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| **Joint Collaborative Team on Video Coding (JCT-VC)**  **of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29/WG 11**  18th Meeting: Sapporo, JP, 30 June – 9 July 2014 | Document: JCTVC-R0059 |

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| *Title:* | **HLS: Dependent RAP indication SEI message** | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Proposal | | |
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# Abstract

This contribution proposes a new dependent RAP indication SEI message for the HEVC base specification and its extensions. The SEI message is used to indicate the presence of a dependent random access point (DRAP) picture in the bitstream. A DRAP picture has the following constraints:

* It may only reference the previous IRAP picture
* It shall be a TRAIL\_R picture with temporal id 0
* When only\_skip\_or\_intra\_blocks\_flag is set in the SEI message, the DRAP picture may only contain intra or skip coded blocks

When performing random access at a DRAP picture, the associated IRAP picture must first be decoded. It is asserted that DRAP pictures may be used to improve the compression efficiency for random access coded video, especially for video services that often have very static content including screen sharing and surveillance video. It is further asserted that periodic DRAP pictures may be used to improve error robustness compared to not having periodic IRAP pictures.

A test simulation using a random access configuration has been carried out to indicate how much bitrate can be saved by using DRAP pictures. It was reported by the proponents that an average BD Y gain of 9.5 % was achieved for the HEVC version 1 test set and a BD Y gain of 17.2 % was achieved for the SCC YUV444 test set.

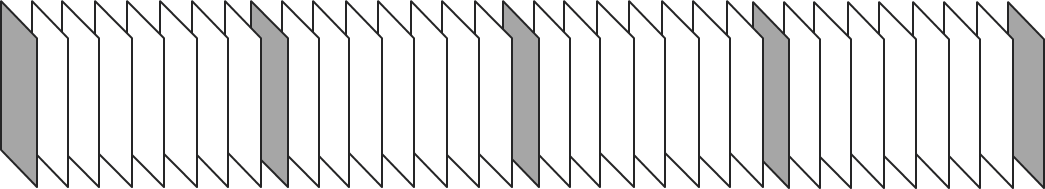
# Introduction and Problem Statement

IRAP pictures can be used in HEVC to enable random access operations and to refresh the video in case of errors. The functionality of IRAP pictures comes with a cost as intra pictures typically are significantly more expensive to encode in terms of bits compared to P- or B-pictures. For video with stationary content the relative cost of coding IRAP pictures becomes even more expensive as reported in the results section below.

# Proposal

In this proposal the problem described in the previous section is addressed by introducing a dependent random access point picture referred to as a DRAP picture. The presence and properties of a DRAP picture is indicated by a new dependent RAP indication SEI message.

A DRAP picture is a TRAIL\_R picture with temporal id 0 with the restriction that it may only reference the previous IRAP picture. In order to decode a DRAP picture in a random access operation its referenced IRAP picture must first be decoded. A random access configuration with IRAP pictures and a random access configuration with both IRAP and DRAP pictures are illustrated in figure 1 below.



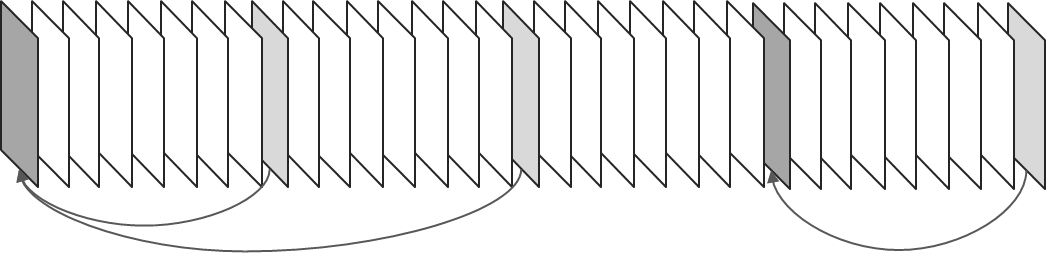


Figure Top: random access configuration with IRAP pictures. Bottom: random access configuration with both IRAP and DRAP pictures. The dark gray images are IRAP pictures, the medium gray pictures are DRAP pictures and the white pictures are either P- or B-pictures.

The referenced IRAP picture can be signaled as a short-term picture or a long-term picture depending on the distance to the IRAP picture.

To increase the error robustness properties, the DRAP picture can be coded using only skip or intra blocks. A simplified example is illustrated in figure 2 below. If the referenced IRAP picture is lost but pictures prior to the IRAP picture are decoded correctly and the IRAP is not a scene cut, the parts of the video that have been static since the IRAP will likely be correctly concealed by copying the skip blocks from the latest decoded picture. The parts of the video that has changed since the IRAP picture will be refreshed by the intra blocks. The computational complexity for performing random access at a DRAP picture is reduced when the DRAP is encoded using only intra and skip since no motion compensation and no sub-pixel interpolation needs to be performed during the decoding of the DRAP picture. An encoder can indicate that the DRAP picture has been encoded using only skip or intra blocks by setting the only\_skip\_or\_intra\_blocks\_flag equal to one in the proposed SEI message.

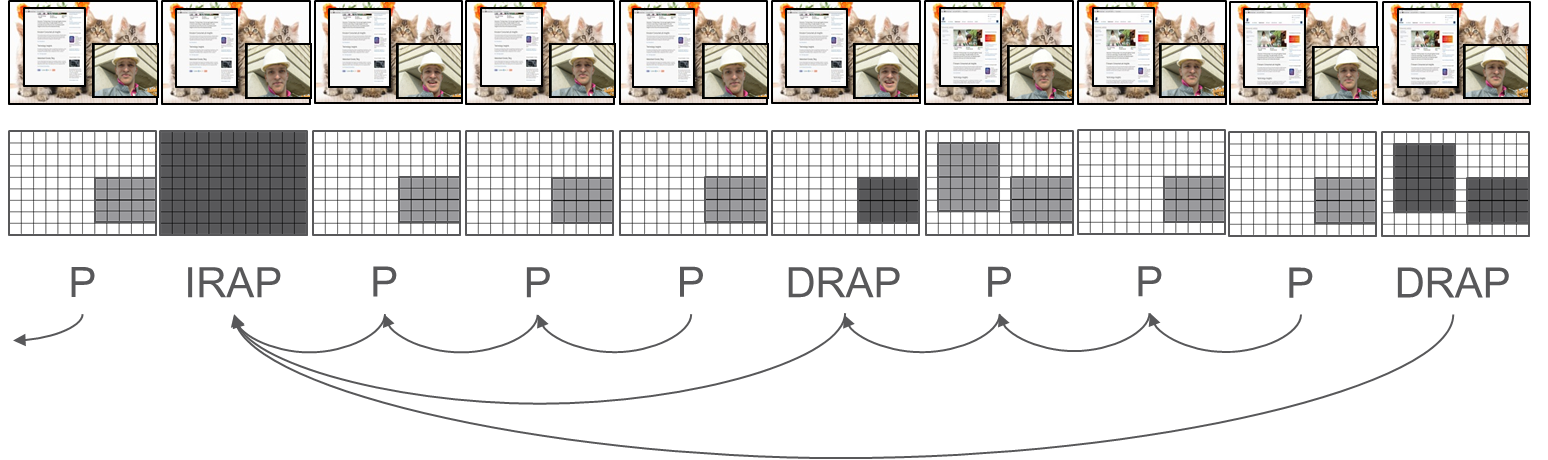


Figure Example of random access coding with DRAP pictures using only intra or skip blocks. The dark gray blocks are intra blocks, the white blocks are skip blocks and the medium gray blocks are inter or intra coded blocks.

Video services that often have very static content includes screen sharing and surveillance video. Screen sharing could for instance be used as a live communication tool between individuals or could be set up to monitor other computers such as servers.

For these services it is often of interest to store the video material. The stored video material should then preferably be easy to search using random access operations. At the same time it is of interest to keep the video bitrate at a minimum, both to limit the bandwidth usage and to save storage space.

By using DRAP pictures with a short periodicity and IRAP pictures with a longer periodicity (for instance DRAP pictures every second and IRAP pictures every 60 seconds) the bitrate can be reduced at the same time as the stored video can be easily searched.

The proposed SEI message contains a broken\_link\_flag that may be set if the encoder knows that the bitstream contains errors before the DRAP picture. It also contains a referenced\_irap\_picture\_poc\_delta\_idc that can be used to indicate the difference between the PicOrderCntVal of the DRAP picture and the PicOrderCntVal of its associated IRAP picture. This can be used either to identify the associated IRAP picture or to retrieve the correct PicOrderCntVal of the DRAP picture when performing random access.

The HEVC specification already contains the related recovery point SEI message that may be used for indicating possibility of random access. However, recovery point SEI messages cannot be used to realize the functionality of DRAP pictures. If a recovery point SEI message is sent together with the associated IRAP picture then all pictures that follow it in decoding order must be decoded up until the DRAP picture, which is not desirable. And the recovery point SEI message cannot be sent together with the DRAP picture since it is not possible to indicate dependency on anything that precedes the recovery point SEI message in decoding order.

## Proposed changes to HEVC specification

It is proposed to insert the following text marked in yellow into the HEVC specification [1] without any restrictions on which profiles and/or extensions it applies to.

D.2.25 Dependent RAP indication SEI message syntax

|  |  |
| --- | --- |
| dependent\_rap\_indication( payloadSize ) { | Descriptor |
| **broken\_link\_flag** | u(1) |
| **only\_skip\_or\_intra\_blocks\_flag** | u(1) |
| **referenced\_irap\_picture\_poc\_delta\_idc** | ue(v) |
| } |  |

D.3.25 Dependent RAP indication SEI message semantics

The dependent RAP indication SEI message assists a decoder in determining what parts of a bitstream need to be decoded in order to achieve correct decoding of the picture associated with the dependent RAP indication SEI message and the pictures that follow it in output order.

The picture associated with the dependent RAP indication SEI message is referred to as the DRAP picture. The DRAP picture shall be a TRAIL\_R picture with TemporalId equal to 0. The DRAP picture may use its associated IRAP picture for reference but shall not use any other picture for reference.

When performing random access at the DRAP picture the value of pic\_output\_flag should be inferred to be equal to 0 for all pictures that precede the DRAP picture in output order. Decoded pictures preceding the DRAP picture in output order may contain references to pictures unavailable in the decoded picture buffer.

Pictures that follow the DRAP picture in output order shall not use for reference any picture that precedes the DRAP picture in output order or decoding order with the exception that other, subsequent DRAP pictures may also use the associated IRAP picture for reference.

**broken\_link\_flag** indicates the presence or absence of a broken link in the NAL unit stream at the location of the dependent RAP indication SEI message and is assigned further semantics as follows:

* If broken\_link\_flag is equal to 1, pictures produced by starting the decoding process at the location of a previous IRAP access unit may contain undesirable visual artefacts to the extent that decoded pictures preceding the access unit associated with the dependent RAP indication should not be displayed.
* Otherwise (broken\_link\_flag is equal to 0), no indication is given regarding any potential presence of visual artefacts.

**only\_skip\_or\_intra\_blocks\_flag** indicates whether the DRAP picture contains only intra coded blocks or blocks with cu\_skip\_flag set to 1 according to:

* If only\_skip\_or\_intra\_blocks\_flag equals 1, the DRAP picture shall only contain intra coded blocks or blocks with cu\_skip\_flag set to 1.
* Otherwise, if only\_skip\_or\_intra\_blocks\_flag equals 0, the DRAP picture may contain blocks other than intra coded blocks or blocks with cu\_skip\_flag set to 1.

**referenced\_irap\_picture\_poc\_delta\_idc,** when greater than zero, specifies the difference between the PicOrderCntVal of the DRAP picture and the PicOrderCntVal of the IRAP picture referenced by the DRAP picture. If referenced\_irap\_picture\_poc\_delta\_idc equals 0, the difference between the PicOrderCntVal of the DRAP picture and the PicOrderCntVal of the IRAP picture referenced by the DRAP picture is unspecified.

# Results

To get an indication of how much can be gained from using the DRAP approach a simulation was made using a modified version of SCM-1.0 [2] and its random access configuration file. In the anchor simulation CRA pictures were inserted every 32nd picture for every sequence. In the DRAP test, DRAP pictures were inserted every 32nd picture only referencing to the first IDR picture. To realize this, the first IDR picture was signaled as a long-term picture and kept in the decoded picture buffer.

The tables below show the BD rates between the CRA anchor and the DRAP test for the HEVC version 1 and the SCC YUV444 test sets.

|  |  |  |  |
| --- | --- | --- | --- |
| **Sequence** | **BD Y** | **BD U** | **BD V** |
| Traffic\_2560x1600\_30\_crop2 | -19.21 | -17.63 | -16.31 |
| PeopleOnStreet\_2560x1600\_30\_crop | -2.68 | -1.37 | -2.34 |
| Nebuta\_2560x1600\_60\_10bit\_crop | -4.15 | 5.33 | 8.25 |
| SteamLocomotiveTrain\_2560x1600\_60\_10bit\_crop | -9.39 | -2.76 | -5.66 |
| Kimono1\_1920x1080\_24 | -1.23 | 1.79 | 4.60 |
| ParkScene\_1920x1080\_24 | -5.82 | -1.31 | 0.94 |
| Cactus\_1920x1080\_50 | -16.73 | -17.01 | -11.92 |
| BasketballDrive\_1920x1080\_50 | -2.01 | 1.80 | 1.25 |
| BQTerrace\_1920x1080\_60 | -16.36 | -2.84 | -10.49 |
| BasketballDrill\_832x480\_50 | -16.40 | -15.62 | -15.75 |
| BQMall\_832x480\_60 | -4.73 | -0.05 | -0.94 |
| PartyScene\_832x480\_50 | -5.00 | 0.28 | 0.32 |
| RaceHorses\_832x480\_30 | -2.37 | 0.89 | 1.49 |
| BasketballPass\_416x240\_50 | -1.31 | 1.27 | 0.00 |
| BQSquare\_416x240\_60 | -6.57 | -0.23 | 1.12 |
| BlowingBubbles\_416x240\_50 | -1.98 | 3.35 | 2.66 |
| RaceHorses\_416x240\_30 | -1.38 | 1.86 | 1.64 |
| BasketballDrillText\_832x480\_50 | -17.03 | -16.30 | -16.25 |
| ChinaSpeed\_1024x768\_30 | -11.70 | -9.42 | -10.02 |
| SlideEditing\_1280x720\_30 | -55.90 | -54.50 | -54.97 |
| SlideShow\_1280x720\_20 | 1.78 | 8.12 | 7.19 |
| **Average** | **-9.53** | **-5.44** | **-5.49** |

Table BD rates for the HEVC version 1 test set.

|  |  |  |  |
| --- | --- | --- | --- |
| **Sequence** | **BD Y** | **BD U** | **BD V** |
| sc\_flyingGraphics\_1920x1080\_60\_8bit\_444\_yuv | -1.19 | -0.45 | -0.44 |
| sc\_desktop\_1920x1080\_60\_8bit\_444\_yuv | -38.64 | -38.58 | -38.61 |
| sc\_console\_1920x1080\_60\_8bit\_444\_yuv | -7.94 | -7.38 | -7.13 |
| sc\_web\_browsing\_1280x720\_30\_300\_8bit\_444\_yuv | -25.56 | -24.38 | -25.43 |
| sc\_map\_1280x720\_60\_8bit\_444\_yuv | -17.08 | -15.89 | -14.23 |
| sc\_programming\_1280x720\_60\_8bit\_444\_yuv | -10.49 | -10.31 | -10.50 |
| sc\_SlideShow\_1280x720\_20\_8bit\_500\_444\_yuv | 1.63 | 3.55 | 3.96 |
| Basketball\_Screen\_2560x1440\_60p\_8b444\_yuv | -57.68 | -57.65 | -57.64 |
| MissionControlClip2\_2560x1440\_60p\_8b444\_yuv | -10.90 | -8.72 | -8.03 |
| MissionControlClip3\_1920x1080\_60p\_8b444\_yuv | -40.91 | -40.26 | -39.99 |
| sc\_robot\_1280x720\_30\_8bit\_300\_444\_yuv | -8.83 | -7.59 | -6.42 |
| EBURainFruits\_1920x1080\_50\_10bit\_444\_yuv | -3.46 | 1.54 | 1.52 |
| Kimono1\_1920x1080\_24\_10bit\_444\_yuv | -2.10 | -2.47 | -0.74 |
| **Average** | **-17.17** | **-16.05** | **-15.67** |

Table BD rates for the SCC YUV444 test set.

It is reported that for the simulated DRAP test an average BD Y gain of -9.5 % was achieved for the HEVC version 1 test set and a BD Y gain of -17.2 % was achieved for the SCC YUV444 test set. Gains are generally higher for typical screen content sequences where parts of the screen tend to be stationary for long periods of time.

# References

[1] “Recommendation ITU-T H.265 - High Efficiency Video Coding”, April 2013, http://www.itu.int/rec/T-REC-H.265-201304-I

[2] https://hevc.hhi.fraunhofer.de/svn/svn\_HEVCSoftware/tags/HM-14.0+RExt-7.0+SCM-1.0/

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