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**Title**      **On Layered-HEVC in MPEG-2 TS**  
**Author**    Jean Le Feuvre, Cyril Concolato, Hendry, Adarsh K. Ramasubramonian, Ye-Kui Wang,

## **1 Introduction**

During its 108<sup>th</sup> meeting, the WG11 Systems subgroup has issued the CD of the carriage of Layered HEVC over MPEG-2 TS. The CD features a tool to separate layers in an HEVC access unit, the *Layer picture delimiter NAL unit*. This contribution further explores usage of this tool.

## **2 Problem description**

### **2.1 On the identification of access unit / HEVC layer component boundary**

When multiple layers are carried over the same PID, it is important to make sure that a demultiplexer can easily identify the different layers and access unit partitioning without any deep inspection of the HEVC bitstream. Layers are trivially identified using the `nuh_layer_id`, however identifying an AU is more delicate:

- If AUs are “data-aligned” with the PES packet, then each layer found in this PES packet belongs to the same AU, and no other specific inspection is needed by the demultiplexer;
- If AUs are not aligned with PES packets boundaries, three possible cases can be found:
  - o The PID contains 2 or more layers and `nuh_layer_id` decreases in the PES packet: in this case, the demultiplexer can easily find the AU delimiter by inspecting `nuh_layer_id`: as soon as the `nuh_layer_id` decreases, this implies that the AU has changed
  - o The PID contains one single layer: in this case, the demultiplexer cannot decide from the nal header if the nal at the beginning of the PES packet belongs to the AU started in the previous PES packet or to the AU starting in this PES packet; the only way to take this decision is by inspecting the slice segment header and checking the POC of the slice to detect picture changes .Figure 1 illustrates this problem: a demultiplexer cannot know that the white-colored blocks in the PES#N+3 belongs to another access unit just from inspecting information carried in the NAL unit header.

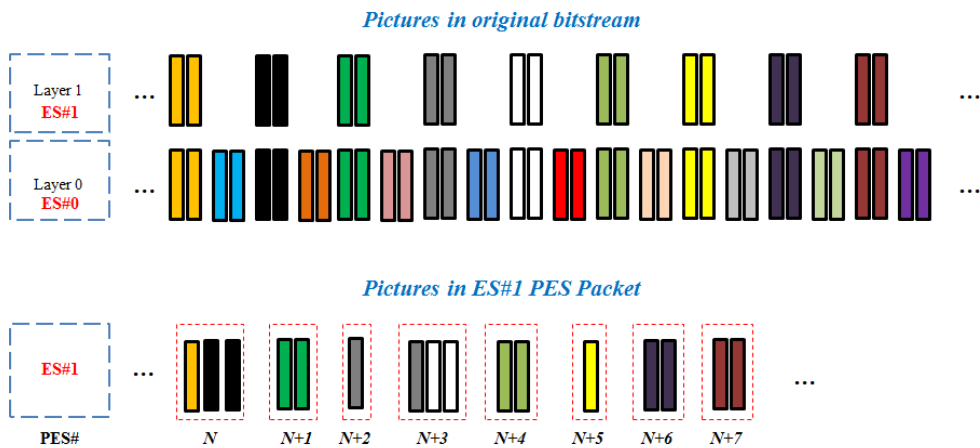


Figure 1 – Example of a bitstream where identifying HEVC layer component boundary needs deep inspection of NAL units.

- The PID contains more than one layer and nuh\_layer\_id of the packets increase. In this case, the PES packet could contain pictures of two AUs and if the latter AU does not have pictures present in one or more layers. The demultiplexer cannot decide from the NAL unit header if the NAL unit at the beginning of the PES packet belongs to the AU started in the previous PES packet or to the AU starting in this PES packet; the only way to make this decision is to inspect the slice segment header and checking the POC of the slice to detect picture changes. Figure 2 illustrates this problem: a demultiplexer cannot know that the red-colored blocks in the PES#N+6 belong to another access unit just from inspecting information carried in the NAL unit header.

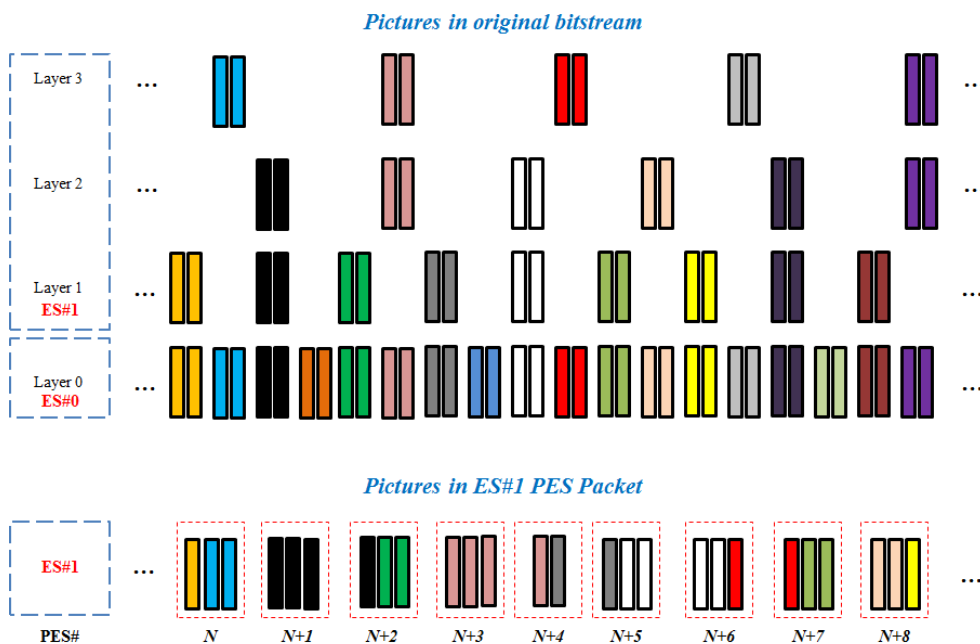


Figure 2 – Another example of bitstream where identifying HEVC layer component boundary needs deep inspection of NAL units

## 2.2 On the layer ID of layer picture delimiter

The value of layer ID of an LPD NAL unit can be of any value. However, it does not make sense to have layer ID of an LPD NAL unit to be equal to 0 because LPD NAL unit with layer ID

equal to 0 is basically an access unit delimiter (AUD) NAL unit. In such case, it is more appropriate to label the NAL unit as AUD NAL unit.

### **2.3 On the number of layer picture delimiter in a PES packet**

The number of LPD NAL unit that may be present in a PES packet is not limited in the current specification. However, if the LPD NAL unit is to be used to help identifying HEVC layer component boundary, the number of LPD NAL unit that may present in a PES packet must be at most one, otherwise, it is possible for content source to put one LPD for each picture in an HEVC layer component, which will be equivalent as no LPD at all (e.g., deep inspection of the slice header will be needed).

## **3 Proposed solutions**

### **3.1 On the presence of LPD**

We believe that slice segment header inspection is too complex for the demultiplexer, as information from the PPS is required to parse the header.

The *Layer picture delimiter NAL unit* introduced in the CD can help in this case, as it will directly inform the demultiplexer where the new picture starts in the PES packet. We therefore suggest making its presence in a PES packet mandatory when the following conditions are all satisfied:

- The first VCL NAL unit in the PES payload is not the first VCL NAL unit of the HEVC layer component that commences in the PES packet.
- The layer ID of the first VCL NAL unit of the HEVC layer component that commences in the PES packet is greater than or equal to the layer ID of the last VCL NAL unit of the previous HEVC layer component in the same PES packet.
- The PES packet does not contain an AUD NAL unit.

Add to 2.17.6.1:

The `LPD_nal_unit` shall be present in a PES packet after the last VCL NAL unit of HEVC layer component *lcA* and before the first VCL NAL unit of HEVC layer component *lcB* when all of the followings conditions are satisfied:

- *lcA* is the HEVC layer component that immediately precedes *lcB*.
- The PES packet contains the last VCL NAL unit of *lcA* and the first VCL NAL unit of *lcB*.
- The value of `nuh_layer_id` of the first VCL NAL unit of *lcB* is greater than or equal to the value of `nuh_layer_id` of of the last VCL NAL unit of *lcA*.

### **3.2 On the layer ID of LPD**

The following update is proposed to the semantic of `lpd_nuh_layer_id`.

**`lpd_nuh_layer_id`** – specifies the layer identifier of the layer picture delimiter NAL unit. **The value of `lpd_nuh_layer_id` shall be greater than 0.**

### **3.3 *On the number of LPD NAL unit in a PES packet***

Add to 2.17.6.2:

When present, there shall be at most one LPD NAL unit in a PES payload..

Add to 2.17.6.3:

A PES packet shall not contain both LPD NAL unit and AUD NAL unit.

## **4 Conclusion**

We recommend WG11 to include the proposals in the study text of 13818 PDAM7.