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**Information technology** — **Coded representation of immersive media (MPEG-I) — Part 18: Carriage of Geometry-based Point Cloud Compression Data — Amendment 1 : Support for Temporal Scalability**

DIS stage

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CH-1214 Vernier, Geneva

Phone: +41 22 749 01 11

Email: copyright@iso.org

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# *Change 1:* *Temporal scalability support of in timed G-PCC data*

*Add following definition in clause 3.1.*

**Temporal level track**

volumetric visual track which carries a subset of point cloud frames in the G-PCC bitstream that constitute a temporal sub-sequence of the actual G-PCC bitstream sequence.

**Temporal level tile track**

volumetric visual track which carries one or more G-PCC tiles of a subset of point cloud frames in the G-PCC bitstream that constitute a temporal sub-sequence of the actual G-PCC bitstream sequence.

*Add following clauses after clause 7.*

# X. Temporal scalability in G-PCC content

## **X.1 Temporal levels**

A G-PCC temporal level is a subset of the point cloud frames that constitute a temporal sub-sequence of the actual G-PCC bitstream sequence. Each point cloud frame may be associated with a particular temporal level. Each temporal level is identified by a unique temporal level identifier with the first temporal level having the id 0.

A G-PCC bitstream may be carried/stored in one or more temporal level tracks. Necessary information to describe the temporal level tracks and the mapping between a sample and its temporal level may be available in the file. A G-PCC sample belonging to a certain temporal level shall not have any decoding dependency on any G-PCC samples present in higher temporal levels. Prior to decoding process, necessary samples are extracted from the temporal level track(s) and combined into a single conforming G-PCC bitstream. When extracting a G-PCC bitstream for a target temporal level with an id greater than 0 and target tile ids, data from all lower temporal level samples are also included in the resulting output bitstream, and the required G-PCC tracks are selected accordingly during the extraction process.

Figure A shows an example of enabling the playback of a G-PCC bitstream at 30 fps, 45 fps, and 60 fps when the G-PCC bitstream are encapsulated into three temporal levels; temporal level 0 represents a 30 fps subsequence, and temporal levels 1 and 2 represent a 15 fps subsequence, respectively. A combination of temporal Level 0 and Temporal Level 1 enables the playback of G-PCC bitstream as a 45 fps in average and the combination of all three temporal levels enables the playback of G-PCC bitstream as 60 fps in average.



Figure A. Temporal levels in a G-PCC sequence

## **X.2 Common data structures**

**X.2.1 Temporal level sample group**

The temporal level sample grouping (‘tele’) defined in ISO/IEC 14496-12 provides a codec-independent sample grouping that can be used to group G-PCC samples in a G-PCC track (and potential track fragments) according to temporal level, where samples of one temporal level have no coding dependencies on samples of higher temporal levels. This sample group may be present in temporal level track or in temporal level tile track.

When present in a G-PCC track, temporal level sample group provides mechanism to indicate the temporal level identifier value for each sample in that track.

#### **X.2.1.1 Temporal level sample group in temporal level track**

When the G-PCC bitstream is carried using multiple temporal level tracks, the ‘tele’ sample group shall only be present in a temporal level track that contains geometry component when the number of temporal levels in the track is greater than one. When the ‘tele’ sample group is present in a temporal level track, the samples belonging to a temporal level identifier shall be mapped to the sample group description index equal to temporal level identifier plus 1. The list of temporal level identifier is available in the GPCCScalabilityInfoBox that is present in the sample entry of the track.

When sample group description box with grouping\_type equal to ‘tele’ is present in temporal level track, the value of entry\_count shall be equal to the highest temporal level identifier value contained in the track plus one. The highest temporal level identifier value is the highest value in the list of temporal level identifiers present in the GPCCScalabilityInfoBox of that temporal level track.

When each temporal level track carries a single component data, the temporal level of a sample in a track containing attribute component is identical to the temporal level of the corresponding sample, i.e., the sample with the same composition time stamp, in the associated track containing geometry component.

#### **X.2.1.2 Temporal level sample group in temporal level tile track**

When the G-PCC bitstream is carried using multiple temporal level tile tracks, the ‘tele’ sample group shall only be present in a temporal level tile track that contains geometry component when the number of temporal levels in the track is greater than one. When the ‘tele’ sample group is present in a temporal level tile track, the samples belonging to a temporal level identifier shall be mapped to the sample group description index equal to temporal level identifier plus 1. The list of temporal level identifier is available in the GPCCTileScalabilityInfoBox if it is present in the sample entry of the temporal level tile track or in the GPCCScalabilityInfoBox that is present in the sample entry of the associated tile base track.

When sample group description box with grouping\_type equal to ‘tele’ is present in a temporal level tile track, the value of entry\_count shall be equal to the highest temporal level identifier value contained in the track plus one. The highest temporal level identifier value contained in the temporal level tile track is derived as follows:

* If GPCCTileScalabilityInfoBox is present in the temporal level tile track, the highest temporal level identifier is the highest value in the list of temporal level identifiers present in that track’s GPCCTileScalabilityInfoBox box.
* Otherwise (i.e., GPCCTileScalabilityInfoBox is not present in the temporal level tile track), the highest temporal level identifier is the highest value in the list of temporal level identifiers present in the GPCCScalabilityInfoBox in the associated tile base track of that temporal level tile track.

When each temporal level tile track carries a single component data, the temporal level of a sample in a tile track containing attribute component is identical to the temporal level of the corresponding sample, i.e., the sample with the same composition time stamp, in the associated tile track containing geometry component.

## **X.3. Temporal level track**

A G-PCC track containing GPCCScalabilityInfoBox in the sample entry is referred as temporal level track carrying a temporal subset of the G-PCC bitstream. When the G-PCC bitstream is carried in multiple temporal level tracks, all temporal level tracks carrying a subset of same G-PCC bitstream shall use the same sample entry type.

In each sample entry, the value of simple\_profile\_compatibility\_flag, dense\_profile\_compatibility\_flag, predictive\_profile\_compatibility\_flag, and main\_profile\_compatibility\_flag shall indicate a profile to conform to samples in temporal level tracks with current and lower temporal level ids. The value of level\_idc shall indicate a level of capability equal to or greater than the highest level required for samples in temporal level tracks with current and lower temporal level ids.

Temporal level tracks with temporal level id greater than 0 shall have their track\_in\_movie flags set to 0.

**X.3.1 G-PCC scalability information box**

#### **X.3.1.1 Definition**

Box Types: ‘gsci’  
Container: GPCCSampleEntry (‘gpe1’, ‘gpeg’, ‘gpc1’, ‘gpcg’, ‘gpcb’, or ‘gpeb’)   
Mandatory: No  
Quantity: Zero or one

This box signals scalability information for a G-PCC track. When this box is present in a G-PCC track with sample entries of type ‘gpe1’, ‘gpeg’, ‘gpc1’, ‘gpcg’, ‘gpcb’, or ‘gpeb’, it indicates that temporal scalability is supported and provides information about the temporal levels present in this G-PCC track. This box shall not be present in a G-PCC track when the temporal scalability is not used.

This box shall not be present in G-PCC tile track with a sample entry of type ‘gpt1’.

For track with sample entry type ‘gpc1’ or ‘gpcg’, the GPCCScalabilityInfoBox may be present only in the track that carries G-PCC geometry component. For the track with sample entry type ‘gpc1’ or ‘gpcg’ which carries attribute component, the GPCCScalabilityInfoBox shall not be present but should be inferred from the GPCCScalabilityInfoBox in the sample entry of the corresponding G-PCC geometry track.

#### **X.3.1.2 Syntax**

aligned(8) class GPCCScalabilityInfoBox   
 extends FullBox(‘gsci’, version = 0, 0) {

unsigned int(1) multiple\_temporal\_level\_tracks\_flag;

unsigned int(1) frame\_rate\_present\_flag;

bit(3) reserved = 0;

unsigned int(3) num\_temporal\_levels;

for(i=0; i < num\_temporal\_levels; i++){

bit(5) reserved;

unsigned int(3) temporal\_level\_id;

if (frame\_rate\_present\_flag){  
 unsigned int(16) frame\_rate;

}

}

}

#### **X.3.1.3 Semantics**

multiple\_temporal\_level\_tracks\_flag indicates the presence of multiple temporal level tracks in the file. When the sample entry type is ‘gpe1’, ‘gpeg’, ‘gpc1’, or ‘gpcg’, the following applies:

* If the value of multiple\_temporal\_level\_tracks\_flag is equal to 0, it specifies that there is no other temporal level track for the G-PCC bitstream.
* Otherwise, it specifies that there may be other temporal level track(s) for the G-PCC bitstream.

When one of the following applies, the value of multiple\_temporal\_level\_tracks\_flag shall be equal to 1:

* There are more than one temporal level tracks with sample entry type ‘gpe1’ or ‘gpeg’.
* There are more than one temporal level tracks with sample entry type ‘gpc1’ or ‘gpcg’ containing the same component type.

When the sample entry type is ‘gpcb’ or ‘gpeb’, the following applies.

* If the value of multiple\_temporal\_level\_tracks\_flag is equal to 0, it specifies that each tile track referred to by the tile base track contains samples from all temporal levels for the G-PCC bitstream.
* Otherwise, it specifies that there may be one or more temporal tile tracks that do not contain samples from all temporal levels for the G-PCC bitstream.

When one of the following applies, the value of multiple\_temporal\_level\_tracks\_flag shall be equal to 1:

* The track is a tile base track with sample entry type ‘gpeb’ and it refers to tile tracks in which there are more than one temporal level tile tracks of the same tile(s).
* The track is a tile base track with sample entry type ‘gpcb’ and it refers to tile tracks in which there are more than one temporal level tile tracks of the same tile(s) of the same component type.

frame\_rate\_present\_flag indicates the presence of average frame rate information. Value 1 indicates the average frame rate information is present. Value 0 indicates the average frame rate information is not present.

num\_temporal\_levels indicate the number of temporal levels present in the samples of the respective track. For ‘gpcb’or ‘gpeb’ G-PCC track, this field value indicates the maximum number of temporal levels present in the samples of this G-PCC track. The minimum value of num\_temporal\_levels shall be 1.

temporal\_level\_id indicates temporal level identifier of a G-PCC sample in the respective track.The following applies to the value of temporal\_level\_id:

* The value of temporal\_level\_id shall be in increment of 1. For a temporal level with temporal id *x*, the immediate next temporal level shall have temporal id equal to *x + 1*.
* When a *TrackB* is said to be the next temporal level track of another *TrackA, TrackB s*hall contain samples with temporal id equal to the highest temporal id in *TrackA* plus 1.

frame\_rate gives the average frame rate of a temporal level in units of frames / (256 seconds). Value 0 indicates an unspecified average frame rate.

**X.3.2 Temporal level track samples**

The smallest composition time difference between two consecutive samples in a temporal level track with a maximum temporal\_level\_id Y shall be equal to or greater than the smallest composition time difference between two consecutive samples in a temporal level track with a maximum temporal\_level\_id X when Y is greater than X.

The presentation time of samples present in different temporal level tracks belonging to the same point cloud component shall be different. For example, the presentation time of geometry component samples present in temporal level 0 and temporal level 1 geometry component tracks shall be different.

The syntax and semantics of samples in a temporal level track carrying more than one G-PCC component as defined in subclause 6.3.3, shall be applied. The syntax and semantics of samples in a temporal level track carrying only one G-PCC component as defined in subclause 6.4.3, shall be applied.

#### **X.3.2.1 sub-sample**

The syntax and semantics of the sub-sample with flags equal to 0 or 1 as defined in subclause 6.3.3.4, shall be applied.

For temporal level track carrying multiple G-PCC components, when sub-samples are present, the SubSampleInformationBox with flags equal to 0 in SampleTableBox, or in the TrackFragmentBox of each of its MovieFragmentBoxes shall be present.

For temporal level track carrying only one G-PCC component, when sub-samples are present, SubSampleInformationBox with flags equal to 1 in SampleTableBox, or in the TrackFragmentBox of each of its MovieFragmentBoxes shall be present.

**X.3.4 Temporal scalability track grouping**

#### **X.3.4.1 Definition**

The temporal level tracks carrying the G-PCC geometry component may be grouped into a G-PCC temporal scalability track group.

When the G-PCC bitstream are encapsulated using multiple temporal level tracks and there are one or more alternative tracks to the temporal level tracks, all temporal level tracks carrying the geometry component of the same G-PCC bitstream shall be grouped into the same G-PCC temporal scalability track group.

A GPCCTemporalScalabilityGroupBox may be present in a track with sample entry type ‘gpe1’, ‘gpeg’, ‘gpc1’, or ‘gpcg’. When GPCCTemporalScalabilityGroupBox is present, to get a bitstream with more temporal levels, only the tracks with the same track\_group\_id of a GPCCTemporalScalabilityGroupBox shall be combined. A GPCCTemporalScalabilityGroupBox may be present in a track that contains the geometry component. When GPCCTemporalScalabilityGroupBox is present in tracks with sample entry 'gpc1' or 'gpcg', the combination of G-PCC geometry tracks within the same temporal scalability track group implies the combination of G-PCC attribute tracks which are referenced by the G-PCC geometry tracks.

#### **X.3.4.2 Syntax**

aligned(8) class GPCCTemporalScalabilityGroupBox

extends TrackGroupTypeBox('gtsg') {

// track\_group\_id is inherited from TrackGroupTypeBox;

}

## **X.4 Temporal level tile track**

A G-PCC tile track containing GPCCTileScalabilityInfoBox in its sample entry is referred as G-PCC temporal level tile track and it carries one or more G-PCC tiles of a temporal subset of the G-PCC bitstream. When the G-PCC bitstream is carried in multiple temporal level tile tracks, all temporal level tile tracks shall use the sample entry type ‘gpt1’.

**X.4.1 G-PCC tile track scalability information box**

#### **X.4.1.1 Definition**

Box Types: 'gtsi'  
Container: SampleEntry ('gpt1')   
Mandatory: No  
Quantity: Zero or one

This box contains the scalability information for a G-PCC tile track with sample entry type ‘gpt1’. This box may only be present in a tile track when the sample entry of the associated G-PCC tile base track contains a GPCCScalabilityInfoBox. When GPCCTileScalabilityInfoBox presents, it shall only present in a G-PCC temporal level tile track that contains geometry component.

When temporal scalability is not supported, this box shall not be present in any of G-PCC tile tracks. This box shall not be present in the G-PCC tile track when the GPCCScalabilityInfoBox is not present in the sample entry of the associated G-PCC tile base track.

The following applies:

* If this box is present in the sample entry of a G-PCC tile track, it indicates that temporal scalability is supported and the number of temporal levels in the G-PCC tile track is less than the number of temporal levels signalled in GPCCScalabilityInfoBox present in the associated G-PCC tile base track.
* Otherwise, if this box is not present in the sample entry of a G-PCC tile track and GPCCScalabilityInfoBox is present in the associated G-PCC tile base track, the temporal scalability is supported and the temporal scalability information for the G-PCC tile track is derived from the GPCCScalabilityInfoBox in the associated G-PCC tile base track. The number of temporal levels and temporal level identifiers for the G-PCC tile track are inferred to be equal to the number of temporal levels and temporal level identifiers signalled in GPCCScalabilityInfoBox,respectively.
* Otherwise (this box is not present in a G-PCC tile track and GPCCScalabilityInfoBox is not present in the associated G-PCC tile base track), temporal scalability is not supported.

This box may only be present in the G-PCC temporal level tile tracks carrying geometry component and shall not be present in the G-PCC temporal level tile tracks carrying attribute component only, but the temporal level information is inferred from the GPCCTileScalabilityInfoBox present in the sample entry of the corresponding G-PCC temporal level tile track carrying the geometry component or from the GPCCScalabilityInfoBox present in the sample entry of the associated G-PCC tile base track.

#### **X.4.1.2 Syntax**

aligned(8) class GPCCTileScalabilityInfoBox   
 extends FullBox('gtsi', version = 0, 0) {

bit(5) reserved;

unsigned int(3) num\_temporal\_levels;

for(i=0; i < num\_temporal\_levels; i++){

bit(5) reserved;

unsigned int(3) temporal\_level\_id;

}

}

#### **X.4.1.2 Semantics**

num\_temporal\_levels indicate the number of temporal levels present in the samples of the respective tile track.

temporal\_level\_id indicates a temporal level identifier of the samples signalled in the respective tile track.

**X.4.2 Temporal level tile track samples**

The syntax and semantics of samples in a temporal level tile track as defined in subclause 6.5.3.2, shall be applied.

#### **X.4.2.1 sub-sample**

The syntax and semantics of the sub-sample as defined in subclause 6.5.3.2.1, shall be applied.

# *Change 2: player behavior with temporal support*

*Add following clause.*

**Y. Player behavior with temporal scalability support (informative)**

For handling G-PCC bitstream stored in an ISOBMFF file with temporal level tracks, the G-PCC player is provided with a target temporal level and optionally target tile ids, if the file contains G-PCC tile tracks. When extracting a G-PCC bitstream for a target temporal level with an id greater than 0 and target tile ids, data from all lower temporal level samples are also included in the resulting bitstream, and the required tracks are selected accordingly during the extraction process. The extracted G-PCC samples are used to form the output bitstream. The extracted G-PCC samples in the output bitstream are in increasing order of the decoding time.

The extraction process may extract samples from one or more temporal level tracks, and it combines the extracted samples into one single output bitstream. Encoder may split a single G-PCC bitstream and store it into multiple temporal level tracks or multiple temporal level tile tracks and transmits the file over the network. Prior to decoding process, G-PCC player extracts samples from the temporal level tracks, combines them into an output bitstream, and feeds it to a single G-PCC decoder.

NOTE: The player feeds the output bitstream to a single decoder as there is no scalability concept in G-PCC codec. However, implementation with multiple decoders may be possible but out of the scope of this specification.

NOTE: Example of extraction process is given in Annex xx.

*Add the following clause after Annex E.*

**Annex xx: Temporal level Extraction Process (Informative)**

**XX.1: Temporal level extraction from temporal level tracks**

To extract samples from temporal level tracks, the G-PCC player is provided with a given target temporal level and a variable *lastPresentationTime*. The process is as follows:

1. The G-PCC player identifies the set of tracks in which each of the identified track contains temporal level that is less than or equal to the given target temporal level.
2. From the set of tracks, the player extracts samples that belong to temporal level that is less than or equal to the given target temporal level and have presentation time greater than the value of *lastPresentationTime*.
3. The extracted samples are delivered to the decoder according to their decoding time.
4. Once decoded, the decoded samples are delivered for rendering according to their presentation / composition time.

**XX.2: Temporal level extraction from temporal level tile tracks**

To extract samples from temporal level tile tracks, the G-PCC player is provided with a given target temporal level, target tile ids, and a variable *lastPresentationTime*. The process is as follows:

1. The G-PCC player identifies a set of temporal level tile tracks in which each of the identified tile track contains a tile id which is one of target tile ids.
2. The player refines the selection criteria of the tile tracks in step 1 by selecting the set of tile tracks in which each of the identified track contains temporal level that is less than or equal to the given target temporal level.
3. From the set of selected tile tracks, the player extracts samples that belong to temporal level that is less than or equal to the given target temporal level, contains tile id which is one of the target tile ids, and have presentation time greater than the value of *lastPresentationTime*.
4. The extracted samples are delivered to the decoder according to their decoding time.
5. Once decoded, the decoded samples are delivered for presentation according to their presentation / composition time.

When the extraction process is invoked for the first time, the value of *lastPresentationTime* is set equal to the least possible presentation time.

Figure B presents an example of how point cloud frames are encapsulated into multiple temporal level tile tracks during encapsulation and how the G-PCC samples are extracted from the temporal level tile tracks. In this example, each point cloud frame is composed of eight tiles and all the point cloud frames in the G-PCC bitstream are grouped into three temporal levels. The G-PCC samples are encapsulated into an ISOBMFF file using temporal level tile tracks. Each temporal level tile track represents G-PCC samples of a specific tile belonging to a specific temporal level. Each tile track carries all the G-PCC components data.

The G-PCC player selects the corresponding temporal level tile tracks based on the given target temporal level and target tile ids which are based on the user’s viewing orientation. The player may initially select tile tracks with a target temporal level id equal to 0 and enhance the temporal resolution by selecting additional tile tracks with temporal level 1 and higher at later stage. In this example, the G-PCC player initially receives tile tracks 1, 2, 5 and 6 with a target temporal level id 0. The player extracts the G-PCC samples of tiles 1, 2, 5 and 6 for a specific presentation time from those tile tracks. To enhance the user’s quality of experience, the player may receive additional tile tracks with temporal level id 1 and 2 for tiles 1, 2, 5 and 6 and extract the G-PCC samples of those tiles for a specific presentation time from the tile tracks.



Figure B. Example of G-PCC samples extraction from temporal level tile tracks

**XX.3: Change of parameters**

When the target parameters (i.e., target temporal level and / or target tile ids) change, the players invoke the following process:

1. Set the value of *targetChangeTime* equal to the time of the new target parameters is given plus a fixed amount of offset time. The fixed amount of offset time can be set externally. For example, this can be a one of configuration parameter for the player operation
2. Discard the following samples:
3. Samples that have been extracted but not yet decoded and that have presentation time less than the value of *targetChangeTime*.
4. Samples that have been decoded but not yet presented and that have presentation time less than the value of *targetChangeTime*.
5. Delivers the remaining extracted samples to the decoder according to their decoding time and then delivers the decoded samples for presentation according to their presentation time.
6. Set the value of *lastPresentationTime* to be equal to the presentation time of the last presented sample and invoke the extraction process based on the new target parameter(s).

# *Change 3: temporal level sample group indication*

*Add the following clause after Annex E.*

**Annex xx: Indication of Temporal Level Sample Group (Informative)**Figure XX1 below illustrates an example of GPCC file structure with two temporal level tracks. Each track contains samples from two temporal levels. For each track, sample group description box and sample to group box with grouping type ‘tele’ are present. In the first track (Track 1), the sample group description box contains two ‘tele’ sample group description entries as the highest temporal level identifier in that track is one. In the second track (Track 2), the sample group description box contains four ‘tele’ sample group description entries as the highest temporal level identifier in that track is three.

Graphical user interface

Description automatically generated with low confidence

Figure XX1 –Example of using ‘tele’ sample group in temporal level tracks

Figure XX2 below illustrates an example of a GPCC file structure that contains a tile base track (Track 1) and two temporal level tile tracks (Track 2 and Track 3). In each temporal level tile track, the number of ‘tele’ sample group description entries in the sample group description box is equal to the max value of temporal\_level\_id plus 1 in the GPCCTileScalabilityInfoBox that is present in each of the temporal level tile track.

A picture containing table

Description automatically generated

Figure XX2 – Example of using ‘tele’ sample group in temporal level tile tracks that contain GPCCTileScalabilityInfoBox.

In another example, Figure XX3 below illustrates a GPCC file structure with a tile base track (Track 1) and a temporal level tile track (Track 2). Track 2 contains samples from all temporal levels so that it does not contain a GPCCTileScalabilityInfoBox. In this case, the number of ‘tele’ sample group description entries in the sample group description box is equal to the max value of temporal\_level\_id plus 1 in the GPCCScalabilityInfoBox signalled in the associated tile base track (i.e., Track 1).

Text

Description automatically generated

Figure XX3 – Example of using ‘tele’ sample group in temporal level tile tracks that contains all temporal levels described in ‘gsci’ box in the associated tile base track.

# *Change 4: Multiple temporal level tracks/temporal level tile tracks indication*

*Add the following clause after Annex E.*

**Annex XX: Multiple temporal level tracks / temporal level tile tracks (Informative)**

**XX.1: Removal of tracks containing higher temporal level samples**

Samples of coded GPCC frames can be stored in multiple temporal level tracks in which each track contains one or more temporal levels. Likewise, when GPCC frames contain multiple tiles, they can be stored in multiple temporal level tile tracks in which each track contains one or more temporal levels. When there are more than one temporal level tracks / temporal level tile tracks for a G-PCC bitstream, the value of multiple\_temporal\_level\_tracks\_flag shall be set to be equal to 1. However, when one or more track containing higher temporal levels is removed from the file at any stages during transport from sender to receiver, it is not mandated to change the value of the flag.

Figure XX1 illustrates the case when track containing higher temporal level samples. When the file was generated, the value of multiple\_temporal\_level\_tracks\_flag for each temporal level tracks is equal to 1. When Track 2 is removed from the file, there is no change needed on Track 1.

Graphical user interface

Description automatically generated

Figure XX1 – Example of removal of temporal level track

Figure XX2 illustrates the case when tracks containing higher temporal level samples of GPCC tiles. When the file was generated, the value of multiple\_temporal\_level\_tracks\_flag in the associated tile base track is equal to 1. When Track 4 and Track 5 are removed from the file, there is no change needed on the tile base track.

Graphical user interface, table

Description automatically generated

Figure XX2 − Example of removal of temporal level tile track

**XX.2: Implementation guideline for handling multiple temporal level tracks / tile tracks**

When the value of multiple\_temporal\_level\_tracks\_flag in the GPCCConfigurationBox of a track with sample entry type 'gpe1', 'gpeg', 'gpc1', or 'gpcg' is equal to 1, file player should anticipate that there may be other track(s) with the same sample entry types containing samples of different / higher temporal layers of the G-PCC bitstream. File player is expected to search the other track(s) and may use the samples in the track(s) to reconstruct the final samples for decoding. It is noted that tracks containing samples belong to higher temporal level may not be present which may be resulted from removal of the tracks during transport to the receiver.

When the value of multiple\_temporal\_level\_tracks\_flag in the GPCCConfigurationBox of a track with sample entry type 'gpeb' or 'gpcb' is equal to 1, file player should anticipate that there may be tile track(s), other than the tile track(s) containing samples with temporal level 0, that contains samples of higher temporal layers of the G-PCC bitstream. File player is expected to search the other tile track(s) and may use the samples in the tile track(s) to reconstruct the final samples for decoding. It is noted that tracks containing samples belong to higher temporal level may not be present which may be resulted from removal of the tile tracks during transport to the receiver.

# *Change 5: Signaling for temporal scalable G-PCC content in DASH*

*Add the following clause after clause 10.3*

## **10.4 Signaling temporal level information**

**10.4.1 GPCCTemporalLevelId descriptor**

A SupplementalProperty element with a @schemeIdUri attribute equal to "urn:mpeg:mpegI:gpcc:2022:temporallevelIds" is referred to as GPCCTemporalLevelId descriptor. A GPCCTemporalLevelId descriptor is used to identify the different temporal levels present in a Representation of a G-PCC content. At most one GPCCTemporalLevelId descriptor shall be present at the Representation level for the G-PCC media when the G-PCC media is stored in multiple temporal level tracks.

At most one GPCCTemporalLevelId descriptor may be present at the Representation level for the G-PCC media when the G-PCC component media samples are divided into multiple temporal levels and all temporal level samples are stored in a single temporal level track. The GPCCTemporalLevelId descriptor shall not be present at the Representation level when the G-PCC media samples are not divided based on temporal levels.

The GPCCTemporalLevelId descriptor shall include an @value attribute which specifies a list of space-separated temporal level identifiers for the temporal levels present in the G-PCC track of the Representation.

*In Annex B, replace*

|  |
| --- |
| <?xml version="1.0" encoding="UTF-8"?>  <xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"  targetNamespace="urn:mpeg:mpegI:gpcc:2021"  xmlns:v3c="urn:mpeg:mpegI:gpcc:2021"  elementFormDefault="qualified">  <xs:attribute name="gpcId" type="xs:string" use="optional" />  <xs:attribute name="tile\_Ids" type="xs:UIntVectorType" use="required" />  <xs:attribute name="temporal\_level\_Ids" type="xs:UIntVectorType" use="required" />  <xs:element name="component" type="gpcc:gpccComponentType"/>  <xs:complexType name="gpccComponentType">  <xs:attribute name="type" type="xs:string" use="required" />  <xs:attribute name="attr\_type" type="xs:unsignedByte" use="optional" />  <xs:attribute name="attr\_index" type="xs:unsignedByte" use="optional" />  <xs:attribute name="tile\_ids" type="xs:UIntVectorType" use="optional" />  </xs:complexType>  <xs:element name="gpsr" type="gpcc:spatialRegionMapType" />    <xs:complexType name="spatialRegionMapType">   <xs:element name="spatialRegion" type="gpcc:spatialRegionType" minOccurs="1"/>   </xs:complexType>  <xs:complexType name="spatialRegionType">   <xs:attribute name="id" type="xs:unsignedShort" use="required" />   <xs:attribute name="x" type="xs:int" use="optional" default="0" />   <xs:attribute name="y" type="xs:int" use="optional" default="0" />   <xs:attribute name="z" type="xs:int" use="optional" default="0" />  <xs:attribute name="dx" type="xs:int" use="required" />   <xs:attribute name="dy" type="xs:int" use="required" />   <xs:attribute name="dz" type="xs:int" use="required" />  <xs:attribute name="tileIds" type="xs:UIntVectorType" use="optional" />   </xs:complexType>  <xs:attribute name="viewport\_id" type="xs:integer" use="optional" />  <xs:element name="ViewportInfo" type=" gpcc:ViewportInfoType"/>  <!-- viewport -->  <xs:complexType name="ViewportInfoType">  <xs:attribute name="vp\_pos" type="FloatVectorType" use="required"  minLength="3" maxLength="3"/>  <xs:attribute name="vp\_quat" type="IntVectorType" use="required"  minLength="3" maxLength="3"/>  <xs:attribute name="vp\_center\_view\_flag" type="xs:boolean" use="optional"/>  <xs:attribute name="vp\_left\_view\_flag" type="xs:boolean" use="optional"/>  <xs:attribute name="viewport\_description" type="xs:string" use="optional"/>  <xs:attribute name="viewport\_type" type="xs:integer" use="optional" default="0"/>  <xs:anyAttribute processContents="skip"/>  </xs:complexType>  </xs:schema> |

*with*

|  |
| --- |
| <?xml version="1.0" encoding="UTF-8"?>  <xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"  targetNamespace="urn:mpeg:mpegI:gpcc:2022"  xmlns:gpcc="urn:mpeg:mpegI:gpcc:2022"  elementFormDefault="qualified">  <xs:attribute name="gpcId" type="xs:string" use="optional" />  <xs:attribute name="tile\_Ids" type="xs:UIntVectorType" use="required" />    <xs:element name="component" type="gpcc:gpccComponentType"/>  <xs:complexType name="gpccComponentType">  <xs:attribute name="type" type="xs:string" use="required" />  <xs:attribute name="attr\_type" type="xs:unsignedByte" use="optional" />  <xs:attribute name="attr\_index" type="xs:unsignedByte" use="optional" />  <xs:attribute name="tile\_ids" type="xs:UIntVectorType" use="optional" />  </xs:complexType>  <xs:element name="gpsr" type="gpcc:spatialRegionMapType" />    <xs:complexType name="spatialRegionMapType">   <xs:element name="spatialRegion" type="gpcc:spatialRegionType" minOccurs="1"/>   </xs:complexType>  <xs:complexType name="spatialRegionType">   <xs:attribute name="id" type="xs:unsignedShort" use="required" />   <xs:attribute name="x" type="xs:int" use="optional" default="0" />   <xs:attribute name="y" type="xs:int" use="optional" default="0" />   <xs:attribute name="z" type="xs:int" use="optional" default="0" />  <xs:attribute name="dx" type="xs:int" use="required" />   <xs:attribute name="dy" type="xs:int" use="required" />   <xs:attribute name="dz" type="xs:int" use="required" />  <xs:attribute name="tileIds" type="xs:UIntVectorType" use="optional" />   </xs:complexType>  <xs:attribute name="viewport\_id" type="xs:integer" use="optional" />  <xs:element name="ViewportInfo" type=" gpcc:ViewportInfoType"/>  <!-- viewport -->  <xs:complexType name="ViewportInfoType">  <xs:attribute name="vp\_pos" type="FloatVectorType" use="required"  minLength="3" maxLength="3"/>  <xs:attribute name="vp\_quat" type="IntVectorType" use="required"  minLength="3" maxLength="3"/>  <xs:attribute name="vp\_center\_view\_flag" type="xs:boolean" use="optional"/>  <xs:attribute name="vp\_left\_view\_flag" type="xs:boolean" use="optional"/>  <xs:attribute name="viewport\_description" type="xs:string" use="optional"/>  <xs:attribute name="viewport\_type" type="xs:integer" use="optional" default="0"/>  <xs:anyAttribute processContents="skip"/>  </xs:complexType>  </xs:schema> |

*Add the following example after clause Annex G.4*

**G.5 Temporal level indication**

An example of a DASH MPD file signaling a G-PCC content with three temporal levels encapsulated into two temporal level and component tracks, each described in a Representation is as shown below.

|  |
| --- |
| <?xml version="1.0" encoding="UTF-8"?>  <MPD   xmlns="urn:mpeg:dash:schema:mpd:2011"   xmlns:gpcc="urn:mpeg:mpegI:gpcc:2022"  type="static"  mediaPresentationDuration="PT10S"  minBufferTime="PT1S"  profiles="urn:mpeg:dash:profile:isoff-on-demand:2011">  <Period>   <!-- GPCC Geometry AdaptationSet -->   <AdaptationSet id="1" codecs="gpc1">   <Representation id="1">   <SupplementalProperty schemeIdUri="urn:mpeg:mpegI:gpcc:2022:GPCCTemporalLevelId" temporal\_level\_Ids="0 1"/>   ...  </Representation>   <Representation id="2">   <SupplementalProperty schemeIdUri="urn:mpeg:mpegI:gpcc:2022:GPCCTemporalLevelId" temporal\_level\_Ids="2"/>  ...  </Representation>  </AdaptationSet>  <!—Attribute 0 Component AdaptationSet -->  <AdaptationSet id="2" codecs="gpc1">   <EssentialProperty schemeIdUri="urn:mpeg:dash:preselection:2016" />   <EssentialProperty schemeIdUri="urn:mpeg:mpegI:gpcc:2022:component">   <gpcc:component component\_type="attr" attribute\_type="0" attr\_index="0"/>   </EssentialProperty>   <Representation id="3">  <SupplementalProperty schemeIdUri="urn:mpeg:mpegI:gpcc:2022:GPCCTemporalLevelId" temporal\_level\_Ids="0 1"/>  ...   </Representation>  <Representation id="4">   <SupplementalProperty schemeIdUri="urn:mpeg:mpegI:gpcc:2022:GPCCTemporalLevelId" temporal\_level\_Ids="2"/>  ...   </Representation>  </AdaptationSet>    <!-- Attribute 1 Component AdaptationSet -->  <AdaptationSet id="3" codecs="gpc1">   <EssentialProperty schemeIdUri="urn:mpeg:dash:preselection:2016" />   <EssentialProperty schemeIdUri="urn:mpeg:mpegI:gpcc:2022:component">   <gpcc:component component\_type="attr" attribute\_type="1" attr\_index="1"/>   </EssentialProperty>   <Representation id="5">  <SupplementalProperty schemeIdUri="urn:mpeg:mpegI:gpcc:2022:GPCCTemporalLevelId" temporal\_level\_Ids="0 1"/>  ...   </Representation>  <Representation id="6">  <SupplementalProperty schemeIdUri="urn:mpeg:mpegI:gpcc:2022:GPCCTemporalLevelId" temporal\_level\_Ids="2"/>  ...   </Representation>  </AdaptationSet>    <!-- Attribute 2 Component AdaptationSet -->  <AdaptationSet id="4" codecs="gpc1">   <EssentialProperty schemeIdUri="urn:mpeg:dash:preselection:2016" />   <EssentialProperty schemeIdUri="urn:mpeg:mpegI:gpcc:2022:component">   <gpcc:component component\_type="attr" attribute\_type="4" attr\_index="2"/>   </EssentialProperty>   <Representation id="7">  <SupplementalProperty schemeIdUri="urn:mpeg:mpegI:gpcc:2022:GPCCTemporalLevelId" temporal\_level\_Ids="0 1"/>  ...   </Representation>  <Representation id="8">  <SupplementalProperty schemeIdUri="urn:mpeg:mpegI:gpcc:2022:GPCCTemporalLevelId" temporal\_level\_Ids=”"2"/>  ...   </Representation>  </AdaptationSet>      <!—G-PCC Preselections -->   <Preselection id="1" tag="1" preselectionComponents="1 2 3 4" codecs="gpc1">   </Preselection>  </Period>  </MPD> |

# *Change 6: Carriage of changing parameter sets over time*

*Add following clause after clause 6.2.4.*

**X.X.X. G-PCC parameter set sample group**

**X.X.X.1 Definition**

Group Types: 'gpsg'  
Container: Sample Group Description Box ('sgpd')  
Mandatory: No  
Quantity: Zero or more

A G-PCC parameter set sample group entry defines the parameter set information for all the samples that refer to shared G-PCC parameter sets. When multiple instances of the SampleToGroupBox with grouping\_type equal to 'gpsg' are present, the version of all the SampleToGroupBox boxes shall be set to 1.

When sample group description and sample to group boxes with grouping\_type equal to 'gpsg' are present, the following applies:

* When a parameter set PS\_A is updated by a new occurrence of parameter set PS\_B at sample sampleX, there shall be no samples that follows sampleX, in decoding order, that refers to PS\_A.
* For a parameter set with particular parameter set type (i.e., SPS, GPS and APS) that are carried in a sample sampleX and referred to by more than one samples, it is constrained that sampleX shall be mapped in a sample to group with grouping type ‘gpsg’ and with a unique group\_type\_parameter based on the type of parameter set present in that sample.
* Any sample that does not contain parameter set or contains parameter set but of different type shall have group\_description\_index value 0.

NOTE: When doing random access from a particular sample sampleX, in the presence of parameter set sample group box, the file parser/player identifies samples, that precede the random-access starting point sampleX, that may be sampleX itself or samples that contain each of the parameter set and extract those parameter sets so that they can be included in the sampleX prior to sending it for decoding.

Multiple SampleToGroupBox with grouping\_type equal to ‘gpsg’ but with a different grouping\_type\_parameter may be present. A sample group for a specific type of parameter sets is identified using the ‘gpsg’ grouping\_type and the unique grouping\_type\_parameter value.

A SampleGroupDescriptionEntry of grouping type equal to ‘gpsg’ shall describe one of the SPS, GPS and APS. This sample group describes the samples that carry the G-PCC parameter sets required to decode samples present in that track.

When the parameter sets are changing over time, the parameter sets are carried as the below:

* When the G-PCC bitstream is carried using multiple G-PCC tracks or temporal level tracks, the parameter sets information related to the samples present in that track is signalled using the G-PCC parameter set sample group with grouping\_type equal to 'gpsg'. This sample group shall be used to group samples that contains parameter sets of the indicated type in the track. When a SampleToGroupBox with grouping\_type equal to 'gpsg' is present, an accompanying SampleGroupDescriptionBox with the same grouping type shall be present and SampleToGroupBox contains the index of the sample group description entry that the samples belong to. When multiple SampleToGroupBox are present with different grouping\_type\_parameter, each SampleGroupDescriptionEntry present in a SampleGroupDescriptionBox with grouping type 'gpsg' represent one of SPS, GPS or APS presence in the corresponding samples. For example, a SampleToGroupBox with grouping\_type equal to 'gpsg' and grouping\_type\_parameter value 2 refers to the SampleGroupDescriptionEntry entry that represent the presence of GPS in the samples.
* When the G-PCC bitstream is carried using multiple tile tracks or temporal level tile tracks, the parameter set sample group with a grouping\_type equal to 'gpsg' shall not be present in tracks with sample entry ‘gpcb’, ‘gpeb’, or ‘gpt1’.

**X.X.X.2 Syntax**

aligned(8) class GPCCParameterSetInfoEntry() extends VolumetricVisualSampleGroupEntry ('gpsg') {

unsigned int(8) parametersetType;  
}

**X.X.X.3 Semantics**

parametersetType indicates the type of the parameter set, such as SPS, GPS and APS, available in corresponding samples as indicated in Table 1.

**Table 1 Parameter set type**

|  |  |
| --- | --- |
| **Parameterset type** | **Description** |
| 0 | Reserved |
| 1 | Sequence Parameter set |
| 2 | Geometry parameter set |
| 3 | Attribute parameter set |
| 4 to 255 | Reserved |

# *Change 7: On support for random access*

*Add following clause after clause 6.6*

## **6.X. Sync sample box**

Sync sample box may be present in the following tracks:

* Track with sample entry type ‘gpeg’
* Track with sample entry type ‘gpcg’
* Track with sample entry type ‘gpeb’ or‘gpcb’

NOTE : Sync sample box is not present in track with sample entry type ‘gpe1’ and in track with sample entry type ‘gpc1’ since all samples have intra coded frame and parameter sets that are needed to decode any sample in the track are carried in sample entry.

A sync sample shall satisfy all the following conditions:

* It shall be independently decodable.
* None of the samples that come after the sync sample (in decoding order) have any decoding dependency on any sample prior to the sync sample.
* All samples that come after the sync sample (in decoding order) are successfully decodable.
* It shall contain the parameter set(s) required to decode the sample either in the sample or in the sample entry.

When it is present in the track with sample entry type ‘gpcg’, SyncSampleBox shall be present in the geometry track and the associated attribute tracks. The sync samples in the geometry track and its associated attribute tracks that are indicated in SyncSampleBox shall be aligned.

When it is present in the track with sample entry type ‘gpeb’ or‘gpcb’, then a sample that contains all the parameter sets (i.e., SPS, GPS, and APS) is indicated as a sync sample in the SyncSampleBox.

When either SyncSampleBox or parameter sets sample group boxes is not present in a track with sample entry type ‘gpeg’, gpcg’, ‘gpeb’ or‘gpcb’, the method to perform random access playback is not specified.

When temporal scalability is supported and the G-PCC bitstream is stored in multiple temporal level tracks, SyncSampleBox may be present in all the tracks.

*Add following clause after Annex E.*

**Annex XX: Player behavior when random access**

When random access from a particular sample *sampleX*, the file player performs the following steps:

1. If the sample entry of the track is ‘gpe1’ or ‘gpc1’, then file player can directly start the decoding and playback from *sampleX*. The necessary parameter sets for decoding *sampleX* and samples that follow it in decoding order are available in the sample entry of the track.
2. Otherwise, if SyncSampleBox is present and sampleX is indicated as sync sample, then file player can directly start the decoding and playback from the *sampleX*. The necessary parameter sets for decoding sampleX and samples that follow it in decoding order shall be available either in the sample entry of the track or in *sampleX*.
3. Otherwise, if parameter sets sample group boxes are present, then file player locates from information provided by the parameter sets sample group boxes the samples that contain the required parameter sets (i.e., SPS, GPS, and APS) for decoding to start from *sampleX*. The samples that contain the needed parameter sets may be *sampleX* itself or samples that precede *sampleX*. Once those samples are located, file parser extract all parameter sets in those samples and made them available for decoding / playback starting from *sampleX*.
4. Otherwise, (i.e., the track is not ‘gpe1’ or ‘gpc1’, no SyncSampleBox, and no parameter sets sample group boxes), random access from *sampleX* is not specified.

# *Change 8: On support for sub-frame timing*

*Add following clause after clause 6.2.4.*

**X.X.X. sub-frame timing sample group**

**X.X.X.1 Definition**

A sub-frame timing sample group provides sub-frame timing information. The sub-frame timing information is indicated as a time offset to the composition time of the G-PCC sample containing the sub-frame. As stated in ISO/IEC 14496-12: The composition time to sample table is optional and shall only be present if DT and CT differ for any samples. Then, when the track containing this sample group has no CompositionOffsetBox, the composition time of the G-PCC sample corresponds to the decoding time of this sample. The composition times for G-PCC sub-frames contained in a G-PCC sample is derived after the composition time of the containing G-PCC sample is resolved.

* When the difference between sub-frame time offsets are constant (constant\_time\_offset\_delta equals 1) for a group of G-PCC samples, the time offset of the i-th G-PCC sub-frame in a sample is equal to subframe\_time\_offset\_delta \* *i* and the composition timestamp of the i-th G-PCC sub-frame in a sample is computed as CTS[i] = CT + subframe\_time\_offset\_delta \* i, where CT is the composition time of the sample containing the G-PCC sub-frame and i is varying from 0 to subframe\_count – 1, included.
* When the difference between sub-frame time offsets are not constant (constant\_time\_offset\_delta equals 0) for a group of G-PCC samples, the time offset of the i-th G-PCC sub-frame in a sample is equal to subframe\_time\_offset[i] and the composition timestamp of the i-th G-PCC sub-frame in a sample is computed as CTS[i] = CT + subframe\_time\_offset[i], where CT is the composition time of the sample containing the sub-frame and i is varying from 0 to subframe\_count – 1, included.

The loop on subframe\_time\_offset[i] is implicitly ordered in the order of sub-frames present in the samples mapped to this entry with increasing frame index or frame number attribute values.

When a G-PCC bitstream contains sub-frames, i.e. frame number or frame index attribute, the following constraints are applied:

* For single track multiplexed encapsulation, when the G-PCC bitstream is carried using G-PCC tracks with ‘gpe1’ or ‘gpeg’ sample entry type, the subframe timing sample group may be present in the G-PCC bitstream track.
* For multi-track non-multiplexed encapsulation, when the G-PCC bitstream is carried in multiple G-PCC tracks with 'gpc1' or 'gpcg' sample entry type, the subframe timing sample group may be present only in the G-PCC attribute track carrying the frame number or frame index attribute data units. The subframe timing sample group shall not be present in G-PCC geometry track or G-PCC attribute track which does not carry the frame number or frame index attribute data units.
* For encapsulation with G-PCC tile tracks, the sub-frame timing sample group may be present only in the G-PCC tile track ('gpt1') carrying all components or in G-PCC attribute tile track carrying the frame number or frame index attribute data units. The subframe timing sample group shall not be present in a tile base track with a sample entry type 'gpcb' or 'gpeb'. The subframe timing sample group shall not be present in the following G-PCC tile tracks.
  + G-PCC tile track carrying all components which are not comprised of the frame number or frame index attribute data units
  + G-PCC geometry tile track,
  + G-PCC attribute tile track which are not comprised of frame number or frame index attribute data units
* The sub-frame timing sample group may be present in temporal level tracks or temporal level tile tracks with the same constraints as for single track or multi-track encapsulations described in this clause.

NOTE : The sub-frame timing sample group, when present, allows file readers to access to precise timing information (e.g. corresponding to a capture time by a 3D sensor). When the G-PCC bitstream contains the frame number attribute data units potentially leading to sub-frame reordering across samples, the subframe timing sample group may be present in the appropriate G-PCC tracks to help file readers in reordering the sub-frames.

**X.X.X.2 Syntax**

aligned(8) class SubFrameTimingGroupEntry ()   
extends VolumetricVisualSampleGroupEntry ('sfcf') {

unsigned int (1) constant\_time\_offset\_delta;   
 unsigned int (7) reserved;   
 unsigned int(32) subframe\_count;  
 if (constant\_time\_offset\_delta == 1) {  
 unsigned int(32) subframe\_time\_offset\_delta;   
 }  
 else {   
 for (int i=0; i < subframe\_count; i++) {   
 signed int(32) subframe\_time\_offset[i];   
 }  
 }  
}

**X.X.X.3 Semantics**

constant\_time\_offset\_delta indicates whether all G-PCC sub-frames contained in the G-PCC samples mapped to this entry have a constant time offset delta with the previous G-PCC sub-frame in the increasing order of their frame index or frame number attribute values. Value 1 indicates that the time offset delta is constant. Value 0 indicates that the time offset delta may not be constant.

subframe\_count is an unsigned integer that counts the number of G-PCC sub-frames in the G-PCC samples mapped to this entry. The value 0 is reserved.

subframe\_time\_offset\_delta is an unsigned integer that gives the difference, in the timescale of the media, between composition timestamps of two successive G-PCC sub-frames present in a G-PCC sample mapped to this entry.

subframe\_time\_offset[i] is a signed integer that indicates the time offset of the i-th G-PCC sub-frame present in the G-PCC samples mapped to this entry, in the timescale of the media. This time offset is relative to the composition timestamp of the sample containing the sub-frame.