

**INTERNATIONAL ORGANISATION FOR STANDARDISATION
ORGANISATION INTERNATIONALE DE NORMALISATION
ISO/IEC JTC1/SC29/WG11
CODING OF MOVING PICTURES AND AUDIO**

**ISO/IEC JTC1/SC29/WG11 MPEG2014/M32286
January 2014, San Jose, USA**

Source **Telecom ParisTech, Canon Research Centre France**
Status **For consideration at the 107th MPEG Meeting**
Title **Clarifications on HEVC Tile tracks**
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1 Introduction

During the 106th MPEG meeting, contribution [m31439](#) was presented to investigate how multi-layer tiling could be represented in the HEVC file format using structures in place for the single layer tiling.

It was noted during the discussion that there is currently no restrictions on the number of references a tile may predict from, while the proposal assumed only one reference used from lower layer.

This contribution attempts at covering the subject of tiling and dependencies.

2 Possible dependencies

In ISO/IEC 23008-2 Annex F, an inter-layer constrained tile sets SEI message is defined to indicate constraints on inter-layer prediction process when layers are encoded with tiles. This SEI message is defined for a given layer as follows:

“The inter-layer constrained tile sets SEI message shall not be present for a layer unless every PPS that is active for the layer has *tile_boundaries_aligned_flag* equal to 1” (in VPS VUI) “or fulfills the conditions that would be indicated by *tile_boundaries_aligned_flag* being equal to 1”.

This SEI message “indicates that the **inter-layer inter prediction process is constrained such that no sample value outside each identified tile set**, and no sample value at a fractional sample position that is derived using one or more sample values outside the identified tile set, **is used for inter prediction of any sample within the identified tile set**”. More specifically, the prediction constraints for each tile set are given by a specific *ilc_idc* flag:

ilc_idc[i] is a flag for a tile or a tile set with following values:

- 0: undetermined
- 1: indicates that, within the CVS, no samples outside of the i-th identified tile set and no samples at a fractional sample position that is derived using one or more samples outside of the i-th identified tile set are used for inter-layer prediction of any sample within the i-th identified tile set with *nuh_layer_id* equal to *ictsNuhLayerId*, where *ictsNuhLayerId* is the value of *nuh_layer_id* of this message.

- 2: indicates that, within the CVS, no prediction block in the i-th identified tile set with nuh_layer_id equal to ictsNuhLayerId is predicted from an inter-layer reference picture.
- 3: reserved.

Moreover, the reference picture list construction algorithm (Annex H.8.1.2 and H.8.3.4) indicates that for layered HEVC, one or more inter-layer reference pictures can be used, depending on direct dependencies between layers (as illustrated on Figure 1). For instance, the maximum number of pictures present in one of this list is given by a parameter *NumActiveRefLayerPics* in slice header segment.

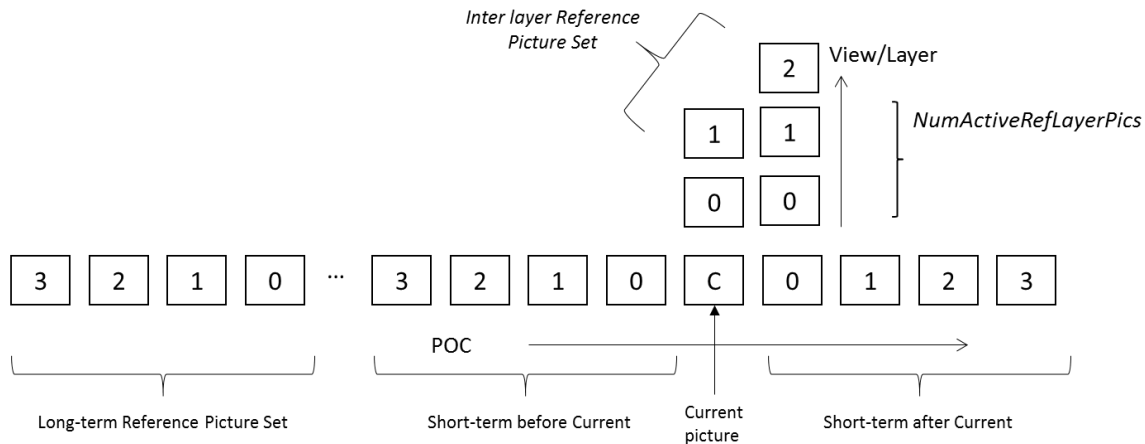


Figure 1: reference pictures for layered HEVC

This confirms that multiple inter-layer reference pictures can be used for a given tile and that previous tile descriptor from m31439, was too limited.

3 Proposed approach

From the above discussion, it seems clear that we need:

- a way to describe tiling
- a way to describe how these tiles depend on each other across layers.

Since a same tile may have varying dependencies over time, at least from one GOP to another, either we duplicate the tiling configuration for each possible dependency or we introduce an explicit dependency grouping. Given the size needed to describe the tile (ID + offset(x,y) + size(w,h)), we believe a better approach is to describe dependencies.

Fortunately, we already have in the WD a tool that builds a set of tiles based on coding dependencies, the *TileSetGroupEntry*, which allows describing a *TileSet* using individual tile IDs. In other words, it is possible to indicate that a *TileSet* is made of a single tile. The dependency list that follows allows listing any number of tiles, which could be from different layers. Hence, it is possible to list in a tsif sample description box the dependencies of a tile to other tile IDs in lower layers.

To cover the use case of tile base and tile layer, we will have a file with:

- For each tile of the base layer, one tile region flagged as “independent” with value 1 (or 2 if IDR only), i.e. can be decoded without temporal dependencies from other tile in this layer

- For each tile of the enhancement layer, one tile region flagged as “independent” (with value 1), i.e. can be decoded without temporal dependencies from other tile **in this layer**
- For each tile of the enhancement layer, one tile set made of a single tile and dependencies to the base tile(s)
- In the enhancement layer track, a ‘nalm’ sample group description box with two entries (Figure 2):
 - o one entry mapping NALUs to a ‘tsif’ group, where use of inter-tile dependencies (including inter-layer dependencies) are described; and
 - o one entry mapping NALUs to a ‘trif’ group for independent tiles (i.e. tiles having no dependencies to other, non co-located, tiles).

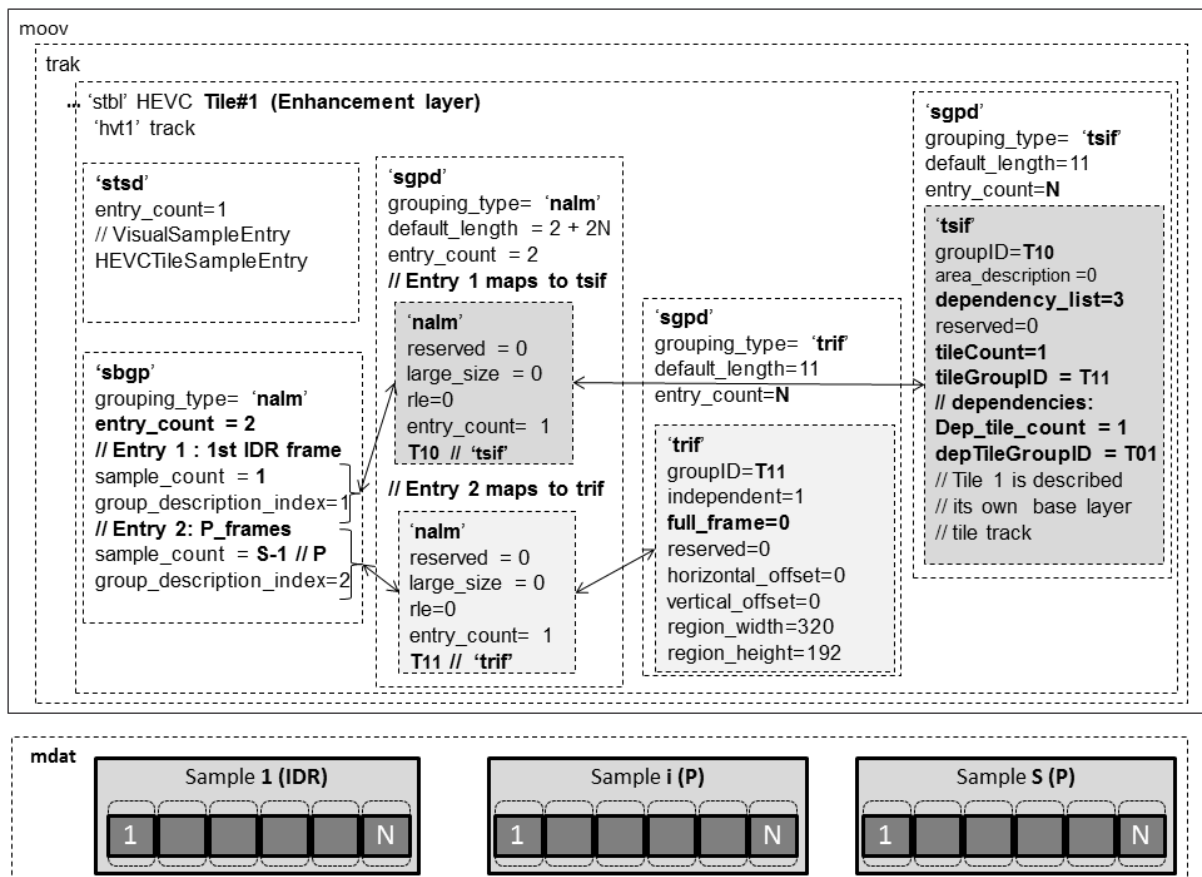


Figure 2: Example of signaling a tile track containing both independent tile samples and tile samples with inter-layer dependences

The remaining problem with this approach happens when describing dependencies between a tile layer and a non-tile layer. m31439 proposed the definition of a new sample group entry (*HEVCLayerDefinitionBox*) dedicated to non-tile layer and having an associated ID in the same namespace as tiles and tile sets; it however makes the reading of dependencies difficult (three different sample groups plus the ‘nalm’ group are needed). We suggest simplifying the design by allowing a non-tile layer to be described by a *TileRegionGroupEntry*, so that all dependencies between layers, whether tiled or not, can be expressed through a single description tool, the tile set.

One final modification is that it is expected that one common use case will be to have inter-layer dependency only on the first frame of the GOP (IDR/BLA/CRA), while the rest of the GOP will not use inter-layer prediction. This could be described using additional ‘nalm’ and ‘tsif’ entries for IDR samples, but it then requires using a dedicated sample to group box rather than relying on the default sample group description, which is less efficient; we propose adding an optional dependency list only valid for intra tiles.

4 Proposed modification

In 8.5.3.2 change:

```
class TileRegionGroupEntry() extends VisualSampleGroupEntry ('trif')
{
  unsigned int(16) groupID;
  unsigned int(2)  independent;
  unsigned int(6)  reserved=0;
  unsigned int(16) horizontal_offset;
  unsigned int(16) vertical_offset;
  unsigned int(16) region_width;
  unsigned int(16) region_height;
}
```

with

```
class TileRegionGroupEntry() extends VisualSampleGroupEntry ('trif')
{
  unsigned int(16) groupID;
  unsigned int(2)  independent;
  unsigned int(1)  full_frame;
  unsigned int(5)  reserved=0;
  if (!full_frame) {
    unsigned int(16) horizontal_offset;
    unsigned int(16) vertical_offset;
  }
  unsigned int(16) region_width;
  unsigned int(16) region_height;
}
```

In 8.5.3.3 change

“independent specifies the coding dependencies between this tile and other tiles in the current frame and in reference frames:”

with

“independent specifies the coding dependencies between this tile and other tiles in the current frame and in reference frames **of the same layer**. Inter-tile dependencies, if any, are indicated by means of dependency_list in TileSetGroupEntry. This flag takes the following values:”

and add

“

`full_frame`, when set, indicates that this tile is actually a complete frame, in which case `region_width` and `region_height` shall be set to the layer luma size, and `independent` shall be set to 1. This allows expressing dependencies between tiles of a layer to a non-tiled layer using the ‘tsif’ sample group referencing a ‘trif’ sample group with *full_frame* parameter set to 1.”

Change the sentence in 8.5.1:

“Each of these groups is assigned a unique identifier, which can be used to associate a NALU to a group. Tile and Tile Sets share the same namespace for `groupID` (ie, there shall not be two tile and tile sets with the same `groupID`).”

To

“Each of these groups is assigned a unique identifier, which can be used to associate a NALU to a group. Tile Regions and Tile Sets share the same namespace for `groupID`, scoped by the base HEVC layer, as indicated by `tbas` track reference; i.e. there shall not be two tile regions or tile sets with the same `groupID` in any tracks having the same base layer.”

In `TileSetGroupEntry` change

```
if (dependency_list==1) {
    unsigned int(16) dependency_tile_count;
    for (i=1; i<= dependency_tile_count; i++){
        unsigned int(16) dependencyTileGroupID;
    }
}
```

with

```
if ((dependency_list==1)|| (dependency_list==3)) {
    unsigned int(16) dependency_tile_count;
    for (i=1; i<= dependency_tile_count; i++){
        unsigned int(16) dependencyTileGroupID;
    }
    if (dependency_list==3) {
        unsigned int(16) idr_dependency_tile_count;
        for (i=1; i<= idr_dependency_tile_count; i++){
            unsigned int(16) idr_dependencyTileGroupID;
        }
    }
}
```

In semantics of `dependency_list`, replace

“If set to 3, the list of dependencies for this tile set is not known.”

with

“If set to 3, an additional list of tile dependencies is given for the case where the sample is a sync sample as defined for this HEVC layer.”

And add the following semantics:

`idr_dependency_tile_count`, `idr_dependencyTileGroupID`: specifies the list of Tile Region or Tile Sets this tile set depends on when the sample this tile belongs to is a sync sample as defined for this HEVC layer.

Editorial edit: in the semantics of “TileRegionGroupEntry”, replace

“If independent equals 1, there are no spatial coding dependencies between this tile and other tiles in the same frame, no temporal dependencies between this tile ...”

with

“If independent equals 1, there are no temporal coding dependencies between this tile ...”

5 Conclusion

We suggest adding the proposed clarifications and modifications to the WD on multi-layer HEVC storage “Enhanced support of HEVC and MVC+D”.