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SERIES H: AUDIOVISUAL AND MULTIMEDIA SYSTEMS

Infrastructure of audiovisual services – Telepresence, immersive environments, virtual and extended reality

Service configuration, media transport protocols, signalling information of MPEG media transport for immersive live experience (ILE) systems

Recommendation ITU-T H.430.4

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Recommendation ITU-T H.430.4

Service configuration, media transport protocols, signalling information of MPEG media transport for immersive live experience (ILE) systems

Summary

Recommendation ITU-T H.430.4 identifies service configuration, media transport protocol and signalling information of MPEG media transport (MMT) for immersive live experience (ILE) systems, in order to provide ILE services.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T H.430.4	2019-11-29	16	11.1002/1000/14108

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Descriptor, immersive live experience, media transport, MPEG media transport, service configuration, XML syntax.

* 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.

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Service configuration, media transport protocols, signalling information of MPEG media transport for immersive live experience (ILE) systems

1 Scope

Immersive live experience (ILE) systems consist of several devices such as cameras, displays and transmission networks from the source site to viewing sites, as described in [ITU-T H.430.1]. Synchronous signalling transmission including video and audio were studied in ISO/IEC JTC1/SC29/WG11 (MPEG), and MPEG media transport (MMT) [ISO/IEC 23008-1] is a well-suited approach for transporting synchronously several media from event sites to remote sites on ILE systems. However, MMT might not consider transporting spatial information, such as the X-Y-Z coordinate of objects, and stage effect information such as lighting. In order to utilize MMT for ILE systems, it needs to clarify the ILE profile of the MMT, which includes some constraints of the MMT specification, for example, usage of optional attributes.

This Recommendation identifies service configuration, system structure, media transport protocol and signalling information for immersive live experience (ILE) systems using MPEG media transport [ISO/IEC 23008-1] and specifies constraints to ISO/IEC 23008-1 for use in ILE systems.

The scope of this Recommendation includes:

– service configuration and system structure for MMT-based ILE systems

– media transport protocol for MMT-based ILE systems

– signalling information for MMT-based ILE systems.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T H.265] Recommendation ITU-T H.265 | ISO/IEC 23008-2 (2019), *High efficiency video coding*.

[ITU-T H.430.1] Recommendation ITU-T H.430.1 (2018), *Requirements for immersive live experience (ILE) services*.

[ITU-R BT.2074-1] Recommendation ITU-R BT.2074-1 (2017), *Service configuration, media transport protocol, and signalling information for MMT-based broadcasting systems*.

[ISO/IEC 14496-3] ISO/IEC 14496-3:2019, *Coding of audio-visual objects – Part 3: Audio*.

[ISO/IEC 14496-12] ISO/IEC 14496-12:2015, *Coding of audio-visual objects – Part 12: ISO base media file format*.

[ISO/IEC 23008-1] ISO/IEC 23008-1:2017, *Information technology – High efficiency coding and media delivery in heterogeneous environments – Part 1: MPEG Media Transport (MMT)*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following term defined elsewhere:

3.1.1 immersive live experience (ILE) [ITU-T H.430.1]: A shared viewing experience that stimulates emotions within audiences at both the event site and the remote sites, as if the audience at the remote sites had wandered into a substantial event venue and had actually watched the events taking place in front of them. This impression is due to high-realistic sensations provided by a combination of multimedia technologies such as sensorial information acquisition, media processing, media transport, media synchronization and media presentation.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AAC MPEG-4 Advanced Audio Coding

ALS MPEG-4 Audio Lossless Coding

cc closed caption

DMX Digital Multiplex

HEVC High Efficiency Video Coding

ILE Immersive Live Experience

MFU Media Fragmentation Unit

MMT MPEG Media Transport

MMTP MMT Protocol

MMT-SI MMT Signalling Information

MPI Media Presentation Information

MPT MMT Package Table

MPU Media Processing Units

NAL Network Abstraction Layer

PA Package Access

PI Presentation Information

UTC Coordinated Universal Time

5 Conventions

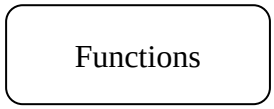
In this Recommendation:

– The keywords "is required to" indicate a requirement which must be strictly followed and from which no deviation is permitted, if conformance to this Recommendation is to be claimed.

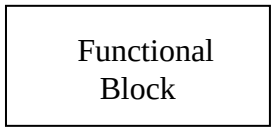
– The keywords "is recommended" indicate a requirement which is recommended but which is not absolutely required. Thus, this requirement need not be present to claim conformance.

– The keywords "can optionally" indicate an optional requirement that is permissible, without implying any sense of being recommended. This term is not intended to imply that the vendor's implementation must provide the option, and the feature can be optionally enabled by the network operator/service provider. Rather, it means the vendor may optionally provide the feature and still claim conformance with this Recommendation.

– The keyword "functions" are defined as a collection of functionalities. It is represented by the following symbol in this Recommendation:



– The keyword "functional block" is defined as a group of functionalities that has not been further subdivided at the level of detail described in this Recommendation. It is represented by the following symbol in this Recommendation:



NOTE – In the future, other groups or other Recommendations may possibly further subdivide these functional blocks.

Frame borders of "functions" and "functional block", and relational lines between "functions" and "functional block" are drawn with solid lines or dashed lines. The solid lines mean required functionalities or relations. On the other hand, the dashed lines mean optional functionalities or relations.

6 Requirements to MMT for ILE services

Most users want to watch sports games in real time and with high-realistic sensations. Real-time content delivery or live video streaming usually require time synchronization between transmitted video and audio. For displaying pseudo-3D objects, time synchronization between the spatial information and the displayed objects is also required. One of the key features on ILE services is live experience which can be realized through the synchronization of multiple media, such as video, audio and spatial data stream of objects, video and audio streams of background, and other stage effect information.

In order to synchronize and transport video and audio combined with spatial information, MMT, an optimized protocol for media synchronization, can be utilized with MMT assets, describing the specific signalling information of the objects such as their three-dimensional size, position and direction. This technology makes it possible to correlate the physical spatial parameters such as the size and position of the display device with asset data (frame pixel data) so that the space can be reconstructed with high realism at the destination at the intended size. In addition, transmission of the digital multiplex (DMX) [b-DMX] signals, which are commonly used in production to control stage lighting and audio devices, as one of the MMT assets enables realistic presentations that accurately synchronize remote stage equipment with the media.

MMT is defined in [ISO/IEC 23008-1] (MPEG media transport) for streaming information, and it is one of the major technologies for synchronous media transport. In order to utilize MMT for ILE services, constraints to [ISO/IEC 23008-1] for ILE systems need to be specified since MMT was designed for transporting multiple media synchronously and MMT does not focus on transmitting the information required for ILE systems such as spatial information and stage effect information.

7 Service configuration and system structure of ILE

7.1 Service configuration of ILE

[ISO/IEC 23008-1] specifies the MMT package as a logical structure of content. The MMT package includes presentation information (PI) and associated assets that constitute content. For broadcasting services, [ITU-R BT.2074-1] provides service configuration, media transport protocol and signalling information for MMT-based broadcasting systems. Because ILE services are not broadcasting services [ITU-R BT.2074-1] could not be utilized for ILE services as it is. For providing ILE services, various kinds of information collected from source sites, such as video stream data shot by multiple cameras, audio data collected by multiple microphones, the location information of objects and stage effect information including lighting control, need to be synchronously transmitted to one or more viewing sites, and reconstructed at the viewing sites.

In [ISO/IEC 23008-1] an asset is defined as a media component. An asset is equivalent to a series of media processing units (MPUs). In ILE systems, one entertainment programme is an MMT package including one or more assets and signalling information. A package access (PA) message is an MMT signalling information (MMT-SI), and the MMT package table (MPT) carried in the PA message identifies assets constituting the ILE programme.

7.2 System structure

This section describes the general structure of MMT-based ILE systems. Figure 7-1 shows the protocol stack of MMT for ILE services based on the protocol stack for broadcasting services written in [ITU-R BT.2074-1].

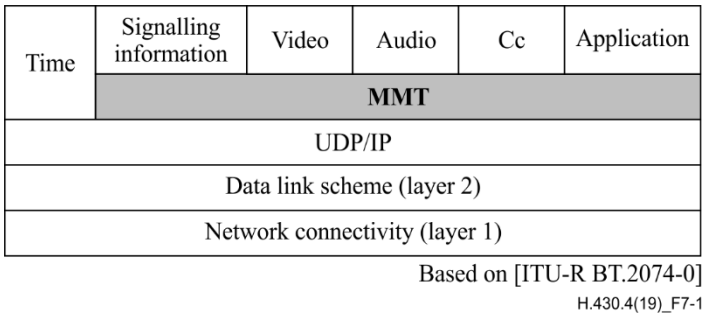


Figure 7-1 – Protocol stack of MMT for ILE services

In ILE systems, most features of MMT-based broadcasting systems could be utilized. Media components, such as video, audio, closed caption (cc) and stage effects including lighting, are encapsulated into media fragment units (MFUs)/ MPUs. They are carried as MMT payloads in IP packets.

The systems also have MMT-SI. MMT-SI is signalling information on the structure of an event program. MMT-SI is carried in MMT payloads in MMTP packets over IP.

In order for the receiver terminals to synchronize with the event venue, time information in Coordinated Universal Time (UTC) is also delivered in IP packets.

7.3 Spatial information

One of the most important information which realizes immersion is spatial information, such as the spatial location of objects. Because the screen sizes of viewing sites differ, it is necessary to provide information which can be used for adjusting the projection parameters to the presentation environment at each viewing site.

In order to reconstruct the atmosphere of the source site at the viewing sites, the spatial information at the source site needs to be transferred. The information can be transferred either by sending the size and location of the screens, speakers and other objects one by one, or simply by using reference space.

Reference space provides an easier way to describe the spatial information at the source site in a normalized format, which can be in turn accessed in order to adjust to the actual environment at the viewing sites. The reference space is shown in Figure 7-2.

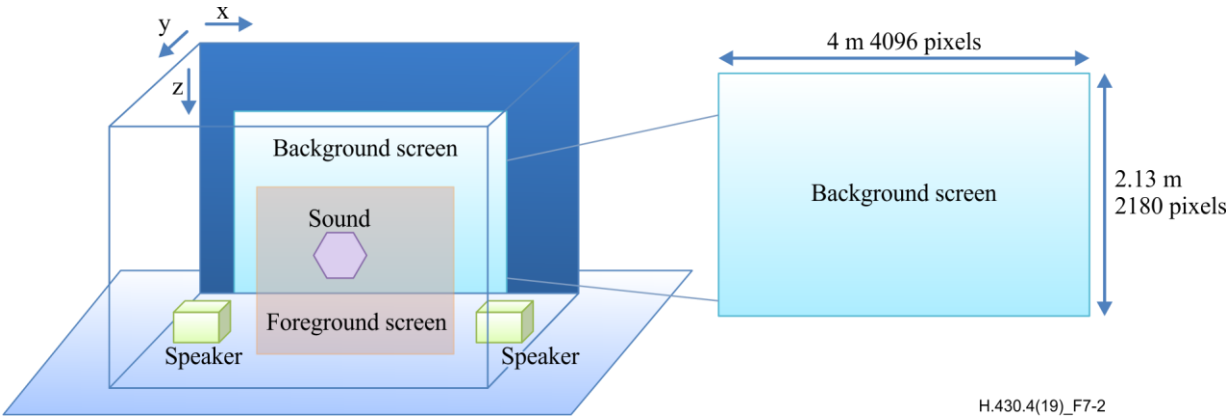


Figure 7-2 – Example of reference space describing the location and size of equipment

This kind of information could be transferred from the source site to the viewing sites by utilizing MMT [ISO/IEC 23008-1].

7.4 Lighting information

Most lighting devices can be controlled by DMX (Digital multiplex: DMX512 referred to by ANSI standard USITT DMX512-A) [b-DMX], and there exists lighting devices which can be controlled by Art-Net (the specification of transporting DMX signals over UDP/IP) [b-Art-Net]. Art-Net may be highly compatible with MMT in terms of transmission over IP networks. This subclause describes the way to encapsulate Art-Net by MMT.

When using DMX-capable devices, DMX signals are converted to Art-Net signals bilaterally, and the devices are connected to each other. The lighting information to be transferred to viewing sites is recommended to be treated as follows:

- At the event site:
  - converting DMX signals into Art-Net packets by using convertors;
  - receiving Art-Net packets by MMT servers;
  - creating MPU from Art-Net packets (or storing Art-Net packets into MPU), and creating MMT packets;
  - setting play time into MPU time stamp descriptors;
  - transferring MMT packets as MPU mode.
- At the viewing sites:
  - reconstructing Art-Net packets from MMT packets;
  - playing Art-Net packet at designated time according to MPU time stamps;
  - controlling devices which are not capable Art-Net by DMX signals that are converted by convertors.

8 Media transport protocols for ILE system

8.1 Encapsulation of multimedia data

In order to improve the interoperability of MMT-based ILE systems, the following constraint applies to the carriage of multimedia data in MMT protocol (MMTP) packets.

8.1.1 MFU format for video and audio streams

[ISO/IEC 23008-1] specifies an encapsulation format, but there are some variations of the MFU format.

When a high efficiency video coding (HEVC) stream is transported in the MMTP, a network abstraction layer (NAL) unit is encapsulated into an MFU of the MMTP. If an HEVC encoder generates the byte stream format specified in Annex B of [ITU-T H.265], one start code prefix (0x000001) followed by one NAL unit is replaced with 4 bytes length information of the NAL unit (unsigned integer format). Each box defined in [ISO/IEC 14496-12] is selectively carried in the MMT stream.

When an MPEG-4 advanced audio coding (AAC) stream or MPEG-4 audio lossless coding (ALS) stream is carried in the MMT protocol, one AudioMuxElement () specified in [ISO/IEC 14496-3] is encapsulated into an MFU of the MMTP for the AAC stream and, a raw data stream is encapsulated into an MFU of the MMTP for the ALS stream.

9 Signalling information for ILE system

[ISO/IEC 23008-1] specifies signalling information to handle encapsulated asset data in MMTP packets. However, these descriptors have a lot of flexibility. In order to handle assets including spatial information for realizing ILE services and for ensuring interoperability of MMT-based ILE systems, the following constraints are applied to the signalling information for media descriptors.

9.1 Environment descriptor

For displaying objects at viewing sites of ILE services, a presentation information (PI) content in media presentation information (MPI) tables is required to carry the spatial environment information. The syntax of the environment descriptor is provided in Table 9-1, and the XML syntax sample of the environment descriptor is shown in Table 9-2.

As one media descriptor, the syntax of environment descriptor contains environmental information such as site and equipment information to reconstruct images at viewing sites. The information will be processed by media processing functions.

Table 9-1 – Syntax of environment descriptor

Name	Data	Form
environment		
@xmlns	Default	String
site	Site information	
@id	Site identification	String
@width	Width of site	decimal
@height	Height of site	decimal
@depth	Depth of site	decimal
@unit	Unit of size	string
equipments	Equipment info	
equipment	Equipment	
@id	Identification	string
@type	Type of equipment	string
position	Position	
location	XYZ location	
@x	x axis	decimal
@y	y axis	decimal
@z	z axis	decimal
@unit	Unit of location	String
rotation	Rotation information	
@x	Roll	Decimal
@y	Pitch	Decimal
@z	Yaw	Decimal
@unit	Unit of rotation	String
size	Size information	
@width	Width	Decimal
@height	Height	Decimal
@depth	Depth	Decimal
@unit	Unit of size	String
offset	Offset	
@left	Left offset	Decimal
@right	Right offset	Decimal
@top	Top offset	Decimal
@bottom	Bottom offset	Decimal
@unit	Unit of offset	String

Table 9-2 – XML Syntax sample of environment descriptor

```
<?xml version="1.0" encoding="UTF-8"?>
<environment xmlns="http://xxx.yyy.zz/mmt/artnet">
  <!—Environment information  -->
  <site id="main" width="1000" height="1500" depth="10000" unit="mm"/>

  <!—Equipments information -->
  <equipments>
    <equipment id="screen 1" type="screen">
      <position>
        <location x="10" y="20" z="130" unit="mm"/>
        <rotation x="10" y="20" z="30" unit="deg"/>
      </position>
      <size width="200" height="100" depth="1" unit="mm">
        <offset left="10" right="10" top="10" bottom="20" unit="mm"/>
      </size>
    </equipment>
    <equipment id="light" type="lighting">
      <position>
        <location x="110" y="120" z="1130" unit="mm"/>
        <rotation x="45" y="90" z="70" unit="deg"/>
      </position>
      <size width="1000" height="1000" depth="1000" unit="mm"/>
    </equipment>
  </equipments>
</environment>
```

9.2 Object recognition and location descriptor

In order to achieve auditory lateralization on large-sized screens at viewing sites of ILE services, it could use wave field synthesis. Object recognition information and location information should be transferred from the source site to viewing sites, so that audio from the object could be homologized to the displayed objects at the viewing sites. In addition, the objects displayed at viewing sites could be optimized to the different display facilities by using the object recognition and location information. An object recognition and location descriptor is transferred on MMT. In most cases, objects move around in the source site, so location information of the objects should be captured in each frame. In other words, object recognition and location information are necessary to reproduce the event at viewing sites.

As one of the media descriptors, the syntax of object recognition and location descriptor contains spatial information of objects to reconstruct audio direction aligned with the displayed image of objects at the viewing sites. The information will be processed by media processing functions.

ILE has several viewing styles, and one of the typical ILE services is amphitheatre (arena style) viewing, which enables all audiences to share one stage from all directions. This kind of omnidirectional viewing style needs special information such as the X-Y-Z coordinate of moving objects in addition to background information for displaying objects.

Objects are moving around in the arena at the event site, so it is required to reconstruct the actual trajectory of the moving objects. For this purpose, the ILE system needs to transport tracking information through MMT. The tracking information is used to specify the sound source and associate it with the object profiles. In order to reconstruct 3D images in omnidirectional display, some other data is also required, such as distance of objects sensed by laser.

The data schema of moving objects, which is transferred on MMT, is shown in Figure 9-1.

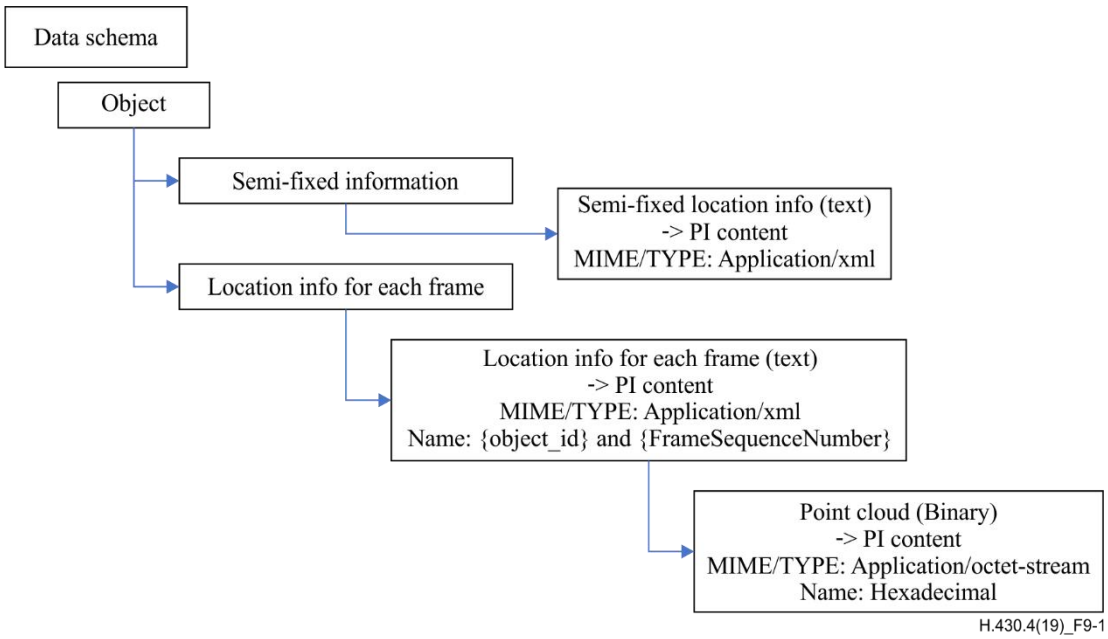


Figure 9-1 – Data schema of moving objects

Object information in each frame consists of object label, location information in the global coordinates, location information in the local coordinates, and location information in the image coordinates. The syntax of location information includes centre of mass, rectangle and point cloud. Camera ID is used to identify the camera which captured images, and the direction of the shooting angle.

The syntax of location_data and XML syntax sample are shown in Tables 9-3 and 9-4. The data schema in Figure 9-1 has "Point cloud" for future development, whose syntax is not elaborated on this document.

Table 9-3 – Syntax of location_data

Name	Data	Form	Repetition
location_data	Three-dimensional location information of each object		1
timecode	Time at which location info is consumed, which is denoted by UTC for time synchronization between objects	String	1
object	Name of the target object	String	0..*
label	The label of target object, which can be used for object identification	String	0..*
global_locations	Location of the object in the world coordinates		0..1
center_point	Centre of mass of the object		0..1
point	Position of the centre of mass		1
x	X-coordinate	decimal	1
y	Y-coordinate	decimal	1
z	Z-coordinate	decimal	1
unit	Unit of the coordinates	String	1
rectangle	Rectangle covering the target object		0..1
point	Dimensions of the rectangle		2
x	X-coordinate (width)	decimal	1
y	Y-coordinate (height)	decimal	1
z	Z-coordinate (depth)	decimal	1
unit	Unit of the coordinate	String	1
local_locations	Location information in the local coordinate system		0..1
center_point	Centre of mass		0..*
camera_id	ID of camera	decimal	1
point	3D coordinates		1
x	X-coordinate (width)	decimal	1
y	Y-coordinate (height)	decimal	1
z	Z-coordinate (depth)	decimal	1
unit	Unit of the coordinates	String	1
rectangle	Rectangle covering the target object		0..*
camera_id	ID of camera	decimal	1
point	3D coordinates		2
x	X-coordinate (width)	decimal	1
y	Y-coordinate (height)	decimal	1
z	Z-coordinate (depth)	decimal	1
unit	Unit of the coordinates	String	1
image_locations	Location information in the image coordinate system		0..1
rectangle	Rectangle covering the target object		0..*
camera_id	ID of camera	decimal	1
w	Width	decimal	1
h	Height	decimal	1
point	2D coordinates		2
x	X-coordinate (width)	decimal	1
y	Y-coordinate (height)	decimal	1
unit	Unit of the coordinates	String	1

Table 9-4 – XML syntax sample of location_data

```
<?xml version="1.0" encoding="UTF-8" ?>
     <location_data>
          <timecode>DF9F7CB944EF4217</timecode>
          <object>
               <label>Object0</label>
               <local_locations>
                    <center_point>
                         <camera_id>VC002</camera_id>
                         <point>
                          <x>392</x>
                          <y>129</y>
                          <z>6405</z>
                          <unit>mm</unit>
                          </point>
                    </center_point>
                    <rectangle>
                         <camera_id>VC002</camera_id>
                         <point>
                          <x>523</x>
                          <y>456</y>
                          <z>6331</z>
                          <unit>mm</unit>
                          </point>
                         <point>
                          <x>262</x>
                          <y>-197</y>
                          <z>6480</z>
                          <unit>mm</unit>
                          </point>
                    </rectangle>
               </local_locations>
               <image_locations>
                    <rectangle>
                         <camera_id>VC002</camera_id>
                         <w>1920</w>
                         <h>1080</h>
                         <point>
                          <x>2176</x>
                          <y>1349</y>
                          <unit>pixel</unit>
                          </point>
                         <point>
                          <x>2037</x>
                          <y>969</y>
                          <unit>pixel</unit>
                          </point>
                    </rectangle>
               </image_locations>
          </object>
     </location_data>
```

The semi-fixed information periodic_data contains the size of the event venue, object profile information and camera information. The syntax of the periodic_data, which is stored separately in the PI content of the MPI table, is shown in Table 9-5.

Table 9-5 – Syntax of periodic_data

Name	Data		Repetition
periodic_data	Semi-fixed location information		1
Site	Venue information		1
Width	Width	decimal	1
Height	Height	decimal	1
Depth	Depth	decimal	1
Unit	Unit	String	1
Object	Object		1..*
Label	Object label	decimal	1
Profile	Profile	String	1
Property	Property	String	1
Camera	Camera		1..*
Id	ID for camera	decimal	1

The timing and repetition of data sent from sensors might differ by sensor types, thus each application might require different conditions such as repetition and timing of receiving the sensed data. In addition, it might occur that some objects could not be detected in the cases where several objects exist. In these cases, simple processing, such as ignoring the missing information and waiting for all required data might cause lower accuracy of location information, and also longer processing times. In order to solve the above problems, the timing and repetition of sending and receiving data needs to be aligned with the designated frame rate for synchronizing sensed data and image.

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