SPATIAL COGNITION

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Extra materials...

For discussion and further information

(not necessarily intelligible without an accompanying description!)

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Example 1

Plug-and-play spatial ontologies

Modeling space

- Different tasks require different perspectives on space
  - Spatial inclusion relationships, e.g., region connectivity (RCC-5, RCC-8, etc.)
  - Navigation and way finding, e.g., route graphs, double cross calculus, dipoles, ...
  - Natural language interaction: e.g., reference systems, figure-ground relationships
  - Commonsense artefactual ontologies

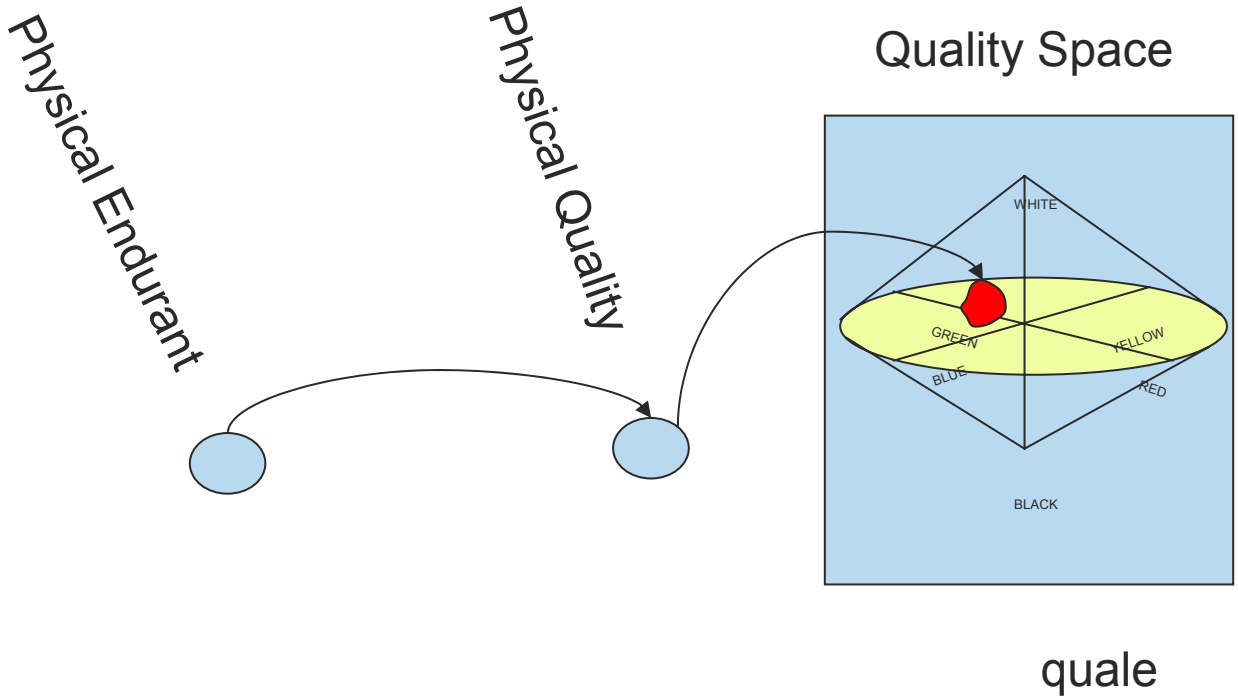
Locating objects...

- Every physical endurant (object) has the quality of being located
- Location is made with respect to a spatial quality region: the ‘space region’

- Questions are:
  - How to characterize that location?
  - How to characterize its space?

Defining Qualities in DOLCE

I1-[OntoSpace]



`Swappable' treatments of space

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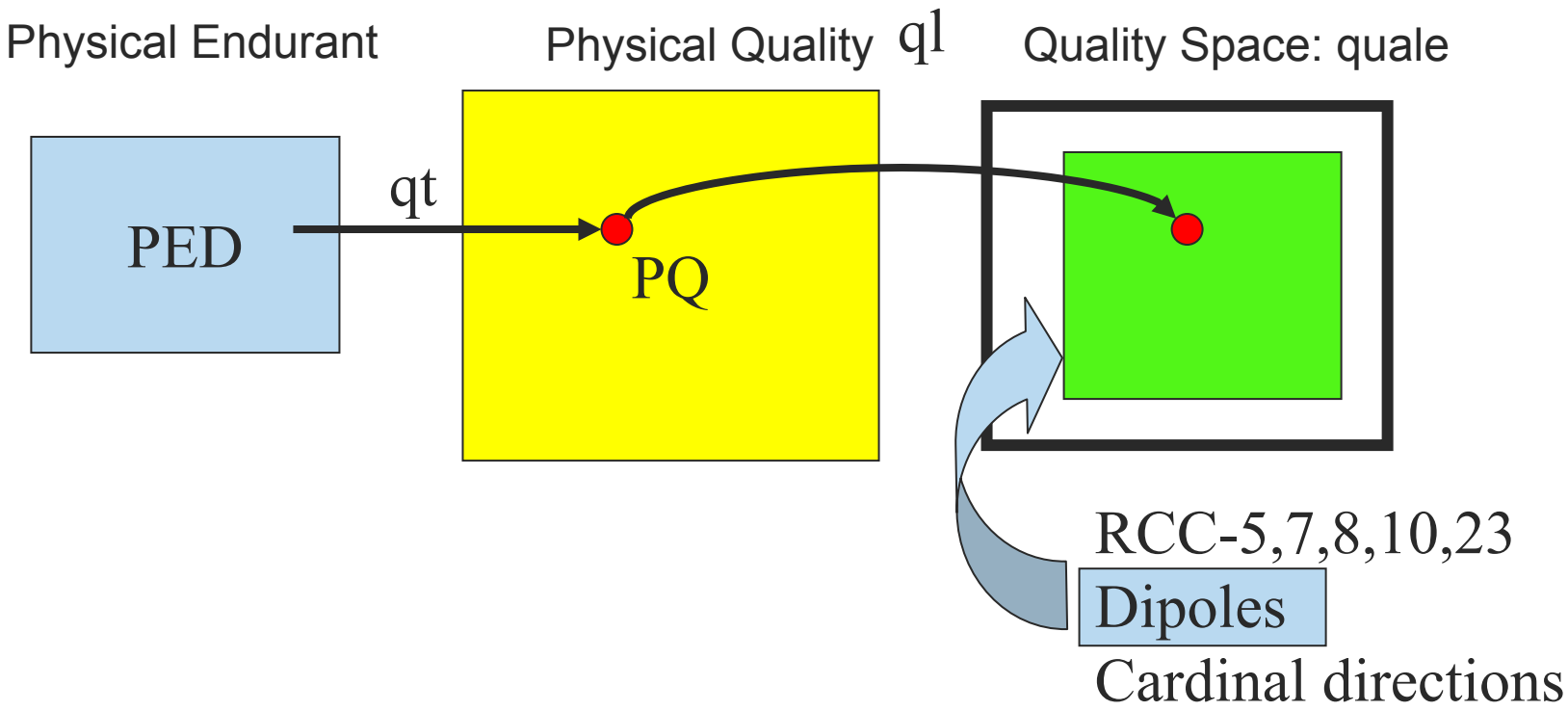
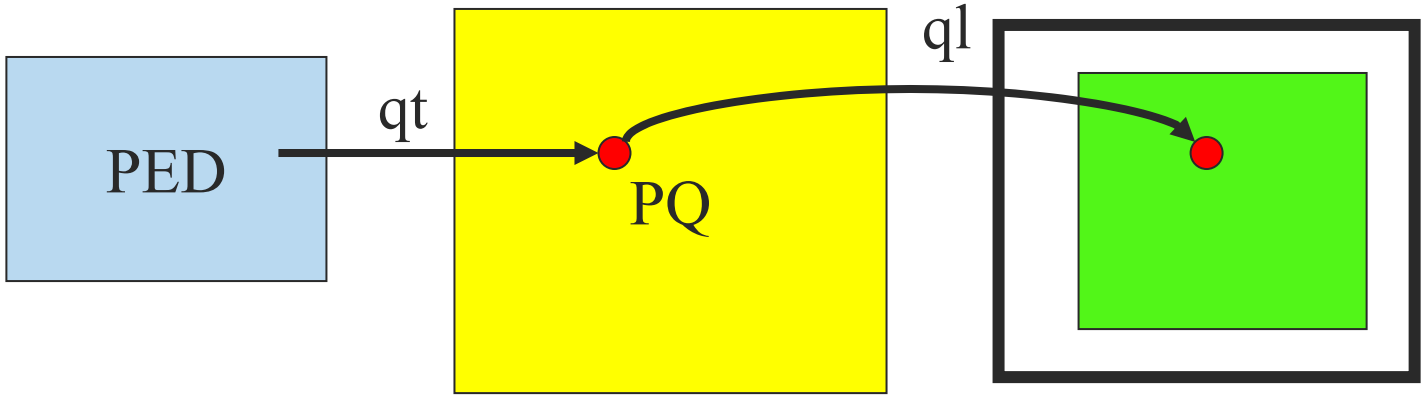


`Swappable' treatments of space: specification

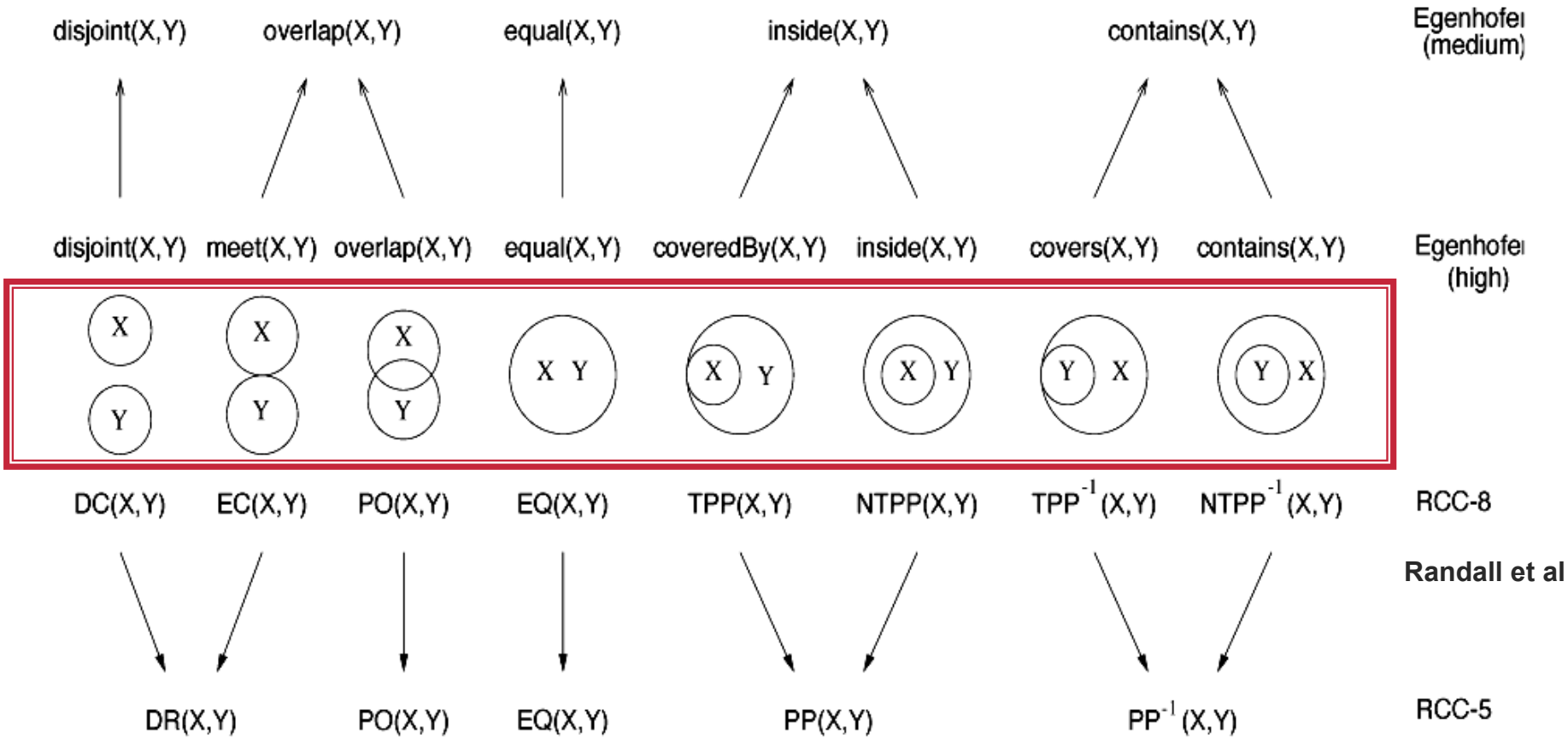
CASL modules for each spatial 'theory'



CASL specification of DOLCE first order specification

Example:

Region-Connection Spaces RCC-5, RCC-8, etc.



Definitions of Spatial Calculi
(Wölfl & Mossakowski)

spec RCC5BASERELATIONS = **%mono**
  free type *BaseRel* ::= *dr* | *po* | *pp* | *ppi* | *eq*
end

spec RCC5COMPOSITIONTABLE =
  sort *BaseRel*
  ops *dr*,*po*,*pp*, *ppi*,*eq*: *BaseRel*
  and COMPOSITIONTABLE **with op** *id* → *eq*
then
...
end

spec RCC5 =
  CONSTRUCTRELATIONALGEBRA [RCC5BASERELATIONS]
  [RCC5COMPOSITIONTABLE **fit op** *id*:*BaseRel* → *eq*]
end

Definitions of Spatial Calculi
(Wölfl & Mossakowski)

Theory morphisms via views

view RCC5 AS ATOMICRELATIONALGEBRA :
ATOMICRELATIONALGEBRA **to** RCC5 = *AtomRel* → *BaseRel*
end

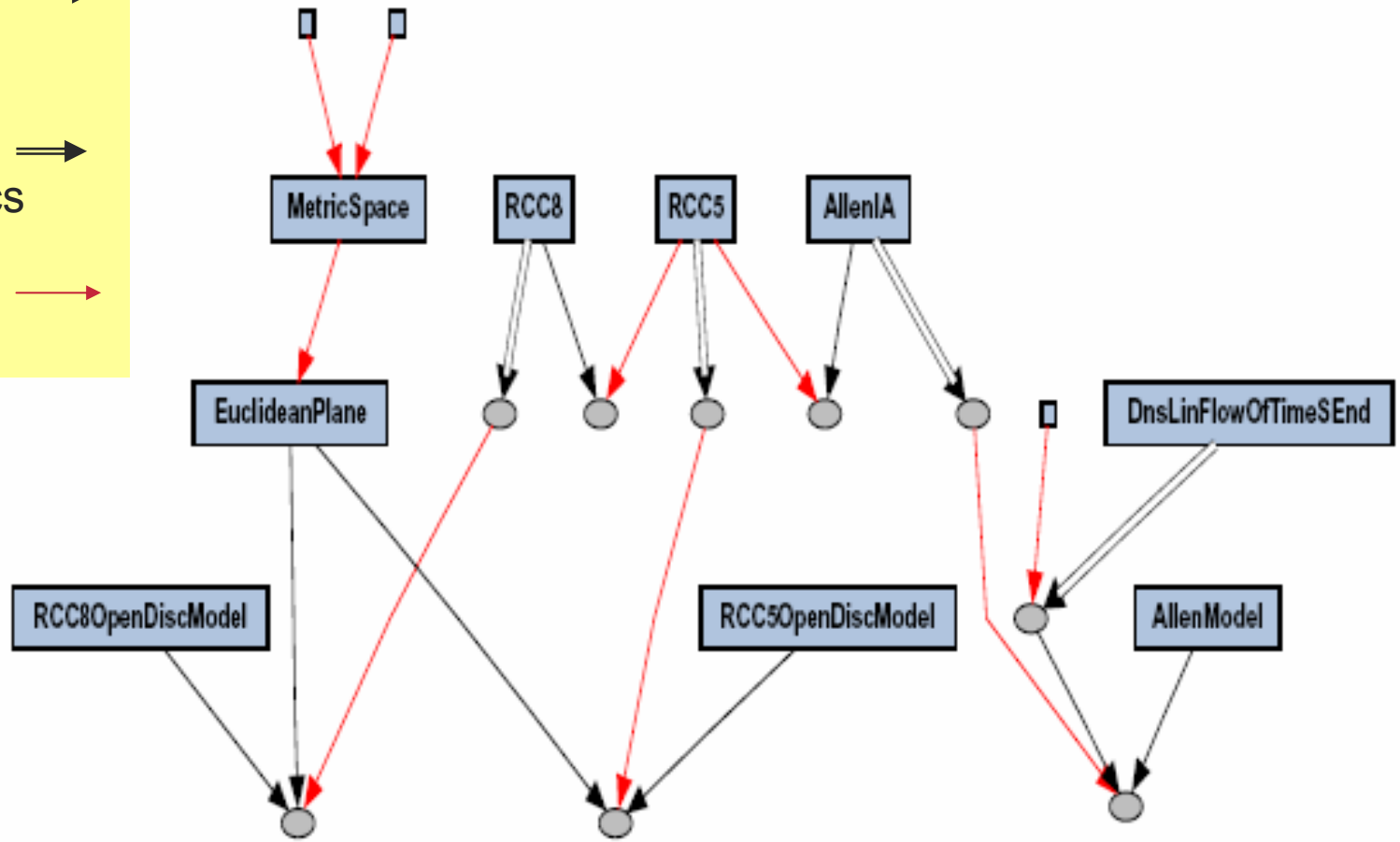
view RCC5 TO RCC8 :
RCC5
to { RCC8 **then %def**
ops *dr*,*pp*, *ppi* : *Rel*
• *dr* = *dc* ⊔ *ec*
• *pp* = *tpp* ⊔ *ntpp*
• *ppi* = *tppi* ⊔ *ntppi* }
= **sort** *BaseRel* → *Rel*
end

CASL development graph
(Wölfl & Mossakowski)

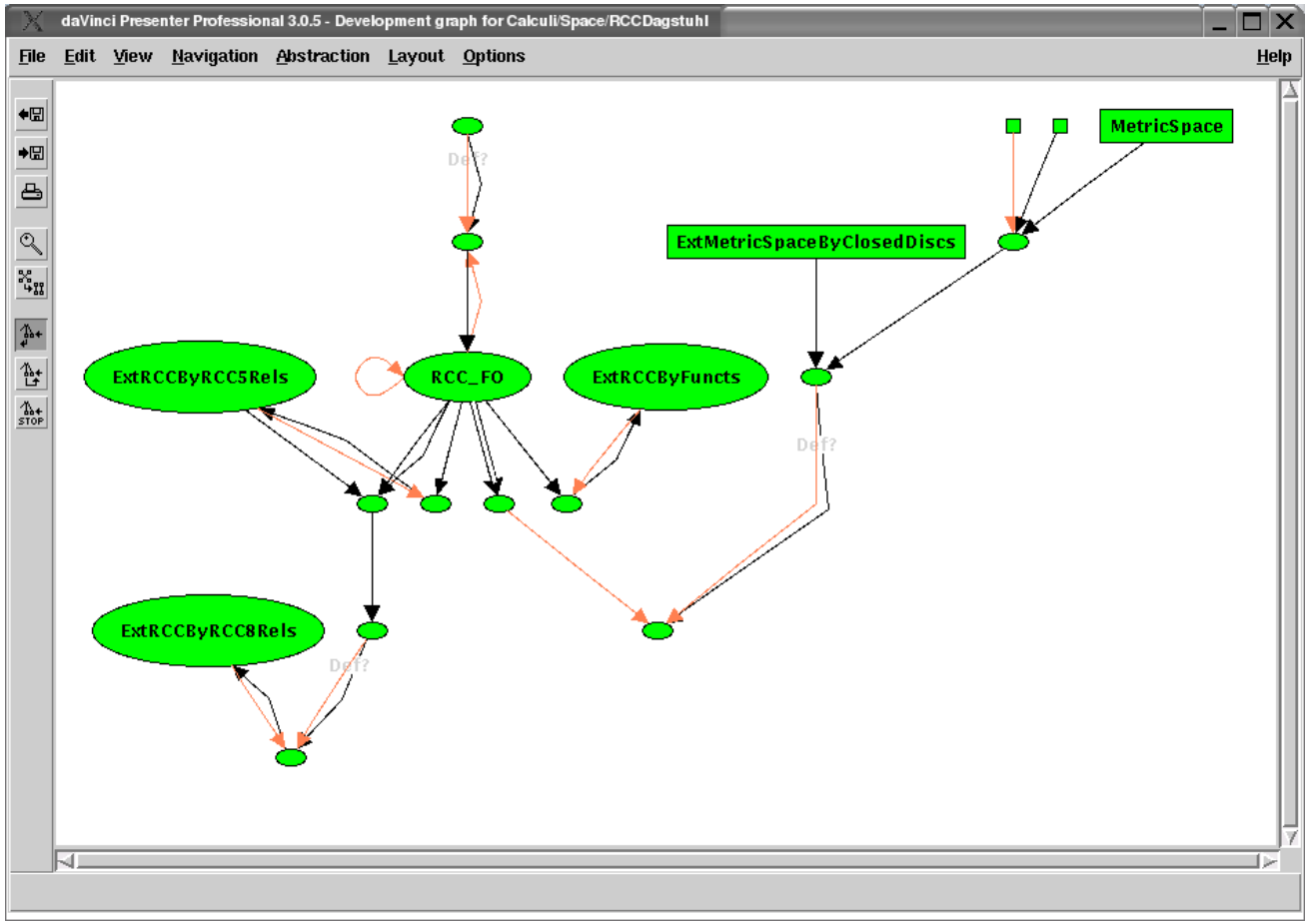
theory inclusion →

theory inclusion across logics ⟹

proof obligations →

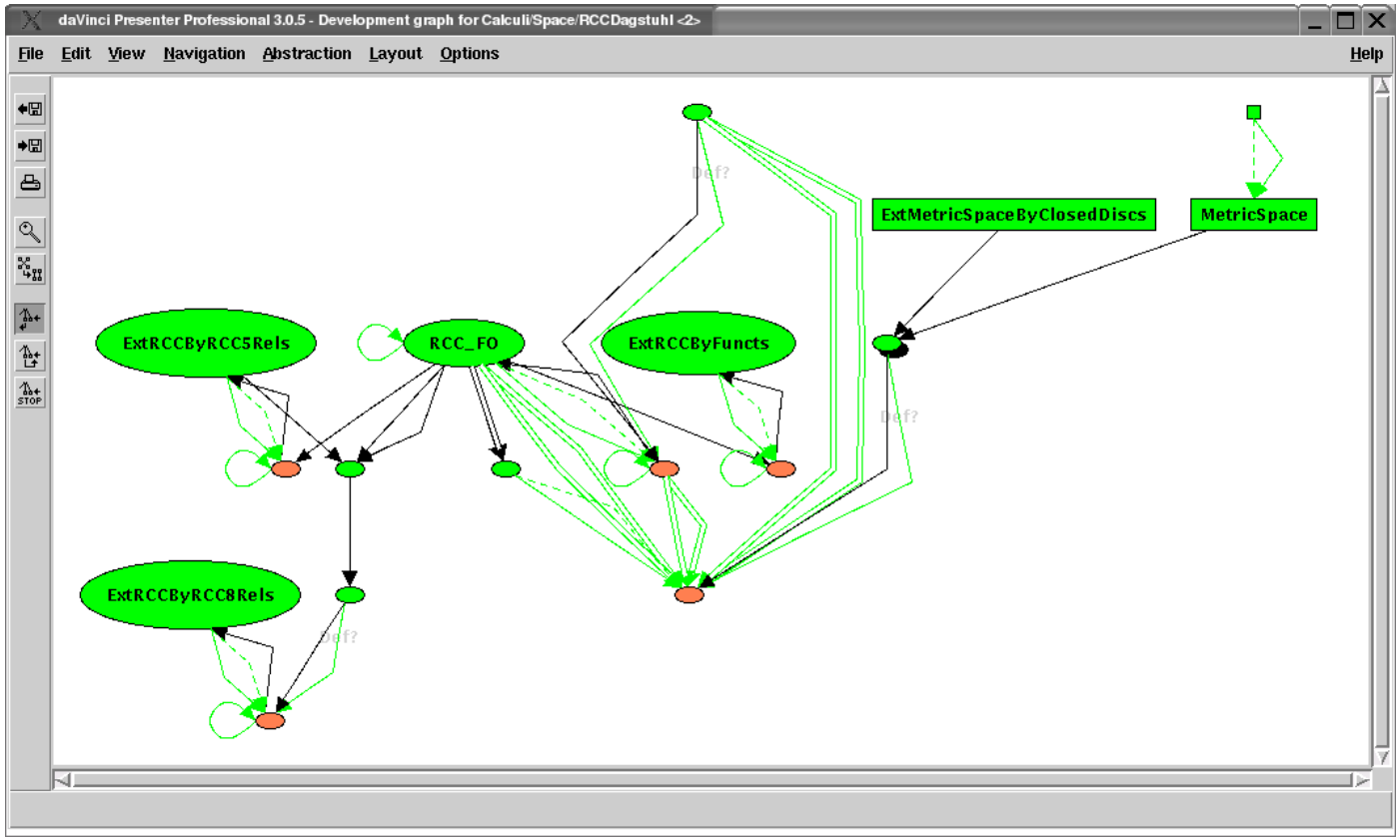


CASL development graphs



(Wölfl & Mossakowski)

CASL development graphs



(Wölfl & Mossakowski)

Example 2

More complex spatial categories

BFO: Sites and Niches (Smith)

- Niches are entities in which inhabitants carry out distinctive activities
  - niches have spatial extent
  - niches exist over time
  - niches may have real and/or fiat boundaries

- Niches may have particular properties that support their inhabitants (biological examples)

Artefactual niches: constructed ‘habitats’

- Artefacts are a further abstraction over and above objects.
- Artefacts are constructed with the intention of providing ‘capabilities’

- Objects (PED) may ‘support’ artefactual niches
  - e.g., a $\text{church}_{\text{PED}}$ supports a $\text{church}_{\text{niche}}$
  - a $\text{university}_{\text{PED}}$ supports a $\text{university}_{\text{niche}}$

Artefactual Sites and Niches

ONTOLOGY

building$_{PED}$

floors$_{PED}$

ceilings$_{PED}$

walls$_{PED}$

"support"

university$_{niche}$

lecture room$_{niche}$

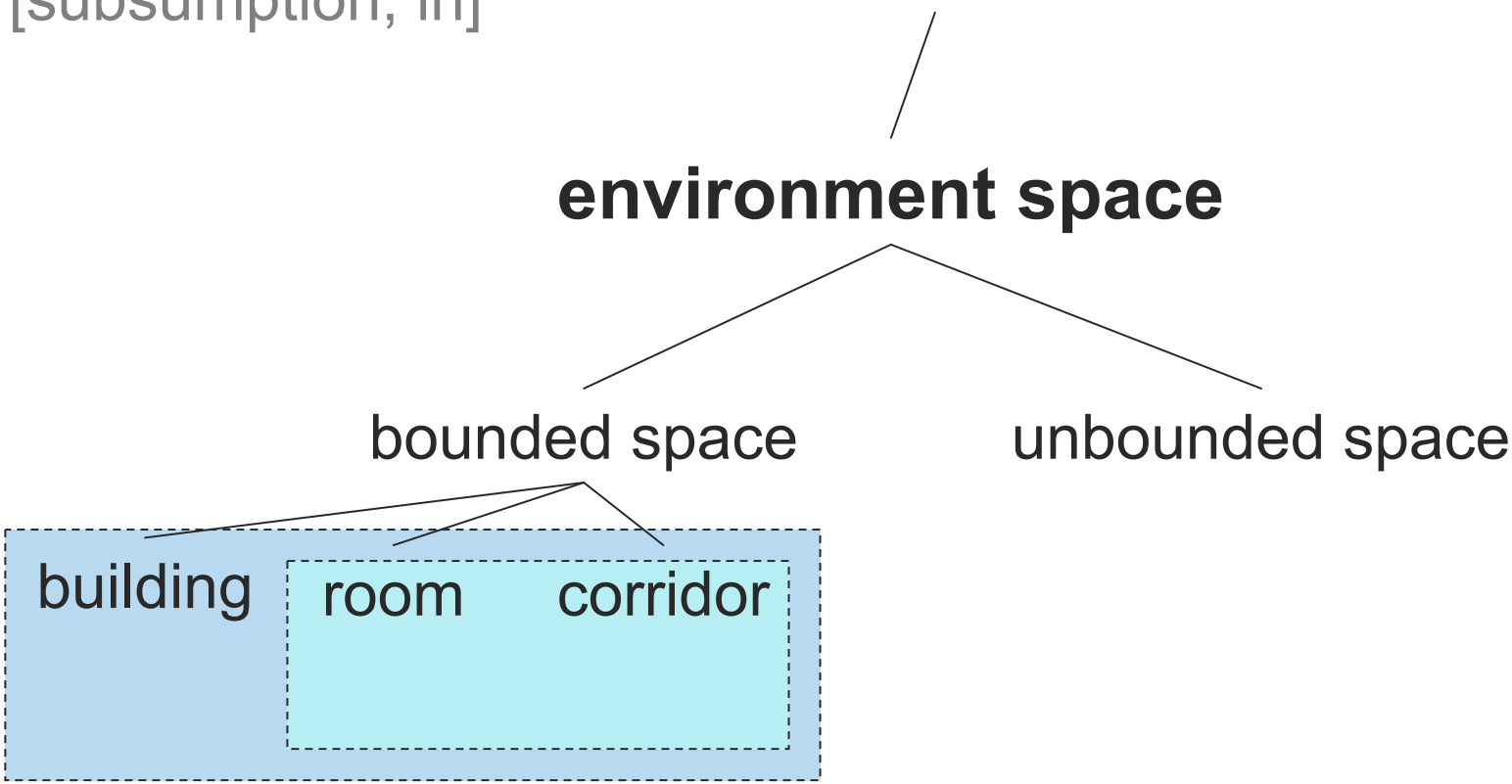
typical activities that define:
- functional parts
- functional objects

EPISTEMOLOGY (Nondeterministic, nondiscrete?)

Artefactual Sites: Environment spaces

I1-[OntoSpace]

[subsumption, in]



partonomies/granular partitions

Example 3

Applications to problems of pervasive computing

Applications to problems of pervasive computing:

I1-[OntoSpace]

Chen / Finin / Joshi (2004)

- Example context reasoning:
  - “No agent can be physically present in two different atomic places during the same time interval.”
  - “An agent can be physically present in two different compound places during the same time interval just in case one spatially subsumes the other.”
- Sensor mismatch / inconsistency detection
  - Person X is located in Parking Lot A
  - Person X is located in Room 210

The same problem addressed within our approach

I1-[OntoSpace]

- Person X is located in Parking Lot A
- Person X is located in Room 210

- Properties of ‘persons’
- Properties of Physical Endurants
  - Location
  - Specification of an appropriate quality region
  - Use of appropriate spatial theory
  - Combination of ontological diversity
  - Selection of appropriate granularity

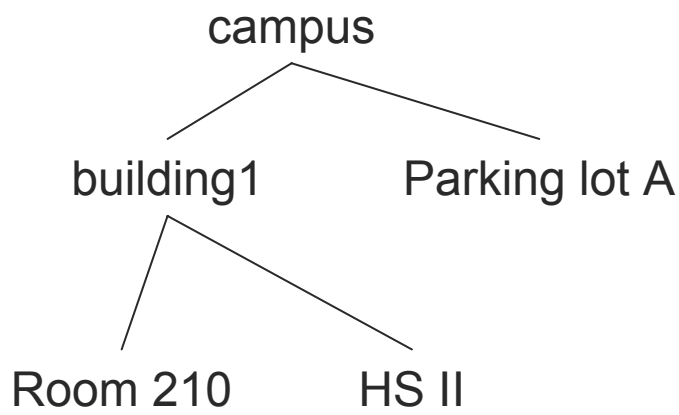
The same problem addressed within our approach

I1-[OntoSpace]

- Person X is located in Parking Lot A
- Person X is located in Room 210

Characterize the space:

- select a granular partition appropriate for the task
- site artefacts : environment spaces



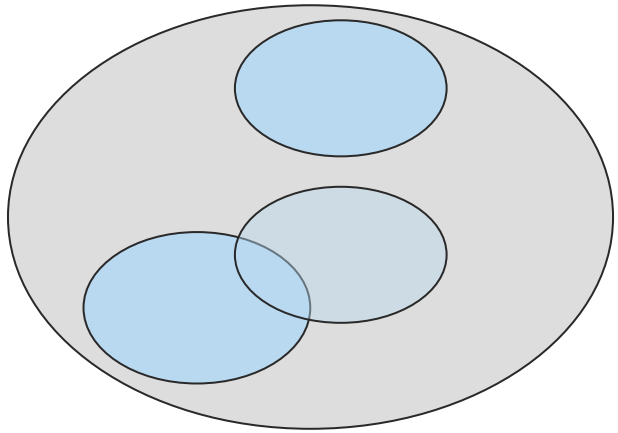
The same problem addressed within our approach

I1-[OntoSpace]

- Person X is located in Parking Lot A
- Person X is located in Room 210

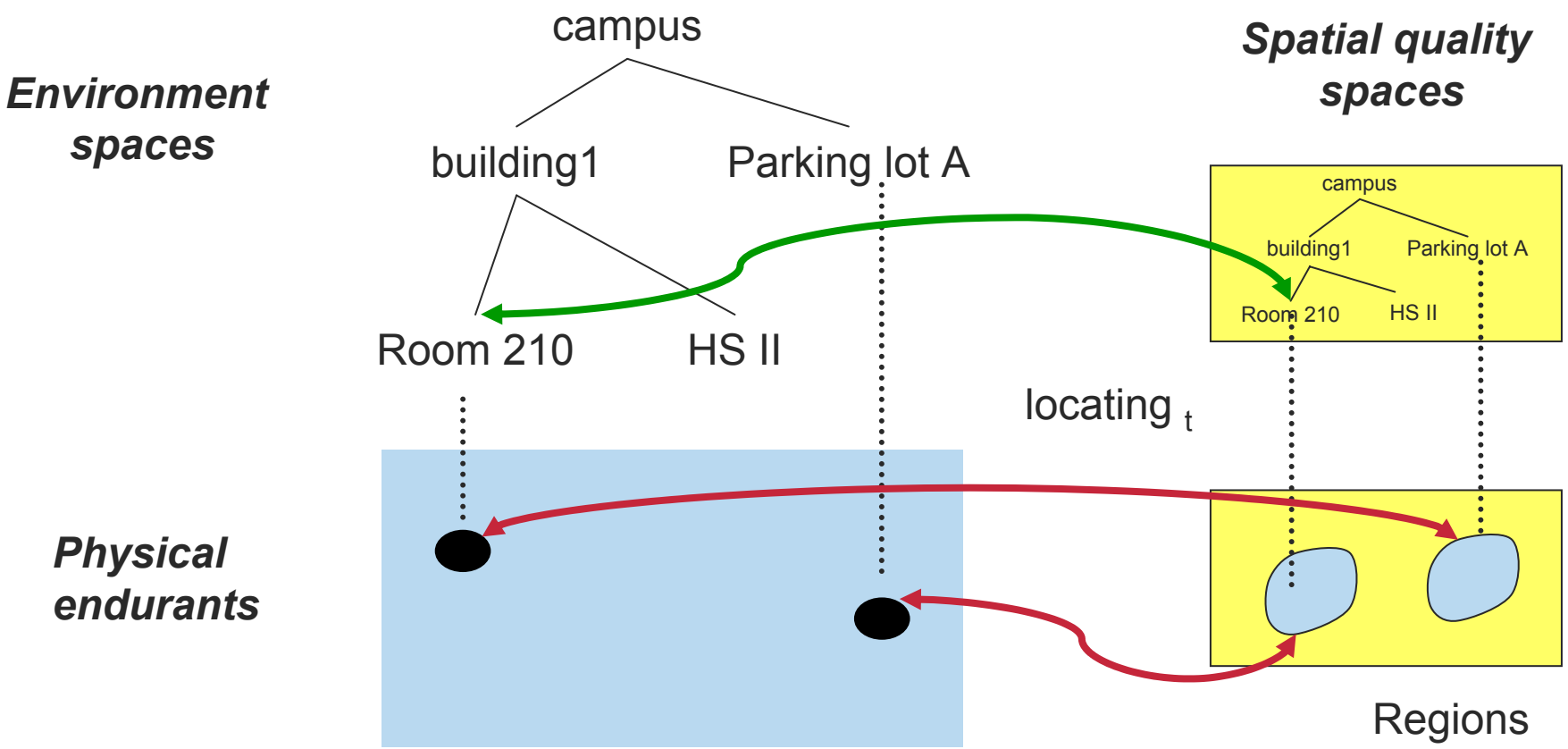
Characterize the spatial task:

- spatial inclusion
- regions: parts and connections



RCC-n

The same problem addressed within our approach



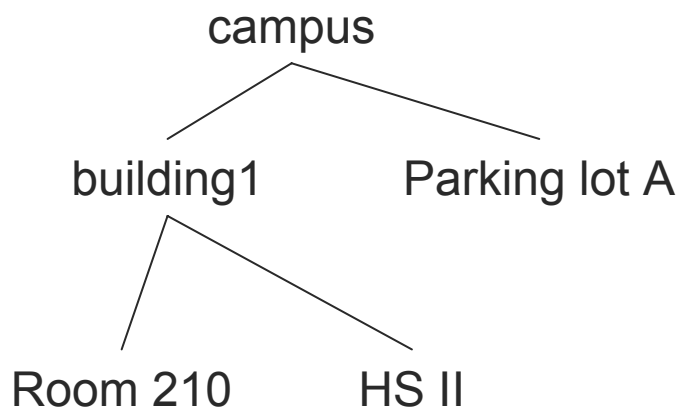
A related problem addressed within our approach

I1-[OntoSpace]

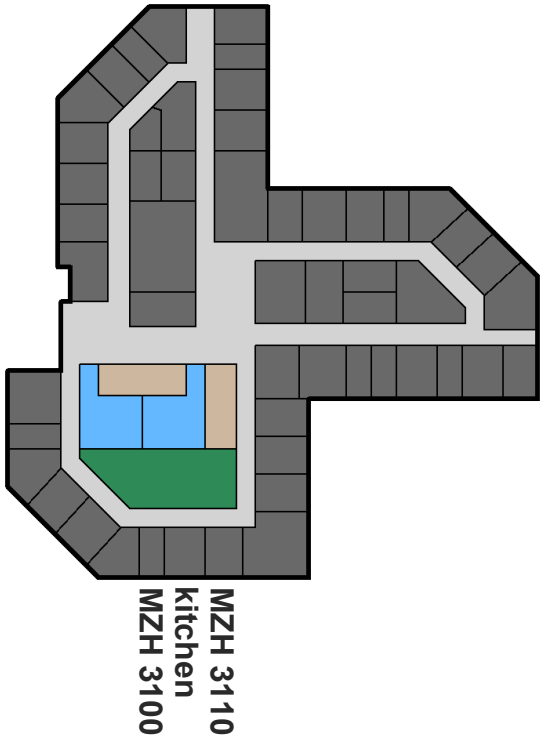
- Person X is located in Parking Lot A
- Person X **wants to be** located in Room 210

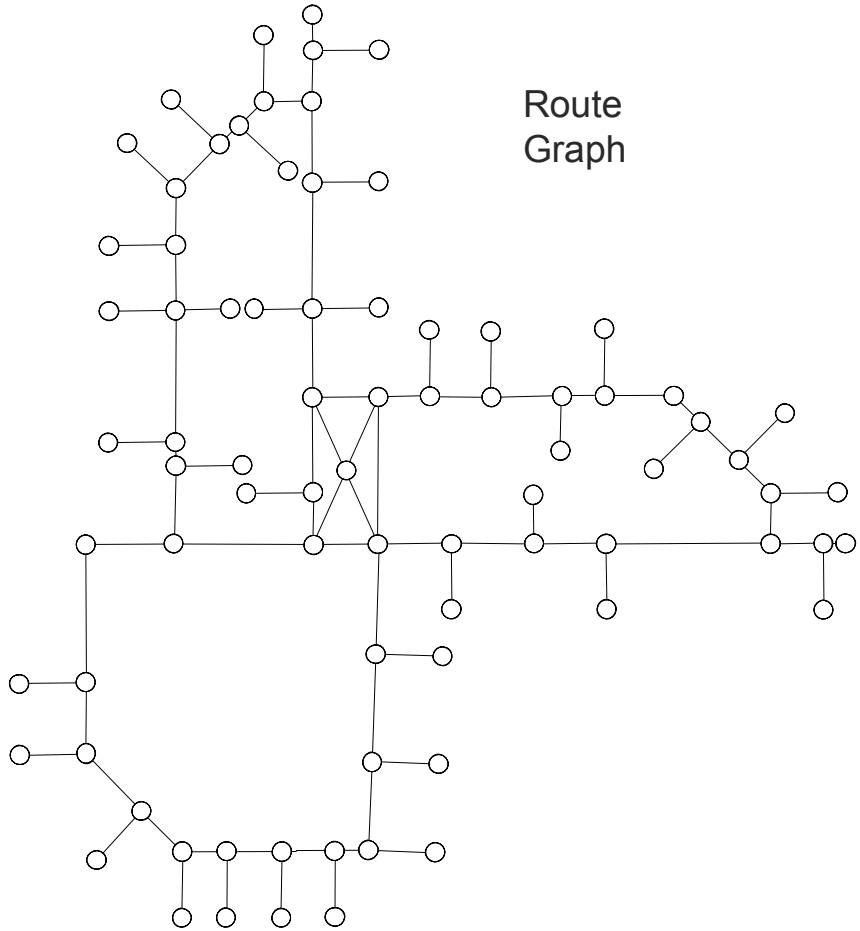
Characterize the space:

- select a granular partition appropriate for the task
- site artefacts : environment spaces



A route graph





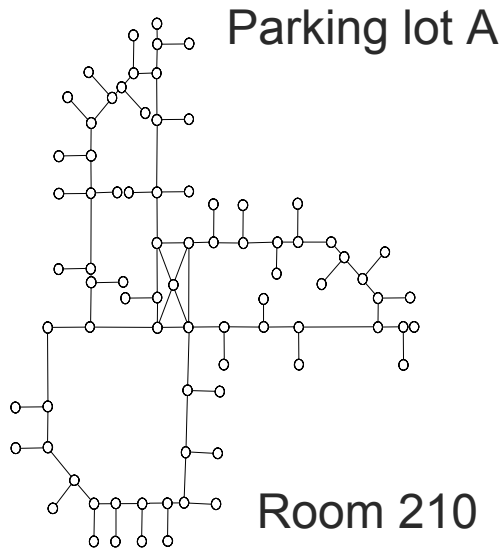
A related problem addressed within our approach

I1-[OntoSpace]

- Person X is located in Parking Lot A
- Person X **wants to be** located in Room 210

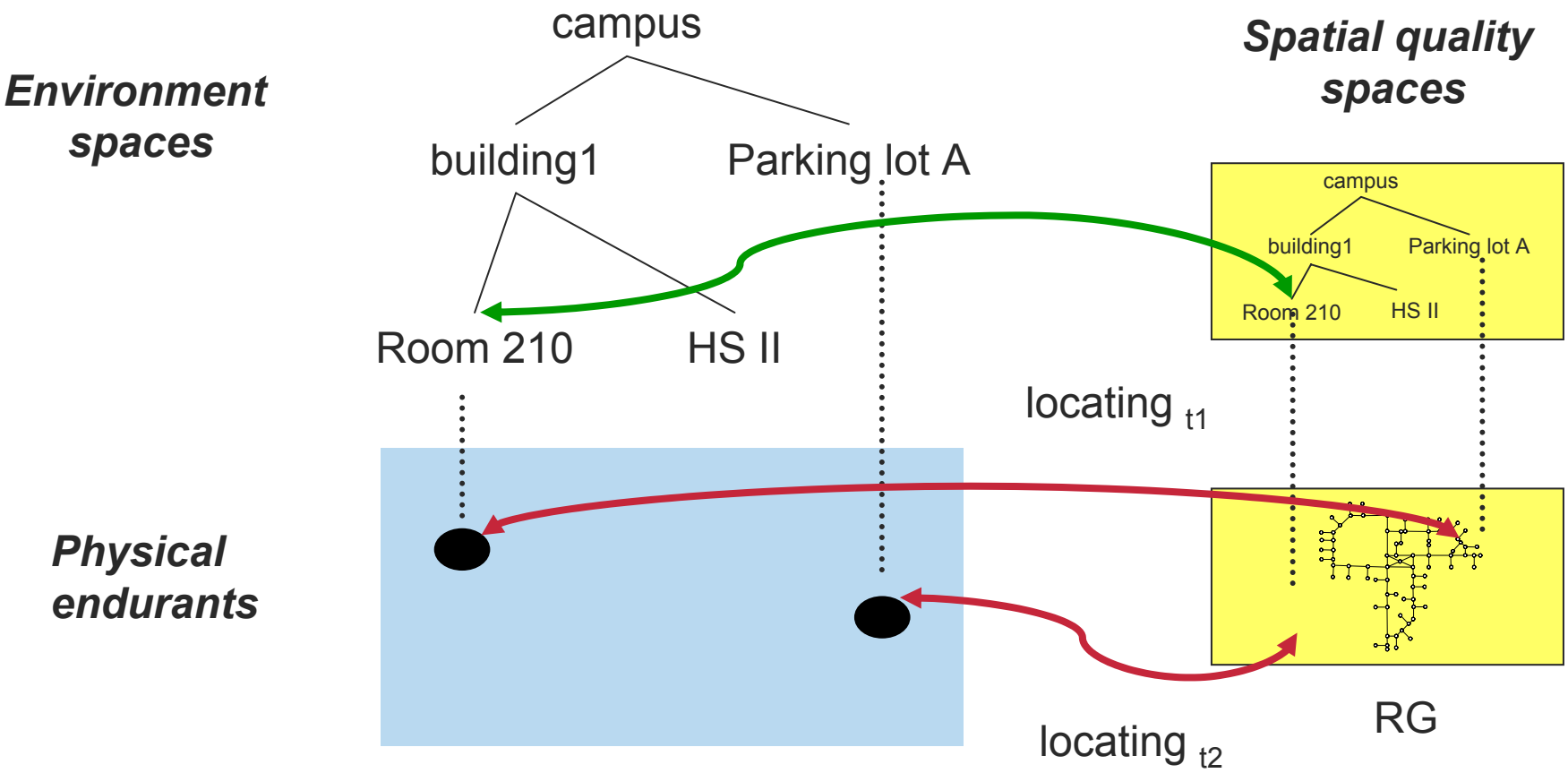
Characterize the spatial task:

- navigation
- space: supporting route planning, e.g., route graphs



Route graph

A related problem addressed within our approach



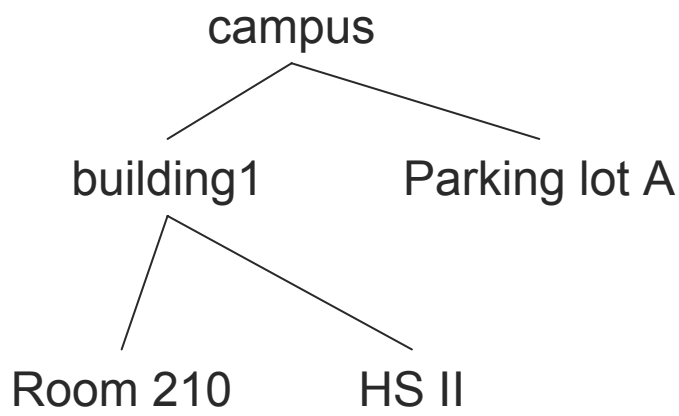
Another related problem addressed within our approach

I1-[OntoSpace]

- Person X needs a **description** of how to get from Parking Lot A to Room 210

Characterize the space:

- select a granular partition appropriate for the task
- site artefacts : environment spaces



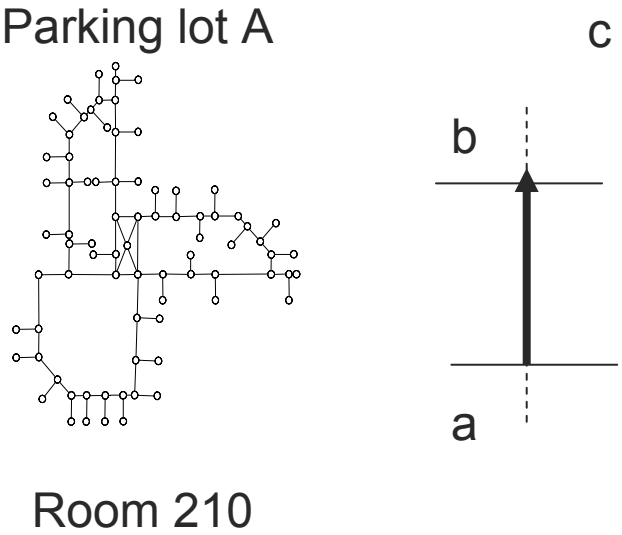
Another related problem addressed within our approach

I1-[OntoSpace]

- Person X needs a **description** of how to get from Parking Lot A to Room 210

Characterize the spatial task:

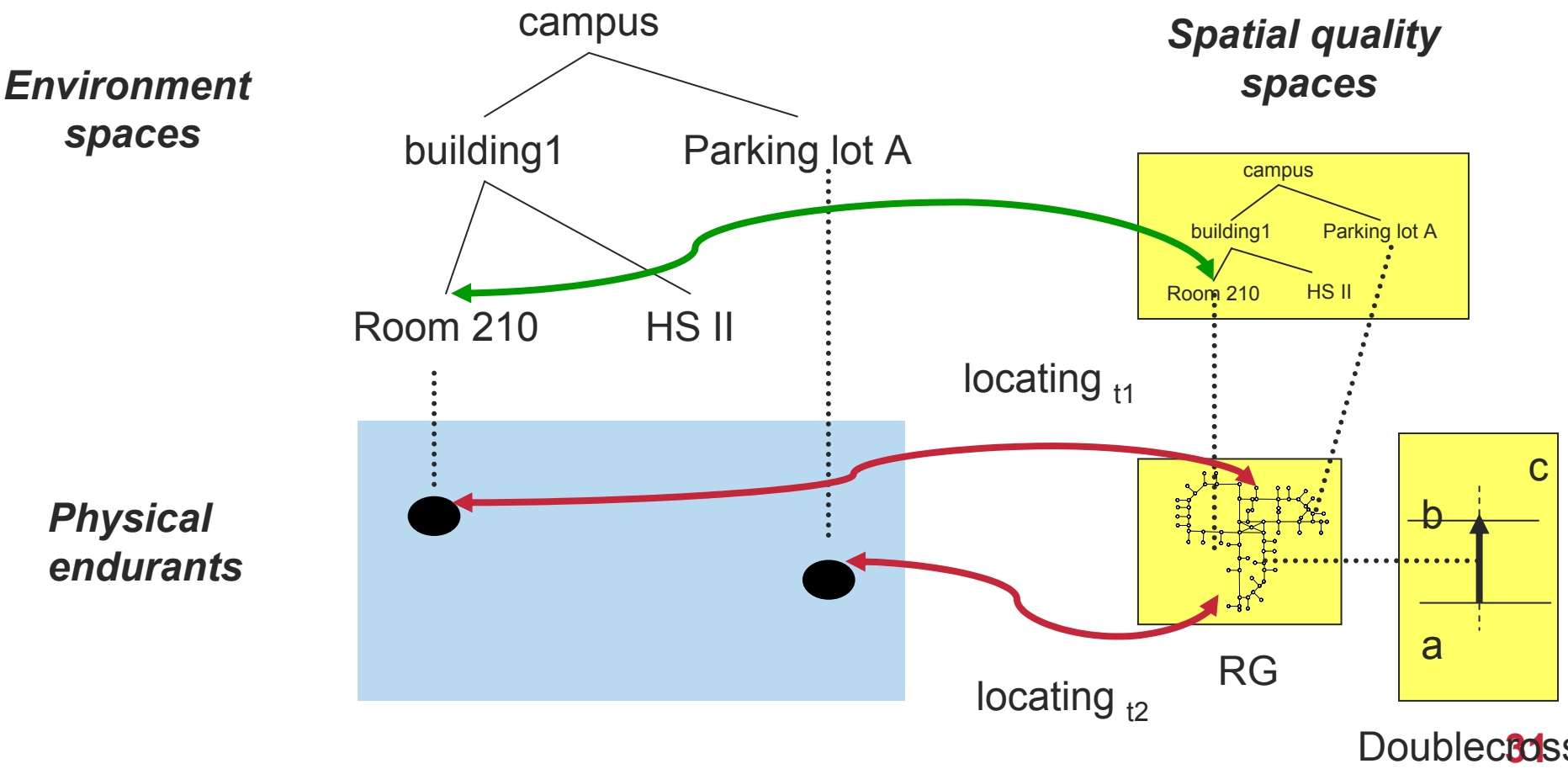
- navigation
- space: supporting route planning, e.g., route graphs
- route description: linguistic expression



Route graph PLUS double-cross

A related problem addressed within our approach

I1-[OntoSpace]



Applications to problems of pervasive computing:

I1-[OntoSpace]

Chen / Finin / Joshi (2004)

- Definition of problematic categories:
  - CompoundPlace vs. AtomicPlace
  - Many relations: locatedInCompoundPlace, locatedInRoom, locatedInRestroom, ...
  - Specific reasoning rules

- Most, if not all, of these are derivable from properly defined foundational ontologies

Route Graph: Inter-ontological relations