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**Information technology — Generic coding  
of moving pictures and associated audio  
information —**

**Part 1:  
Systems**

**AMENDMENT 2: Carriage of layered HEVC**

*Technologies de l'information — Codage générique des images  
animées et du son associé —*

*Partie 1: Systèmes*

*AMENDEMENT 2: Transport du codage vidéo à haute efficacité en  
couches*



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Fax + 41 22 749 09 47  
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## Foreword

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INTERNATIONAL STANDARD  
ITU-T RECOMMENDATION**Information technology – Generic coding of moving pictures and associated audio information: Systems****Amendment 2****Carriage of layered HEVC****1) Clause 1.2.2***Replace:*

- Recommendation ITU-T H.264 (2013), *Advanced video coding for generic audiovisual services*.  
ISO/IEC 14496-10:2013, *Information technology – Coding of audio-visual objects – Part 10: Advanced video coding*.
- Recommendation ITU-T H.265 (2013), *High efficiency video coding*.  
ISO/IEC 23008-2:2013, *Information technology – High efficiency coding and media delivery in heterogeneous environments – Part 2: High efficiency video coding*.

*with:*

- Recommendation ITU-T H.264 (2014), *Advanced video coding for generic audiovisual services*.  
ISO/IEC 14496-10:2014, *Information technology – Coding of audio-visual objects – Part 10: Advanced video coding*.
- Recommendation ITU-T H.265 (2015), *High efficiency video coding*.  
ISO/IEC 23008-2:2015, *Information technology – High efficiency coding and media delivery in heterogeneous environments – Part 2: High efficiency video coding*.

**2) Clauses 2.1.95, 2.1.96, 2.1.106 and 2.1.107***Replace clause 2.1.95 with:***2.1.95 HEVC video stream:** Byte stream as specified in Rec. ITU-T H.265 | ISO/IEC 23008-2 Annex B.

NOTE – This term represents either a byte stream as specified in Annex B of the first version of Rec. ITU-T H.265 | ISO/IEC 23008-2 or an HEVC layered video sub-bitstream.

*Replace clause 2.1.96 with:***2.1.96 HEVC access unit:** An access unit as defined in Annex F of Rec. ITU-T H.265 | ISO/IEC 23008-2 with the constraints specified in 2.17.1.*Replace clause 2.1.106 with:***2.1.106 HEVC temporal video sub-bitstream:** An HEVC video sub-bitstream that contains all VCL NAL units and associated non-VCL NAL units of the temporal sub-layer of the same layer, as specified in Rec. ITU-T H.265 | ISO/IEC 23008-2, associated with TemporalId equal to 0 and which may additionally contain all VCL NAL units and associated non-VCL NAL units of all temporal sub-layers of the same layer associated with a contiguous range of TemporalId from 1 to a value equal to or smaller than `sps_max_sub_layers_minus1` included in the active sequence parameter set, as specified in Rec. ITU-T H.265 | ISO/IEC 23008-2.*Replace clause 2.1.107 with:***2.1.107 HEVC temporal video subset:** An HEVC video sub-bitstream that contains all VCL NAL units and the associated non-VCL NAL units of one or more temporal sub-layers of the same layer, as specified in Rec. ITU-T H.265 | ISO/IEC 23008-2, with each temporal sub-layer not being present in the corresponding HEVC temporal video sub-bitstream and TemporalId associated with each temporal sub-layer forming a contiguous range of values that is equal to

or smaller than `sps_max_sub_layers_minus1` included in the active sequence parameter set, as specified in Rec. ITU-T H.265 | ISO/IEC 23008-2.

NOTE – According to the constraints for the transport of HEVC specified in 2.17.1, each temporal sub-layer of an HEVC video stream is present either in the HEVC temporal video sub-bitstream or in exactly one HEVC temporal video subset which is carried in a set of elementary streams that are associated by hierarchy descriptors or HEVC hierarchy extension descriptors. This prevents multiple inclusions of the same temporal sub-layer and allows aggregation of the HEVC temporal video sub-bitstream with associated HEVC temporal video subsets according to the hierarchy descriptors, as specified in 2.17.3 and according to the hierarchy descriptors or HEVC hierarchy extension descriptors, as specified in 2.17.4.

### 3) Clauses 2.1.116 to 2.1.127

Add the following definitions after clause 2.1.115:

**2.1.116 HEVC base layer:** HEVC layer with `nuh_layer_id` equal to 0.

**2.1.117 HEVC base sub-partition:** HEVC video sub-bitstream that is also a conforming bitstream as specified in Rec. ITU-T H.265 | ISO/IEC 23008-2, which contains all VCL NAL units and the associated non-VCL NAL units of an HEVC base layer up to a target highest TemporalId identified by a target HEVC operation point.

**2.1.118 HEVC enhancement sub-partition:** One HEVC layer with a particular value of `nuh_layer_id` greater than 0 in the NAL unit header syntax element or an HEVC temporal video sub-bitstream or HEVC temporal video subset thereof, of which the HEVC layer aggregation with an HEVC base sub-partition and zero or more other HEVC sub-partitions, according to HEVC layer list, results in a valid HEVC layered video stream.

**2.1.119 HEVC layer:** HEVC video sub-bitstream that contains all VCL NAL units with a particular value of `nuh_layer_id` in the NAL unit header syntax element and associated non-VCL NAL units, as defined in Annex F of Rec. ITU-T H.265 | ISO/IEC 23008-2.

**2.1.120 HEVC layer aggregation:** Successive HEVC layer component aggregation of all HEVC layer components in an HEVC video sequence.

**2.1.121 HEVC layer component:** VCL NAL units and the associated non-VCL NAL units of an HEVC access unit which belong to an HEVC sub-partition.

**2.1.122 HEVC layer component aggregation:** Concatenation of all HEVC layer components with the same output time from all HEVC sub-partitions indicated in an HEVC layer list in the order indicated by the HEVC layer list, resulting in a valid HEVC access unit as defined in Annex F of Rec. ITU-T H.265 | ISO/IEC 23008-2.

**2.1.123 HEVC layer list:** Ordered list of HEVC sub-partitions for a target HEVC operation point of which the HEVC layer aggregation results in a valid HEVC layered video stream.

NOTE – An HEVC layer list is signalled for each target HEVC operation point using the HEVC operation point descriptor.

**2.1.124 HEVC layered video stream:** HEVC video stream that contains all VCL NAL units and associated non-VCL NAL units conforming to one or more profiles defined in Annex G or Annex H of Rec. ITU-T H.265 | ISO/IEC 23008-2.

**2.1.125 HEVC operation point:** Operation point based on a target highest TemporalId, and a target layer identifier list as specified in Rec. ITU-T H.265 | ISO/IEC 23008-2.

NOTE – Rec. ITU-T H.265 | ISO/IEC 23008-2 specifies the sub-bitstream extraction process for an operation point according to which the operation point is a conforming bitstream. An operation point is associated with an HEVC layered video stream or HEVC base layer.

**2.1.126 HEVC sub-partition:** Either an HEVC base sub-partition or an HEVC enhancement sub-partition.

NOTE – An HEVC sub-partition can either be an HEVC temporal video sub-bitstream if it includes VCL NAL units with the minimum value of TemporalId (i.e., including TemporalId equal to 0), or it can be an HEVC temporal video subset, if it complements an HEVC base sub-partition or HEVC enhancement sub-partition with the same target layer identifier.

**2.1.127 HEVC temporal enhancement sub-partition:** An HEVC temporal video subset of the same HEVC layer as another HEVC enhancement sub-partition of the same HEVC video stream which contains one or more complementary temporal sub-layers, as specified in Rec. ITU-T H.265 | ISO/IEC 23008-2.

**4) Clause 2.4.2.13**

Add the following new clause immediately after 2.4.2.12:

**2.4.2.13 T-STD extensions for carriage of MV HEVC and SHVC**

T-STD extensions and T-STD parameters for decoding of HEVC layered video streams are defined in 2.17.4. Program stream support including P-STD extensions and P-STD parameters are not specified for HEVC extension video streams.

**5) Clause 2.4.3.7**

In the section specifying the PTS (presentation time stamp), replace:

For HEVC video streams, HEVC temporal video sub-bitstreams and HEVC temporal video subsets, if a PTS is present in the PES packet header, it shall refer to the first HEVC access unit that commences in this PES packet. To achieve consistency between the STD model and the HRD model defined in Annex C of Rec. ITU-T H.265 | ISO/IEC 23008-2, for each HEVC access unit the PTS value in the STD shall, within the accuracy of their respective clocks, indicate the same instant in time as the nominal DPB output time in the HRD, as defined in Annex C of Rec. ITU-T H.265 | ISO/IEC 23008-2.

with:

For HEVC video streams, HEVC temporal video sub-bitstreams and HEVC temporal video subsets, if a PTS is present in the PES packet header, it shall refer to the first HEVC access unit that commences in this PES packet. For HEVC video sub-partitions, if a PTS is present in the PES packet header, it shall refer to the first HEVC layer component that commences in this PES packet. An HEVC layer component commences in a PES packet if the first byte of the HEVC layer component is present in the PES packet. To achieve consistency between the STD model and the HRD model defined in Annex C of Rec. ITU-T H.265 | ISO/IEC 23008-2, for each HEVC access unit the PTS value in the STD shall, within the accuracy of their respective clocks, indicate the same instant in time as the nominal DPB output time in the HRD, as defined in Annex C of Rec. ITU-T H.265 | ISO/IEC 23008-2.

In the section specifying the DTS (decoding time stamp), replace:

For HEVC video streams, HEVC temporal video sub-bitstreams and HEVC temporal video subsets, if a DTS is present in the PES packet header, it shall refer to the first HEVC access unit that commences in this PES packet. To achieve consistency between the STD model and the HRD model defined in Annex C of Rec. ITU-T H.265 | ISO/IEC 23008-2, for each HEVC access unit the DTS value in the STD shall, within the accuracy of their respective clocks, indicate the same instant in time as the nominal CPB removal time in the HRD, as defined in Annex C of Rec. ITU-T H.265 | ISO/IEC 23008-2.

with:

For HEVC video streams, HEVC temporal video sub-bitstreams and HEVC temporal video subsets, if a DTS is present in the PES packet header, it shall refer to the first HEVC access unit that commences in this PES packet. For HEVC video sub-partitions, if a DTS is present in the PES packet header, it shall refer to the first HEVC layer component that commences in this PES packet. An HEVC layer component commences in a PES packet if the first byte of the HEVC layer component is present in the PES packet. To achieve consistency between the STD model and the HRD model defined in Annex C of Rec. ITU-T H.265 | ISO/IEC 23008-2, for each HEVC access unit the DTS value in the STD shall, within the accuracy of their respective clocks, indicate the same instant in time as the nominal CPB removal time  $t_r$  in the HRD, as defined in Annex C of Rec. ITU-T H.265 | ISO/IEC 23008-2.

**6) Clause 2.4.4.9**

In Table 2-34 – Stream type assignments, replace the following lines:

0x1B	AVC video stream conforming to one or more profiles defined in Annex A of Rec. ITU-T H.264   ISO/IEC 14496-10 or AVC video sub-bitstream of SVC as defined in 2.1.78 or MVC base view sub-bitstream, as defined in 2.1.85, or AVC video sub-bitstream of MVC, as defined in 2.1.88 or MVCD base view sub-bitstream, as defined in 2.1.97, or AVC video sub-bitstream of MVCD, as defined in 2.1.100
0x28-0x7E	Rec. ITU-T H.222.0   ISO/IEC 13818-1 Reserved

with:

0x1B	AVC video stream conforming to one or more profiles defined in Annex A of Rec. ITU-T H.264   ISO/IEC 14496-10 or AVC video sub-bitstream of SVC as defined in 2.1.78 or MVC base view sub-bitstream, as defined in 2.1.85, or AVC video sub-bitstream of MVC, as defined in 2.1.88 or MVCD base view sub-bitstream, as defined in 2.1.97, or AVC video sub-bitstream of MVCD, as defined in 2.1.100, or AVC base layer of an HEVC video stream conforming to one or more profiles defined in Annex G or Annex H of Rec. ITU-T H.265   ISO/IEC 23008-2
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0x28	HEVC enhancement sub-partition which includes TemporalId 0 of an HEVC video stream where all NALs units contained in the stream conform to one or more profiles defined in Annex G of Rec. ITU-T H.265   ISO/IEC 23008-2
0x29	HEVC temporal enhancement sub-partition of an HEVC video stream where all NAL units contained in the stream conform to one or more profiles defined in Annex G of Rec. ITU-T H.265   ISO/IEC 23008-2
0x2A	HEVC enhancement sub-partition which includes TemporalId 0 of an HEVC video stream where all NAL units contained in the stream conform to one or more profiles defined in Annex H of Rec. ITU-T H.265   ISO/IEC 23008-2
0x2B	HEVC temporal enhancement sub-partition of an HEVC video stream where all NAL units contained in the stream conform to one or more profiles defined in Annex H of Rec. ITU-T H.265   ISO/IEC 23008-2
0x2C-0x7E	Rec. ITU-T H.222.0   ISO/IEC 13818-1 Reserved

7) **Clause 2.6.6**

Replace Table 2-49 with:

**Table 2-49 – Hierarchy descriptor**

Syntax	No. of bits	Mnemonic
hierarchy_descriptor () {		
<b>descriptor_tag</b>	<b>8</b>	<b>uimsbf</b>
<b>descriptor_length</b>	<b>8</b>	<b>uimsbf</b>
<b>no_view_scalability_flag</b>	<b>1</b>	<b>bslbf</b>
<b>no_temporal_scalability_flag</b>	<b>1</b>	<b>bslbf</b>
<b>no_spatial_scalability_flag</b>	<b>1</b>	<b>bslbf</b>
<b>no_quality_scalability_flag</b>	<b>1</b>	<b>bslbf</b>
<b>hierarchy_type</b>	<b>4</b>	<b>uimsbf</b>
<b>reserved</b>	<b>2</b>	<b>bslbf</b>
<b>hierarchy_layer_index</b>	<b>6</b>	<b>uimsbf</b>
<b>tref_present_flag</b>	<b>1</b>	<b>bslbf</b>
<b>reserved</b>	<b>1</b>	<b>bslbf</b>
<b>hierarchy_embedded_layer_index</b>	<b>6</b>	<b>uimsbf</b>
<b>reserved</b>	<b>2</b>	<b>bslbf</b>
<b>hierarchy_channel</b>	<b>6</b>	<b>uimsbf</b>

8) **Clause 2.6.7**

Replace:

**temporal\_scalability\_flag** – A 1-bit flag, which when set to '0' indicates that the associated program element enhances the frame rate of the bit-stream resulting from the program element referenced by the hierarchy\_embedded\_layer\_index. The value of '1' for this flag is reserved.

**spatial\_scalability\_flag** – A 1-bit flag, which when set to '0' indicates that the associated program element enhances the spatial resolution of the bit-stream resulting from the program element referenced by the hierarchy\_embedded\_layer\_index. The value of '1' for this flag is reserved.

**quality\_scalability\_flag** – A 1-bit flag, which when set to '0' indicates that the associated program element enhances the SNR quality or fidelity of the bit-stream resulting from the program element referenced by the hierarchy\_embedded\_layer\_index. The value of '1' for this flag is reserved.

**hierarchy\_type** – The hierarchical relation between the associated hierarchy layer and its hierarchy embedded layer is defined in Table 2-50. If scalability applies in more than one dimension, this field shall be set to the value of '8' ("Combined Scalability"), and the flags `temporal_scalability_flag`, `spatial_scalability_flag` and `quality_scalability_flag` shall be set accordingly. For MVC video sub-bitstreams, this field shall be set to the value of '9' ("MVC video sub-bitstream") and the flags `temporal_scalability_flag`, `spatial_scalability_flag` and `quality_scalability_flag` shall be set to '1'. For MVC base view sub-bitstreams, this field shall be set to the value of '15' and the flags `temporal_scalability_flag`, `spatial_scalability_flag` and `quality_scalability_flag` shall be set to '1'. For MVCD video sub-bitstreams, this field shall be set to the value of '9' ("MVCD video sub-bitstream") and the flags `temporal_scalability_flag`, `spatial_scalability_flag` and `quality_scalability_flag` shall be set to '1'. For MVCD base view sub-bitstreams, this field shall be set to the value of '15' and the flags `temporal_scalability_flag`, `spatial_scalability_flag` and `quality_scalability_flag` shall be set to '1'.

with:

**no\_view\_scalability\_flag** – A 1-bit flag, which when set to '0' indicates that the associated program element enhances the number of views of the bit-stream resulting from the program element referenced by the `hierarchy_embedded_layer_index`. The value of '1' for this flag is reserved.

**no\_temporal\_scalability\_flag** – A 1-bit flag, which when set to '0' indicates that the associated program element enhances the frame rate of the bit-stream resulting from the program element referenced by the `hierarchy_embedded_layer_index`. The value of '1' for this flag is reserved.

**no\_spatial\_scalability\_flag** – A 1-bit flag, which when set to '0' indicates that the associated program element enhances the spatial resolution of the bit-stream resulting from the program element referenced by the `hierarchy_embedded_layer_index`. The value of '1' for this flag is reserved.

**no\_quality\_scalability\_flag** – A 1-bit flag, which when set to '0' indicates that the associated program element enhances the SNR quality or fidelity of the bit-stream resulting from the program element referenced by the `hierarchy_embedded_layer_index`. The value of '1' for this flag is reserved.

**hierarchy\_type** – The hierarchical relation between the associated hierarchy layer and its hierarchy embedded layer is defined in Table 2-50. If scalability applies in more than one dimension, this field shall be set to the value of '8' ("Combined Scalability"), and the flags `no_view_scalability_flag`, `no_temporal_scalability_flag`, `no_spatial_scalability_flag` and `no_quality_scalability_flag` shall be set accordingly. For MVC video sub-bitstreams, this field shall be set to the value of '9' ("MVC video sub-bitstream") and the flags `no_view_scalability_flag`, `no_temporal_scalability_flag`, `no_spatial_scalability_flag` and `no_quality_scalability_flag` shall be set to '1'. For MVC base view sub-bitstreams, this field shall be set to the value of '15' and the flags `no_view_scalability_flag`, `no_temporal_scalability_flag`, `no_spatial_scalability_flag` and `no_quality_scalability_flag` shall be set to '1'. For MVCD video sub-bitstreams, this field shall be set to the value of '9' ("MVCD video sub-bitstream") and the flags `no_view_scalability_flag`, `no_temporal_scalability_flag`, `no_spatial_scalability_flag` and `no_quality_scalability_flag` shall be set to '1'. For MVCD base view sub-bitstreams, this field shall be set to the value of '15' and the flags `no_view_scalability_flag`, `no_temporal_scalability_flag`, `no_spatial_scalability_flag` and `no_quality_scalability_flag` shall be set to '1'.

Replace in Table 2-50 the description for values 8, 10 and 15, and redefine the reserved range as follows:

**Table 2-50 – Hierarchy\_type field values**

Value	Description
8	Combined Scalability or MV-HEVC sub-partition.
10	Auxiliary picture layer as defined in Annex F of Rec. ITU-T H.265   ISO/IEC 23008-2.
11-14	Reserved
15	Base layer or MVC base view sub-bitstream or AVC video sub-bitstream of MVC or HEVC temporal video sub-bitstream or HEVC base sub-partition.



**11) Clause 2.6.95**

Add the following text immediately before Table 2-109:

This descriptor, when present, shall only be used for elementary streams with a `stream_type` value of 0x24 or 0x25. When the program element for which this descriptor is used is part of an HEVC layered video stream, i.e., the program contains at least one other program element with a `stream_type` value in the range of 0x28-0x2B, the semantics of `HEVC_still_present_flag`, `HEVC_24hr_picture_present_flag` and `sub_pic_hrd_params_not_present_flag` shall apply to the whole HEVC layered video stream, i.e., also to all program elements with a `stream_type` value in the range of 0x28-0x2B.

NOTE – For elementary streams with a `stream_type` value in the range of 0x28-0x2B, the applicable value of `level_idc` can be ambiguous and depend on the output layer set, i.e. the combination with other elementary streams. This information is signalled by the HEVC operation point descriptor.

**12) Clause 2.6.96**

Replace:

**HEVC\_still\_present\_flag** – This 1-bit field, when set to '1', indicates that the HEVC video stream or the HEVC highest temporal sub-layer representation may include HEVC still pictures. When set to '0', then the associated HEVC video stream shall not contain HEVC still pictures.

NOTE 2 – According to Rec. ITU-T H.265 | ISO/IEC 23008-2, IDR pictures are always associated with a `TemporalId` value equal to 0. Consequently, if the HEVC video descriptor applies to an HEVC temporal video subset, HEVC still pictures can only be present in the associated HEVC temporal video sub-bitstream.

**HEVC\_24\_hour\_picture\_present\_flag** – This 1-bit flag, when set to '1', indicates that the associated HEVC video stream or the HEVC highest temporal sub-layer representation may contain HEVC 24-hour pictures. For the definition of an HEVC 24-hour picture, see clause 2.1.97. If this flag is set to '0', the associated HEVC video stream shall not contain any HEVC 24-hour pictures.

**sub\_pic\_hrd\_params\_not\_present\_flag** – This 1-bit field, when set to '0', indicates that the VUI in the HEVC video stream shall have the syntax element `sub_pic_hrd_params_present_flag` set to '1'. When the `sub_pic_hrd_params_not_present_flag` is set to '1', the associated HEVC video stream may not contain `sub_pic_hrd_params_present_flag` in the VUI or the flag may be set to '0'.

NOTE 3 – Decoders that support the sub-picture processing mode are expected to manage the T-STD using the appropriate delay values in the HEVC video stream specified in the relevant SEI messages defined in ISO/IEC 23008-2:2013 and in addition in Annex C.2.3 (timing of decoding unit removal and decoding of decoding unit) instead of the time stamp values in the PES header.

with:

**HEVC\_still\_present\_flag** – This 1-bit field, when set to '1', indicates that the HEVC video stream or the HEVC highest temporal sub-layer representation may include HEVC still pictures. For the definition of an HEVC still picture, see clause 2.1.103. When the `HEVC_still_present_flag` is set to '0', the associated HEVC video stream shall not contain HEVC still pictures.

When the program element to which this descriptor applies is part of an HEVC layered video stream and the `HEVC_still_present_flag` is set to '0', the whole HEVC layered video stream shall not contain HEVC still pictures.

NOTE 2 – According to Rec. ITU-T H.265 | ISO/IEC 23008-2, IDR pictures are always associated with a `TemporalId` value equal to 0. Consequently, if the HEVC video descriptor applies to an HEVC temporal video subset, HEVC still pictures can only be present in the associated HEVC temporal video sub-bitstream.

**HEVC\_24\_hour\_picture\_present\_flag** – This 1-bit flag, when set to '1', indicates that the associated HEVC video stream or the HEVC highest temporal sub-layer representation may contain HEVC 24-hour pictures. For the definition of an HEVC 24-hour picture, see clause 2.1.97. When the `HEVC_24_hour_picture_present_flag` is set to '0', the associated HEVC video stream shall not contain any HEVC 24-hour pictures.

When the program element to which this descriptor applies is part of an HEVC layered video stream and `HEVC_24_hour_picture_present_flag` is set to '0', the whole HEVC layered video stream shall not contain any HEVC 24-hour pictures.

**sub\_pic\_hrd\_params\_not\_present\_flag** – This 1-bit field, when set to '0', indicates that the VUI in the HEVC video stream shall have the syntax element `sub_pic_hrd_params_present_flag` set to '1'. When the `sub_pic_hrd_params_not_present_flag` is equal to '1', the associated HEVC video stream may not contain `sub_pic_hrd_params_present_flag` in the VUI or the `sub_pic_hrd_params_present_flag` may be set to '0'.

When the program element to which this descriptor applies is part of an HEVC layered video stream and `sub_pic_hrd_params_not_present_flag` is set to '0', the following apply:

- The HEVC timing and HRD descriptor shall be present in the program map table associated with the program.  
NOTE 3 – If `sub_picture_hrd_params_not_present` equals '0', HRD parameters can be expected to be present, though the `hrd_management_valid_flag` is not mandated to be set to '1' in this case.
- The HRD parameter structures that are applicable for all program elements with `stream_type` value of 0x24, 0x25, or in the range of 0x28-0x2B, inclusively, shall be present in the HEVC video stream and the value of `sub_pic_hrd_params_present_flag` in those HRD parameter structures shall be set to '1'.

13) **Clause 2.6.97**

Replace Table 2-110 with the following:

Table 2-110 – HEVC timing and HRD descriptor

Syntax	No. of bits	Mnemonic
HEVC_timing_and_HRD_descriptor() {		
<b>hrd_management_valid_flag</b>	1	bslbf
<b>target_schedule_idx_not_present_flag</b>	1	bslbf
<b>target_schedule_idx</b>	5	uimsbf
<b>picture_and_timing_info_present_flag</b>	1	bslbf
if (picture_and_timing_info_present_flag == '1') {		
<b>90kHz_flag</b>	1	bslbf
<b>reserved</b>	7	bslbf
if (90kHz_flag == '0') {		
N	32	uimsbf
K	32	uimsbf
}		
<b>num_units_in_tick</b>	32	uimsbf
}		
}		

14) **Clause 2.6.98**

Replace the following paragraphs:

**hrd\_management\_valid\_flag** – This 1-bit flag is only defined for use in transport streams. When the HEVC timing and HRD descriptor is associated with an HEVC video stream or with an HEVC highest temporal sub-layer representation carried in a transport stream, then the following apply.

If the `hrd_management_valid_flag` is set to '1', then Buffering Period SEI and Picture Timing SEI messages, as defined in Annex C of Rec. ITU-T H.265 | ISO/IEC 23008-2, shall be present in the associated HEVC video stream or HEVC highest temporal sub-layer representation. These buffering period SEI messages shall carry coded `nal_initial_cpb_removal_delay` and `nal_initial_cpb_removal_delay_offset` values and may additionally carry `nal_initial_alt_removal_delay` and `nal_initial_alt_cpb_removal_delay_offset` values for the NAL HRD. If the `hrd_management_valid_flag` is set to '1', then the transfer of each byte from  $MB_n$  to  $EB_n$  in the T-STD as defined in 2.17.2 or the transfer from  $MB_{n,k}$  to  $EB_n$  in the T-STD as defined in 2.17.3 shall be according to the delivery schedule for that byte into the CPB in the NAL HRD, as determined from the coded `nal_initial_cpb_removal_delay` and `nal_initial_cpb_removal_delay_offset` or from the coded `nal_initial_alt_cpb_removal_delay` and `nal_initial_alt_cpb_removal_delay_offset` values for `SchedSelIdx` equal to `cpb_cnt_minus1`, as specified in Annex C of Rec. ITU-T H.265 | ISO/IEC 23008-2. When the `hrd_management_valid_flag` is set to '0', the leak method shall be used for the transfer from  $MB_n$  to  $EB_n$  in the T-STD as defined in 2.17.2 or the transfer from  $MB_{n,k}$  to  $EB_n$  in the T-STD as defined in 2.17.3.

with:

**hrd\_management\_valid\_flag** – This 1-bit flag is only defined for use in transport streams. When the HEVC timing and HRD descriptor is associated with an HEVC video stream or with an HEVC highest temporal sub-layer representation carried in a transport stream, then the following rules apply.

When the value of `hrd_management_valid_flag` is equal to '1', Buffering Period SEI and Picture Timing SEI messages, as defined in Annex C of Rec. ITU-T H.265 | ISO/IEC 23008-2, shall be present in the associated HEVC video stream or HEVC highest temporal sub-layer representation. For HEVC layered video streams, each HEVC operation point signalled in the HEVC operation point descriptor shall have applicable Buffering Period SEI and Picture Timing SEI messages. All Buffering Period SEI messages shall carry coded `nal_initial_cpb_removal_delay` and `nal_initial_cpb_removal_offset` values and may additionally carry `nal_initial_alt_removal_delay` and `nal_initial_alt_cpb_removal_offset` values for the NAL HRD. If the `hrd_management_valid_flag` is set to '1', then the transfer of each byte from  $MB_n$  to  $EB_n$  in the T-STD as defined in 2.17.2 or the transfer from  $MB_{n,k}$  to  $EB_n$  in the T-STD as defined in 2.17.3 or the transfer of each byte from  $MB_n$  to  $EB_n$  in the T-STD as defined in 2.17.4 shall be according to the delivery schedule for that byte into the CPB in the NAL HRD, as determined from the coded `nal_initial_cpb_removal_delay` and `nal_initial_cpb_removal_offset` or from the coded `nal_initial_alt_cpb_removal_delay` and `nal_initial_alt_cpb_removal_offset` values for `SchedSelIdx` equal to `target_schedule_idx` as specified in Annex C of Rec. ITU-T H.265 | ISO/IEC 23008-2. When the `hrd_management_valid_flag` is set to '0', the leak method shall be used for the transfer from  $MB_n$  to  $EB_n$  in the T-STD as defined in 2.17.2, 2.17.3 and 2.17.4.

**target\_schedule\_idx\_not\_present\_flag** – This 1-bit flag when set to '0' indicates that the following 5 bits represent the value `target_schedule_idx` as specified below. When set to '1', the following 5 bits are unspecified. When `hrd_management_valid_flag` is equal to 0, then `target_schedule_idx_not_present_flag` shall be set to '1'.

**target\_schedule\_idx** – When `target_schedule_idx_not_present_flag` is equal to '0', this 5-bit field indicates the index of the delivery schedule which is assigned for `SchedSelIdx`. When the value of `target_schedule_idx_not_present_flag` is equal to '1' and the value of `hrd_management_valid_flag` is equal to '1', the value of `target_schedule_idx` is inferred to be equal to '0'.

## 15) Clauses 2.6.100 to 2.6.103

Add the following new clauses immediately after clause 2.6.99:

### 2.6.100 HEVC operation point descriptor

The HEVC operation point descriptor provides a method to indicate profile and level for one or more HEVC operation points. When present, the HEVC operation point descriptor shall be included in the group of data elements which immediately follow the `program_info_length` field in the `program_map` section.

NOTE – For some applications, the TS may not contain all operation points described in the HEVC operation point descriptor, or the HEVC operation point descriptor may not describe all operation points available in the TS. However, as far as matching elementary streams are found in the TS, the information provided in the descriptor should describe the operation points correctly.

Table 2-111bis – HEVC operation point descriptor

Syntax	No. of bits	Mnemonic
HEVC_operation_point_descriptor() {		
<b>reserved</b>	2	<b>bslbf</b>
<b>num_ptl</b>	6	<b>uimsbf</b>
for ( i = 0; i < num_ptl; i++, i++ ) {		
<b>profile_tier_level_info[i]</b>	96	<b>bslbf</b>
}		
<b>operation_points_count</b>	8	<b>uimsbf</b>
for ( i = 0; i < operation_points_count; i++ ) {		
<b>target_ols[i]</b>	8	<b>uimsbf</b>
<b>ES_count[i]</b>	8	<b>uimsbf</b>
for ( j = 0; j < ES_count[i]; j++ ) {		
<b>reserved</b>	1	<b>bslbf</b>
<b>prepend_dependencies[i][j]</b>	1	<b>bslbf</b>
<b>ES_reference[i][j]</b>	6	<b>uimsbf</b>
}		
<b>reserved</b>	2	<b>bslbf</b>
<b>numEsInOp[i]</b>	6	<b>uimsbf</b>
for ( k = 0; k < NumESinOP[i]; k++ ) {		
<b>necessary_layer_flag[i][k]</b>	1	<b>bslbf</b>
<b>output_layer_flag[i][k]</b>	1	<b>bslbf</b>
<b>ptl_ref_idx[i][k]</b>	6	<b>uimsbf</b>
}		
<b>reserved</b>	1	<b>bslbf</b>
<b>avg_bit_rate_info_flag[i]</b>	1	<b>bslbf</b>
<b>max_bit_rate_info_flag[i]</b>	1	<b>bslbf</b>
<b>constant_frame_rate_info_idc[i]</b>	2	<b>uimsbf</b>
<b>applicable_temporal_id[i]</b>	3	<b>uimsbf</b>
if ( constant_frame_rate_info_idc[i] > 0 ) {		
<b>reserved</b>	4	<b>bslbf</b>
<b>frame_rate_indicator[i]</b>	12	<b>uimsbf</b>
}		
if ( avg_bit_rate_info_flag[i] == '1' ) {		
<b>avg_bit_rate[i]</b>	24	<b>uimsbf</b>
}		
if ( max_bit_rate_info_flag[i] == '1' ) {		
<b>max_bit_rate[i]</b>	24	<b>uimsbf</b>
}		
}		
}		

**2.6.101 Semantic definition of fields in HEVC operation point descriptor**

**num\_ptl** – This 6-bit field specifies the number of profile, tier and level structures signalled in this descriptor.

**profile\_tier\_level\_info[i]** – This 96-bit field shall be coded according to the syntax structure of profile\_tier\_level defined in clause 7.3.3 of Rec. ITU-T H.265 | ISO/IEC 23008-2 with the value of profilePresentFlag set equal to '1' and maxNumSubLayersMinus1 set equal to 6.

If multiple HEVC operation point descriptors are found for the same program, all profile\_tier\_level\_info[x] elements of all HEVC operation point descriptors for this program are aggregated in their order of occurrence into a common array, which is referenced in this specification as profile\_tier\_level\_array[]. If there is only a single HEVC operation point descriptor, profile\_tier\_level\_array[] contains the elements profile\_tier\_level\_info[x] in the order as found in that single descriptor.

**operation\_points\_count** – This 8-bit field indicates the number of HEVC operation points described by the list included in the following group of data elements.

**target\_ols[i]** – An 8-bit field that specifies the index into the list of output layer sets in the VPS, associated with the i-th HEVC operation point defined in this descriptor.

**ES\_count[i]** – This 8-bit field indicates the number of ES\_reference values included in the following group of data elements. The aggregation of elementary streams, according to the ordered list indicated in the following group of data elements, forms an HEVC operation point. The value 0xff is reserved.

Let OperationPointESList[i] be the list of elementary streams that are part of the i-th HEVC operation point.

**prepend\_dependencies[i][j]** – This flag if set to '1' specifies that the elementary stream indicated by ES\_reference[i][j], when not present yet in OperationPointESList[i], shall be added into OperationPointESList[i] and the elementary stream indicated by the syntax element hierarchy\_embedded\_layer\_index in the hierarchy descriptor, or all of the elementary streams indicated by the syntax element hierarchy\_ext\_embedded\_layer\_index in the HEVC hierarchy extension descriptor, with the hierarchy layer index value specified by the following syntax element ES\_reference[i][j], when not present yet in OperationPointESList[i], shall be added into OperationPointLayerList[i] immediately before the elementary stream signalled by the ES\_reference[i][j] in ascending order of the value of their associated hierarchy\_embedded\_layer\_index or hierarchy\_ext\_embedded\_layer\_index. When the value of prepend\_dependencies[i][j] is equal to '0', only the elementary stream indicated by ES\_reference[i][j], when not present yet in OperationPointESList[i], shall be added into OperationPointESList[i]. The elementary stream indicated by ES\_reference[i][m] shall be placed earlier (i.e., with a lower index) into OperationPointESList[i] than the elementary stream indicated with ES\_reference[i][n] when m is less than n. The order of elementary stream in the OperationPointESList[i] shall be in ascending order of their hierarchy\_layer\_index values.

**ES\_reference[i][j]** – This 6-bit field indicates the hierarchy layer index value present in the hierarchy descriptor or HEVC hierarchy extension descriptor which identifies an elementary stream. The value of ES\_reference[i][m] and ES\_reference[i][n] for m not equal to n shall not be the same.

**numEsInOp[i]** – This 6-bit field indicates the number of elementary streams in OperationPointESList[i] after all the ESs that are part of the i-th HEVC operation point have been included into OperationPointESList[i] (i.e., after parsing prepend\_dependencies[i][ES\_count[i] – 1]).

**necessary\_layer\_flag[i][k]** – This flag when set to '1' indicates that the k-th elementary stream in OperationPointESList[i] is a necessary layer, as defined in Annex F of Rec. ITU-T H.265 | ISO/IEC 23008-2, of the i-th operation point. This flag equal to '0' indicates that the k-th elementary stream in OperationPointESList[i] is not a necessary layer, as defined in Annex F of Rec. ITU-T H.265 | ISO/IEC 23008-2, of the i-th operation point.

**output\_layer\_flag[i][k]** – This flag when set to '1' indicates that the k-th elementary stream in OperationPointESList[i] is an output layer. Otherwise, when set to '0', it indicates that the k-th elementary stream in OperationPointESList[i] is not an output layer. When the value of necessary\_layer\_flag[i][k] is equal to '0', the value of output\_layer\_flag[i][k] shall be ignored.

**ptl\_ref\_idx[i][k]** – A 6-bit field that indicates the index x to the profile\_tier\_level\_info[x] element of the profile\_tier\_level\_array which applies to the k-th elementary stream in OperationPointESList[i]. When the value of necessary\_layer\_flag[i][k] is equal to '0', the value of ptl\_ref\_idx[i][k] shall be ignored.

**avg\_bit\_rate\_info\_flag[i]** – This flag indicates whether the syntax element avg\_bit\_rate[i] is present in this descriptor.

**max\_bit\_rate\_info\_flag[i]** – This flag indicates whether the syntax element max\_bit\_rate[i] is present in this descriptor.

**constant\_frame\_rate\_info\_idc[i]** – This 2-bit field, in combination with the syntax element frame\_rate\_indicator as specified below, indicates how the frame rate for the associated operation point j is determined. The value of '0' indicates that the frame rate is not specified for the i-th HEVC operation point and that the syntax element frame\_rate\_indicator is not present in this descriptor for the i-th HEVC operation point.

**applicable\_temporal\_id[i]** – This 3-bit field indicates the highest value of TemporalId of the VCL NAL units in the re-assembled HEVC video stream for operation point i.

**frame\_rate\_indicator[i]** – If constant\_frame\_rate\_info\_idc[i] is equal to '1', this 12-bit field indicates a constant number of ticks, as specified in the HEVC timing and HRD descriptor, for the distance in time between two pictures at the i-th HEVC operation point. If constant\_frame\_rate\_info\_idc[i] equals '2', this 12-bit field indicates the frame rate for the i-th operation point measured in frames per second. If constant\_frame\_rate\_info\_idc[i] equals '3', this 12-bit field indicates the frame rate for the i-th HEVC operation point measured in frames per 1.001 seconds.

**avg\_bit\_rate[i]** – This 24-bit field indicates the average bit rate, in 1000 bits per second, of the HEVC layered video stream corresponding to the i-th HEVC operation point.

**max\_bit\_rate[i]** – This 24-bit field indicates the maximum bit rate, in 1000 bits per second, of the HEVC layered video stream corresponding to the i-th HEVC operation point.

2.6.102 HEVC hierarchy extension descriptor

The HEVC hierarchy extension descriptor provides information to identify the program elements containing components of layered HEVC streams (see Table 2-111ter). When present, this descriptor shall only be used for elementary streams with the stream\_type value 0x28, 0x29, 0x2A or 0x2B.

Table 2-111ter – HEVC hierarchy extension descriptor

Syntax	No. of bits	Mnemonic
HEVC_hierarchy_extension_descriptor() {		
<b>extension_dimension_bits</b>	<b>16</b>	<b>bslbf</b>
<b>hierarchy_layer_index</b>	<b>6</b>	<b>uimsbf</b>
<b>temporal_id</b>	<b>3</b>	<b>uimsbf</b>
<b>nuh_layer_id</b>	<b>6</b>	<b>uimsbf</b>
<b>tref_present_flag</b>	<b>1</b>	<b>bslbf</b>
<b>Reserved</b>	<b>2</b>	<b>bslbf</b>
<b>num_embedded_layers</b>	<b>6</b>	<b>uimsbf</b>
<b>Reserved</b>	<b>2</b>	<b>bslbf</b>
<b>hierarchy_channel</b>	<b>6</b>	<b>uimsbf</b>
for ( i = 0 ; i < num_embedded_layers ; i++ ) {		
<b>Reserved</b>	<b>2</b>	<b>bslbf</b>
<b>hierarchy_ext_embedded_layer_index[i]</b>	<b>6</b>	<b>uimsbf</b>
}		
}		

2.6.103 Semantic definition of fields in HEVC hierarchy extension descriptor

When the HEVC hierarchy extension descriptor is present, it is used to specify the dependency of the associated elementary stream to other elementary streams in the same program.

**extension\_dimension\_bits** – A 16-bit field indicating the possible enhancement of the associated program element from the base layer resulting from the program element of the layer with nuh\_layer\_id equal to '0'.

The allocation of the bits to enhancement dimensions is given in Table 2-111quater.

Table 2-111quater – Semantics of extension dimension bits

Index to bits	Description
0	Multi-view enhancement
1	Spatial scalability, including SNR quality or fidelity enhancement
2	Depth enhancement
3	Temporal enhancement
4	Auxiliary enhancement
5-15	Reserved

The i-th bit equal to '1' indicates that the corresponding enhancement dimension is present. When the elementary stream contains auxiliary pictures as defined in Annex F of Rec. ITU-T H.265 | ISO/IEC 23008-2, the value of the 4th bit of extension\_dimension\_bits shall be set equal to '1', otherwise, it shall be set equal to '0'. When the elementary stream contains auxiliary pictures that are depth pictures, as defined in Annex F of Rec. ITU-T H.265 | ISO/IEC 23008-2, the value of both the 2nd and the 4th bits of extension\_dimension\_bits shall be set equal to '1'.

**hierarchy\_layer\_index** – A 6-bit field that defines a unique index of the associated program elements in a table of coding layer hierarchies. Indices shall be unique within a single program definition. For video sub-bitstreams of HEVC video streams conforming to one or more profiles defined in Annex F of Rec. ITU-T H.265 | ISO/IEC 23008-2, this is the program element index, which is assigned in a way that the bitstream order will be correct if the associated dependency layers of the video sub-bitstreams of the same HEVC access unit are re-assembled in increasing order of hierarchy\_layer\_index.

**temporal\_id** – A 3-bit field that specifies the highest TemporalId of the NAL units in the elementary stream associated with this HEVC hierarchy extension descriptor.

**nuh\_layer\_id** – A 6-bit field that specifies the highest nuh\_layer\_id of the NAL units in the elementary stream associated with this HEVC hierarchy extension descriptor.

**tref\_present\_flag** – A 1-bit flag, which when set to '0' indicates that the TREF field may be present in the PES packet headers in the associated elementary stream. The value of '1' for this flag is reserved.

**num\_embedded\_layers** – A 6-bit field that specifies the number of direct dependent program elements that need to be accessed and be present in decoding order before decoding of the elementary stream associated with this HEVC hierarchy extension descriptor.

**hierarchy\_channel** – A 6-bit field that indicates the intended channel number for the associated program element in an ordered set of transmission channels. The most robust transmission channel is defined by the lowest value of this field with respect to the overall transmission hierarchy definition.

NOTE – A given hierarchy\_channel may at the same time be assigned to several program elements.

**hierarchy\_ext\_embedded\_layer\_index[i]** – A 6-bit field that defines the hierarchy\_layer\_index of the program element that needs to be accessed and be present in decoding order before decoding of the elementary stream associated with this HEVC hierarchy extension descriptor.

## 16) Clause 2.17.1

Replace the following text:

- An HEVC video stream or HEVC temporal video sub-bitstream shall be an element of an Rec. ITU-T H.222.0 | ISO/IEC 13818-1 program and the stream\_type for this elementary stream shall be equal to 0x24.

with:

- An HEVC video stream or HEVC temporal video sub-bitstream of an HEVC video stream conforming to one or more profiles defined in Annex A of Rec. ITU-T H.265 | ISO/IEC 23008-2 shall be an element of an Rec. ITU-T H.222.0 | ISO/IEC 13818-1 program and the stream\_type for this elementary stream shall be equal to 0x24.

NOTE 1bis – Such a stream can be the HEVC base sub-partition of an HEVC video stream conforming to one or more profiles defined in Annex G or Annex H of Rec. ITU-T H.265 | ISO/IEC 23008-2.

Replace the following text:

- For each HEVC temporal video subset that is an element of the same Rec. ITU-T H.222.0 | ISO/IEC 13818-1 program, the stream\_type for this elementary stream shall be equal to 0x25.
- When a Rec. ITU-T H.222.0 | ISO/IEC 13818-1 program includes more than one HEVC video temporal subset, or more than one HEVC temporal video sub-bitstream and at least one HEVC temporal video subset, a hierarchy\_descriptor as defined in 2.6.7 shall be present for all associated elementary streams with stream type equal to 0x24 or 0x25. The hierarchy descriptors shall be used to indicate the dependencies of the HEVC temporal video sub-bitstreams and all HEVC temporal video subsets .

with:

- For each HEVC temporal video subset of an HEVC video stream conforming to one or more profiles defined in Annex A of Rec. ITU-T H.265 | ISO/IEC 23008-2 that is an element of the same Rec. ITU-T H.222.0 | ISO/IEC 13818-1 program, the stream\_type for this elementary stream shall be equal to 0x25.

NOTE 1ter – Such a stream can be an HEVC sub-partition of an HEVC video stream conforming to one or more profiles defined in Annex G or Annex H of Rec. ITU-T H.265 | ISO/IEC 23008-2.

- An HEVC enhancement sub-partition of an HEVC video stream conforming to one or more profiles defined in Annex G or Annex H of Rec. ITU-T H.265 | ISO/IEC 23008-2 shall be an element of an Rec. ITU-T H.222.0 | ISO/IEC 13818-1 program. The stream\_type for this elementary stream shall be set according to Table 2-34.
- The video parameter sets, sequence parameter sets, and picture parameter sets, as specified in Rec. ITU-T H.265 | ISO/IEC 23008-2, necessary for decoding an HEVC video stream, HEVC temporal video sub-bitstream, or HEVC base sub-partition shall be present within the elementary stream carrying that HEVC video stream, HEVC temporal video sub-bitstream, or HEVC base sub-partition.

- When an Rec. ITU-T H.222.0 | ISO/IEC 13818 1 program includes one or more elementary streams with stream\_type equal to 0x28, 0x29, 0x2A or 0x2B, at least one HEVC operation point descriptor shall be present in the program map table associated with the program.
- When an Rec. ITU-T H.222.0 | ISO/IEC 13818 1 program includes more than one elementary stream with the same stream\_type value of 0x24, 0x25 or in the range of 0x28-0x2B and hierarchy cannot be implied as specified in table 2-121, one hierarchy descriptor as defined in 2.6.7 shall be present for each elementary stream with a stream\_type value of 0x24, 0x25 and one HEVC hierarchy extension descriptor as defined in 2.6.102 shall be present for each elementary stream with a stream\_type value in the range of 0x28-0x2B.

NOTE 1quarter – Hierarchy descriptors or HEVC hierarchy extension descriptors are needed to assign a hierarchy layer index to each elementary stream if hierarchy cannot be implied, as specified in Table 2-121.

Add at the end of the bulleted list:

- The aggregation, as specified in 2.17.4, of an HEVC enhancement sub-partition with all HEVC sub-partitions according to the HEVC operation signalled in the HEVC operation point descriptor shall result in a valid layered HEVC video stream.

NOTE 2bis – The resulting HEVC video stream is the HEVC operation point of that HEVC enhancement sub-partition.

- Each HEVC picture with nuh\_layer\_id larger than 0 shall be contained within an elementary stream with a stream\_type equal to either 0x28, 0x29, 0x2A or 0x2B.
- An elementary stream ES<sub>te</sub> with stream\_type equal to either 0x29 or 0x2B shall satisfy the following:
  - The elementary stream ES<sub>te</sub> contains an HEVC temporal video subset which is a temporal enhancement for exactly one reference elementary stream ES<sub>ref</sub>, i.e., the layer L<sub>i</sub> present in the reference elementary stream ES<sub>ref</sub> shall also be present in the elementary stream ES<sub>te</sub>.

NOTE 2ter – The reference elementary stream ES<sub>ref</sub> is either an HEVC temporal video sub-bitstream with a stream\_type equal to either 0x28 or 0x2A or another HEVC temporal video subset with stream\_type equal to either 0x29 or 0x2B, respectively, for which the same applies.

Replace the following text:

Rec. ITU-T H.265 | ISO/IEC 23008-2 Video is carried in PES packets as PES\_packet\_data\_bytes, using one of the 16 stream\_id values assigned to video, while signalling the Rec. ITU-T H.265 | ISO/IEC 23008-2 video stream by means of the assigned stream-type value in the PMT (see Table 2-34). The highest level that may occur in an HEVC video stream as well as a profile and tier that the entire stream conforms to should be signalled using the HEVC video descriptor. If an HEVC video descriptor is associated with an HEVC video stream, an HEVC temporal video sub-bitstream, an HEVC temporal video subset, then this descriptor shall be conveyed in the descriptor loop for the respective elementary stream entry in the Program Map Table. This Recommendation | International Standard does not specify presentation of Rec. ITU-T H.265 | ISO/IEC 23008-2 streams in the context of a program.

with:

Rec. ITU-T H.265 | ISO/IEC 23008-2 video is carried in PES packets as PES\_packet\_data\_bytes, using one of the 16 stream\_id values assigned to video, while signalling the Rec. ITU-T H.265 | ISO/IEC 23008-2 video stream, by means of the assigned stream-type value in the PMT (see Table 2-34). The highest level that may occur in an HEVC video stream as well as a profile and tier that the entire stream conforms to should be signalled using the HEVC video descriptor. If an HEVC video descriptor is associated with an HEVC video stream, an HEVC temporal video sub-bitstream, an HEVC temporal video subset, or an HEVC enhancement sub-partition, then this descriptor shall be conveyed in the descriptor loop for the respective elementary stream entry in the program map table. This Recommendation | International Standard does not specify the presentation of Rec. ITU-T H.265 | ISO/IEC 23008-2 streams in the context of a program.

Replace the following text:

Carriage of an HEVC video stream, an HEVC temporal video sub-stream or an HEVC temporal video subset over Rec. ITU-T H.222.0 | ISO/IEC 13818-1 does not impact the size of buffer DPB. For decoding of an HEVC video stream, an HEVC temporal video sub-bitstream or an HEVC temporal video sub-bitstream and its associated HEVC temporal video subsets in the STD, the size of DPB is as defined in Rec. ITU-T H.265 | ISO/IEC 23008-2. The DPB shall be managed as specified in Annex C of Rec. ITU-T H.265 | ISO/IEC 23008-2 (clauses C.3 and C.5). A decoded HEVC access unit enters the DPB instantaneously upon decoding of the HEVC access unit, hence at the CPB removal time of the HEVC access unit. A decoded HEVC access unit is presented at the DPB output time. If the HEVC video stream, HEVC temporal video sub-bitstream or HEVC temporal video subset provides insufficient information to determine the CPB removal time and the DPB output time of HEVC access units, then these time instants shall be determined in the STD model from PTS and DTS timestamps as follows:

with:

Carriage of an HEVC video stream, an HEVC temporal video sub-stream, an HEVC temporal video subset or an HEVC enhancement sub-partition over Rec. ITU-T H.222.0 | ISO/IEC 13818-1 does not impact the size of buffer DPB. For decoding of an HEVC video stream, an HEVC temporal video sub-bitstream or an HEVC temporal video sub-bitstream and its associated HEVC temporal video subsets in the STD, the size of DPB is as defined in Rec. ITU-T H.265 | ISO/IEC 23008-2. The DPB shall be managed as specified in Annex C of Rec. ITU-T H.265 | ISO/IEC 23008-2 (clauses C.3 and C.5). A decoded HEVC access unit enters the DPB instantaneously upon decoding of the HEVC access unit, hence at the CPB removal time of the HEVC access unit. A decoded HEVC access unit is presented at the DPB output time. If the HEVC video stream, HEVC temporal video sub-bitstream or HEVC temporal video subset provides insufficient information to determine the CPB removal time and the DPB output time of HEVC access units, then these time instants shall be determined in the STD model from PTS and DTS timestamps as follows:

17) Clause 2.17.4

Add the following new clause after clause 2.17.3:

2.17.4 T-STD extensions for layered transport of HEVC sub-partitions with bitstream-partition-specific CPB operation

When there is at least one elementary stream with stream\_type value in the range of 0x28 to 0x2B in a Rec. ITU-T H.222.0 | ISO/IEC 13818-1 program, the T-STD model as described in 2.4.2 is extended for elementary streams with a stream\_type value in the range of 0x28 to 0x2B as illustrated in Figure 2-20 and as specified below.

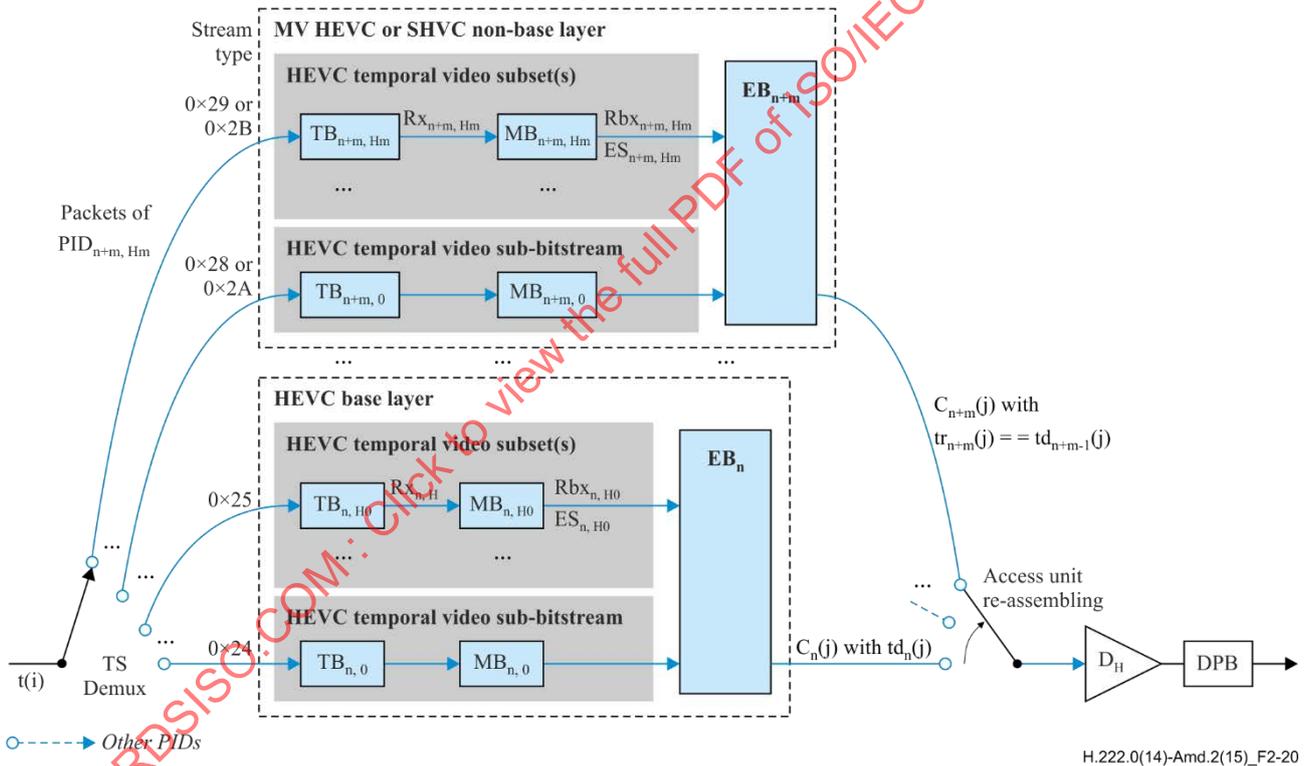


Figure 2-20 – T-STD model extensions for bitstream-partition-specific CPB operation

NOTE – The lower dashed box containing blocks that handle the HEVC base layer represents the T-STD buffer model as specified in 2.17.2, if there are no HEVC temporal video subsets, or 2.17.3, if the program contains at least one program element with stream\_type equal to 0x25.

The following additional notations are used to describe the T-STD extensions and are illustrated in Figure 2-20 above.

- t(i) Indicates the time in seconds at which the i-th byte of the transport stream enters the system target decoder.
- l Is an index into the received HEVC sub-partitions of stream\_type 0x28 or 0x2A (which include TemporalId 0). The order of HEVC sub-partitions is indicated by the HEVC operation point descriptor. The same index also applies to corresponding HEVC temporal enhancement sub-partitions. Here, l starts from n, which is associated with the HEVC base sub-partition, and runs up to (n+m), where m is specified below.

m	Is the number of received HEVC sub-partitions of stream_type 0x28 or 0x2A.
HI	Is the number of received HEVC corresponding temporal enhancement sub-partitions of the l-th received HEVC sub-partition of stream_type 0x28 or 0x2A, associated by HEVC hierarchy extension descriptors with the same HEVC base sub-partition.
ES <sub>l,k</sub>	Is the received elementary stream which contains the k-th HEVC corresponding temporal enhancement sub-partition of the l-th received HEVC sub-partition of stream_type 0x28 or 0x2A, or the l-th HEVC sub-partition of stream_type 0x28 or 0x2A if k equals 0.
ES <sub>n+m,Hm</sub>	Is the received elementary stream which contains the HEVC sub-partition of the highest HEVC operation point in the set of received elementary streams.
PID <sub>n+m,Hm</sub>	Is the packet identifier value which identifies ES <sub>n+m,Hm</sub> .
j	Is an index to the output HEVC access units.
C <sub>l(j)</sub>	Is the j-th HEVC layer component of the l-th received HEVC sub-partition of stream_type 0x28 or 0x2A or HEVC corresponding temporal enhancement sub-partition.
A <sub>n(j)</sub>	Is the j-th HEVC access unit of the HEVC complete temporal representation.
td <sub>n(j)</sub>	Is the decoding time of A <sub>n(j)</sub> in the system target decoder.
tr <sub>n(j)</sub>	Is the value of TREF, if available in the PES header attached to C <sub>l(j)</sub> , else the decoding time of A <sub>n(j)</sub> in the system target decoder.
TB <sub>l,k</sub>	Is the transport buffer for elementary stream ES <sub>l,k</sub> .
TBS <sub>l,k</sub>	Is the size of the transport buffer TB <sub>l,k</sub> , measured in bytes.
MB <sub>l,k</sub>	Is the multiplexing buffer for elementary stream ES <sub>l,k</sub> .
MBS <sub>l,k</sub>	Is the size of the multiplexing buffer MB <sub>l,k</sub> , measured in bytes.
EB <sub>l</sub>	Is the elementary stream buffer for the received HEVC temporal video sub-bitstream ES <sub>l,0</sub> and the received HEVC temporal video subsets ES <sub>l,1</sub> to ES <sub>l,H</sub> .
NOTE 1	– Each buffer EB <sub>l</sub> contains one partition as specified in Annex F of Rec. ITU-T H.265   ISO/IEC 23008-2.
EBS <sub>l</sub>	Is the size of elementary stream buffer EB <sub>l</sub> , measured in bytes.
Rx <sub>l,k</sub>	Is the transfer rate from the k-th transport buffer TB <sub>l,k</sub> to the k-th multiplex buffer MB <sub>l,k</sub> as specified below.
Rbx <sub>l,k</sub>	Is the transfer rate from the k-th multiplex buffer MB <sub>l,k</sub> to the elementary stream buffer EB <sub>l</sub> as specified below.

NOTE 2 – The index n, where used, indicates that the received elementary streams and associated buffers belong to a certain HEVC base sub-partition, distinguishing these elementary streams and associated buffers from other elementary streams and buffers, maintaining consistency with the notation in Figure 2-1 and other T-STD extensions.

### TB<sub>l,k</sub>, MB<sub>l,k</sub>, EB<sub>l</sub> buffer management

The following applies:

- There is one transport buffer TB<sub>l,k</sub> for each received elementary stream ES<sub>l,k</sub>, where the size TBS<sub>l,k</sub> is fixed to 512 bytes.
- There is one multiplex buffer MB<sub>l,k</sub> for each received elementary stream ES<sub>l,k</sub>, where the size MBS<sub>l,k</sub> of the multiplex buffer MB<sub>l,k</sub> is constrained as follows:

$$MBS_{n,k} = BS_{mux} + BS_{oh} + CpbBrNalFactor \times MaxCPB[tier, level] - cpb\_size \text{ (measured in bytes)}$$

where

BS<sub>oh</sub>, packet overhead buffering, and BS<sub>mux</sub>, additional multiplex buffering, are as specified in 2.17.2;

MaxCPB[tier, level] and MaxBR[tier, level] are taken from the tier and level specification of the HEVC for the tier and level of ES<sub>l,k</sub> the HEVC operation point associated with ES<sub>l,k</sub>;

cpb\_size is taken from the sub-layer HRD parameters within the applicable hrd\_parameters( ), as specified in Annex F of Rec. ITU-T H.265 | ISO/IEC 23008-2, for the HEVC operation point associated with ES<sub>l,k</sub>.

- There is one elementary stream buffer EB<sub>l</sub> for the HI + 1 elementary streams in the set of received elementary streams ES<sub>l,0</sub> to ES<sub>l,m,HI</sub>, with a total size EBS<sub>l</sub>  
EBS<sub>l</sub> = cpb\_size (measured in bytes)

where  $cpb\_size$  is taken from the sub-layer HRD parameters within the applicable  $hrd\_parameters()$ , as specified in Annex F of Rec. ITU-T H.265 | ISO/IEC 23008-2, for the HEVC operation point associated with  $ES_{i,H}$ .

- Transfer from  $TB_{i,k}$  to  $MB_{i,k}$  is applied as follows:
  - When there is no data in  $TB_{i,k}$  then  $R_{x_{i,k}}$  is equal to zero.
  - Otherwise,  $R_{x_{i,k}} = bit\_rate$

$bit\_rate$  is taken from the NAL HRD parameters within the applicable  $hrd\_parameters()$ , as specified in Annex F of Rec. ITU-T H.265 | ISO/IEC 23008-2, for the HEVC operation point associated with  $ES_{i,k}$ , if sub-layer HRD parameters are present in the VPS and  $nal\_hrd\_parameters\_present\_flag$  is set to '1'.

Otherwise:

$bit\_rate = BrNalFactor / BrVclFactor \times BitRate_{VCL}$ , if sub-layer HRD parameters within the applicable  $hrd\_parameters()$ , as specified in Annex F of Rec. ITU-T H.265 | ISO/IEC 23008-2, for the HEVC operation point associated with  $ES_{i,k}$  are present in the VPS and  $vcl\_hrd\_parameters\_present\_flag$  is set to '1';  $BitRate_{VCL}$  is taken from the VCL HRD parameters.

$BrNalFactor$  and  $BrVclFactor$  are as defined in Rec. ITU-T H.265 | ISO/IEC 23008-2 for the profile, tier, and level of  $ES_{i,k}$  the HEVC operation point associated with  $ES_{i,k}$ .

In both cases, the index of the applicable  $hrd\_parameters()$  syntax structure in the active VPS of the HEVC video stream is given by:  $bsp\_hrd\_idx[target\_ols][0][max\_temporal\_id][target\_schedule\_idx][1+1]$  as specified in Annex F of Rec. ITU-T H.265 | ISO/IEC 23008-2, where  $target\_ols$  and  $max\_temporal\_id$  are signalled in the HEVC operation point descriptor for the HEVC operation point associated with  $ES_{i,k}$ , and  $target\_schedule\_idx$  is signalled in the HEVC timing and HRD descriptor.

- Transfer from  $MB_{i,k}$  to  $EB_i$  is applied as follows:
  - If the  $HEVC\_timing\_and\_HRD\_descriptor$  is present with the  $hrd\_management\_valid\_flag$  set to '1' for the HEVC video sub-bitstream, then the transfer of data from  $MB_{i,k}$  to  $EB_i$  shall follow the HRD defined scheme for data arrival in the CPB of elementary stream  $ES_{i,H}$  as defined in Annex C of Rec. ITU-T H.265 | ISO/IEC 23008-2.
  - Otherwise, the leak method shall be used to transfer data from  $MB_{i,k}$  to  $EB_i$  as follows:

$$R_{bx_{i,k}} = CpbBrNalFactor \times MaxBR[tier, level]$$

where  $MaxBR[tier, level]$  is as defined for the byte stream format in the tier and level specification of Rec. ITU-T H.265 | ISO/IEC 23008-2 (Table A.2) for the tier and level for  $ES_{i,k}$  signalled in the HEVC operation point descriptor for  $ES_{i,k}$ .

If there is PES packet payload data in  $MB_{i,k}$ , and  $EB_i$  is not full, the PES packet payload is transferred from  $MB_{i,k}$  to  $EB_i$  at a rate equal to  $R_{bx_{i,k}}$ . If  $EB_i$  is full, data are not removed from  $MB_{i,k}$ . When a byte of data is transferred from  $MB_{i,k}$  to  $EB_i$ , all PES packet header bytes that are in  $MB_{i,k}$  and precede that byte are instantaneously removed and discarded. When there is no PES packet payload data present in  $MB_{i,k}$ , no data is removed from  $MB_{i,k}$ . All data that enters  $MB_{i,k}$  leaves it. All PES packet payload data bytes enter  $EB_i$  instantaneously upon leaving  $MB_{i,k}$ .

### Aggregation of elementary streams

The HEVC layer list for an HEVC operation point is the  $OperationPointESList[]$  associated with the HEVC operation point.

When there is no hierarchy descriptor or HEVC hierarchy extension descriptor present in the program map table associated with an Rec. ITU-T H.222.0 | ISO/IEC 13818-1 program, a value for the  $hierarchy\_layer\_index$  is implicitly assigned for each elementary stream with  $stream\_type$  0x24, 0x25, 0x28, 0x29, 0x2A and 0x2B as described in Table 2-121.

Table 2-121 – Implied hierarchy\_layer\_index if no hierarchy descriptors are used

Existing stream types	Implied hierarchy_layer_index for program element with stream_type value					
	0x24	0x25	0x28	0x29	0x2A	0x2B
0x24	0					
0x24, 0x25	0	1				
0x24, 0x28	0		1			
0x24, 0x25, 0x28	0	1	2			
0x24, 0x25, 0x28, 0x29	0	1	2	3		
0x24, 0x2A	0				1	
0x24, 0x2A, 0x2B	0				1	2
0x24, 0x25, 0x2A	0	1			2	
0x24, 0x25, 0x2A, 0x2B	0	1			2	3

The HEVC operation point is aggregated from the HEVC layer components at the output of the elementary stream buffers  $EB_1$  by determining the value of TREF, if available in the PES header, or else TREF is set to DTS, for the next HEVC layer component at the output of  $EB_{n+m}$ , and gathering all HEVC layer components with a DTS equal to TREF, in the order given by the HEVC layer list as specified above, and transferring them to the HEVC decoder  $D_H$ .

**Carriage in PES packets**

For correct re-assembling of the HEVC layer components to an HEVC access unit, if there is an HEVC dependency representation in the same HEVC access unit in more than one elementary stream, the following applies:

- Each PES packet shall contain exactly one HEVC layer component;
- The PTS and, if applicable, the DTS value shall be provided in the PES header of each HEVC layer component;
- If the DTS value of the HEVC layer component in an elementary stream is different from the DTS value of the HEVC layer component of the same HEVC access unit in an ES listed in the hierarchy descriptor or the HEVC hierarchy extension descriptors of the first elementary stream, the TREF field as defined in 2.4.3.7 shall be present in the PES header extension of the HEVC layer component of first elementary stream and the TREF field value shall be equal to the DTS value of the HEVC layer component of the second elementary stream.

**STD delay**

The STD delay of any Rec. ITU-T H.265 | ISO/IEC 23008-2 data other than HEVC still picture data through the System Target Decoders buffers  $TB_{l,k}$ ,  $MB_{l,k}$ , and  $EB_1$  shall be constrained by  $td_l(j) - t(i) \leq 10$  seconds for all l, all k, all j, and all bytes i in HEVC access unit  $A_n(j)$ .

The delay of any HEVC still picture data through the system target decoders  $TB_{l,k}$ ,  $MB_{l,k}$ , and  $EB_1$  shall be constrained by  $td_l(j) - t(i) \leq 60$  seconds for all l, all k, all j, and all bytes i in HEVC access unit  $A_n(j)$ .

**Buffer management conditions**

Transport streams shall be constructed so that the following conditions for buffer management are satisfied:

- Each  $TB_{l,k}$  shall not overflow and shall be empty at least once every second;
- Each  $MB_{l,k}$ ,  $EB_1$ , and DPB shall not overflow;
- $EB_1$  shall not underflow, except when VUI parameters are present for the HEVC video sequence with the low\_delay\_hrd\_flag set to '1'. Underflow of  $EB_1$  occurs for HEVC access unit  $A_n(j)$  when one or more bytes of  $A_n(j)$  are not present in  $EB_1$  at the decoding time  $td_n(j)$ .