 to 231 − 1, inclusive. ~~In one CVS, the PicOrderCntVal values for any two coded pictures in the same layer shall not be the same~~.

In one CVS, the same values of PicOrderCntVal for any two coded pictures in the same layer (exclude base layer) means that the first picture with this value of POC in decoding order is a primary coded picture and the following pictures with the same POC are redundant coded pictures.

In any reference picture set, the PicOrderCntVal values for any two coded pictures in the same layer shall not be the same.

NOTE: the redundant coded pictures can have different Nal unit types (NUTs) and can appear in the stream later in decoding order for reducing redundancy and for better error resilience.

…

## Redundant frames for enhancement layers

For the conformance to current HEVC version 1 for base layer, the following technique is proposed. The redundant coded pictures in extension layers need to have interlayer reference frame in layer 0 (base layer). Current version of HEVC version 1 does not allow to have it. It’s proposed to use resampled reference layer picture of the primary coded picture as a resampled reference layer picture for the redundant coded picture for inter layer prediction. Figures 1 and 2 show the example for using redundant P and B frames. The blue arrow corresponds to protection from the loss of the primary coded picture, black arrows are temporal prediction references, the orange arrow corresponds to interlayer intra prediction of the redundant frames from the base layer, the red arrow is a broken reference link, the green arrow is the recovered reference link after replacing the primary frame by the redundant frame, the red block is a the primary coded picture which can be lost, the green block corresponds to the redundant frame.



*Fig 1. Example of redundant P-frame.*



*Fig 2. Example of redundant B-frame.*

The following modification is required in the current specification of SHVC:

**H.8.1.2 Decoding process for inter-layer reference picture set**

for( i = 0; i < NumActiveRefLayerPics; i++ )

{ if( there is a picture picX in the DPB that ~~is in the same access unit~~ has the same PicOrderCntVal as the current picture and has nuh\_layer\_id equal to RefPicLayerId[ i ] )

{

*Interlayer reference picture derivation process …*

}

## Redundant frames usage without signalling ( Solution A )

The proposed algorithm describes method of redundant frame usage in decoding process. If any received frame has the same POC number as any frame in DPB, then this frame is discarded. If there is no frame with the same POC number in DPB then this frame is decoded. Proposed algorithm can only be implemented if redundant frame includes all coding tree units. Does not allow to protect IRAP frames with nal\_unit\_type value in the range of BLA\_W\_LP to RSV\_IRAP\_VCL23.



*Figure 3. Decoding algorithm with processing redundant frames by solution A.*

The following text should be included in the specification of SHVC:

Before any RPS list construction perform the following:

If( there is a picture in the DPB that has the same PicOrderCntVal as the current picture )

Stop the current picture decoding process and proceed to the following access units

**Advantages:**

* simple solution – minor changes
* keeps the NAL unit type of primary coded picture
* no need for any additional signaling

## Signalling of redundant frames (Solution B)

The slice header parsing process is required for solution A. It makes impossible early detection of redundant slices in CVS for discarding from decoding process in case of absence of errors in previously decoded frames. The solution A has some restriction on protection IRAP frames. For early detection it is proposed to include new NAL unit type RDN\_NUT instead of RSV\_VCL24.

|  |  |  |  |
| --- | --- | --- | --- |
| **nal\_unit\_type** | **Name of**  **nal\_unit\_type** | **Content of NAL unit and RBSP syntax structure NAL unit** | **type class** |
| 24 | RDN\_NUT | Coded slice segment of a redundant picture  slice\_segment\_layer\_rbsp( ) | VCL |

Introduction of NAL unit type RDN\_NUT doesn’t allow to protect IRAP frames by redundant frames because the redundant frame can not be an IRAP picture. So it is proposed to insert the *nal\_unit\_type* of the protected *primary coded picture* into the *slice header* of the redundant slice.

|  |  |
| --- | --- |
| slice\_segment\_header( ) { | **Descriptor** |
| if ( nal\_unit\_type == RDN\_NUT) |  |
| **nal\_unit\_type\_primary** | u(6) |
| … |  |
| } |  |

Prior to decode the first slice of the redundant picture, the value PicOrderCntValRdn derived as follows:

Invoke the subclause 8.3.1 for derivation of PicOrderCntVal value.

PicOrderCntValRdn = PicOrderCntVal

- If the current picture is an IRAP picture with NoRaslOutputFlag equal to 1, PicOrderCntMsb is set equal to 0.

If the picture with PicOrderCntVal is in DPB

Discard all NAL units corresponding to redundant coded picture

Otherwise

Invoke the sublause 8.3.2 with PicOrderCntValRdn as input

Decode redundant coded picture started from subclause 8.3.3

After the last decoding unit of the redundant coded picture is decoded set PicOrderCntVal to PicOrderCntPrmVal and put picture to DPB using PicOrderCntPrmVal



*Figure 4. Decoding algorithm with processing redundant frames by solution B.*

**Advantages:**

* the redundant coded slice can be easily discarded without parsing slice header for efficient bitstream extraction
* allows to protect IRAP frames with redundant frames

## Redundant frames for HEVC

Due to constraints described in HEVC version 1 section F.8.3.1 “Decoding process for picture order count” which disallow usage of any two coded pictures in the same layer with the same value of PicOrderCntVal. The HEVC version 1 HRD must discard picture with the POC which is already present in DPB. It’s proposed to include redundant frames in HEVC for error resilience functionality using the same approach as described in solution A. The bitstream with redundant frames will be compatible with already implemented decoders and allows improvement of the error resilience characteristics for newer implementations.

If the new NAL unit type is added for redundant frames then the constraints described in section F.8.3.1 “Decoding process for picture order count” which disallow usage of any two coded pictures in the same layer with the same value of PicOrderCntVal will not affect HEVC version 1 decoder due to discarding new NAL unit type. It’s proposed to include redundant frames in updated specification of HEVC for error resilience using the same approach as described in solution B.

## Recovering process for lost frames

For solution B the following modification in specification SHVC is proposed:  
…

For recovered IRAP pictures (IDR, CRA, BLA) the NAL unit type applied only after replacing process of the lost primary frame by the corresponding redundant frame. This is required to protect IRAP frames using redundant frames.

**Modification process for reference picture set**

If primary picture was replaced by redundant picture the following process is performed before replacing:

When the recovered primary picture is an IRAP picture with NoRaslOutputFlag equal to 1, all reference pictures currently residing in the DPB (if any) are marked as "unused for reference".

If the recovered primary picture is an IRAP picture with NoRaslOutputFlag equal to 1, PicOrderCntMsb is set equal to 0.

More flexible replacing process can be used for those areas (slices) of primary coded picture which were lost during transmission.

# Conclusion

Proposed solutions are describing the error robustness methods for protection of the video stream using redundant frames. Redundant frames are very useful in different error protection scenarios such as the interactive scenario using the feedback channel to signal lost data and non-interactive scenarios based on forward error correction approach.

As opposed to redundant frames solution used in H.264/AVC the proposed technique allows to separate the protected primary coded picture and the associated redundant frame which allows to protect video stream from the packet loss. The other benefit of proposed solution (B) is the ability to protect the large sized IRAP frames which are more sensitive to transmission errors.

The new redundant frames are constructed in a manner which allows to add such functionality to HEVC version 1 because the redundant frames will be discarded by current decoders and can be used in future versions with little modifications in HLS.

Our experiments with such redundant frame solutions show the good coding and protecting efficiency in error prone channels.

# References

1. P. Frossard, “FEC Performance in multimedia streaming,” IEEE Communications Letters, vol. 5, no. 3, pp. 122-124, Mar. 2001.
2. T. Stockhammer, D. Kontopodis, and T. Wiegand, “Rate-distortion optimization for JVT/H.26L coding in packet loss environment”, Packet Video Workshop 2002, Pittsburgh, PY, USA, Apr. 2002.
3. I. Radulovic, P. Frossard, Y. Wang, M.M. Hannuksela, A. Hallapuro “Multiple Description Video Coding with H.264/AVC Redundant Pictures”, IEEE transactions on circuits and systems for video technology, vol. 20, no. 1, January 2010.
4. ITU-T, “Advanced video coding for generic audiovisual services”, ITU-T Recommendation H.264, May 2003.
5. Y.-K. Wang, S. Wenger and M.M. Hannuksela, “Common conditions for SVC error resilience testing,” JVT document P206, Aug. 2005.
6. P.Baccichet, S.Raneand B.Girod, ”Systematic Lossy Error Protection based on H.264/AVC Redundant Slices and Flexible Macroblock Ordering”, PV2006, Hangzhou, PRC.

# Patent rights declaration(s)

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