International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

H.222.0

Amendment 2

(12/2015)

SERIES H: AUDIOVISUAL AND MULTIMEDIA SYSTEMS

Infrastructure of audiovisual services – Transmission multiplexing and synchronization

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Information technology – Generic coding of moving pictures and associated audio information: Systems

Amendment 2: Carriage of layered HEVC

Recommendation ITU-T H.222.0 (2014) – Amendment 2

International Telecommunication Union

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INTERNATIONAL STANDARD ISO/IEC 13818-1
RECOMMENDATION ITU-T H.222.0

Information technology – Generic coding of moving pictures and associated audio information: Systems

Amendment 2

Carriage of layered HEVC

Summary

Amendment 2 to ITU-T H.222.0 (2014) | ISO/IEC 13818-1:2015 specifies the carriage of layered HEVC (also called scalable HEVC) in MPEG-2 transport streams. Similar to other recent amendments, this does not cover carriage in "program streams". The amendment defines four new stream_type values to signal base layers and spatial as well as view enhancements. It also defines a 'hierarchy extension' descriptor to enable enhancement layer assembly and an 'operation point' descriptor which allows receivers to select the streams that match their resources and rendering capability prior to decoding the components of a program.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
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2.1	ITU-T H.222.0 (2000) Technical Cor. 1	2001-03-01	16	11.1002/1000/5419
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2.5	ITU-T H.222.0 (2000) Amd. 2	2003-06-29	16	11.1002/1000/6363
2.6	ITU-T H.222.0 (2000) Amd. 3	2004-03-15	16	11.1002/1000/7208
2.7	ITU-T H.222.0 (2000) Technical Cor. 3	2005-01-08	16	11.1002/1000/7435
2.8	ITU-T H.222.0 (2000) Amd. 4	2005-01-08	16	11.1002/1000/7436
2.9	ITU-T H.222.0 (2000) Amd. 5	2005-01-08	16	11.1002/1000/7437
2.10	ITU-T H.222.0 (2000) Technical Cor. 4	2005-09-13	16	11.1002/1000/8560
3.0	ITU-T H.222.0	2006-05-29	16	11.1002/1000/8802
3.1	ITU-T H.222.0 (2006) Amd. 1	2007-01-13	16	11.1002/1000/9024
3.2	ITU-T H.222.0 (2006) Amd. 2	2007-08-29	16	11.1002/1000/9214
3.3	ITU-T H.222.0 (2006) Cor. 1	2008-06-13	16	11.1002/1000/9471

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

3.4	ITU-T H.222.0 (2006) Cor. 2	2009-03-16	16	11.1002/1000/9692
3.5	ITU-T H.222.0 (2006) Amd. 3	2009-03-16	16	11.1002/1000/9691
3.6	ITU-T H.222.0 (2006) Cor. 3	2009-12-14	16	11.1002/1000/10621
3.7	ITU-T H.222.0 (2006) Cor. 4	2009-12-14	16	11.1002/1000/10622
3.8	ITU-T H.222.0 (2006) Amd. 4	2009-12-14	16	11.1002/1000/10623
3.9	ITU-T H.222.0 (2006) Amd. 5	2011-05-14	16	11.1002/1000/11287
3.10	ITU-T H.222.0 (2006) Amd. 6	2011-05-14	16	11.1002/1000/11288
4.0	ITU-T H.222.0	2012-06-29	16	11.1002/1000/11655
4.1	ITU-T H.222.0 (2012) Amd. 1	2014-01-13	16	11.1002/1000/12054
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4.5	ITU-T H.222.0 (2012) Amd. 5	2014-10-14	16	11.1002/1000/12306
5.0	ITU-T H.222.0	2014-10-14	16	11.1002/1000/12359
5.1	ITU-T H.222.0 (2014) Amd. 1	2015-04-29	16	11.1002/1000/12452
5.2	ITU-T H.222.0 (2014) Amd. 1 Cor. 1	2015-11-29	16	11.1002/1000/12625
5.3	ITU-T H.222.0 (2014) Amd. 2	2015-12-14	16	11.1002/1000/12632
5.4	ITU-T H.222.0 (2014) Amd. 3	2015-12-14	16	11.1002/1000/12633

FOREWORD

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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As of the date of approval of this Recommendation, ITU had received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

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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 230082, 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 230082.

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

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 ( ) {		
descriptor_tag	**8**	**uimsbf**
descriptor_length	**8**	**uimsbf**
no_view_scalability_flag	**1**	**bslbf**
no_temporal_scalability_flag	**1**	**bslbf**
no_spatial_scalability_flag	**1**	**bslbf**
no_quality_scalability_flag	**1**	**bslbf**
hierarchy_type	**4**	**uimsbf**
reserved	**2**	**bslbf**
hierarchy_layer_index	**6**	**uimsbf**
tref_present_flag	**1**	**bslbf**
reserved	**1**	**bslbf**
hierarchy_embedded_layer_index	**6**	**uimsbf**
reserved	**2**	**bslbf**
hierarchy_channel	**6**	**uimsbf**
}		

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.

9) Clause 2.6.90

Replace Table 2-105 with:

Table 2-105 – Extension descriptor

Syntax	No. of bits	Mnemonic
Extension_descriptor ( ) {		
descriptor_tag	**8**	**uimsbf**
descriptor_length	**8**	**uimsbf**
extension_descriptor_tag	**8**	**uimsbf**
if (extension_descriptor_tag == 0x02) {		
ObjectDescriptorUpdate( )		
}		
else if (extension_descriptor_tag == 0x03) {		
HEVC_timing_and_HRD_descriptor( )		
}		
else if (extension_descriptor_tag == 0x04) {		
af_extension_descriptor( )		
}		
else if (extension_descriptor_tag == 0x05) {		
HEVC_operation_point_descriptor( )		
}		
else if (extension_descriptor_tag == 0x06) {		
HEVC_hierarchy_extension_descriptor( )		
}		
else {		
for (i=0; i<N; i++) {		
reserved	**8**	**bslbf**
}		
}		
}		

10) Clause 2.6.91

Add the following immediately before Table 2-106:

HEVC_operation_point_descriptor( ) – This structure is defined in 2.6.100 and 2.6.101.

HEVC_hierarchy_extension_descriptor( ) – This structure is defined in 2.6.102 and 2.6.103.

Replace in Table 2-106 the description for values 5 to 255 as follows:

Table 2-106 – Extension descriptor tag values

Extension_descriptor_tag	TS	PS	Identification
5	X	n/a	HEVC_operation_point_descriptor( )
6	X	n/a	HEVC_hierarchy_extension_descriptor( )
7-255	n/a	n/a	Rec. ITU-T H.222.0 | ISO/IEC 13818-1 Reserved

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() {		
hrd_management_valid_flag	**1**	**bslbf**
target_schedule_idx_not_present_flag	**1**	**bslbf**
target_schedule_idx	**5**	**uimsbf**
picture_and_timing_info_present_flag	**1**	**bslbf**
if (picture_and_timing_info_present_flag == '1') {		
90kHz_flag	**1**	**bslbf**
reserved	**7**	**bslbf**
if (90kHz_flag = = '0') {		
N	**32**	**uimsbf**
K	**32**	**uimsbf**
}		
num_units_in_tick	**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 2-111*bis* – HEVC operation point descriptor

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

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 2-111*ter*). When present, this descriptor shall only be used for elementary streams with the stream_type value 0x28, 0x29, 0x2A or 0x2B.

Table 2-111*ter* – HEVC hierarchy extension descriptor

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

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 2-111*quater* – 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 1quater – 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_{te} with stream_type equal to either 0x29 or 0x2B shall satisfy the following:
  - The elementary stream ES_{te} contains an HEVC temporal video subset which is a temporal enhancement for exactly one reference elementary stream ES_{ref}, i.e., the layer L_i present in the reference elementary stream ES_{ref} shall also be present in the elementary stream ES_{te}.

NOTE 2ter – The reference elementary stream ES_{ref} 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.

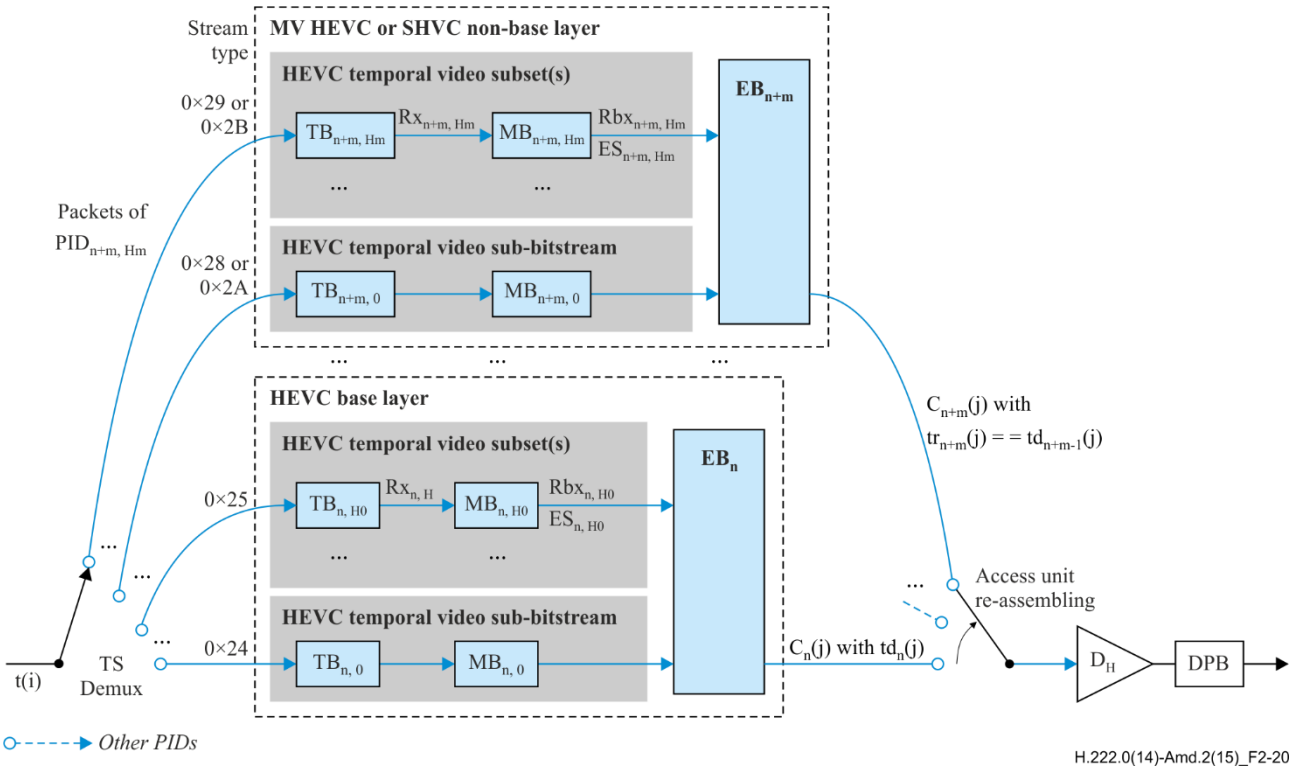

Figure 2-20 – T-STD model extensions for bitstream-partition-specific CPB operation

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.

Hl 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.

$ES_{l,k}$ 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.

$ES_{n+m,Hm}$ Is the received elementary stream which contains the HEVC sub-partition of the highest HEVC operation point in the set of received elementary streams.

$PID_{n+m,Hm}$ Is the packet identifier value which identifies $ES_{n+m,Hm}$.

j Is an index to the output HEVC access units.

$C_l(j)$ 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.

$A_n(j)$ Is the j-th HEVC access unit of the HEVC complete temporal representation.

$td_n(j)$ Is the decoding time of $A_n(j)$ in the system target decoder.

$tr_l(j)$ Is the value of TREF, if available in the PES header attached to $C_l(j)$, else the decoding time of $A_n(j)$ in the system target decoder.

$TB_{l,k}$ Is the transport buffer for elementary stream $ES_{l,k}$.

$TBS_{l,k}$ Is the size of the transport buffer $TB_{l,k}$, measured in bytes.

$MB_{l,k}$ Is the multiplexing buffer for elementary stream $ES_{l,k}$.

$MBS_{l,k}$ Is the size of the multiplexing buffer $MB_{l,k}$, measured in bytes.

EB_l Is the elementary stream buffer for the received HEVC temporal video sub-bitstream $ES_{l,0}$ and the received HEVC temporal video subsets $ES_{l,1}$ to $ES_{l,H}$.

NOTE 1 – Each buffer EB_l contains one partition as specified in Annex F of Rec. ITU-T H.265 | ISO/IEC 23008-2.

EBS_l Is the size of elementary stream buffer EB_l, measured in bytes.

$Rx_{l,k}$ Is the transfer rate from the k-th transport buffer $TB_{l,k}$ to the k-th multiplex buffer $MB_{l,k}$ as specified below.

$Rbx_{l,k}$ Is the transfer rate from the k-th multiplex buffer $MB_{l,k}$ to the elementary stream buffer EB_l 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.

$TB_{l,k}$, $MB_{l,k}$, EB_l buffer management

The following applies:

- There is one transport buffer $TB_{l,k}$ for each received elementary stream $ES_{l,k}$, where the size $TBS_{l,k}$ is fixed to 512 bytes.
- There is one multiplex buffer $MB_{l,k}$ for each received elementary stream $ES_{l,k}$, where the size $MBS_{l,k}$ of the multiplex buffer $MB_{l,k}$ is constrained as follows:

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

where

BS_{oh}, packet overhead buffering, and BS_{mux}, 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 $ES_{l,k}$ the HEVC operation point associated with $ES_{l,k}$;

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 $ES_{l,k}$.

- There is one elementary stream buffer EB_l for the Hl + 1 elementary streams in the set of received elementary streams $ES_{l,0}$ to $ESl_{m,Hl}$, with a total size EBS_l

  $EBS_l = cpb\_size$ (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 $ES_{l,H}$.

- Transfer from $TB_{l,k}$ to $MB_{l,k}$ is applied as follows:
  - When there is no data in $TB_{l,k}$ then $Rx_{l,k}$ is equal to zero.
  - Otherwise, $Rx_{l,k}$ = 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 $ES_{l,k}$, 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 × $BitRate_{VCL}$, 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 $ES_{l,k}$ 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 $ES_{l,k}$ the HEVC operation point associated with $ES_{l,k}$.

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][l + 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 $ES_{l,k}$, and target_schedule_idx is signalled in the HEVC timing and HRD descriptor.

- Transfer from $MB_{l,k}$ to EB_l 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 $MB_{l,k}$ to EB_l shall follow the HRD defined scheme for data arrival in the CPB of elementary stream $ES_{l,H}$ 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 $MB_{l,k}$ to EB_l as follows:

    $$Rbx_{n,k} = CpbBrNalFactor \times MaxBR[tier, level]$$

    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 $ES_{l,k}$ signalled in the HEVC operation point descriptor for $ES_{l,k}$.

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

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_l 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_l 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_l 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_l, and DPB shall not overflow;
- EB_l 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_l occurs for HEVC access unit $A_n(j)$ when one or more bytes of $A_n(j)$ are not present in EB_l at the decoding time $td_n(j)$.

18) New Annex V

Add the following annex after Annex U:

Annex V

Transport of layered HEVC (MV-HEVC, SHVC)

(This annex does not form an integral part of this Recommendation | International Standard.)

V.1 Introduction

Transport of layered HEVC in MPEG-2 systems differs from earlier approaches in some respects, because the individual layers of an MV-HEVC or SHVC bitstream comply with certain profile, tier, and level restrictions depending on their combination within an output layer set, and there is no profile, tier, and level that applies to the output layer set as a whole, as had been for earlier layered video coding standards like SVC or MVC. In addition to this, layered HEVC can provide buffer models for individual layers, which had not been the case for previous scalable or multiview coding standards. The chosen approach for transport of layered HEVC in MPEG-2 systems allows sending at most one layer in one elementary stream, where the separate transport of temporal sub-layers of a single layer is supported. This allows alignment of the underlying HRD buffer model with the T-STD buffer model of systems.

V.2 Terminology

Figures V.1 and V.2 illustrate the terminology used for HEVC temporal sub-bitstreams and HEVC temporal video subsets of HEVC version 1. In Figure V.1, the horizontal axis indicates the different temporal sub-layers. Here, the value of the syntax element nuh_layer_id of all NAL units of all HEVC video sub-bitstreams is 0.

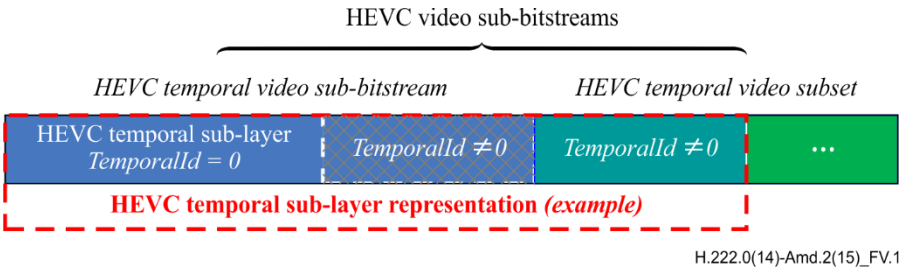

Figure V.1 – Terminology used for HEVC streams conforming to profiles defined in Annex A of ITU-T H.265 (2013) | ISO/IEC 23008-2:2013

Figure V.2 shows the additional layers introduced by the MV HEVC and SHVC extensions in the vertical dimension. In addition to the temporal layers, different values of the syntax element nuh_layer_id are allowed. Just as in Figure V.1, there are temporal video sub-bitstreams, which include the temporal layer with TemporalId equal to 0, and temporal video subsets, which do not. The HEVC base sub-partition contains data with LayerId 0 only, and is at the same time a temporal video sub-bitstream because it includes TemporalId 0. Furthermore, it is a conforming bitstream all by itself and can be independently decoded.

In general, an HEVC enhancement sub-partition can include an HEVC temporal video sub-bitstream with one layer or an HEVC temporal video subset with one layer as shown in Figure V.3. L_i, L_j and L_k stand for increasing values of nuh_layer_id larger than 0.

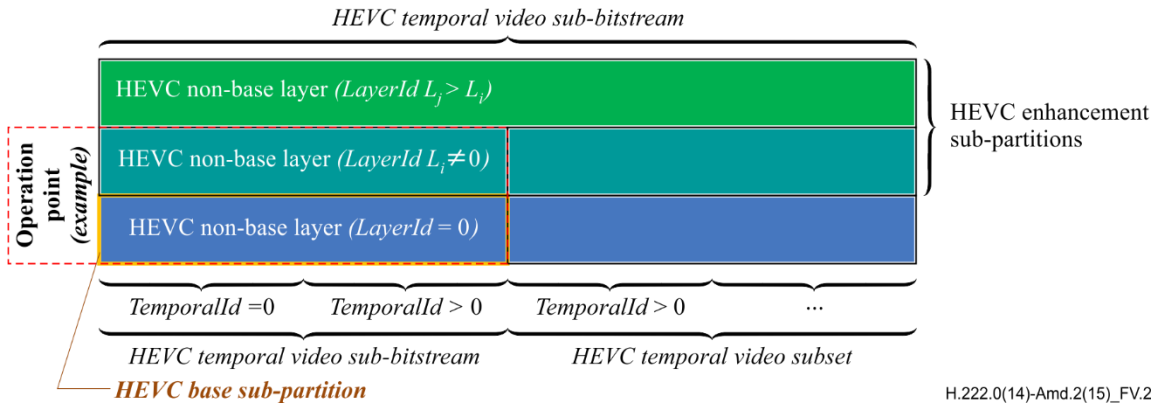

Figure V.2 – Terminology used for HEVC streams conforming to profiles defined in Annexes G and H

An elementary stream consists of an HEVC sub-partition for which one of the following is true:

- It is a conforming bitstream all by itself and can be independently decoded, i.e., it is an HEVC base sub-partition including all coded data with LayerId equal to 0 and TemporalId equal to 0;
- It enhances another elementary stream by adding one or more temporal sub-layers;
- It adds one layer identified by a value of nuh_layer_id > 0.

V.3 Examples

An example of an MV HEVC video stream is shown in Figure V.3. In this example, the base layer contains the central view (LayerId equal to 0) and two more views (left and right) are encoded as further layers with LayerIds equal to 1 and 2, respectively. For this example, the assumption is made that there are coding dependencies between left and central and between right and central only. Each layer is encoded in two temporal levels. In a straight-forward partitioning, all sub-partitions contain a temporal sub-bitstream or subset of a single layer. All possible operation points would be:

1. Single central view @30 fps (HEVC version 1);
2. Single central view @60 fps (HEVC version 1);
3. Left and central view @30 fps;
4. Left and central view @60 fps;
5. Right and central view @30 fps;
6. Right and central view @60 fps;
7. Left and right view @30 fps (central used for reference, but not output);
8. Left and right view @60 fps (central used for reference, but not output);
9. Left, right and central view @30 fps;
10. Left, right and central view @60 fps.

However, a service provider could decide that only a subset of these operation points should be signalled to the consumer, e.g. 1, 2, 3, 4, 7, 10.

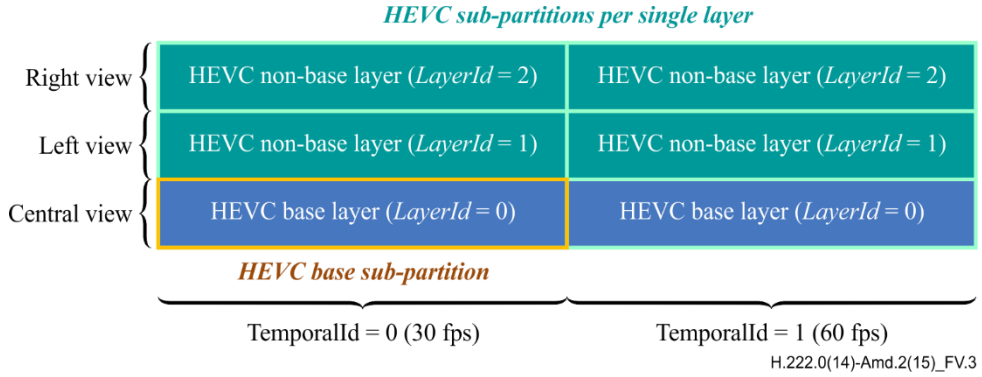

Figure V.3 – Example partitioning of MV-HEVC

In the example above, elementary streams with stream_type value 0x28 and 0x29 occur twice. The streams with stream_type 0x29 have two direct dependencies, thus an HEVC hierarchy extension descriptor is included in the program map table for both streams with stream_type 0x29. In contrast to that, one hierarchy descriptor is included in the program map table for the streams with stream_type0x24 and 0x25. Both streams with stream_type 0x28 have only one direct dependency, which could be signalled with a hierarchy descriptor; however, for this stream type, the use of the HEVC hierarchy extension descriptor is mandated. Even though all dependencies for the set of operations points shown in Figure V.4 could be signalled using a set of hierarchy descriptors and HEVC hierarchy extension descriptors, the HEVC operation point descriptor is mandated. In order to signal dependencies and profile/tier/level for all 10 operation points listed above, the HEVC operation point descriptor is needed.

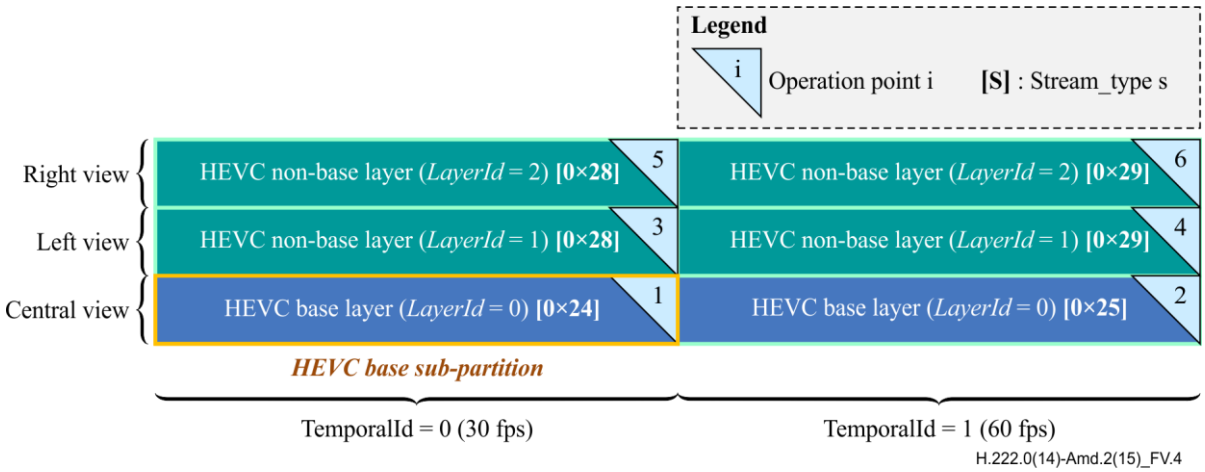

Figure V.4 – Example for layered transport of an MV-HEVC video stream

Figure V.5 shows an example for an SHVC video stream with five possible operation points, indicated by numbered triangles in the upper right corner of each box representing a sub-partition corresponding to an elementary stream. The lowest box represents the HEVC base layer. Further HEVC layers with values of the syntax element nuh_layer_id greater than 0 are shown in the vertical dimension. Note that in this example the frame rate enhancement through LayerId 2 does not add a temporal level, but uses TemporalId 0 again. In this case, dependencies between the streams are straight-forward. Each elementary stream depends on the elementary streams corresponding to operation points with lower numbers. It is sufficient to signal the dependency to the elementary streams corresponding to the operation point OP_{i-1} for the elementary streams corresponding to operation point OP_i. In total, four dependencies would be signalled:

- For OP2: Elementary stream corresponding to OP2 depends on the elementary stream corresponding to OP1;
- For OP3: Elementary stream corresponding to OP3 depends on the elementary stream corresponding to OP2;
- For OP4: Elementary stream corresponding to OP4 depends on the elementary stream corresponding to OP3;
- For OP5: Elementary stream corresponding to OP5 depends on the elementary stream corresponding to OP4.

In this example, indirect dependencies can easily be inferred by recursively resolving the dependencies. However, the HEVC operation point descriptor is mandated.

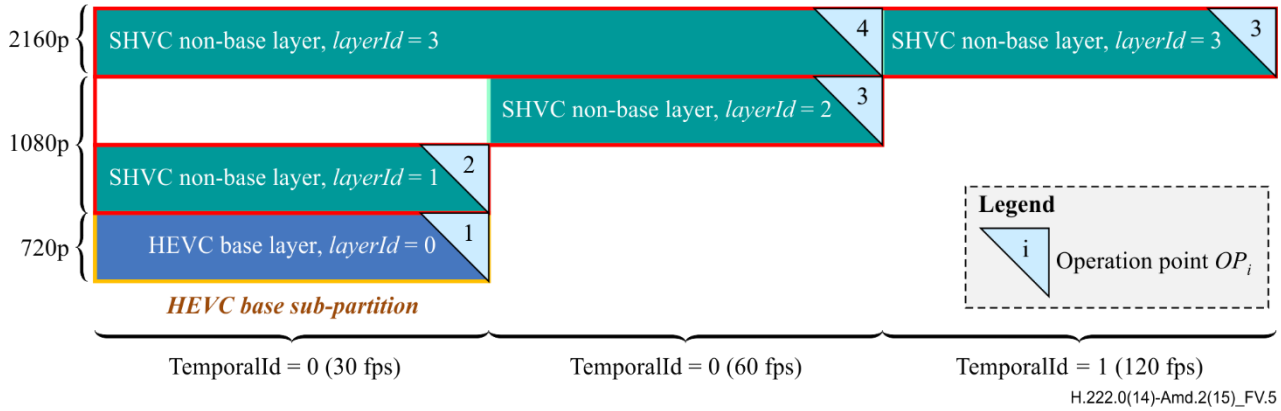

Figure V.5 – Example for layered transport of an SHVC video stream

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