How to Extend IndoorGML for Points of Interest
[Work-in-Progress Paper]

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Abstract. Nowadays, the interest in spatial information services is growing and moving towards indoor spaces. Indoor spatial data is fundamental as the demand for expressing complex urban environments, in the context of providing location-based services. OGC IndoorGML was established as a geospatial data standard, especially for indoor navigation. OGC IndoorGML provides a broad definition of the expression and structure of indoor spaces, but point of interest (POI) is excluded from their scope. However, POIs are useful for indoor navigation not only outdoor navigation. In this paper, we propose a data model that describes POIs in an indoor environment considering various spatial and temporal aspects, as an extension model of the OGC IndoorGML, called indoor POI (InPOI) model. The InPOI model defines new entities to handle Spatio-temporal POI information in indoor space by specifying the OGC IndoorGML core module. Finally, we provide an XML schema of the InPOI model.

Keywords: OGC IndoorGML · Indoor POI · XML Schema

1 Introduction

Nowadays, day-to-day human activities have been closely tied with mobile devices and gadgets that continuously improving in terms of features and speeds while decreasing in size, mostly equipped with GPS receivers and cameras [9,10]. With this, Location-Based Services (LBS) deliver relevant and timely information to mobile users based on their positions [3,9]. These services form a part of the core infrastructures of smart cities, as localities around the world aim to establish seamless integration of technology to the daily life of its citizens.

Points of Interest (POI) data, also sometimes cited as "Places of Interest [1]", "Objects of Interest [2]", or "Landmarks [12]" in some literature, are one of

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the fundamental requirement of any geospatial data infrastructure. They usually point out labeling features in maps instead of geographic coordinates of objects [10]. They are used in a wide range of geospatial applications, such as tourist guidance, indoor mapping [11], 3D visualization [13], and so on. Also, we can define new POI depending on the requirements of the application. In recent, indoor space has become a fundamental domain of geospatial applications and services. Like restaurants in outdoor, POI in indoor, such as toilets and vending machines, can help mobile users to improve their geospatial cognition. However, most indoor LBS are still providing viewer-level service [6]. To support various indoor applications, including navigation, simulation, monitoring, and even facility management, POI is required to be defined as indoor geospatial information.

Indoor Geographic Markup Language (IndoorGML [8]) is the Open Geospatial Consortium (OGC) standard for indoor geospatial information, particularly for navigation systems. OGC IndoorGML focuses on how topological relationships would be represented in indoor space. The OGC IndoorGML provides a broad definition of the expression and structure of indoor spaces, but POIs (such as event, facility, furniture, and installation) are out of their scope. However, the absence of POI information in indoor space brings the limitation of standard implementation and usability.

In this paper, we propose a data model that describes POI in the indoor environment, considering its various spatial and temporal aspects. This paper consists of three parts as follows: In Sect. 2, we briefly introduce previous POI standardization studies and OGC IndoorGML. In the next section, we present our proposed indoor POI model based on OGC IndoorGML, concludes with plans for further developments.

2 Related Studies

2.1 Point of Interest (POI)

POI data is one of the most fundamental requirements in the core infrastructure of smart cities. The definition of POI which provided by the OGC is "A location (with a fixed position) where one can find a place, product or service, typically identified by name rather than by address and characterized by type, which may be used as a reference point or a target in a location based service request." [7] Internationally, there have been activities relating to POIs:

- ISO 19112 [4] connects location references to coordinates. It defined the components of a spatial reference system and the essential components of a gazetteer.
- ISO 19155 [5] defined mechanisms to match multiple Place Identifiers (PI) to the same place, in which an identifier of a place is referred to as a PI.
- The World Wide Web Consortium (W3C) POI Special Working Group (SWG) has become the first step towards the standardization for the definition and exchange of POI data, focusing on web architecture and in AR

applications. In parallel, industry stakeholders, including car industry specialists and experts in mobile technology, navigation systems, and digital maps formulated a general-purpose specification called Point of Interest Exchange Language (POIX) and submitted this as a preliminary proposal to W3C. However, this lacked in certain, descriptive and temporal aspects, and seemed to be geared towards car navigation. The W3C POI SWG has published the Point of Interest Core (POI Core), describing eight categories to describe POI with attributes and various location types. However, it has been described as "quite complex and requires substantial effort to apply."

– Since 2015, the OGC officially started activities for this purpose in its POI SWG. It has since issued OpenPOIs, a public database of POI data based on the earlier W3C model. This, however, contains a large amount of metadata that significantly increases data volume. As of writing, OGC is still undergoing the standardization process.

One major problem that having a POI data standard would resolve is having separate sets of POIs for every application, or infrastructure. For numerous sources of POI data that are available, the W3C workshops raised the issue of connecting POI data from different sources, avoiding information overload, and identifying the veracity of information. For example, in Korea, of the 3 Million POIs being maintained by 12 private companies, 70% have overlapped. For POI data to be comfortable to distribute and lightweight, it must be general-purpose and is dynamically extensible.

2.2 OGC IndoorGML

OGC IndoorGML [8] was established as the OGC international standard for indoor navigation applications and XML-based formats to represent indoor spatial information.

OGC IndoorGML provides a standard data model for indoor space with two spatial models, as shown in Fig. 1: Euclidean Space represents the shape of a three-dimensional (3D) cell space; Topology Space represents connectivity between cell spaces. Topology represents a duality transformation of the 3D cell space and is an essential component for indoor navigation and routing system. By applying a duality transformation, the 3D cells in primal space are mapped to nodes (0D) in dual space. The topological adjacency relationships between 3D cells are transformed to edges (1D) linking pairs of nodes in dual space. Therefore, OGC IndoorGML utilizes a network model for navigation and expresses the connectivity relationships among cell spaces. The nodes of the indoor network represent rooms, corridors, doors, elevators, and staircases. The edges of the indoor network represent the topological relationships among indoor spatial entities and can indicate the paths of pedestrian movement between nodes within a building. Therefore, one edge should be represented by two nodes. The network model in OGC IndoorGML is represented by nodes (as called **State**) and edges (as called **Transition**) feature, as shown in Fig. 2.

However, in certain applications, OGC IndoorGML would necessitate information from other datasets to provide comprehensive information especially in LBS. Indoor POIs provide a useful location on objects, events, or facilities in a specific location in the indoor environment, and may be utilized together with OGC IndoorGML for a more complete depiction of indoor space.

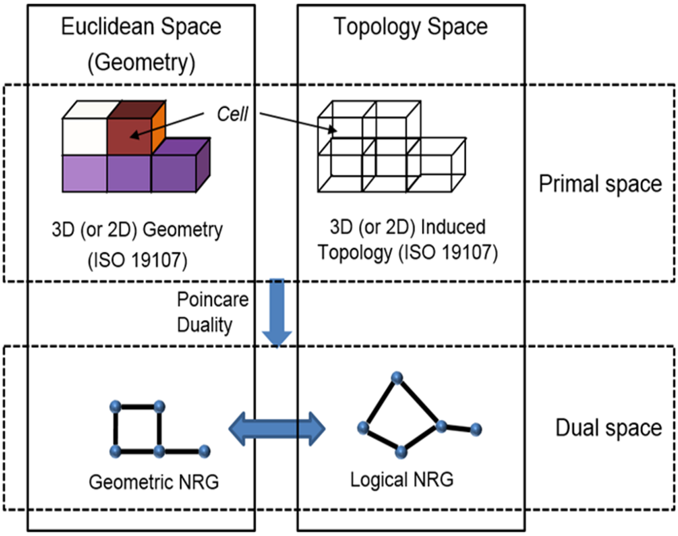

Fig. 1. Structure space model (OGC, IndoorGML [8])

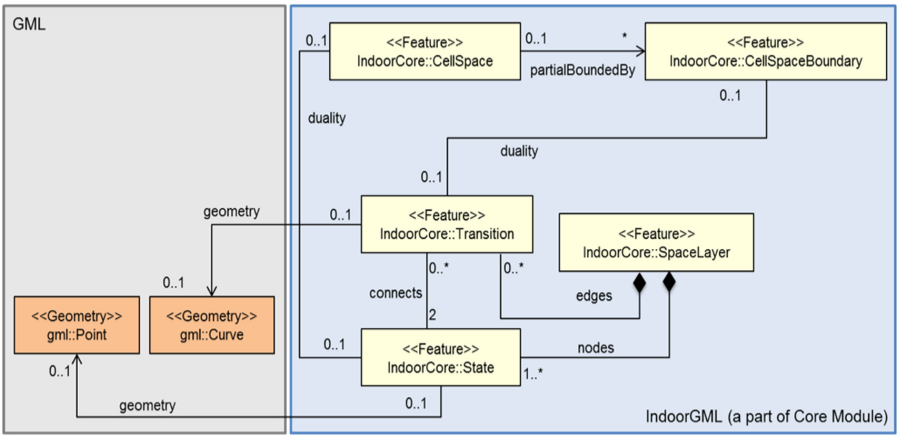

Fig. 2. Part of OGC IndoorGML Core module UML diagram (OGC, IndoorGML [8])

3 Indoor POI Data Model

The indoor POI data model aims to supplement existing descriptions of POI for a more suitable standard in creating such features in the indoor space, to increase utilization and development of indoor location-based services. The data model expresses objects and their respective logical relationships through the Unified Modeling Language (UML).

3.1 Indoor POI Classification

To encourage utilization, increase efficiency and avoid duplication in datasets, a classification scheme was devised to categorize Indoor POI. Created based on the ESRI POI classification scheme, each feature may be classified in three levels of increasing specificity, and each category would correspond to a 6-character category code as an attribute for the indoor POI. Figure 3 shows an example of the classification scheme for indoor POIs.

Indoor POI (reclassified)

Level 1	Level 2	Level 3
Place	Pedestrian	stairs
		slope way
		lobby
	Private	common room
	Relaxation	relaxation room
		smoking area
		men's toilet
		woman's toilet
		disabled toilet
		bench
		rubbish bin
Things	Access facility	door
		ticket gate
		access control units
	Conveyor transport	up escalator
		down escalator
		up moving sidewalk
		down moving sidewalk
		Horizontal moving sidewalk
		Elevator
		Wheelchair lift

Level 1	Level 2	Level 3
Retail + Services	Services	nursery
		drug store
		vending machine
		ticket machine
		information
		lounge
		guest room
		covered car park
		bank
		cash machine or ATM
		post office
		billboard
	Retail	restaurant
		coffee shop
		clothing store
		hair shop
		ticket office
		aquarium
		bowling alley
		swimming-pool
		store

Level 1	Level 2	Level 3
Safety + Security	Fire-fighting supplies	fire protection appliance
		fire extinguishing system
		fire extinguisher
		fire alarm
	Emergency relief supplies	automated external defibrillator
		life-saving trolley
	Evacuation facility	shelter
		emergency call center
		exit
		emergency escape device
		relief goods
Event	Temporal	time
	Type	fire
		earthquake
		power outage
		safety accident

Fig. 3. 3-level indoor POI classification schema

3.2 Indoor POI Model

The proposed indoor POI (InPOI) Model is shown in Fig. 4. The InPOI model consists of five elements: **IndoorPOISpace**, **IndoorPOILocation**, **IndoorPOIAttribute**, **IndoorPOI**, and **IndoorPOIs**. The UML diagram depicted in Fig. 4 shows the InPOI data model based on the OGC IndoorGML core module. The main class of the InPOI module is the **IndoorPOI** class. The **IndoorPOI** class can have one or more **IndoorPOILocation** class instances, at least. POI location information is mandatory for managing POI history. Optionally, the

IndoorPOI class can have multiple **IndoorPOISpace** and **IndoorPOIAttribute** instance. **IndoorPOISpace** instance represents the occupied space of POI. It can have a duality attribute that inherits from the **CellSpace** of OGC IndoorGML core module. The duality attribute of **IndoorPOISpace** class represents an association with **IndoorPOILocation**. The **IndoorPOILocation** also can have a duality attribute for representing an association with **IndoorPOISpace**. The detail description of each class is as below:

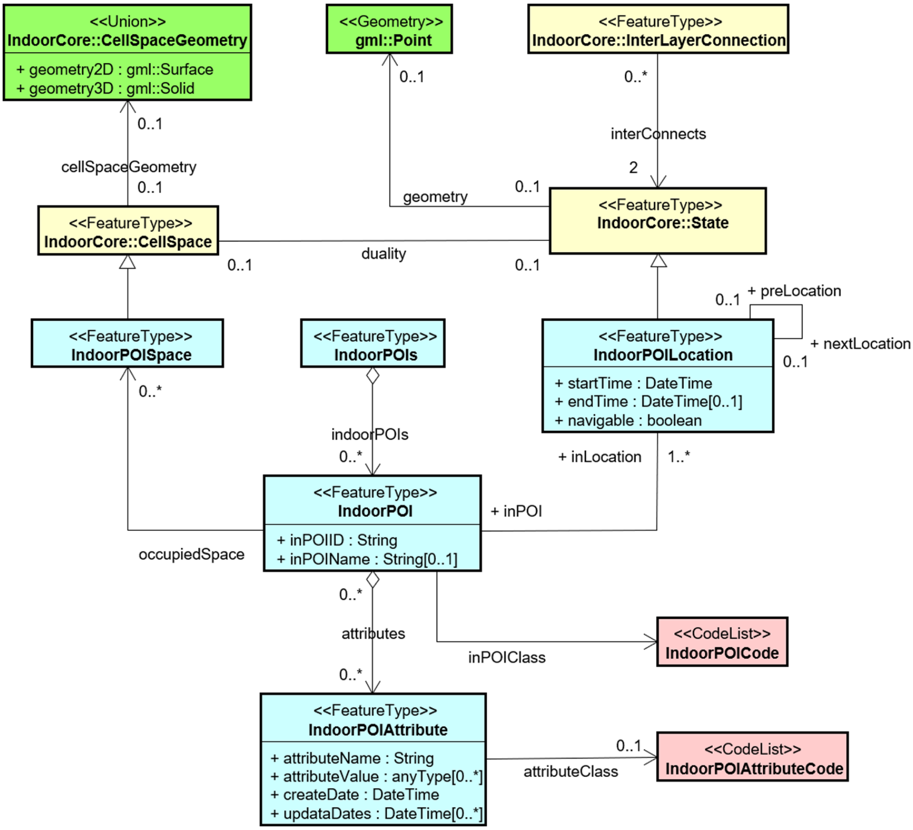

Fig. 4. UML diagram for Indoor POI Model

⟨**IndoorPOISpace**⟩

IndoorPOISpace represents an occupied space of POI. The XML schema for **IndoorPOISpace** as shown in Fig. 5. **IndoorPOISpace** class inherits **CellSpace** class, therefore, **IndoorPOISpace** has a geometry that derived from **CellSpace** class. This geometry information can be useful for creating dynamic map information. For example, to create a map for an autonomous robot, it is important whether it is enough space for the robot to pass through. At this time, this geometry information can be utilized.

```xml
<xs:element name="IndoorPOISpace" type="IndoorPOISpaceType" substitutionGroup="IndoorCore:CellSpace"/>
<!-- ====================================================================== -->
<xs:complexType name="IndoorPOISpacePropertyType">
  <xs:sequence minOccurs="0">
    <xs:element ref="IndoorPOISpace"/>
  </xs:sequence>
  <xs:attributeGroup ref="gml:AssociationAttributeGroup"/>
</xs:complexType>
<!-- ====================================================================== -->
<xs:complexType name="IndoorPOISpaceType">
  <xs:complexContent>
    <xs:extension base="IndoorCore:CellSpaceType">
      <xs:attributeGroup ref="gml:AssociationAttributeGroup"/>
    </xs:extension>
  </xs:complexContent>
</xs:complexType>
```

Fig. 5. XML Schema for **IndoorPOISpace**

⟨**IndoorPOILocation**⟩

IndoorPOILocation represents a specific point location of POI. The XML schema for **IndoorPOILocation** is shown in Fig. 6. **IndoorPOILocation** has a geometry that derived from **State** class, and it can express *WITHIN* topological relation with **CellSpace** using **InterLayerConnection**; i.e., All POIs within a room have *interConnects* with same **State** of a room. The *startTime* and *endTime* elements are installed and uninstalled time of POI respectively. The *navigable* element indicates which people can movable through this POI or not; i.e., usually, the vending machine is not navigable, but the ticket gate is navigable. This element can be used for making an indoor route. **IndoorPOILocation** contains the *preLocation* and *nextLocation* for tracking the location history

```xml
<xs:element name="IndoorPOILocation" type="IndoorPOILocationType" substitutionGroup="IndoorCore:State"/>
<!-- ====================================================================== -->
<xs:complexType name="IndoorPOILocationPropertyType">
  <xs:sequence minOccurs="0">
    <xs:element ref="IndoorPOILocation"/>
  </xs:sequence>
  <xs:attributeGroup ref="gml:AssociationAttributeGroup"/>
</xs:complexType>
<!-- ====================================================================== -->
<xs:complexType name="IndoorPOILocationType">
  <xs:complexContent>
    <xs:extension base="IndoorCore:StateType">
      <xs:sequence>
        <xs:element name="startTime" type="xs:dateTime"/>
        <xs:element name="endTime" type="xs:dateTime" minOccurs="0"/>
        <xs:element name="navigable" type="xs:boolean"/>
        <xs:element name="preLocation" type="IndoorPOILocationPropertyType" minOccurs="0"/>
        <xs:element name="nextLocation" type="IndoorPOILocationPropertyType" minOccurs="0"/>
        <xs:element name="inPOI" type="IndoorPOIPropertyType"/>
      </xs:sequence>
      <xs:attributeGroup ref="gml:AssociationAttributeGroup"/>
    </xs:extension>
  </xs:complexContent>
</xs:complexType>
```

Fig. 6. XML Schema for **IndoorPOILocation**

of POI, when a POI move to another location. Lastly, the *inPOI* element represents an association with the corresponding **IndoorPOI** class which represents a POI information.

⟨**IndoorPOIAttribute**⟩

IndoorPOIAttribute is used to describe the indoor POI property. The XML schema for **IndoorPOIAttribute** as shown in Fig. 7. The *attributeName* and *attributeValue* elements are name and value of user-defined attribute, respectively. The *createDate* and *updateDate* elements are created and updated date of attribute, respectively. The *attributeClass* element is a flexible enumeration that uses string values for expressing a list of attribute class code.

```xml
<xs:element name="IndoorPOIAttribute" type="IndoorPOIAttributeType" substitutionGroup="gml:AbstractFeature"/>
<!-- ====================================================================== -->
<xs:complexType name="IndoorPOIAttributePropertyType">
   <xs:sequence minOccurs="0">
      <xs:element ref="IndoorPOIAttribute"/>
   </xs:sequence>
   <xs:attributeGroup ref="gml:AssociationAttributeGroup"/>
</xs:complexType>
<!-- ====================================================================== -->
<xs:complexType name="IndoorPOIAttributeType">
   <xs:complexContent>
      <xs:extension base="gml:AbstractFeatureType">
         <xs:sequence>
            <xs:element name="attributeName" type="xs:string"/>
            <xs:element name="attributeValue" type="xs:anyType" minOccurs="0" maxOccurs="unbounded"/>
            <xs:element name="createDate" type="xs:dateTime"/>
            <xs:element name="updateDates" type="xs:dateTime" minOccurs="0" maxOccurs="unbounded"/>
            <xs:element name="attributeClass" type="IndoorPOIAttributeCodeType" minOccurs="0" />
         </xs:sequence>
         <xs:attributeGroup ref="gml:AggregationAttributeGroup"/>
      </xs:extension>
   </xs:complexContent>
</xs:complexType>
<!-- ====================================================================== -->
<xs:simpleType name="IndoorPOIAttributeCodeType">
   <xs:restriction base="xs:string">
      <xs:enumeration value="..."/>
         ...
   </xs:restriction>
</xs:simpleType>
```

Fig. 7. XML Schema for **IndoorPOIAttribute**

⟨**IndoorPOI**⟩

IndoorPOI class is a feature class for representing indoor POI. The XML schema for **IndoorPOI** as shown in Fig. 8. To represent spatial objects of indoor POI in indoor space, an **IndoorPOI** has *occupiedSpace* element. Also, to represent location of indoor POI in indoor space, an **IndooPOI** has *inLocation* element. The **IndoorPOI** class has attributes which are *inPOIID*, *inPOIName* and *inPOIClass*. The *inPOIID* and *inPOIName* are the identifier and name of indoor POI, respectively. The attribute *inPOIClass* represents a general classification code of indoor POI, e.g., the classification scheme described at Sect. 3.1. An **IndoorPOI** aggregates **IndoorPOIAttribute** which is user-defined attribute.

```
<xs:element name="IndoorPOI" type="IndoorPOIType" substitutionGroup="gml:AbstractFeature"/>
<!-- ====================================================================== -->
<xs:complexType name="IndoorPOIPropertyType">
  <xs:sequence minOccurs="0">
    <xs:element ref="IndoorPOI"/>
  </xs:sequence>
  <xs:attributeGroup ref="gml:AssociationAttributeGroup"/>
</xs:complexType>
<!-- ====================================================================== -->
<xs:complexType name="IndoorPOIType">
  <xs:complexContent>
    <xs:extension base="gml:AbstractFeatureType">
      <xs:sequence>
        <xs:element name="inPOIID" type="xs:string"/>
        <xs:element name="inPOIName" type="xs:string" minOccurs="0"/>
        <xs:element name="inLocation" type="IndoorPOILocationPropertyType" maxOccurs="unbounded"/>
        <xs:element name="occupiedSpace" type="IndoorPOISpacePropertyType" minOccurs="0" maxOccurs="unbounded"/>
        <xs:element name="attributes" type="IndoorPOIAttributePropertyType" minOccurs="0" maxOccurs="unbounded"/>
        <xs:element name="inPOIClass" type="IndoorPOICodeType"/>
      </xs:sequence>
      <xs:attributeGroup ref="gml:AggregationAttributeGroup"/>
    </xs:extension>
  </xs:complexContent>
</xs:complexType>
<!-- ====================================================================== -->
<xs:simpleType name="IndoorPOICodeType">
  <xs:restriction base="xs:string">
    <xs:enumeration value="..."/>
      ...
  </xs:restriction>
</xs:simpleType>
```

Fig. 8. XML Schema for **IndoorPOI**

⟨**IndoorPOIs**⟩

IndoorPOIs is a root element of to represent the indoor POI. It is an aggregated element with **IndoorPOI**. The **IndoorPOIs** contains a set of **IndoorPOI** as *indoorPOIs*. The XML schema for **IndoorPOI** as shown in Fig. 9.

```
<xs:element name="IndoorPOIs" type="IndoorPOIsType" substitutionGroup="gml:AbstractFeature"/>
<!-- ====================================================================== -->
<xs:complexType name="IndoorPOIsType">
  <xs:complexContent>
    <xs:extension base="gml:AbstractFeatureType">
      <xs:sequence>
        <xs:element name="indoorPOIs" type="IndoorPOIPropertyType" minOccurs="0" maxOccurs="unbounded"/>
      </xs:sequence>
      <xs:attributeGroup ref="gml:AssociationAttributeGroup"/>
    </xs:extension>
  </xs:complexContent>
</xs:complexType>
```

Fig. 9. XML Schema for **IndoorPOIs**

4 Conclusion

OGC IndoorGML was an established OGC standard for indoor spatial information with a focus on navigation. Still, for specific applications, information from other datasets is needed to provide comprehensive information, especially in LBS. Indoor POIs provide a useful location for objects, events, or facilities at specific locations in an indoor environment, and can be used with OGC IndoorGML to more fully depict indoor spaces. This study presents a data model that describes POIs in indoor environments, taking into account various spatial and temporal aspects based on OGC IndoorGML.

However, further researches are required to verify the purposed extension model. Further research will include various use-case, for example, facility management in the hospital. And then, finally, we plan to submit the InPOI model to OGC as a discussion paper with use-cases.

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