IndoorGML – Candidate Standard for Indoor Spatial Information

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Before starting…

• Not (InDoorGML, Indoor GML, In Door GML)
• the correct name is IndoorGML like CityGML
Applications

Indoor LBS

Indoor Geo-Portal

Indoor mCommerce

Emergency Control

Indoor Robot

Hospital

Cruise Ship

Services for handicapped persons

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Prior work on indoor space

- IFC: Mainly focused on BIM
- CityGML: LoD 4: Interior space
- KML
- others
Basic Ideas

Space
*a boundless extent in which objects and events occur and have position* – in online Britannica

空

- Emptiness
- In-Between
Basic Ideas – Components vs. Space
IndoorGML as a complement

- CityGML
- KML
- IFC

IndoorGML

1. Cellular Space
2. Network and
3. Multi-Layered

Space Model

Indoor positioning is out of scope
IndoorGML and Other Standards

IndoorGML

IFC

KML

CityGML

2D Indoor Floor Plan

Services for handicapped persons

Fire exit

Emergency Control

Indoor LBS

Indoor Robot

Application

Indoor mCommerce

Services for handicapped persons

Emergency Control

Indoor LBS

Indoor Robot

Indoor mCommerce
IndoorGML based on Cellular Space Model

- A given space is defined as a set of (Non-Overlapping) cell spaces
  - $C_i \cap C_i = \emptyset$
  - $\cup C \subseteq U$
    (e.g. Shadow area of sensor coverage)
- Given indoor Space $U$ : 2D or 3D
- Each cell has Cell ID.

- 4 aspects of cellular space
  - Geometry
  - Topology
  - Multi-Layered Structure
  - Semantics
Three options to represent geometry of each cell

- **Option 1:** External Reference to room in CityGML
- **Option 2:** Geometry in IndoorGML
- **Option 3:** No Geometry
Topology between Cells

• Poincare Duality
  – Conversion from original (primal space) to dual space
  – Given a $N$-D (e.g. 3D) space, conversion from $k$ D object $\rightarrow N-k$ (e.g. $3-k$) D objects
Topology between Cells

Primal Space

Dual Space

Adjacency Graph

Topology between Cells
Topology between Cells

Connectivity Graph

- W7
- R1
- W6
- W1
- W2
- W3
- W5
- W4
- D3
- D1
- EXT

Topology between Cells
Topology between Cells

Example: Wall and Door as Space Boundary

Topographic Space

Dual Space

Navigable Link (Connectivity)
Non-navigable Link (Adjacency)
Multi-Layered Space

Topographic space

WIFI sensor space

RFID sensor space

Euclidean Space

Dual Space

Multi-Layered Space
Multi-Layered Space – Inter-layer relation

Inter-layer relation, denotes intersecting cells between different space layers

Connectivity(Intra-layer relation) denotes adjacent cells within the same space model

Topographic space

WFI sensor space

RFID sensor space
Example – Multi-Layered Space

Stair

Non-Navigable Space

Room 1
Room 2
Room 3

Room 1
Room 2
Room 3a
Room 3b

WiFi A
WiFi B
WiFi AB
Example – Multi-Layered Space

Layer “Walkable”

Layer “Wheelchair”

Layer “WiFi”
Semantics

- Semantic Interpretation of Indoor Space
  - Classification of Indoor Space
  - Example – Room, Door, Corridor, Stair Space, Elevator Shaft, Gate

- Definition of Attributes
  - Names, Usage, Functions, etc..
  - Directions
  - Accessibility
Semantic Extension for Navigation
Indoor Navigation Module – Anchor Node

Anchor Node also contains
- Conversion Parameters
  - rotation origin point \((x_0, y_0, z_0)\)
  - rotation angles \((\alpha, \beta, \gamma)\), along \(x\), \(y\), and \(z\)-axis),
  - rescaling factor \((s_x, s_y, s_z)\), and
  - translation vector \((t_x, t_y, t_z)\)
- Other attributes
  - URL of fingerprint map
  - Address
Basic Components of IndoorGML

**Module:**
- **Core Module**
  - IndoorGML
  - Cellular Space Model
  - Connectivity Graph
  - Multi-Layered Space Model

**Extension Module**
- Indoor Navigation Module (1.0)

**Extension Modules (possible in IndoorGML 2.0?)**
- Indoor POI?
- FM Module?
- Robotics Module?
- Multimedia Module?

**Standards:**
- GML 3.2
- ISO 19107
Semantic Extension – Future Plan

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Semantic Extension

IndoorGML 1.0

<<Leaf>>
IndoorNavigation

<<ApplicationSchema>>
IndoorGML core

<<XSDschema>>
Geography Markup Language

IndoorGML 2.0

<<Leaf>>
Indoor Facility Management ?

<<Leaf>>
Indoor Robotics ?

IndoorGML 1.0

IndoorGML 2.0
Use-Case – Venue Map Service (COEX, Seoul)
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Composition of Coex Indoor Map

- POI Data
- Network Data (Topology)
  - Geometric Topology
- Space Data
Use-Case – Venue Map Service (COEX, Seoul)
Use-Case – Venue Map Service (COEX, Seoul)
Demands from other standards

- ISO/TC204 WG 17 (Nomadic Devices of ITS Systems)
  - Extension of road navigation standards for covering outdoor space AND Indoor Space in a seamless way
  - NWIP: Adopted on May 7, 2012 (ISO 17438-1) – Part I
    - Indoor navigation for personal and vehicle ITS station
      - Part 1: General information and use cases definition
      - Part 3: Requirements and specification for indoor positioning reference data format
      - Part 4: Personal/Vehicle and central ITS stations interface requirements and specification for indoor map and indoor positioning reference data

- IEEE RAS (Robotics and Automation Society)
  - Indoor maps for localization and navigation of robots
  - IEEE MDR (Map Data Representation for Robots)
    - WG established in Nov. 2011
    - To be published in 2014
Useful Links

• indoorgml.net