**INTERNATIONAL ORGANISATION FOR STANDARDISATION**

**ORGANISATION INTERNATIONALE DE NORMALISATION**

**ISO/IEC JTC1/SC29/WG11**

**CODING OF MOVING PICTURES AND AUDIO**

**ISO/IEC JTC1/SC29/WG11 m54464**

**June-July 2020, Electronic Meeting**

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| **Source** | **InterDigital Communications, Inc.** |
| **Status** | **Input** |
| **Title** | **[PCC Systems] On DASH Signalling of G-PCC Tiles and 3D Spatial Regions** |
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| **Agenda** | 37.1 |

# Introduction

The 3DG workgroup in MPEG is currently working on developing a standard for geometry-based point cloud compression with a draft international standard (DIS) version released in the MPEG#129 meeting [1]. In parallel, MPEG is also developing a Systems standard for carriage of geometry-based point cloud data (ISO/IEC 23090-18) [2]. One important aspect that is still missing in the latest working draft is MPEG-DASH signalling of G-PCC media to support adaptive streaming.

In the latest draft of the G-PCC specification, a G-PCC tile is defined as a group of slices which is an independently decodable cuboid with bounding box information. A slice is defined as a set of points that can be encoded or decoded independently.

In this contribution, we propose a number of new DASH descriptors for signaling G-PCC tiles and 3D spatial regions to support partial access. This contribution is related to, and an extension of, the DASH signalling proposed in m54463 [3].

# Proposed Solution

## Signaling of G-PCC Tiles

Each G-PCC tile may be represented in the DASH manifest (MPD) file as a separate Adaptation Set with the Main Adaptation Set serving as the main access point for the G-PCC content.

### GPCCTileInventory Descriptor

G-PCC tiles may either all be carried in a single coded stream or each tile may be coded in its own stream. When multiple tiles in a geometry-based point cloud are present, the tiles’ bounding box information shall be signaled using a **GPCCTileInventory** descriptor. This descriptor is a **SupplementalProperty** element with a @schemeIdUri attribute equal to "urn:mpeg:mpegI:gpcc:2020:gptl". A **GPCCTileInventory** descriptor shall be present at the adaptation set level of the Main Adaptation Set of the G-PCC content.

The elements and the attributes of the GPCCTileInventory descriptor are shown in Table 1.

Table 1 Elements and attributes for the GPCCTileInventory descriptor

|  |  |  |  |
| --- | --- | --- | --- |
| **Elements and Attributes for GPCCTileInventory descriptor** | **Use** | **Data type** | **Description** |
| **gptl** | 0..1 | gpcc:tileInventory | Container element whose attributes and elements specify the information of GPCC tiles. |
| **gptl.tile** | 1..N | gpcc:tileInfo | An element whose attributes define a tile and provide the information of the G-PCC tiles. |
| **gptl.tile**@tile\_id | M | xs:string | Indicates the unique id of the gpcc tile.  The value of @tile\_id shall be identical to that of the tile\_id field for one of the tiles in tile\_inventory()defined in [1], or identical to the inferred value of the tile id based on the index of the tile in the tile inventory. |
| **gptl.tile**@x\_offset | M | xs:int | The x offset of the tile bounding box. Same as tile\_bounding\_box\_offset\_x in tile\_inventory defined in ISO/IEC 23090-9 |
| **gptl.tile**@y\_offset | M | xs:int | The y offset of the tile bounding box. Same as tile\_bounding\_box\_offset\_x in tile\_inventory defined in ISO/IEC 23090-9 |
| **gptl.tile**@z\_offset | M | xs:int | The z offset of the tile bounding box. Same as tile\_bounding\_box\_offset\_y in tile\_inventory defined in ISO/IEC 23090-9 |
| **gptl.tile**@width | M | xs:int | Width of the tile bounding box. Same as tile\_bouding\_box\_size\_width in tile\_inventory defined in ISO/IEC 23090-9 |
| **gptl.tile**@height | M | xs:int | Height of the tile bounding box. Same as tile\_bouding\_box\_size\_height in tile\_inventory defined in ISO/IEC 23090-9 |
| **gptl.tile**@depth | M | xs:int | Depth of the tile bounding box. Same as tile\_bouding\_box\_size\_depth in tile\_inventory defined in ISO/IEC 23090-9 |
| **gptl.tile**@asIds | CM | StringVectorType | A list of space separated identifiers corresponding to the values of the @id attribute for Component Adaptation Sets associated with the tile.  This attribute shall be absent in the case of single-track encapsulation of the GPCC content. |
| Legend:  For attributes: M=Mandatory, O=Optional, OD=Optional with Default Value, CM=Conditionally Mandatory.  For elements: <minOccurs>..<maxOccurs> (N=unbounded)  Elements are bold; attributes are non-bold and preceded with an @. | | | |

The data types for the various elements and attributes of the **GPCCTileInventory** descriptor shall be as defined in the following XML schema.

<?xml version="1.0" encoding="UTF-8"?>   
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"   
 targetNamespace="urn:mpeg:mpegI:gpcc:2020"   
 xmlns:gpcc="urn:mpeg:mpegI:gpcc:2020"   
 elementFormDefault="qualified">   
  
 <xs:element name="gptl" type="gpcc:tileInventory" />   
  
 <xs:complexType name=" tileInventory">   
 <xs:element name="tile" type="gpcc:tileinfo" minOccurs="1"/>   
 </xs:complexType>   
  
 <xs:complexType name="tileInfo">   
 <xs:attribute name="tile\_id" type="xs:string" use="required" />   
 <xs:attribute name="x\_offset" type="xs:int" use="required" />   
 <xs:attribute name="y\_offset" type="xs:int" use="required" />   
 <xs:attribute name="z\_offset" type="xs:int" use="required" />   
 <xs:attribute name="width" type="xs:int" use="required" />   
 <xs:attribute name="height" type="xs:int" use="required" />   
 <xs:attribute name="depth" type="xs:int" use="required" />   
 </xs:complexType>   
  
</xs:schema>

### GPCCTileID descriptor

A **SupplementalProperty** element with a @schemeIdUri attribute equal to "urn:mpeg:mpegI:gpcc:2020:tileID" referred as **GPCCTileId** descriptor can be used to distinguish between different G-PCC tile streams. At most one **GPCCTileId** descriptor may be present at the adaptation set level for a G-PCC tile Adaptation Set or a G-PCC Component Adaptation Set (when there is more than one Component Adaptation Set for each tile).

The **GPCCTileId** descriptor shall include the attributes defined in Table 2.

Table 2 Attributes for the GPCCTileID descriptor

|  |  |  |  |
| --- | --- | --- | --- |
| **Attributes for GPCCTileId descriptor** | **Use** | **Data type** | **Description** |
| @tile\_Id | M | xs:int | Indicates the unique id of the G-PCC tile.  The value of @tile\_id shall be identical to that of the tile\_id field for one of the tiles in tile\_inventory()defined in [1], or identical to the inferred value of the tile id based on the index of the tile in the tile inventory. |
| Legend:  For attributes: M=Mandatory, O=Optional, OD=Optional with Default Value, CM=Conditionally Mandatory.  For elements: <minOccurs>..<maxOccurs> (N=unbounded)  Elements are **bold**; attributes are non-bold and preceded with an @. | | | |

## Signaling of Static Spatial Regions

If the 3D spatial regions in the geometry point cloud are static (i.e., the position and dimensions of each region do not change over the presentation time), the characteristics of the spatial regions and the mappings between those regions and GPCC tiles shall be signaled using a **GPCC3DRegions** descriptor. This descriptor is a **SupplementalProperty** element with a @schemeIdUri attribute equal to "urn:mpeg:mpegI:gpcc:2020:gpsr". A single **GPCC3DRegions** descriptor shall be present at the adaptation set level or the representation level in the main GPCC track, or at the preselection level for the geometry based volumetric media content. The mapping of the 3D region Id and the respective 3D region component streams is signaled using @asIds attribute of the **GPCC3DRegions** descriptor. The mapping of the 3D region Id and the respective G-PCC tile component streams is signaled using @asIds attribute of the GPCC3DRegions descriptor.

The GPCC3DRegions descriptor shall include elements and attributes as specified in Table 3.

Table Elements and attributes for the GPCC3DRegions descriptor

|  |  |  |  |
| --- | --- | --- | --- |
| **Elements and attributes for GPCC3DRegions descriptor** | **Use** | **Data type** | **Description** |
| **gpsr** | 0..1 | gpcc:spatialRegionMapType | Container element whose attributes and elements specify a mapping between a 3D spatial region and GPCC tiles. |
| **gpsr.spatialRegion** | 1..N | gpcc:spatialRegionType | An element whose attributes define a 3D spatial region and provide a mapping between the defined region and a number of GPCC tiles. |
| **gpsr.spatialRegion**@id | M | xs:unsignedShort | An identifier for the 3D spatial region.  The value of this attribute shall match the value of the 3d\_region\_id field signaled for the corresponding region in the ISOBMFF container. |
| **gspr.spatialRegion**@type | OD | xs:unsignedByte | An attribute whose value indicates the type of the spatial region. Value 0 indicates a cuboid region. The remaining values are reserved.  If not present, the default value is 0. |
| **gpsr.spatialRegion**@x | M | xs:int | The x-coordinate of the reference point for the bounding box defining the spatial region. |
| **gpsr.spatialRegion**@y | M | xs:int | The y-coordinate of the reference point for the bounding box defining the spatial region. |
| **gpsr.spatialRegion**@z | M | xs:int | The z-coordinate of the reference point for the bounding box defining the spatial region. |
| **gpsr.spatialRegion.cuboid** | CM | gpcc:spatialRegionCuboidType | An element specifying a cuboid extending from the reference point of the spatial region. This element shall be present only when the **spatialRegion**@type attribute is set to 0. |
| **gpsr.spatialRegion.cuboid**@dx | M | xs:int | The length of the bounding box along the x-axis (i.e., width). Negative values indicate a length that extends in the negative direction of the axis. |
| **gpsr.spatialRegion.cuboid**@dy | M | xs:int | The length of the bounding box along the y-axis (i.e., height). Negative values indicate a length that extends in the negative direction of the axis. |
| **gpsr.spatialRegion.cuboid**@dz | M | xs:int | The length of the bounding box along the z-axis (i.e., depth). Negative values indicate a length that extends in the negative direction of the axis. |
| **gspr.spatialRegion**@tileIds | CM | StringVectorType | A list of space separated identifiers corresponding to the @tile\_id attribute value of each G-PCC tile in tile inventory descriptor.  This attribute shall be absent if GPCC components are stored as a single-track. |
| **gpsr.spatialRegion**@asIds | CM | StringVectorType | A list of space separated identifiers corresponding to the values of the @id attribute for **AdaptationSet**s and/or **Representation**s mapped to this region.  This attribute shall be absent in the case of single-track encapsulation of the GPCC content. |
| Legend:  For attributes: M=Mandatory, O=Optional, OD=Optional with Default Value, CM=Conditionally Mandatory.  For elements: <minOccurs>..<maxOccurs> (N=unbounded)  Elements are **bold**; attributes are non-bold and preceded with an @. | | | |

## Signaling of dynamic Spatial Regions

When the 3D partitions are dynamic, a timed-metadata track for signaling the position and dimensions of each 3D region in the presentation timeline shall be carried in a separate Adaptation Set with a single Representation and associated (linked) with the Representations of the Main Adaptation Set using the @associationId attribute, defined in ISO/IEC 23009-1 ‎[2], with a @associationType value that includes the 4CC ‘gpdr’ for the corresponding Adaptation Set or Representation.

# Recommendation

We recommend the proposed DASH signaling methods for streaming of G-PCC tile and 3D spatial region content using partial access methods be included in the Carriage of G-PCC data specification (ISO/IEC 23090-18).

# References

1. N19328, “G-PCC Future Enhancements”, MPEG 130, April 2020
2. N19286, “WD of ISO/IEC 23090-18 Carriage of G-PCC Data”, MPEG 130, April 2020
3. m54463, “MPEG DASH Signalling for Streaming of G-PCC”, MPEG 131, June-July 2020
4. N18312, “Revised text of ISO/IEC FDIS 23009-1 3rd edition”, MPEG 125, January 2019