Source	**Telecom ParisTech, Canon Research Centre France**
Status	**For consideration at the 112th MPEG Meeting**
Title	**Clarification on the use of HEVC BLA and CRA Pictures**
Author	Cyril Concolato, Jean Le Feuvre, Franck Denoual, Frédéric Mazé, Naël Ouedraogo, Eric Nassor

1 Introduction

HEVC defines several types of random access pictures (RAP). These pictures are used in diverse ISO standards, in particular the HEVC File Format, the Image File Format and DASH, not always in a similar manner. This contribution reviews the different types of RAP and proposes to harmonize their signaling.

2 Analysis of HEVC RAP types

HEVC defines different IRAP Pictures as follows:

"An IRAP picture contains only I slices, and may be a BLA picture, a CRA picture or an IDR picture"

and

"Provided the necessary parameter sets are available when they need to be activated, the IRAP picture and all subsequent non-RASL pictures in decoding order can be correctly decoded without performing the decoding process of any pictures that precede the IRAP picture in decoding order."

Non-IRAP pictures include Leading Pictures and Trailing Pictures.

There are 6 types of NALU to indicate the type of RAP:
- IDR_N_LP
- IDR_W_RADL
- BLA_W_LP
- BLA_W_RADL
- BLA_N_LP
- CRA_NUT

IDR_N_LP have 3 characteristics: 1) they are RAP; 2) they reset the reference list (i.e. no frame after in decoding order will need frames before the IDR); and 3) they do not have associated leading pictures (there is no frame after in decoding order that will have to be presented before).

BLA_N_LP are similar to IDR_N_LP with the difference that they do not reset the reference list. Some frames after in decoding order may not be decodable if the decoding starts at this BLA because the reference list is not empty.

IDR_W_RADL are RAP that reset the reference list. So, all frames after this IDR in decoding order can be decoded if the decoding starts from the IDR. It may have leading picture, but these leading pictures (if they exist) are decodable.

BLA_W_RADL are similar to IDR_W_RADL, but the reference list is specified in the NAL unit header.

BLA_W_LP are BLA_W_RADL but additionally that there may be associated LP that cannot be decoded.

CRA_NUT are BLA pictures for which the exact BLA type has not been indicated.

CRA Pictures (and therefore BLA) are typically used in Open GoP structures as they provide RAP but allow for a reference list that contains pictures before the BLA or CRA and therefore enables a better coding efficiency. When starting with such frame a compliant HEVC decoder should follow a procedure to discard frames that cannot be decoded.

Typically, an encoder, when using Open GoP structures, will produce CRA pictures. A decoder when tuning in at this point (when starting to decode from the CRA) is forced to discard frames that have references not yet there. The problem happens when this CRA is spliced with another bitstream as it will not be the first frame anymore. Decoders will be able to find some reference frames, but possibly wrong ones. It is the role of a splicing tool to signal a BLA picture instead of the CRA picture, with a proper type depending on the use of LP. Decoders will then discard RASL.

The HEVC standard defines IDR and BLA pictures using "may", which means that an encoder or a packager may signal an IDR of type IDR_W_RADL when in fact there are no RADL. Signaling in File Formats is dependent on the encoder and on the work done at the file packager, i.e. whether it relied on the encoder output or whether it analyzed the frames to set a stricter NALU type. For the sake of simplicity, we assume that the encoder uses the strictest possible NALU types. It does not for instance signal BLA_W_RADL when it is actually BLA_N_LP or other cases.

3   Mapping of HEVC RAP Types to ISOBMFF, DASH and IFF

14496-12 5th edition defines the following term:
"**3.1.11 random access point (RAP)**
sample in a track that starts at the ISAU of a SAP of type 1 or 2 or 3 as defined in Annex I; informally, a sample, from which when decoding starts, the sample itself and all samples following in composition order can be correctly decoded"

This matches all types of HEVC RAP.

"**3.1.16 sync sample**
sample in a track that starts at the ISAU of a SAP of type 1 or 2 as defined in Annex I; informally, a media sample that starts a new independent sequence of samples; if decoding starts at the sync sample, it and succeeding samples in decoding order can all be correctly decoded, and the resulting set of decoded samples forms the correct presentation of the media starting at the decoded sample that has the earliest composition time; a media format may provide a more precise definition of a sync sample for that format"

We believe that for HEVC this definition also matches only IDR_N_LP, IDR_W_RADL, BLA_N_LP and BLA_W_RADL.

14496-12 5th edition defines "leading sample" as follows:
"A leading sample is such a sample associated with an "open" random access point (RAP). It precedes the RAP in presentation order and immediate follows the RAP or another leading sample in decoding order, and when decoding starts from the RAP, the sample cannot be correctly decoded."

This definition (which should be placed in the terms and definition section) is equivalent to an HEVC RASL.

14496-12 5th edition defines RAP sample grouping as follows:
"A sync sample is specified to be a random access point after which all samples in decoding order can be correctly decoded. However, it may be possible to encode an "open" random access point, after which all samples in output order can be correctly decoded, but some samples following the random access point in decoding order and preceding the random access point in output order need not be correctly decodable. For example, an intra picture starting an open group of pictures can be followed in decoding order by (bi-)predicted pictures that however precede the intra picture in output order; though they possibly cannot be correctly decoded if the decoding starts from the intra picture, they are not needed. Such "open" random-access samples can be marked by being a member of this group. Samples marked by this group must be random access points, and may also be sync points (i.e. it is not required that samples marked by the sync sample table be excluded)."

This text (which should probably be trimmed of its repeated sync sample definition) defines the concept "open" RAP that matches the concept of BLA_W_LP.

14496-15 3rd edition specifies:
"An HEVC sample is considered as a sync sample if the VCL NAL units in the sample indicate that the coded picture contained in the sample is an Instantaneous Decoding Refresh (IDR) picture, a Clean Random Access (CRA) picture, or a Broken Link Access (BLA) picture."

The 14496-15 COR and defect report (N15183) also contain the same text. We believe this is an error. It should exclude CRA and BLA_W_LP.

14496-15 defines a 'sync' sample group for providing the NALU type for sync samples. This is redundant with the SAP sample group. We propose to deprecate it.

The DASH IF guidelines indicate:
"IDR pictures with nal_unit_type equal to IDR_N_LP and IDR_W_RADL are mapped to SAP types 1 and 2, respectively. BLA pictures with nal_unit_type equal to BLA_N_LP and BLA_W_RADL are mapped to SAP types 1 and 2, respectively. BLA pictures with nal_unit_type equal to BLA_W_LP are mapped to SAP type 2. CRA pictures with nal_unit_type equal to CRA_NUT are mapped to SAP type 3."

We believe this is an error. It should say that BLA_W_LP are mapped to SAP type 3.

The DVB DASH specification indicates:

"Note: The mapping to SAP type 3 for ISO BMFF with HEVC deliberately remains undefined until MPEG reaches a conclusion. This includes the mapping of all other types of HEVC DVB_RAP pictures (including BLA pictures with nal_unit_type equal to BLA_W_LP, CRA pictures with nal_unit_type equal to CRA_NUT and pictures with nal_unit_type equal to TRAIL_R that contain only slices with slice_type equal to 2 (I slice), as specified in ETSI TS 101 154 [4] clause 5.14.1.8)."

We believe DVB should be informed that MPEG reached a conclusion.

Summary:

	ISOBMFF sync status	DASH SAP type
IDR_N_LP	true	1
IDR_W_RADL	true	2 (or 1 if no RADL is effectively used)
BLA_N_LP	true	1
BLA_W_RADL	true	2 (or 1 if no RADL is effectively used)
BLA_W_LP (RASL, RADL)	false (or true)	3 (or 2 if additionally no RASL is used or 1 if additionally no RADL is used)
CRA	false (or true)	1 or 2 or 3 (depending on which BLA it corresponds to)
Others NALU types	false	0

23008-12 defines image collection and image sequences. In image collection, the possible HEVC profiles are "Main", "Main 10" or "Main Still Picture". In image sequences, the HEVC profiles are not restricted. It is unclear if BLA or CRA pictures are allowed in image collection profiles. We propose to adopt the following:

	IFF Single Image Allowed Image Types	IFF Image sequence Allowed RAP types
IDR_N_LP	Yes	Yes
IDR_W_RADL	Yes	Yes
BLA_N_LP	Yes	Yes
BLA_W_RADL	Yes	Yes
BLA_W_LP (RASL, RADL)	Yes	Not allowed
CRA	Yes	Not allowed
Others NALU types	Not allowed	Not allowed

4 Recommendation

We recommend MPEG to update 14496-12, 14496-15 and 23008-12 to harmonize the definitions so that the mapping of HEVC IRAP pictures is clear and to liaise with DASH-IF and DVB.