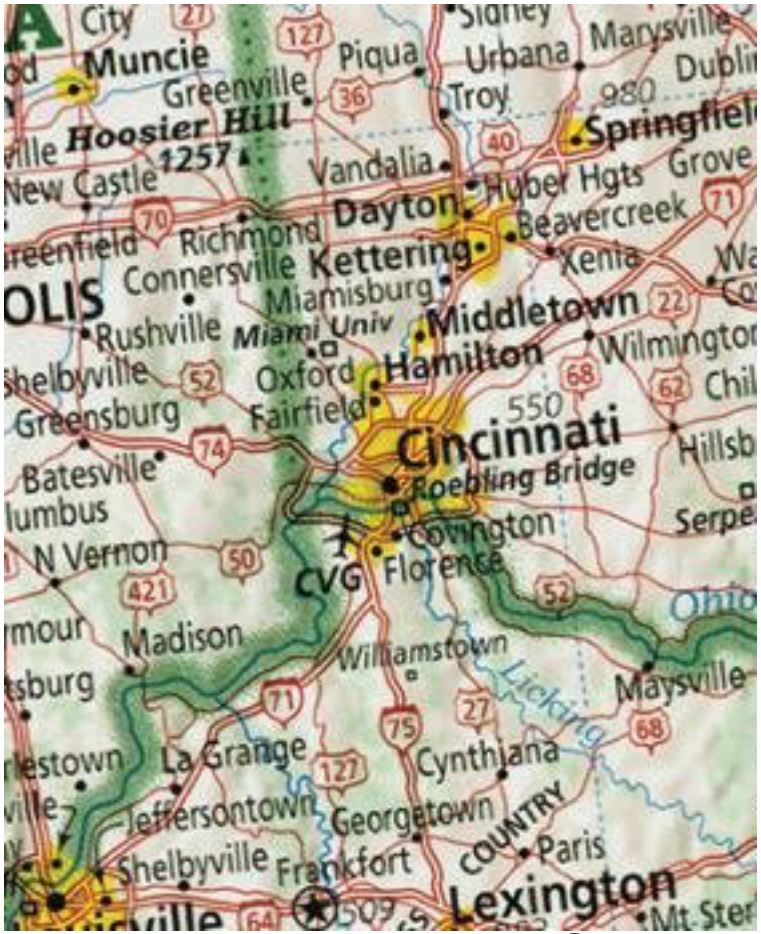
Algorithms for (Dynamic) Map Labeling

joint work with A. Gemsa and B. Niedermann

Map labeling – an old problem



© David Imus

"Poor, sloppy, amateurisch type placement is irresponsible; it spoils even the best image and impedes reading." (E. Imhof '75)

Cartography has long history and experience with manual label placement in maps.

some placement guidelines:

- next to, over, or under the object
- preferably top right
- avoid covering and overlapping
- clear graphic association
- ...

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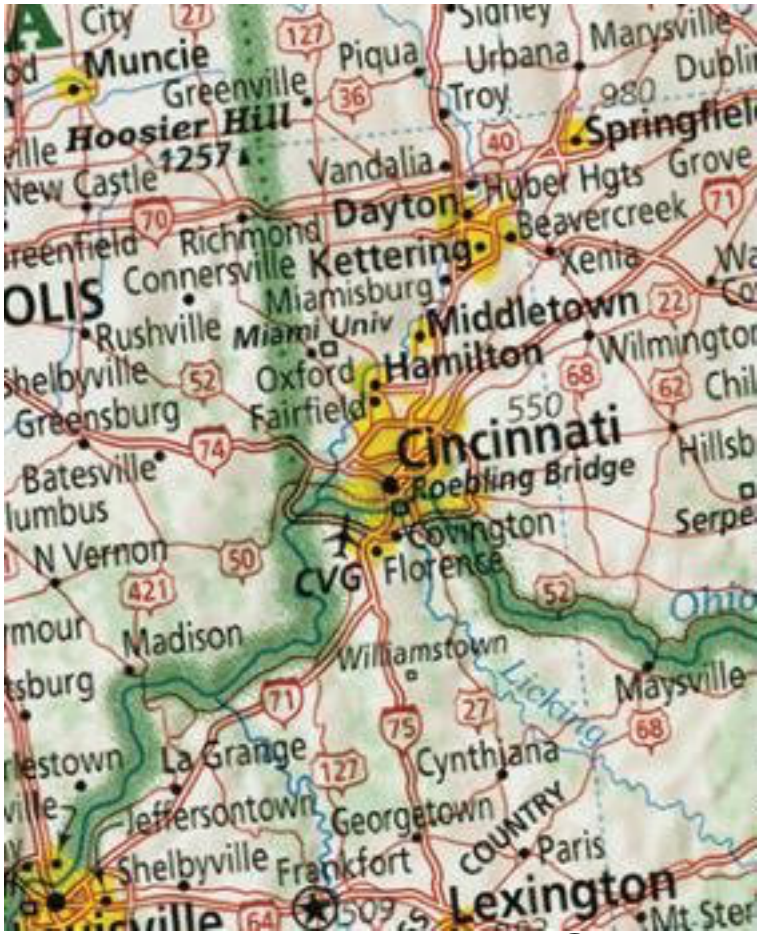

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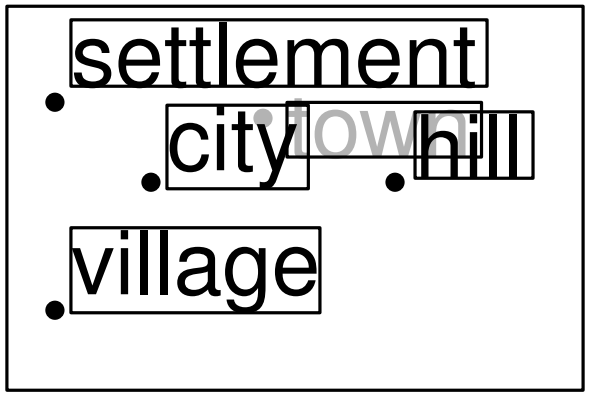
$\rightarrow$ has been translated $>$ 20 years ago into a computational geometry problem for automated label placement

Static geometric labeling models

Input: n points in the plane and for each point a label represented by its bounding box

Goal: find a feasible* label placement for a **maximum subset** of the points such that no two labels overlap (MAXNUMBER)



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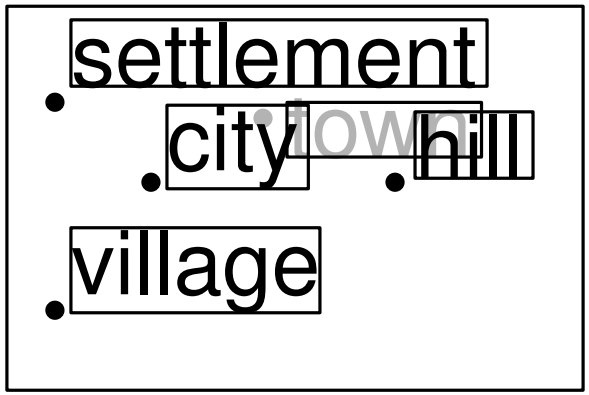
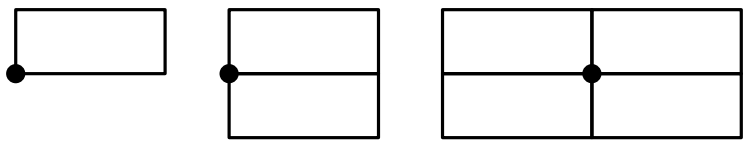


MAXNUMBER

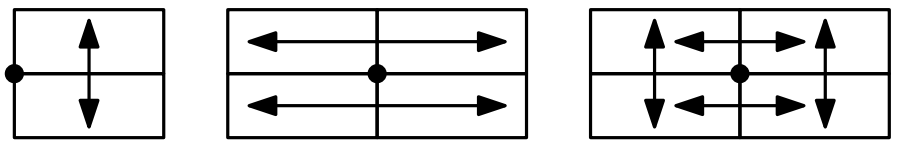
* What is a **feasible** placement?

discrete models



1P 2P 4P

slider models



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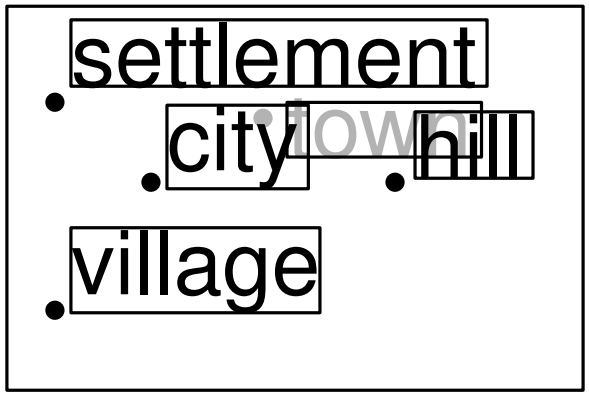

MAXNUMBER

NP-hard in almost all models

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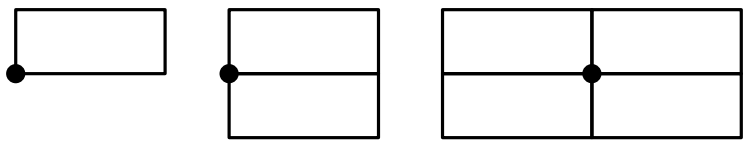

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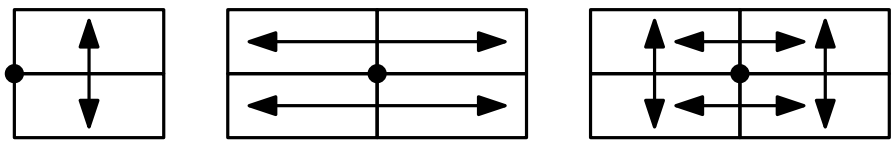

The era of dynamic maps

Most maps today are no longer static and general-purpose but dynamic and individualized.

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map view moves continuously as the user

- zooms
- translates
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- tilts

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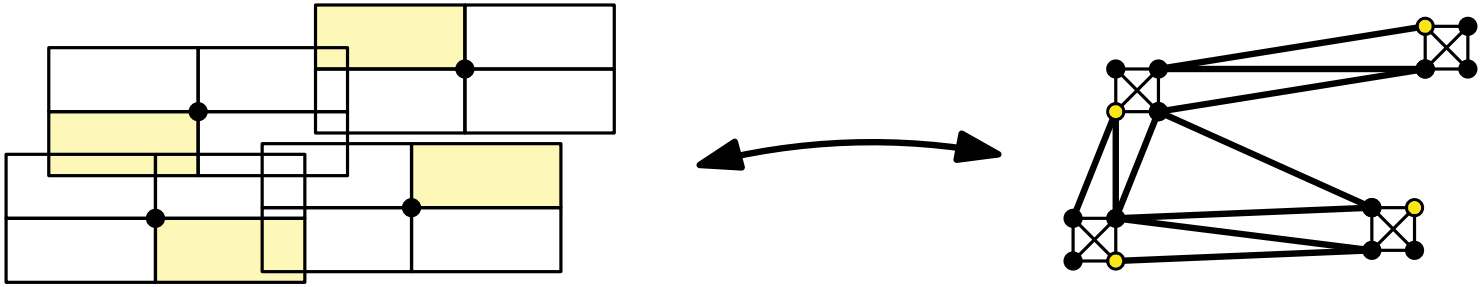
layout and labeling must adapt to dynamic map movement

$\rightarrow$ continuous map generalization

$\rightarrow$ **continuous map labeling**

Dynamic map labeling – a new problem?

Most heuristic **static** approaches use a conflict graph to model overlaps and then use some strategy to find a large independent set of labels.



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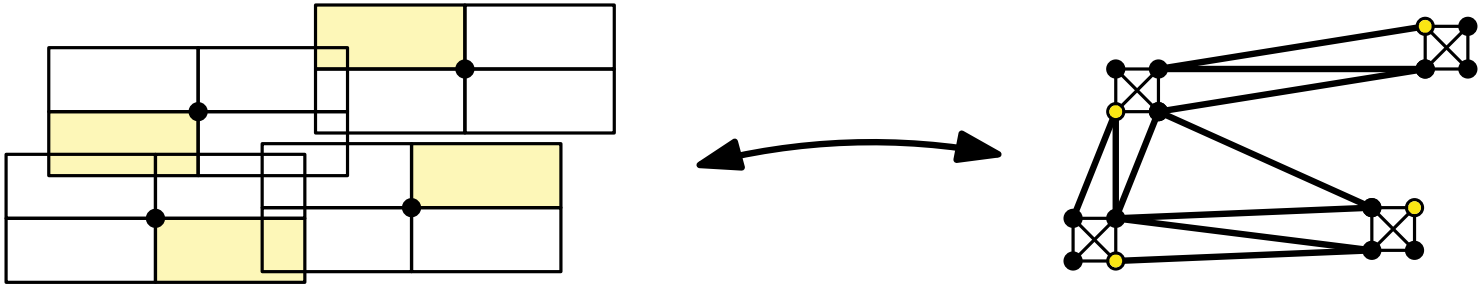

Adaptation to **dynamic** maps: design practically fast algorithms to label each frame of an animation in real time.

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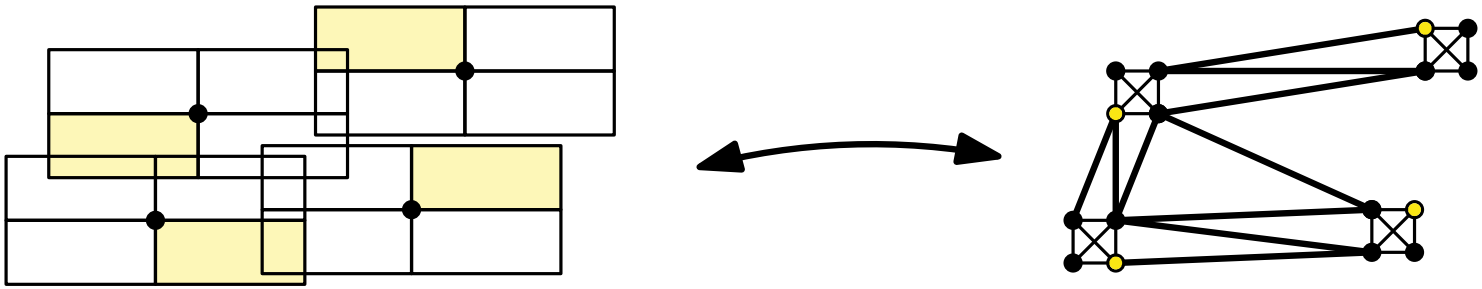
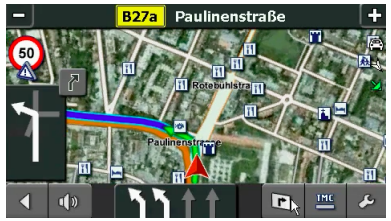


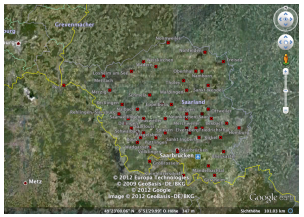
Adaptation to **dynamic** maps: design practically fast algorithms to label each frame of an animation in real time.

Yields fast algorithms, but resulting map animations are often insufficient

- each frame is labeled independently of adjacent frames
- labels tend to show jumping and flickering behaviour
- **temporal coherence** or **consistency** is not considered

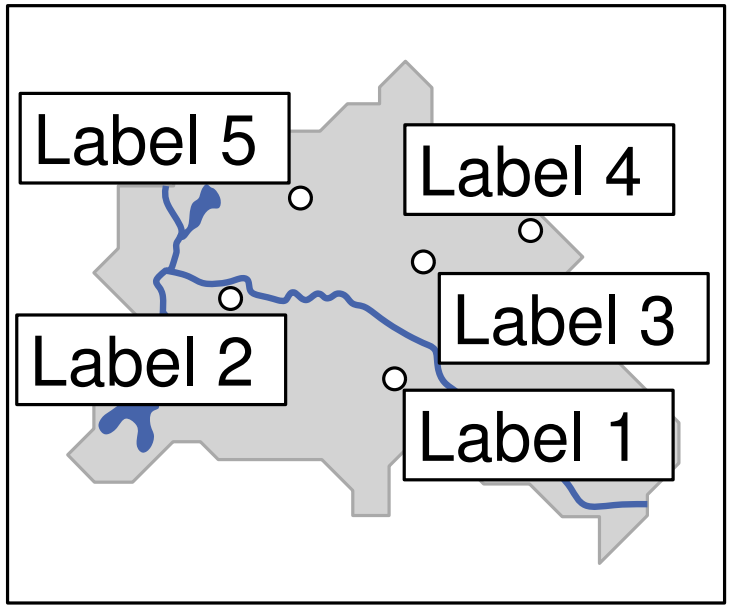


many examples!



Labels in zoomable maps

labeled map at larger scale



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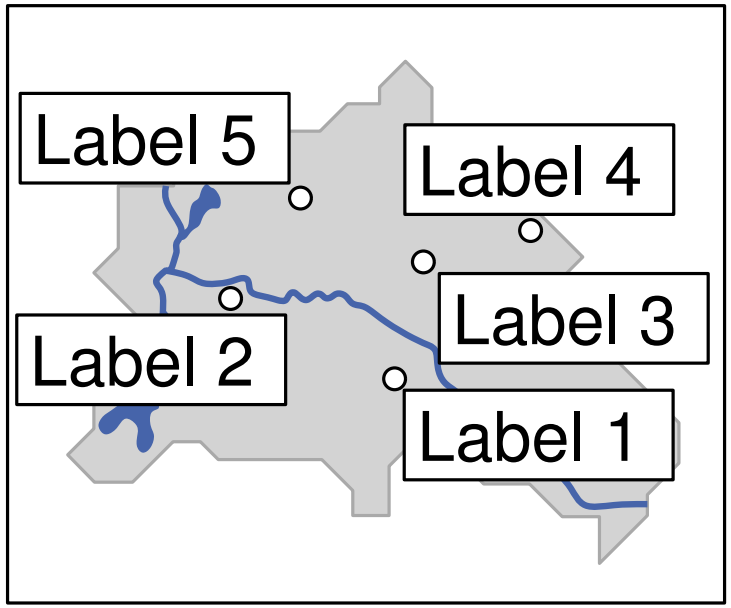

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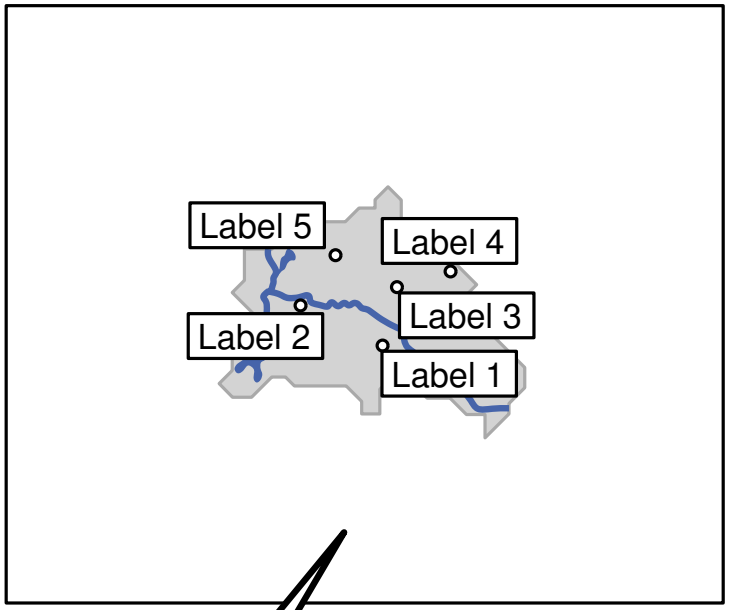

graphical zooming creates tiny labels

Labels in zoomable maps

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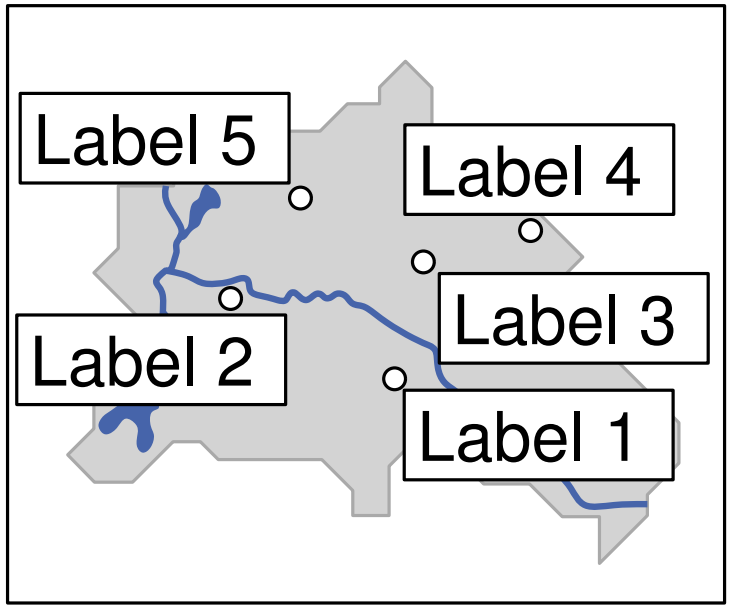

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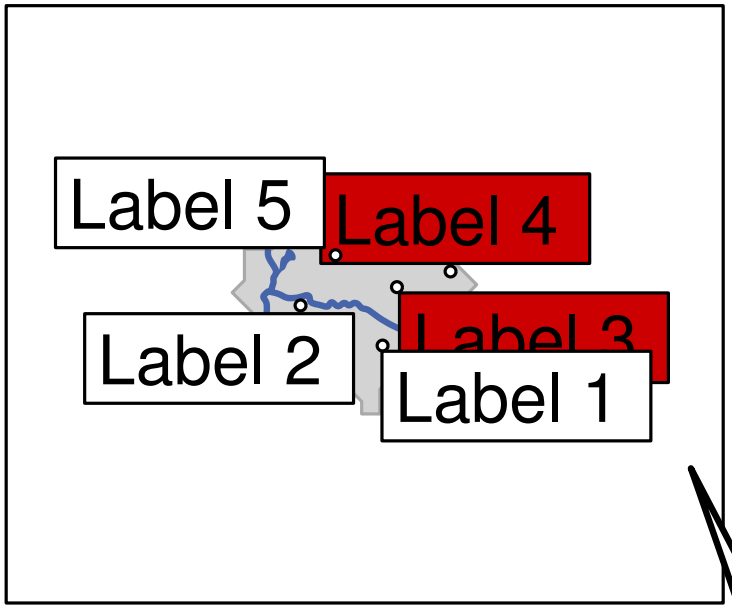

invariant label size creates new conflicts

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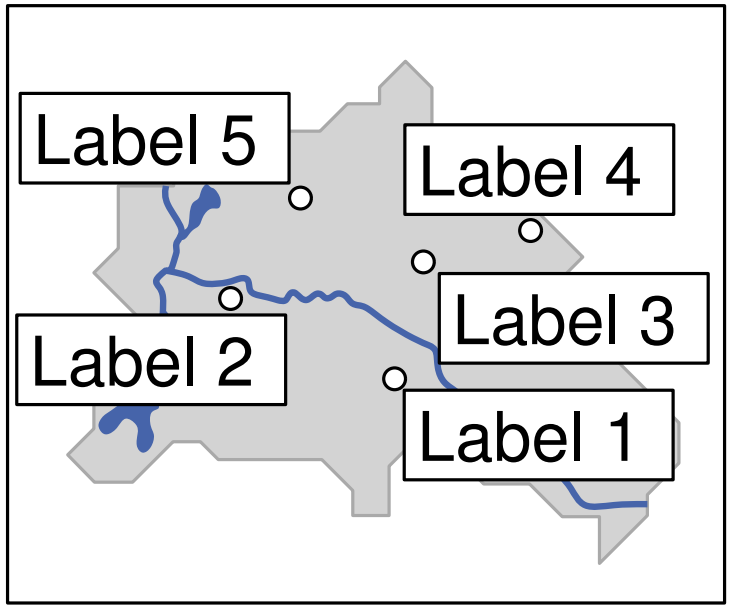

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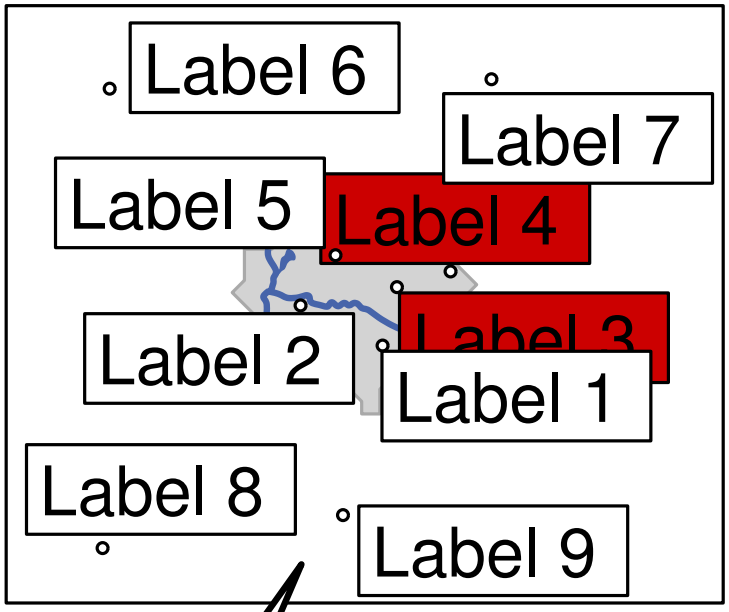

more points become visible

Labels in zoomable maps

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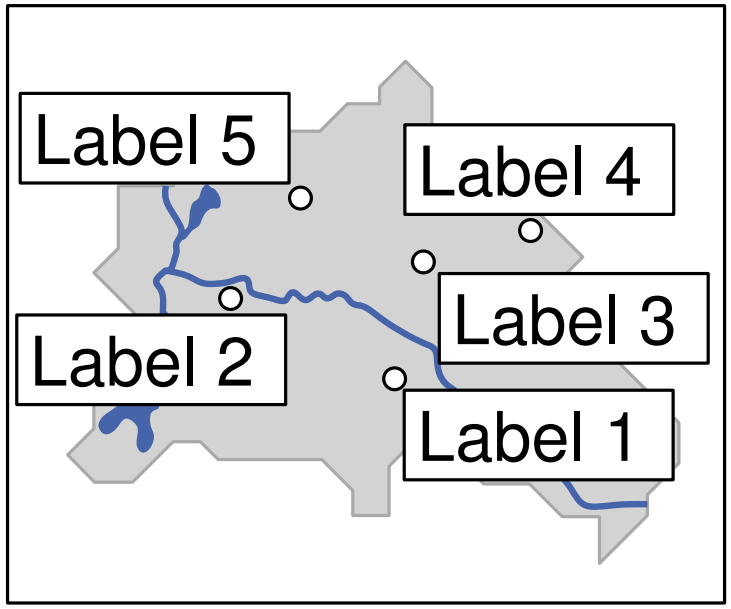

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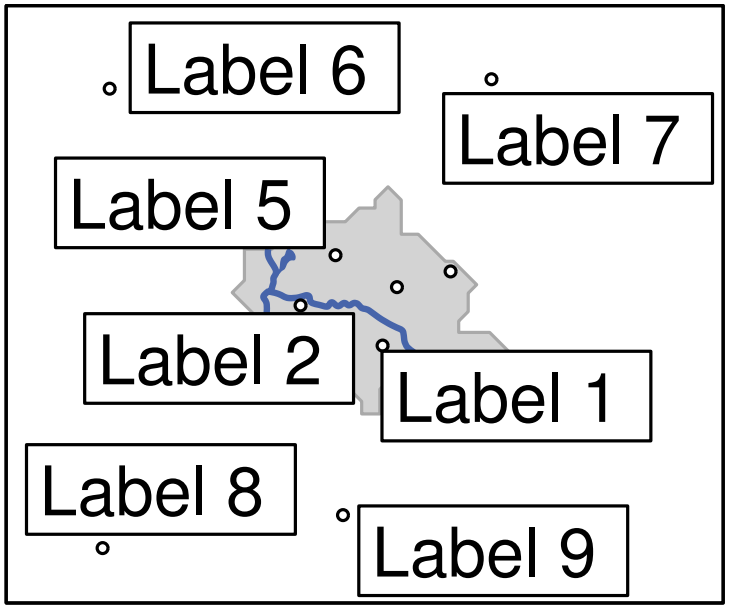

$\Rightarrow$ when zooming out, labels grow relative to the map and new conflicts must be resolved s.t. labels do not jump or flicker

Labels in zoomable maps

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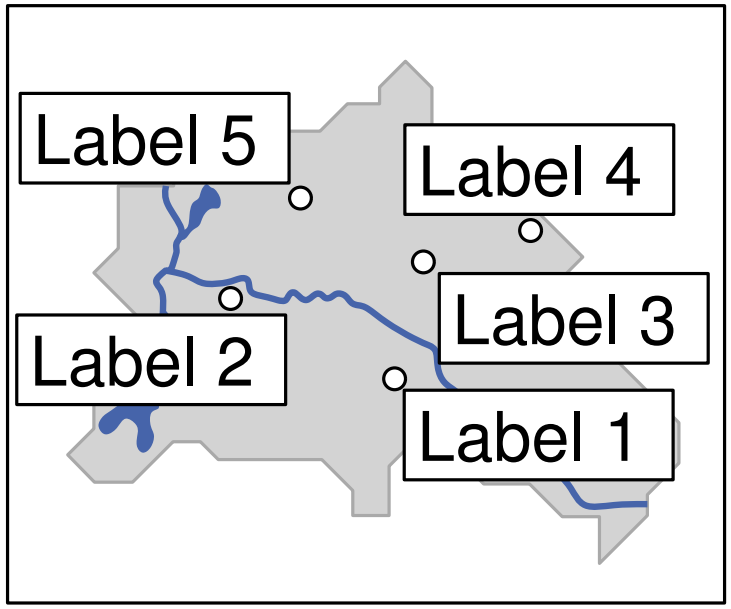

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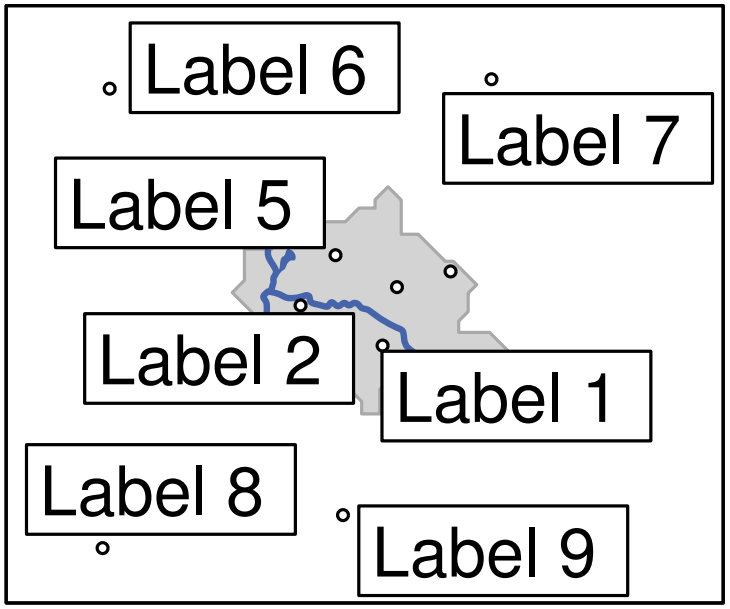

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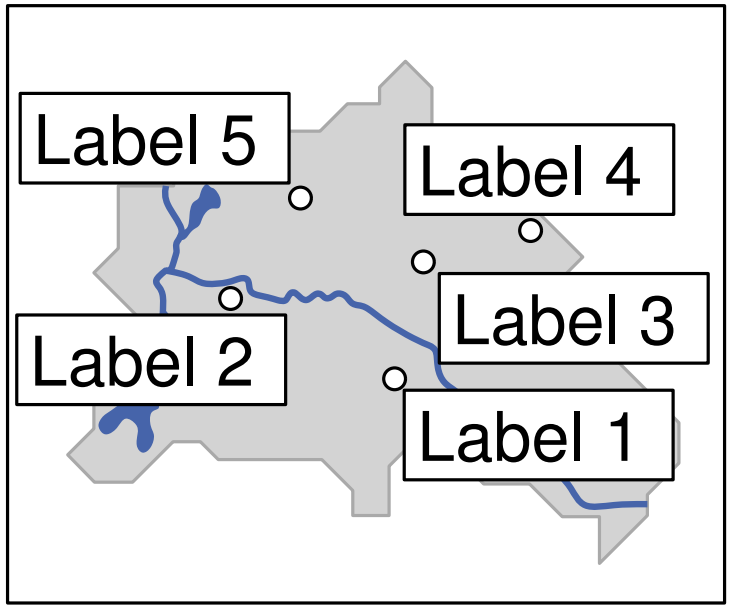
Techniques: Geometric approximation algorithms

Labels in rotating maps

northern orientation



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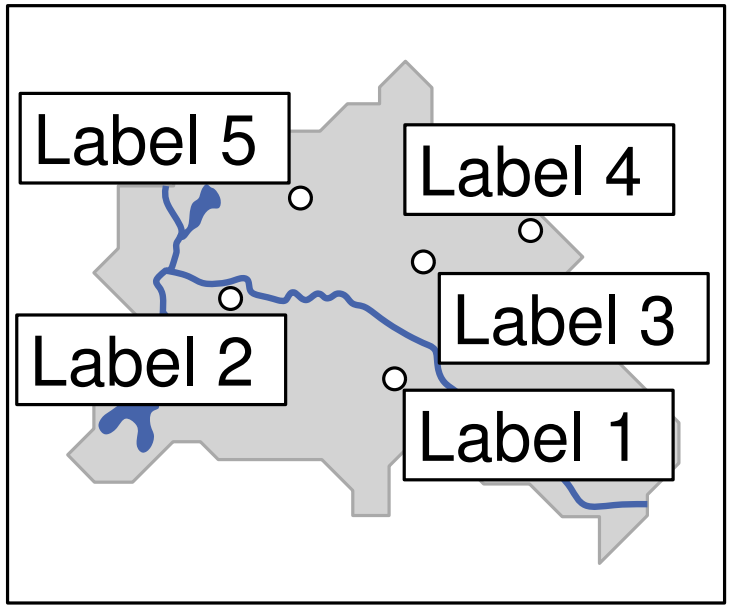
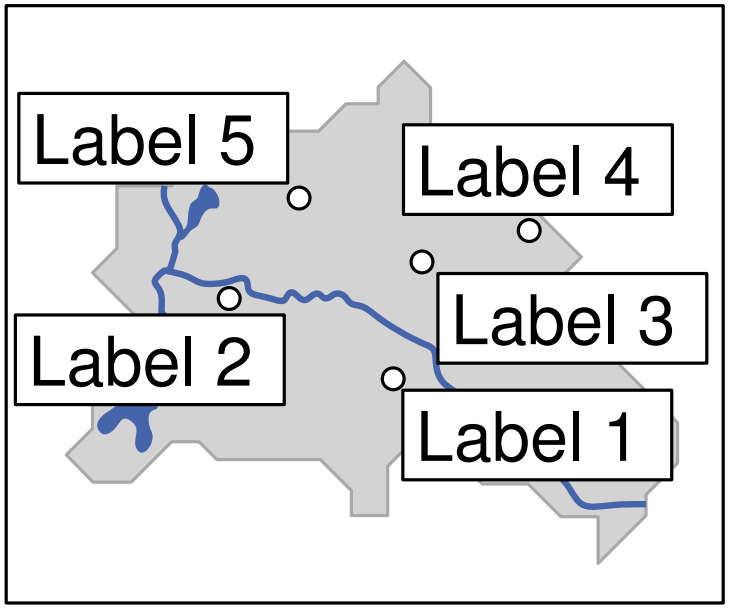


rotated view



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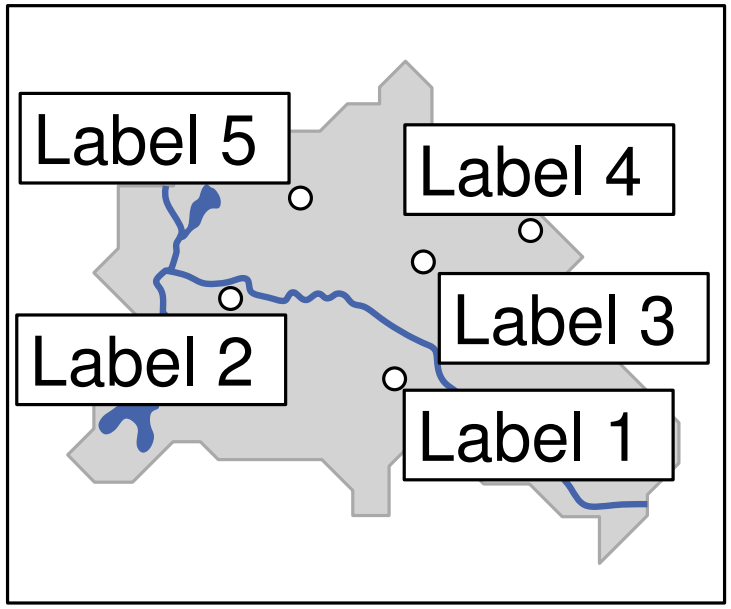

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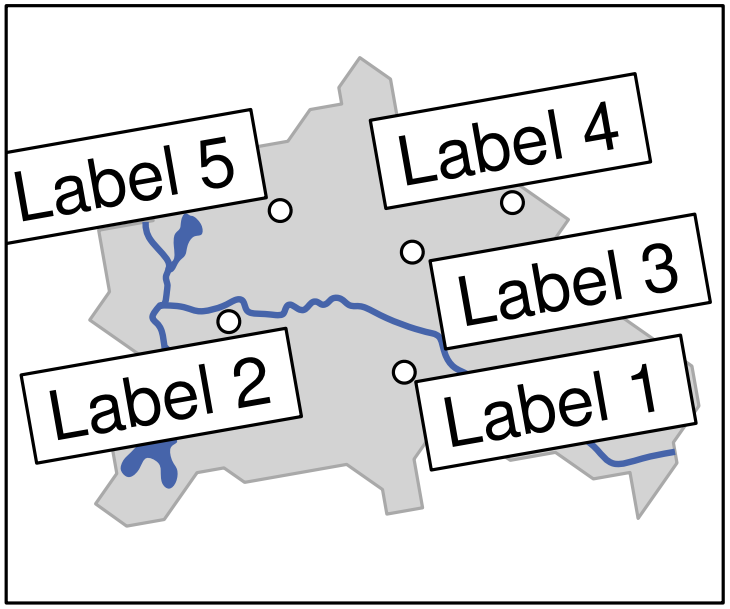

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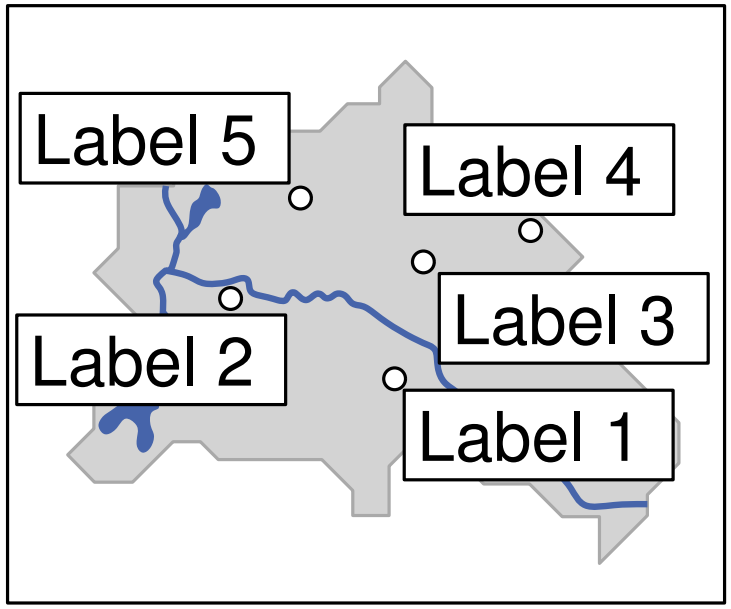

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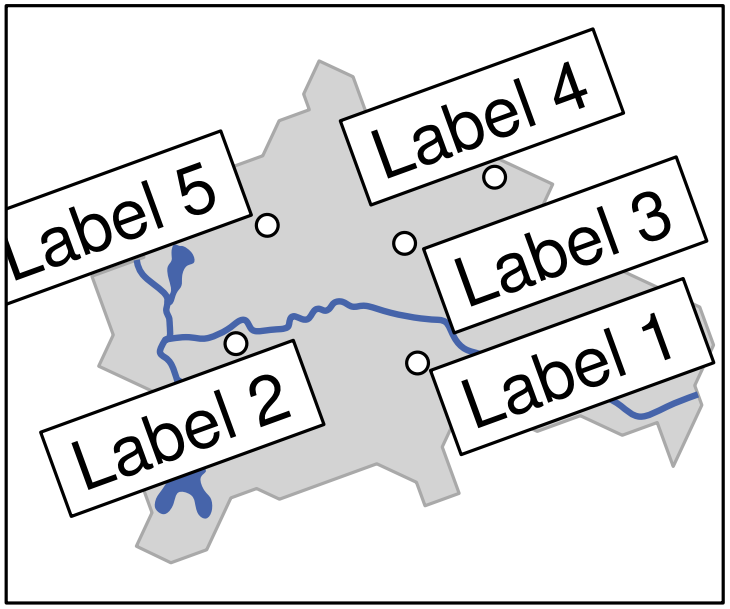

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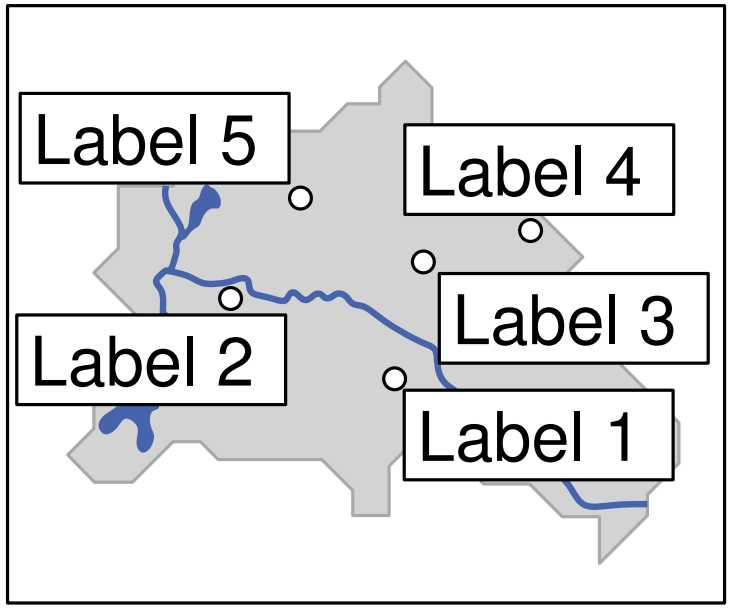

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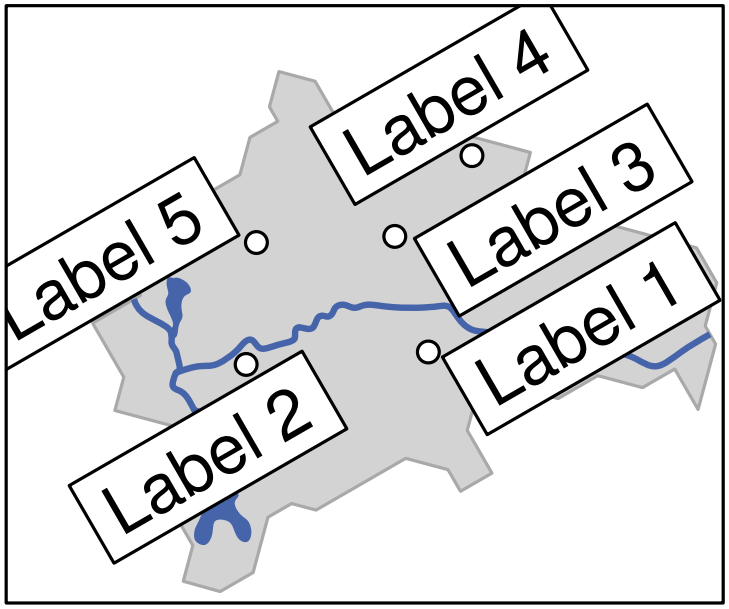

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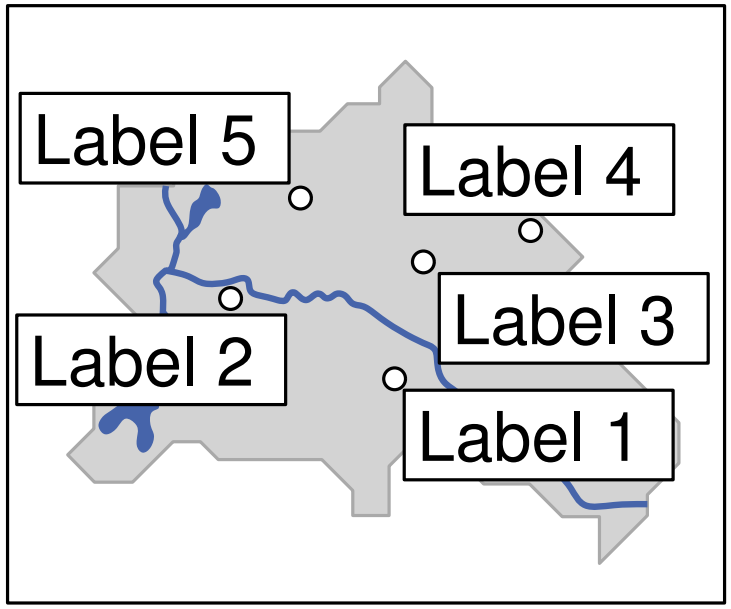

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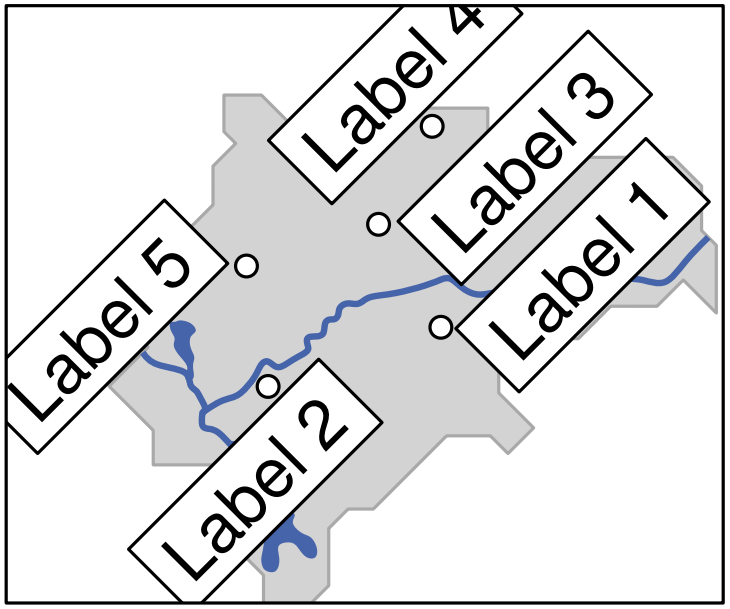

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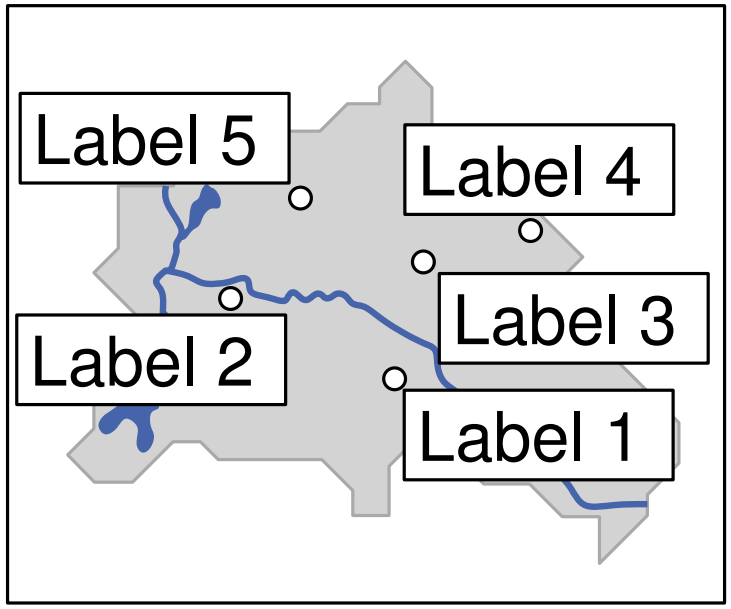

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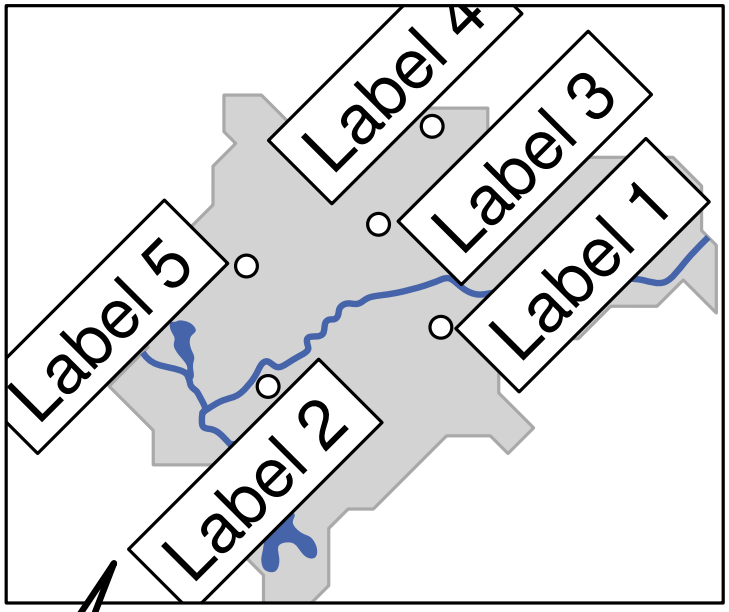

poor readability of map aligned labels

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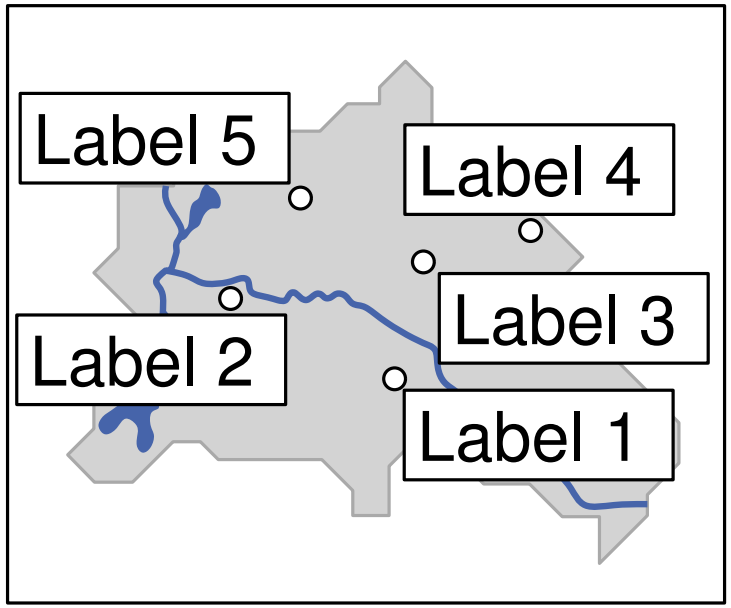

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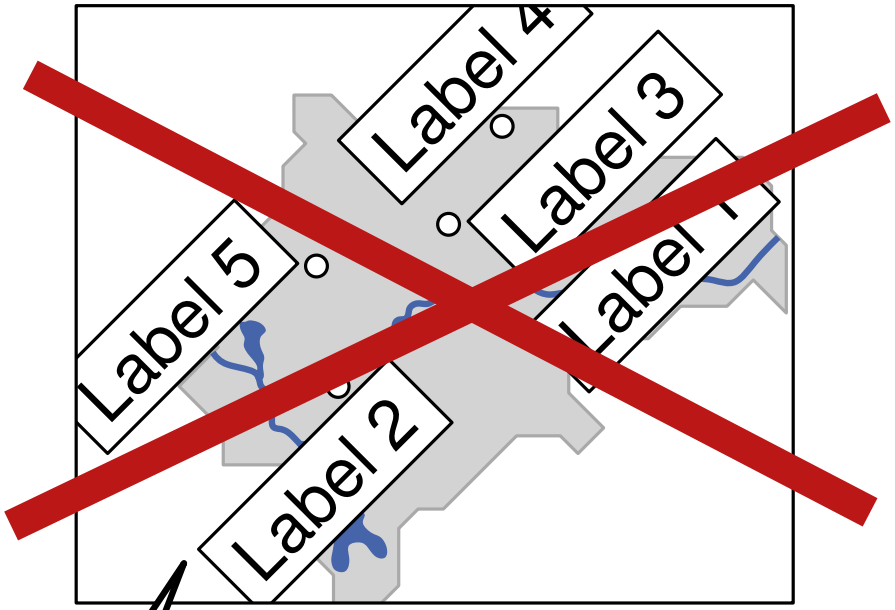

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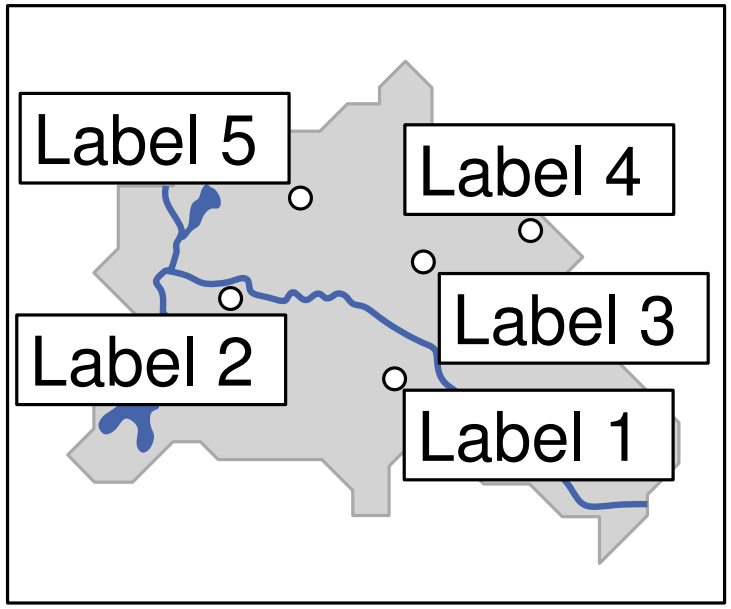

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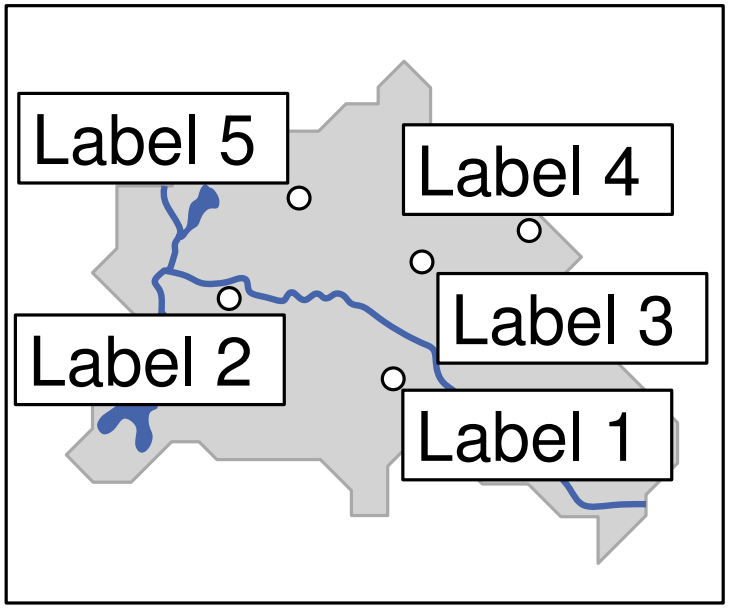

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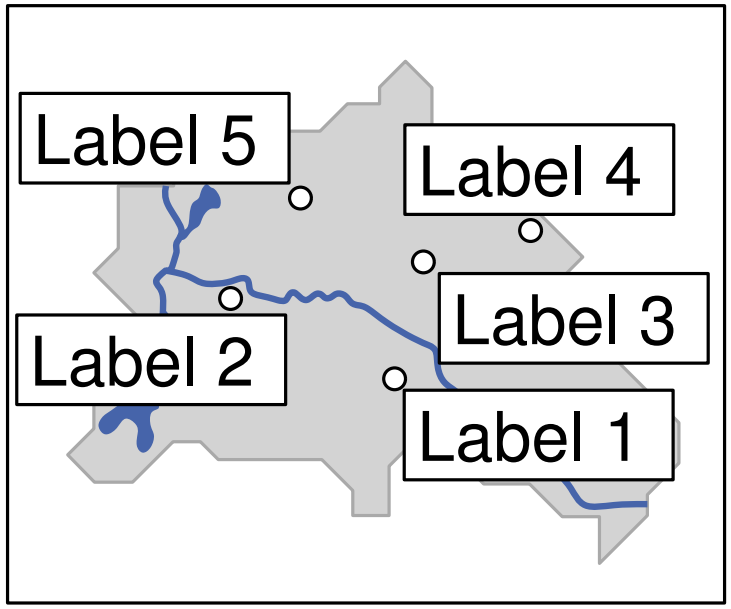

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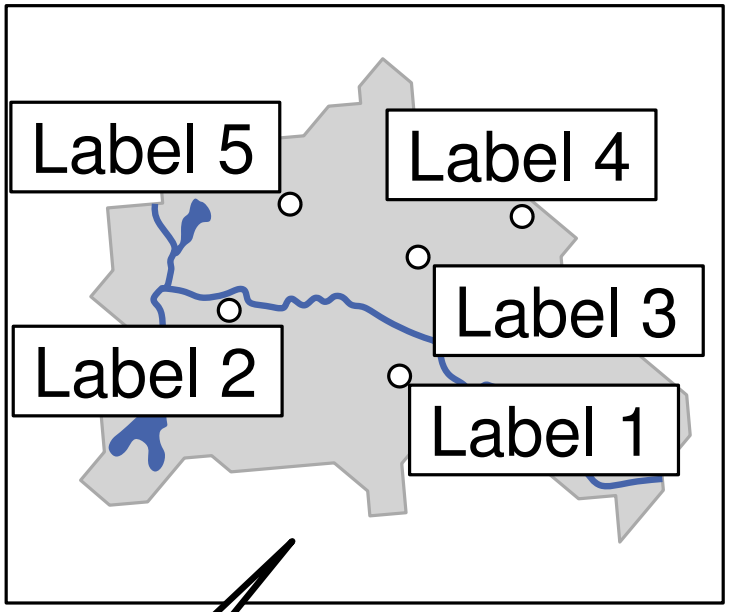

use view-aligned labels instead

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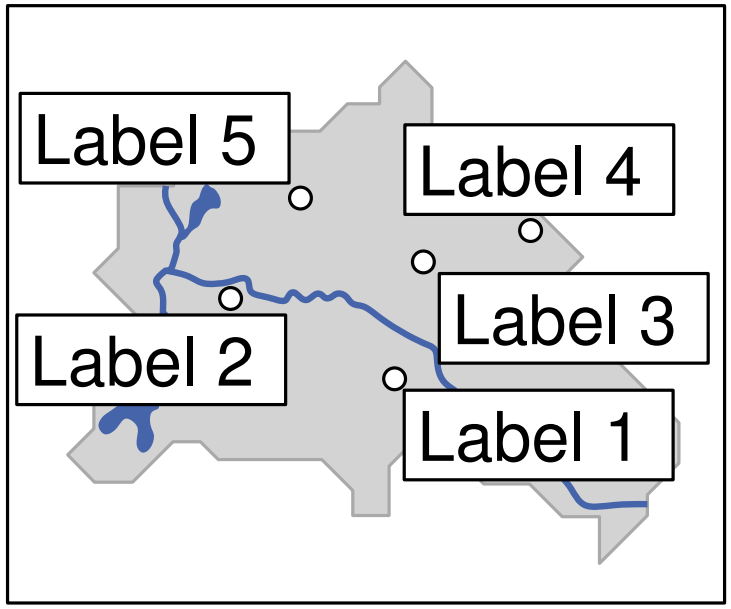

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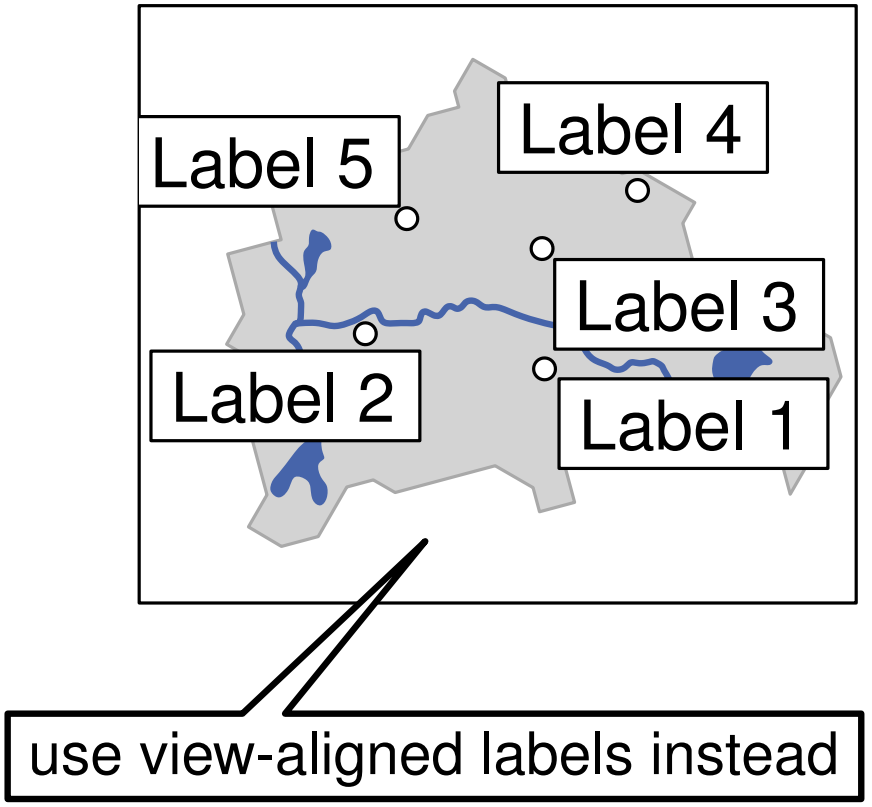

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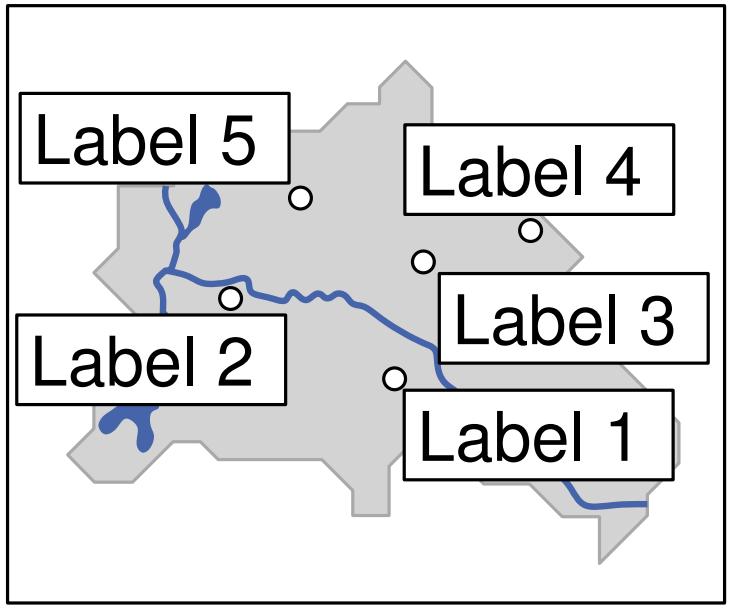

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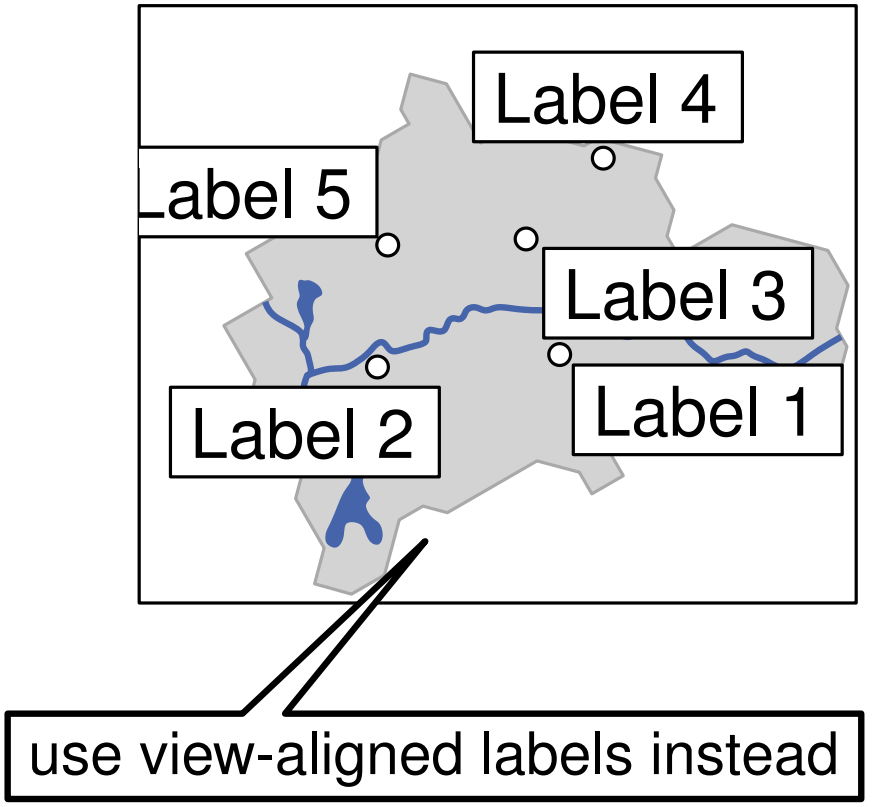

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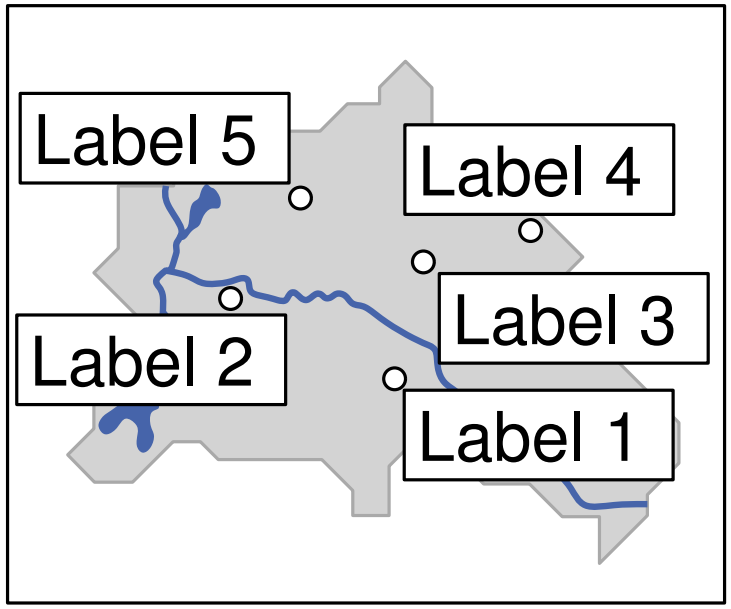

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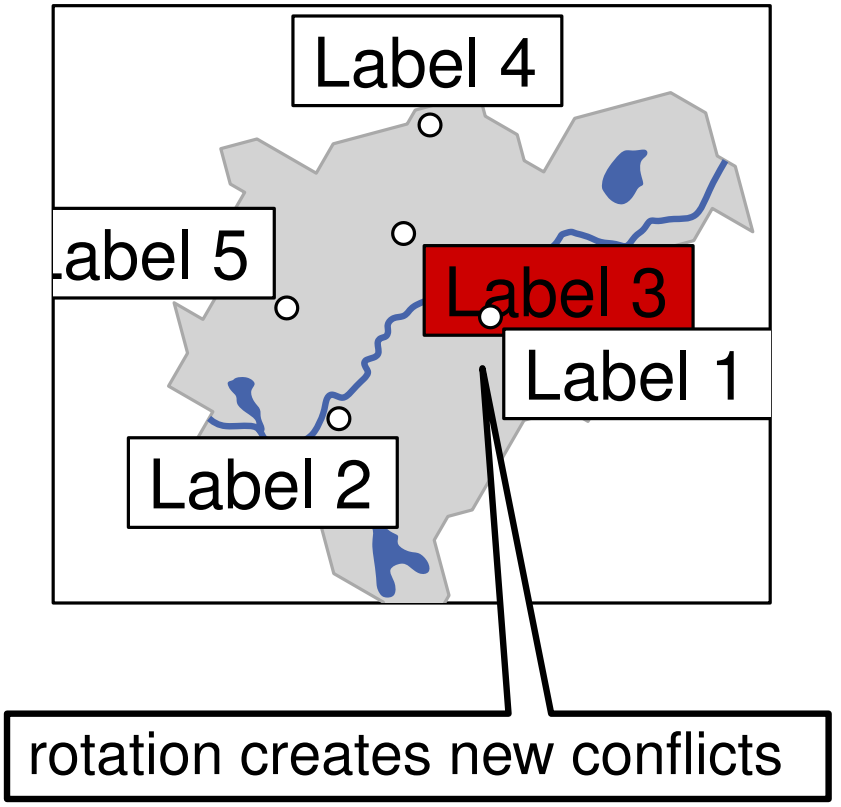

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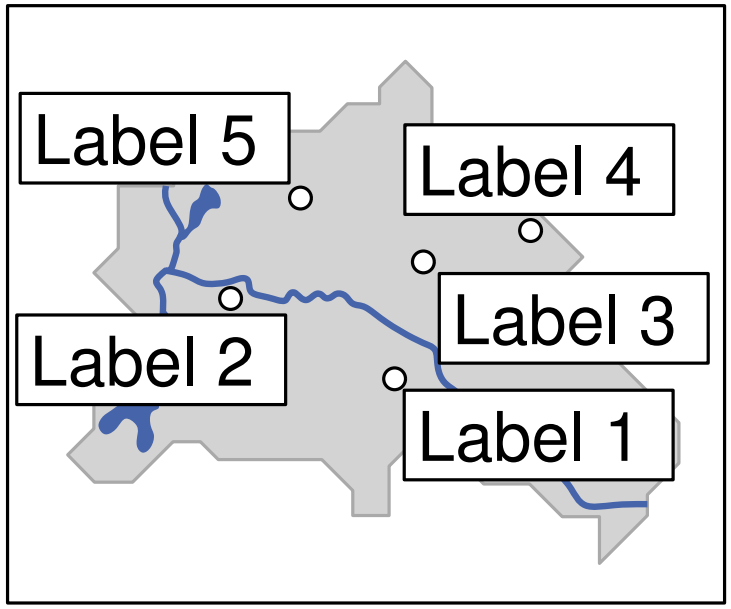

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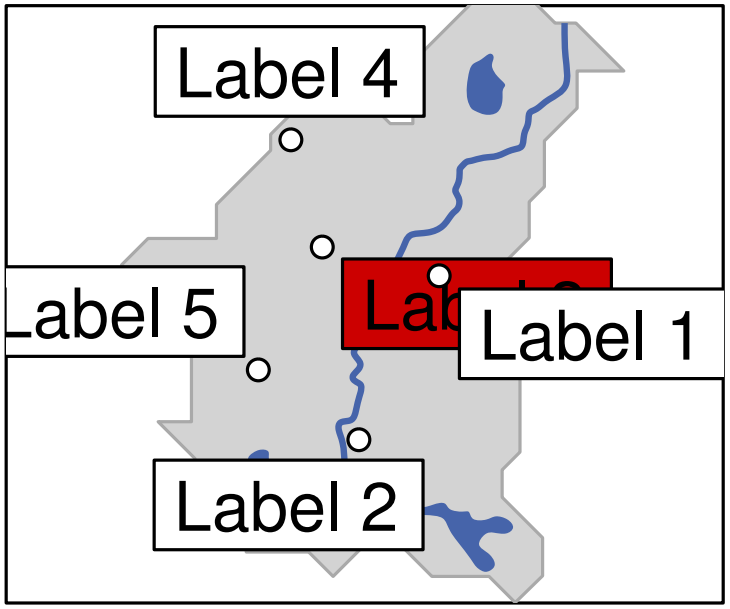
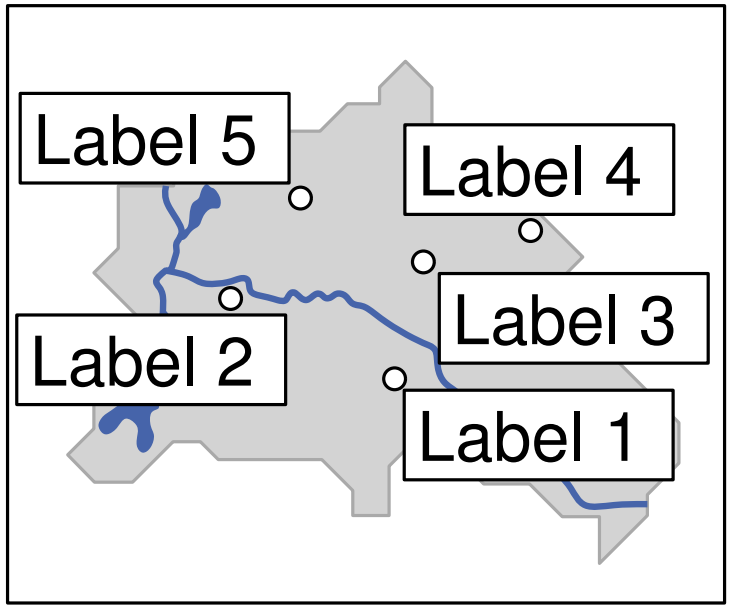


$\Rightarrow$ under rotation, horizontally aligned labels create new conflicts that must be resolved s.t. labels do not jump or flicker

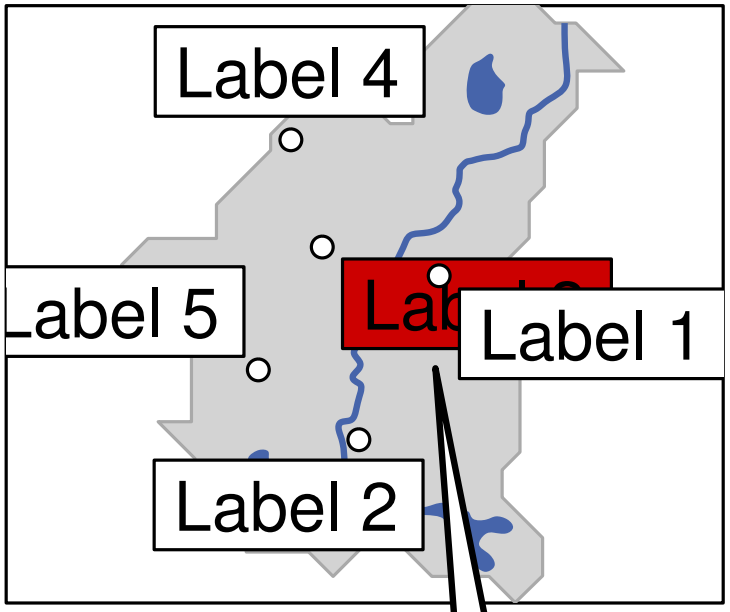
Techniques: approximation via decomposition into geometrically independent and exactly solvable subproblems; heuristics

Labels in rotating maps

northern orientation

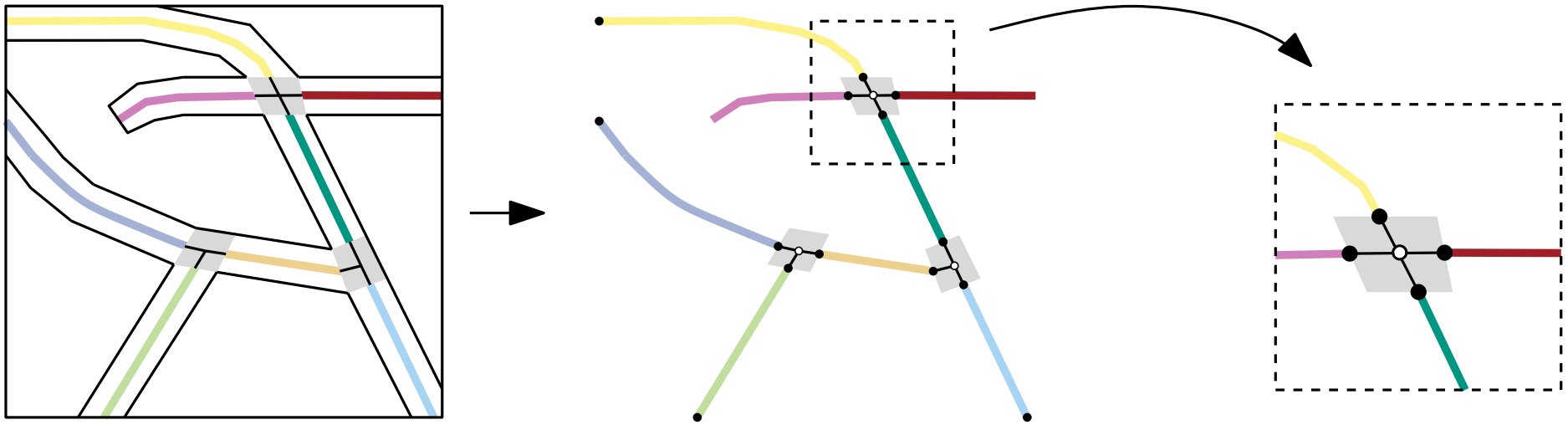


rotated view



$\Rightarrow$ under rotation, horizontally aligned labels create new conflicts that must be resolved s.t. labels do not jump or flicker

Open problem: (dynamic) road labeling



Model road map as a planar embedded graph.

- Each road section becomes an edge
- *Junctions* are shared ressource of multiple roads

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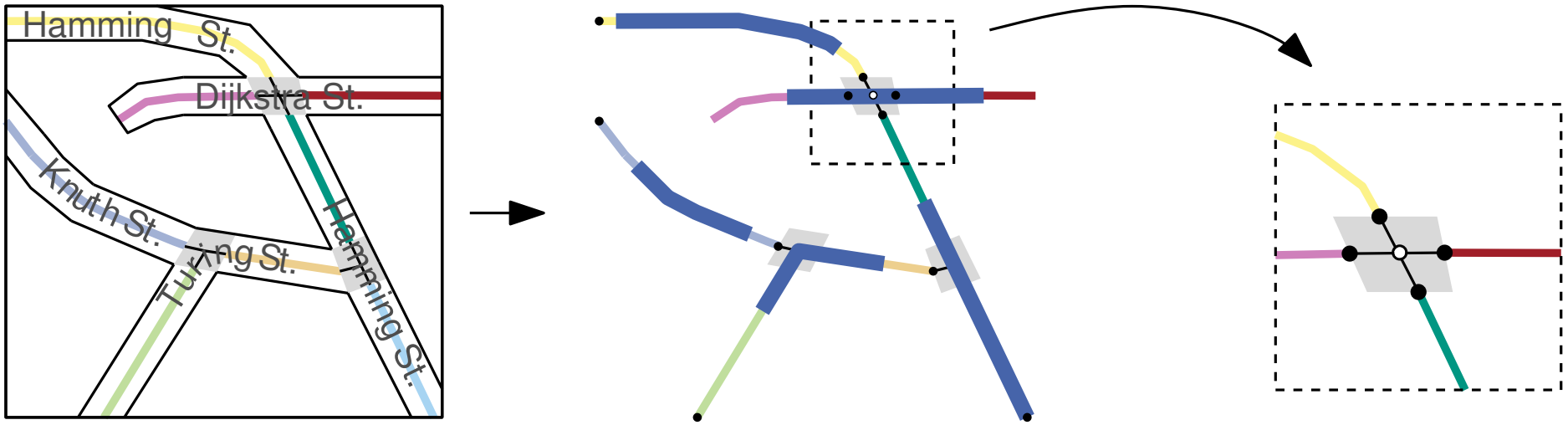

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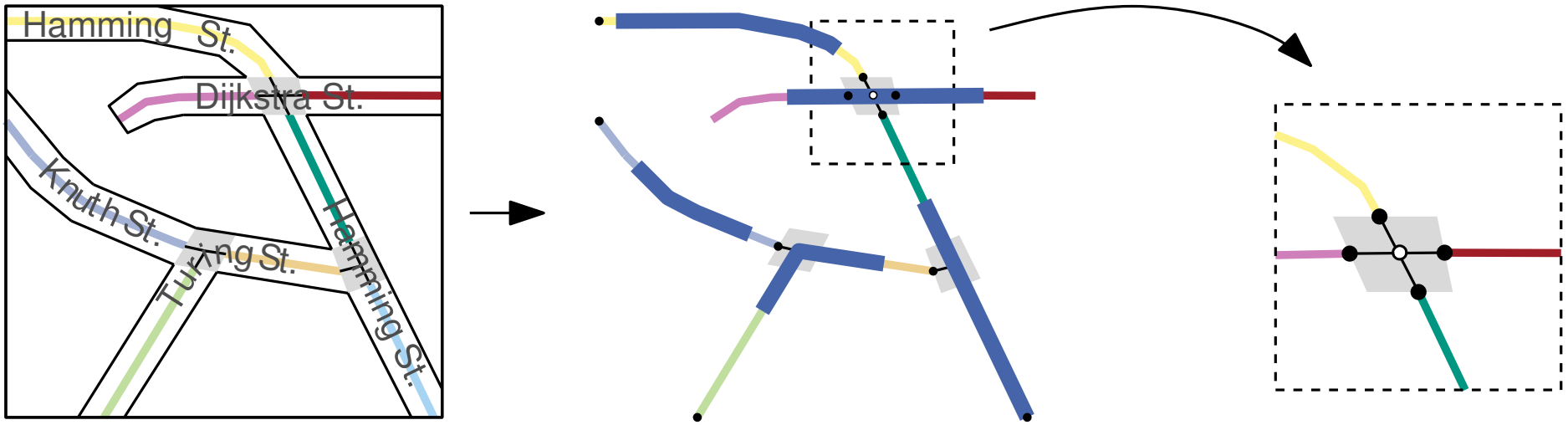

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Minimize label movement when zooming.

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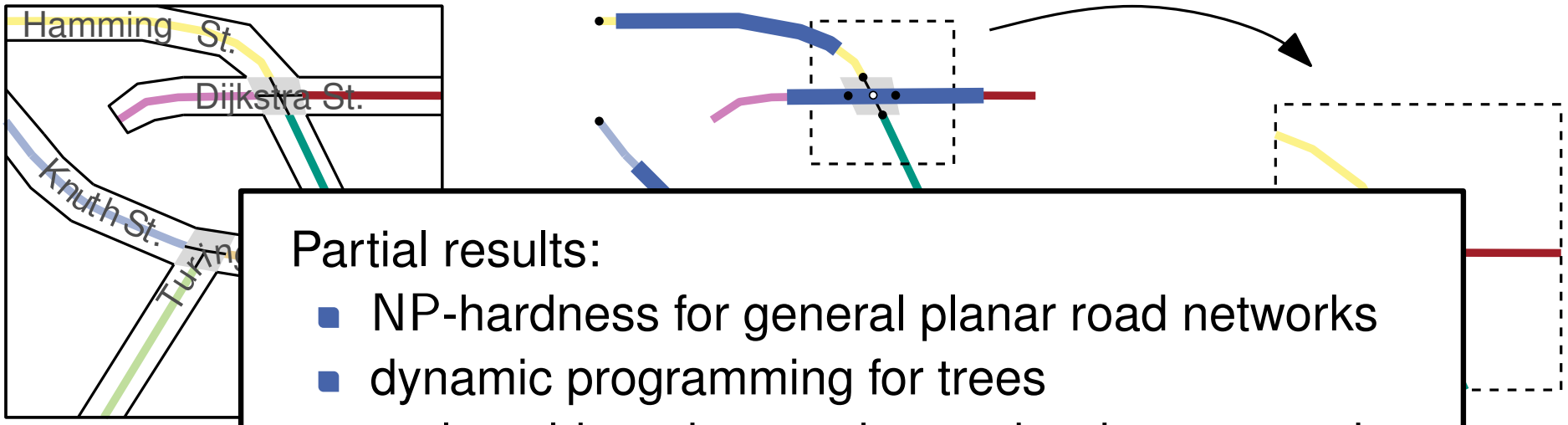

Model ro

- Each
- *Junc*

Partial results:

- NP-hardness for general planar road networks
- dynamic programming for trees
- real-world road networks can be decomposed into many trees
- zooming support still ongoing research

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