IndoorGML -
OGC Candidate Standard for Indoor Navigation

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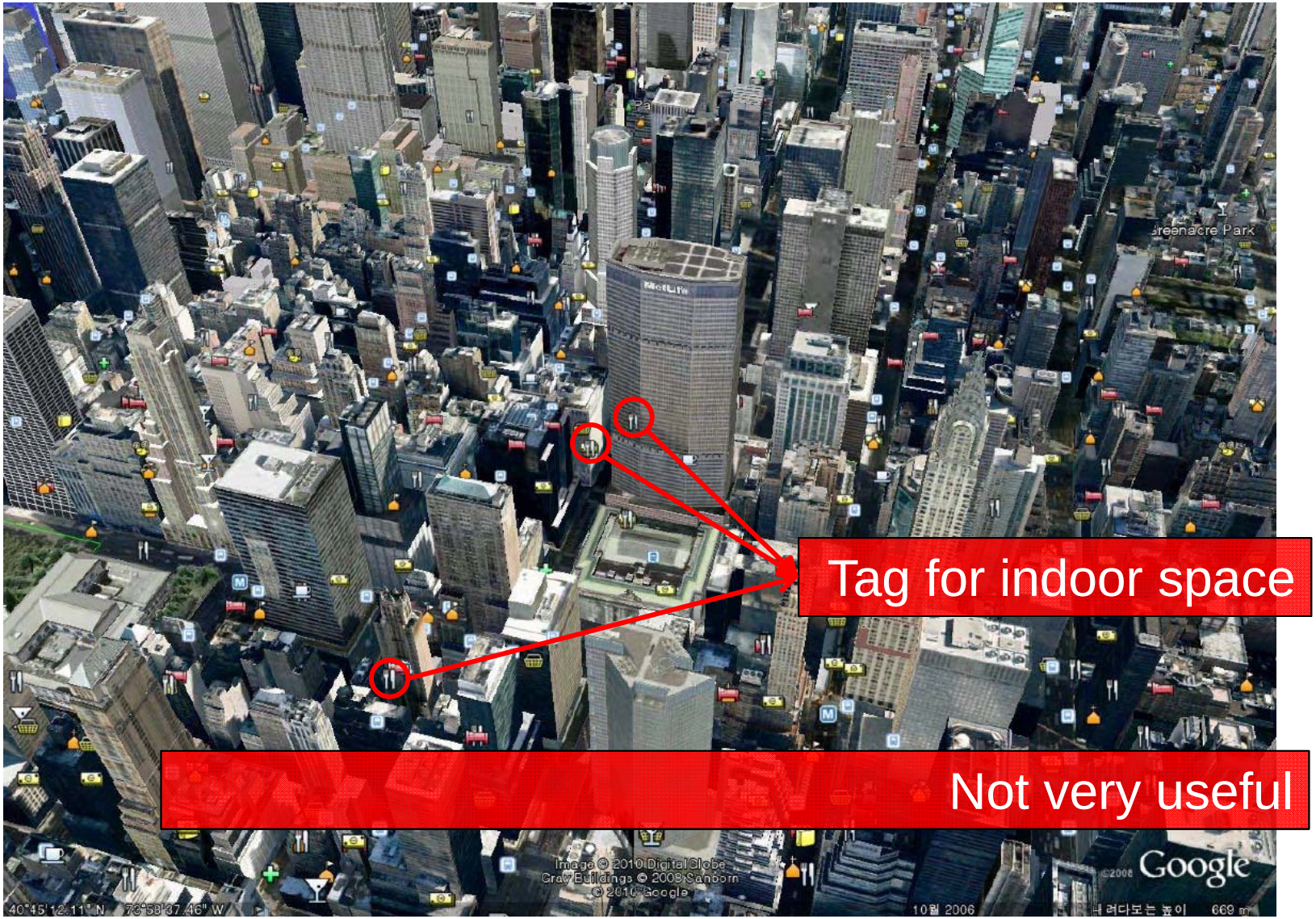
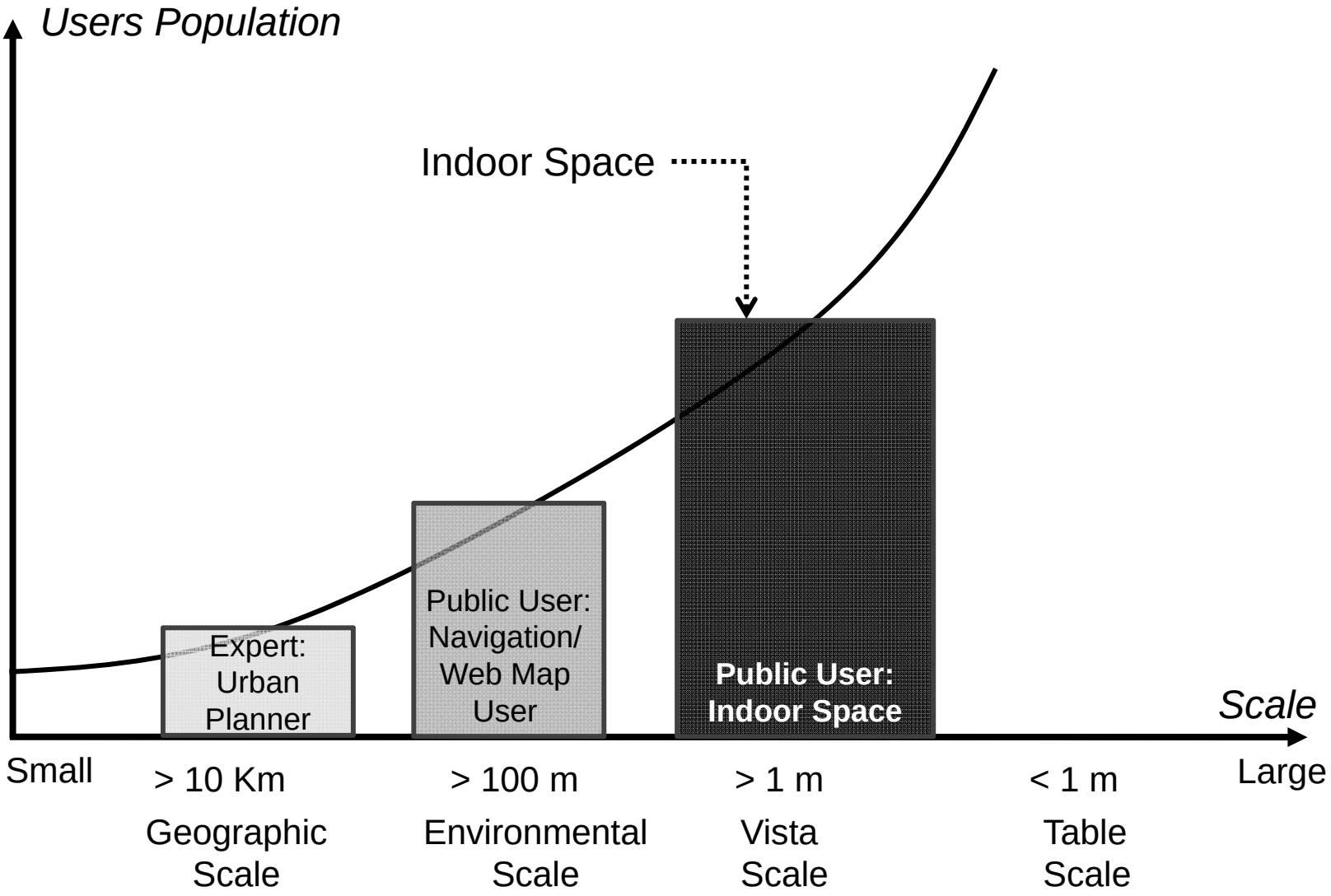


<Source: Google Earth 3D>

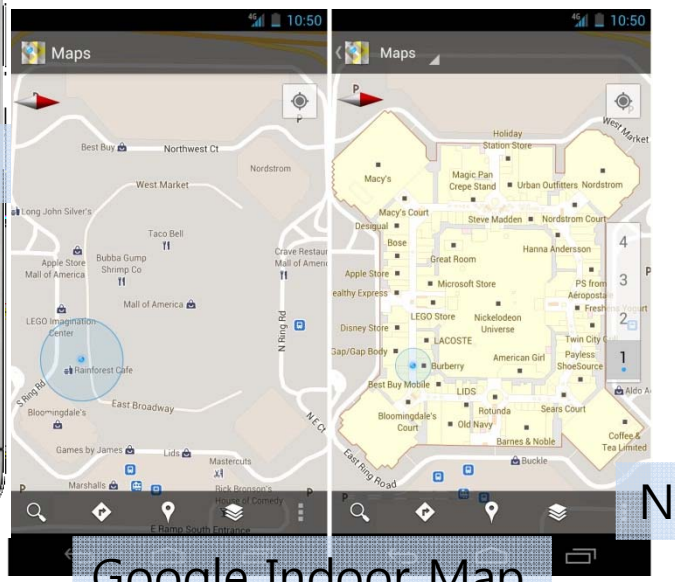
<Source: Google Earth 3D>

Background and Motivations

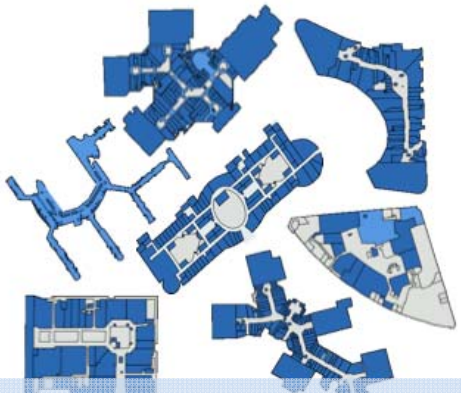


Some services of indoor spatial information

PointInside

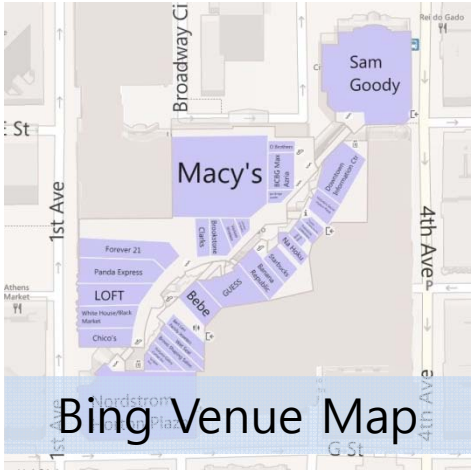


Google Indoor Map



Nokia Destination Map

Aisle411



Bing Venue Map

Indoor OpenStreetMap

Prior work for indoor space

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

CityGML

LOD 0 – Regional model

- 2.5D Digital Terrain Model

LOD 1 – City / Site model

- “block model“ w/o roof structures

LOD 2 – City / Site model

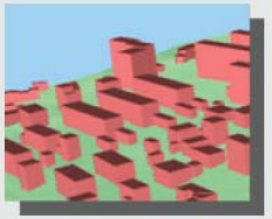
- textured, differenciated roof structures

LOD 3 – City / Site model

- detailed architecture model

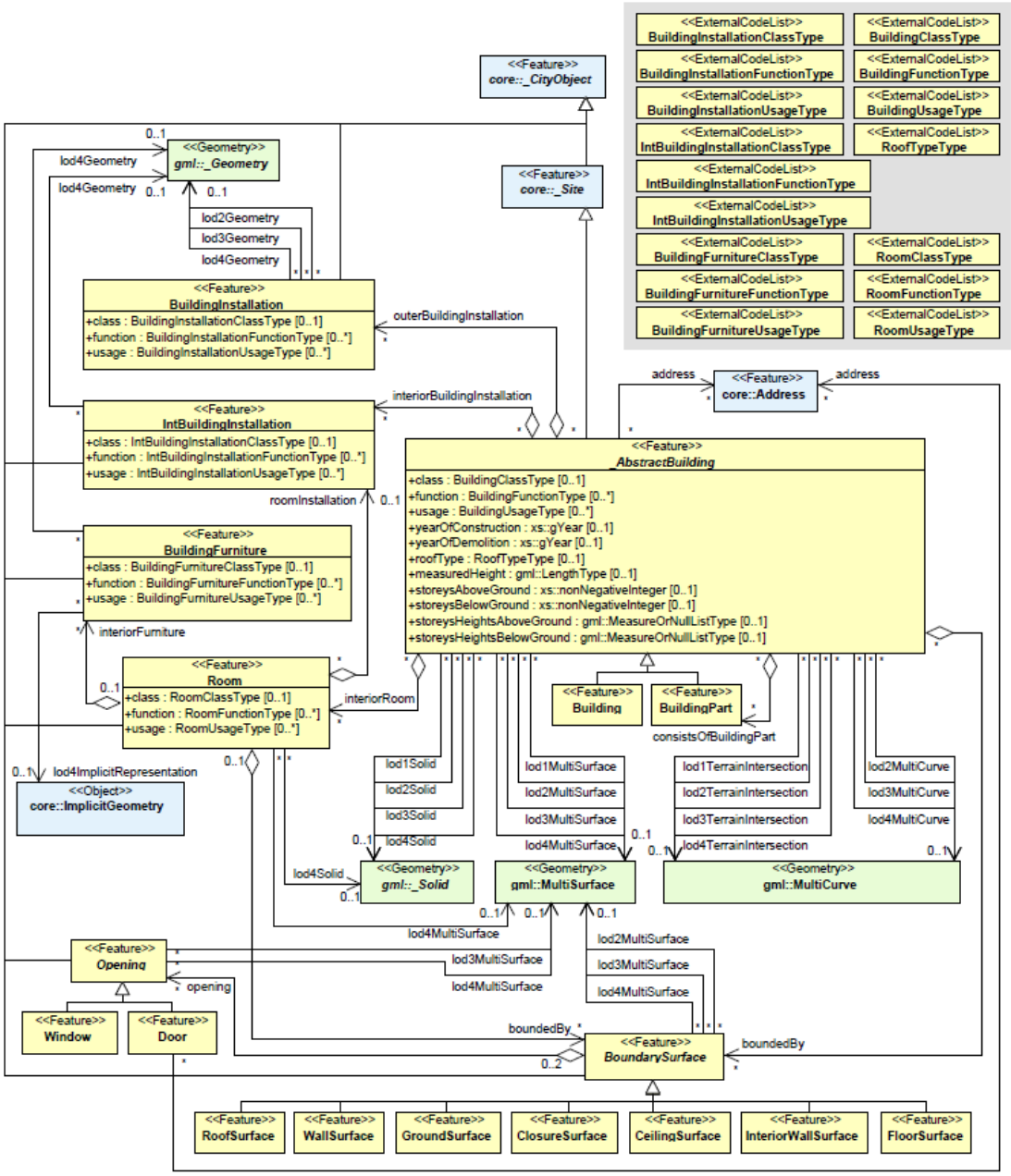
LOD 4 – Interior model

- “walkable“ architecture models



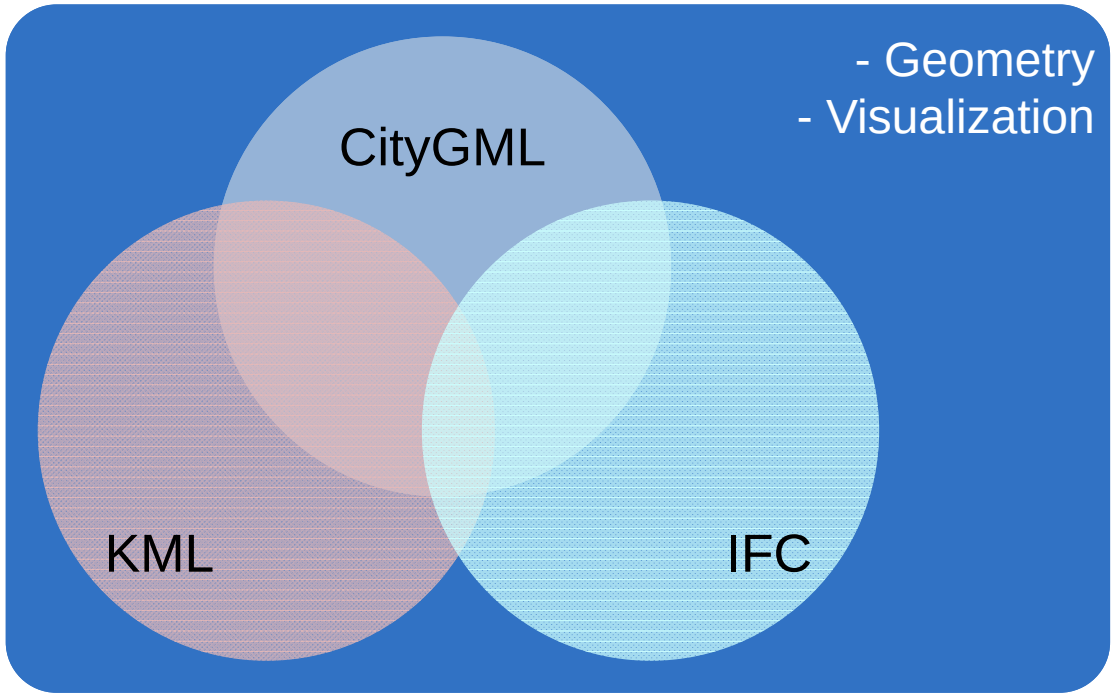
[source: Thomas H. Kolbe, March 21, 2008]

CityGML



[source: OGC CityGML Specification]

What is missing in CityGML



Navigation ??
Symbolic Representation ?

For example, CityGML

- LoD 4 (Interior space)
  - How to compute the optimal path

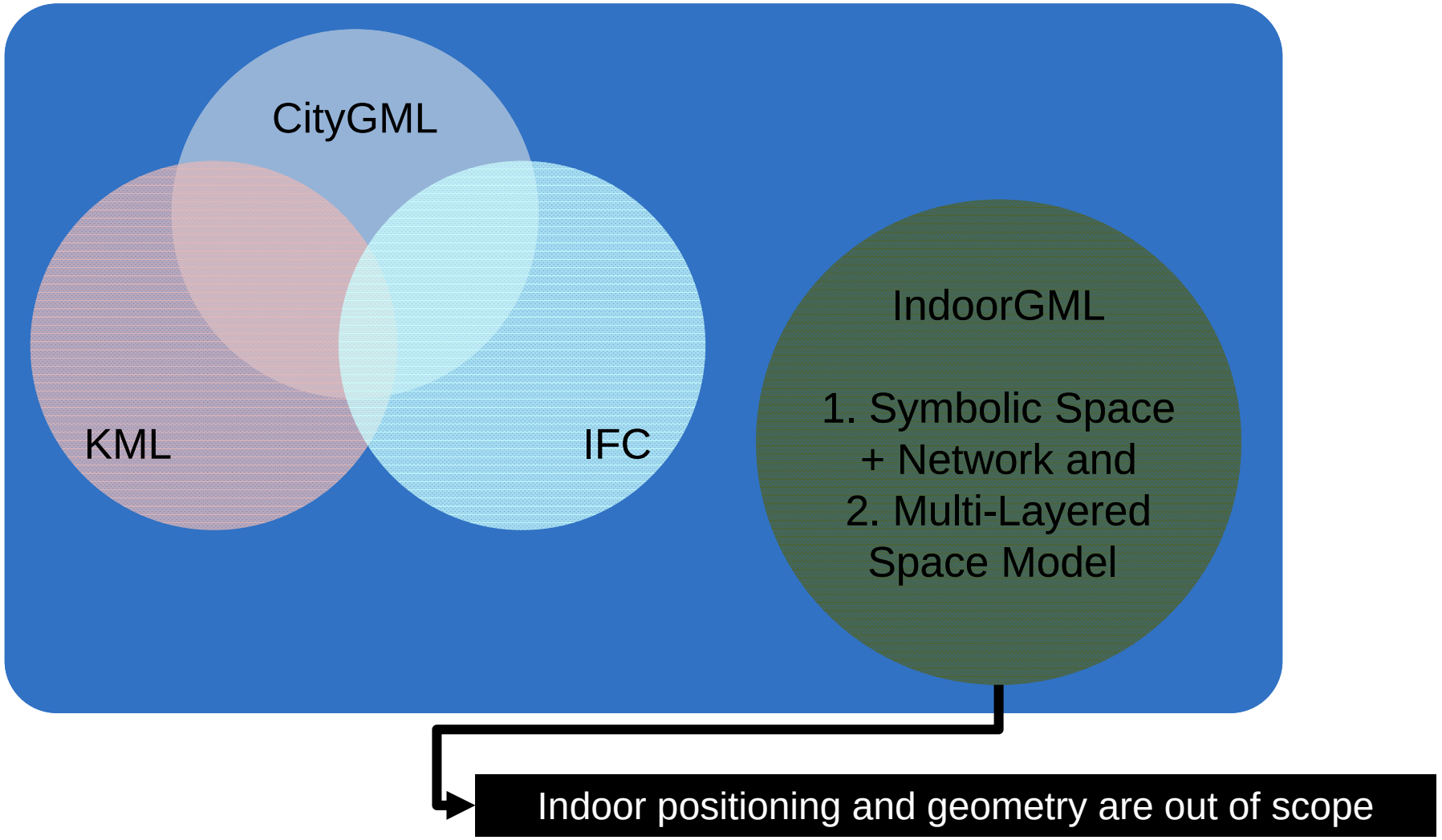
  ➡ navigation network

<Source: CityGML>

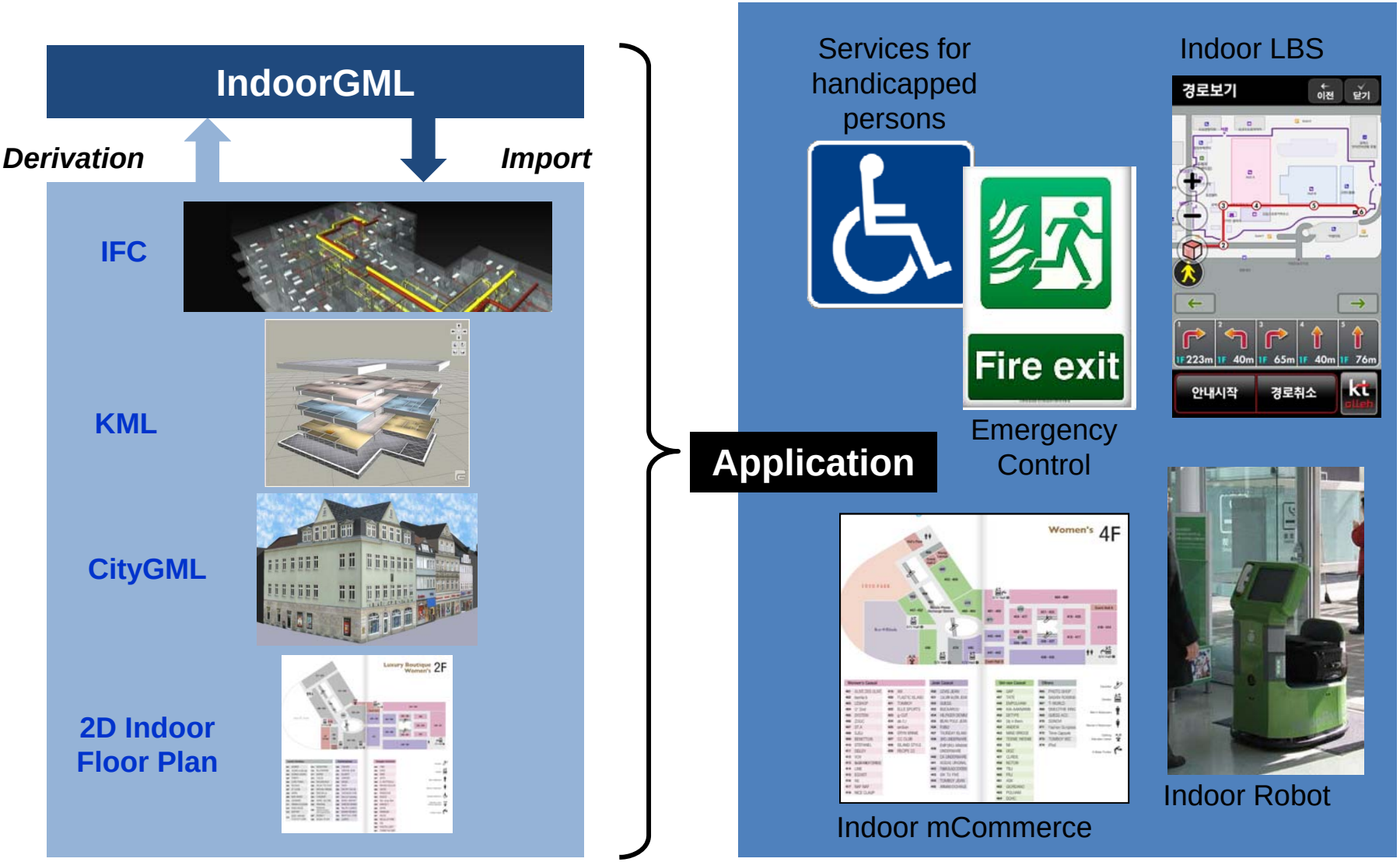
- Specification of location
  - “How many persons are in [(12.45, 43.23),(12.488, 43.27)] ?” or
  - “How many persons are in room 422 of Building C-28?”

  ➡ Symbolic notion of space

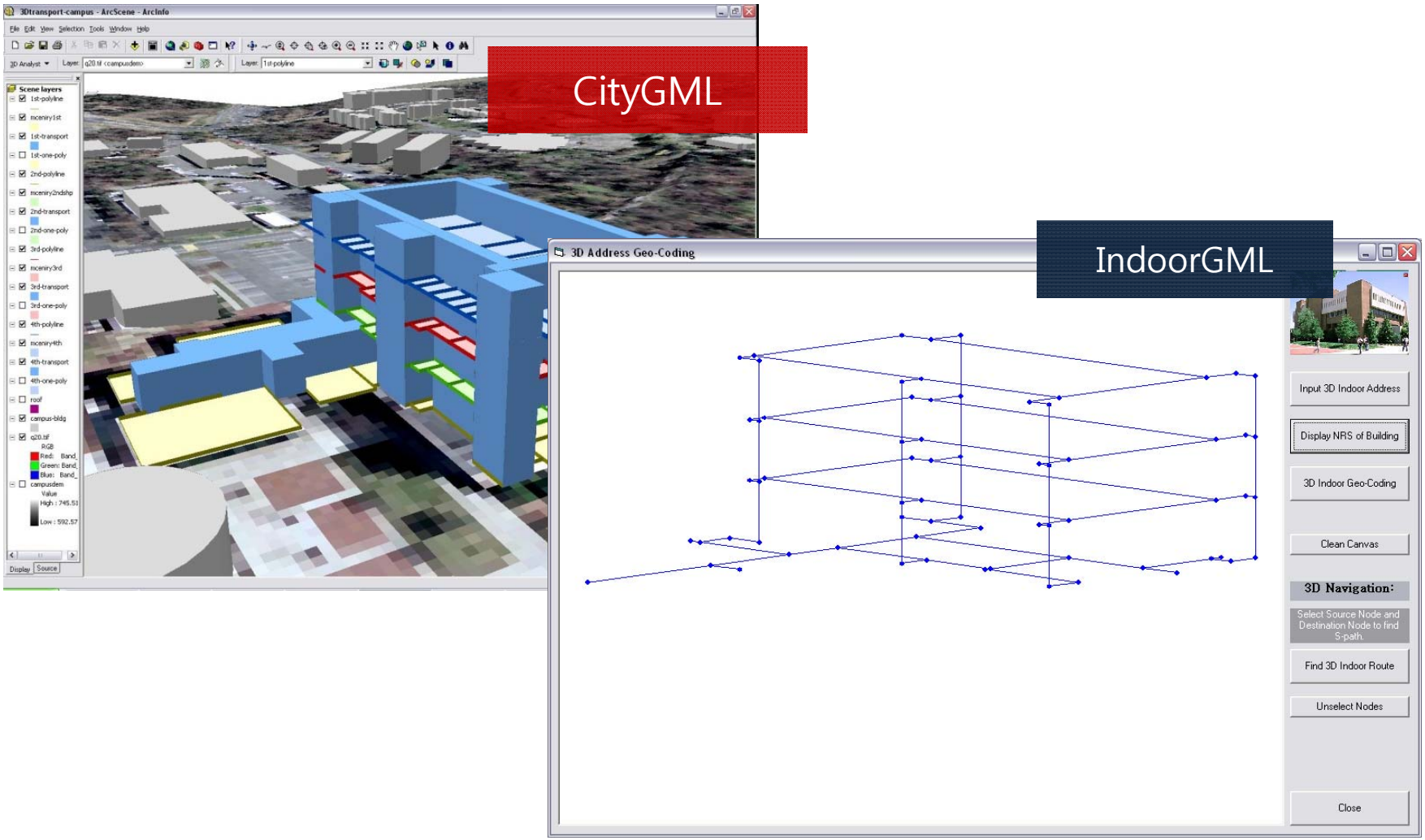
IndoorGML as complements



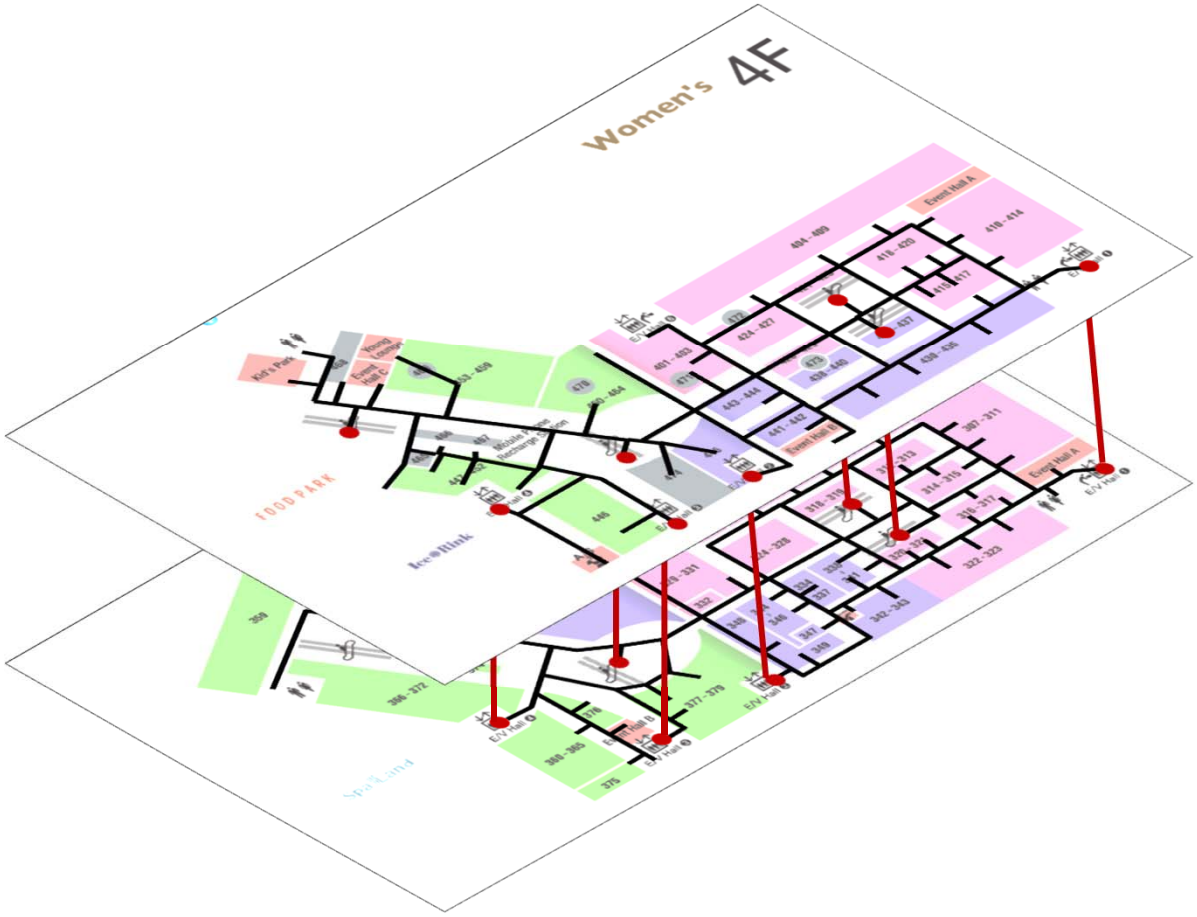
IndoorGML and Other Standards



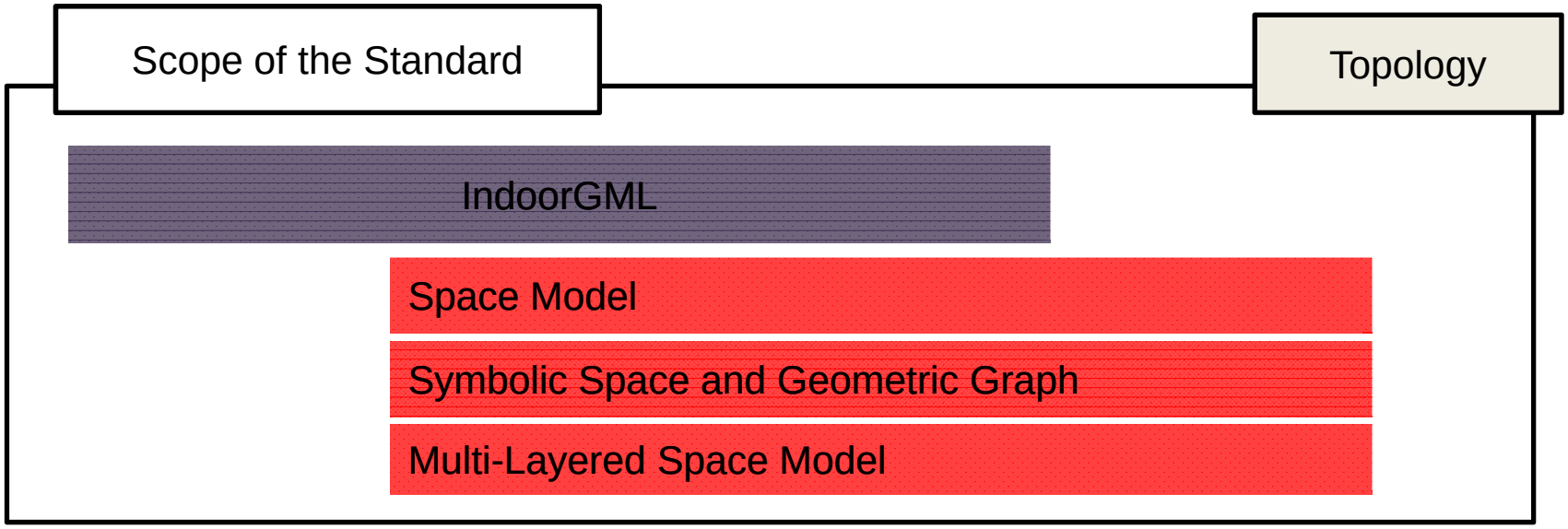
CityGML+IndoorGML



2D Image + IndoorGML

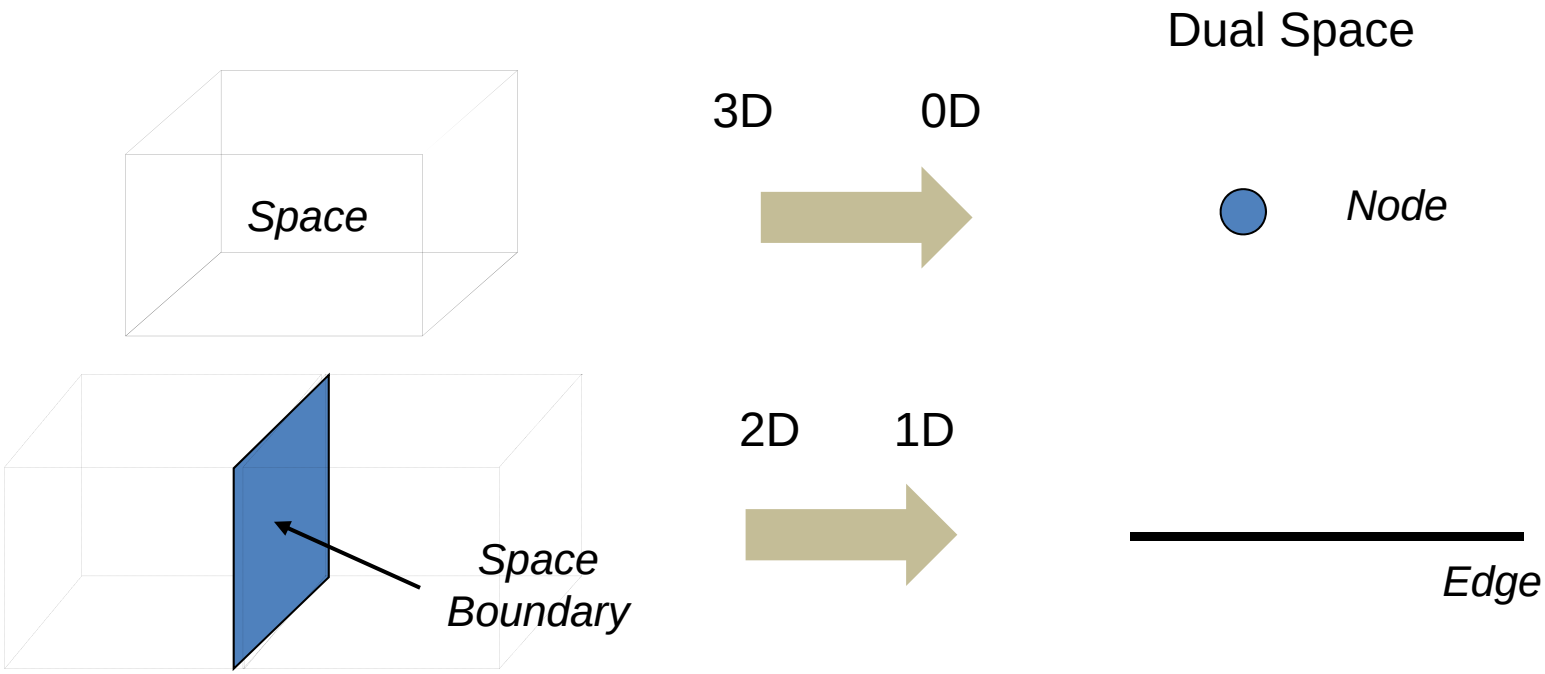


Basic Components of IndoorGML



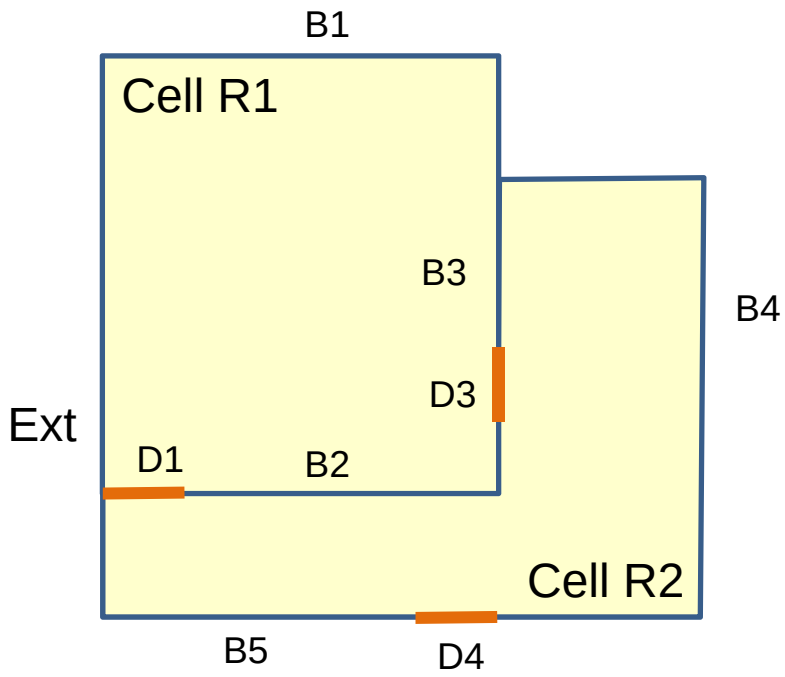
Space Model of IndoorGML

- Poincare Duality
  - Conversion from *k* D object → *3 – k* D objects

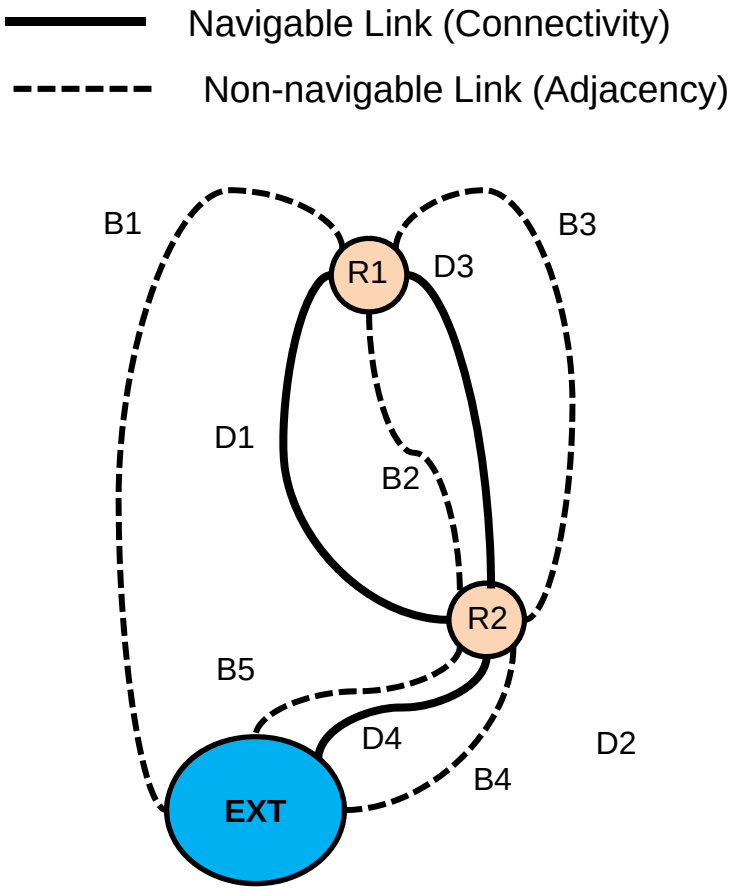


Space Model of IndoorGML - Example

Example: Wall and Door as Space Boundary



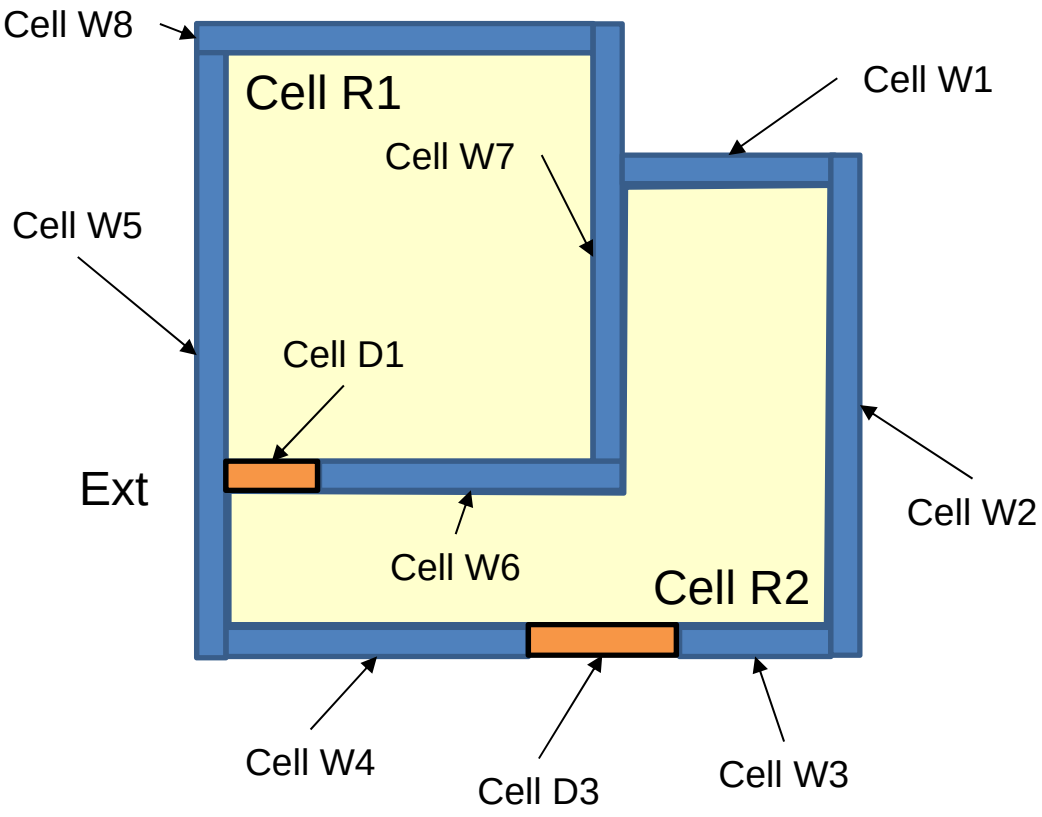
Topographic Space



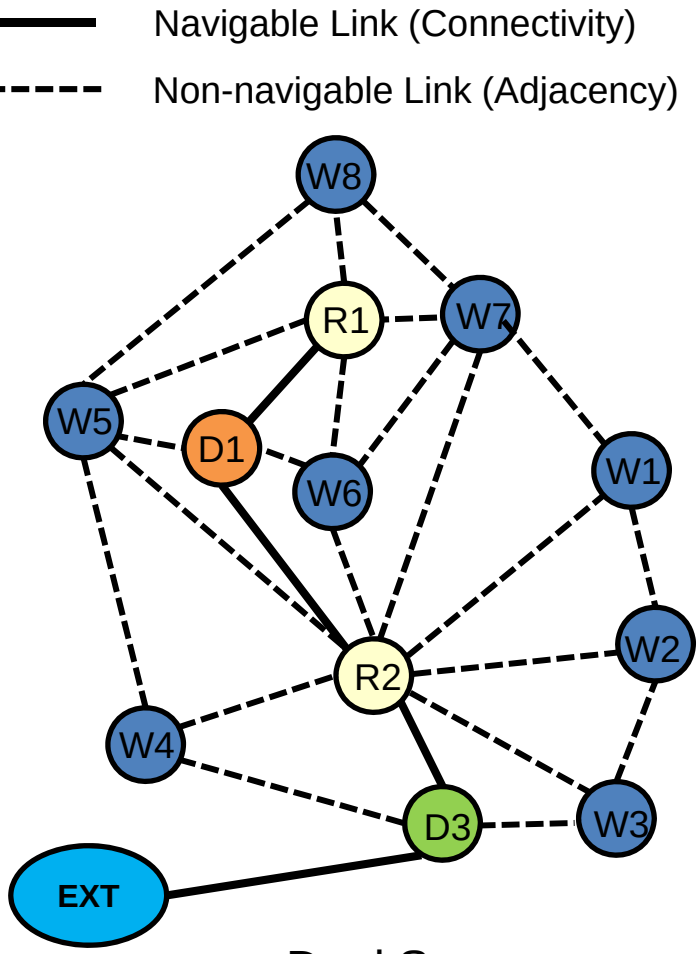
Dual Space

Space Model of IndoorGML - Example

Example: Wall and Door as Space



Topographic Space



Dual Space

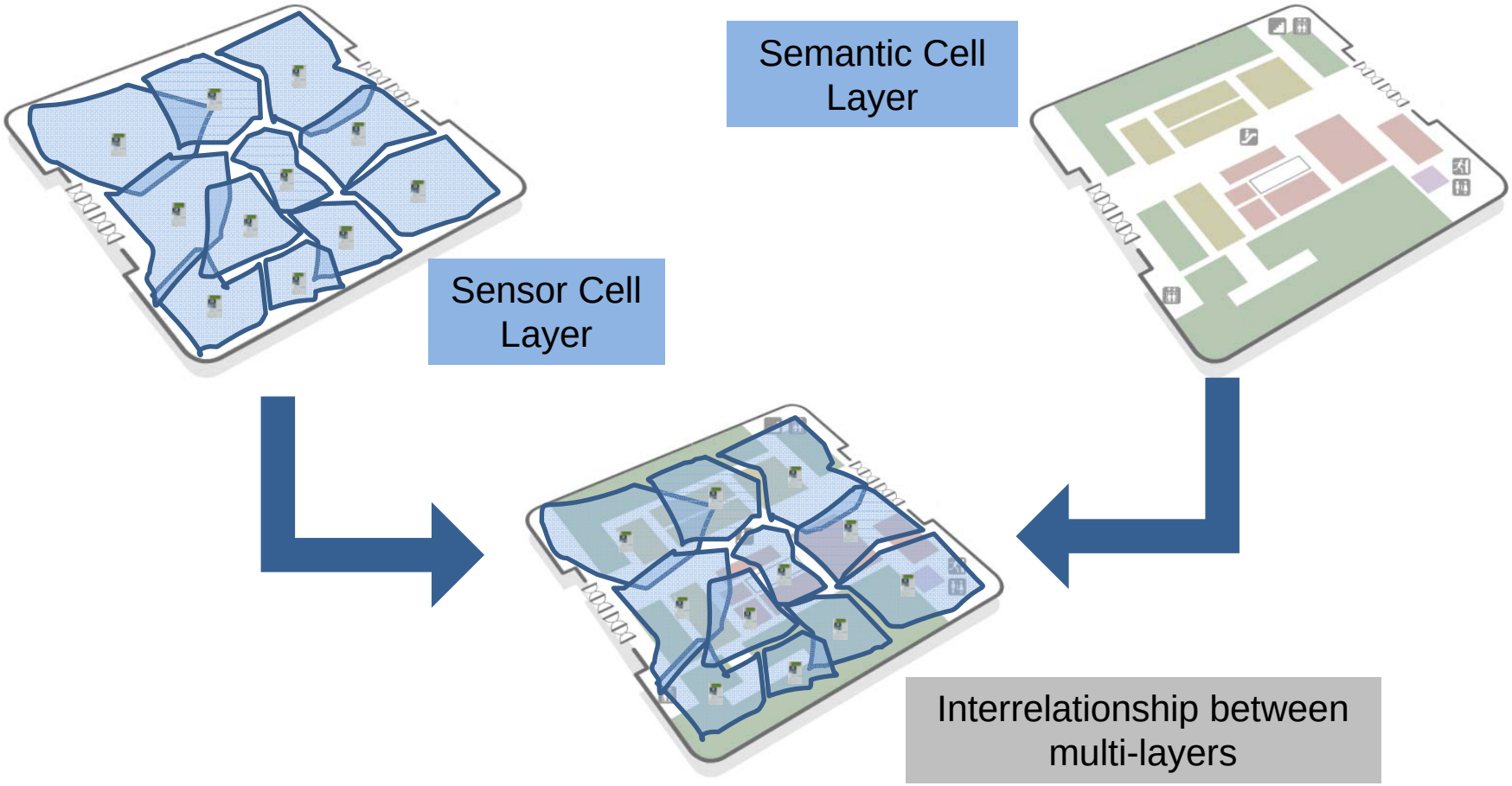
Symbolic space and topology

- **Symbolic Space:**
  - Location is identified by Symbolic Code of Cell (e.g. Room Number)
  - Topology is mandatory
  - Geometry is optional

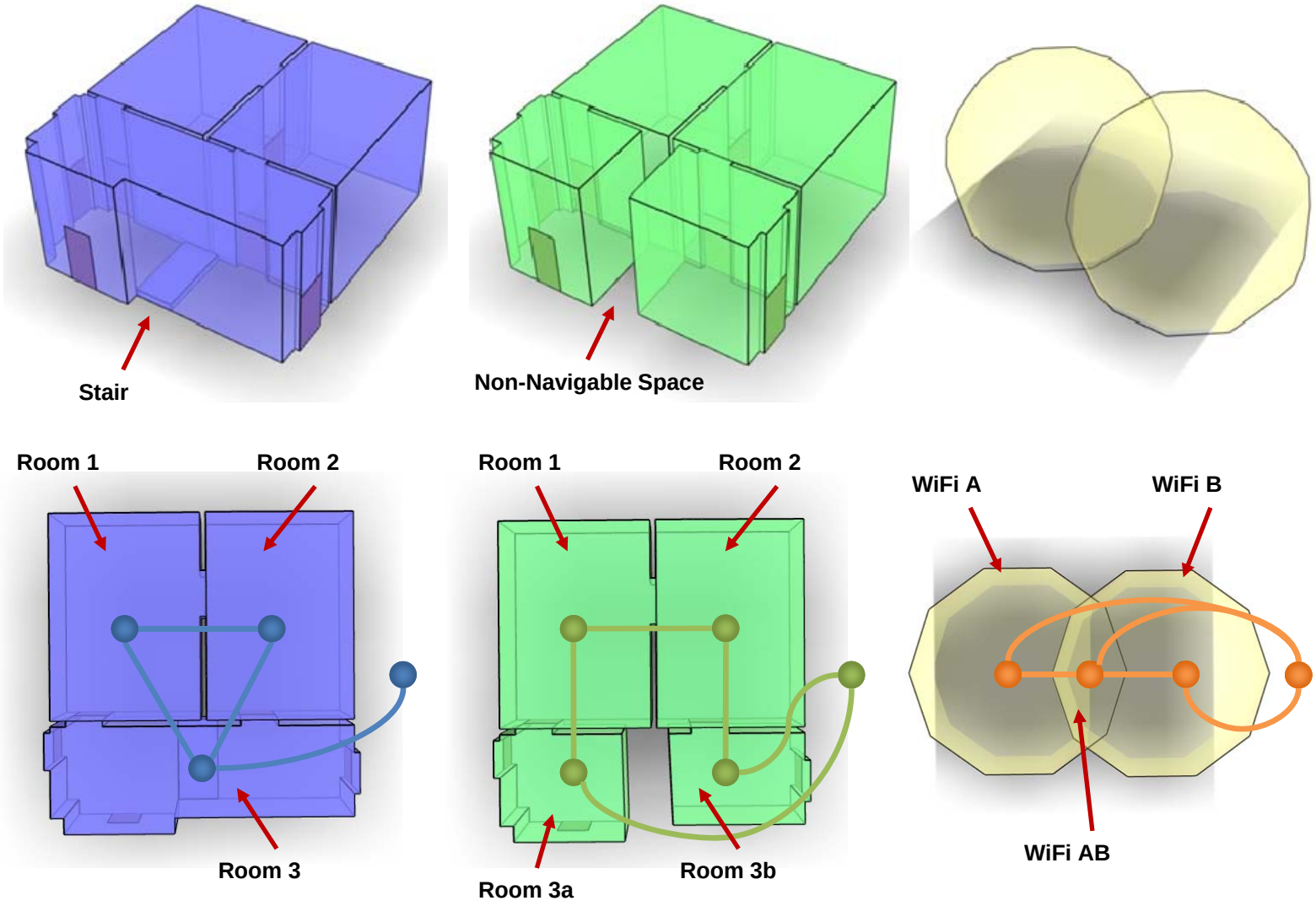
- **Indoor Symbolic Space**:
  - Represented by geometryc graph
    $G = (V, E)$
    $V = \{ n \mid n = (c_{ID}, p, attr), c_{ID}$: cell ID, p: representative point of $c_{ID} \}$
    $E = \{ (n_s, n_e, attr) \mid attr$: distance $\}$

Multiple-Layered Space Model

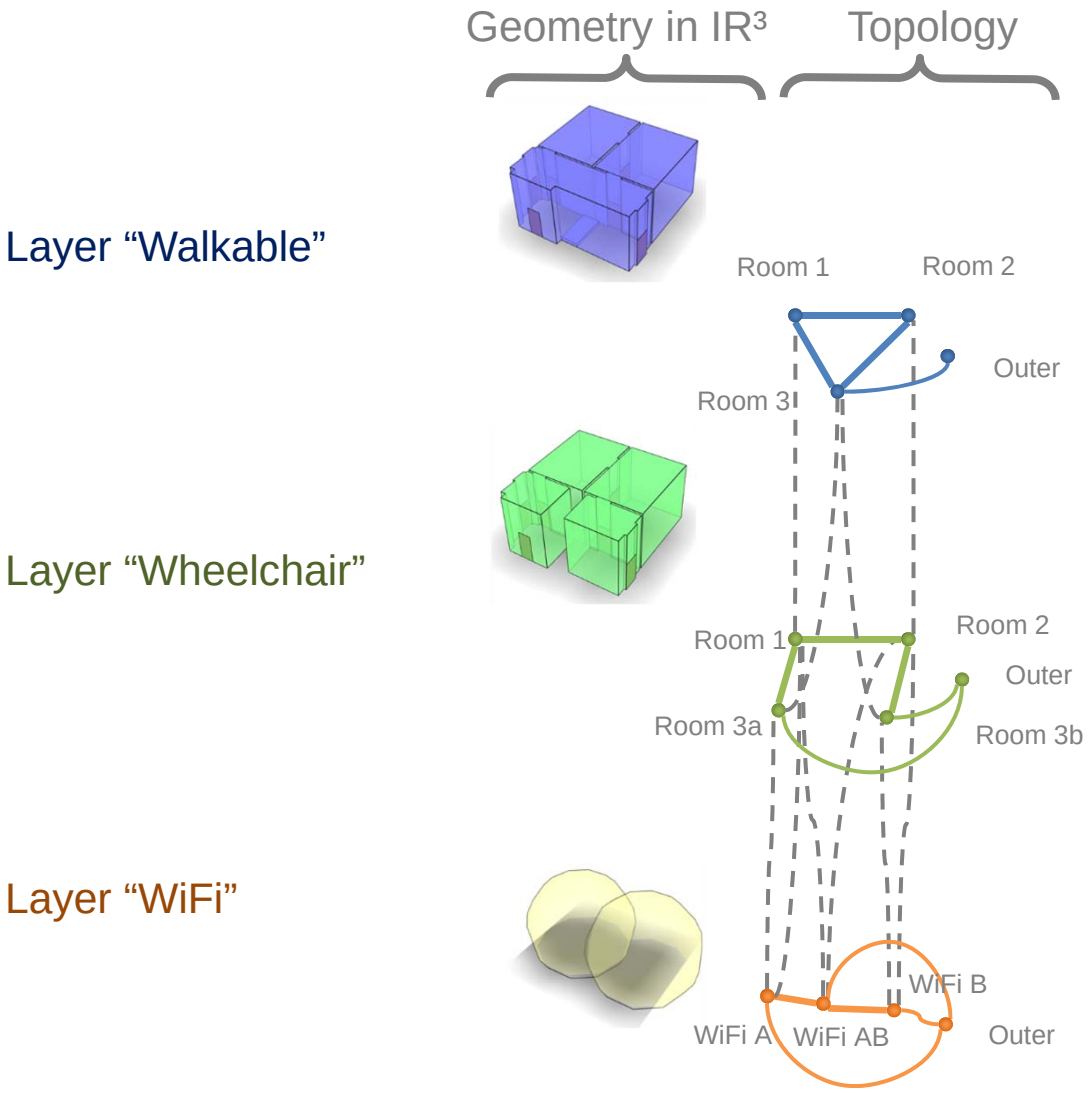
- An given indoor space is interpreted for several purposes



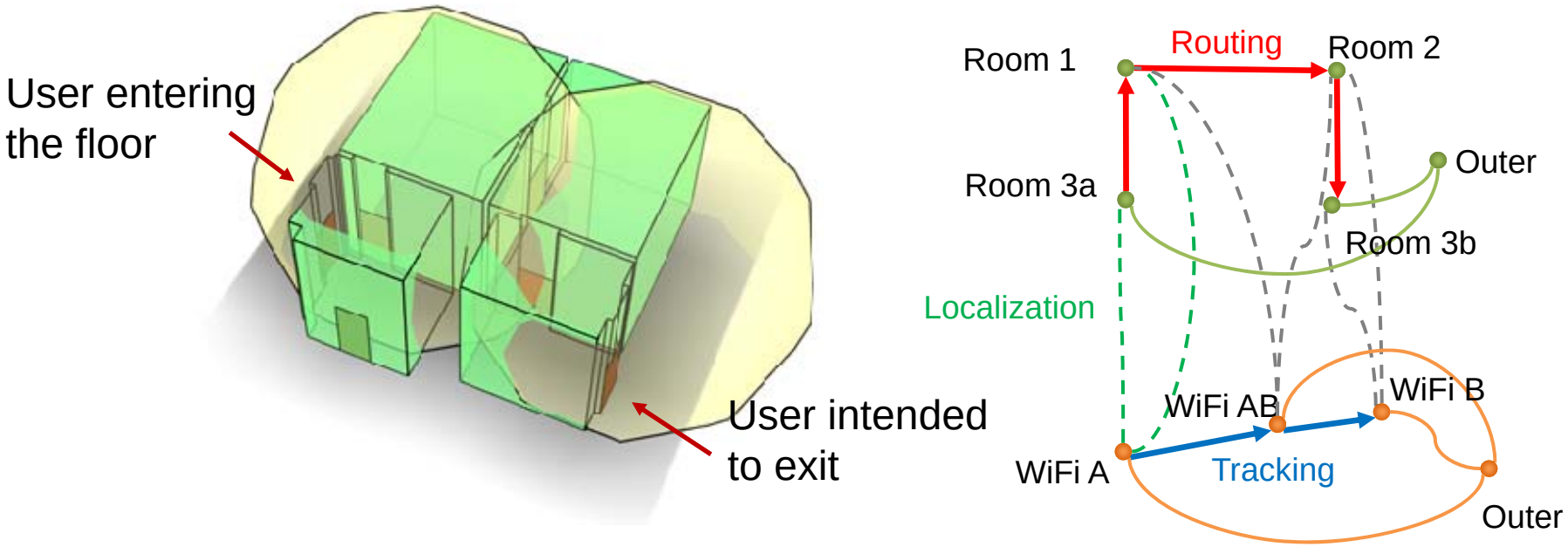
Example – Multi-Layered Space



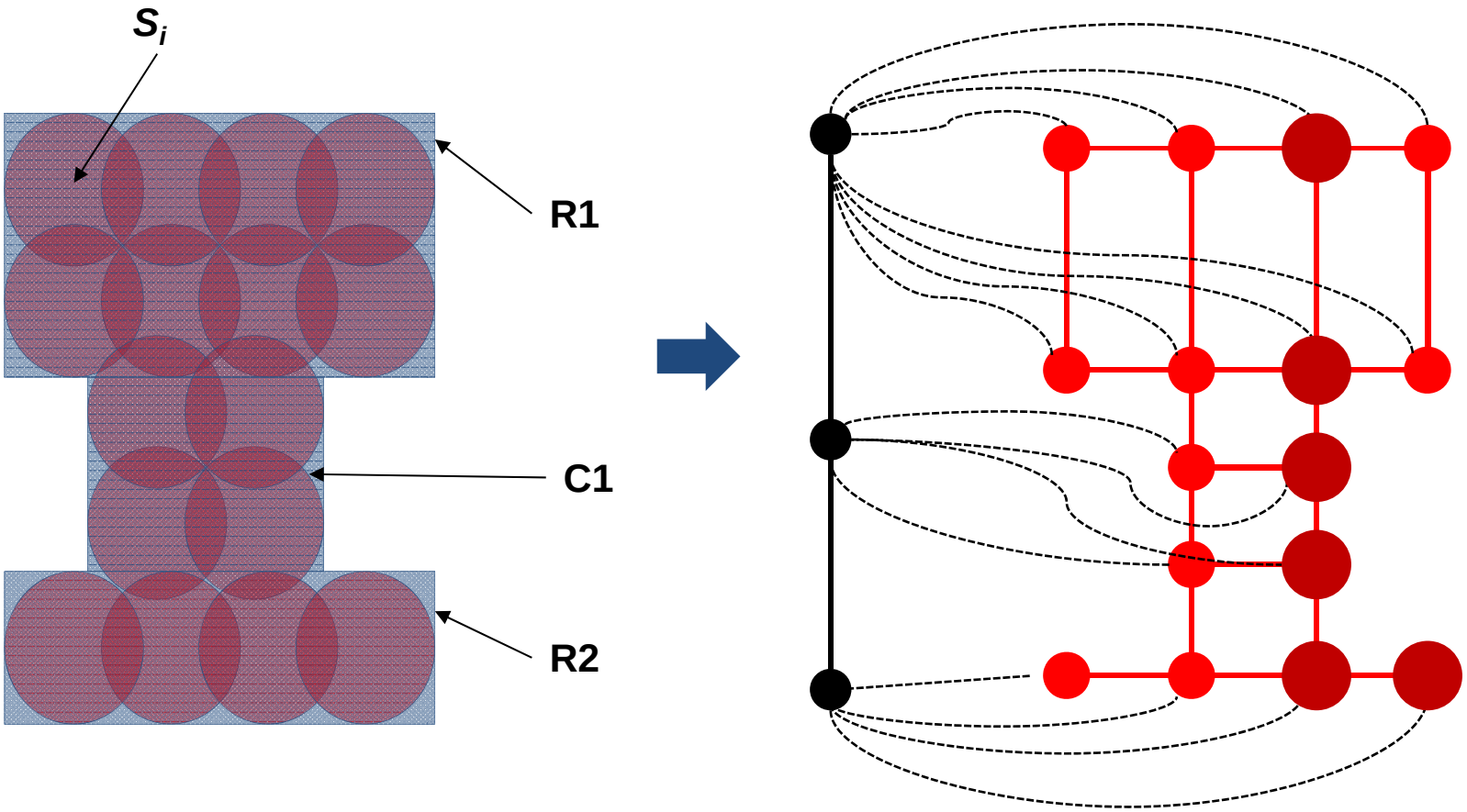
Example – Multi-Layered Space



Example – Multi-Layered Space



Example - Sensor deployment and tracking

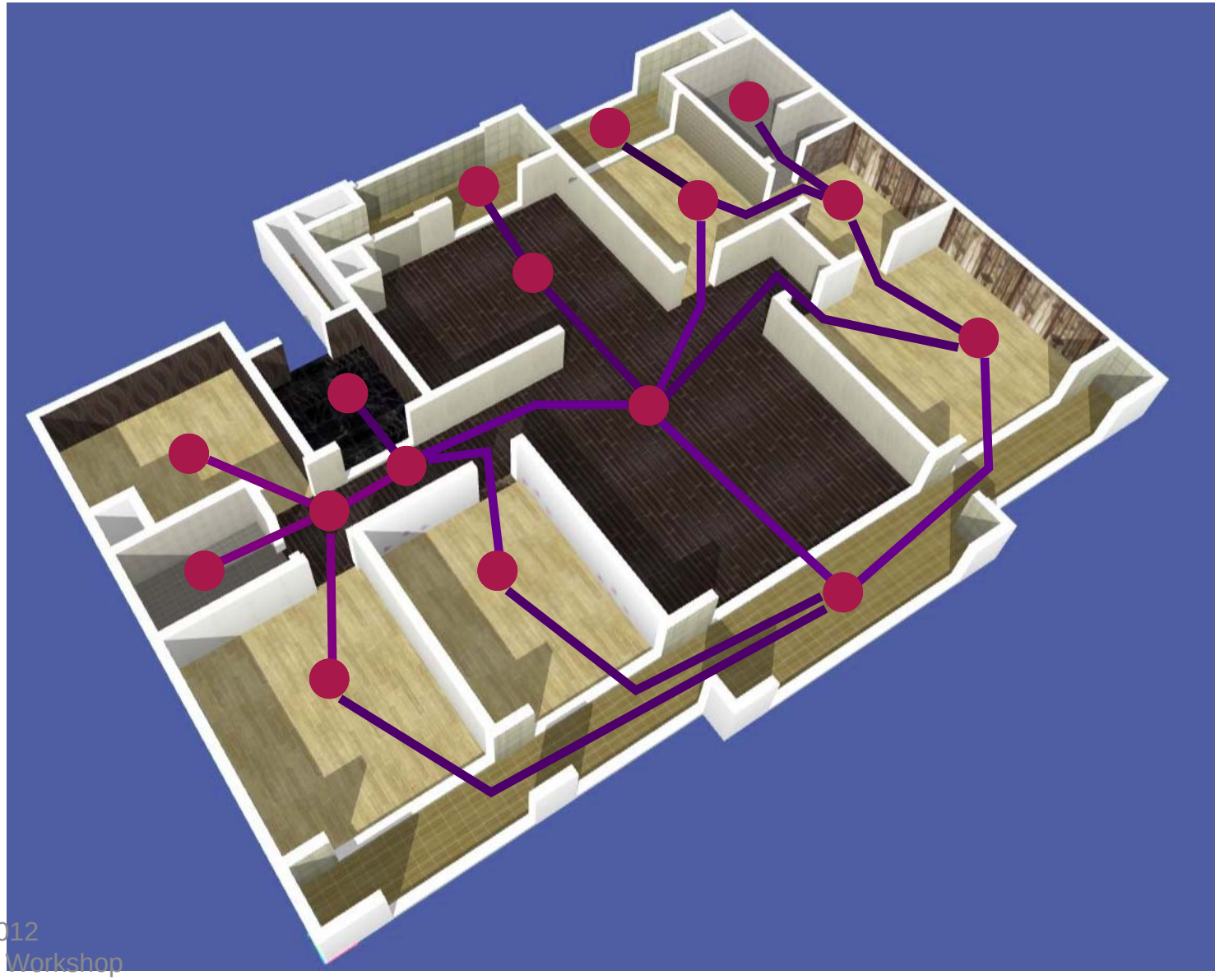


R1 → C1 → R2

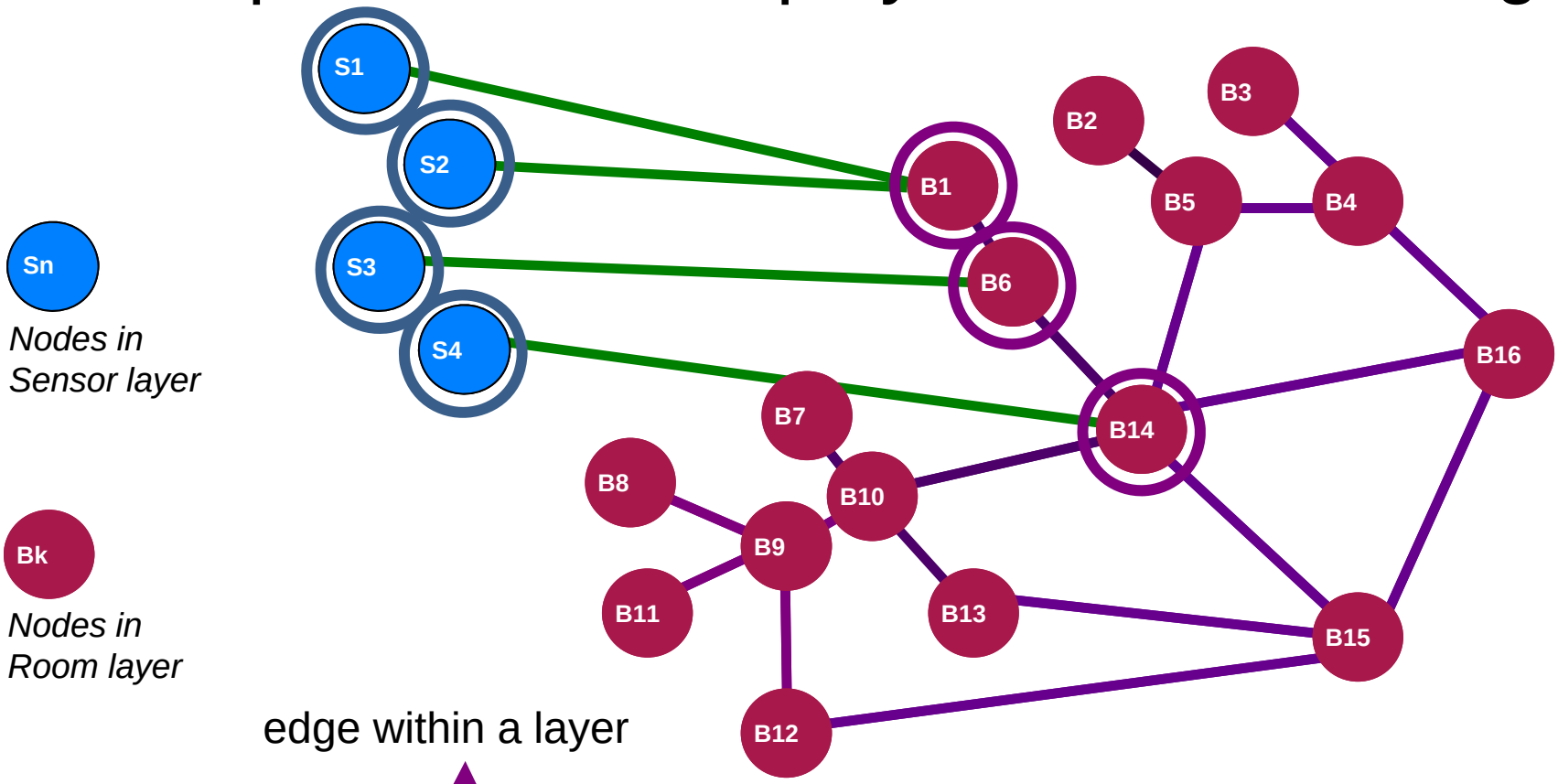
Example – Type of Positioning Sensor

- Point Sensor (or Coordinate Sensor)
  - Gives (x, y, z) coordinates
  - e.g. GPS, WPS
- Presence Sensor
  - Determines whether it is on a sensor coverage or not
  - e.g. RFID
- Indoor Map Matching
  - $F(p) = c$ (c is cellular number)
  - Mapping from (x, y, z) to cellular number

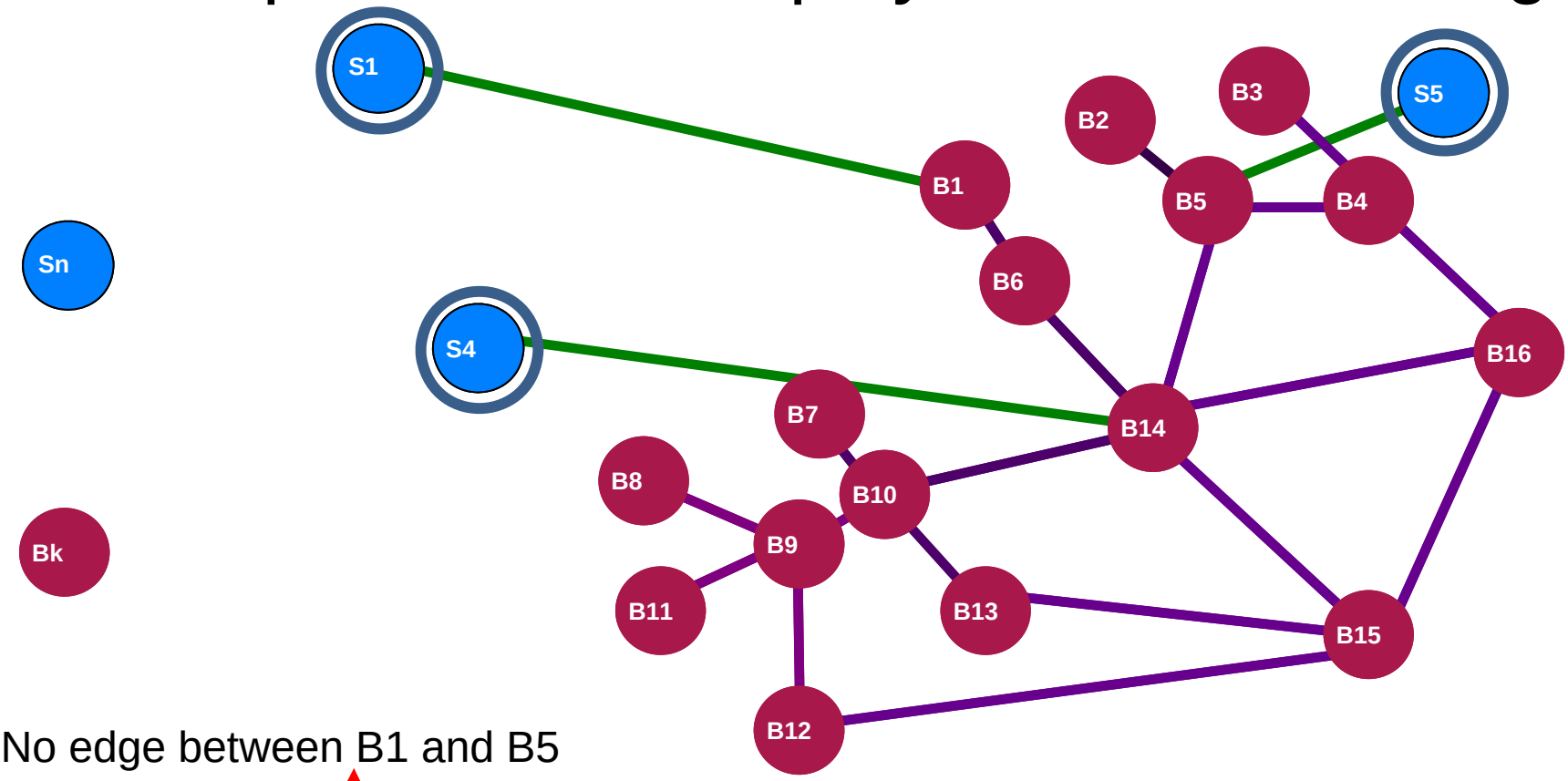
Example - Sensor deployment and tracking



Example - Sensor deployment and tracking



Example - Sensor deployment and tracking

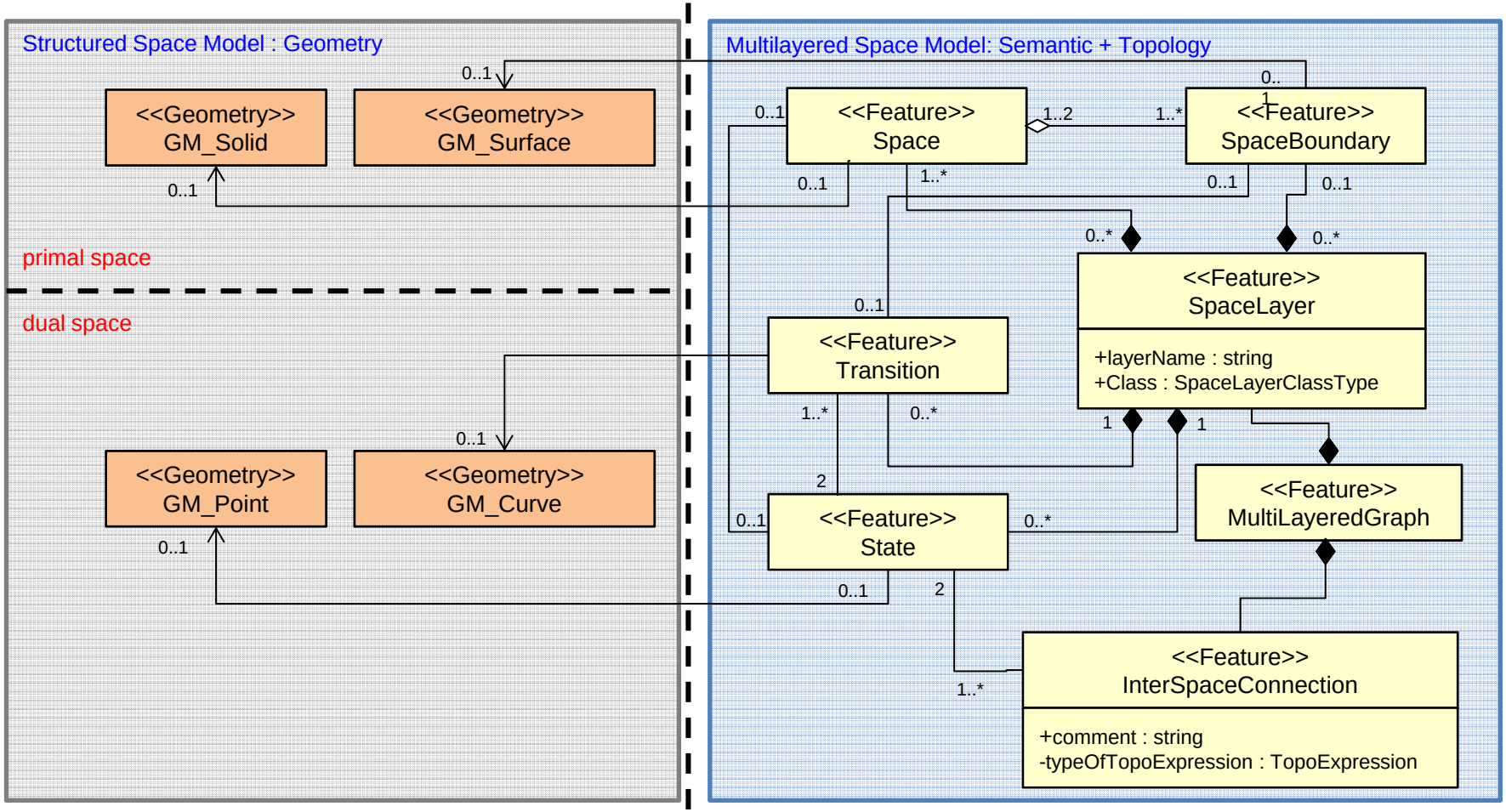


No edge between B1 and B5

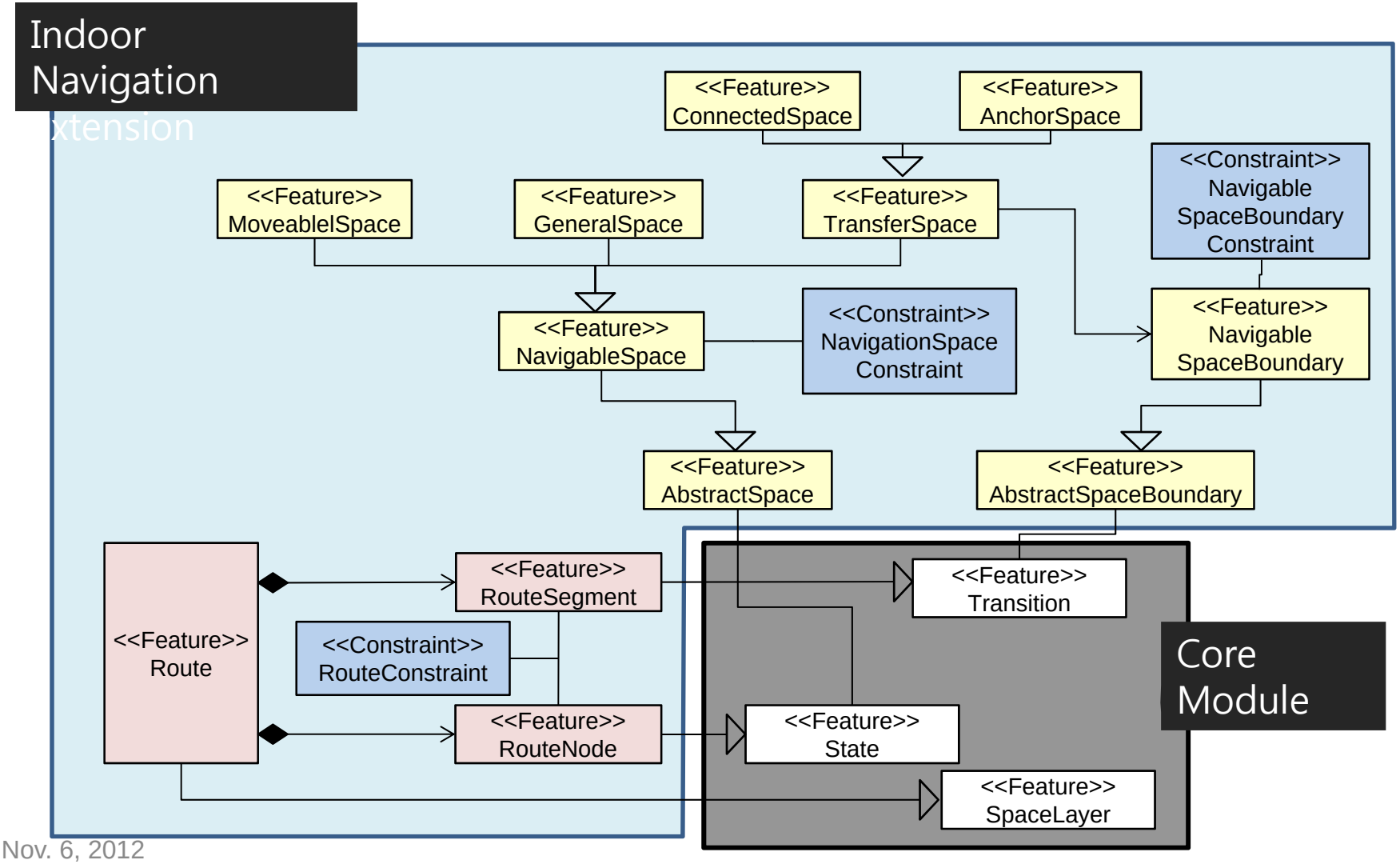
$(S_1 \rightarrow B_1) \rightarrow (S_5 \rightarrow B_5) \rightarrow (S_4 \rightarrow B_{14})$ **Something wrong**

$(S_1 \rightarrow B_1) \rightarrow (B_6) \rightarrow (S_4 \rightarrow B_{14})$ **or** $(B_2) \rightarrow (P_2 \rightarrow B_5) \rightarrow (P_3 \rightarrow B_{14})$

Data Model of IndoorGML – Geometric Graph



IndoorGML – Core Module and Extensions



IndoorGML –Example of multi-layered model

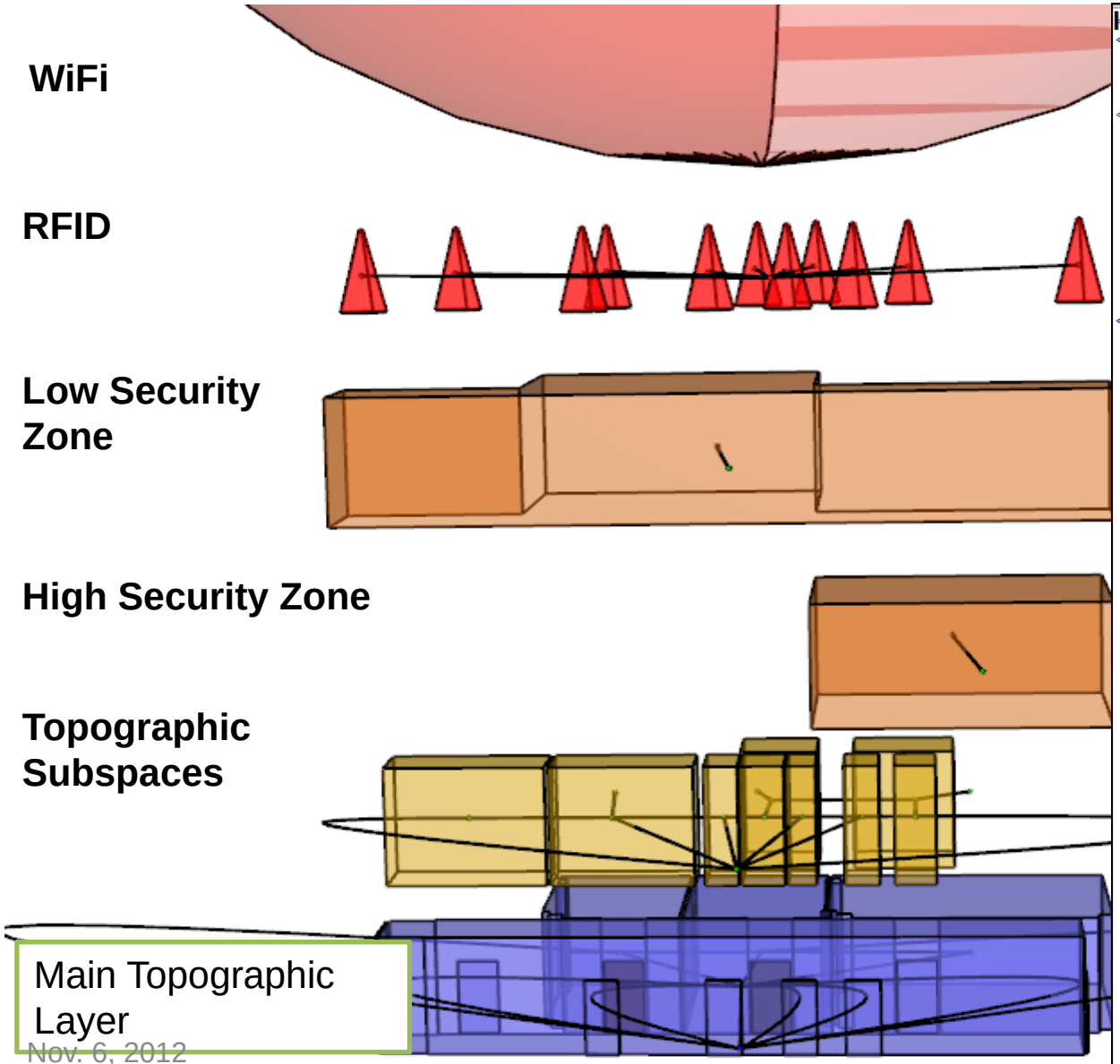
WiFi

RFID

Low Security Zone

High Security Zone

Topographic Subspaces



Main Topographic Layer

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  xsi:schemaLocation="http://www.tu-berlin.de/indoorml/0.
  xmlns:xlink="http://www.w3.org/1999/xlink" xmlns:gml="h
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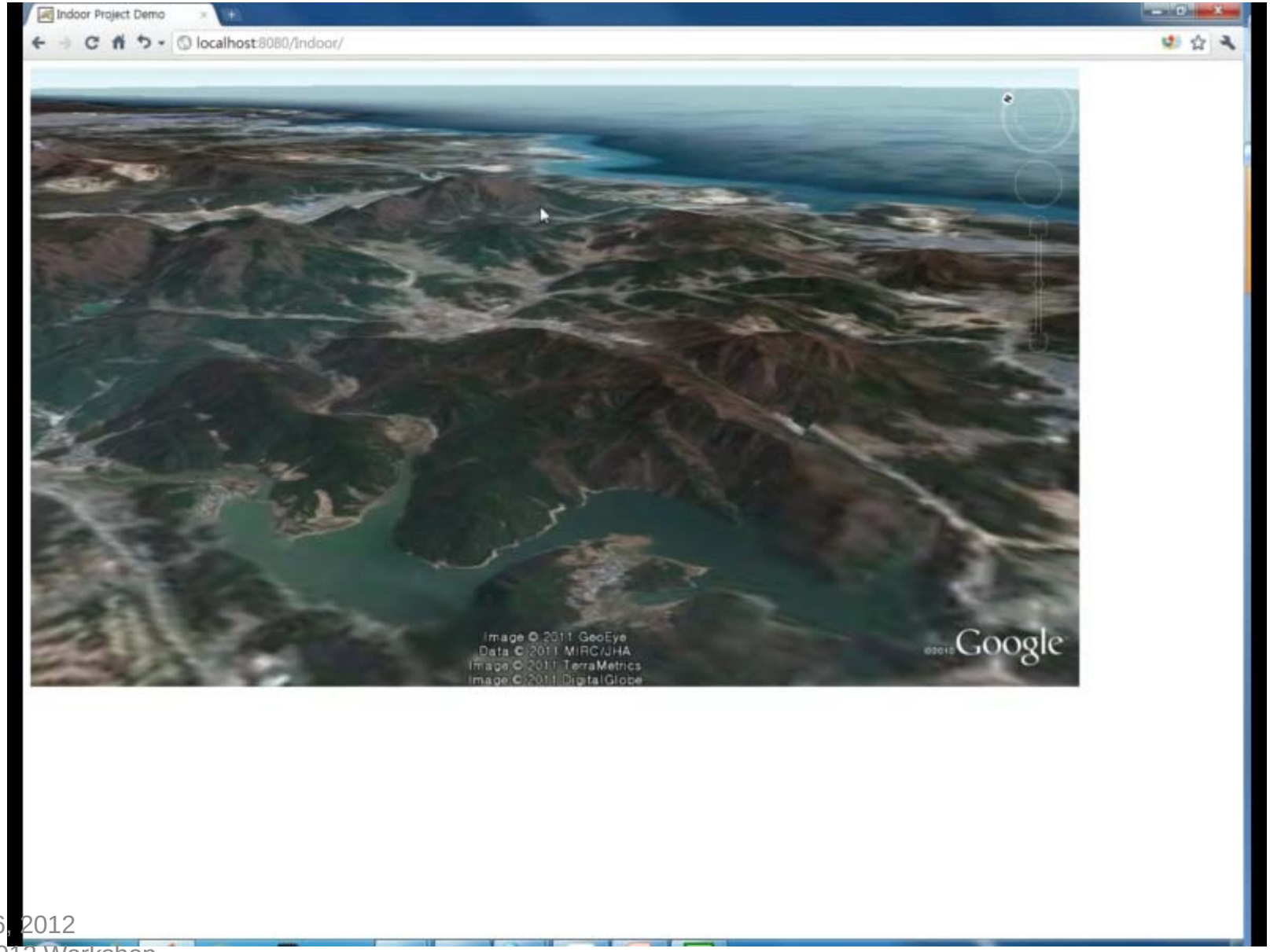
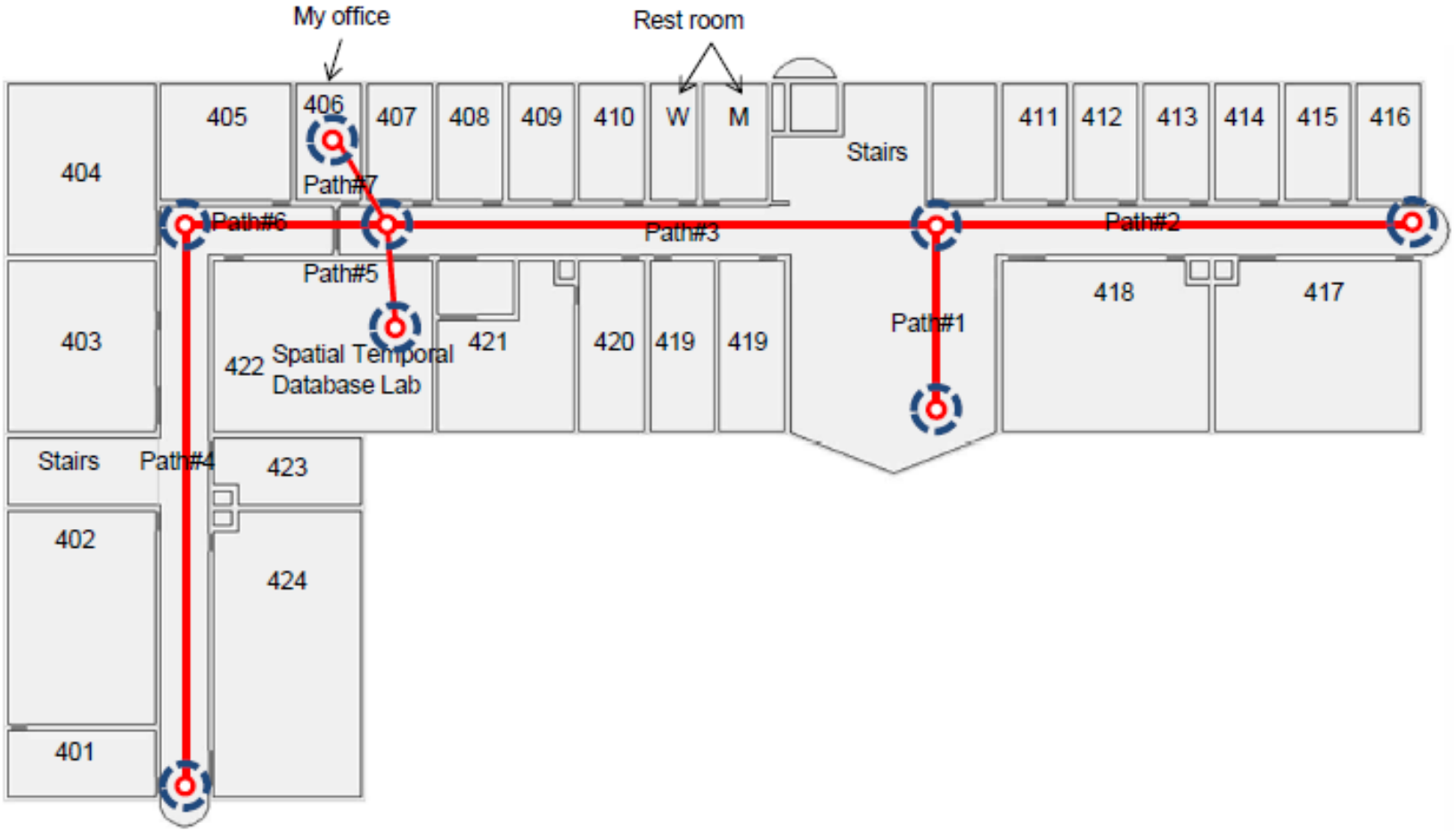
CityGML and IndoorGML

Examples – Browsing indoor map

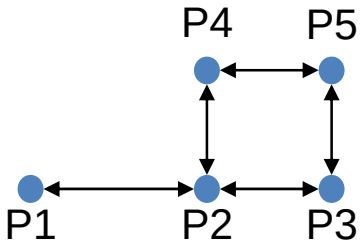


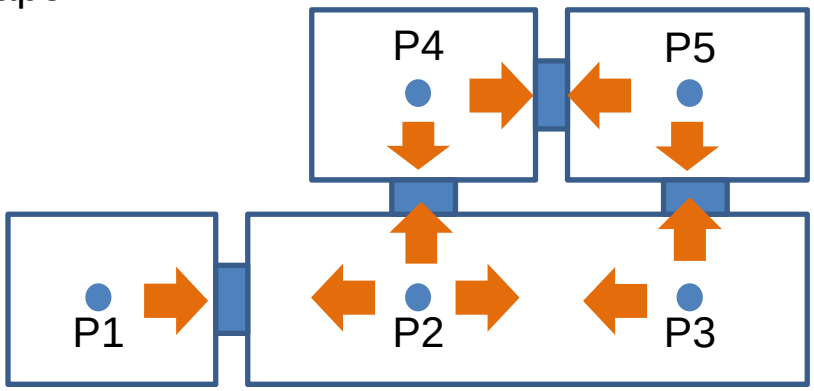
Examples – Browsing indoor map

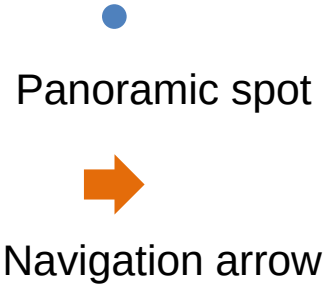


Examples – Panoramic images and IndoorGML

EveryScape



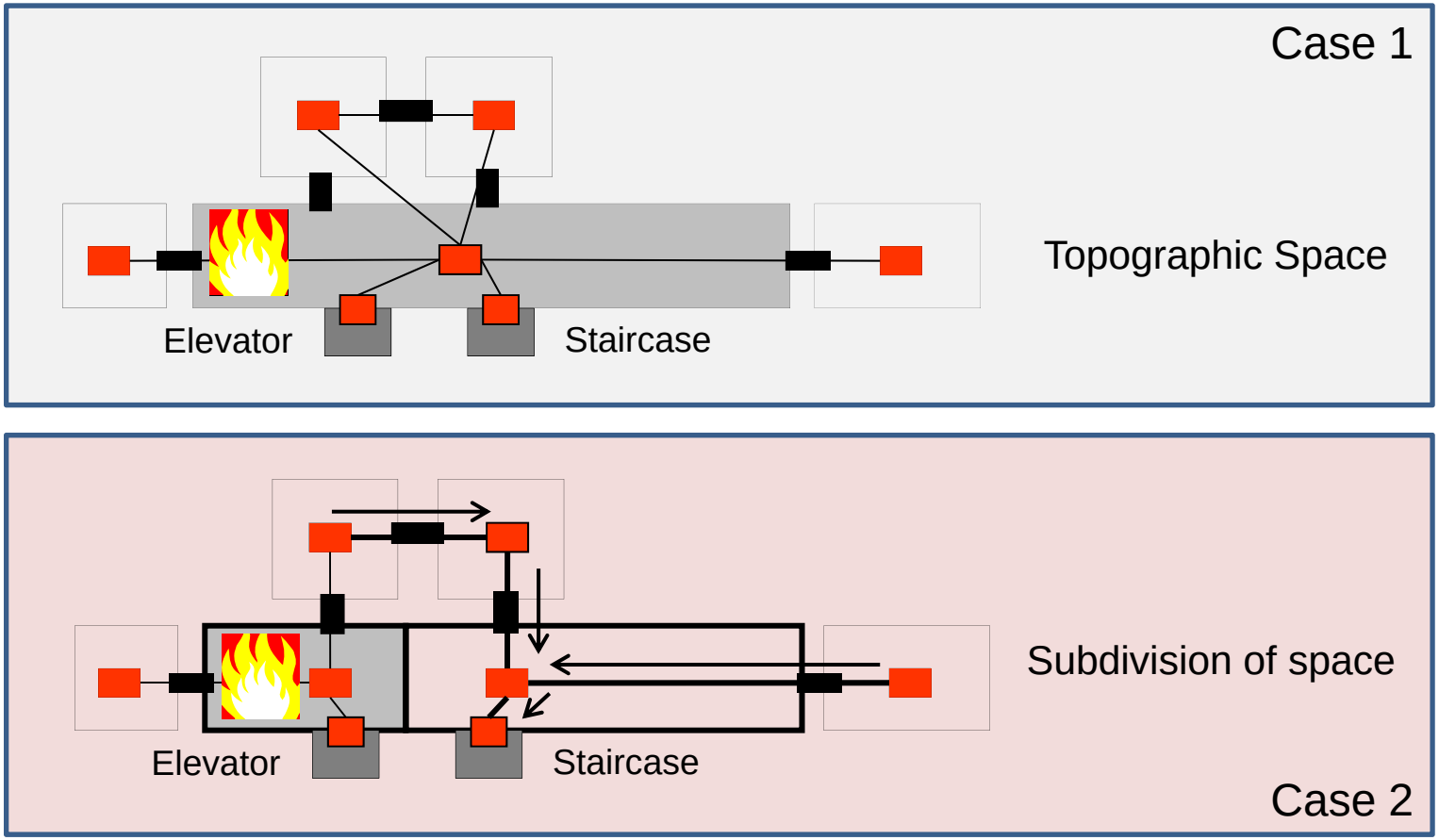




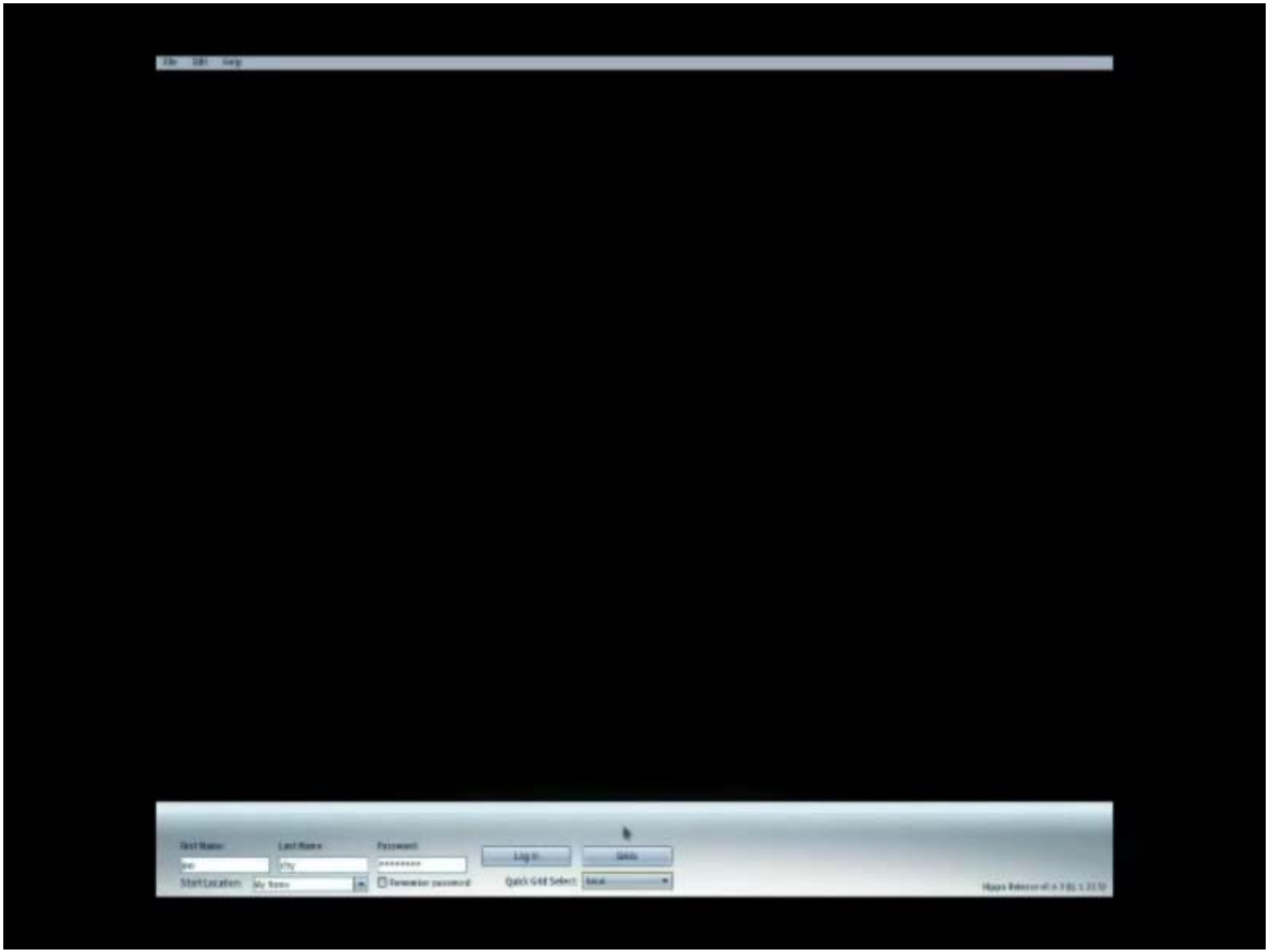
Issues

- Node and Edge definition
- Space subdivision
- Extension for Robotics
- or for Ships, why not?

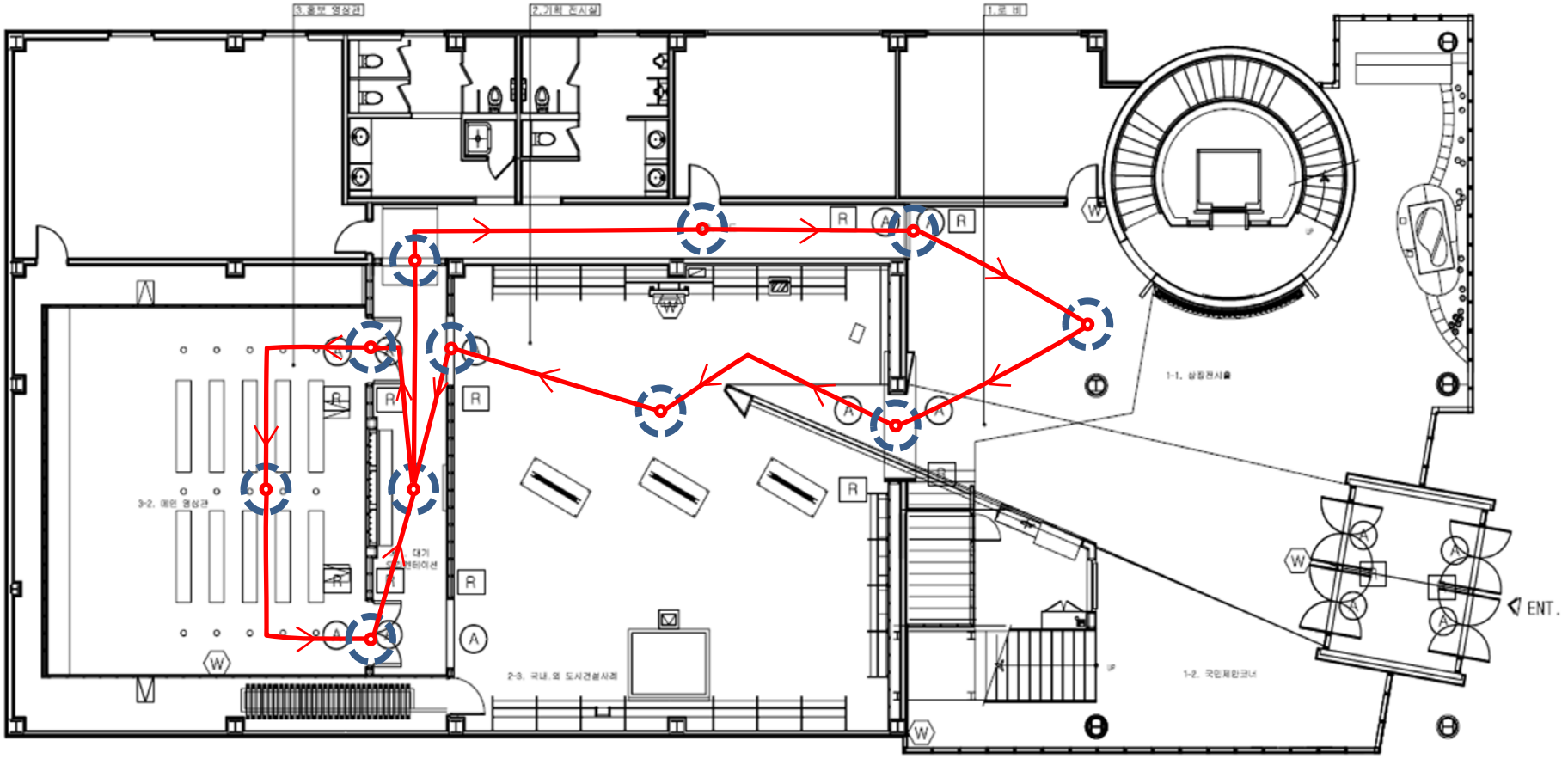
Space Subdivision – Another Example



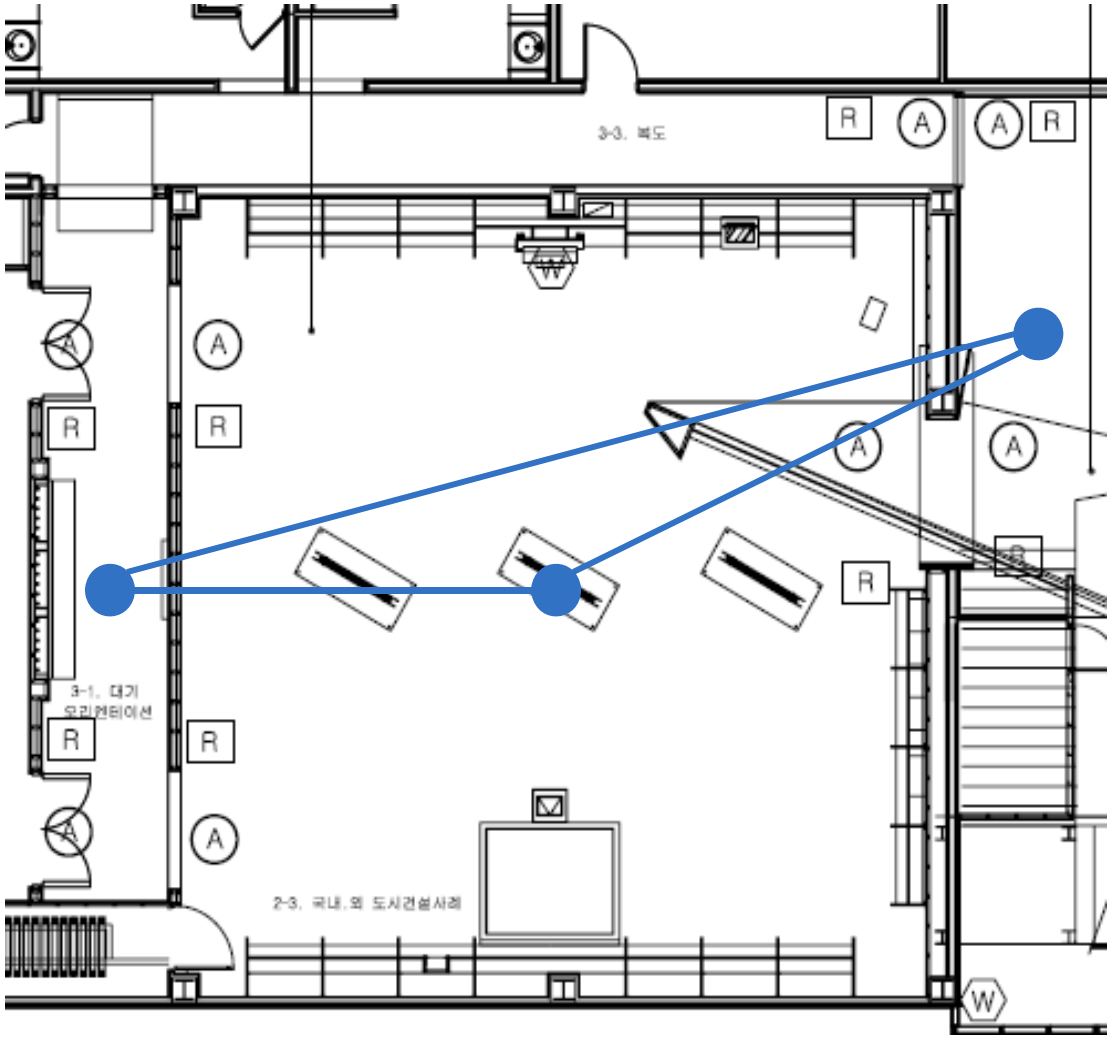
Examples – Avatar movement in indoor space



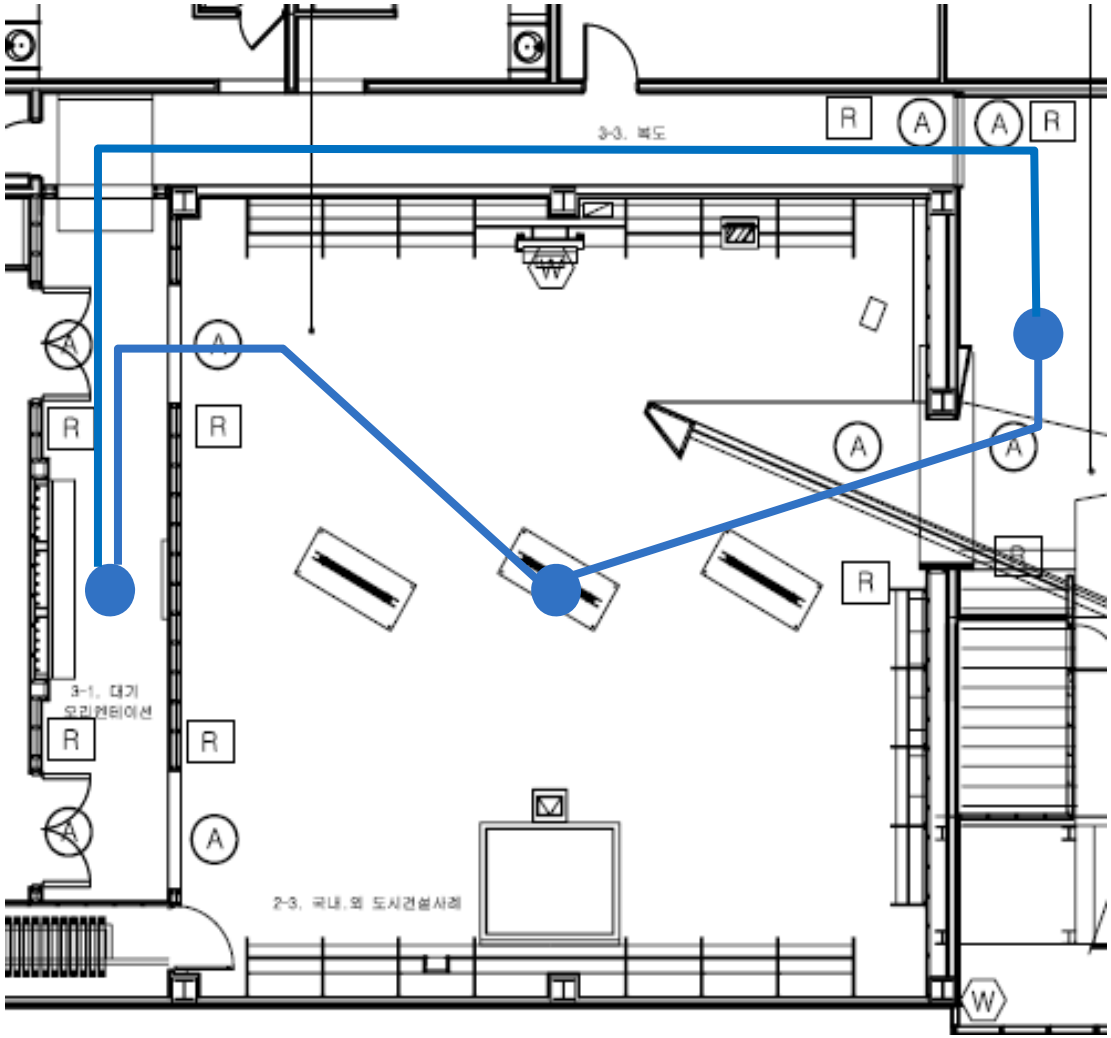
Examples – Avatar movement in indoor space



Issues – Node and edge definition



Issues – Node and edge definition



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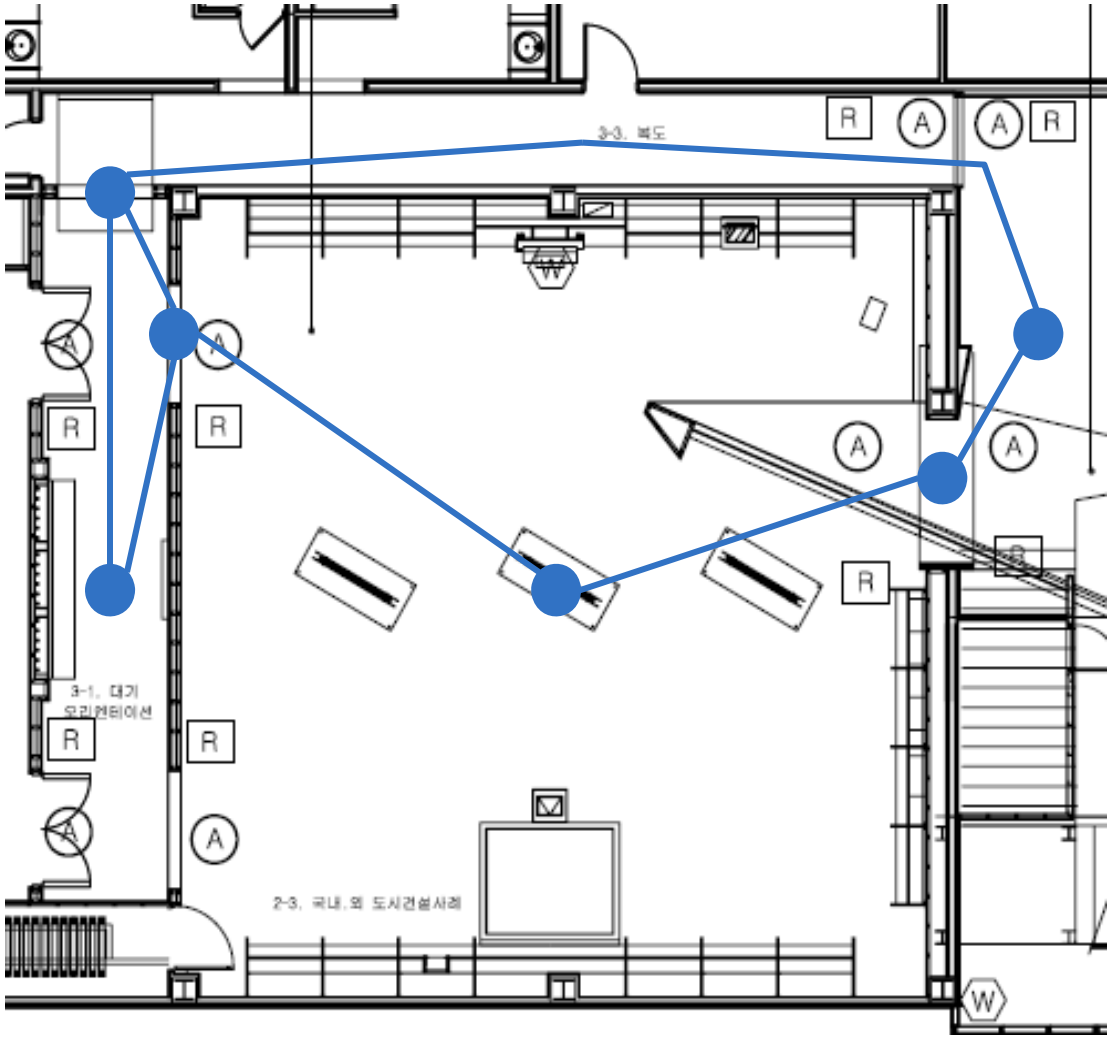

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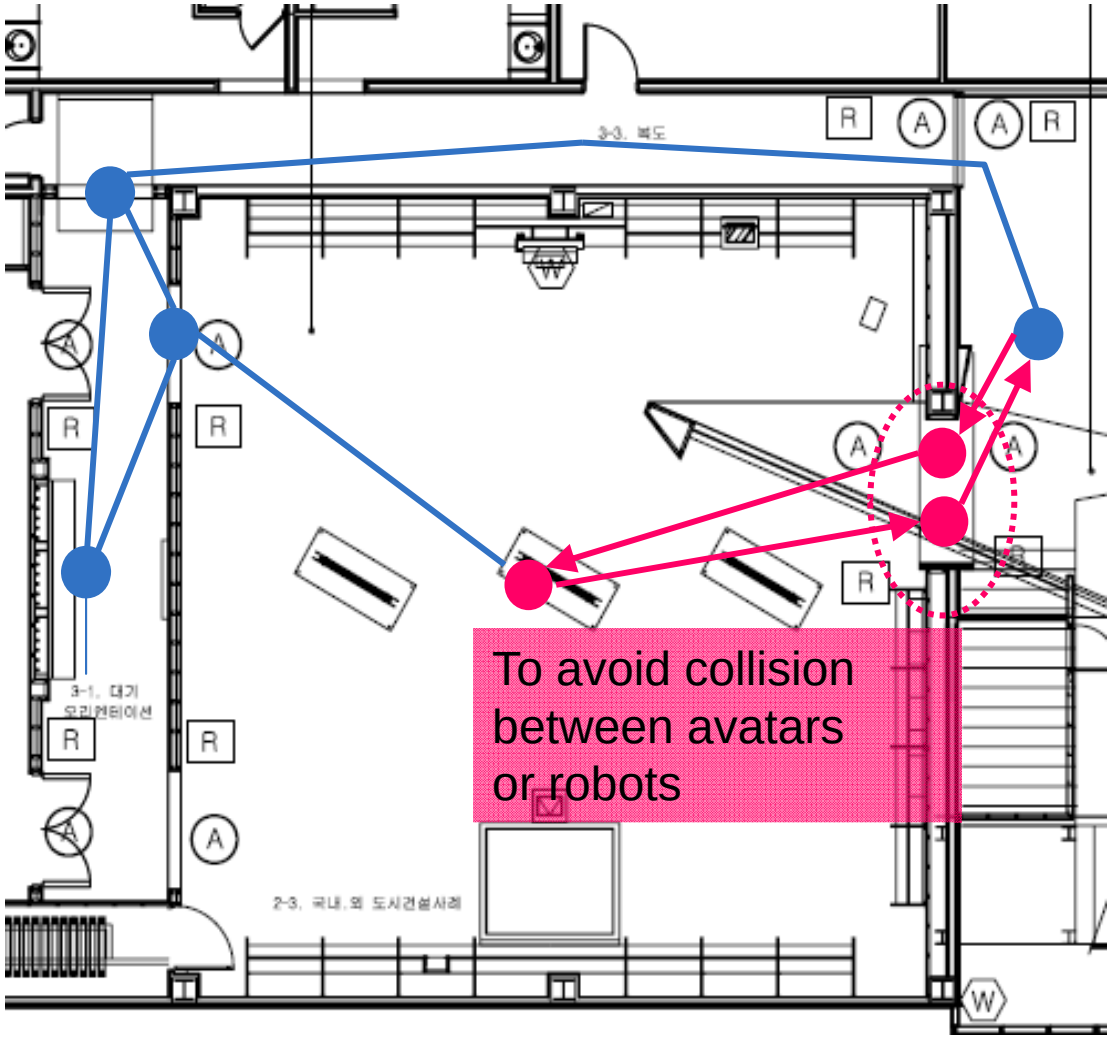
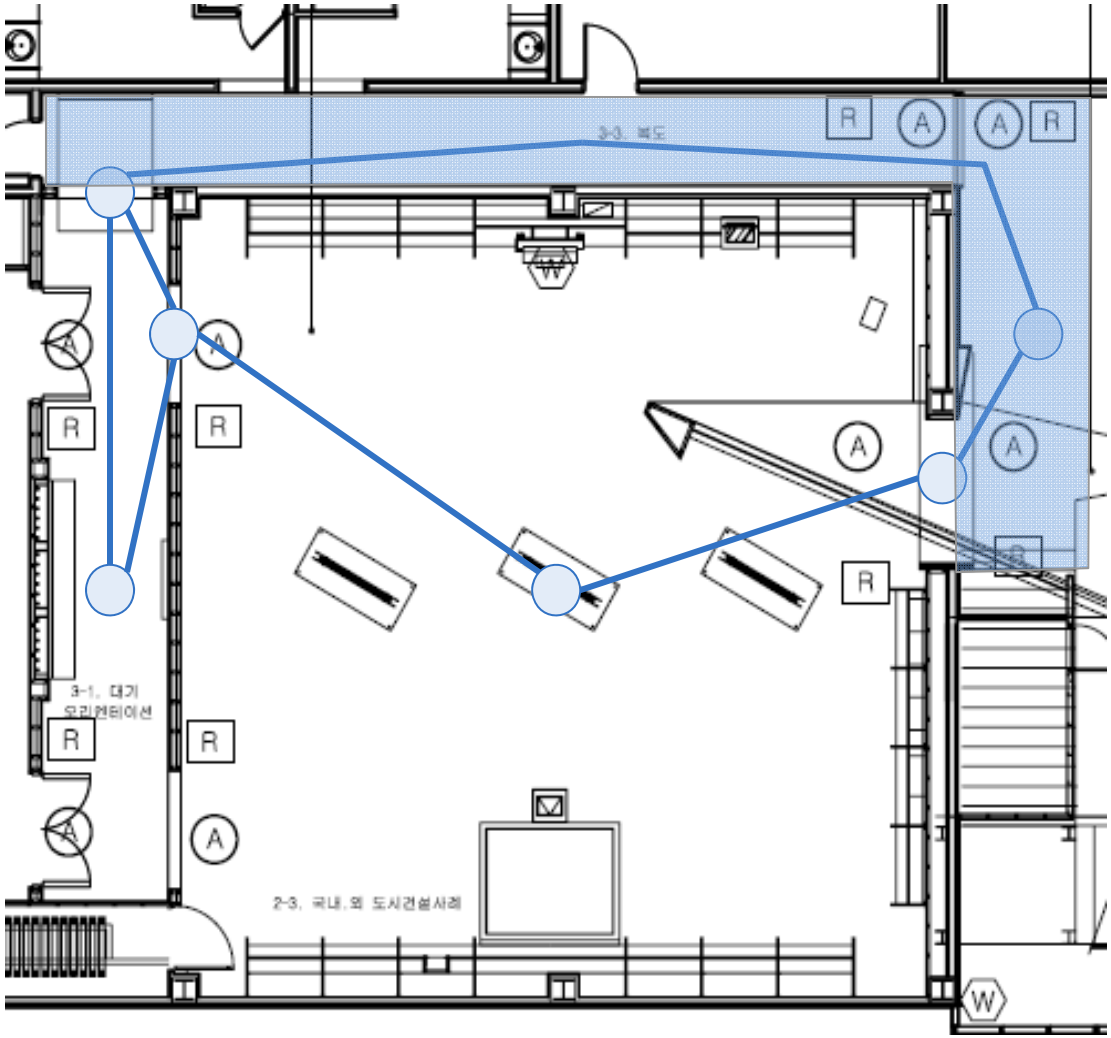


Issues – Space Subdivision



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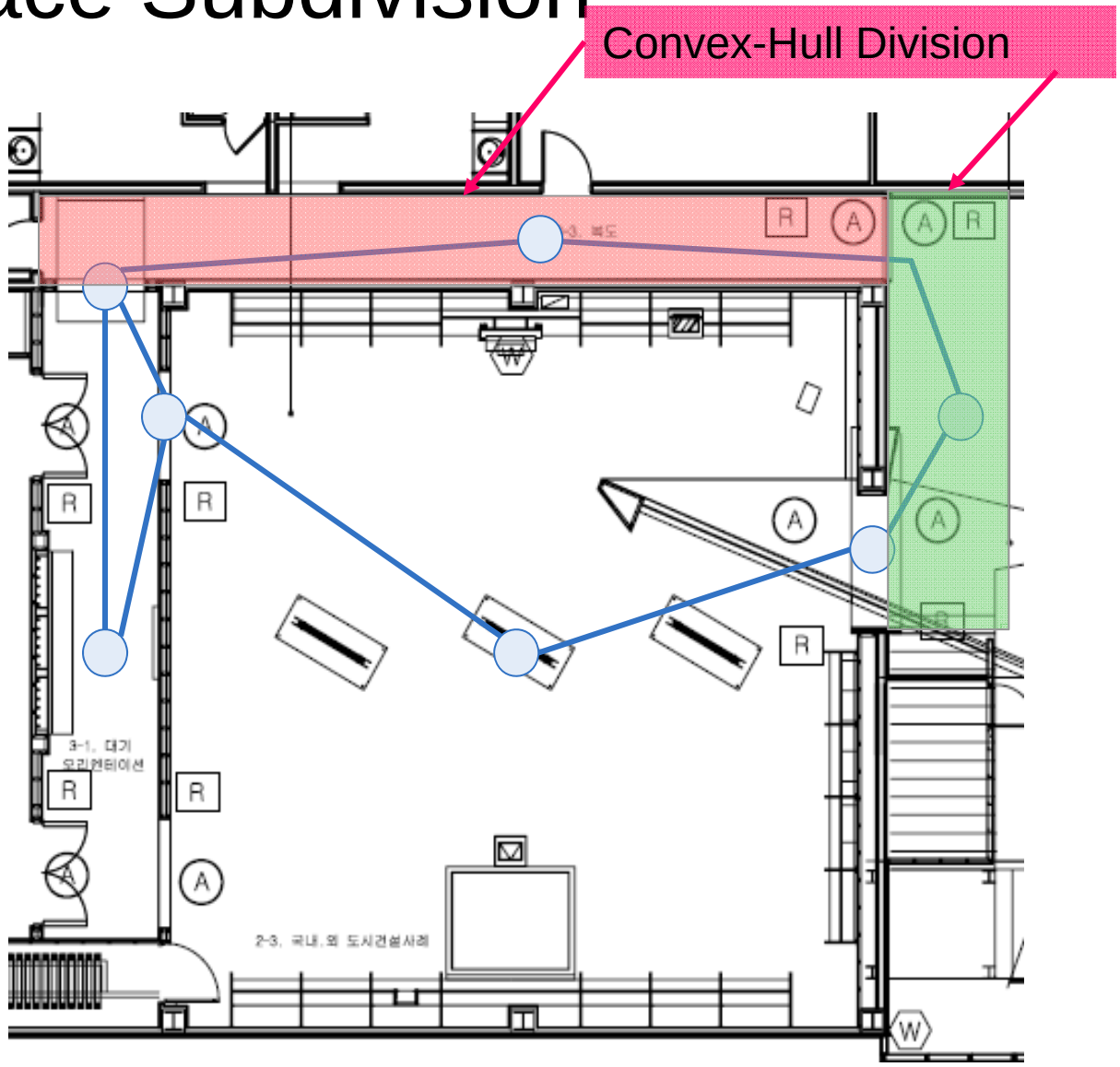
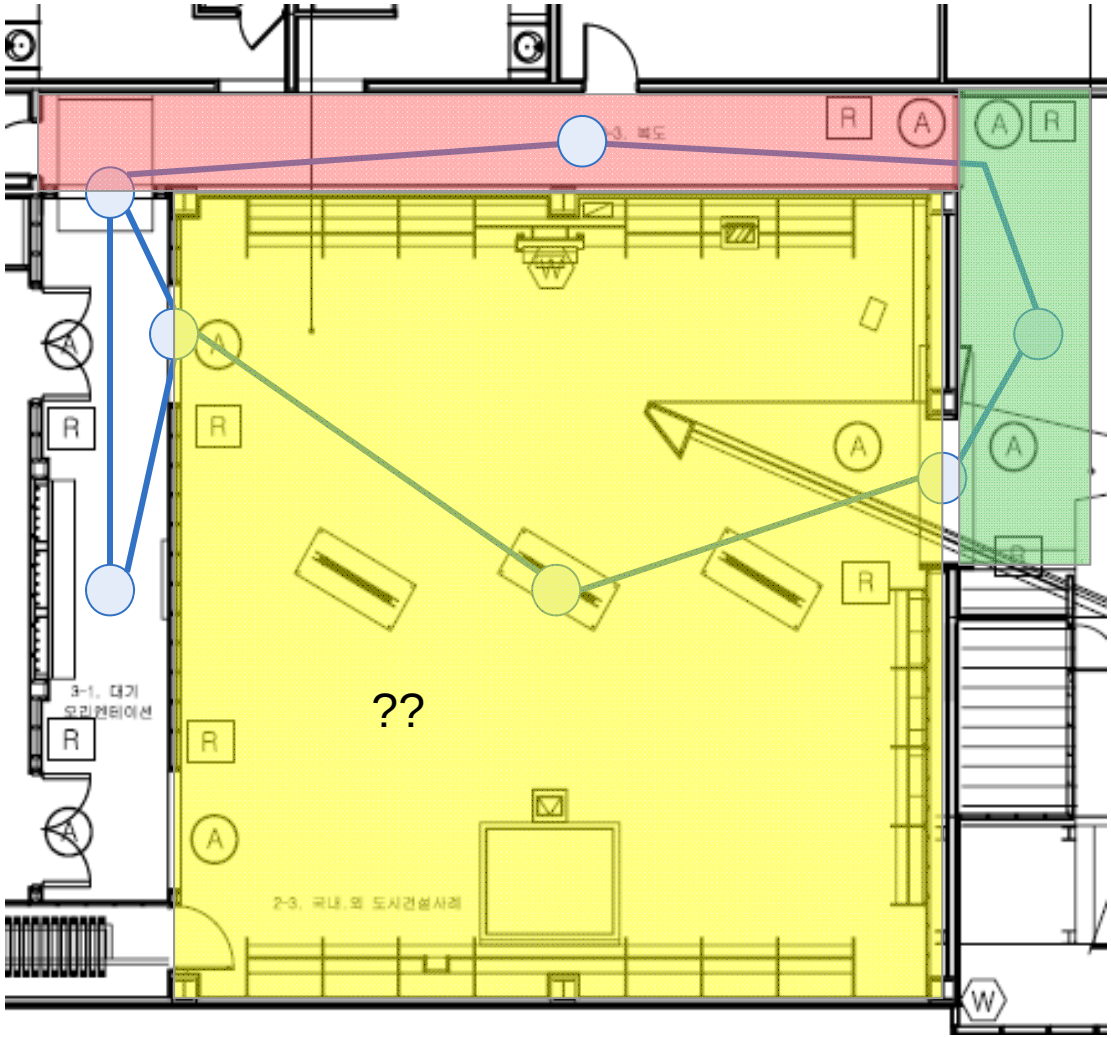
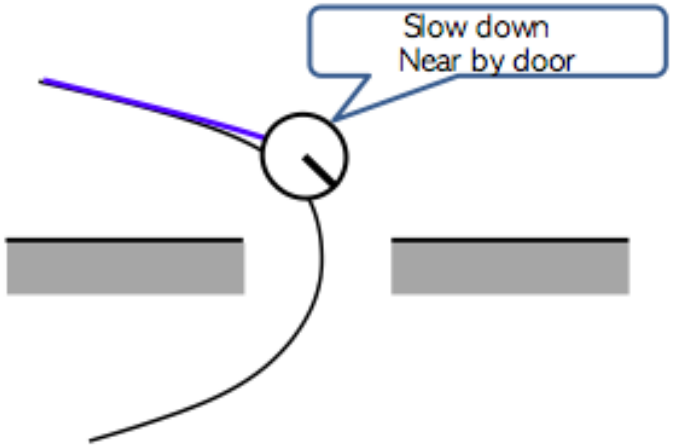
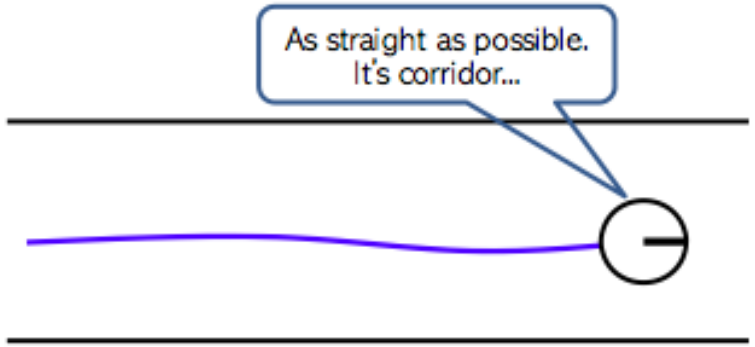


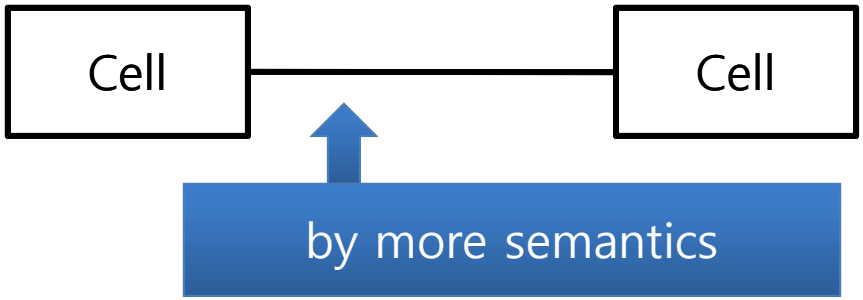
Issues – Space Subdivision

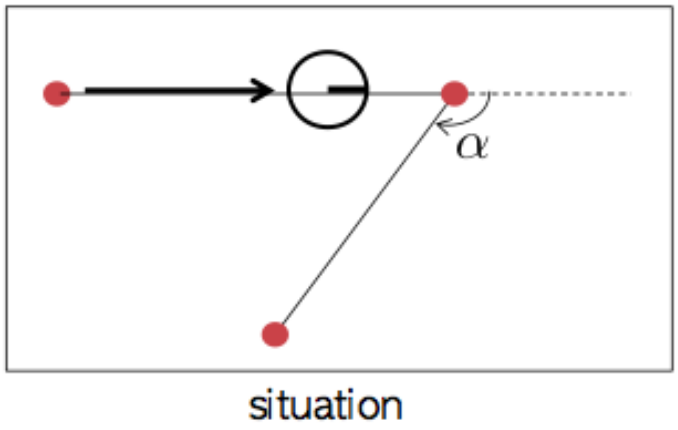


For More Natural Movements of Robots









In a Cruise

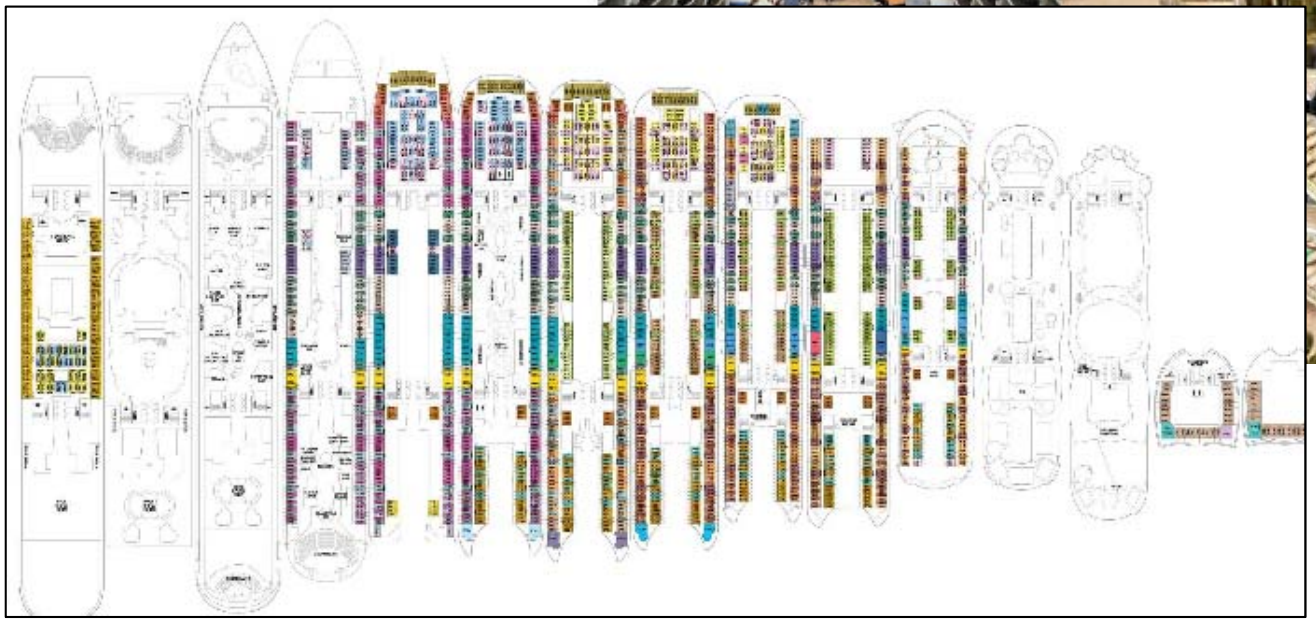
Source: cruises.priceline.com

Source: ship-illustration.com

Oasis of the Seas

- Gross Tonnage: 220,000
- Length: 1,184 feet
- Beam: 154 feet
- No. of Decks: 16
- Hosts : up to 5,400 guests
- Crews: 1,800
- No. of Rooms: 2,700

In a Cruise

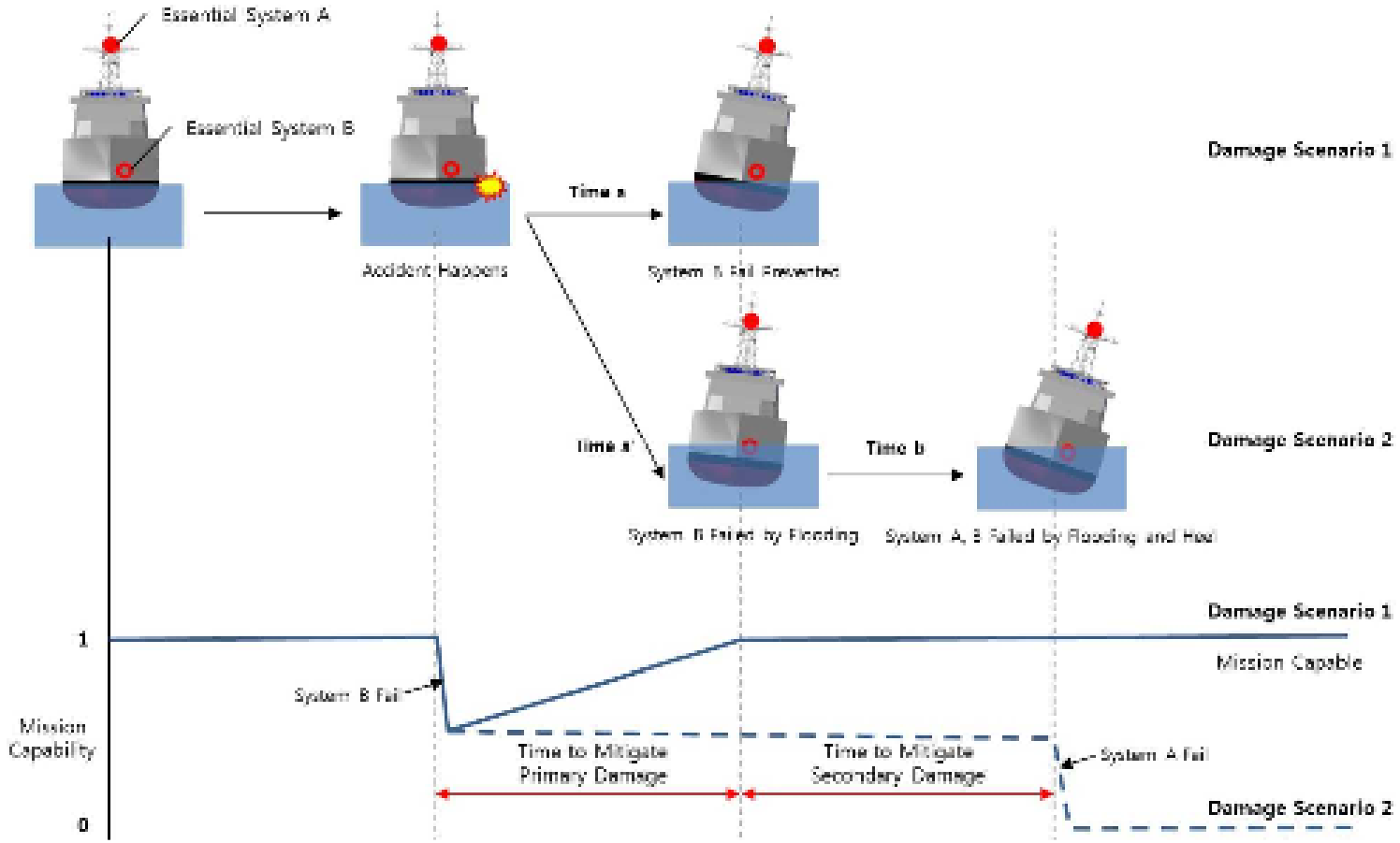


In a Cruise

- IMO requires the evacuation analysis

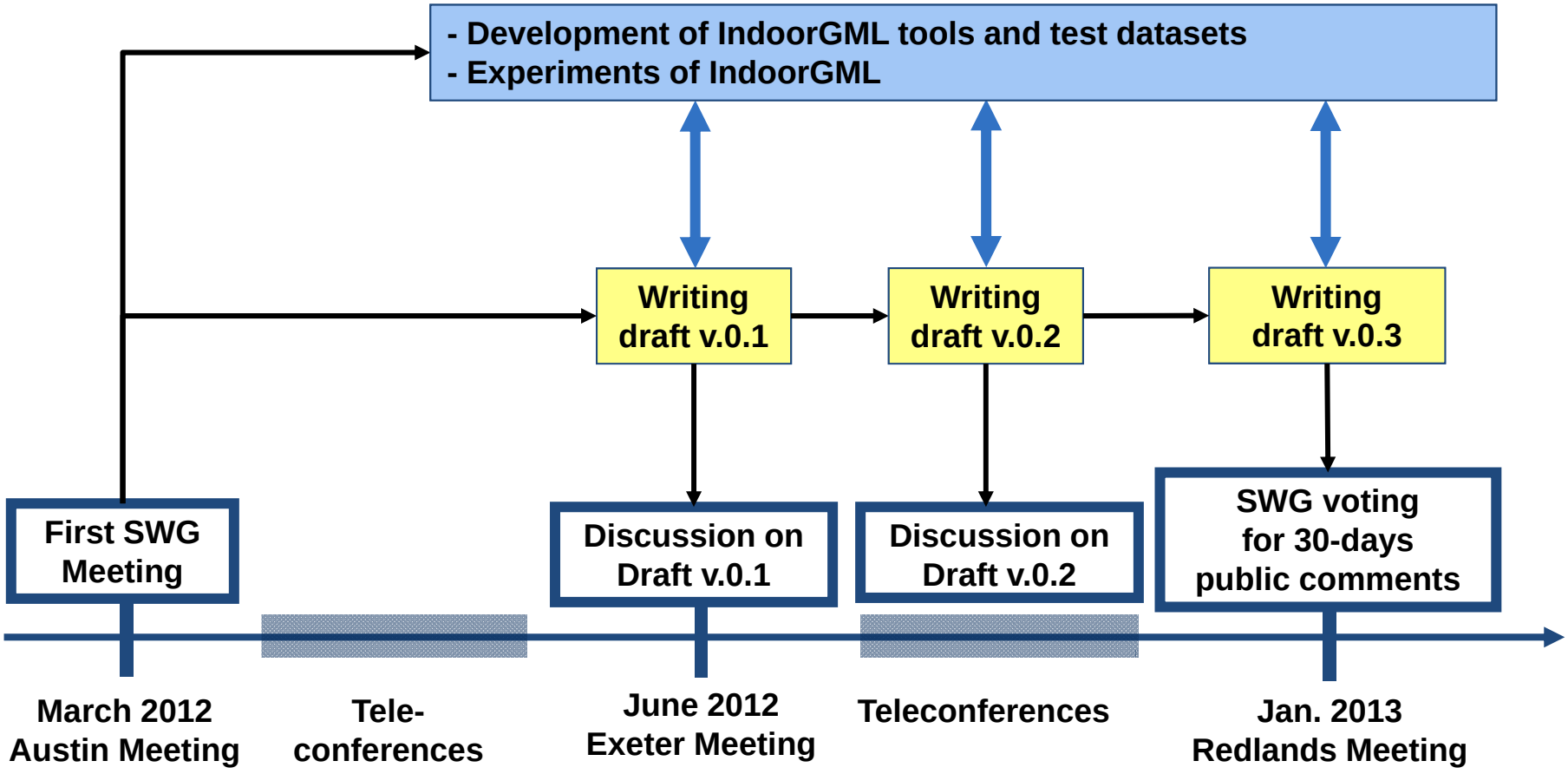
In a Cruise

When the ship is damaged, flooding water changes the damage scenarios

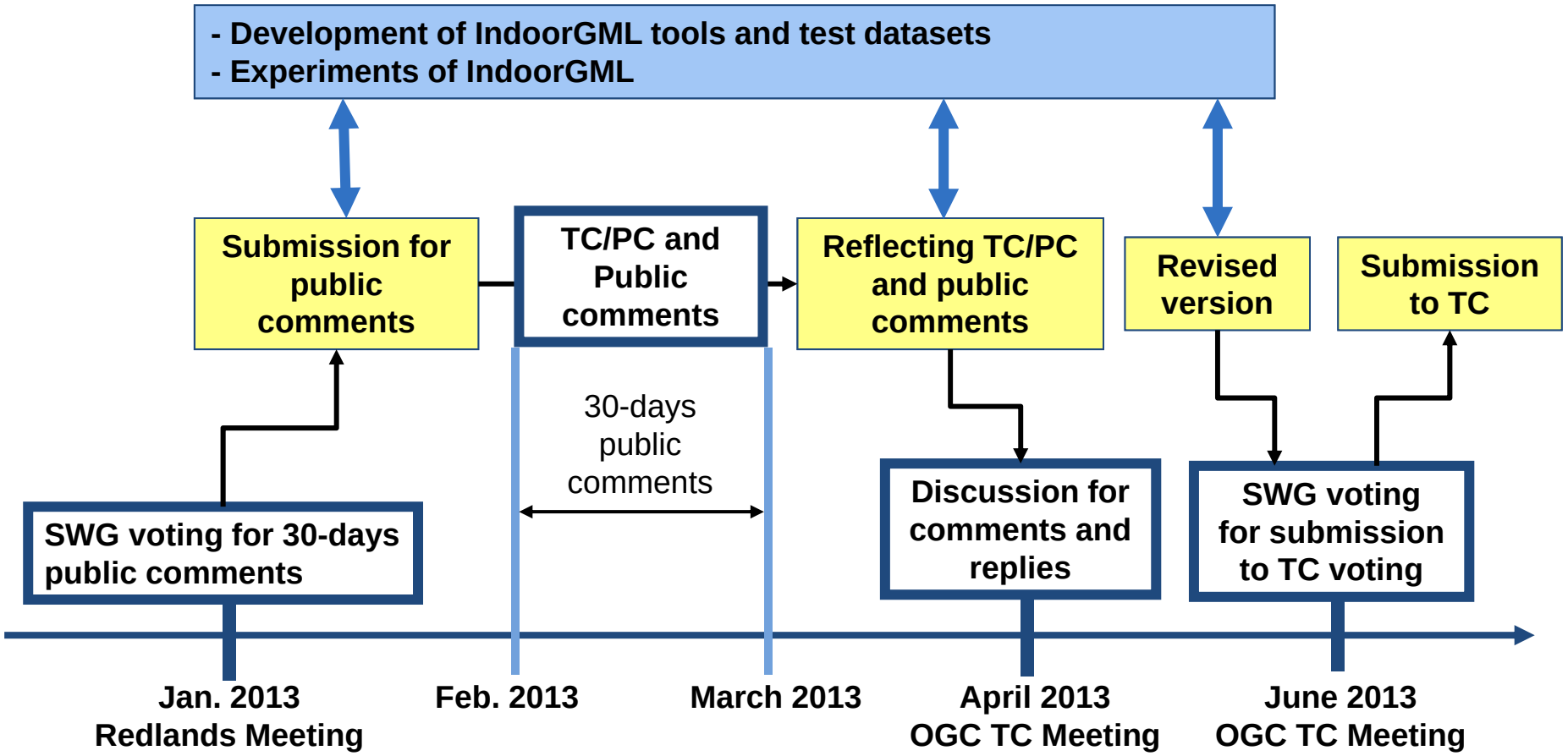


[source: IndoorGML Workshop – http://stem.cs.pusan.ac.kr/indoorGMLWorkshop]

Milestones - 2012



Milestones - 2013



Harmonization with other standardization

1. ISO TC204 – WG 17, WG 3, and WG 8

Indoor navigation for personal and vehicle ITS station
- Part 1: General information and use cases definition
- Part 2: Requirements and specification for indoor map data format
- 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

– New Working Item Proposal: Adopted on May 7, 2012, (ISO 17438-1)

Harmonization with other standardization

IEEE MDR (Map Data Representation for Robotics) WG

– WG Approved on Nov. 2011 by IEEE SA

Summary

- IndoorGML
  - A Candidate Standard for Indoor Navigation
  - Basic Concepts
    - Symbolic Space and Geometric Graph (Topology)
    - Multi-Layered Space
  - Planning to publish it in mid-2013

- Two Strategies
  - As simple as possible: Core Module and Application Modules
  - As flexible as possible
    - To be used as a base standard of other fields and standards

References

- Nagel, Becker, Kaden, Li, Lee, Kolbe, “Requirements and space-eve nt modeling for indoor navigation,” OCG 10- 191r1, 2010
- http://stem.cs.pusan.ac.kr/indoorGMLWorkshop


Indoor spaces of the world, unite
Q&A