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A Platform for Interoperability via Multiple Spatial Views in Open Smart Spaces

SISS'10

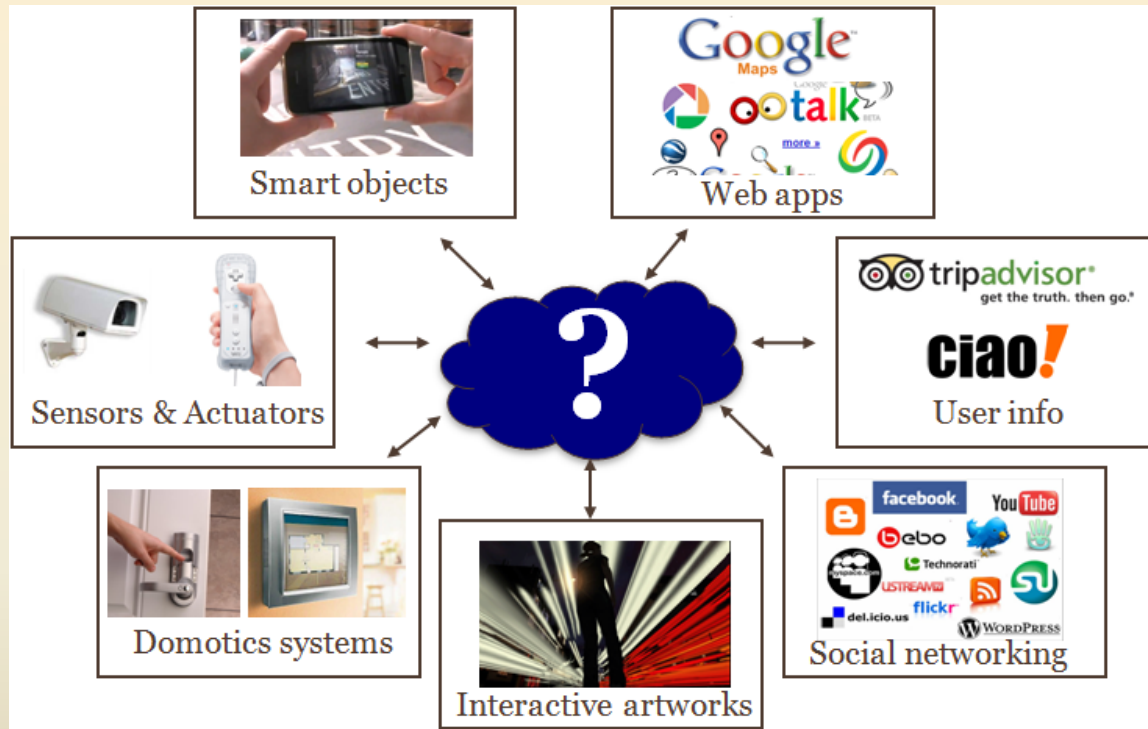
June 22th 2010

Outline

- **Goal**
- Our solution: Space Integration Services
- Real scenario
- Conclusions

Smart Spaces: overall challenge

- Open & Large-scale smart spaces: integration of heterogeneous devices, systems and services



- How to support integration and interoperability?

Our approach

- Approach: reification of a few widespread concepts in a concrete framework
- Space-awareness: *the system capability of localizing information in physical or logical spaces and of behaving according to localized information*
 - A person is
 - located in a room
 - plays a role in an organizational space
 - Is associated with an RFID tag in an identifier space

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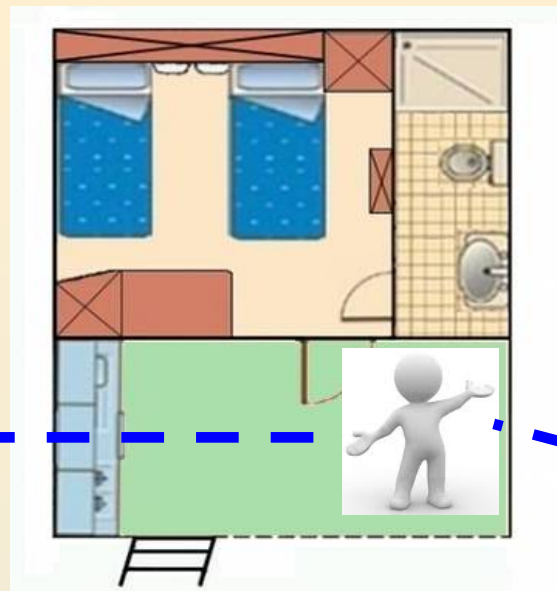
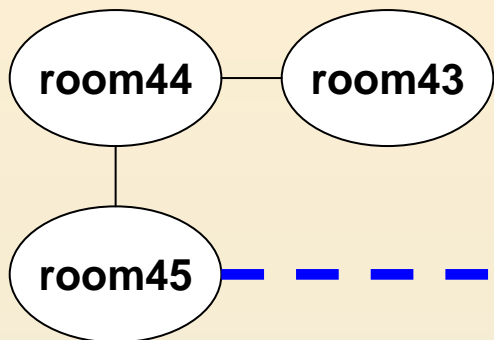
Space Integration Services (SIS)

- An architectural framework where components can
- define **multiple spaces**
- define **mappings among spaces**
- **localize and obtain information on/from multiple spaces**
- **considering the mappings**

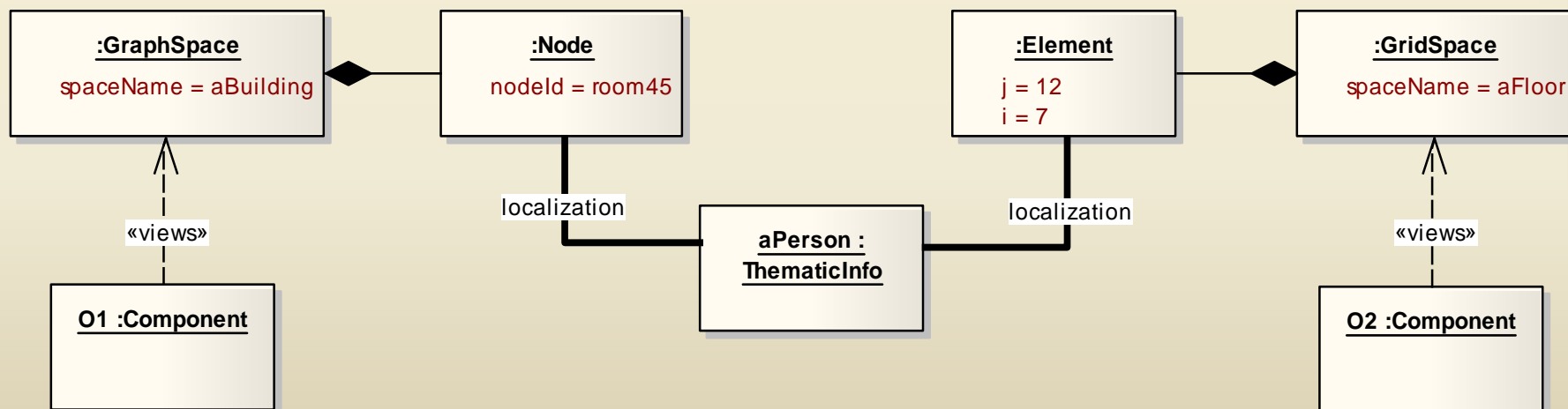
Space: concepts

- *Core spatial model*: it defines a space typology
 - a space typology specifies how locations are defined
 - currently focus on intrinsically finite spatial typologies only
 - *graph-spatial model*, locations: nodes and edges
 - *grid spatial model*, locations: (i,j) cells
 - *name spatial model*, locations: names
- *Environment space*: an instance of a core spatial model
 - a collection of locations
 - what is a location is defined by the related spatial model
- *Thematic information* can be localized in several locations of different spaces

Multiple information localization

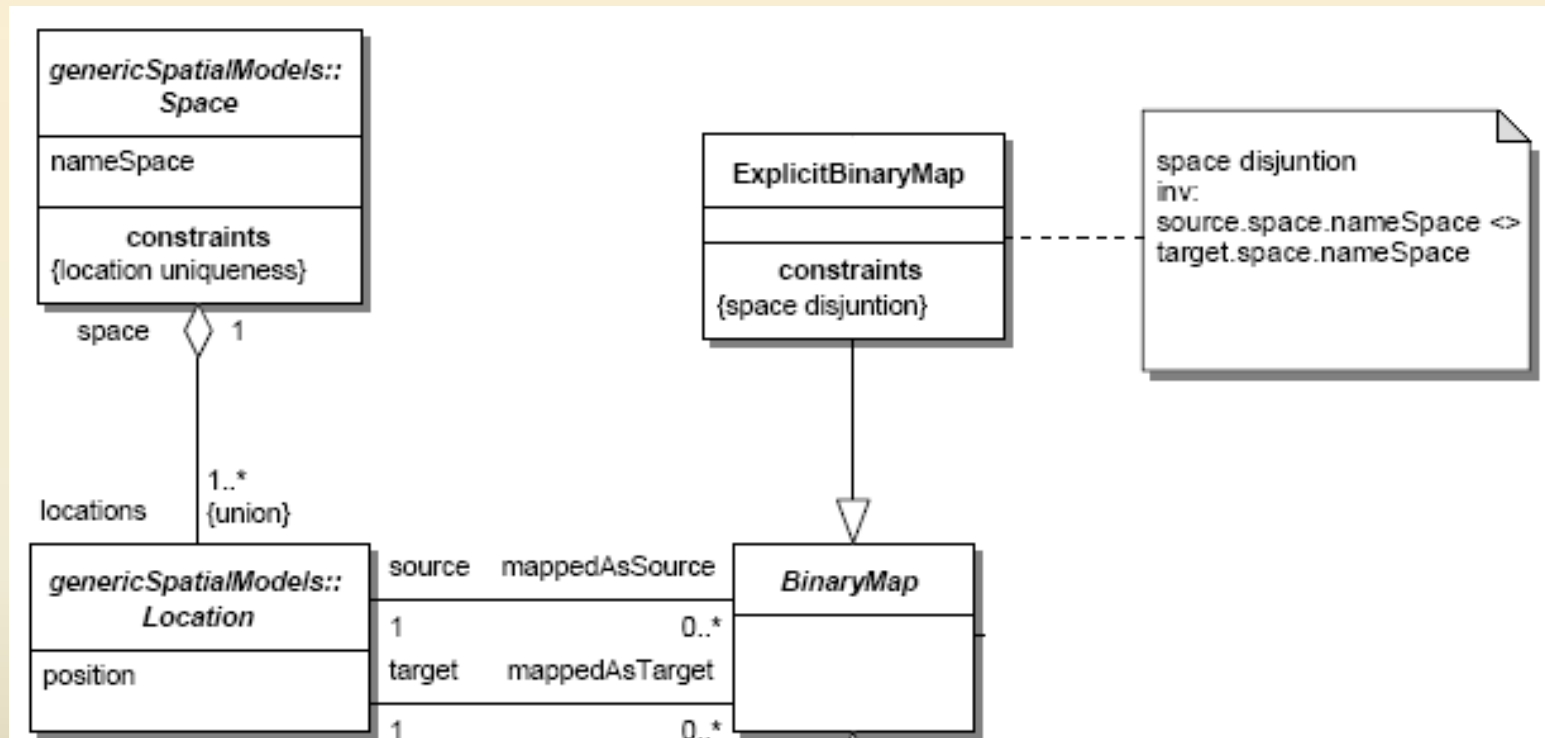


	1	2	3	4	5	6	7
1							
2							
3							
4							
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6							
7							
8							
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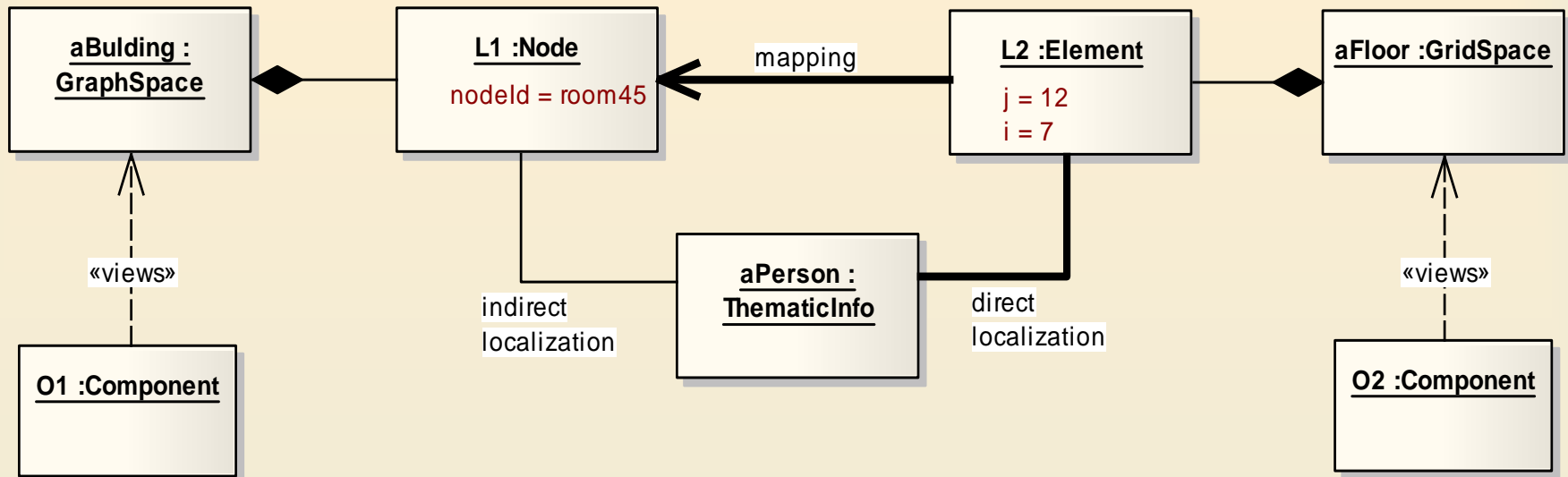


Mappings

- Unidirectional associations among locations of different spaces



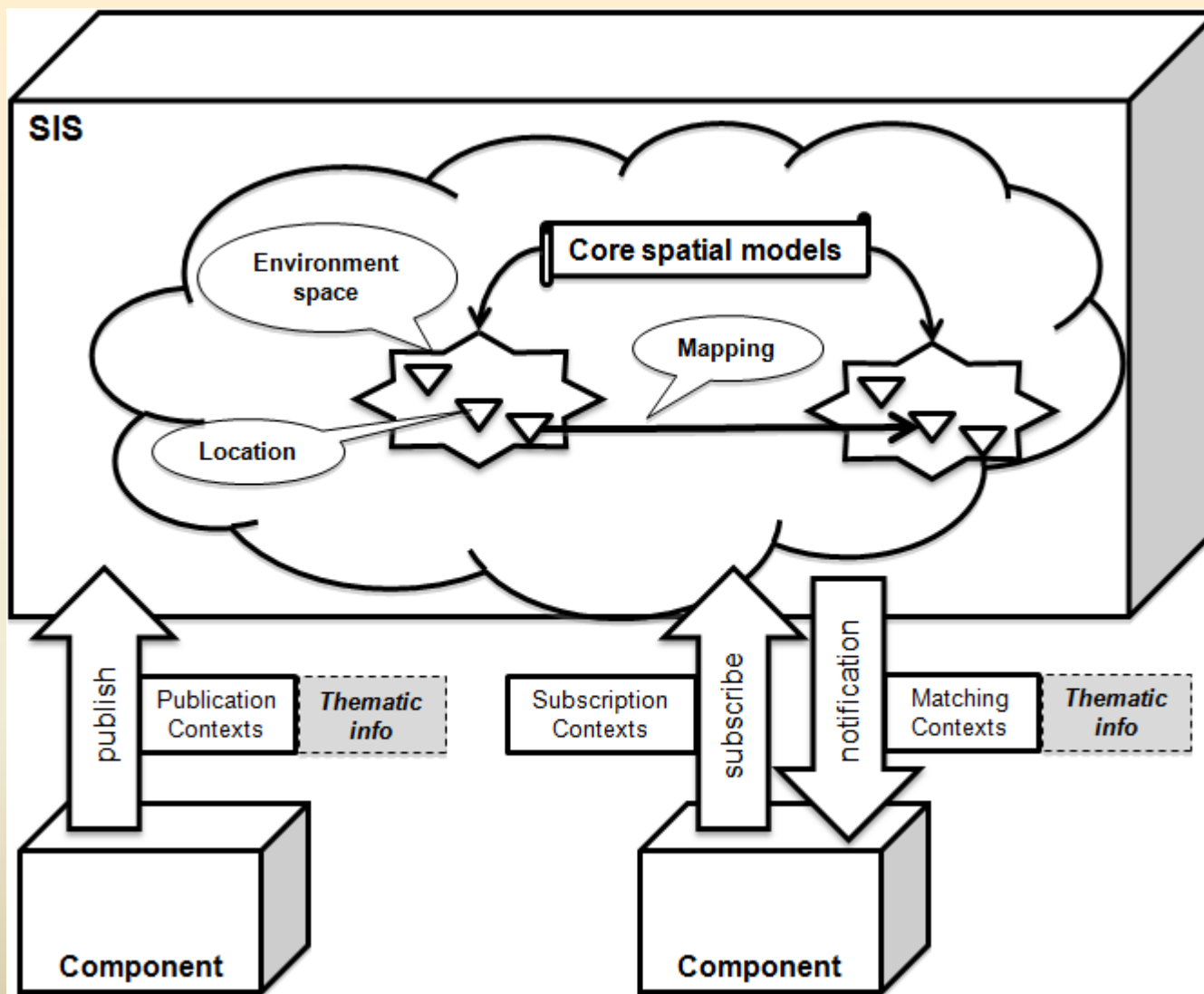
Mapping & indirect localization



Spatial Context

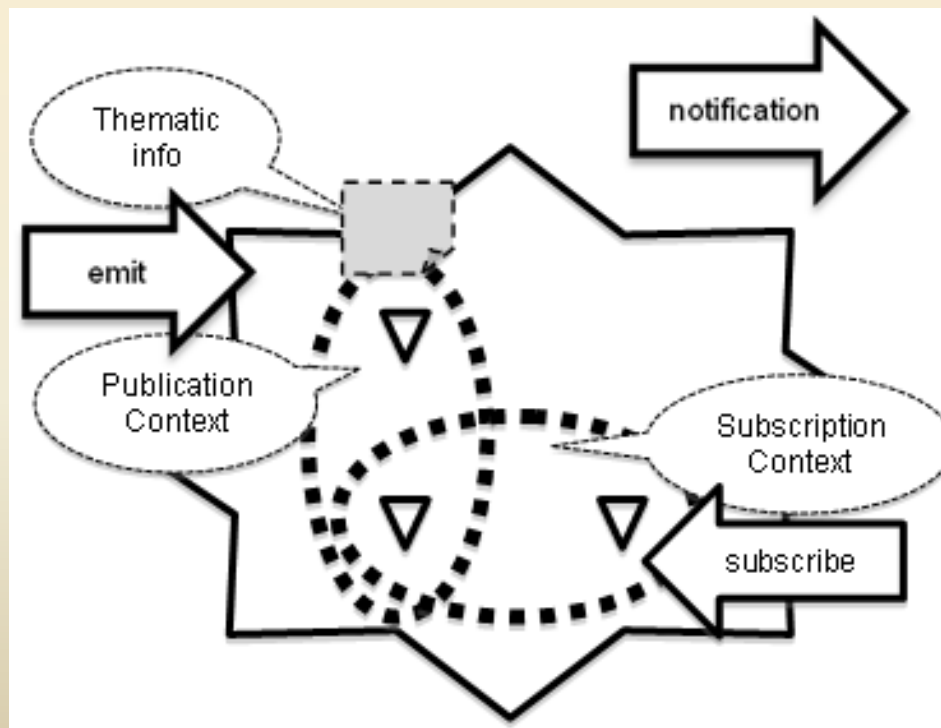
- A specification of one or more locations of an environment space
 - enumerative form
 - <spaceName, locationID+>
 - wildcards
 - <spaceName, *>
 - work-in-progress extension for declarative specification

Space-aware publish/subscribe

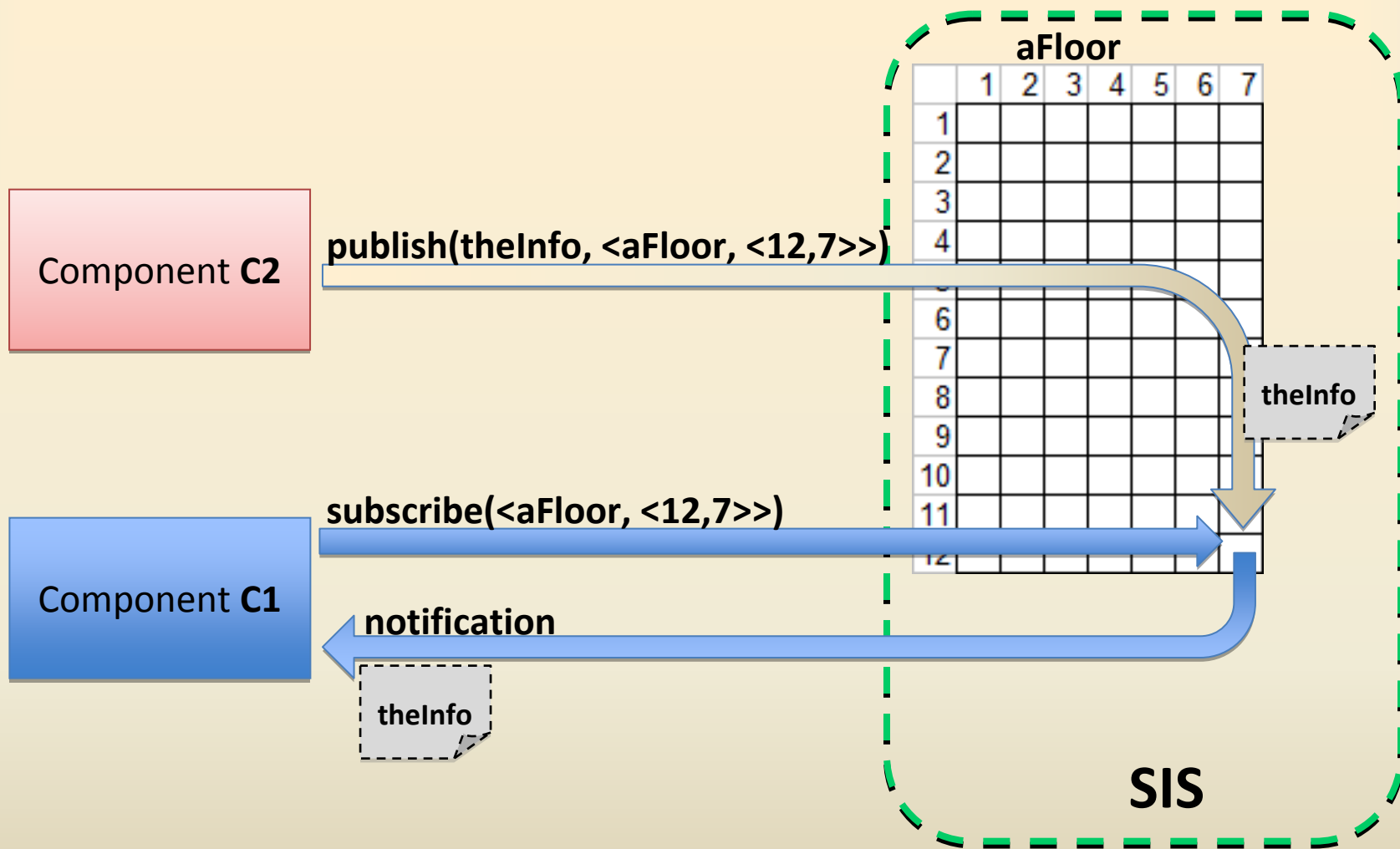


Matching rules

- A publication context PC matches a subscription context SC if
- 1) *direct match*: the intersection of the sets of locations in SC and PC is not empty



Direct match example



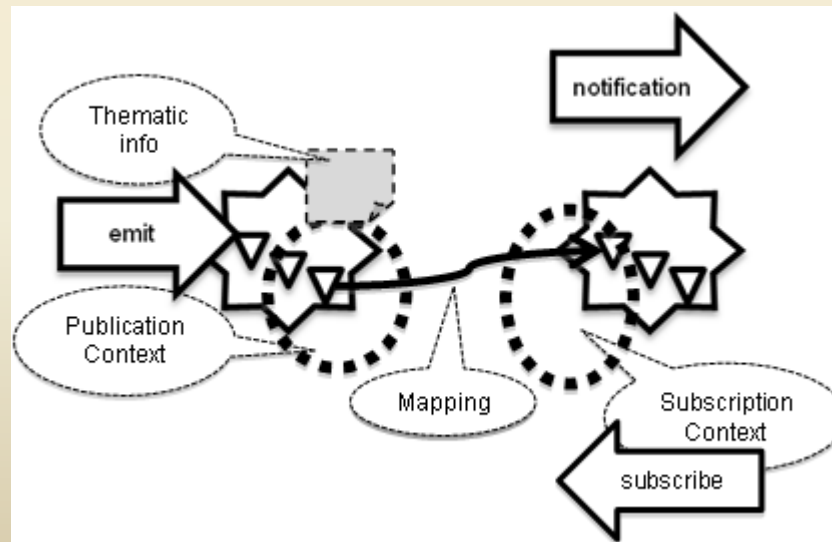
Direct match example

- C1 will be notified with a Matching structure
 - <theInfo,
 - 08:39:02-2010-06-07
 - <aFloor, <12,7>>

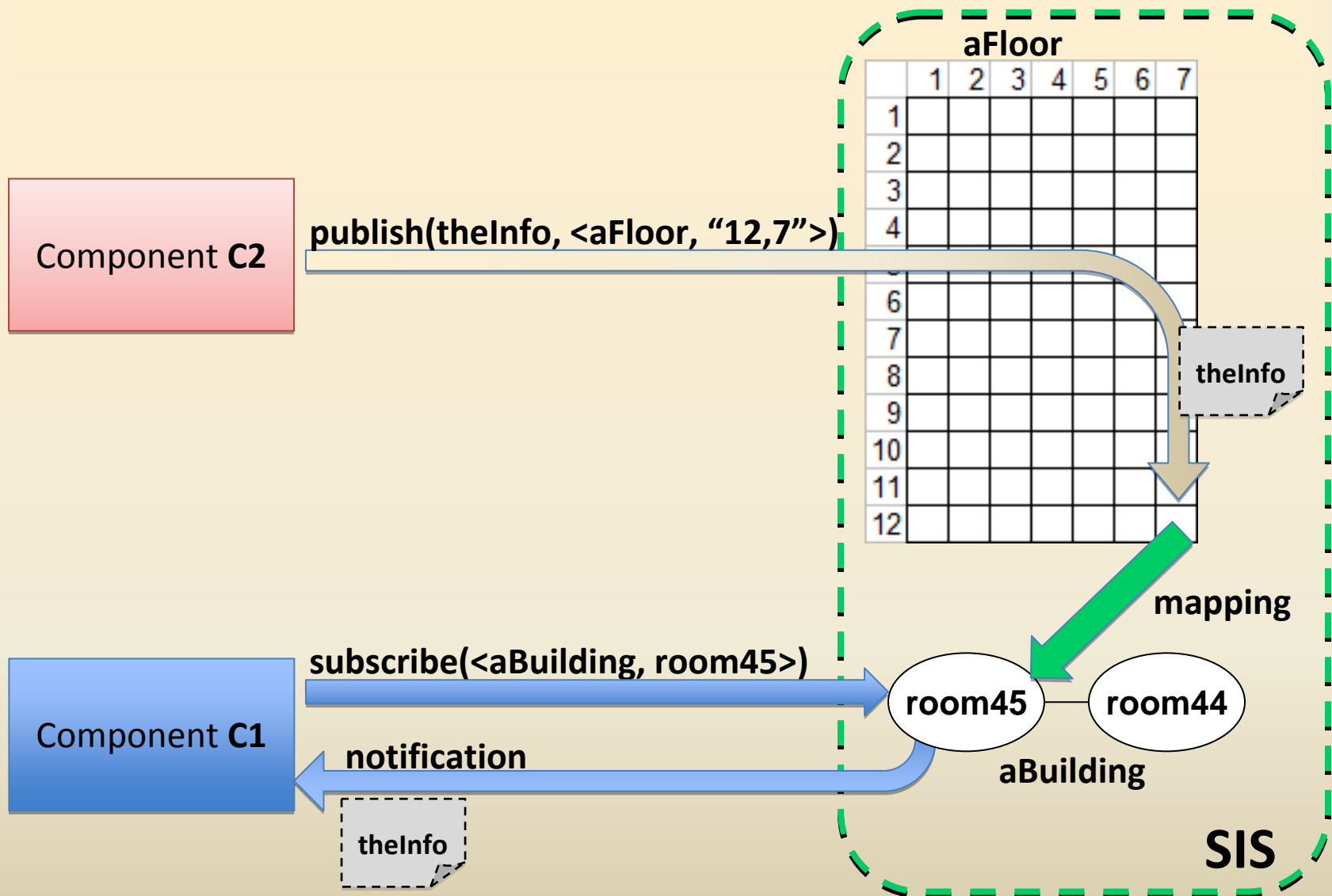
- A notification contains the thematic info plus
 - 1)the emission time of the thematic information
 - 2)the publication contexts associated to the thematic info that match the subscription context

Matching rules (2)

- 2) *indirect match*: the set of locations in PC includes a location L which is mapped to a location L' in SC, by considering the *restricted transitive closure* of the mappings
 - Restricted transitive closure of a mathematical relation R: the relation T containing all the pairs
 - (a,b) belonging to R
 - (a,c) where (a,z) and (z,c) belong to T for some z, and c is not equal to a



Indirect match example



Indirect match example

- C1 will be notified with the following Matching structure
 - <theInfo, 08:39:02-2010-06-07
 - <aFloor, <12,7>> <aBuilding, room45>>
- A notification contains the thematic info plus
 - 1)the emission time of the thematic information
 - 2)the publication contexts associated to the thematic info that match the subscription context...
 - **3)...and those which are explicitly or implicitly mapped from them according to the restricted transitive closure of the mapping relation (*context completeness*)**

Prototypal implementation

- Core: Java + JESS rule engine
- Environment spaces, mappings and matching rules turn into JESS facts and rules
- Environment spaces are defined through XML descriptors which are used by SIS in the initialization phase
- The interaction primitives are exposed as Web Services

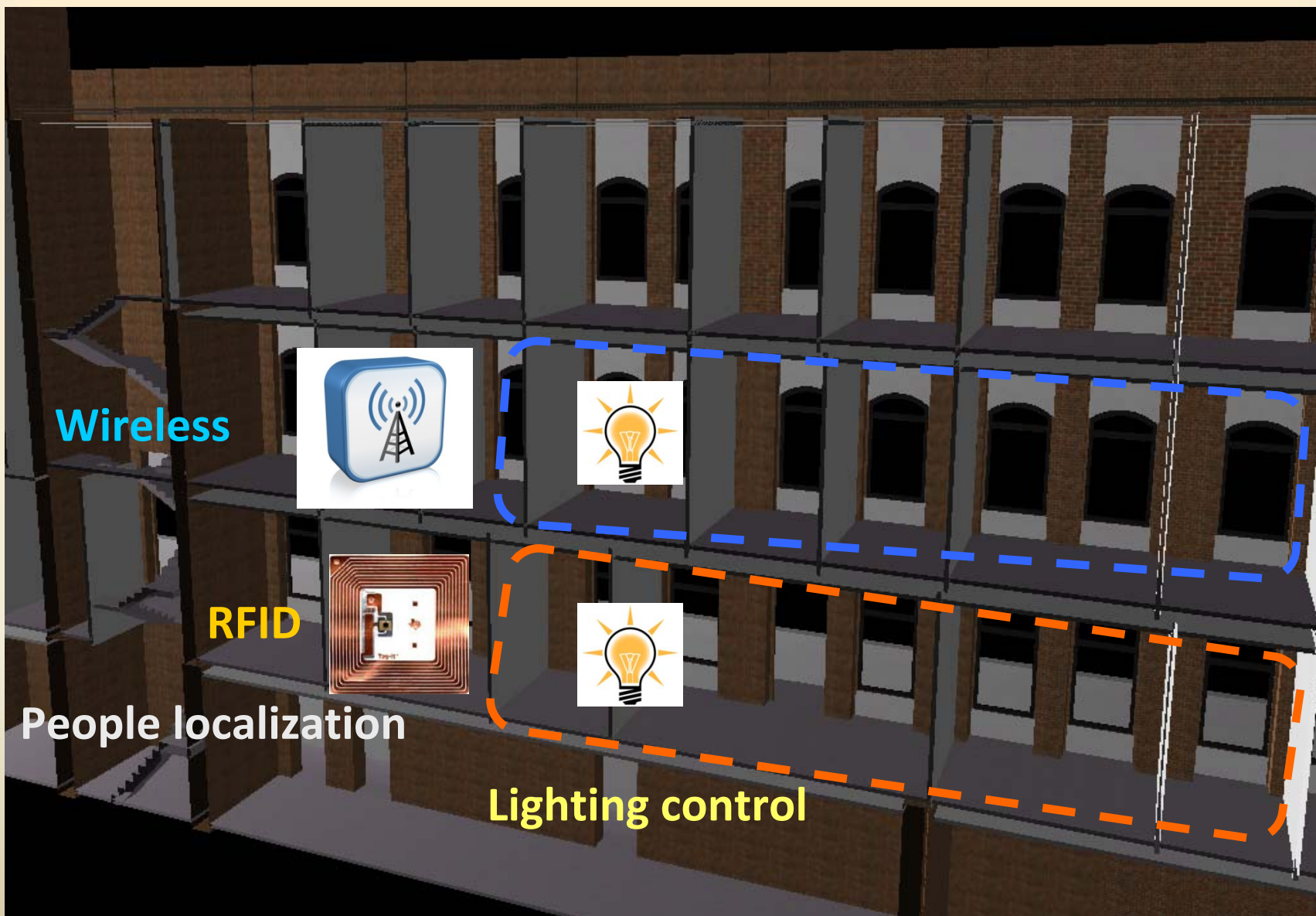
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Real scenario: Smart Building (1)

- Suppose that a building is enriched with sensing and responding technologies providing users with smart services
 - Sensing: RFID and “Wireless” localization systems
 - Responding: light control system
 - DISCO-UniMiB GAS-Intelligent Building project scenario
- Users are identified by their names together with their organization roles (Director, Full Professor, Ph.D. student, etc.)
- Example of “simple” smart feature: “increase the lightning of any room if the Director goes in”

Smart Building (2)



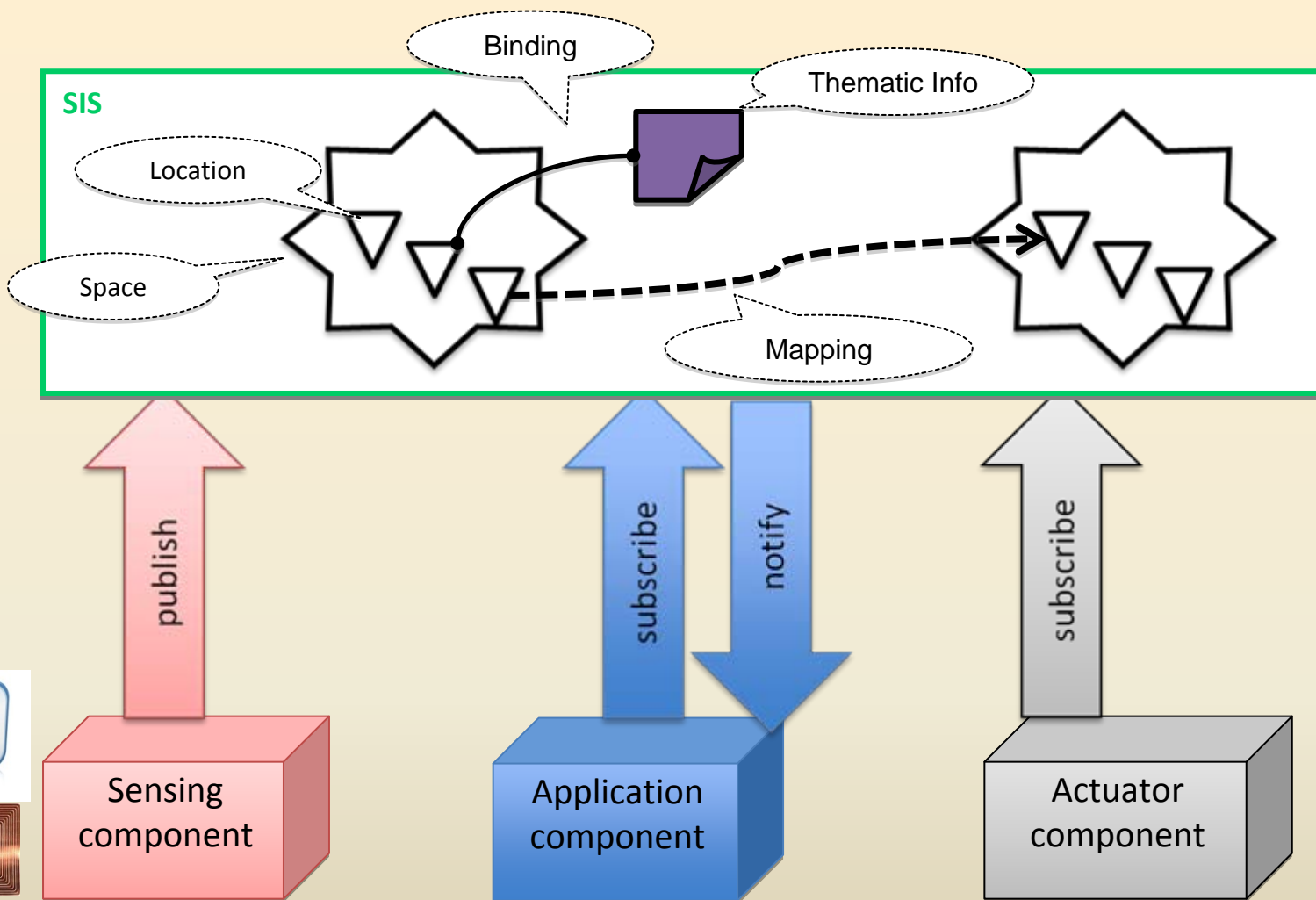
Wireless

RFID

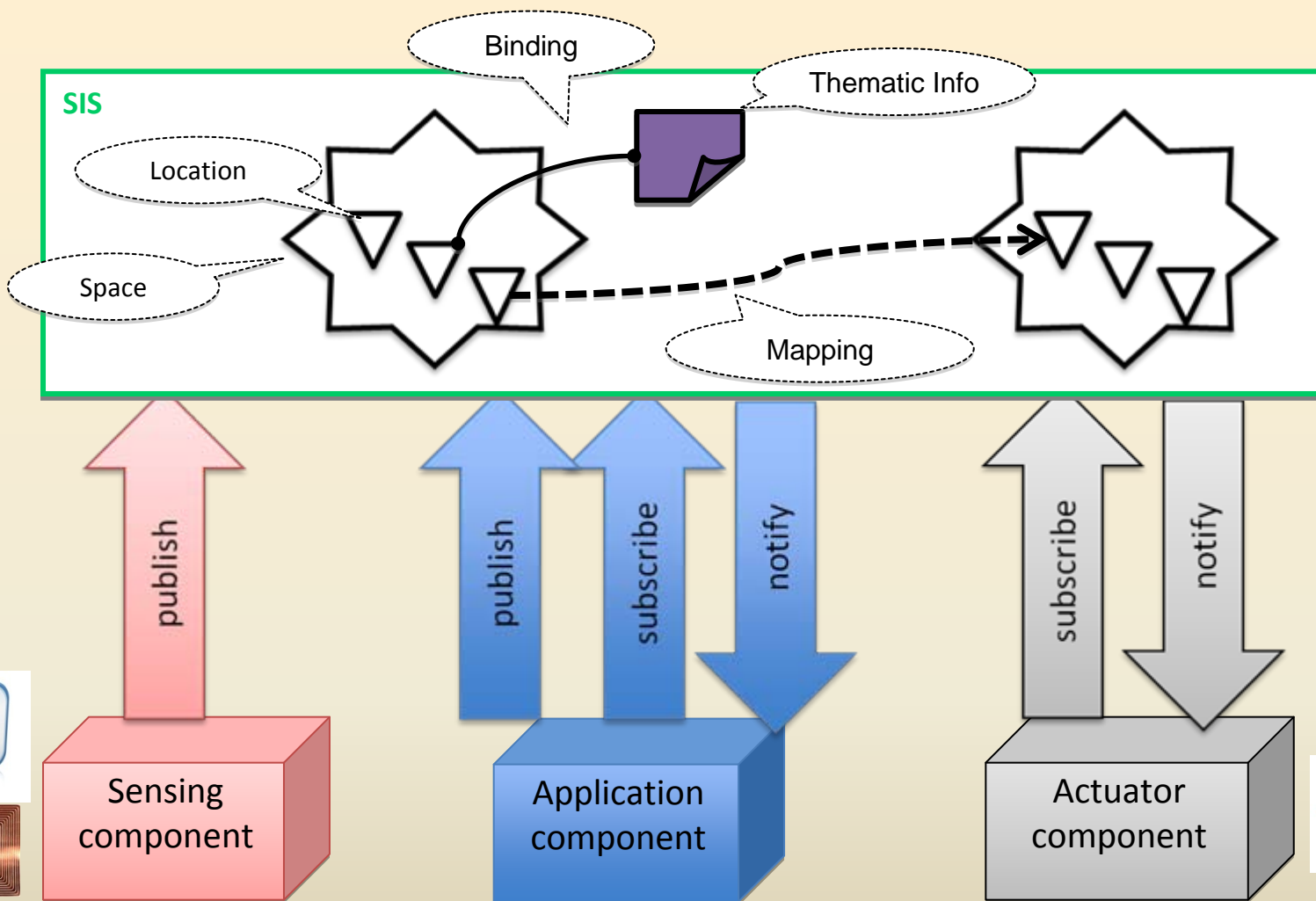
People localization

Lighting control


SIS-based Architecture



SIS-based Architecture



Smart Building spaces




Actuators

LightManager

Roles

```

graph TD
    Director[Director] --> TechChief[TechChief]
    Director --> FullProf[Full Prof.]
    FullProf --> Associate[Associate]
            
```



Smart Service



WiDs

3491234
3381236
335789



WiFloor

People

Brown White
Green


Building

```

graph TD
    Room1[Room1] --> Room2[Room2]
    Room1 --> Room5[Room5]
    Room2 --> Room3[Room3]
    Room2 --> Room4[Room4]
    Room5 --> Room6[Room6]
            
```

Tags

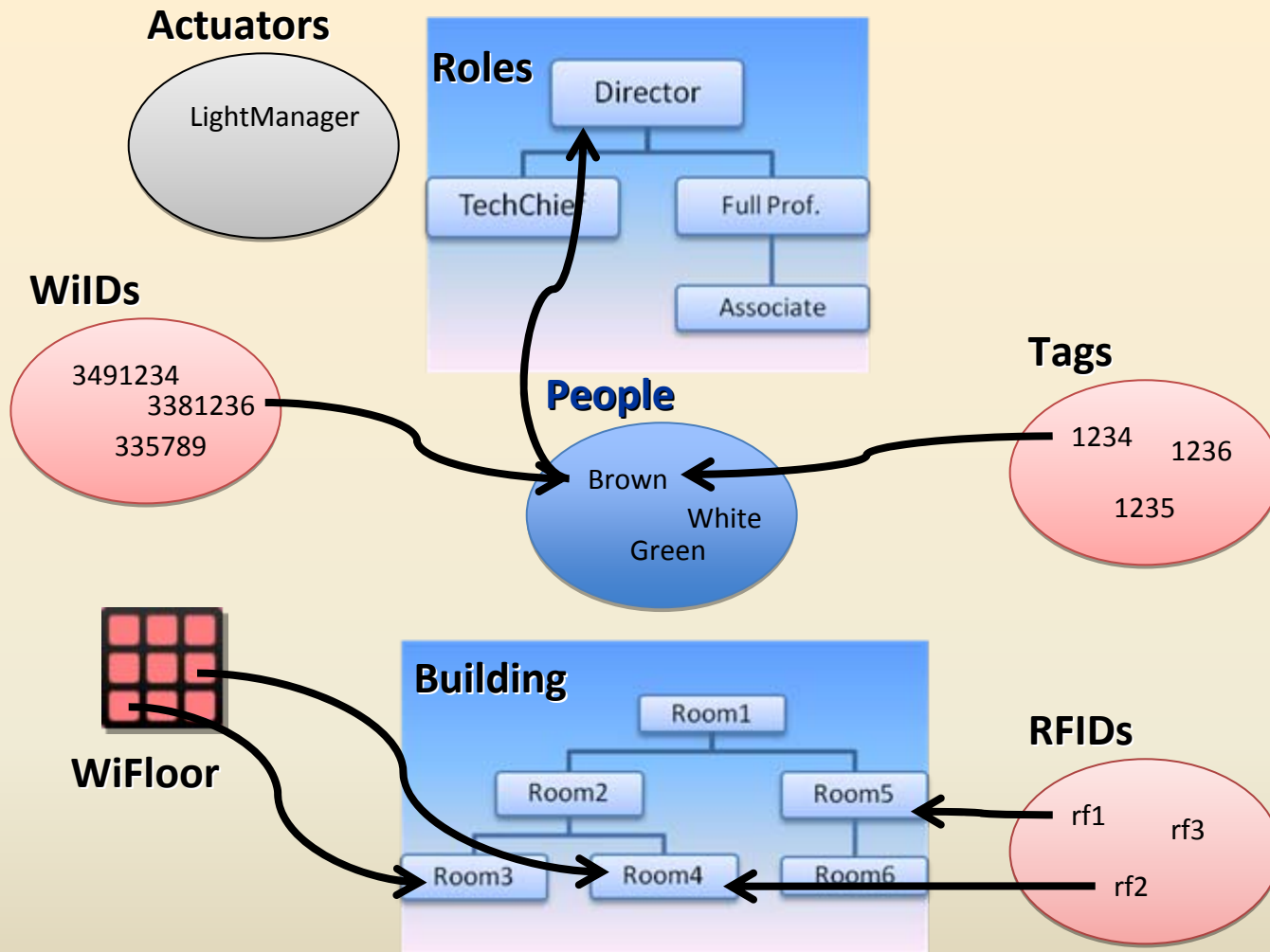
1234 1236
1235



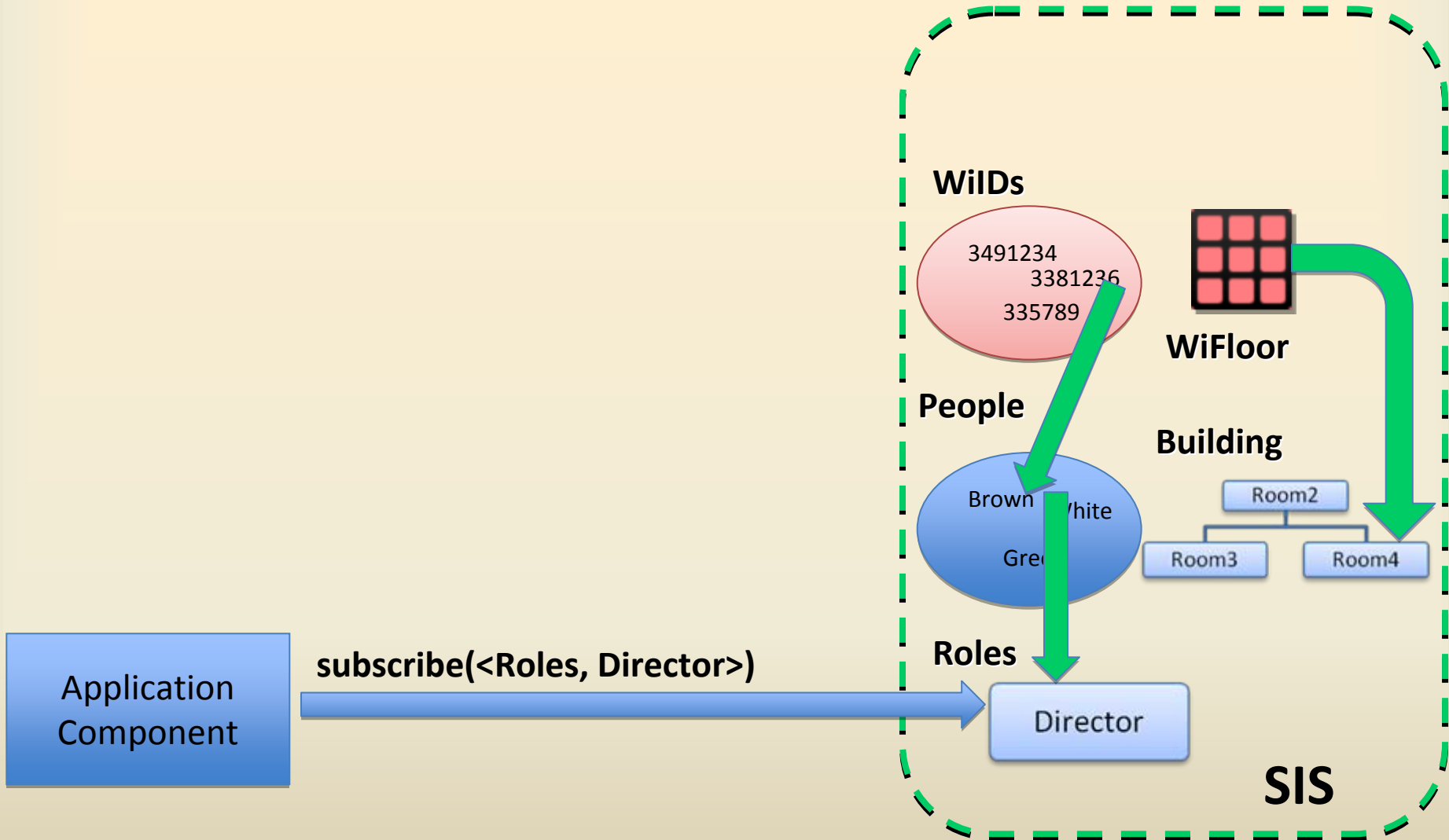
RFIDs

rf1 rf2
rf2

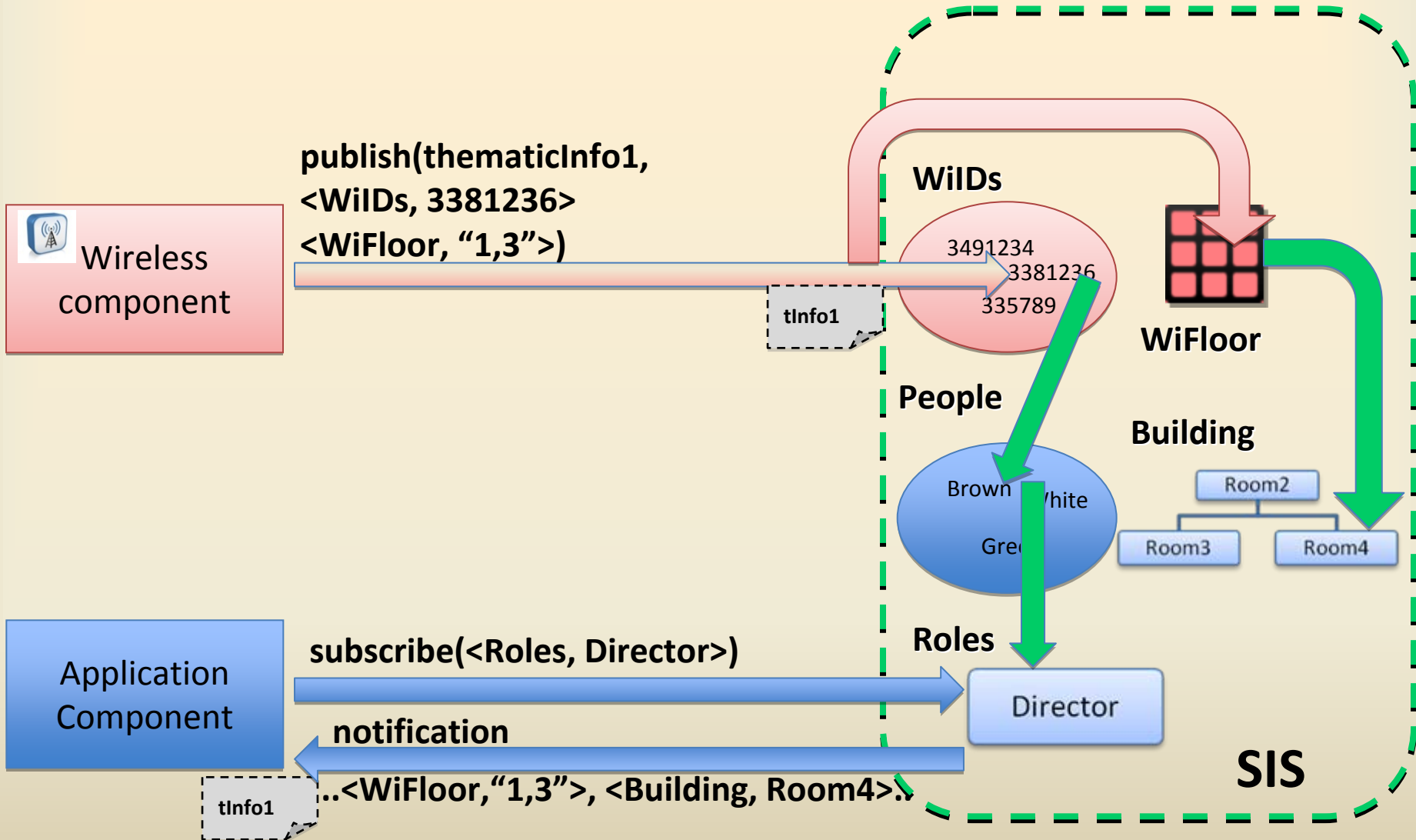
Smart Building mappings



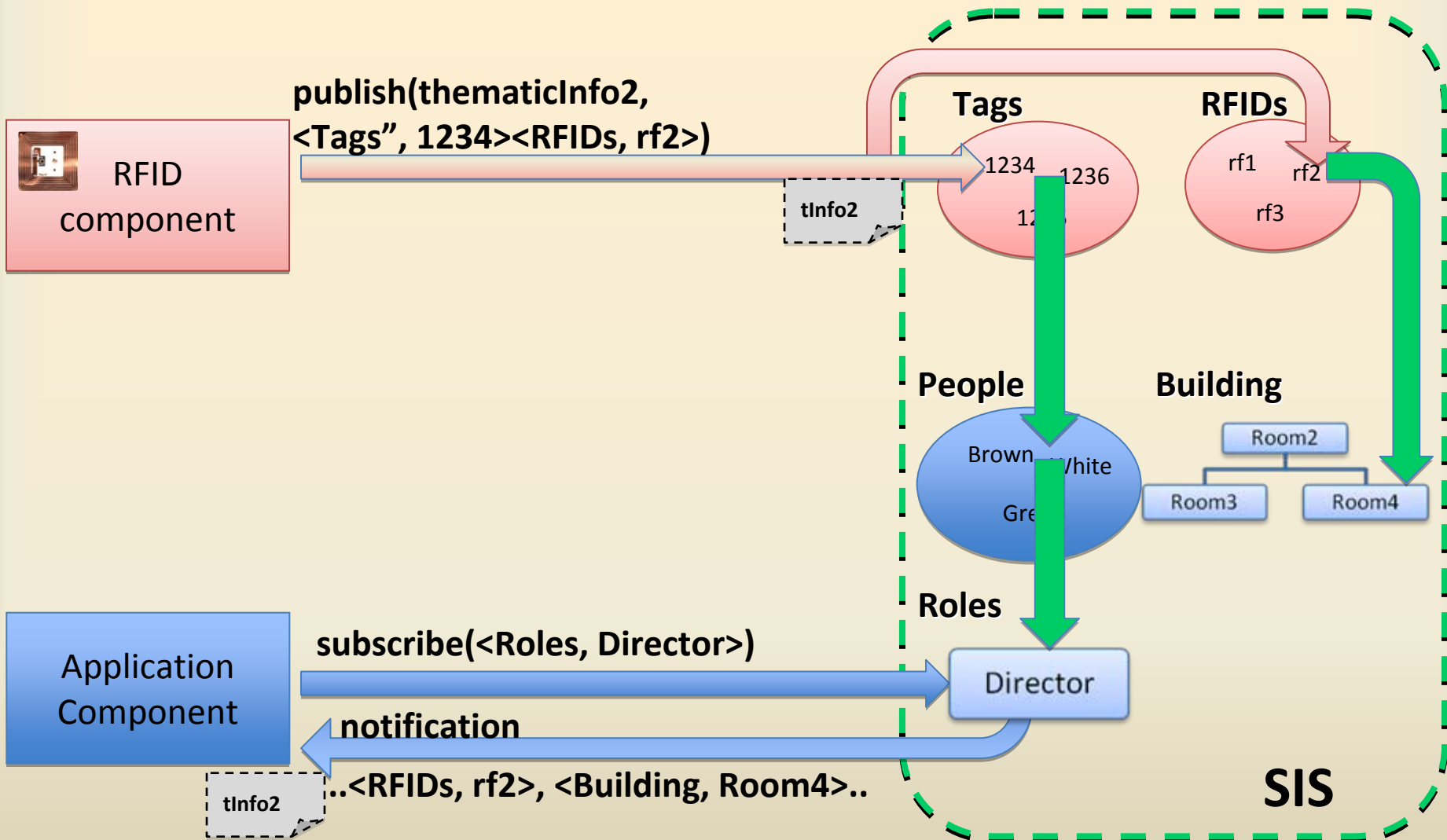
Feature realization (1)



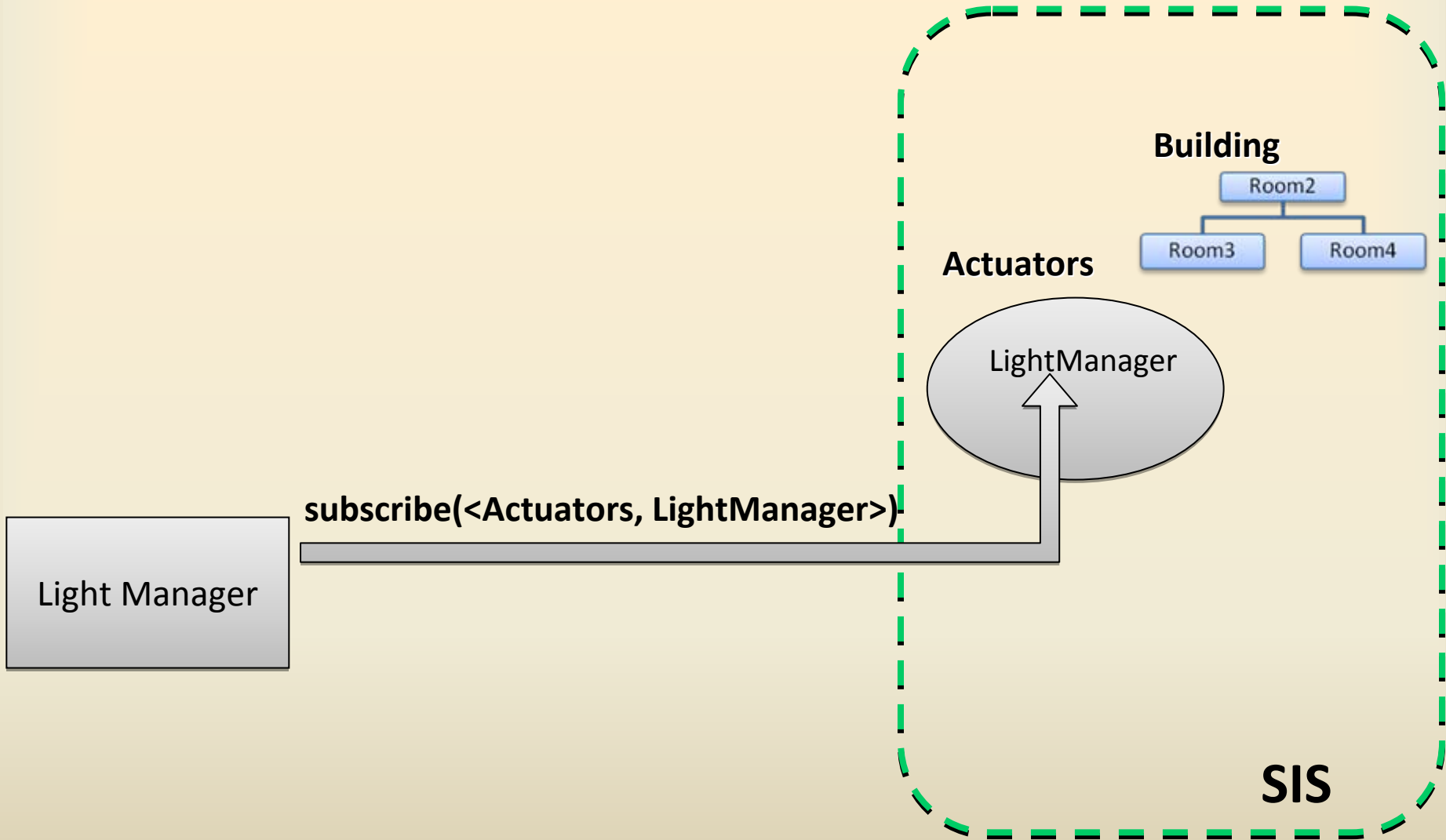
Feature realization (1)



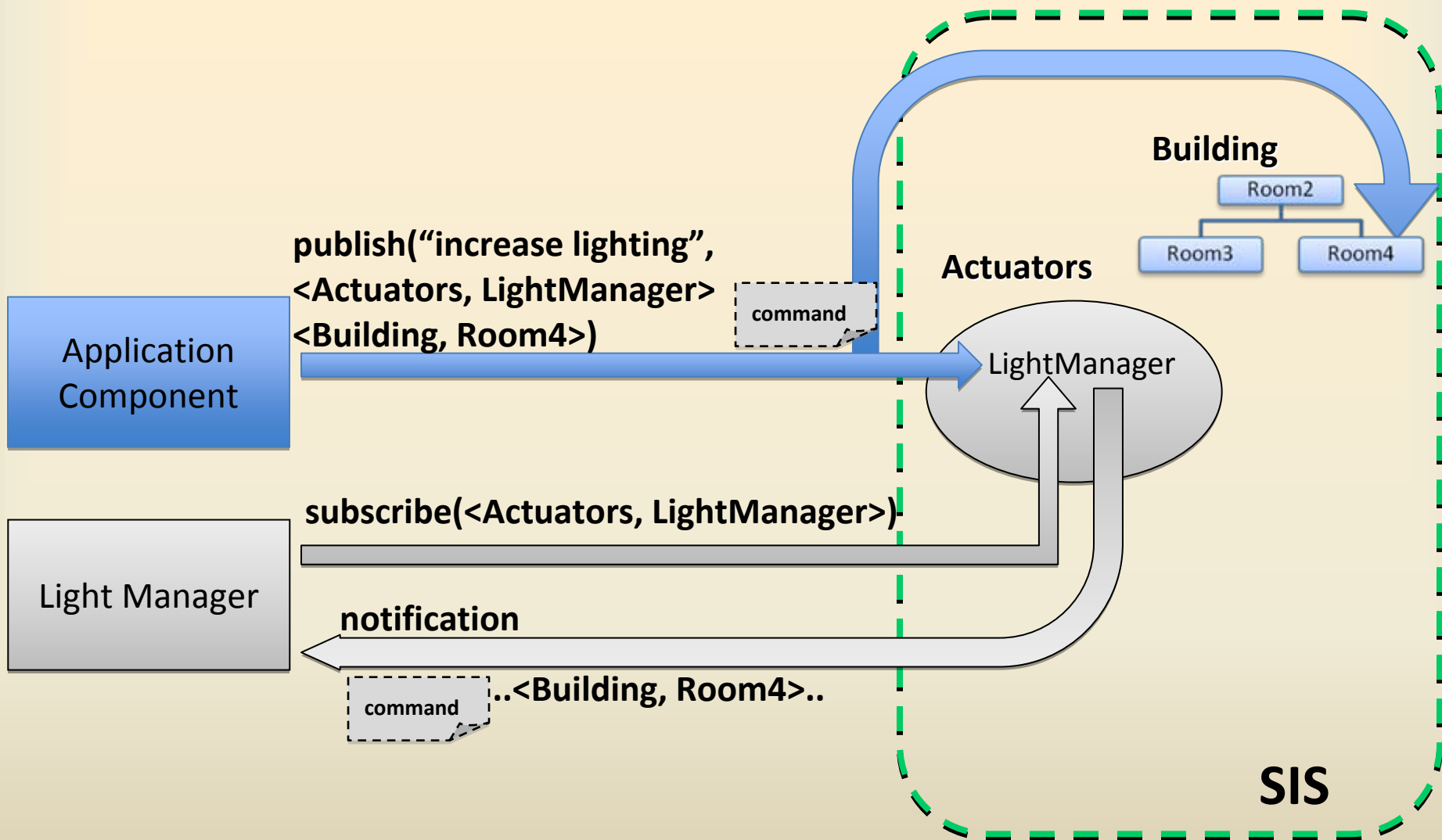
Feature realization (2)



Feature realization (3)



Feature realization (3)



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SIS: advantages

- Environment spaces support individual views of the overall environment
 - The same piece of data can be viewed by different mapped spaces, like role hierarchies or 3D physical spaces
- Information flows are transparently created through multiple spaces and mappings
 - Components can ignore the presence of other components
- It supports the creation of information flows among heterogeneous components

SIS: what semantics?

- SIS does **not** provide a general semantic model
- Spatial contextualization
 - widespread and reusable concepts
 - lightweight framework
- Semantic of Thematic info: out of scope

Extension and Future Works

- Space-based data-sharing
- Declarative context specification
- Filters to constrain the context completeness
- Experiments: efficiency and scalability

Ongoing Experimentations

- F.I.R.B. Integrated Systems for Emergency project- SIS for space-based information flows
- DISCO GAS Intelligent Building- SIS as integration platform
- Augmented classroom
 - with UniMiB DISCO IT IS Lab - Prof. Simone
- Integration of SIS and 3D visualization components
 - with UniMiB DISCO IVL Lab - Prof. Schettini
- Engineering of adaptive lighting systems based on Cellular Automata computational model
 - with UniMIB CSAI Center - Prof. Bandini
 - Acconci Studio, NY, USA, Interactive Art & Architecture
- Interactive art installations distributed over different sites
 - Luca Carrubba, esterotips.net