SUPPORTING SPATIAL PLANNING WITH QUALITATIVE CONFIGURATION ANALYSIS

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SPATIAL PLANNING TODAY SNAPSHOT

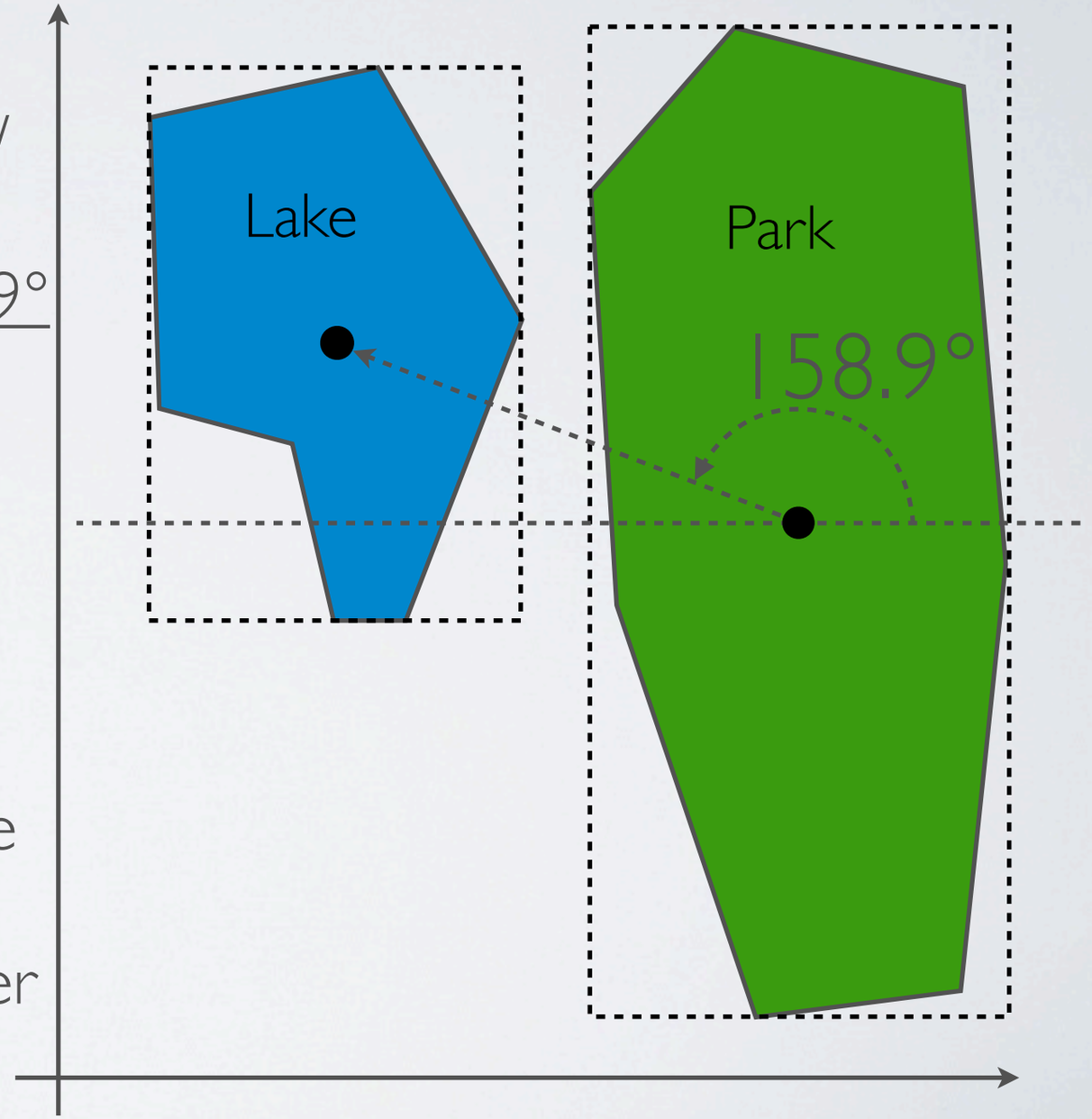
- Spatial planning strongly relies on Spatial Information Systems (SIS):
  - Computer-Aided Design
  - Geographic Information Systems
- SIS offer continuously more powerful spatial data analysis and management options
- Yet, SIS largely lack support for natural human-computer interaction

SIS VS HUMANS

- SIS → quantitative representations (raster/vector) + numerical operations
  E.g.: The angular lake-park distance is 158.9°

- Humans → qualitative representations + reasoning
  E.g.: The lake is to the west of the park

- Today, translation efforts to map qualitative spatial representation into a quantitative (numerical/geometric) one is up to SIS user

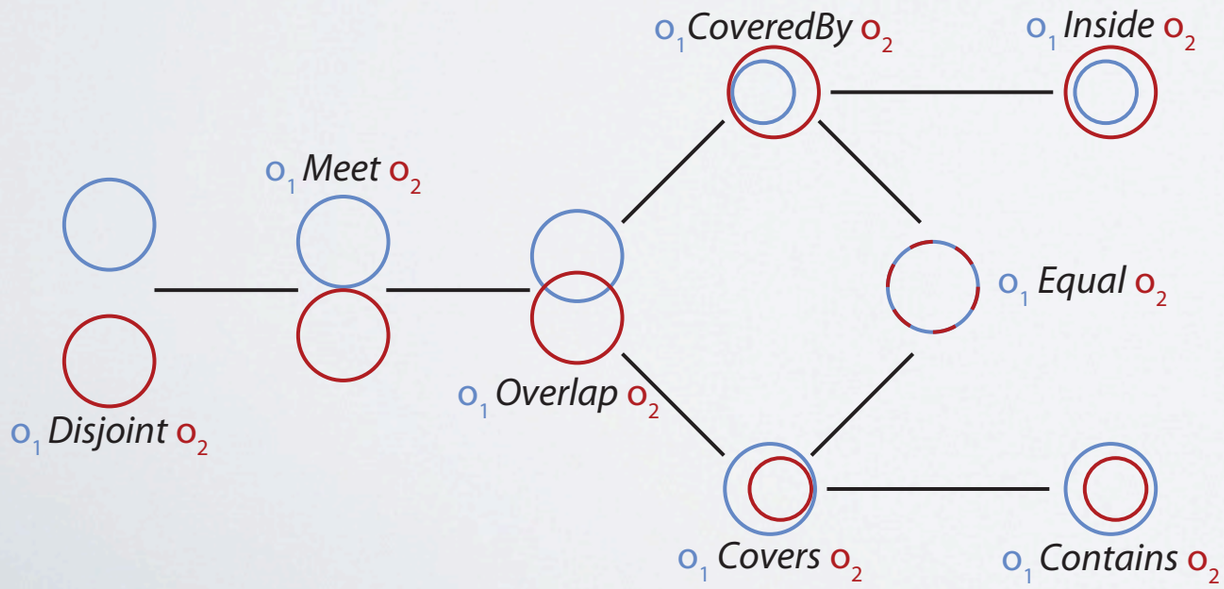


QUALITATIVE INFORMATION

- Qualitative information is, by its own nature, somewhat "vague" and "imprecise"
- It is not a substitute of quantitative information
- Yet, when it comes to interaction with human beings, it plays a fundamental role
- How to embody qualitative models into SIS?

QUALITATIVE SPATIAL REPRESENTATION AND REASONING

- Qualitative Spatial Representation and Reasoning (QSR) is a subfield of Artificial Intelligence providing so-called qualitative spatial calculi
- A qualitative calculus
  - is cognitive suitable
  - focuses on a single aspect of space (e.g. topology, direction, or distance)
  - consists of two main items:
    - a finite set of symbols called qualitative spatial relations: used for representational purposes
    - a finite set of inference rules that allow for symbolic reasoning

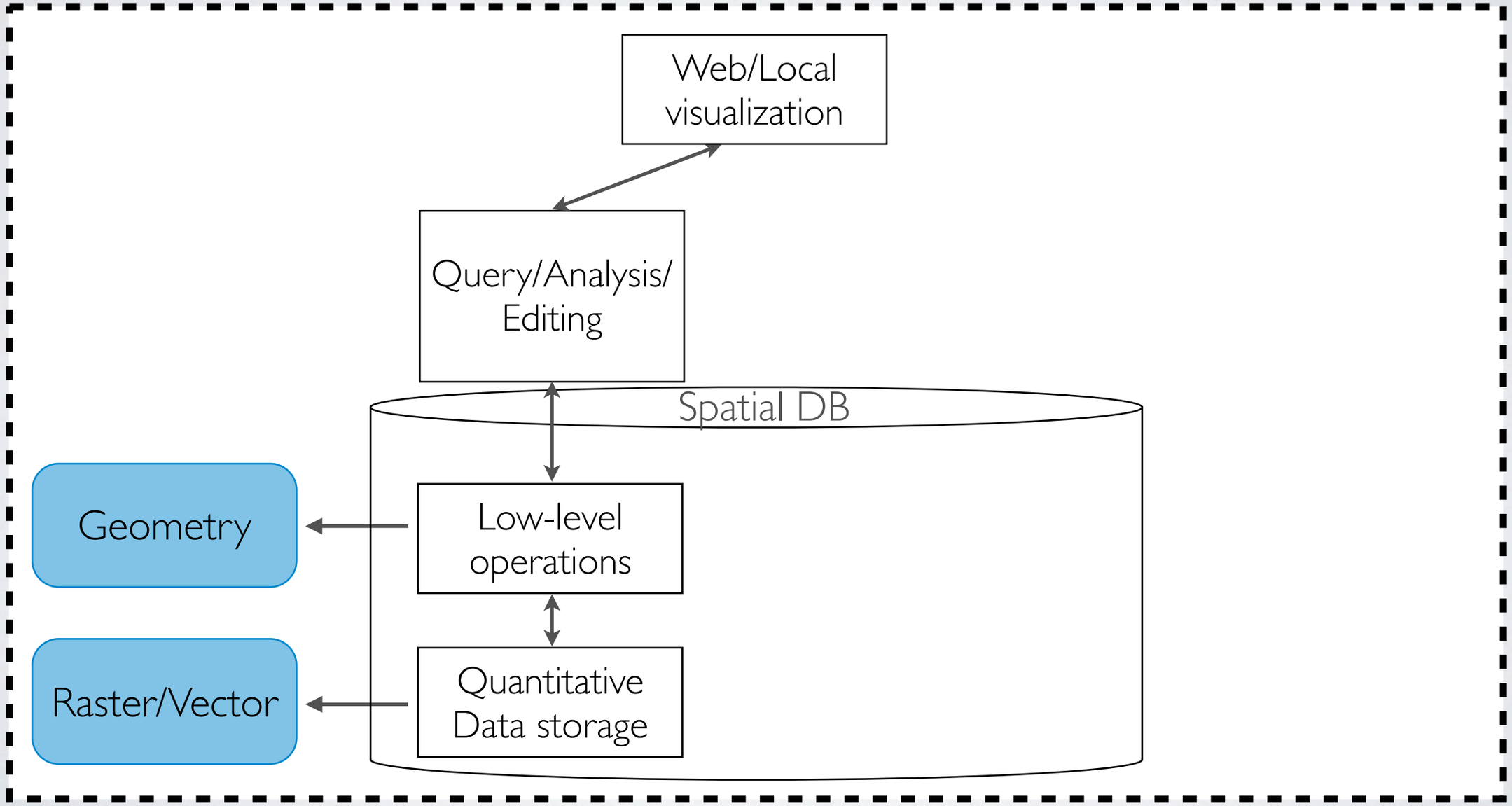


Egenhofer, M.J. (1989).

The 9-intersection model defines the 8 topological relations that can hold between two spatial objects; on the left depicted and arranged according to their conceptual neighborhood.

QUALITATIVE SPATIAL INFORMATION SYSTEM

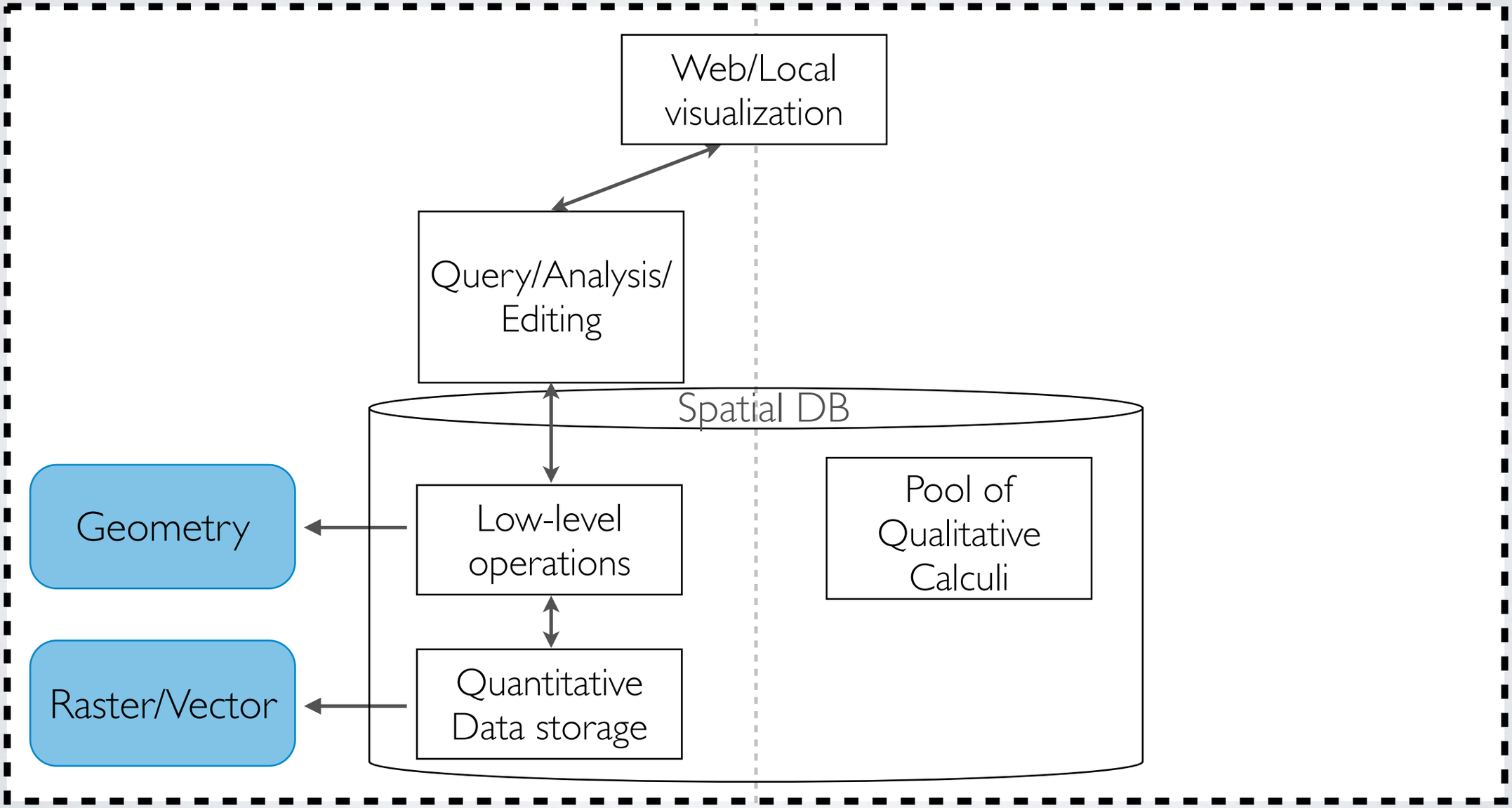
Spatial Information System



Fogliaroni, P. (2012).

QUALITATIVE SPATIAL INFORMATION SYSTEM

Spatial Information System + Qualitative Extension



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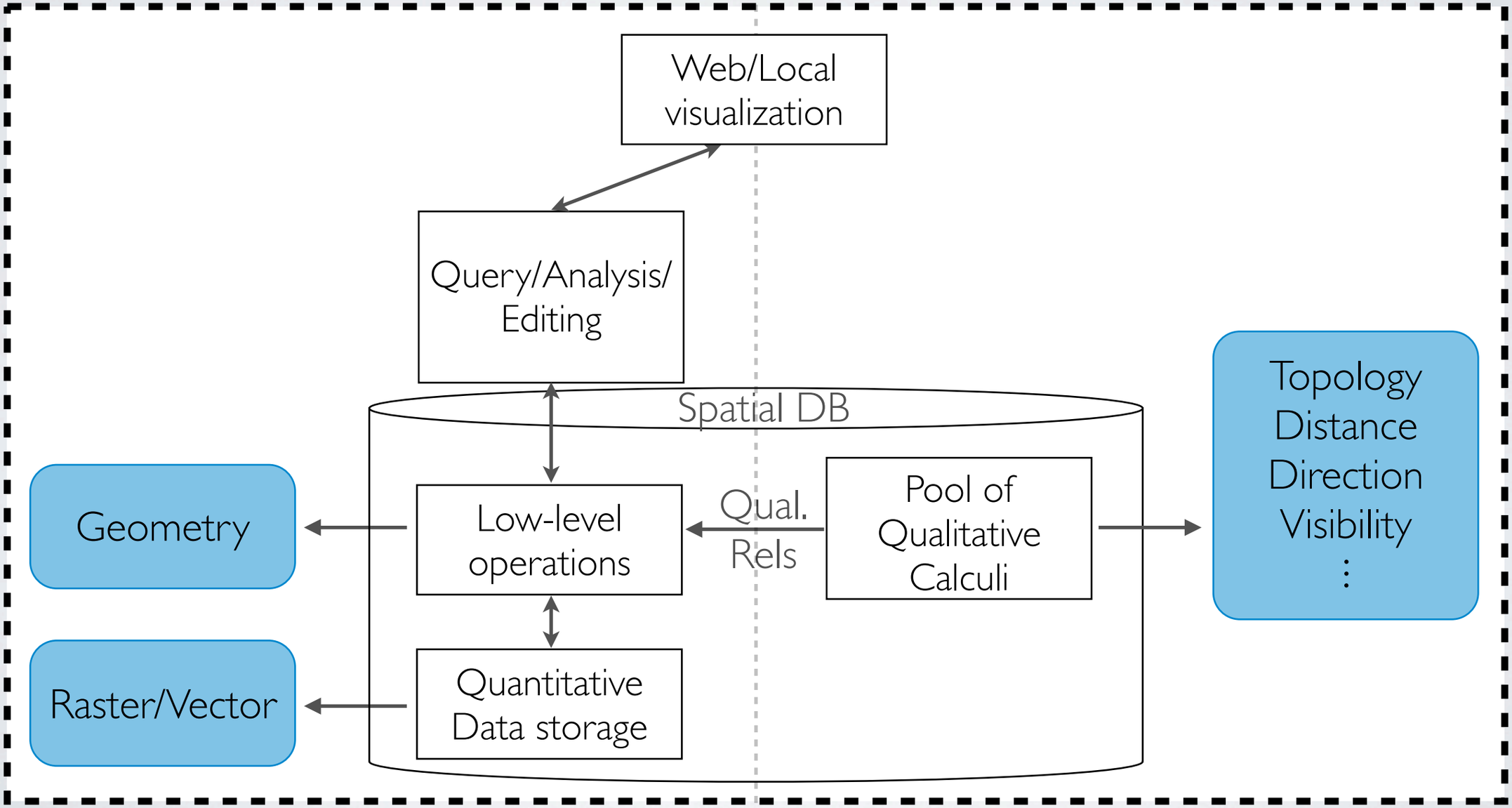

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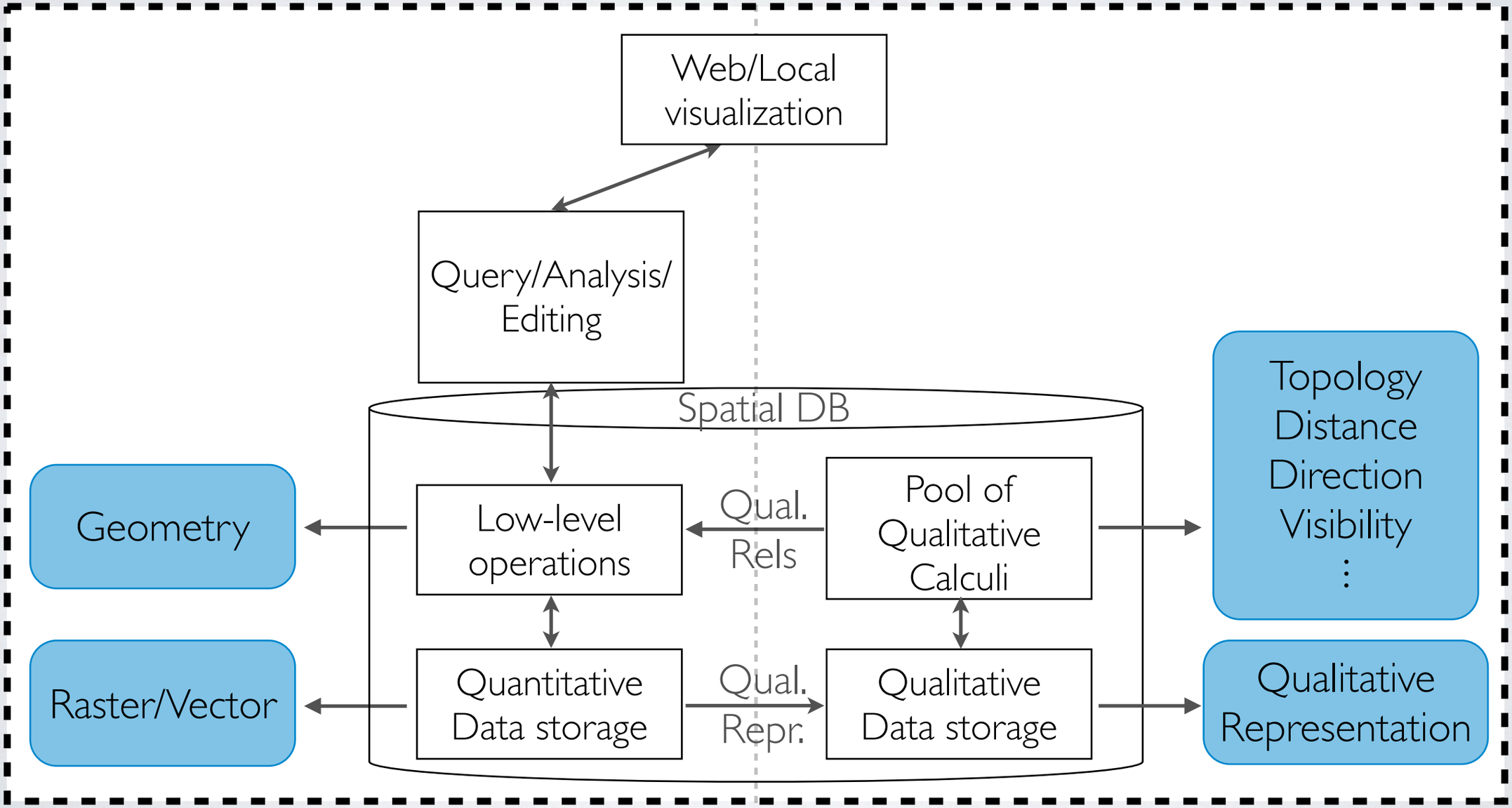

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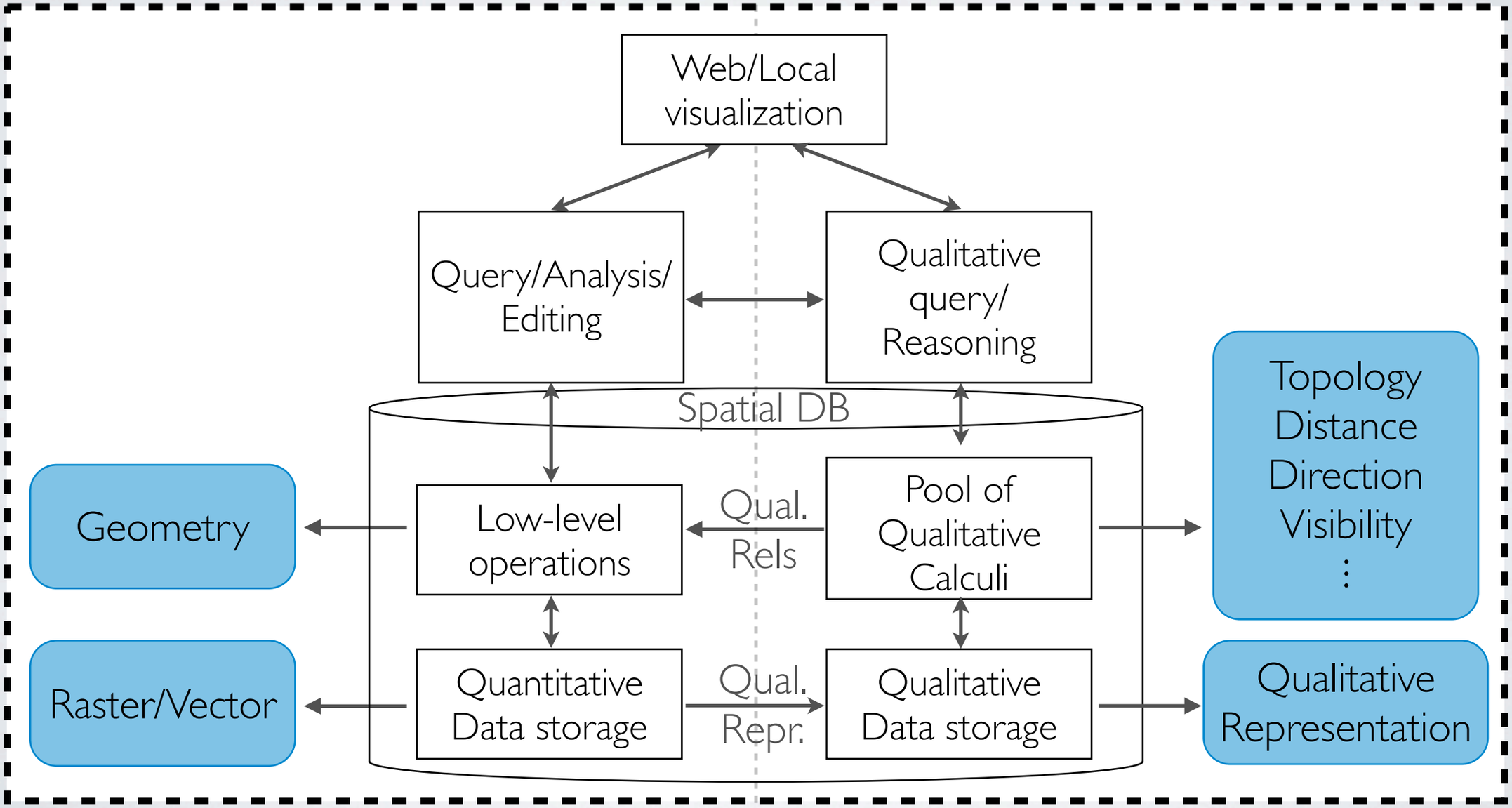
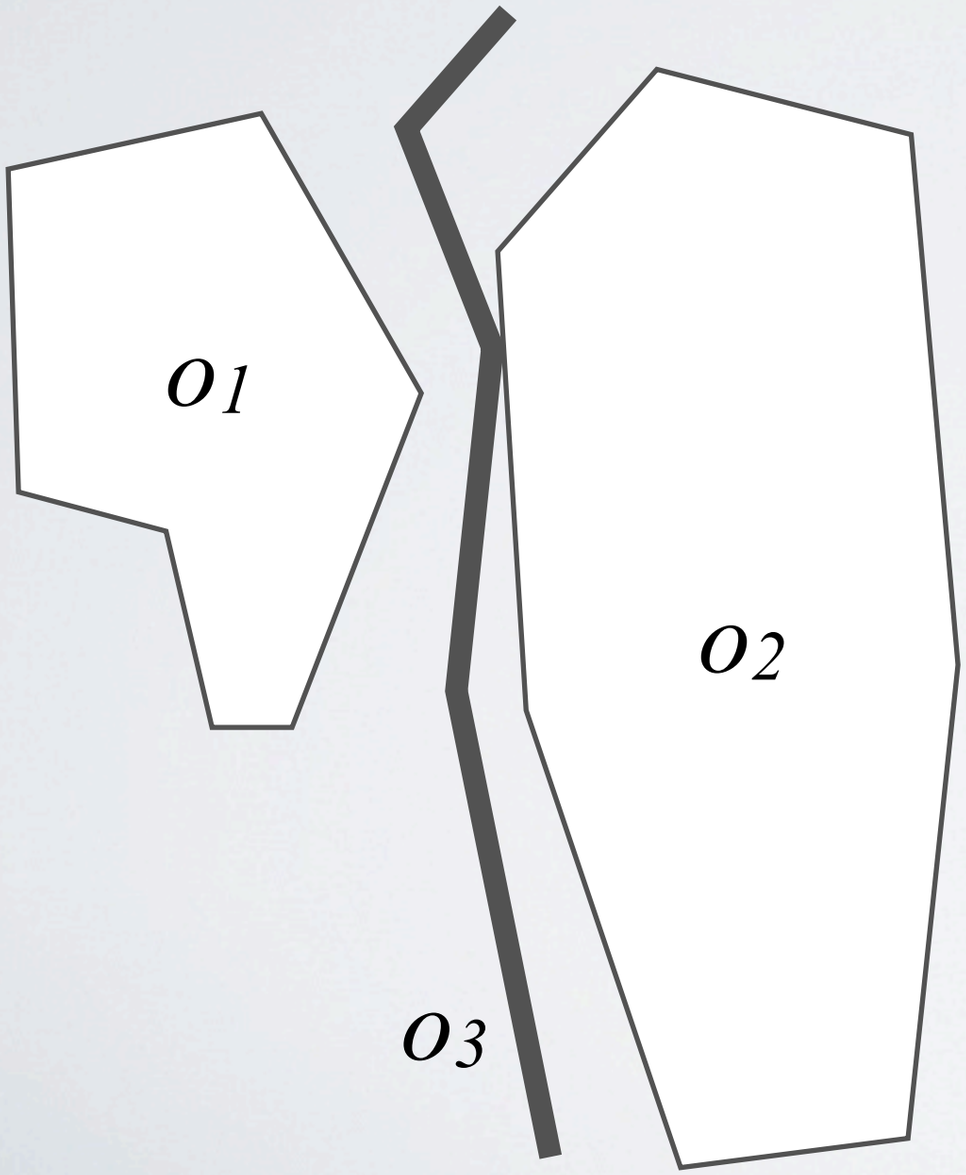


Fogliaroni, P. (2012).

QUALITATIVE REPRESENTATION

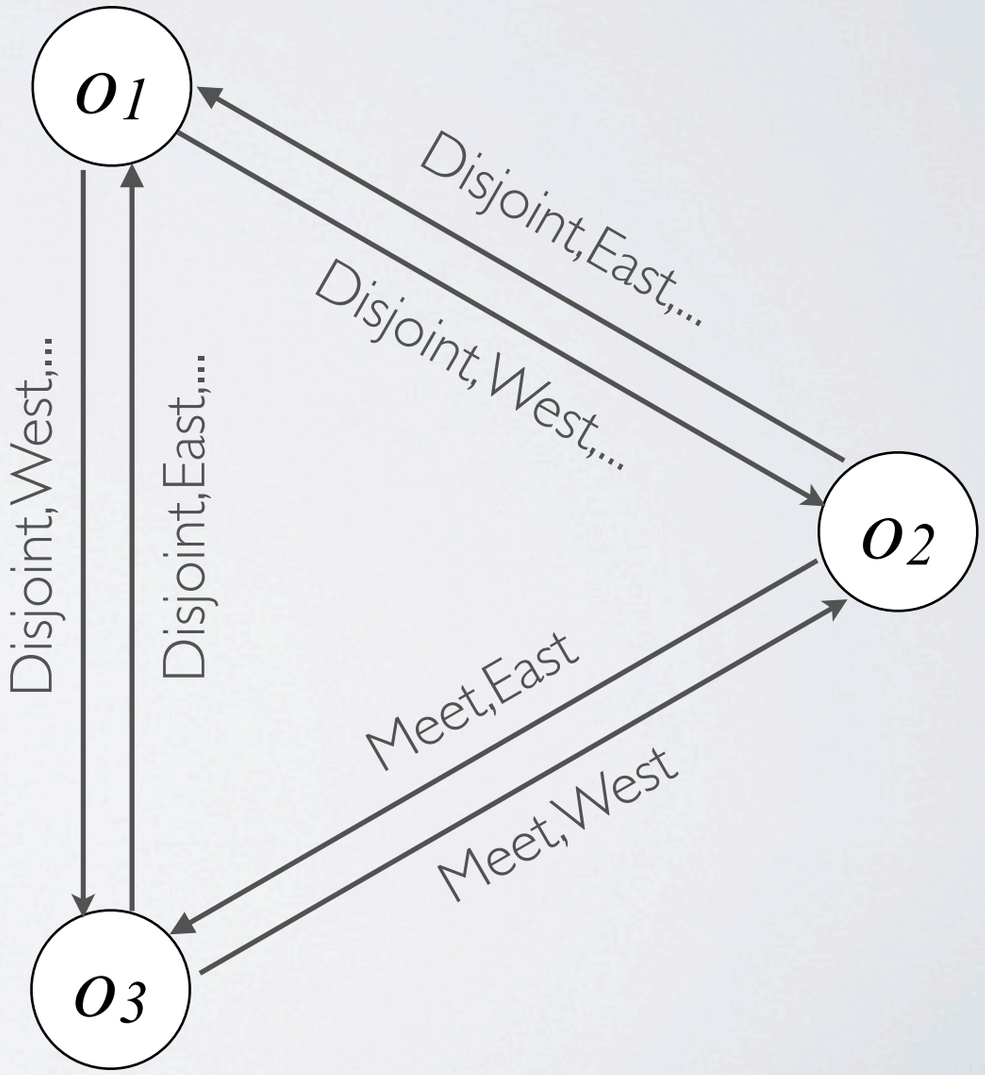
Quantitative representation

Vector



Qualitative representation

Qualitative Constraint Network (QCN)



QUALITATIVE REPRESENTATION

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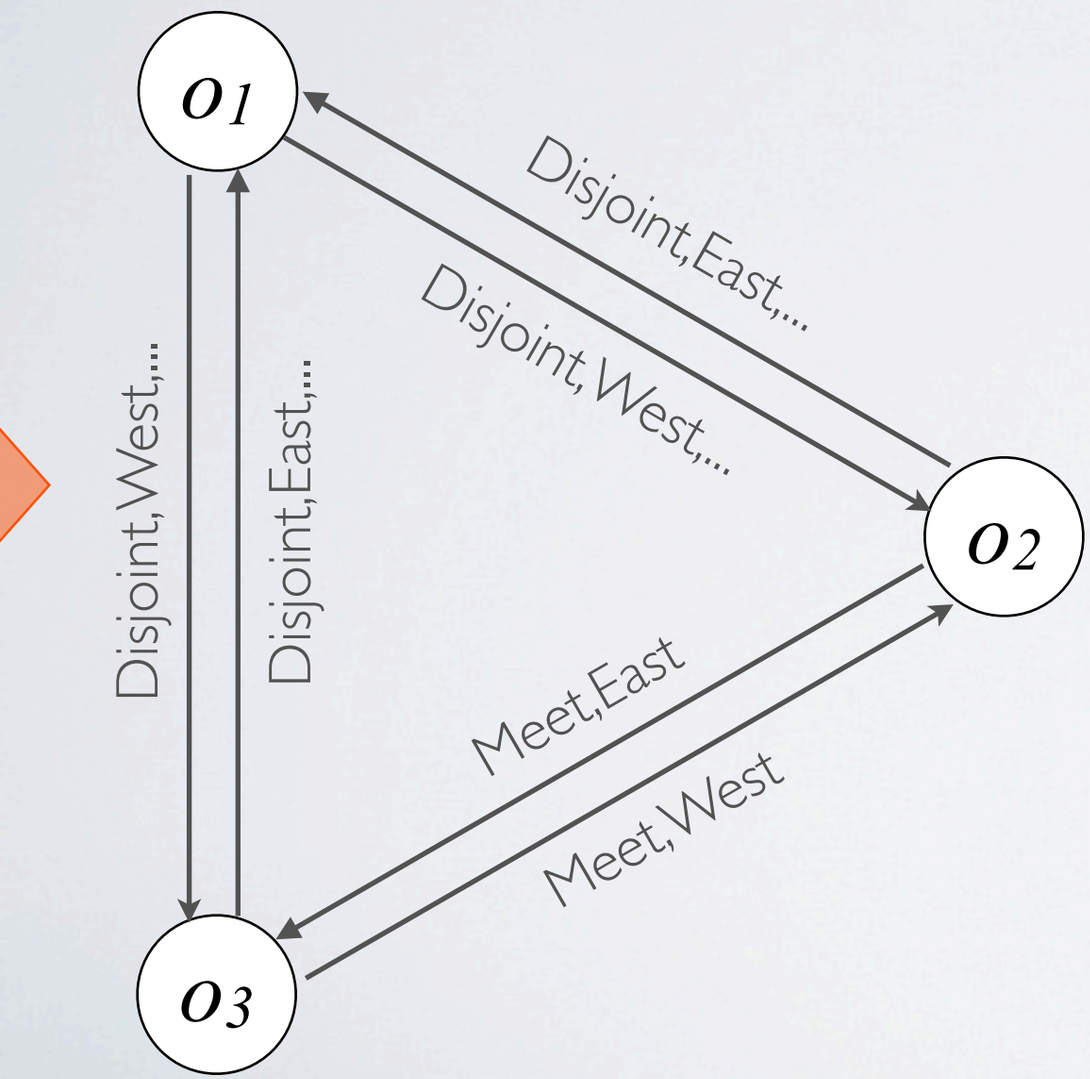


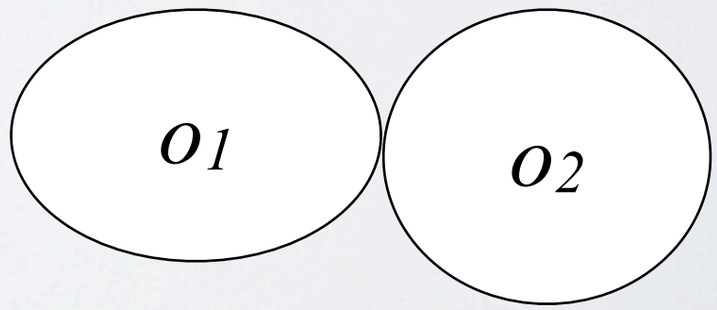
Qualitative Queries

Natural language sentence

I'm looking for a pair of objects such that they are in touch and one lies west of the other!

Does object 1 touch object 2?

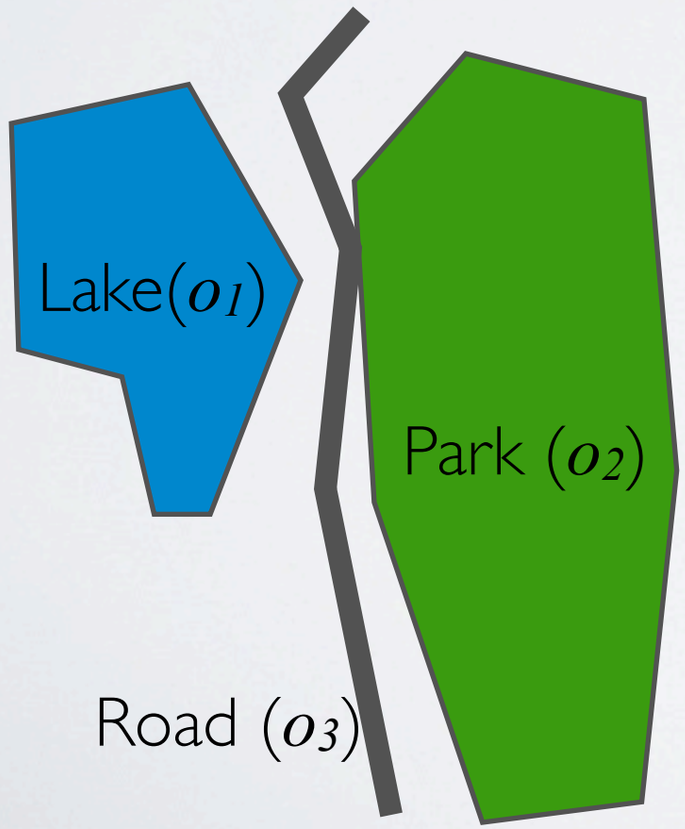
or a sketch



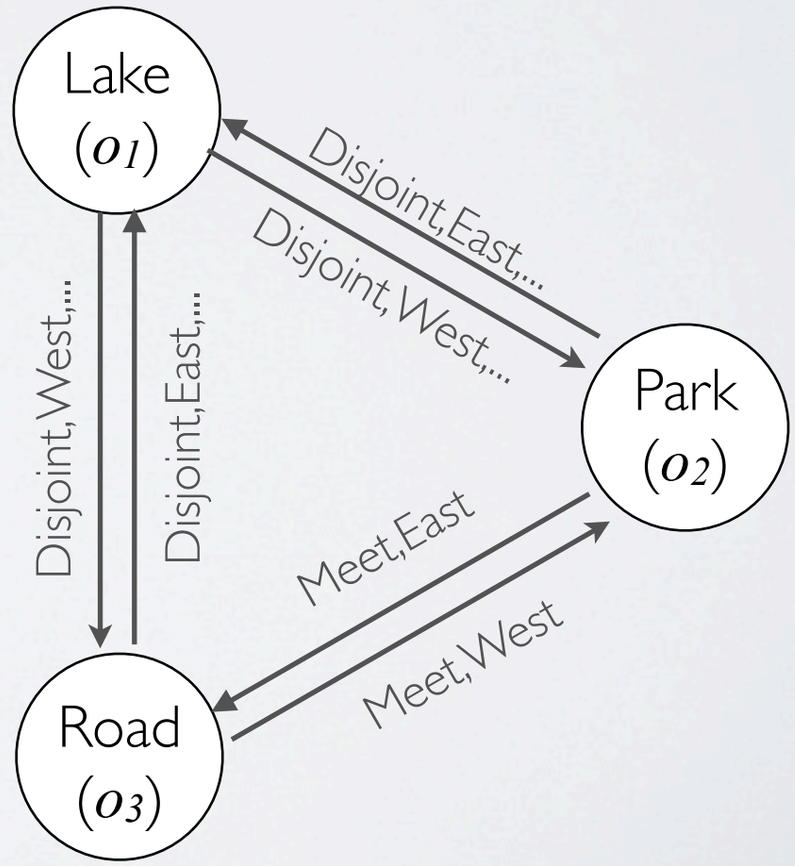
SPATIAL PLANNING SUPPORT

- Qualitative Spatial Information System +
  - spatial object ontology: e.g. lake, park, building, house...
  - spatial plan ontology: e.g. public green, residential area...
- Each designed plan is stored in the database together with the corresponding qualitative config

Geometric Plan Design



Qualitative Configuration



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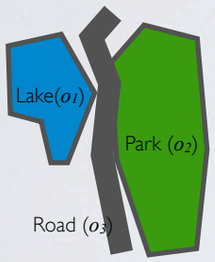

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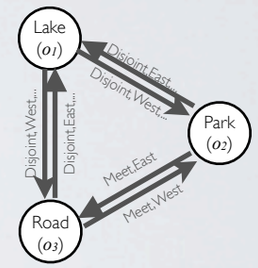

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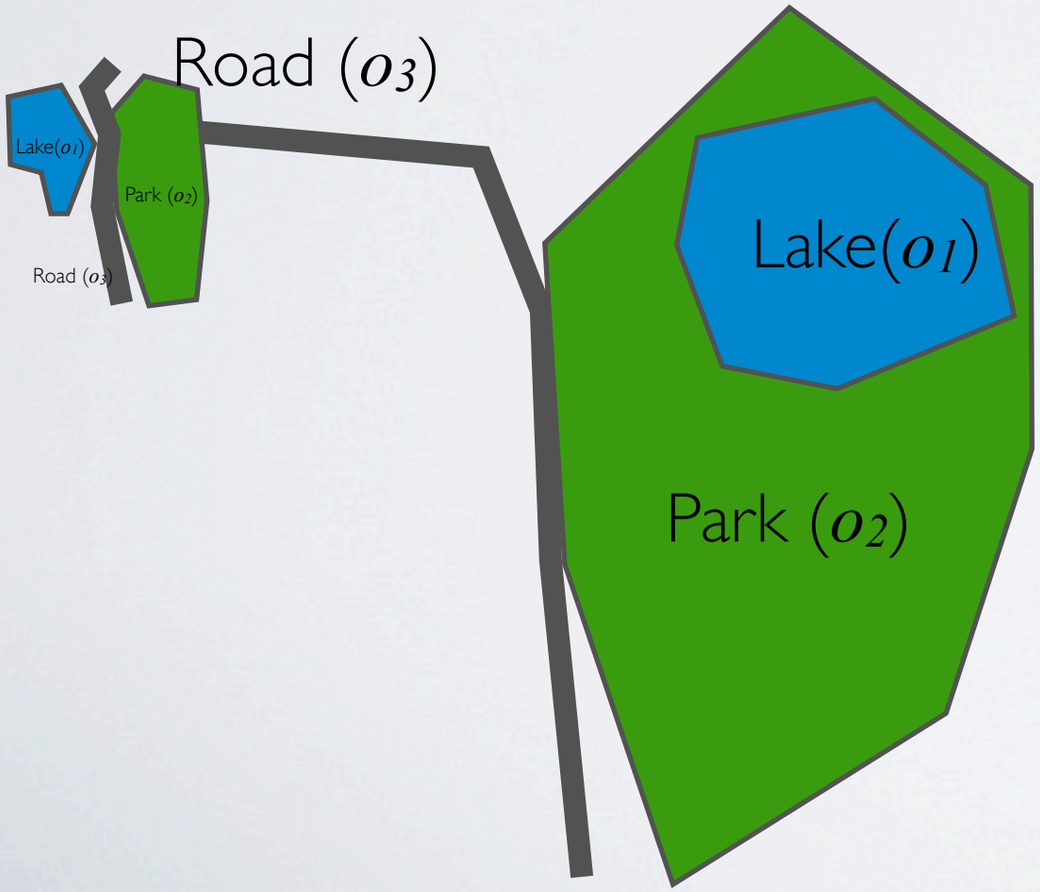

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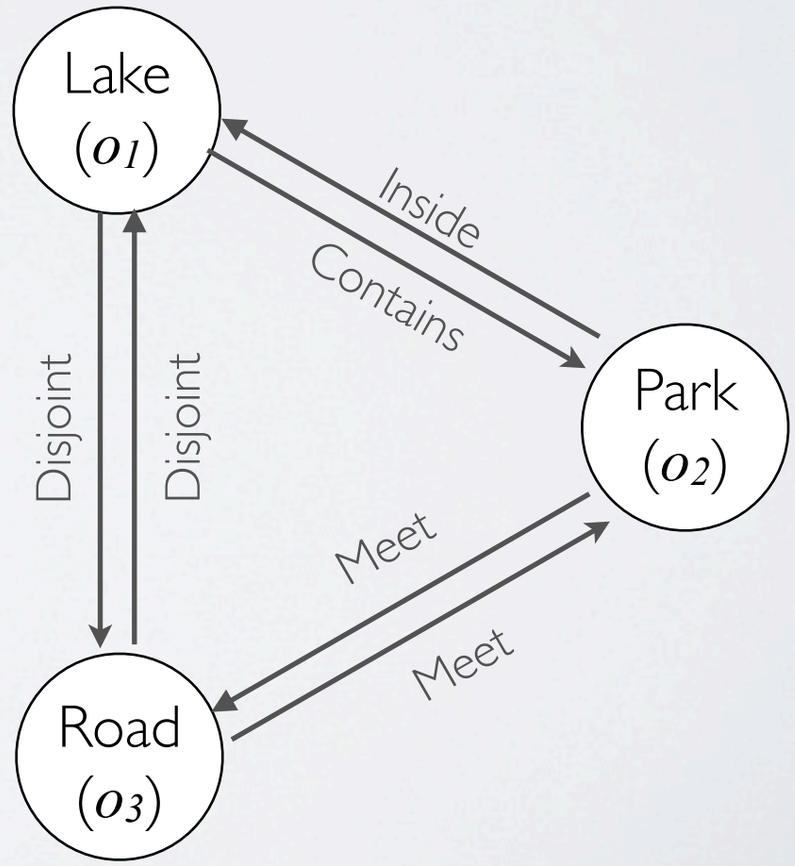

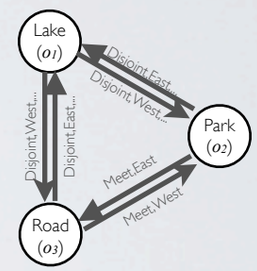

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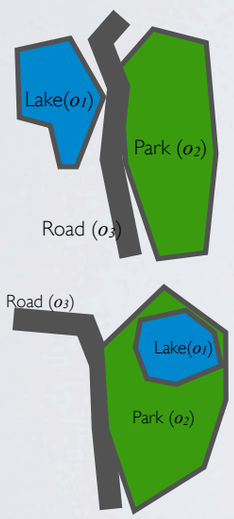

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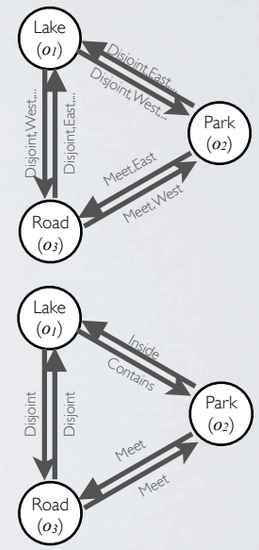

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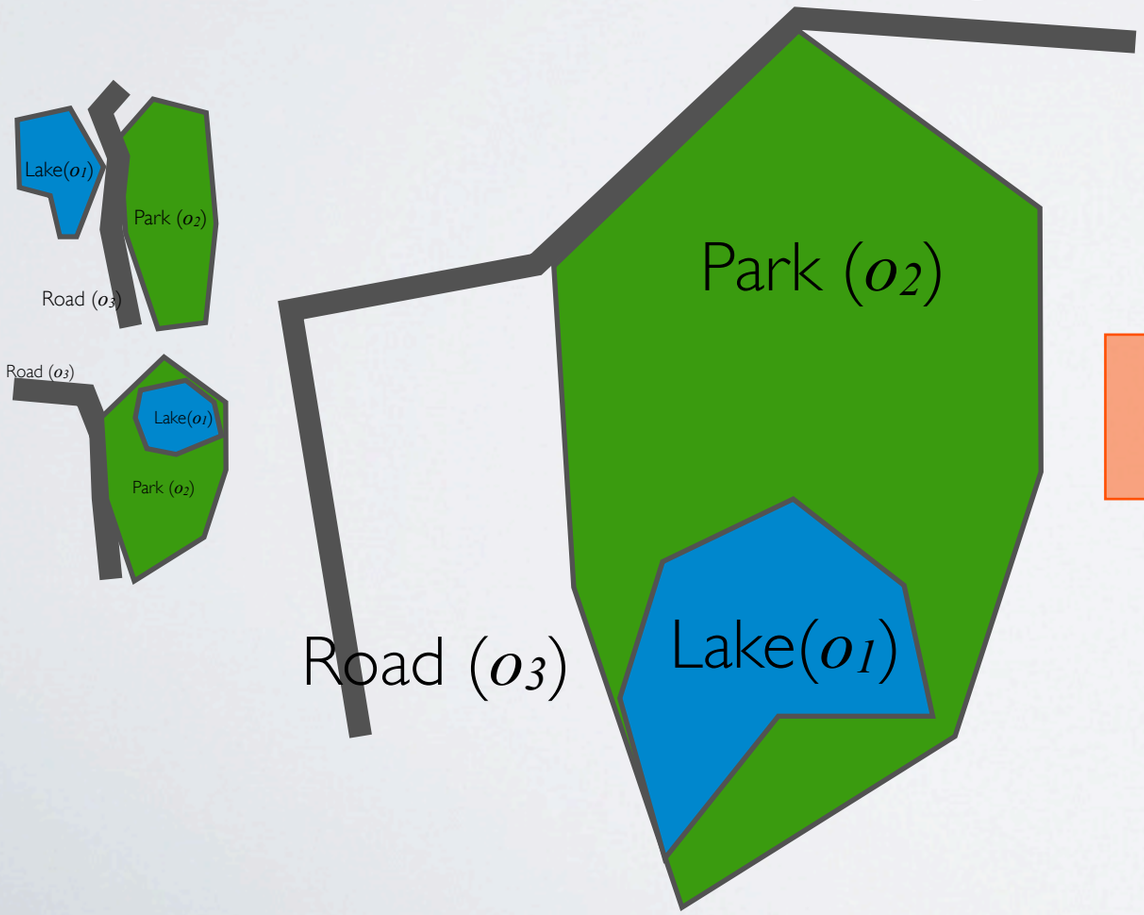

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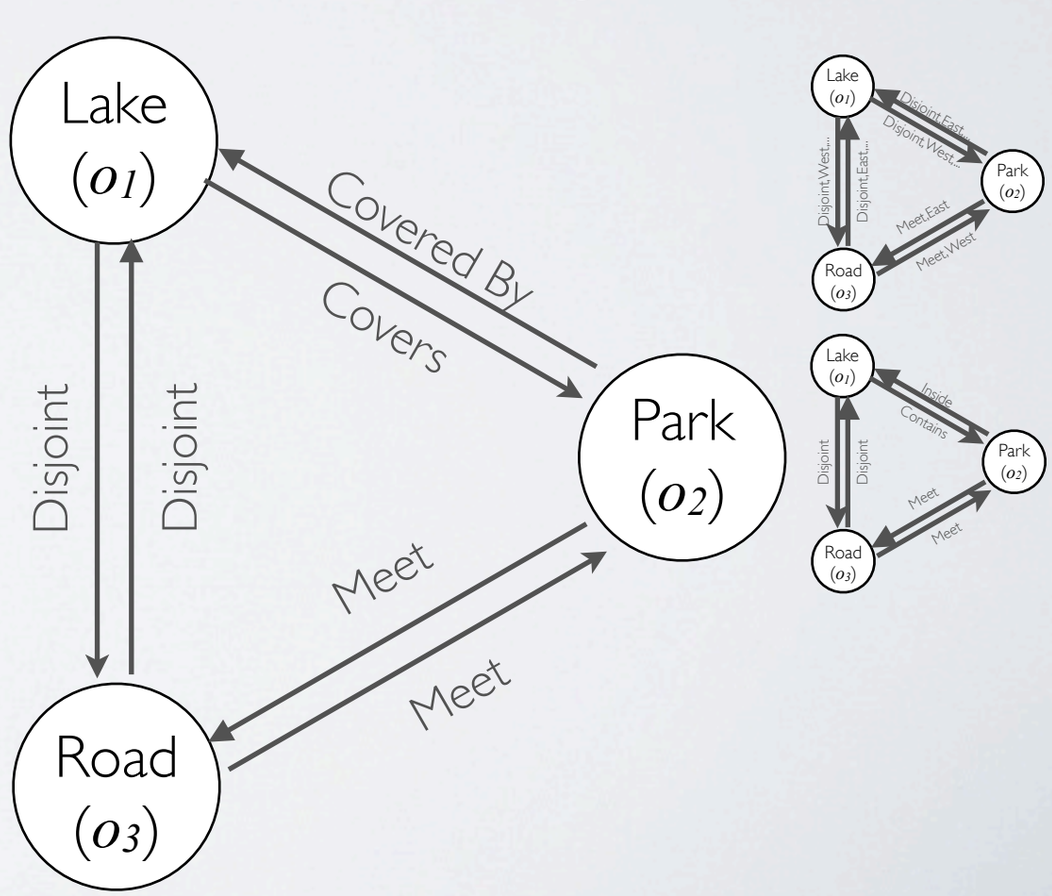

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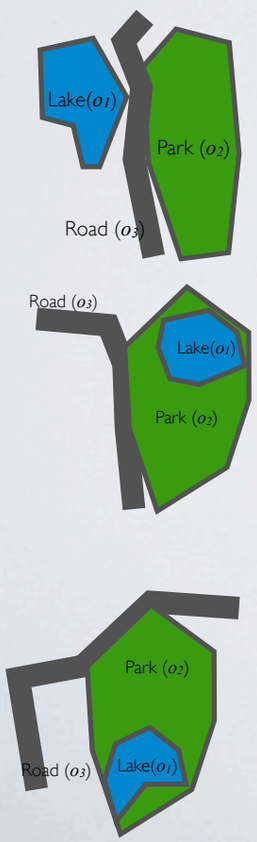
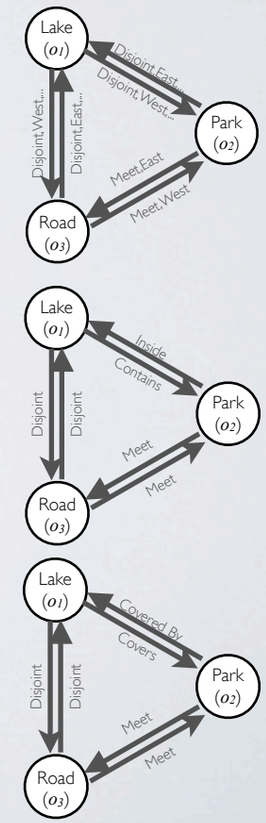




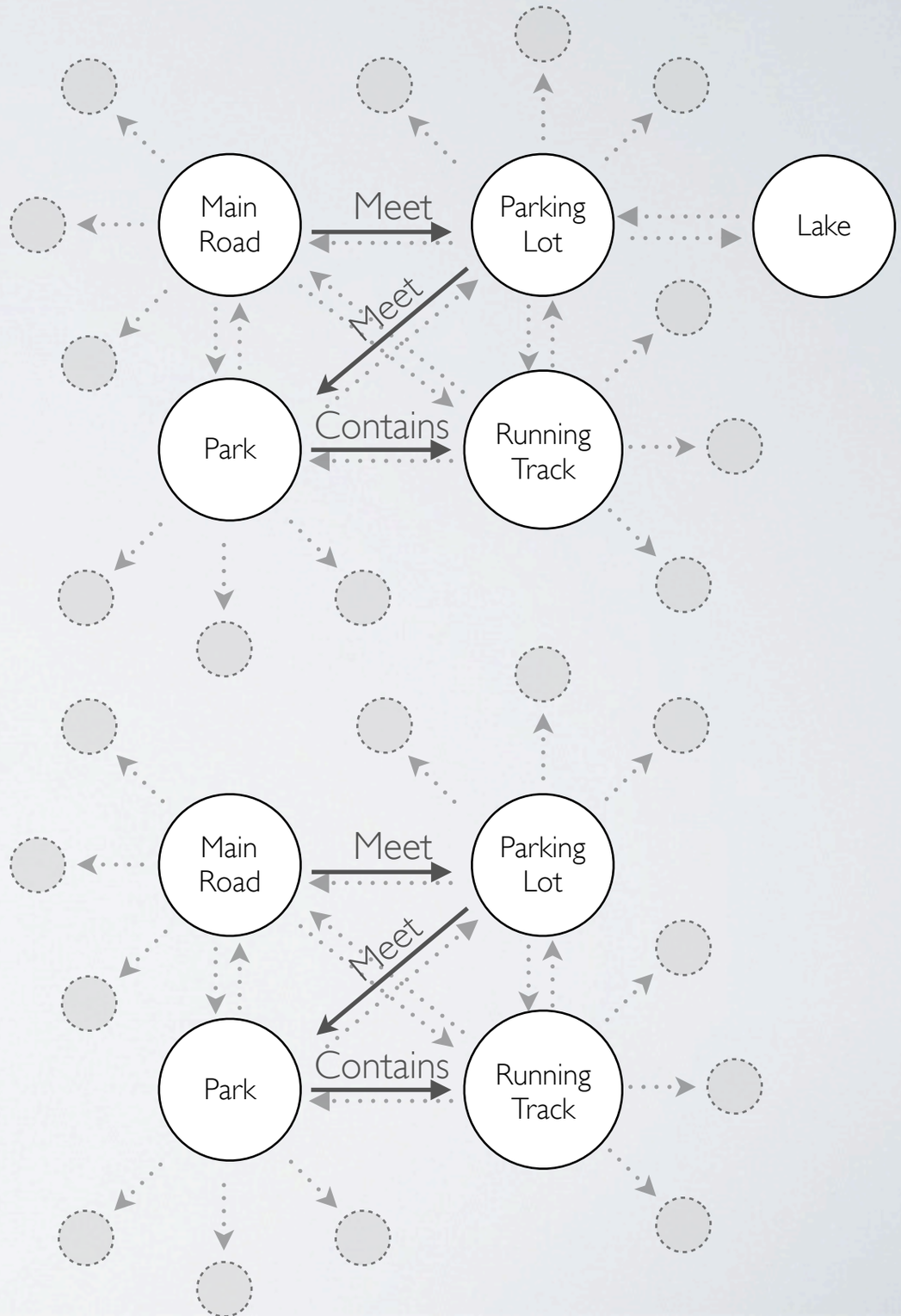
COMPUTING OPTIMAL PLANS

1. Normalize qualitative configs by

   1.1. computing maximum common set of spatial objects

   1.2. removing non-common objects (and relations they are involved in)

2. Compare normalized configs via graph matching techniques to find the minimum common subgraph



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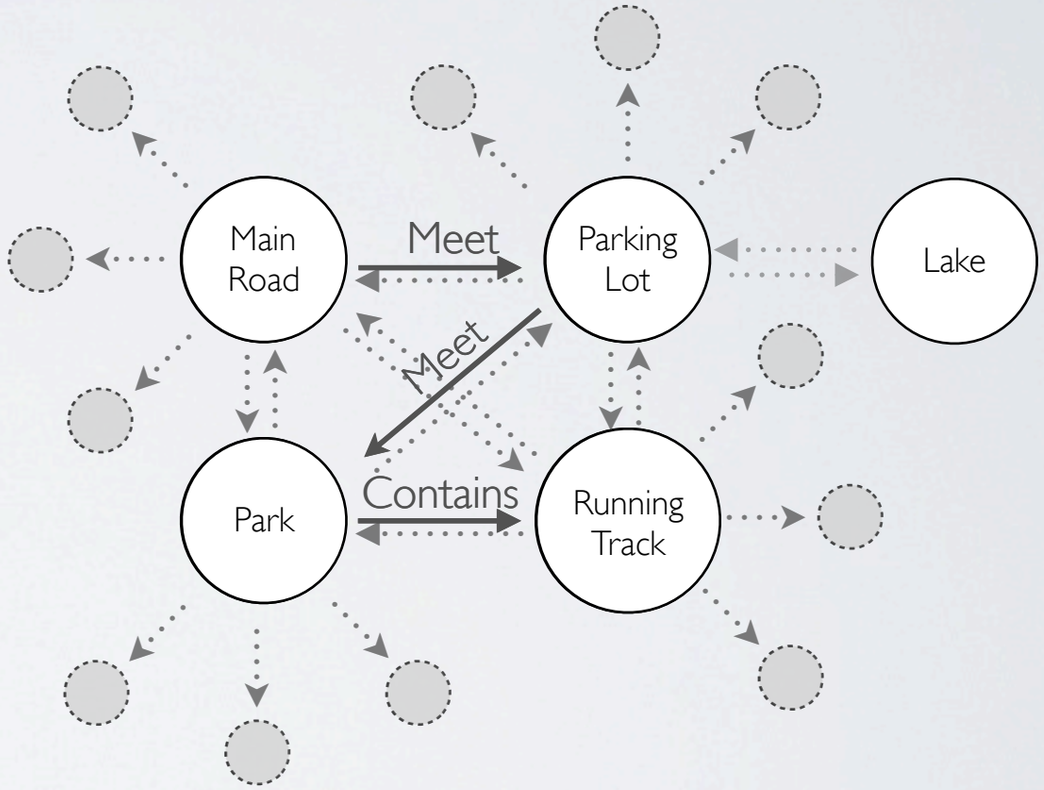

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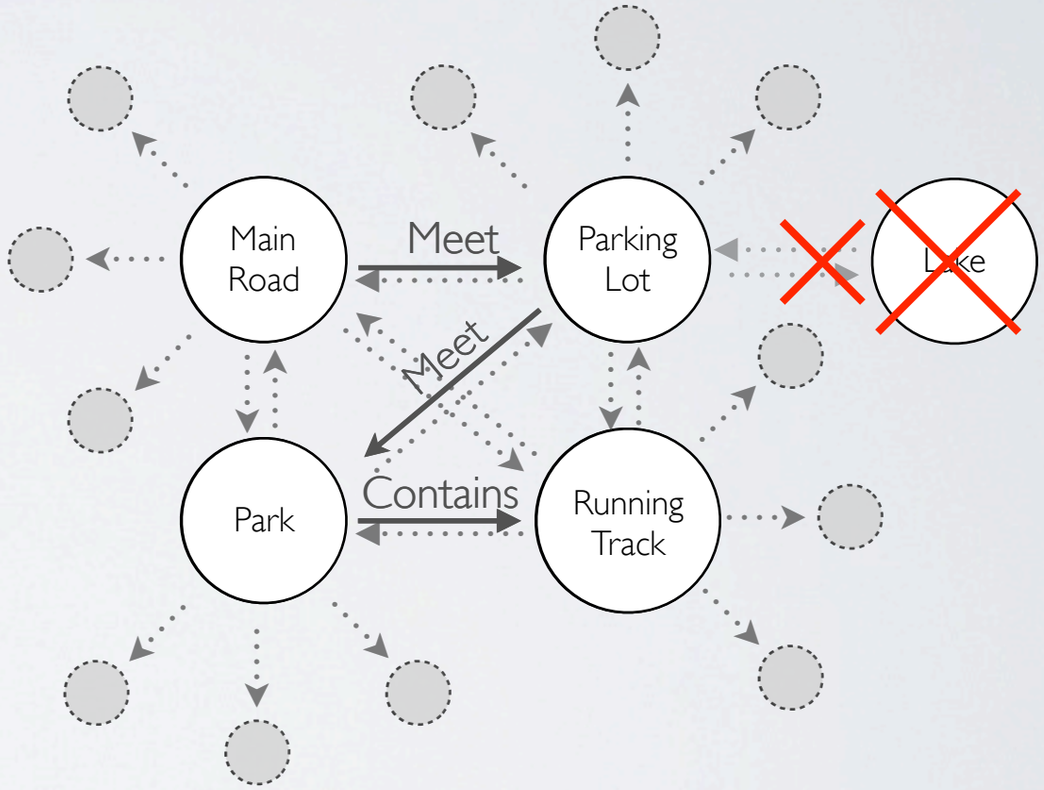

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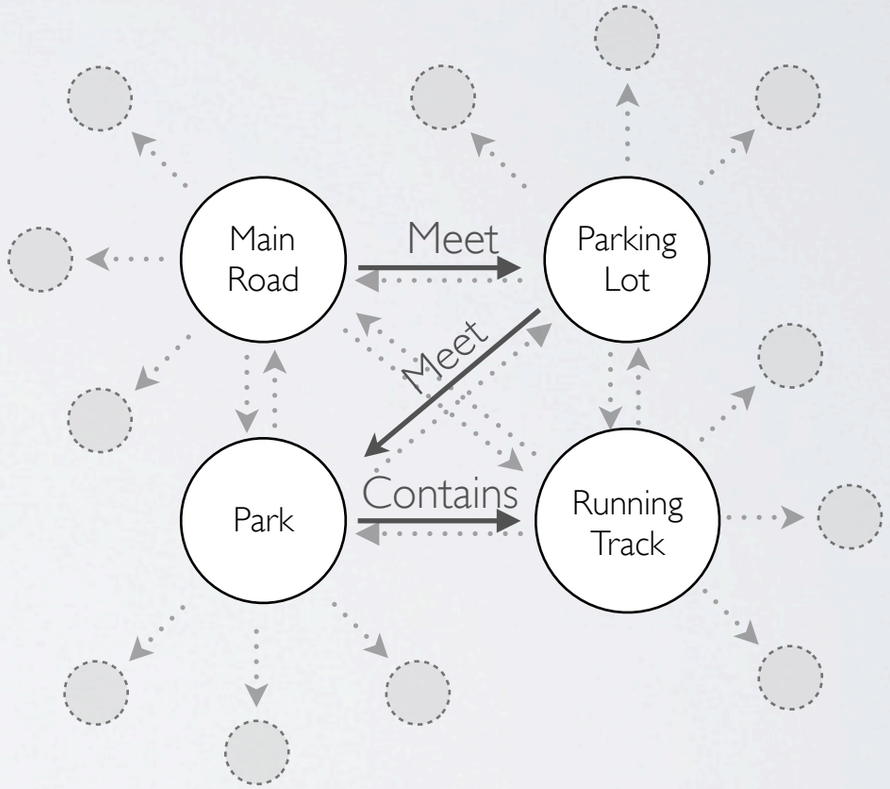


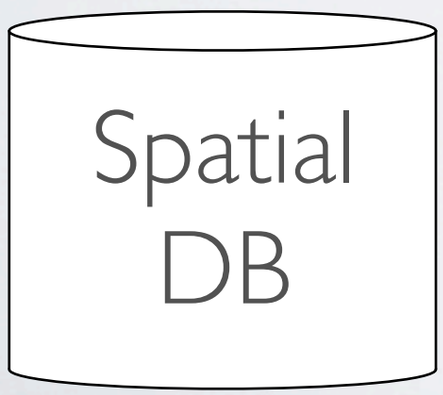
SUPPORTING SPATIAL PLANNING

- Our system supports spatial planners in 3 different stages:
  - Preliminary phase: **site localization**
  - Plan setup: **kickstart configuration**
  - Plan development: **design assistance**

LOCALIZING A PLAN SITE

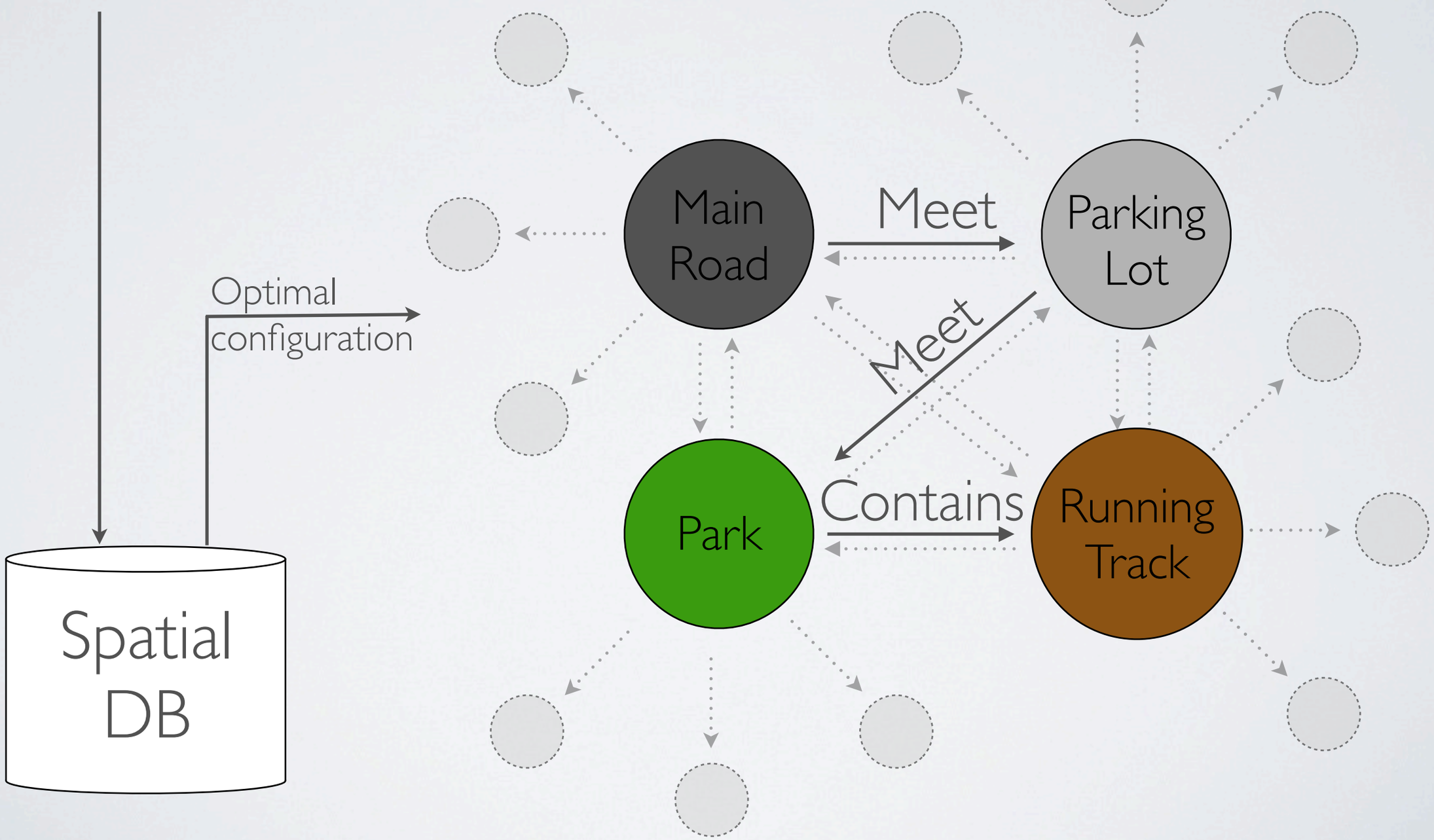
- Finding a suitable location for a new plan consists in finding a number of land parcels satisfying a number of constraints
- Part of such constraints are purely spatial: search for a spatial configuration of objects arranged in a certain manner
- Strict constraints are better expressed with mathematical equations
- Loose constraints are more easily expressed in natural language without resorting to complex equations, inequalities and conditions
- Our system allows for complementing standard search methods via hybrid quantitative-qualitative spatial queries

DESIGN KICKSTARTER



DESIGN KICKSTARTER

Plan category: `public green`



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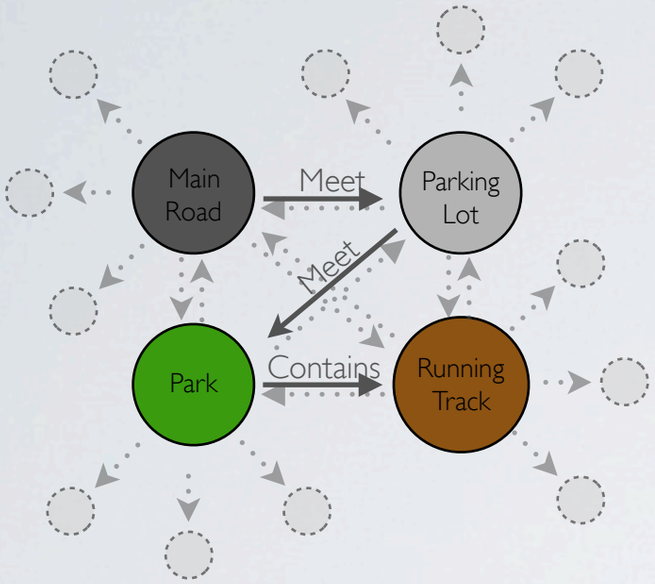
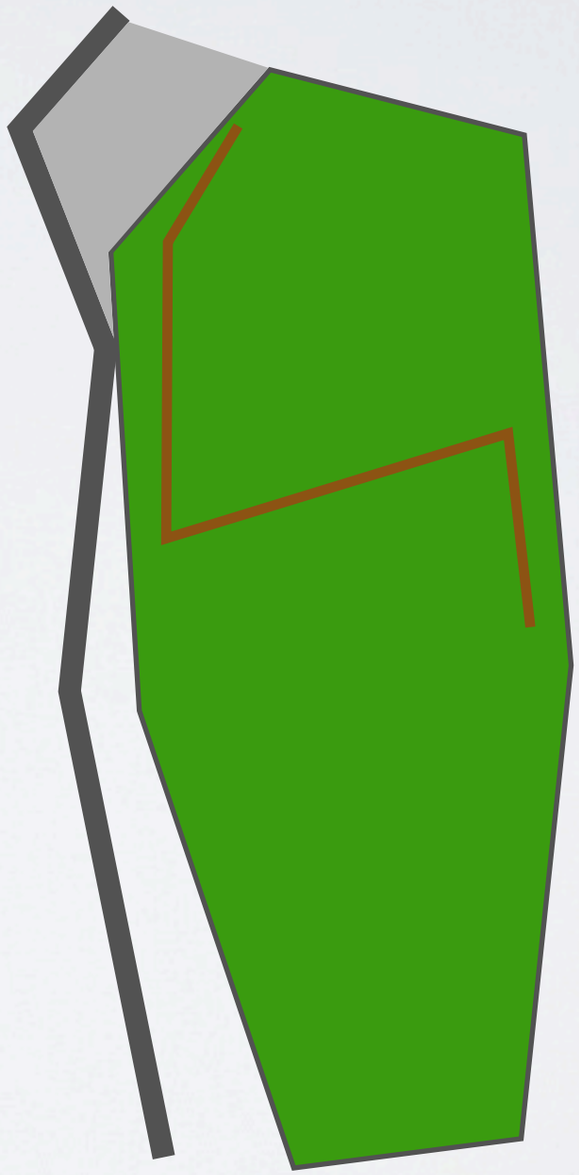
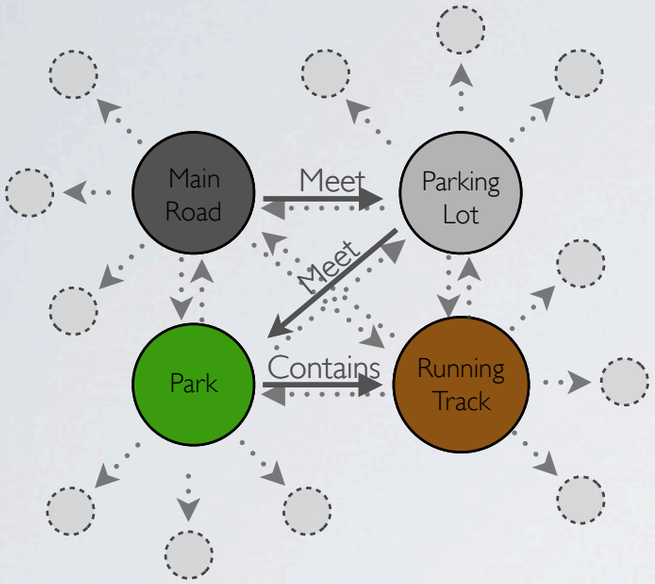


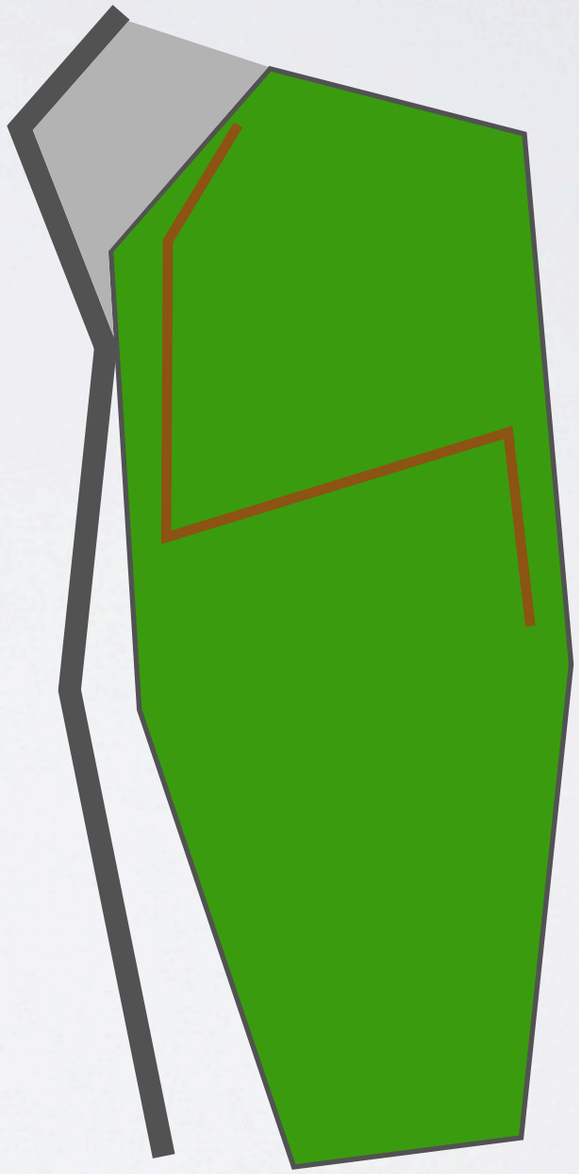


DESIGN ASSISTANT



Optimal configuration

Plan design



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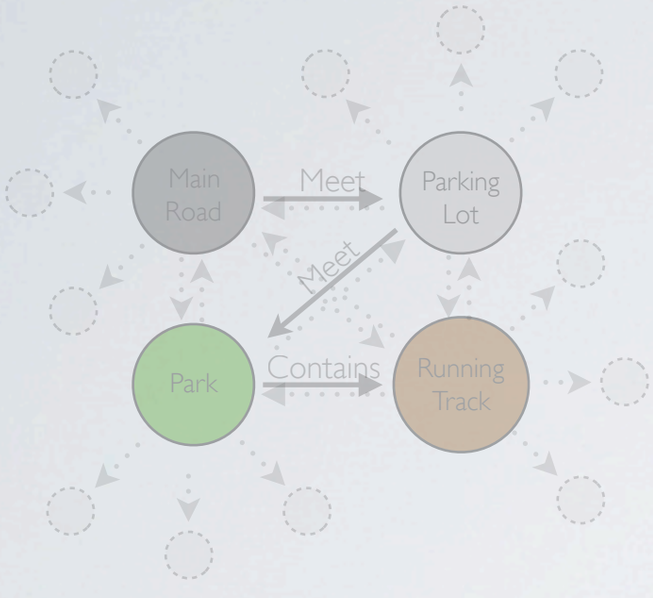
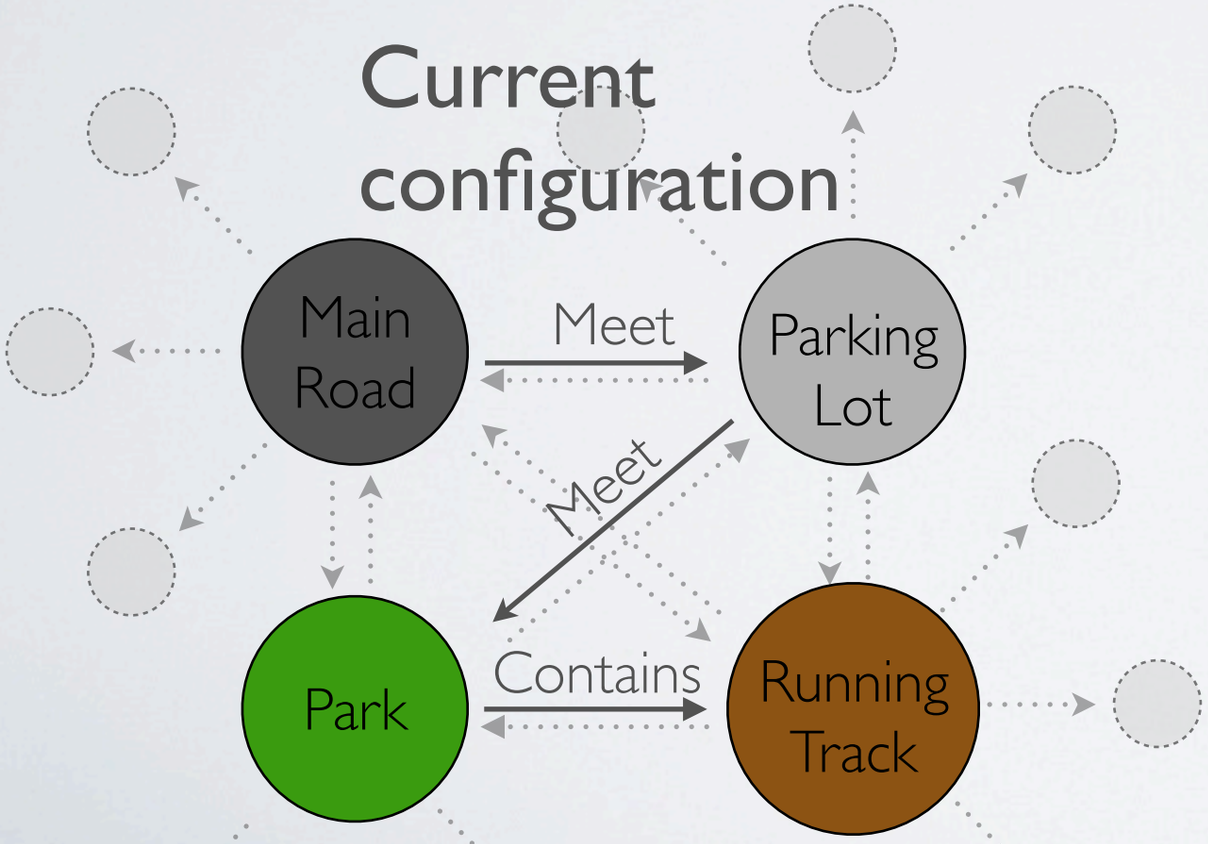
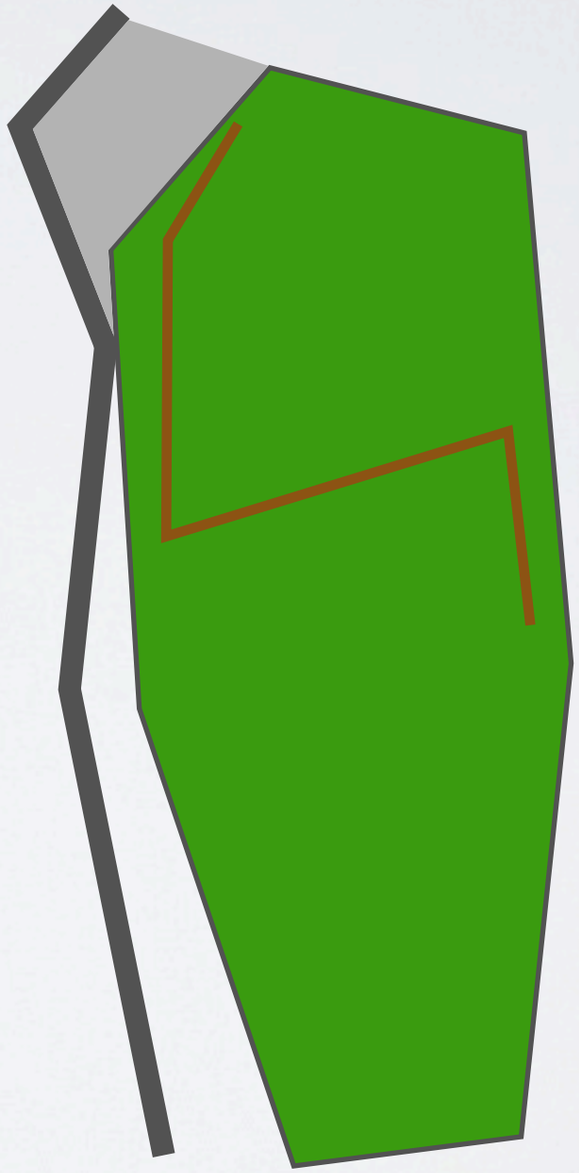


Optimal configuration

Current configuration



Plan design



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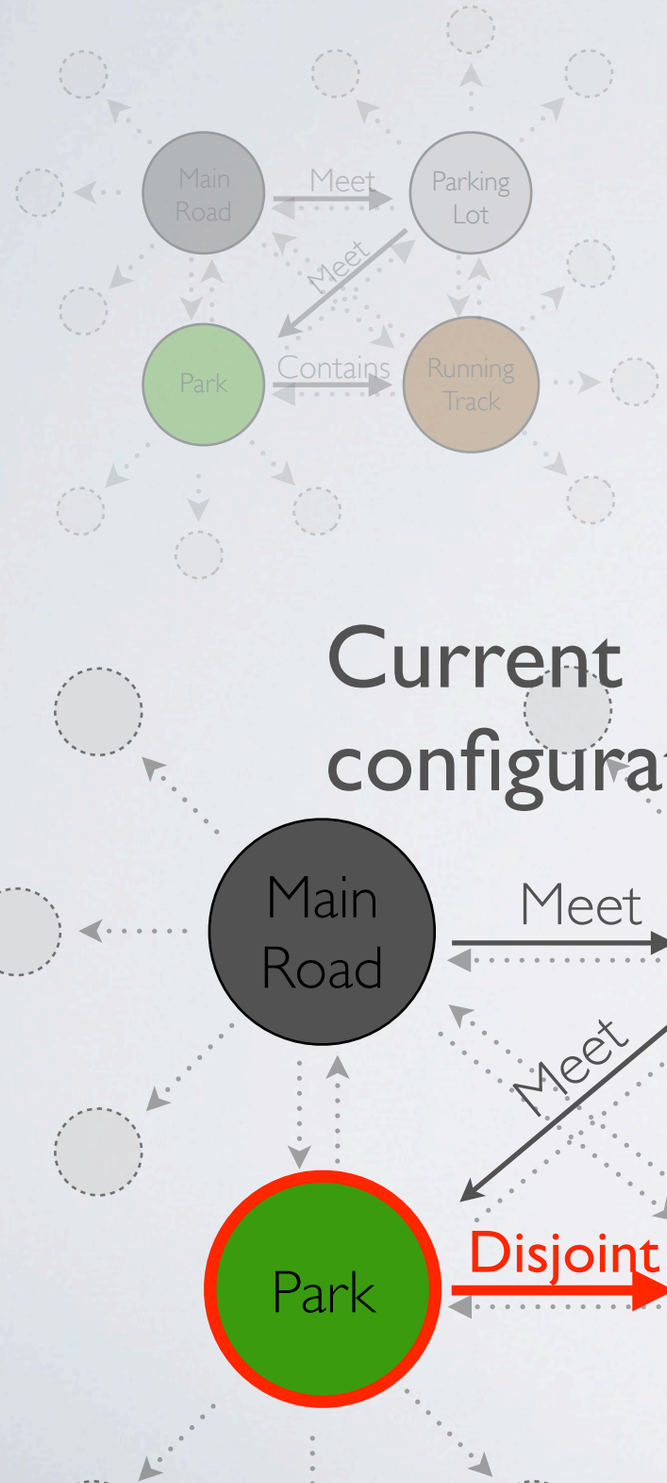

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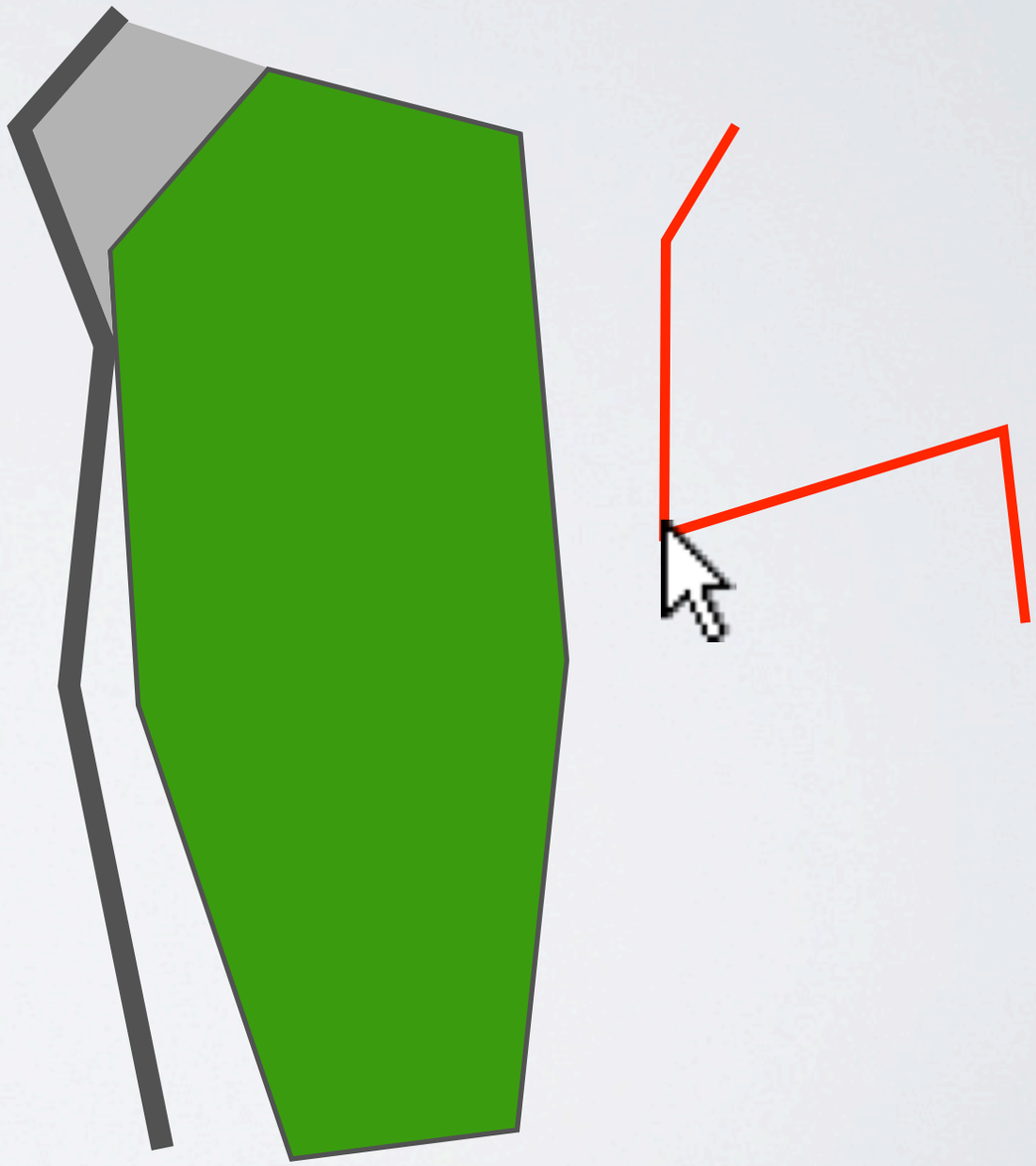

FITTING PLANS TO PUBLIC EXPECTATIONS

- Public Participatory Geographic Information Systems (PPGIS) are web platforms designed to collect public opinion of a topic of interest

- PPGIS allows for adapting optimal plans to public expectation in two ways:

  - ratings collection

  - public envisioning

RATING COLLECTION

- Spatial plan will eventually affect real world
- The resulting environment is best assessed by its users
- PPGIS can be used to collect user feedbacks and generate an overall rating of a certain environment
- The rating is associated to the corresponding plan design in the database
- Ratings are used to weight plans: high-scored designs play an heavier role in the optimal plan generation process

OPTIMAL PLAN FROM PEOPLE EXPECTATION

- Web design tools can be used to let people sketching the new environment as they expect it

- Qualitative configurations can be obtained from such sketches and associated to a certain plan category

B3 (www.geogameslab.com) is a web platform that allows laypeople to draw an environment via drag and drop

Poplin, A. (2012).

THANK YOU FOR YOUR ATTENTION!
QUESTIONS ARE WELCOME

Egenhofer, M.J. (1989). *A formal definition of binary topological relationships.* In: Litwin, W., Schek, H.J. (eds.), FODO 1989, 3rd International Conference on Foundations of Data Organization and Algorithms, Lecture Notes in Computer Science, vol. 367, pp. 457–472. Springer-Verlag

Fogliaroni, P. (2012). *Qualitative Spatial Configuration Queries – Towards Next Generation Access Methods for GIS.* Ph.D. Thesis (http://nbn-resolving.de/urn:nbn:de:gbv:46-00102731-11)

Poplin, A. (2012). *Playful public participation in urban planning: A case study for online serious games.* Computers, Environment and Urban Systems.