Julius-Maximilians-
UNIVERSITÄT
WÜRZBURG

Algorithms for Labeling Focus Regions

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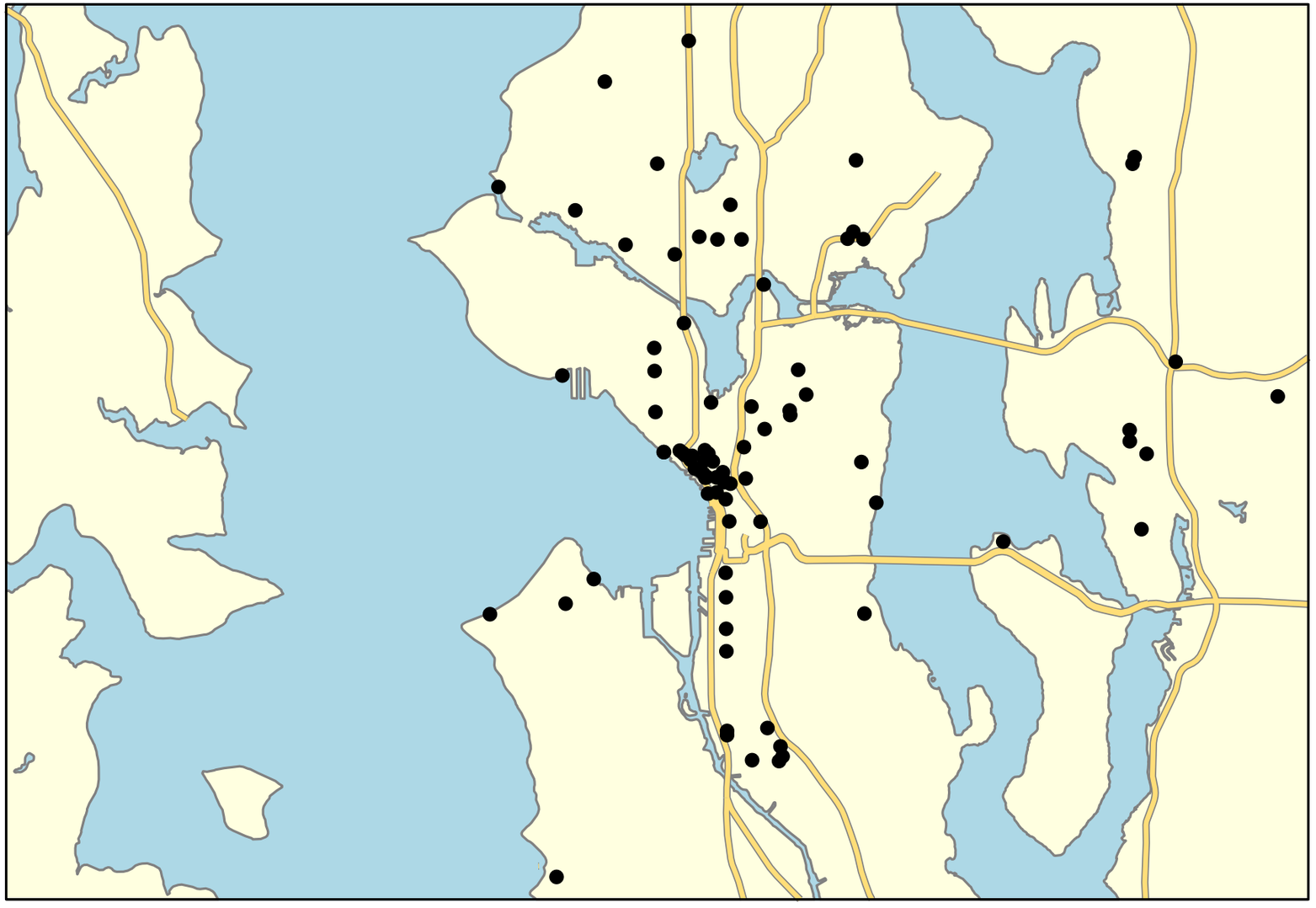
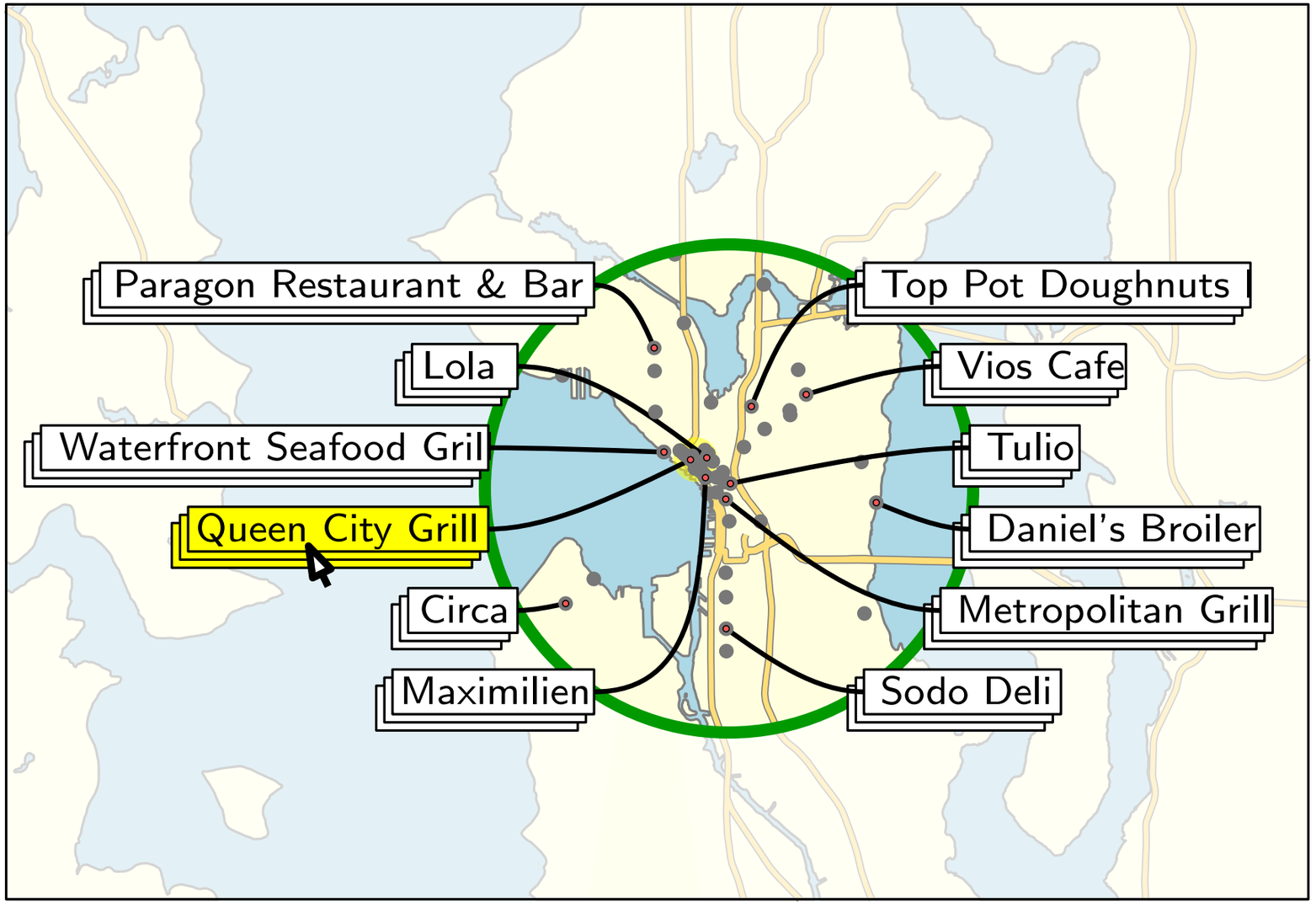
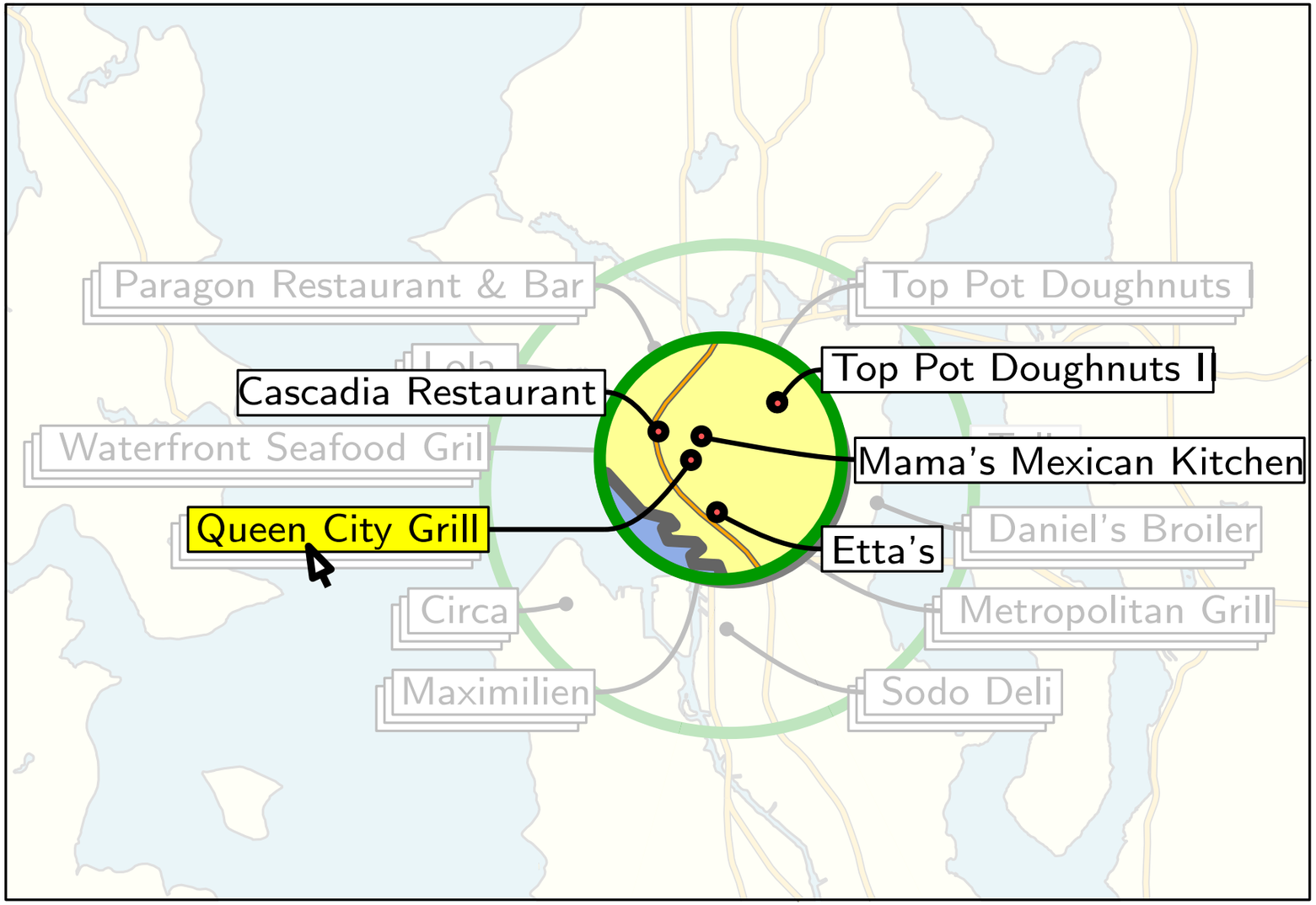
Lehrstuhl für Informatik I
Universität Würzburg

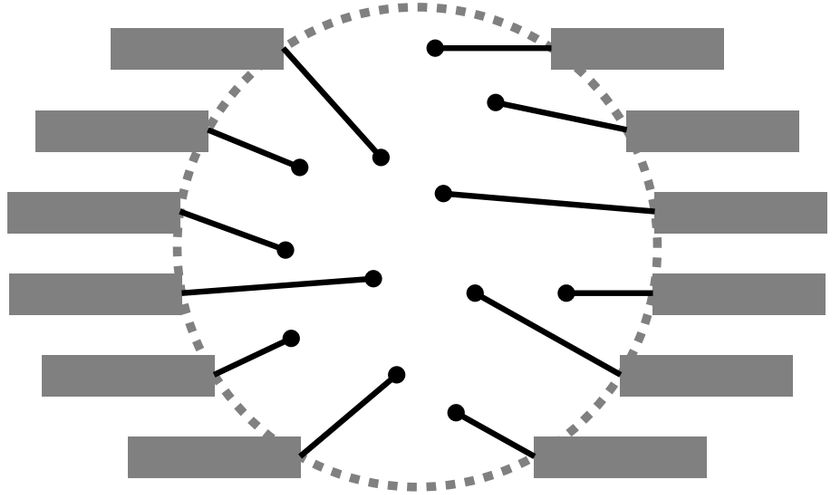
Joint work with
Jan-Henrik Haunert, André Schulz, Joachim Spoerhase, and Alexander Wolff




Paragon Restaurant & Bar
Lola
Waterfront Seafood Gril
Queen City Grill
Circa
Maximilien
Top Pot Doughnuts
Vios Cafe
Tulio
Daniel's Broiler
Metropolitan Grill
Sodo Deli

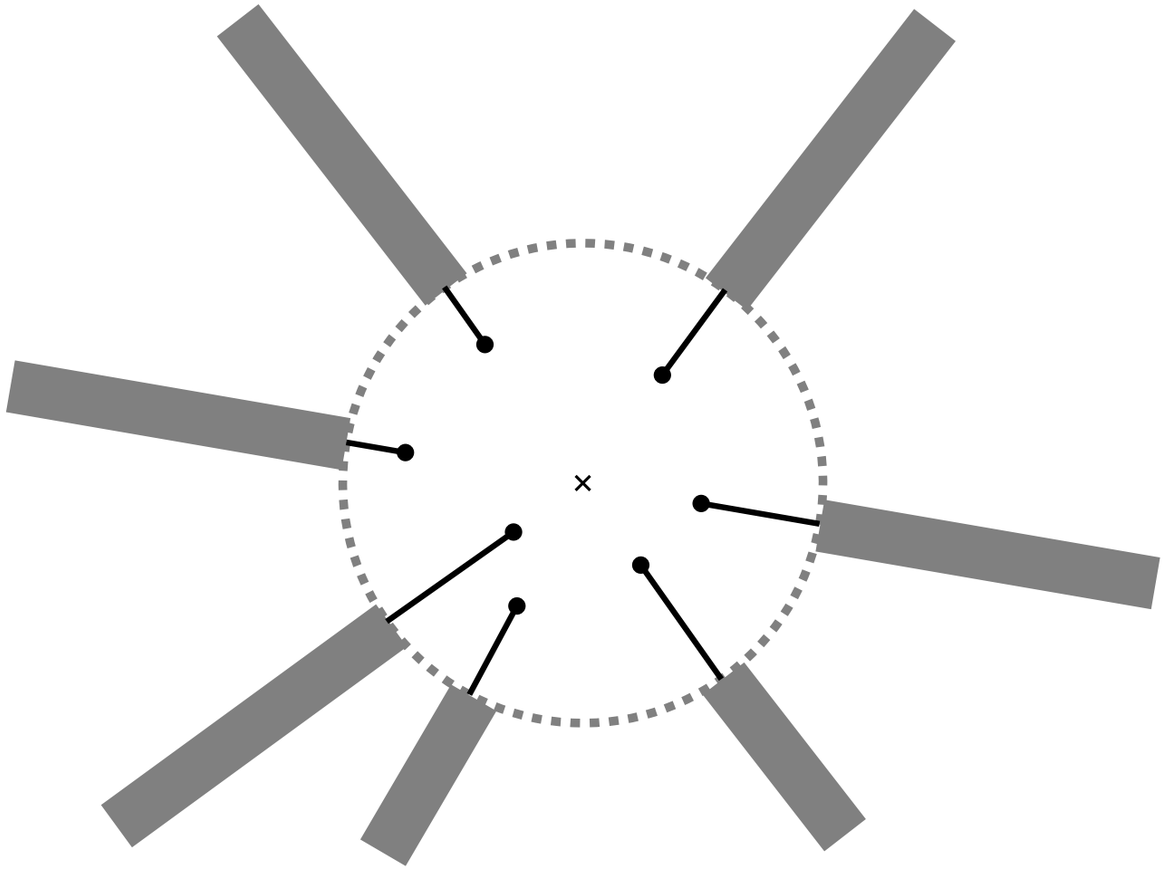

Paragon Restaurant & Bar
Top Pot Doughnuts
Top Pot Doughnuts
Cascadia Restaurant
Waterfront Seafood Gril
Mama's Mexican Kitchen
Queen City Grill
Daniel's Broiler
Etta's
Circa
Metropolitan Grill
Maximilien
Sodo Deli

Our models

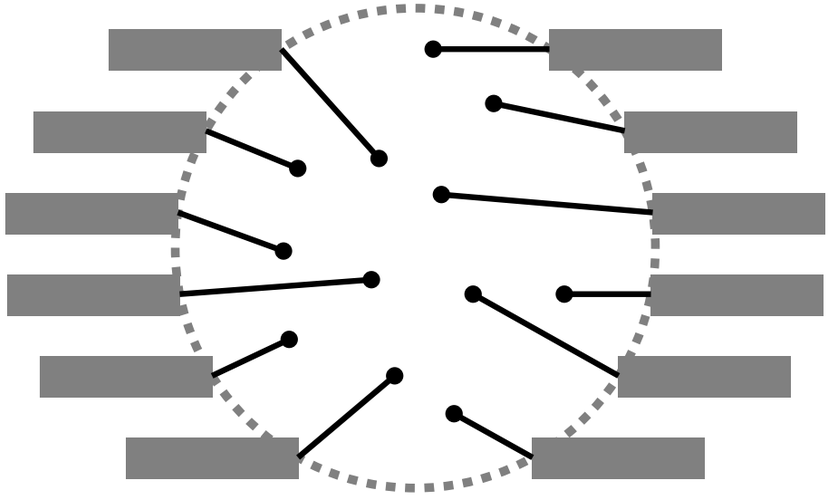


free leaders

Our models



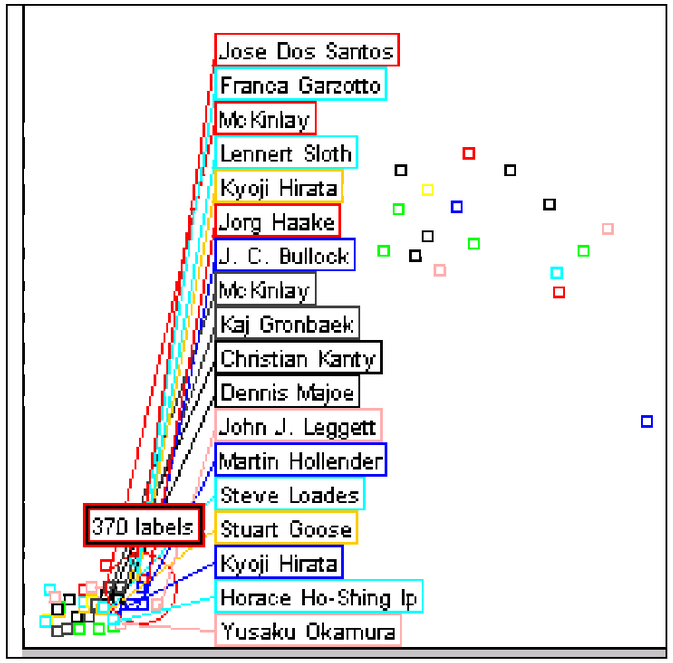
radial leaders



free leaders

Previous Work

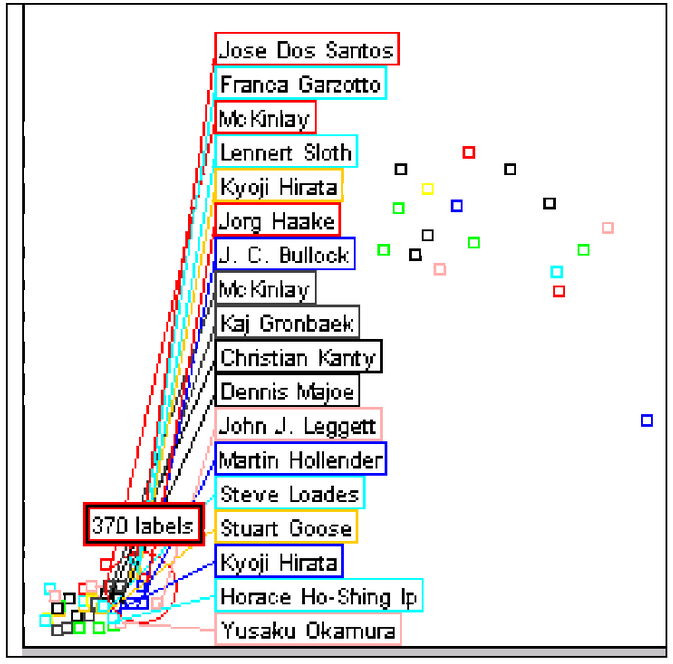
Excentric Labeling



[Fekete and Plaisant, 1999]

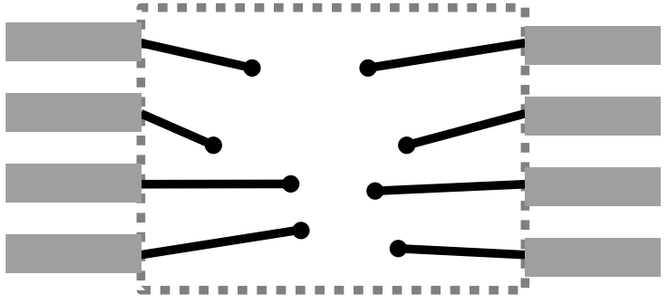
Previous Work

Excentric Labeling



[Fekete and Plaisant, 1999]

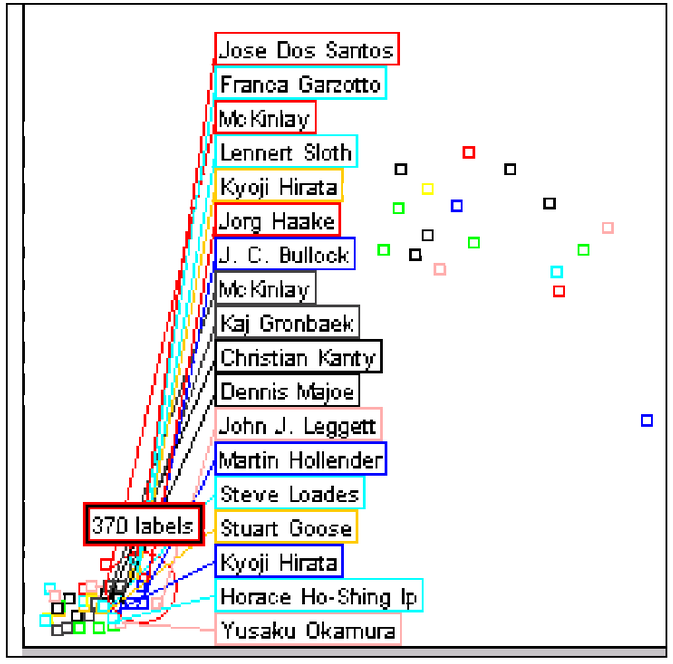
Boundary Labeling



[Bekos et al., 2007]

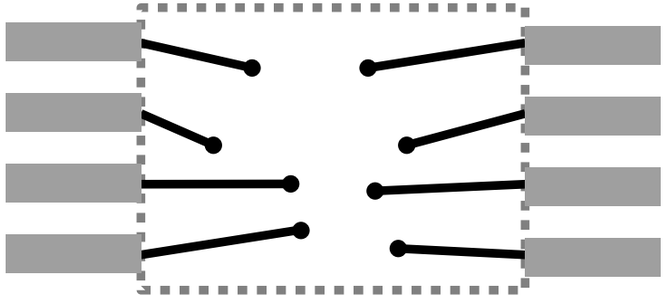
Previous Work

Excentric Labeling



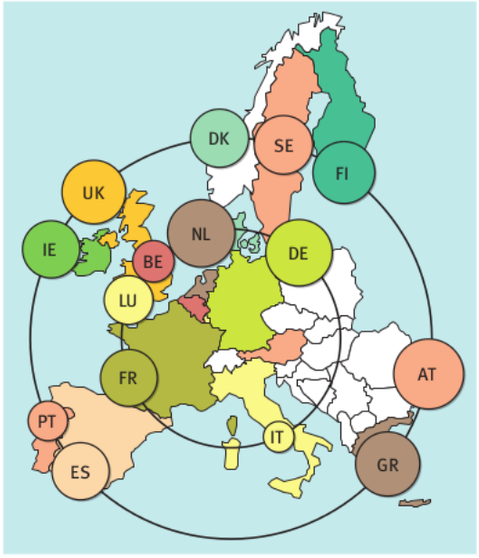
[Fekete and Plaisant, 1999]

Boundary Labeling



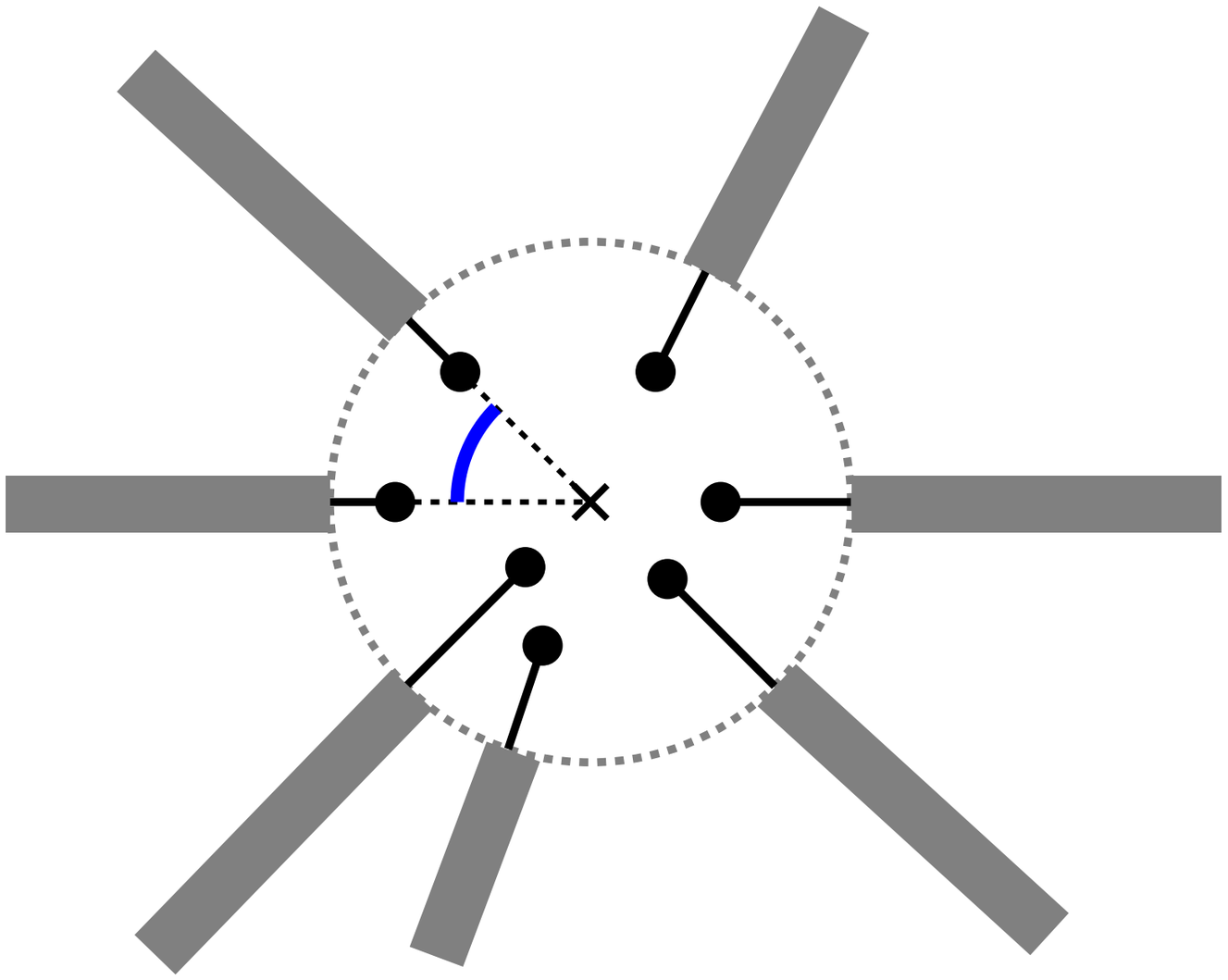
[Bekos et al., 2007]

Necklace Maps



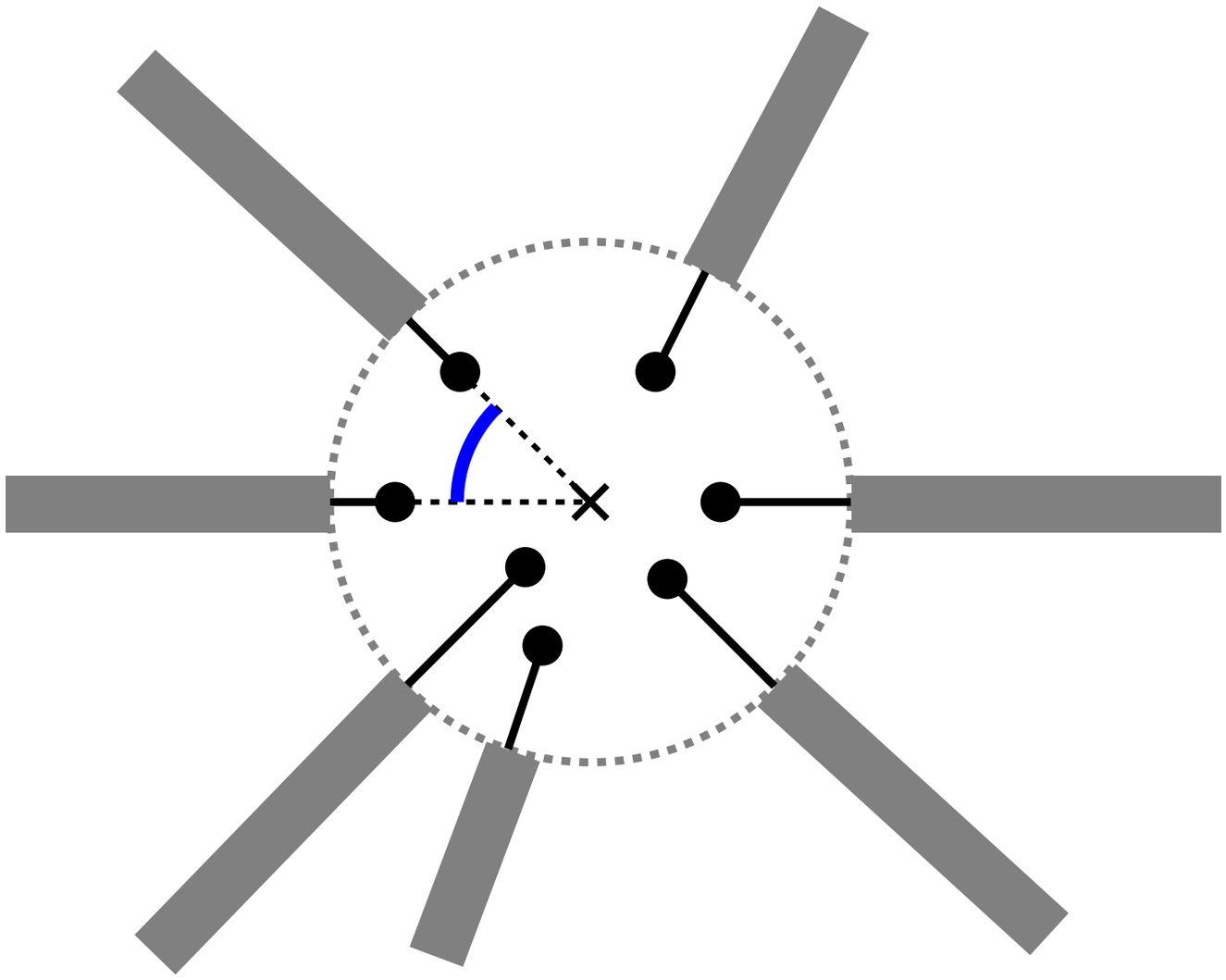
[Speckmann and Verbeek, 2010]

The Radial Leader Model



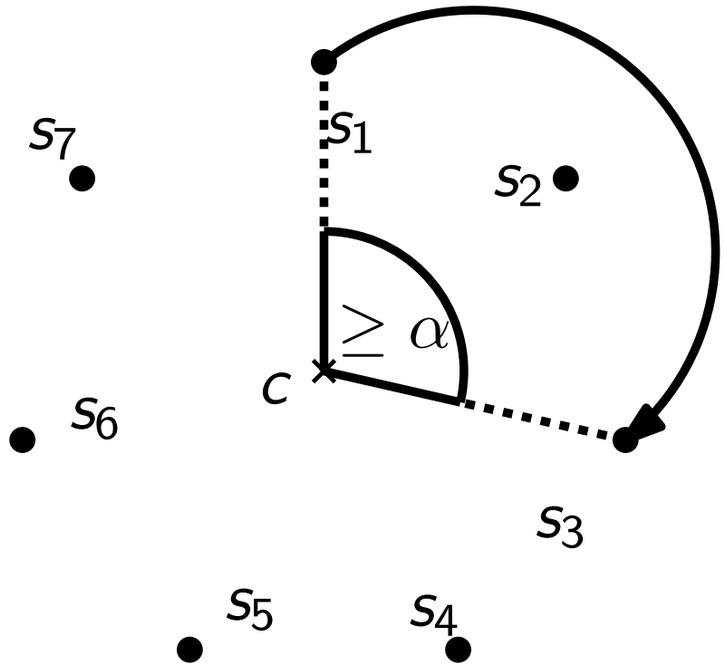
- minimum allowed angle to avoid label collisions

The Radial Leader Model



- minimum allowed angle to avoid label collisions
- maximize number of visible labels by a dynamic program

The Radial Leader Model



- minimum allowed angle to avoid label collisions
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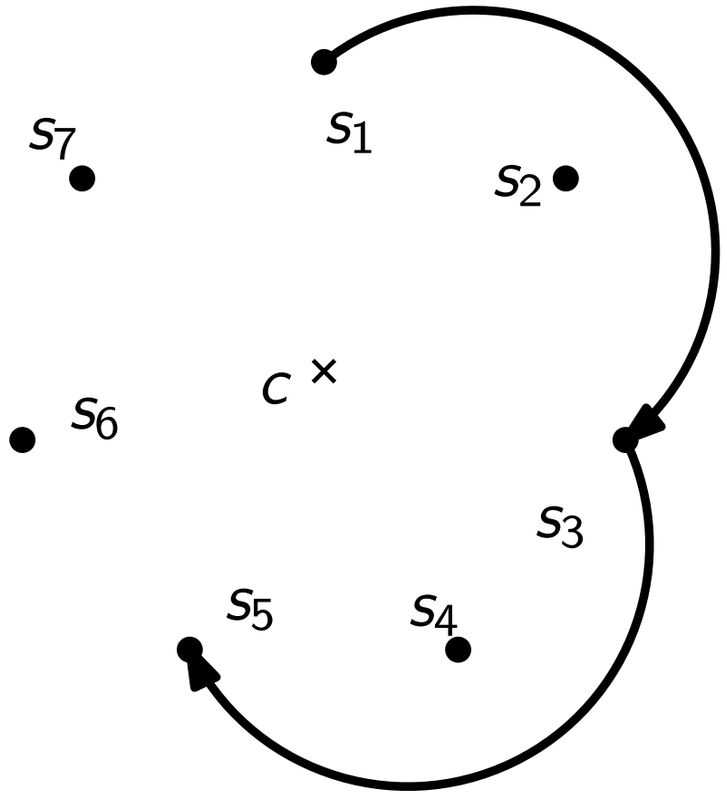
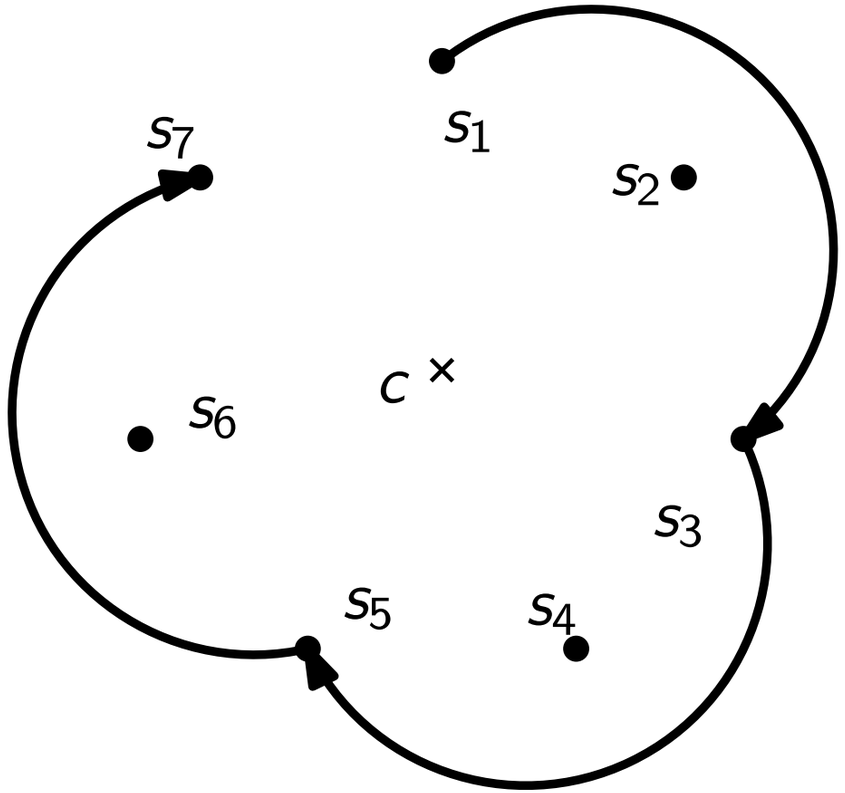
The Radial Leader Model



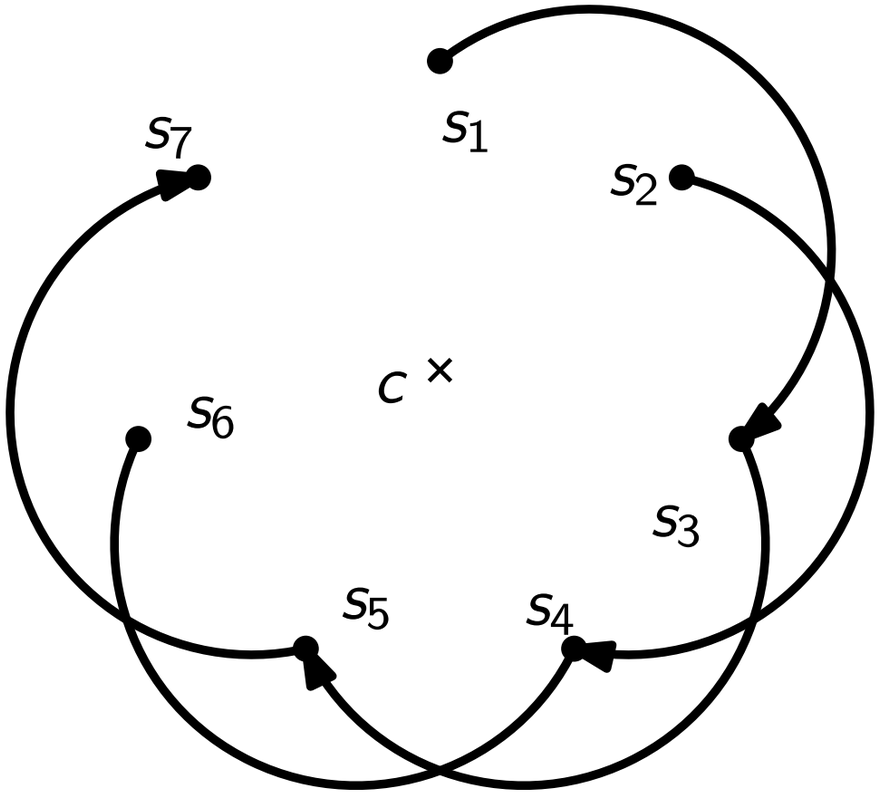
- minimum allowed angle to avoid label collisions
- maximize number of visible labels by a dynamic program

The Radial Leader Model



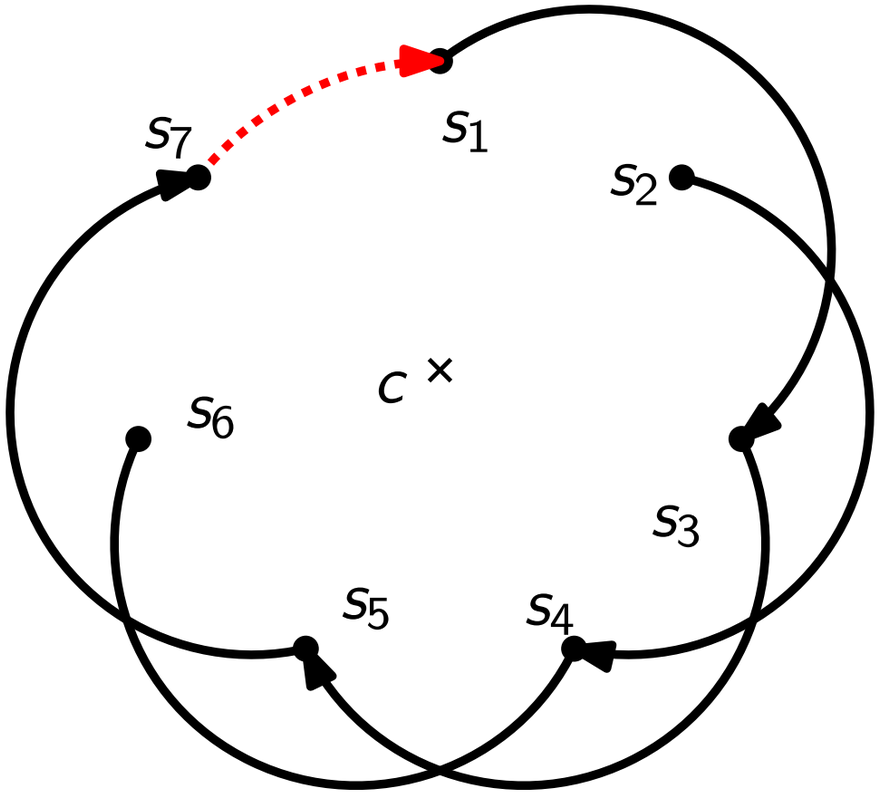
- minimum allowed angle to avoid label collisions
- maximize number of visible labels by a dynamic program

The Radial Leader Model



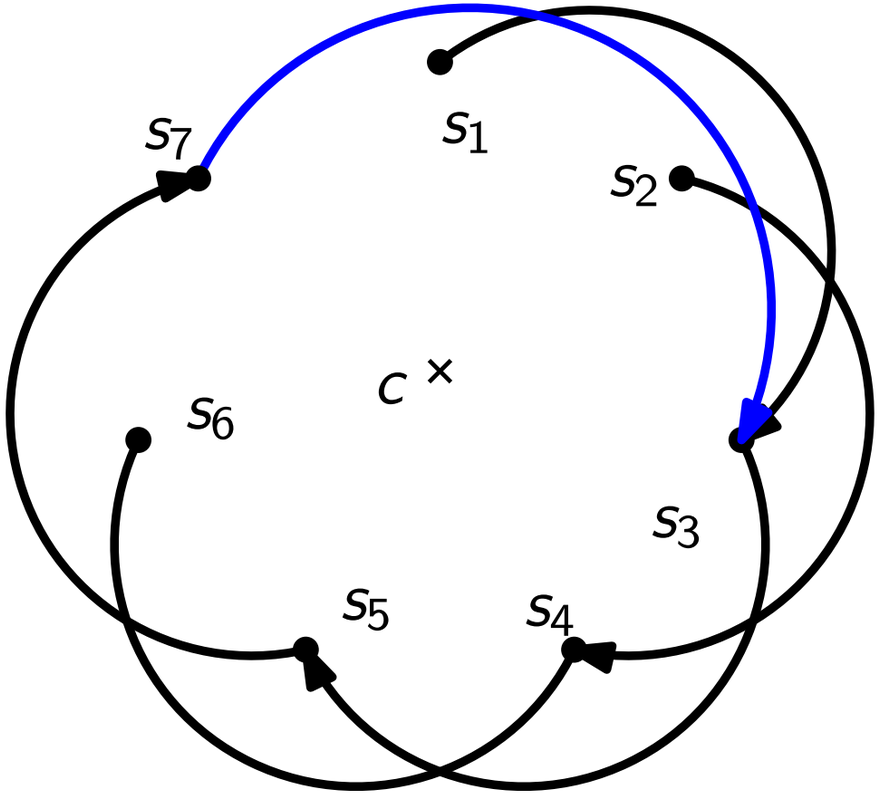
- minimum allowed angle to avoid label collisions
- maximize number of visible labels by a dynamic program

The Radial Leader Model



- minimum allowed angle to avoid label collisions
- maximize number of visible labels by a dynamic program

The Radial Leader Model



- minimum allowed angle to avoid label collisions
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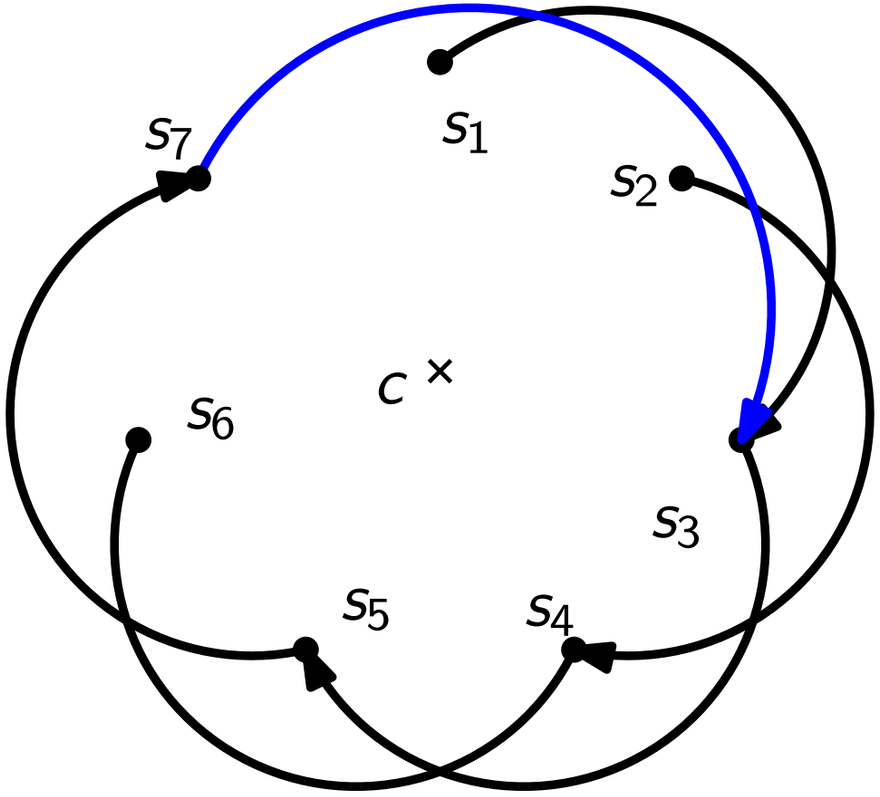
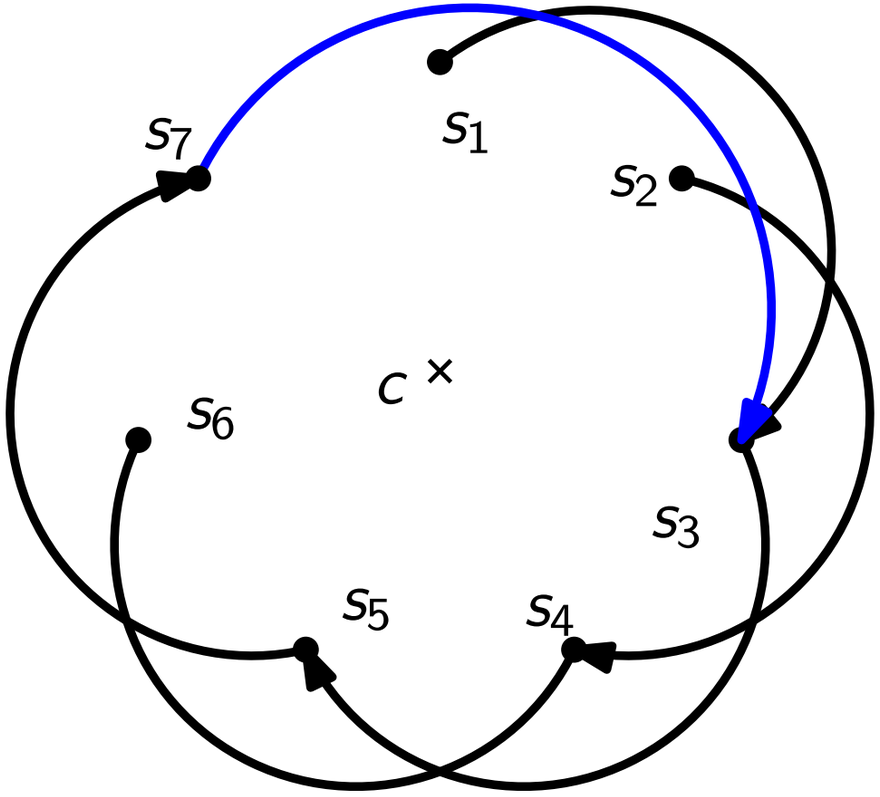
The Radial Leader Model



- minimum allowed angle to avoid label collisions
- maximize number of visible labels by a dynamic program

  $O(n \log n)$ time

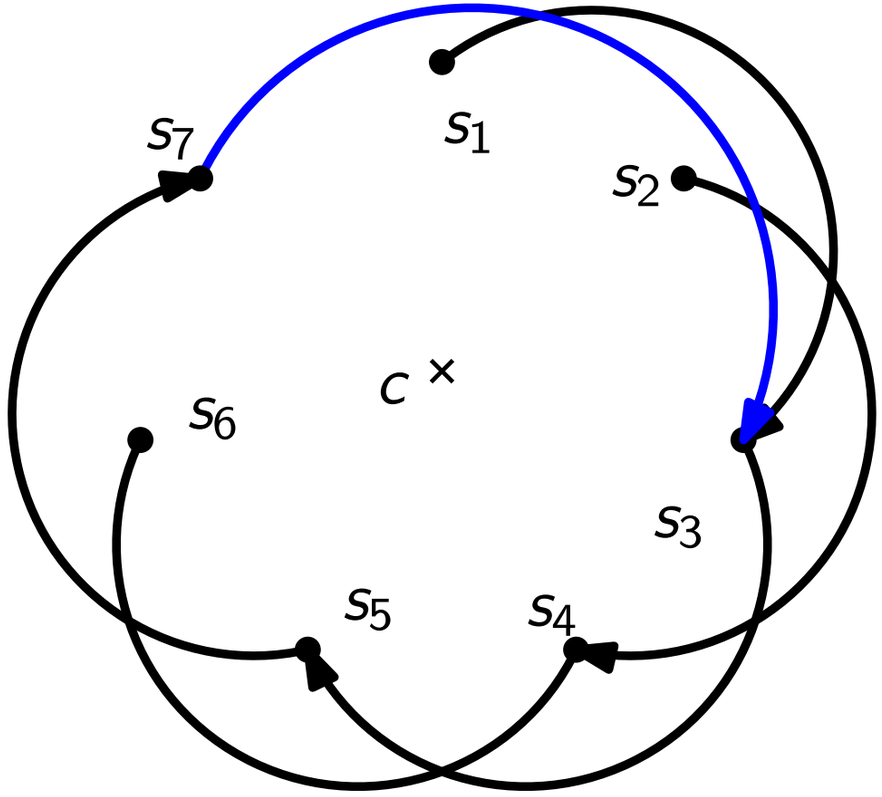
The Radial Leader Model



- minimum allowed angle to avoid label collisions
- maximize number of visible labels by a dynamic program

  $O(n \log n)$ time
- weighted version: prefer higher rated points

The Radial Leader Model

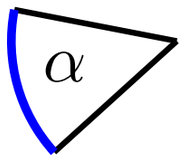


- minimum allowed angle to avoid label collisions
- maximize number of visible labels by a dynamic program

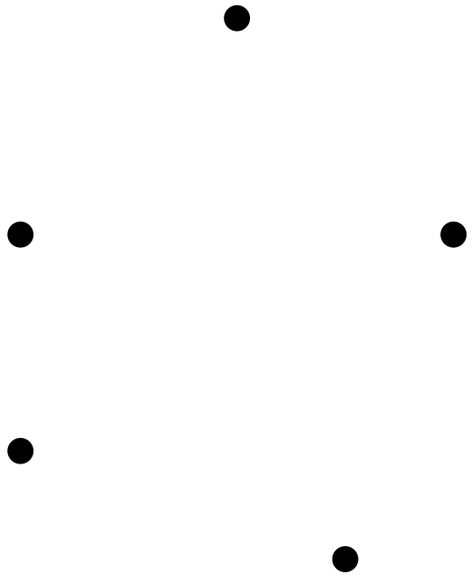
  $O(n \log n)$ time
- weighted version: prefer higher rated points

  $O(n^2)$ time

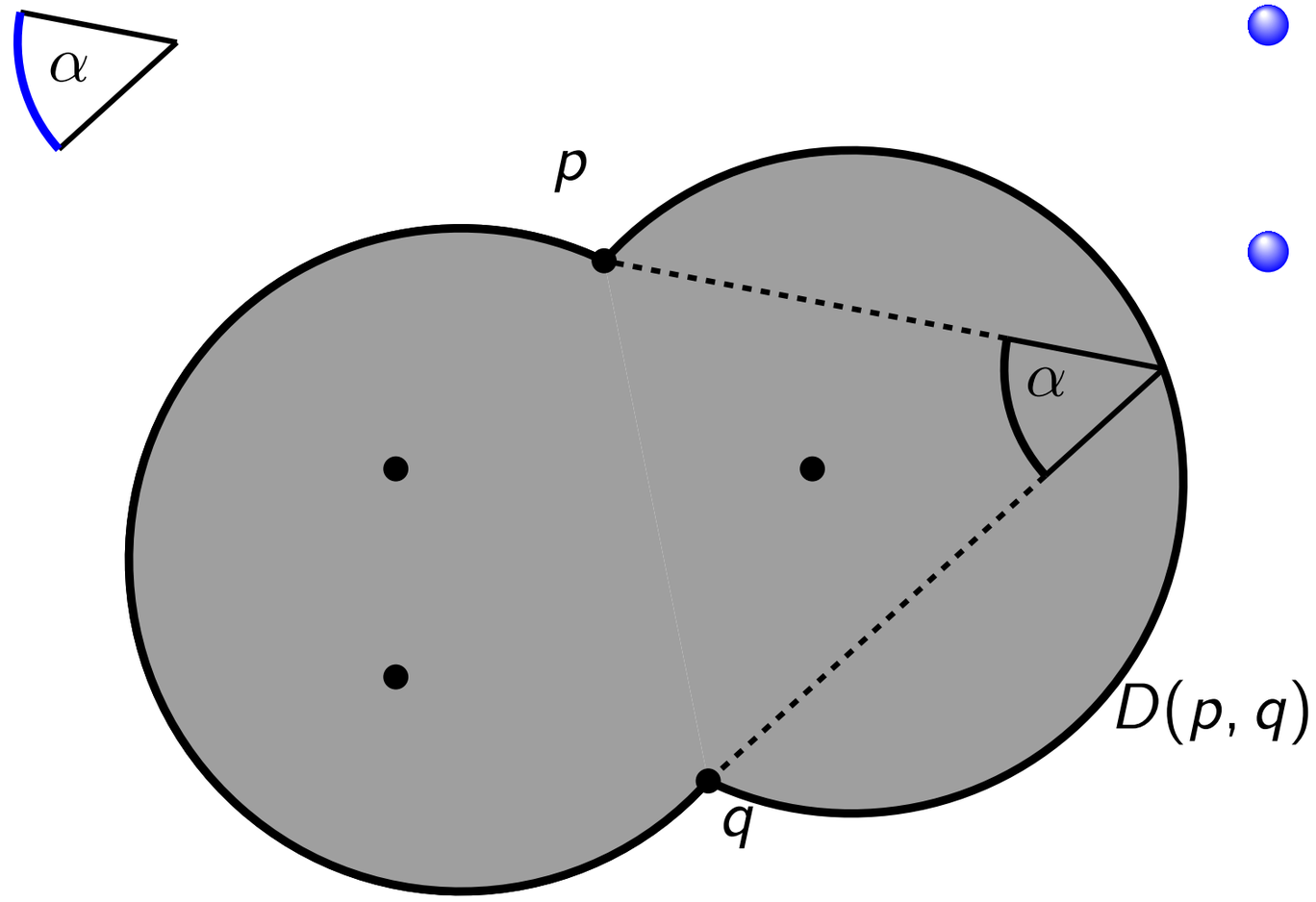
The Radial Leader Model with Flexible Center Position



- find disk that respects minimum angle α

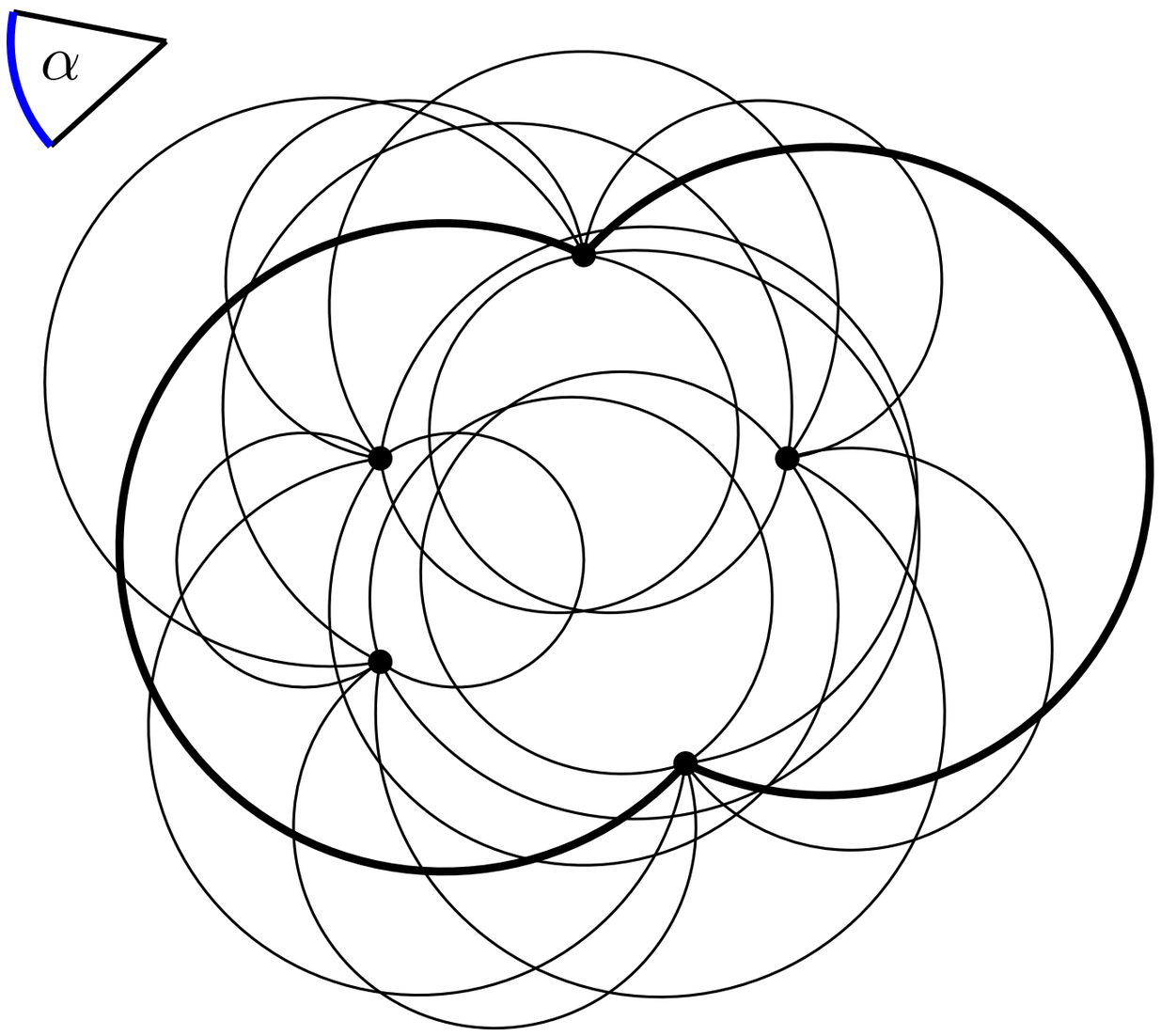


The Radial Leader Model with Flexible Center Position



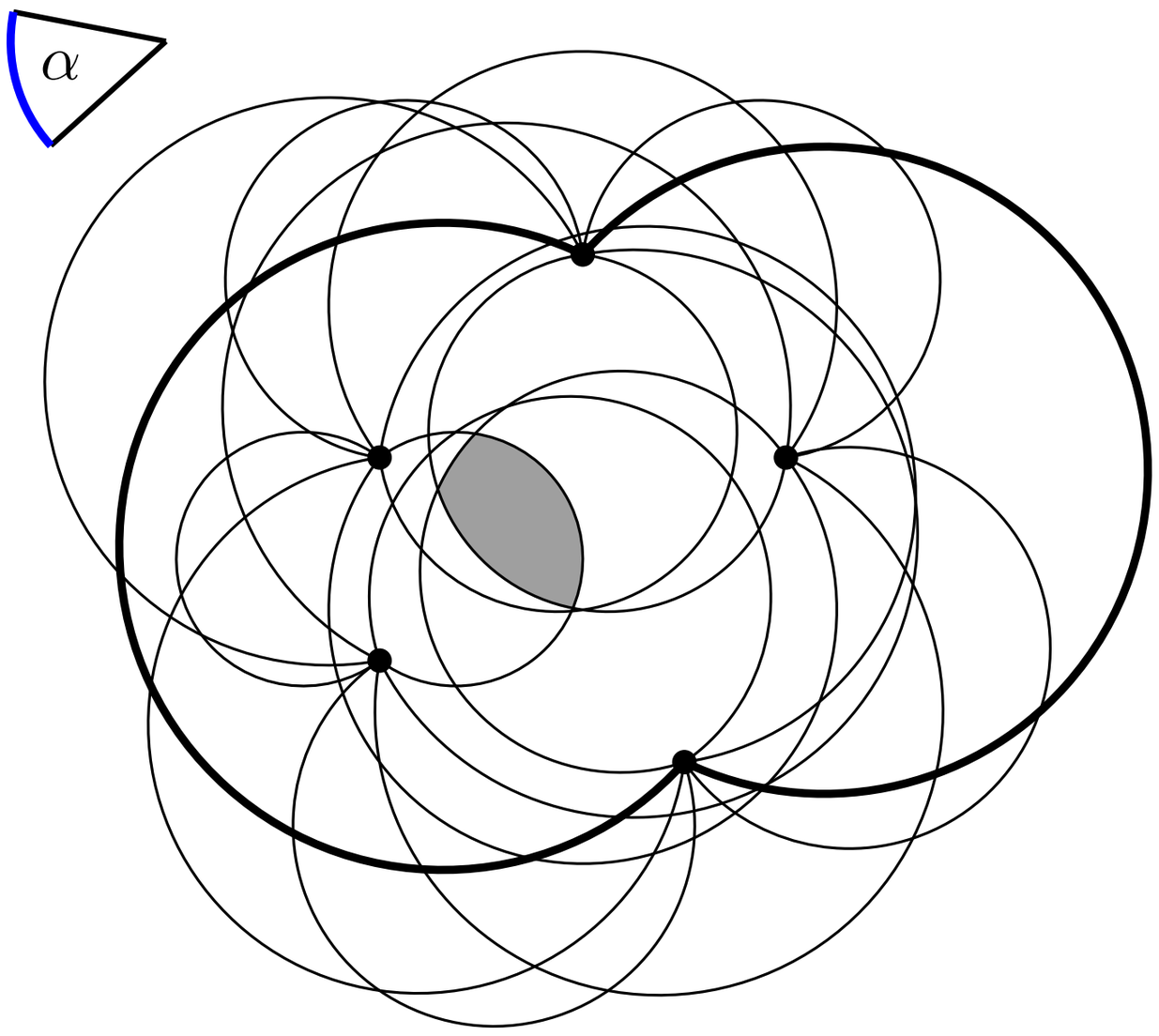
- find disk that respects minimum angle α
- consider double disk $D(p, q)$ of minimum angle α formed with p and q

The Radial Leader Model with Flexible Center Position



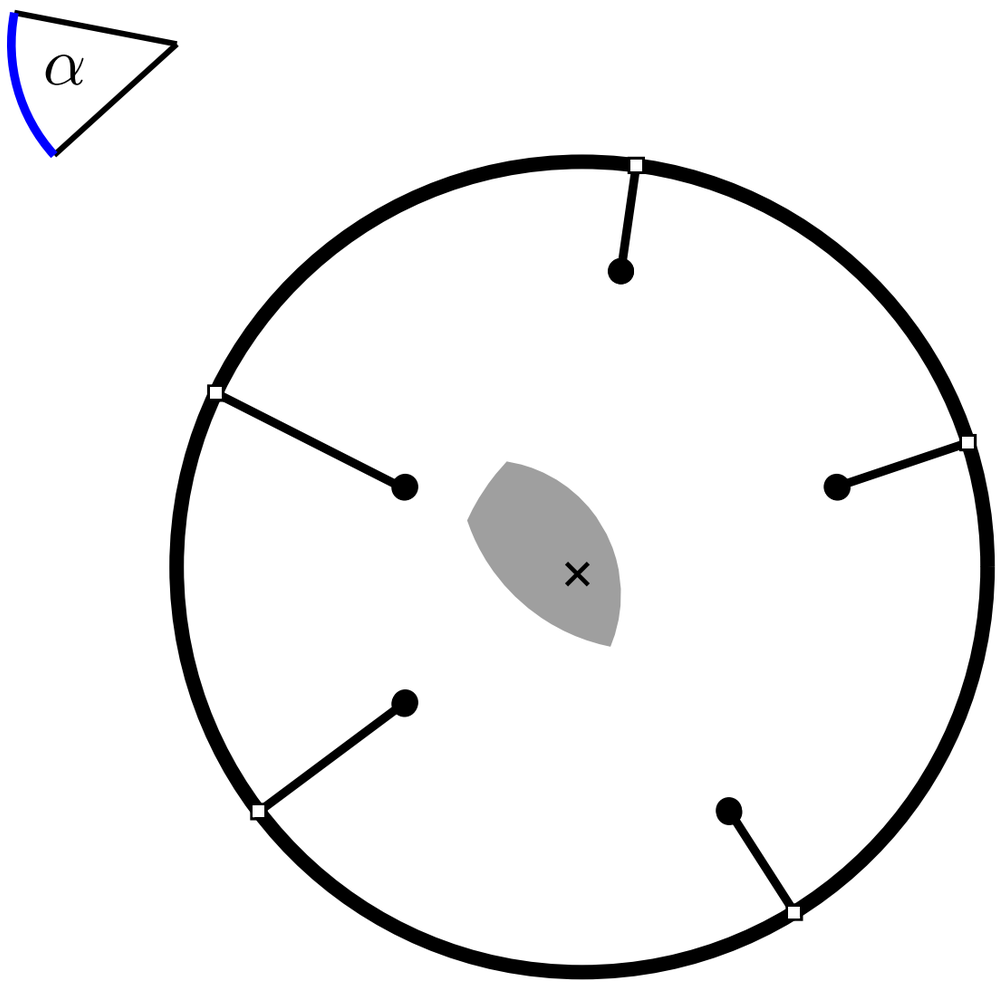
- find disk that respects minimum angle α
- consider double disk $D(p, q)$ of minimum angle α formed with p and q
- build arrangement of all $D(\cdot, \cdot)$

The Radial Leader Model with Flexible Center Position



- find disk that respects minimum angle α
- consider double disk $D(p, q)$ of minimum angle α formed with p and q
- build arrangement of all $D(\cdot, \cdot)$
- check for intersection (cell of depht $\binom{n}{2}$)

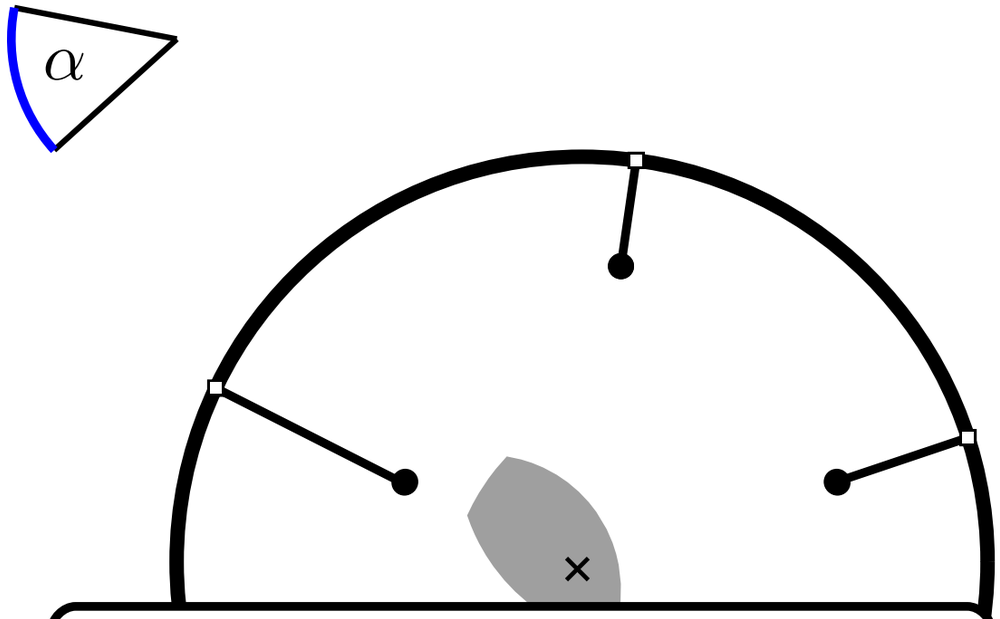
The Radial Leader Model with Flexible Center Position



- find disk that respects minimum angle α
- consider double disk $D(p, q)$ of minimum angle α formed with p and q
- build arrangement of all $D(\cdot, \cdot)$
- check for intersection (cell of depht $\binom{n}{2}$)
- choose center in intersection

$$O(n^4 \log n) \text{ time}$$

The Radial Leader Model with Flexible Center Position



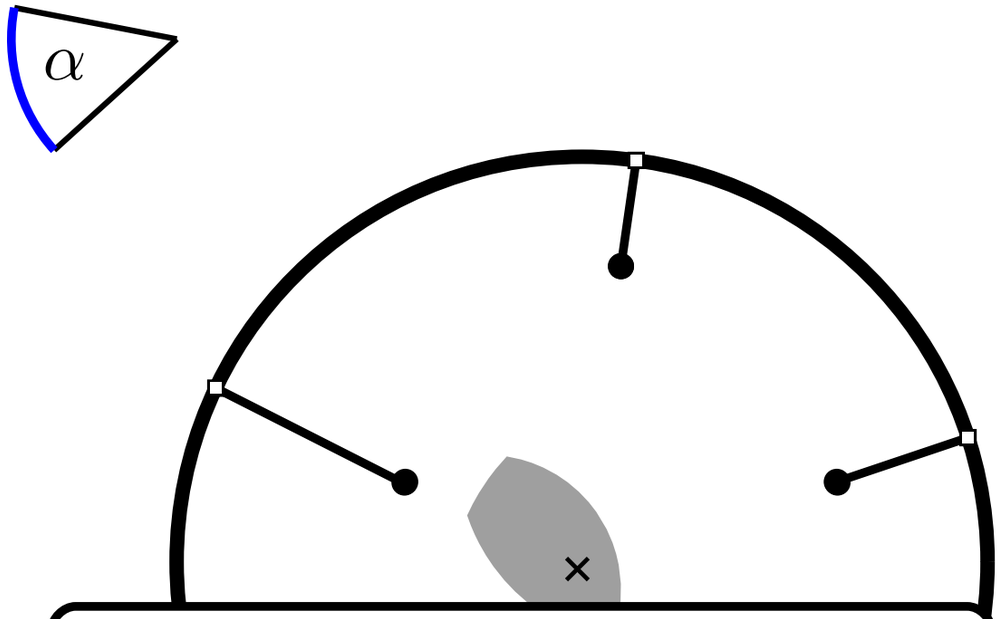
Variants

- maximize labels
  $O(n^5)$ time

- find disk that respects minimum angle α
- consider double disk $D(p, q)$ of minimum angle α formed with p and q
- build arrangement of all $D(\cdot, \cdot)$
- check for intersection (cell of depht $\binom{n}{2}$)
- choose center in intersection

$$O(n^4 \log n) \text{ time}$$

The Radial Leader Model with Flexible Center Position



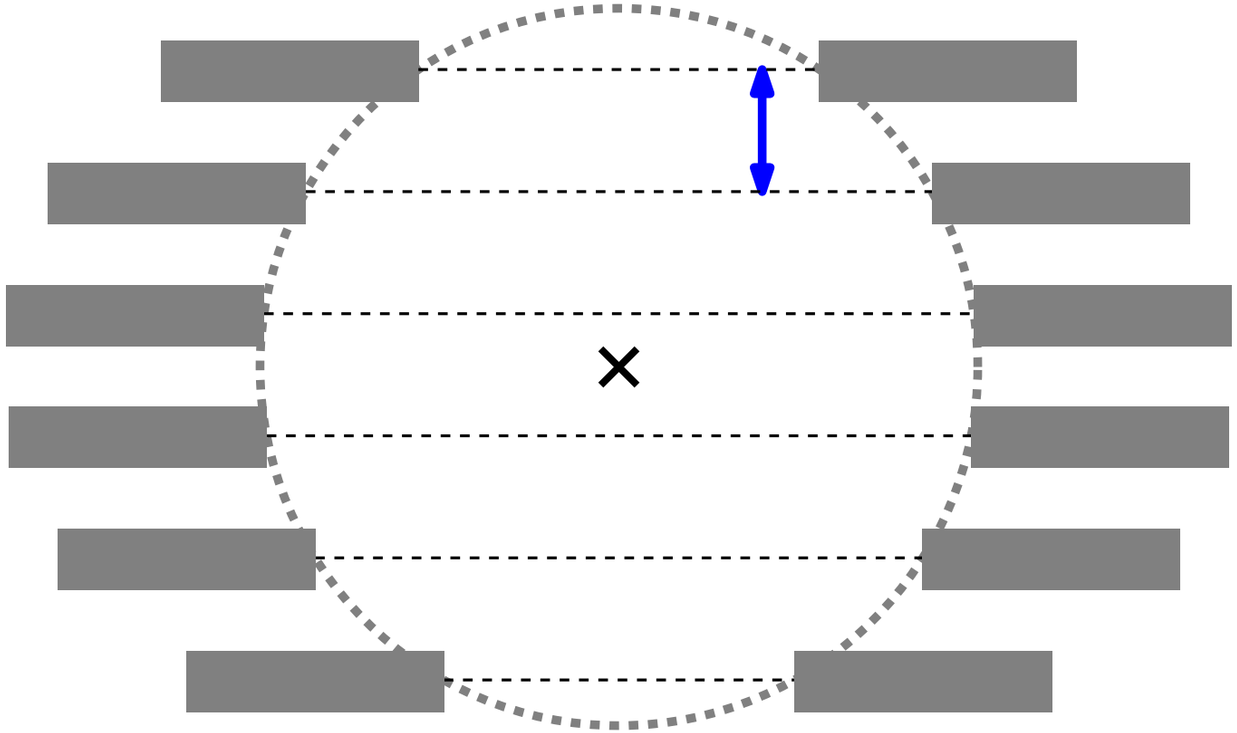
Variants

- maximize labels
  $O(n^5)$ time
- maximize angle
  $O(n^6)$ time

- find disk that respects minimum angle α
- consider double disk $D(p, q)$ of minimum angle α formed with p and q
- build arrangement of all $D(\cdot, \cdot)$
- check for intersection (cell of depht $\binom{n}{2}$)
- choose center in intersection

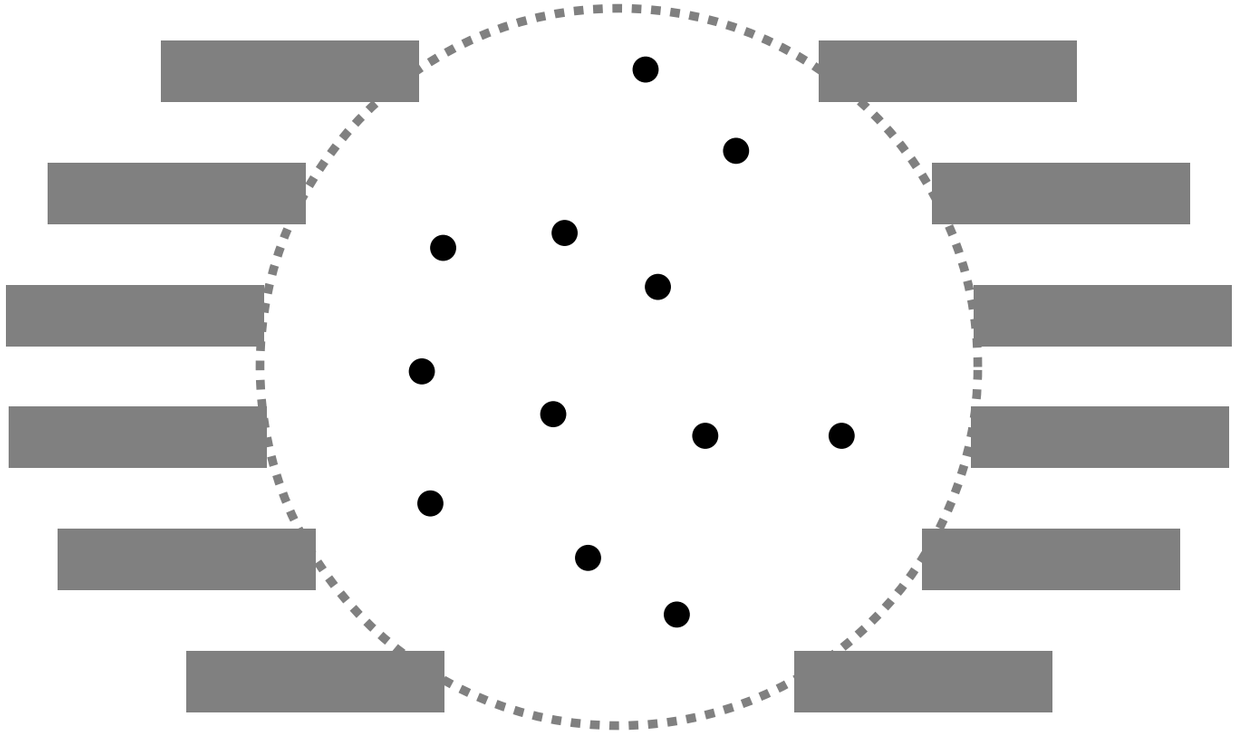
$$O(n^4 \log n) \text{ time}$$

The free leader model



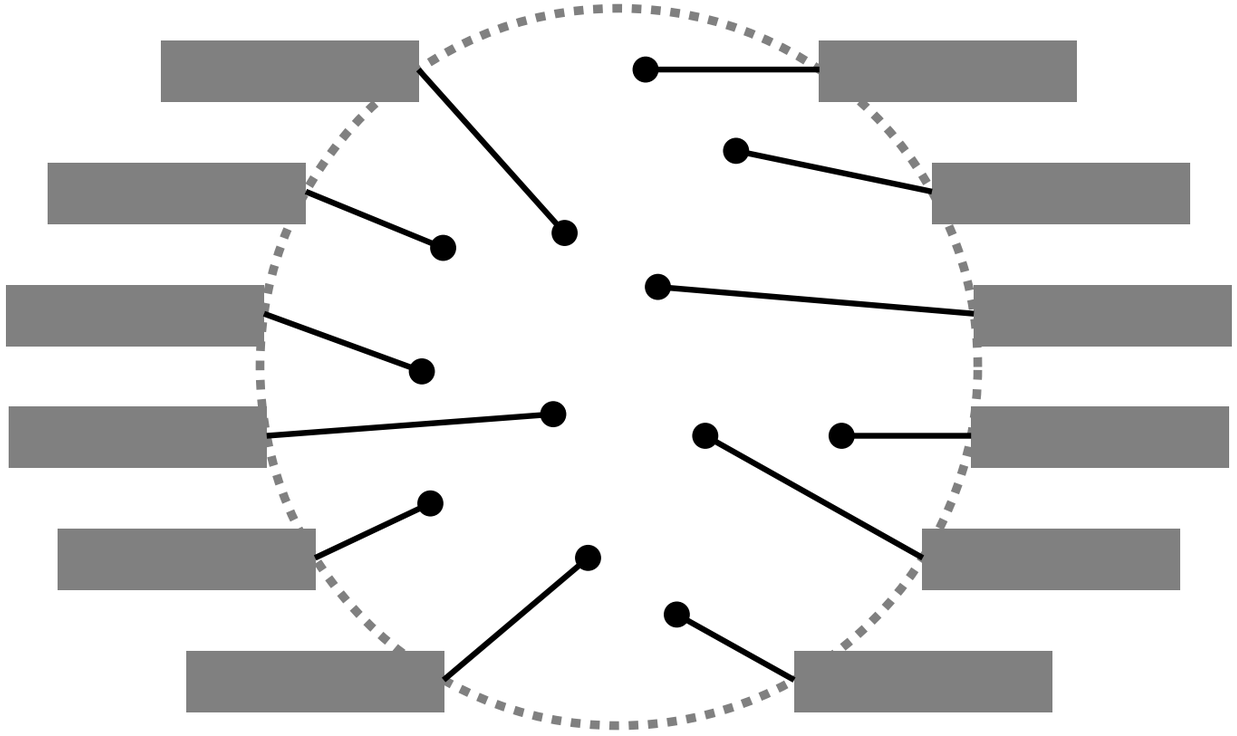
- labels vertically distributed with unit distances

The free leader model



- labels vertically distributed with unit distances
- compute non-crossing leaders

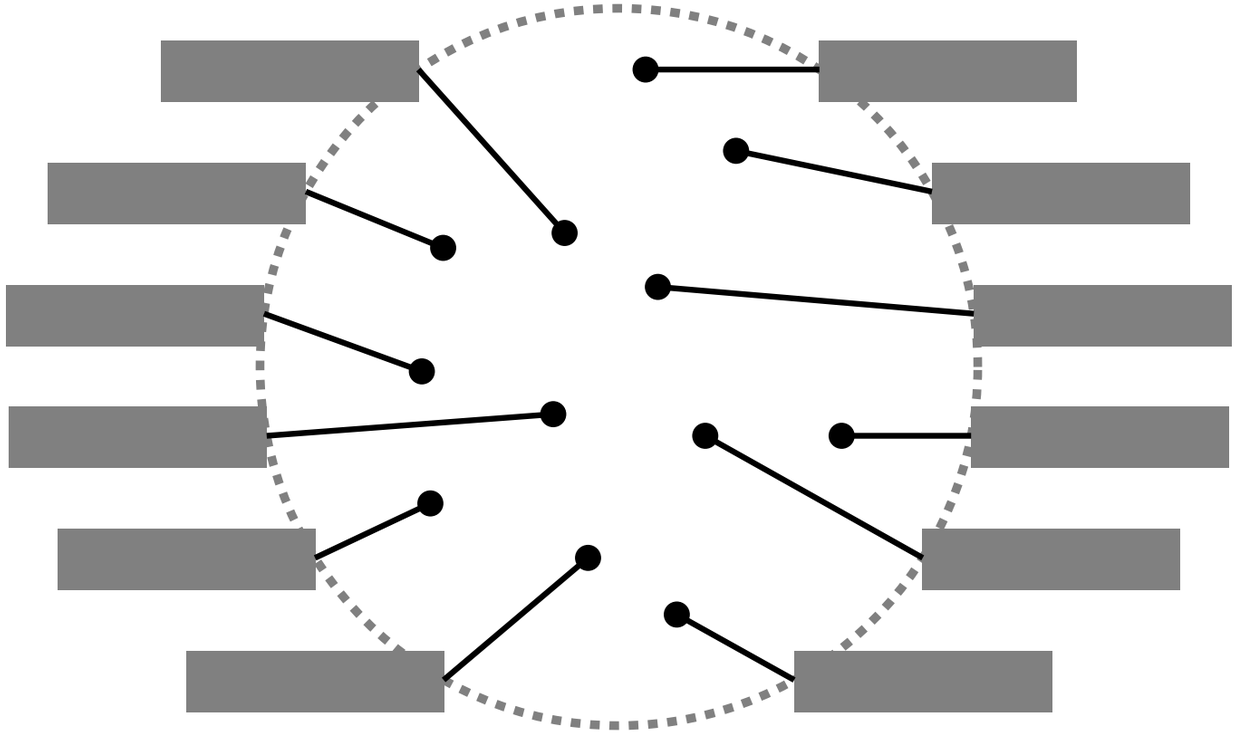
The free leader model



- labels vertically distributed with unit distances
- compute non-crossing leaders
- minimize total leader length: weighted bipartite matching

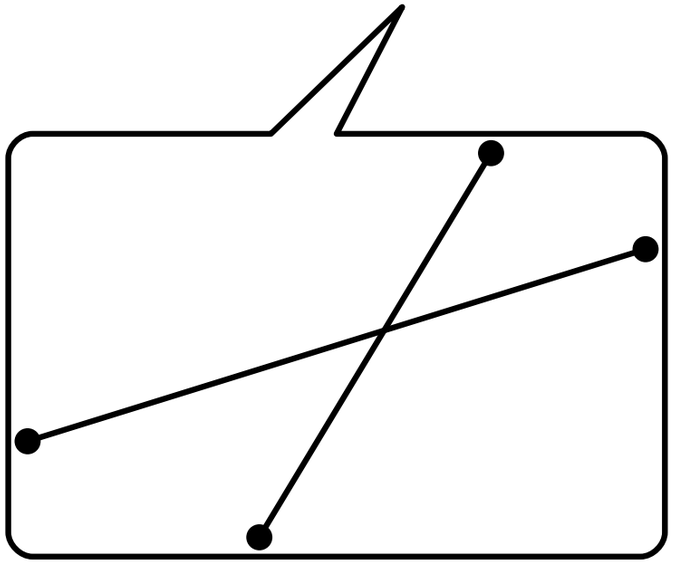
  [Bekos et al., 2007]

The free leader model

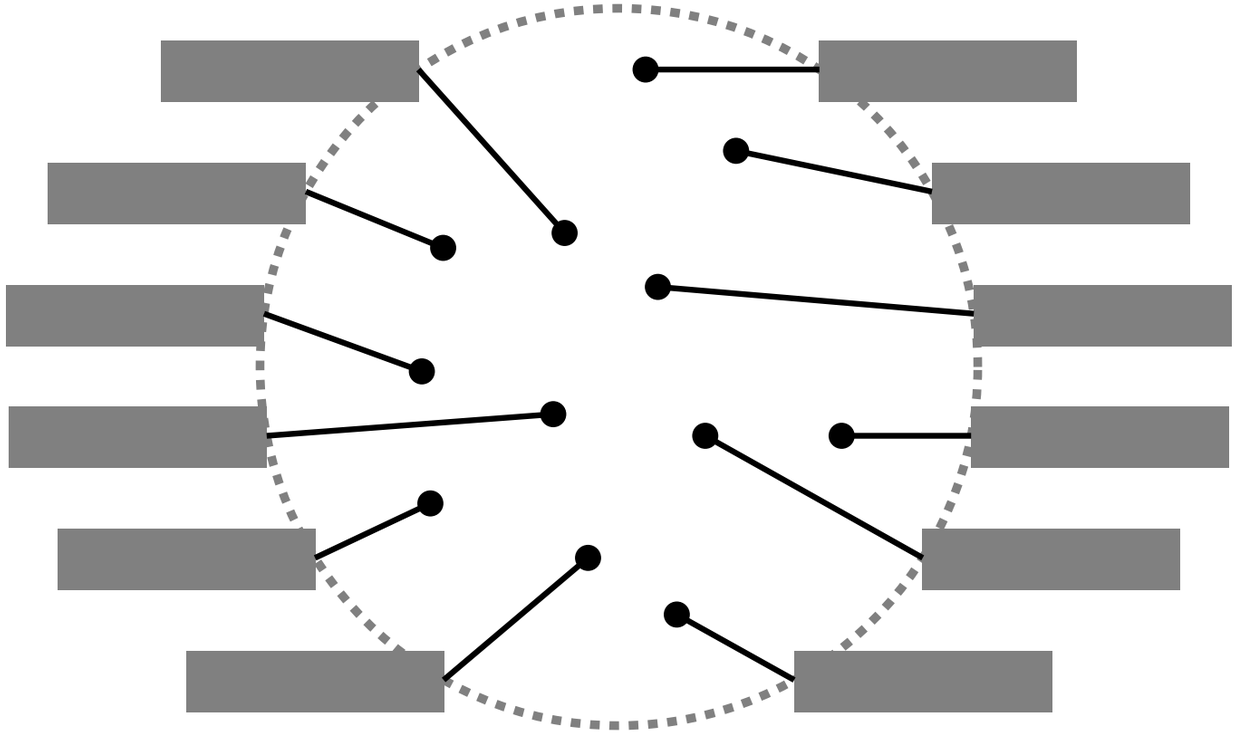


- labels vertically distributed with unit distances
- compute non-crossing leaders
- minimize total leader length: weighted bipartite matching

no crossings ✓

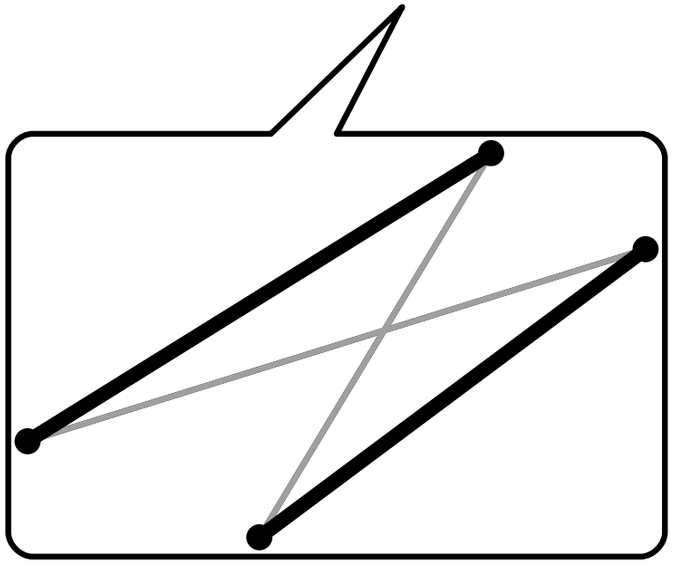


The free leader model

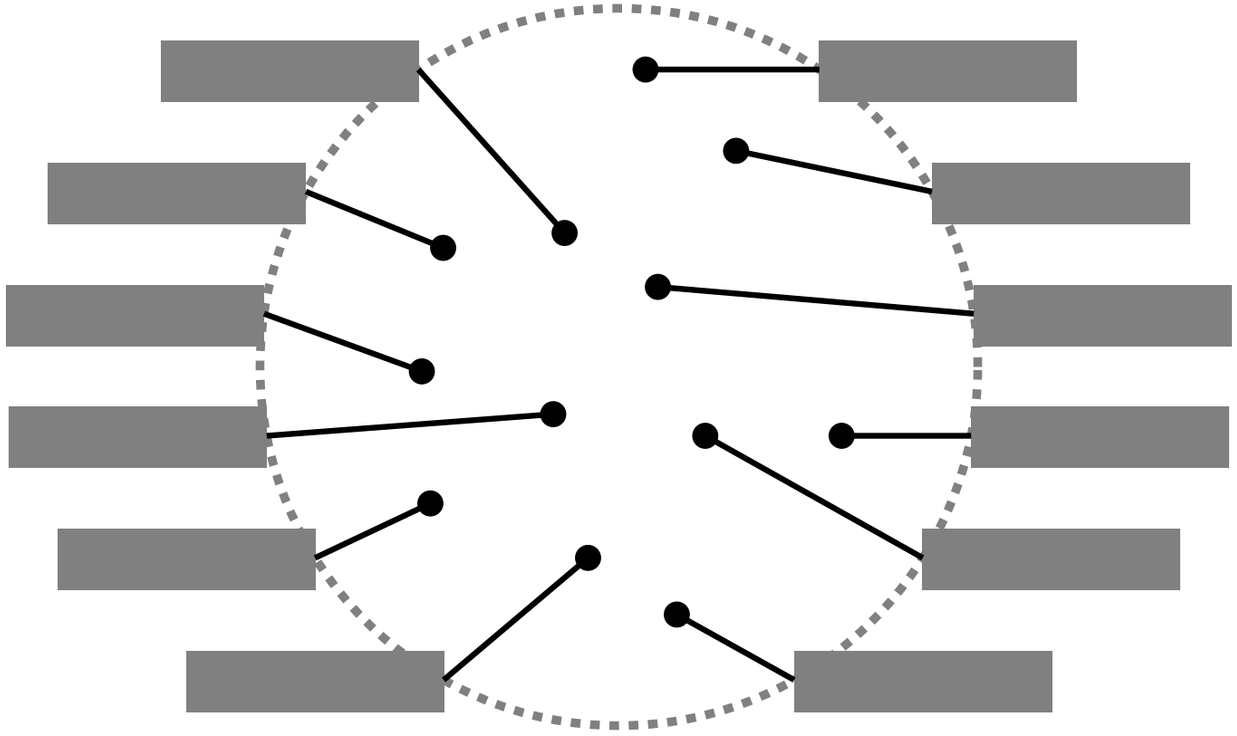


- labels vertically distributed with unit distances
- compute non-crossing leaders
- minimize total leader length: weighted bipartite matching

no crossings ✓



The free leader model

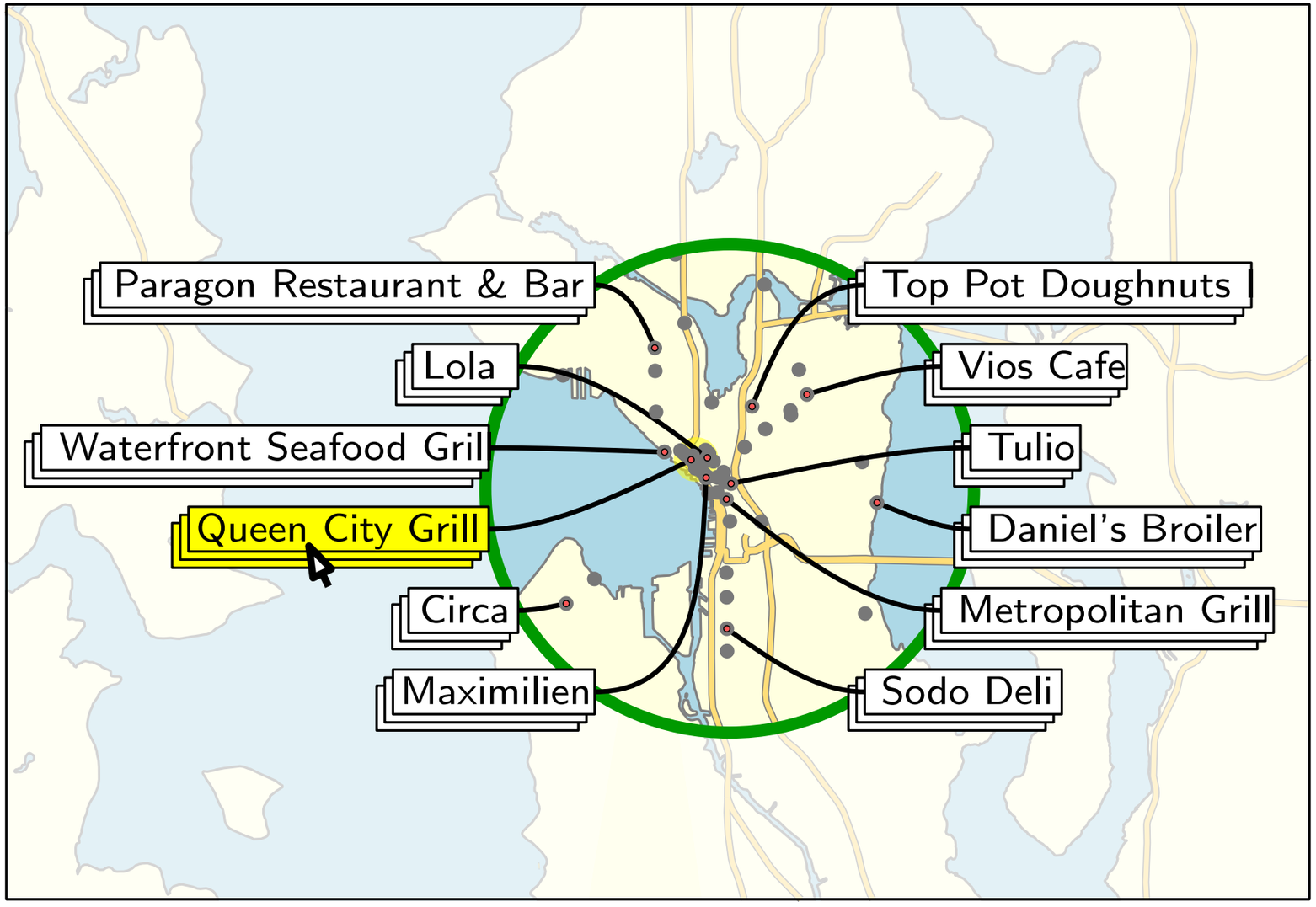


- labels vertically distributed with unit distances
- compute non-crossing leaders
- minimize total leader length: weighted bipartite matching

no crossings ✓

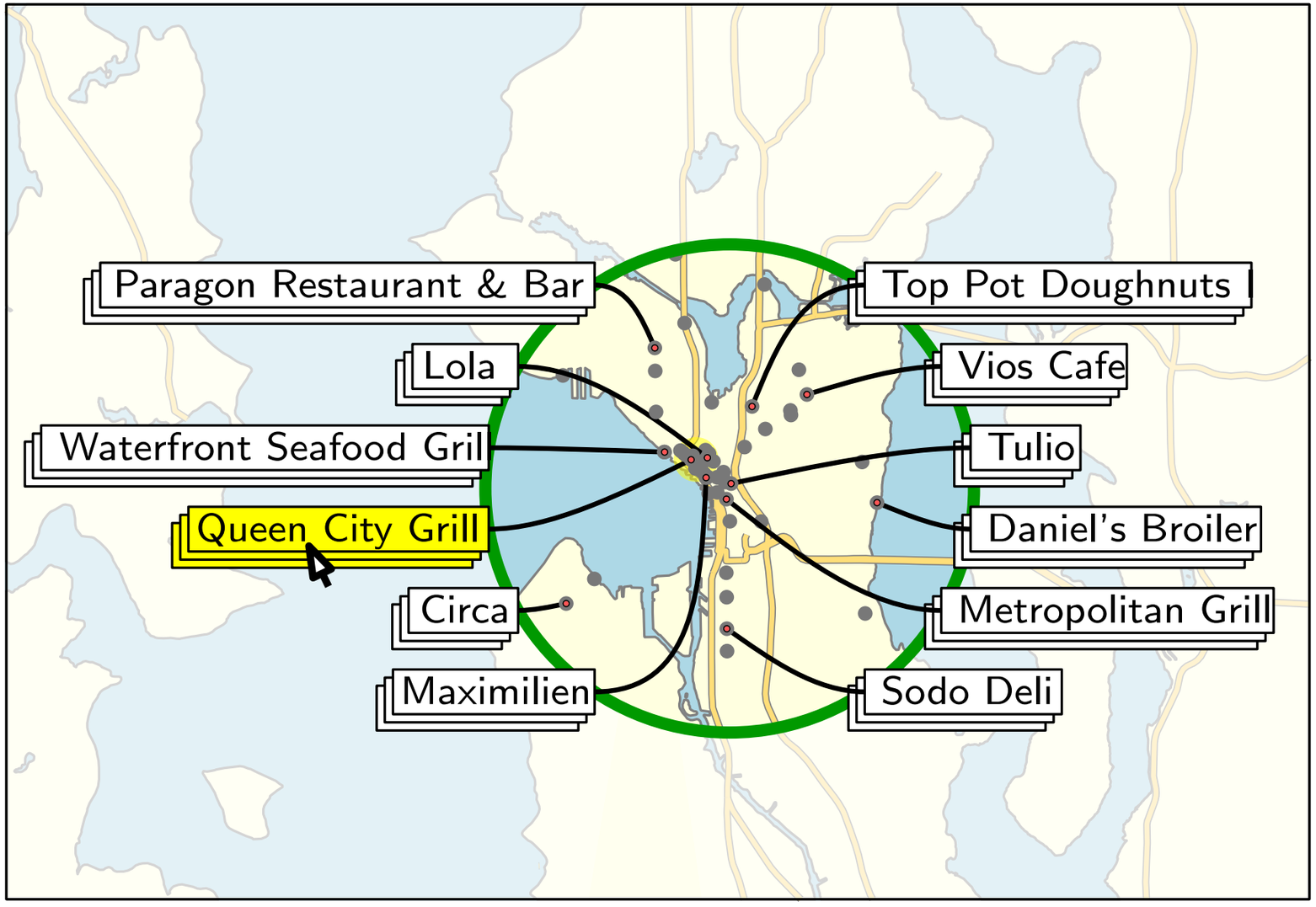
fast ✓ $O(n^{2+\varepsilon})$

Selecting labeled sites



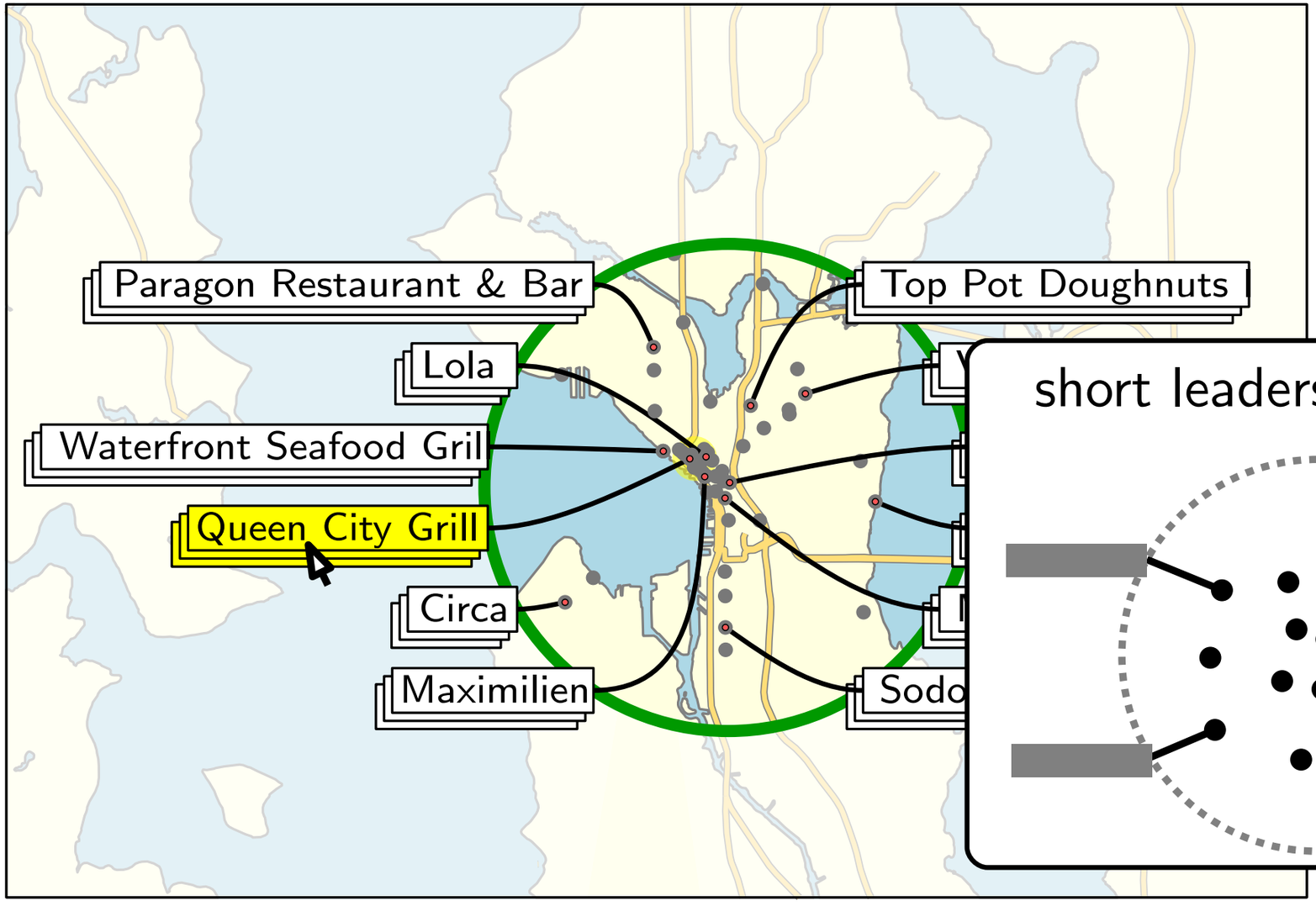
- not all sites can be labeled

Selecting labeled sites



- not all sites can be labeled
- label good subset

Selecting labeled sites



- not all sites can be labeled
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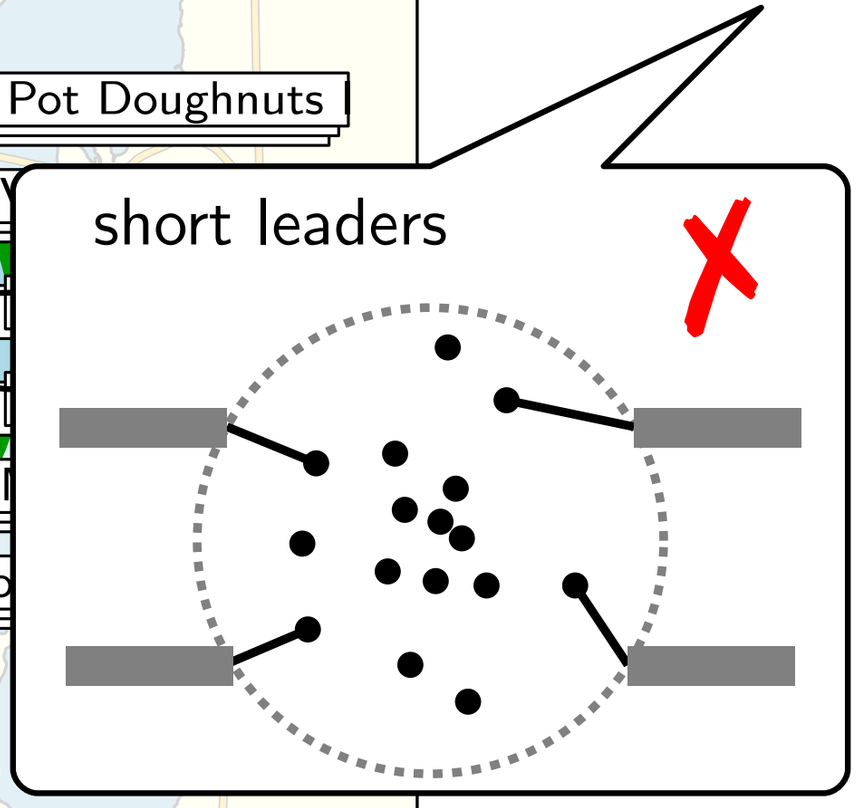
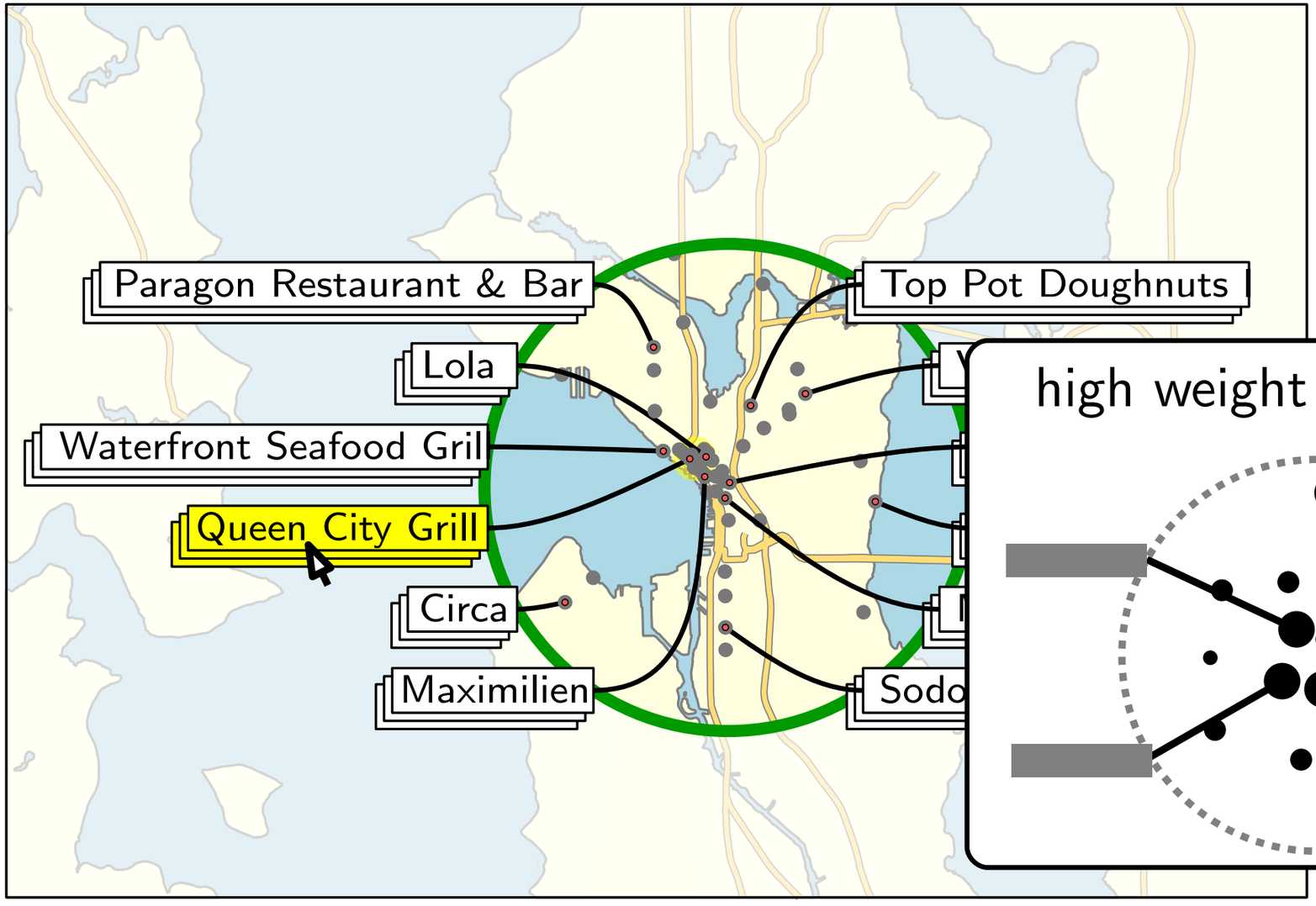
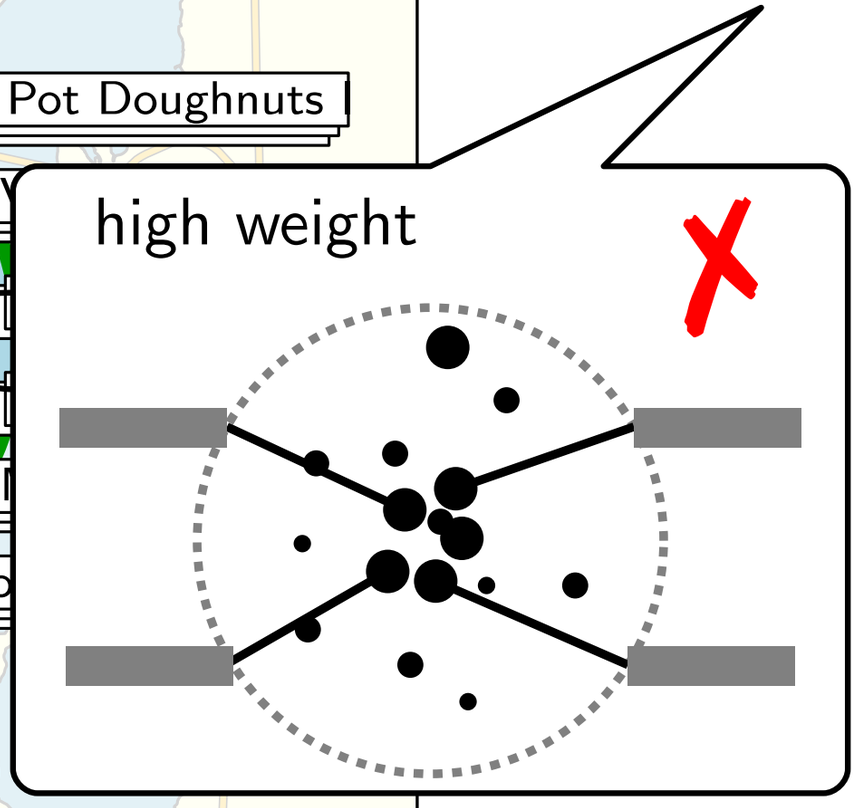


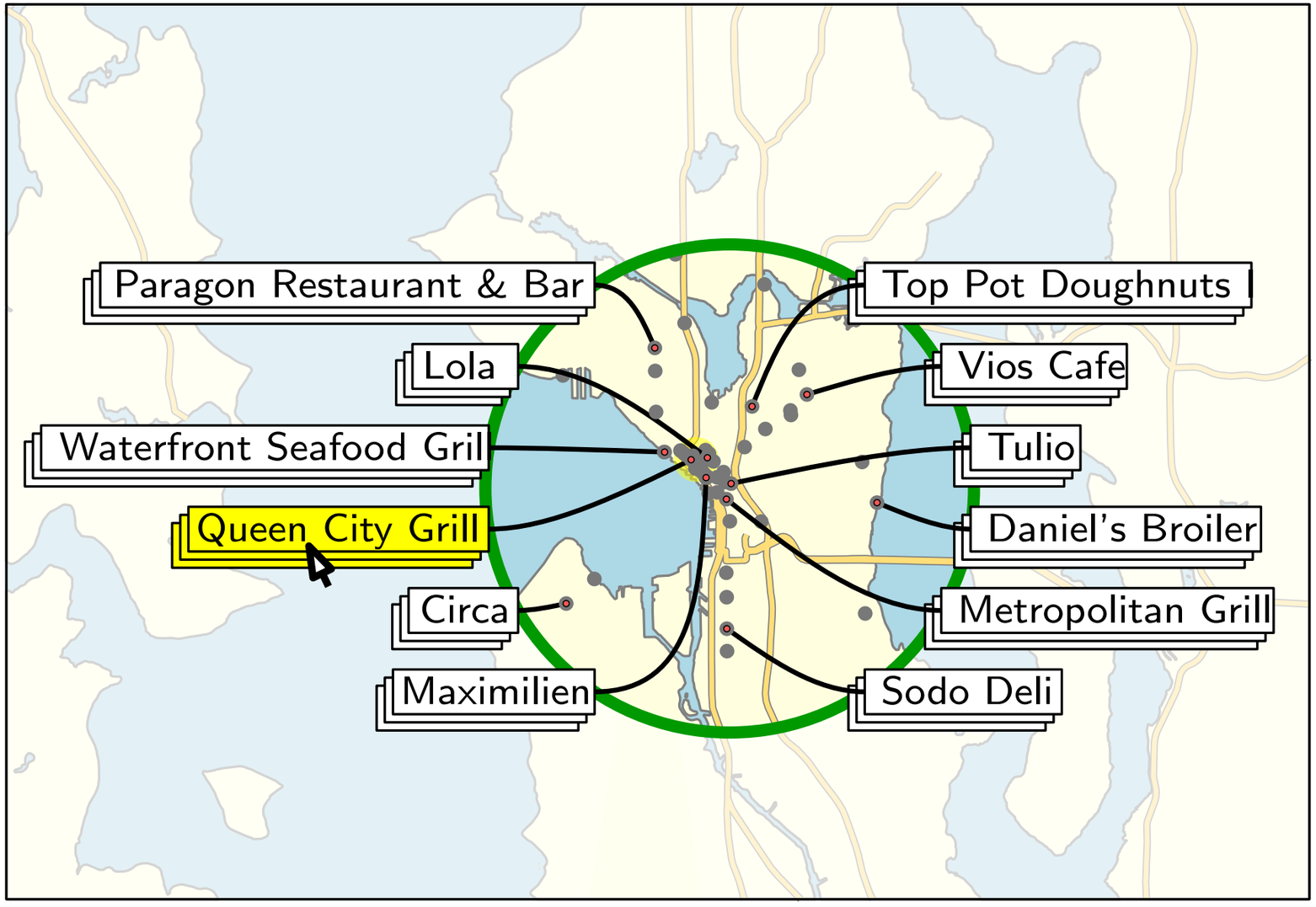
Selecting labeled sites



- not all sites can be labeled
- label good subset

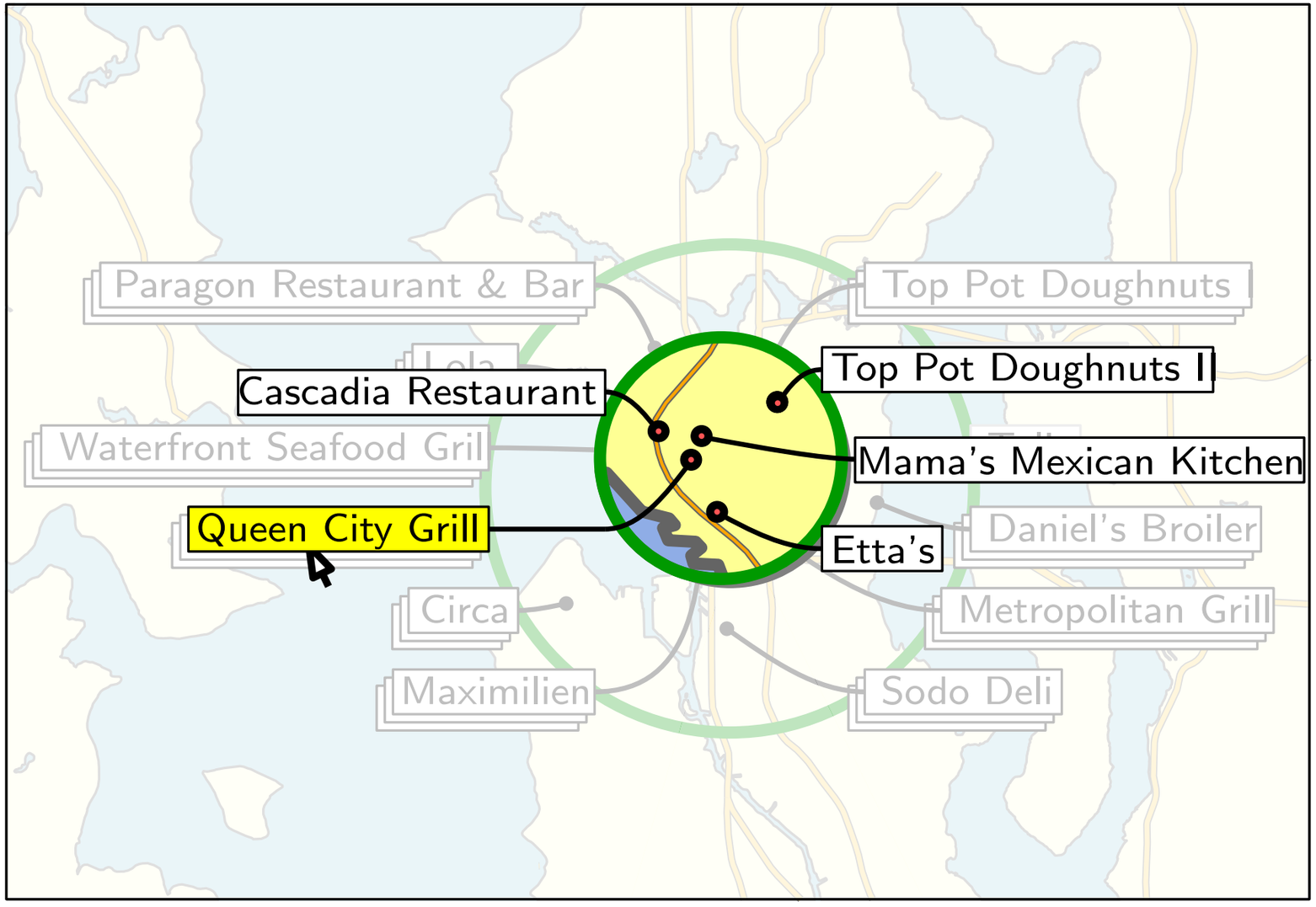


Selecting labeled sites



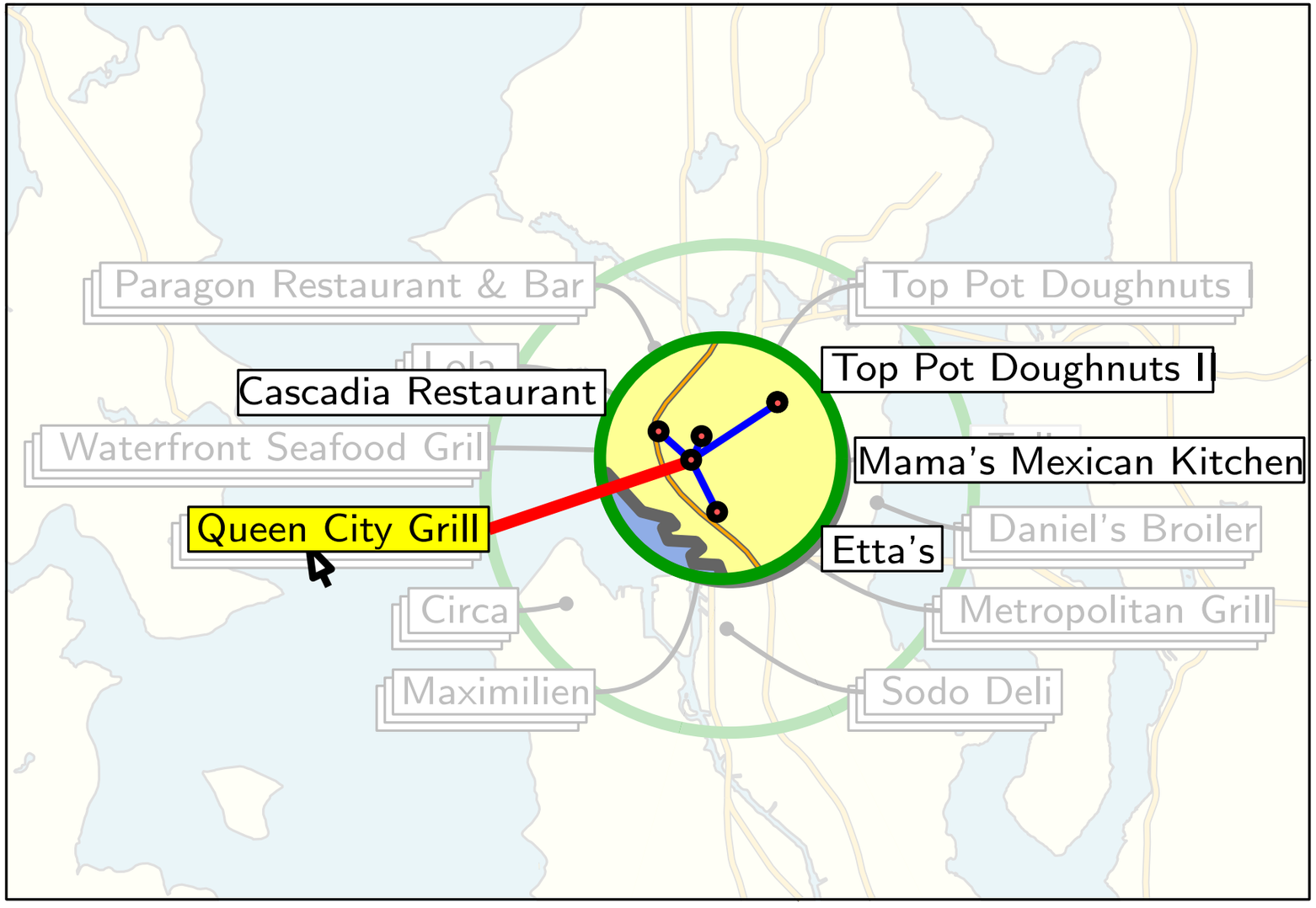
- not all sites can be labeled
- label good subset
  - nice distribution
  - represent all sites

Clustered Labeling



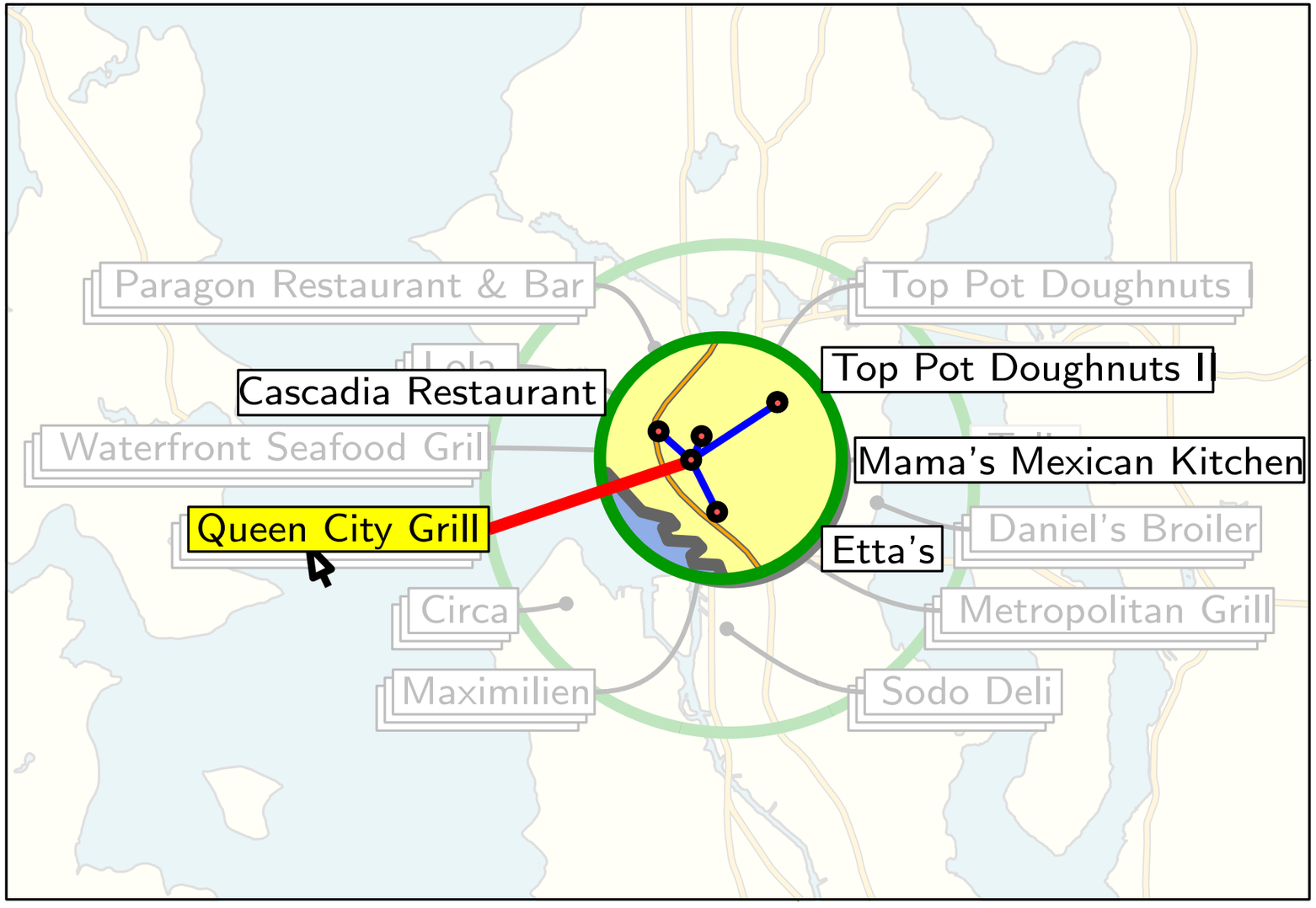
- 1 labeled site
  → k unlabeled sites

Clustered Labeling



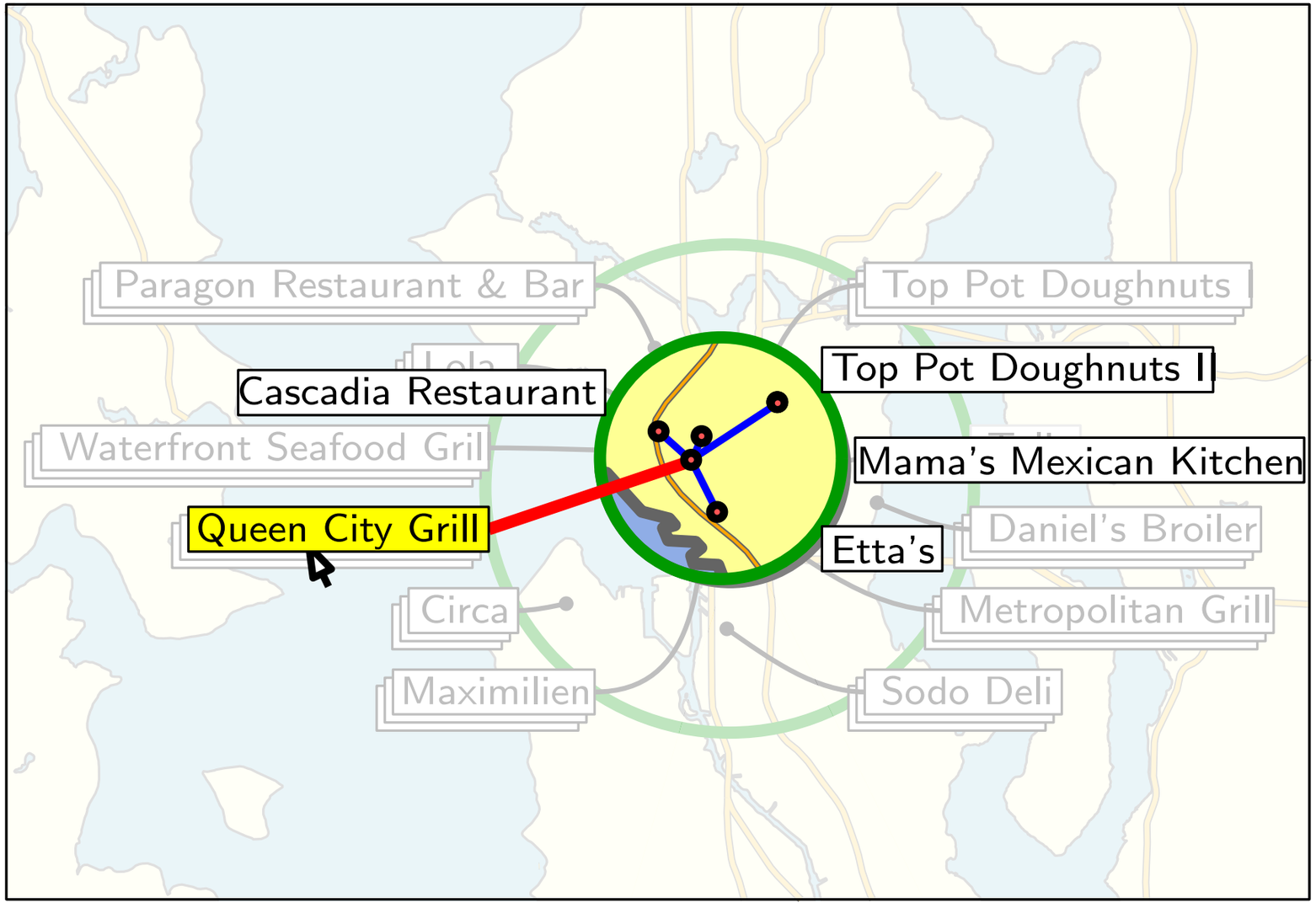
- 1 labeled site
  → k unlabeled sites
- minimize leader length + distance to attached sites

Clustered Labeling



- 1 labeled site
  → k unlabeled sites
- minimize leader length + distance to attached sites
- Facility Location model: solved by ILP

Clustered Labeling



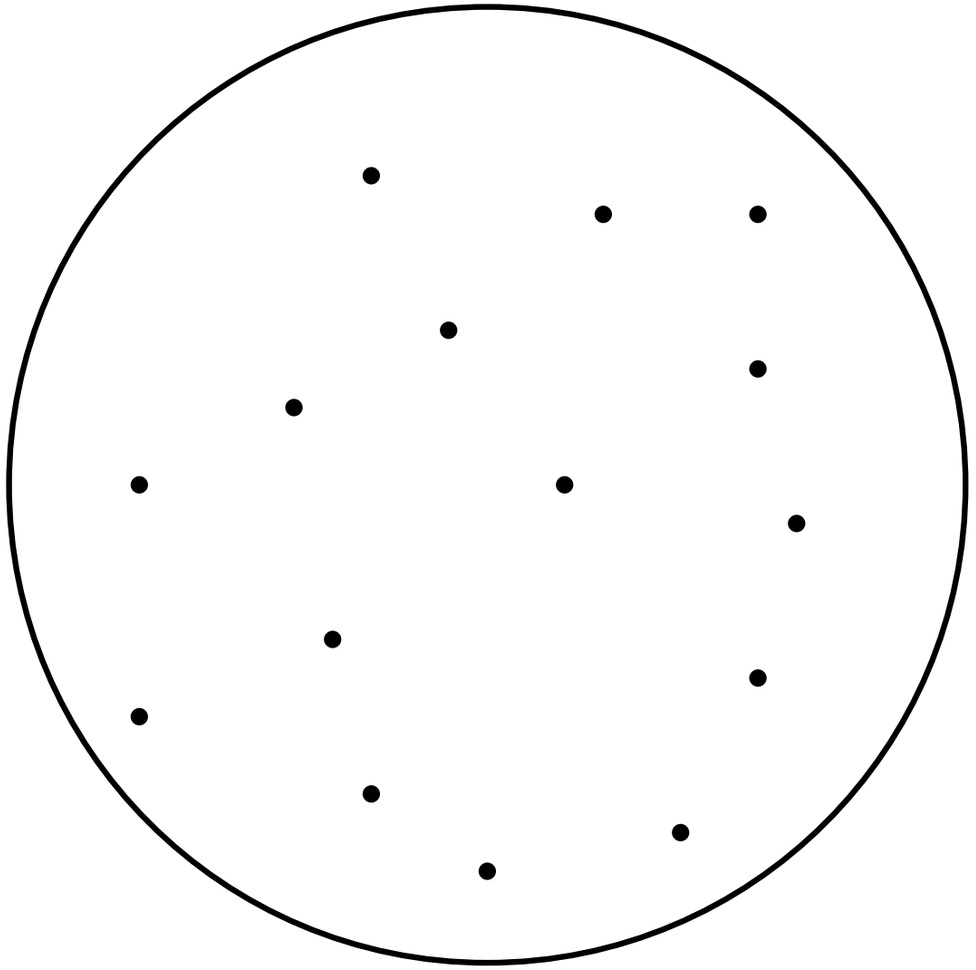
- 1 labeled site
  → k unlabeled sites
- minimize leader length + distance to attached sites
- Facility Location model: solved by ILP

  95 sites, 20 labels:
  124s

A Heuristic for Clustered Labeling

- Randomized initialization heuristic for k-median/k-means [Arthur and Vassilvitski, 2007]

A Heuristic for Clustered Labeling



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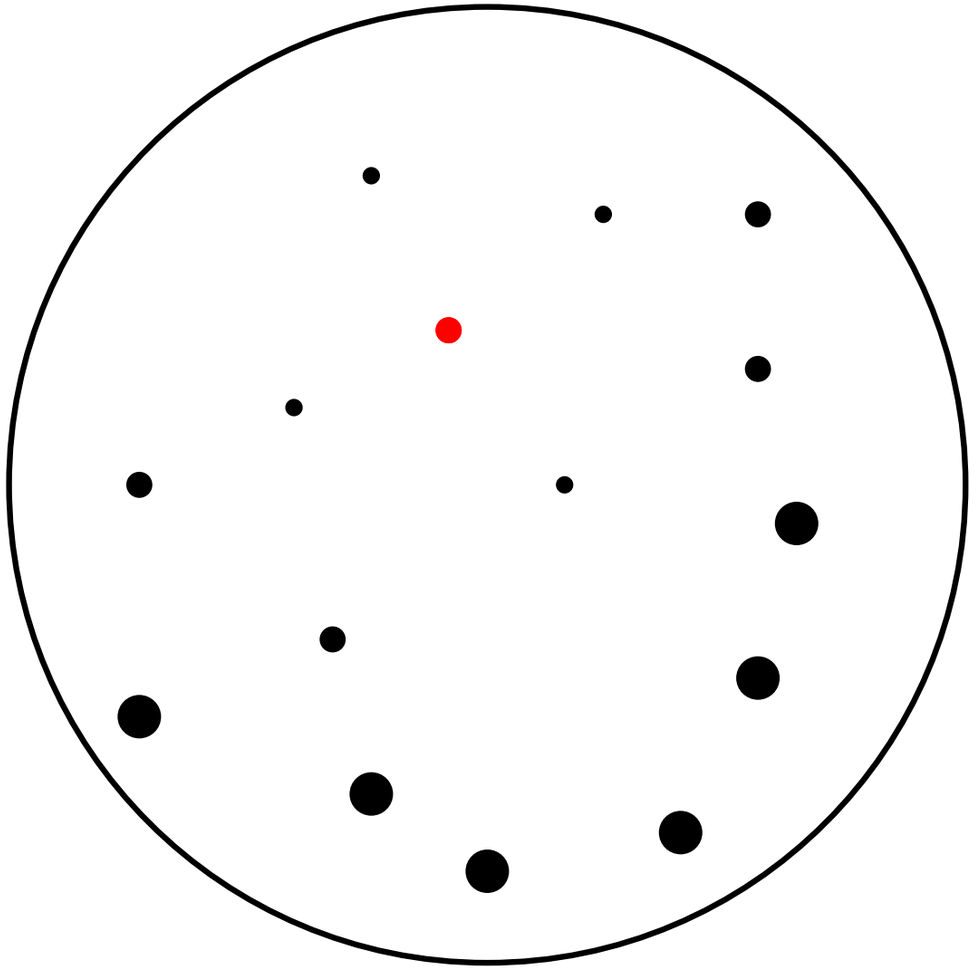

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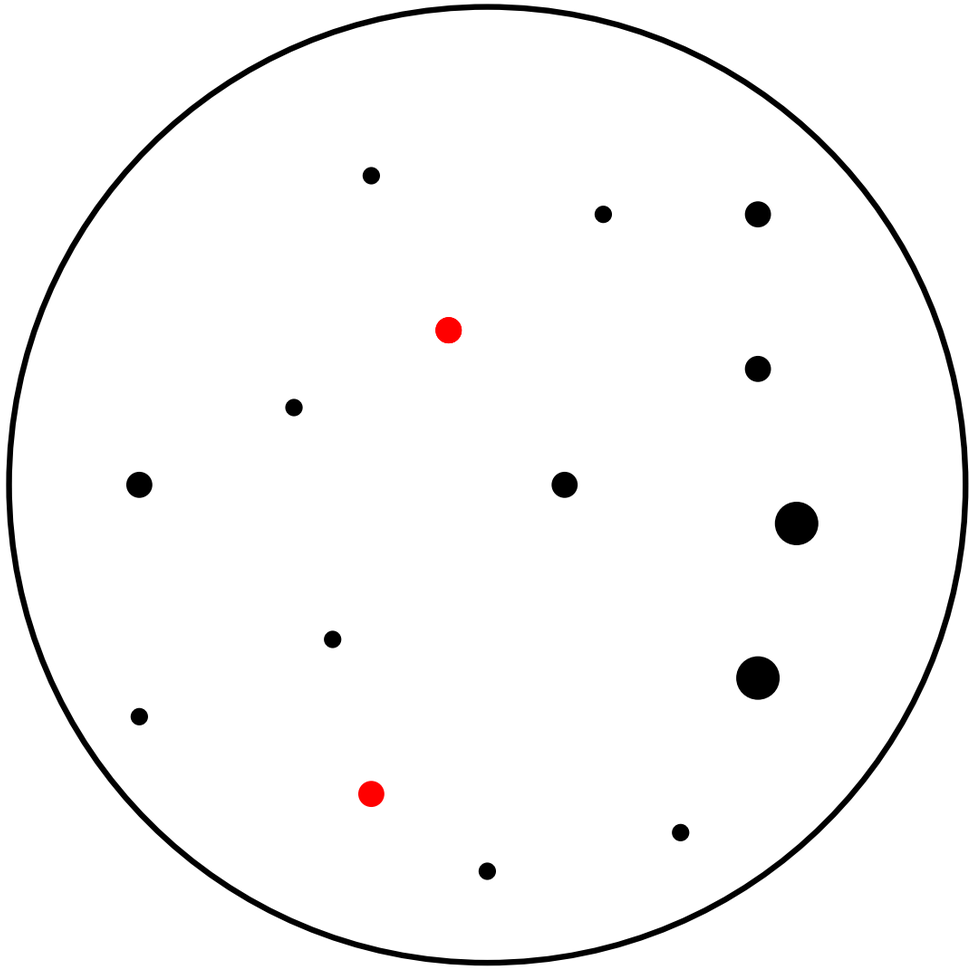

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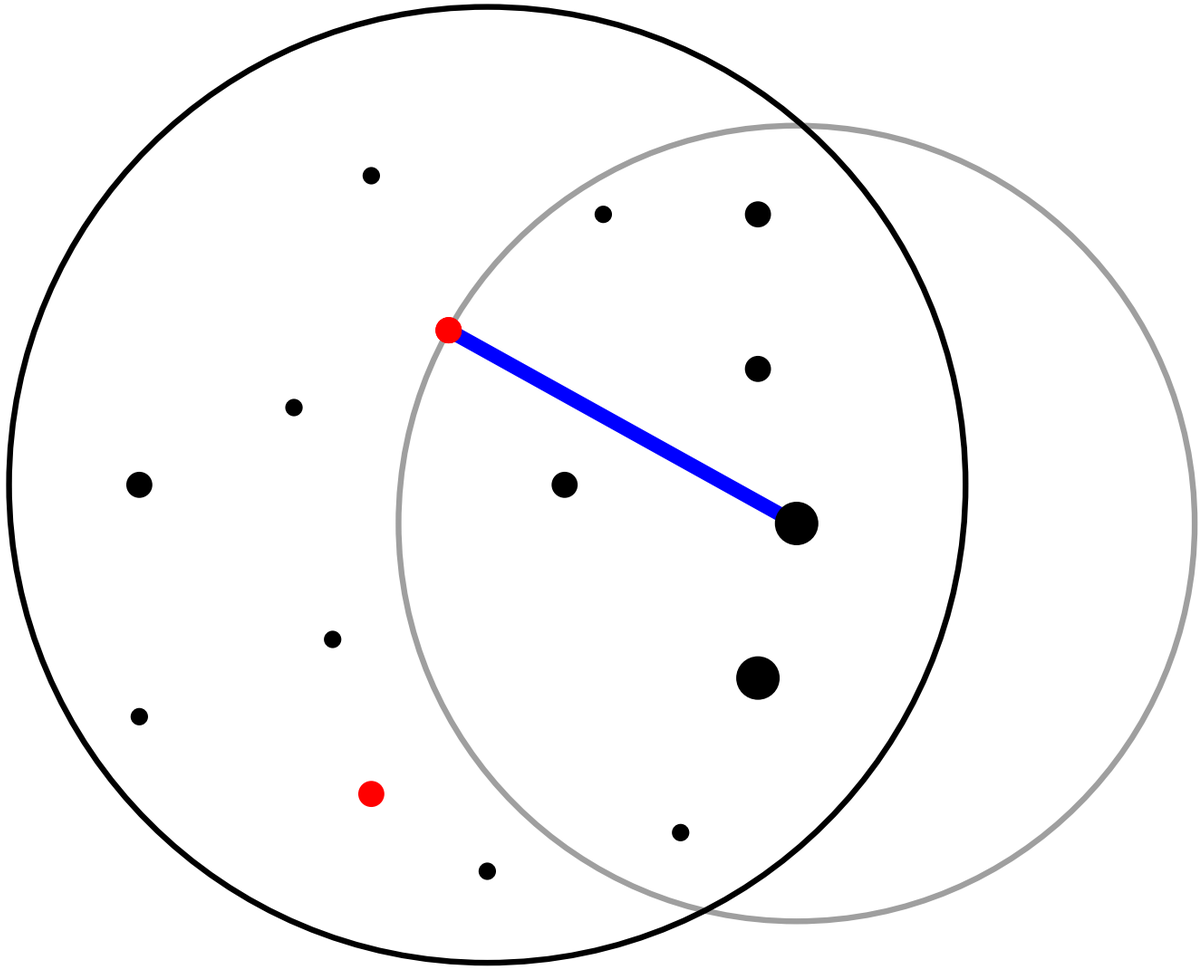

- Randomized initialization heuristic for k-median/k-means [Arthur and Vassilvitski, 2007]
- probability $\approx distance^d$

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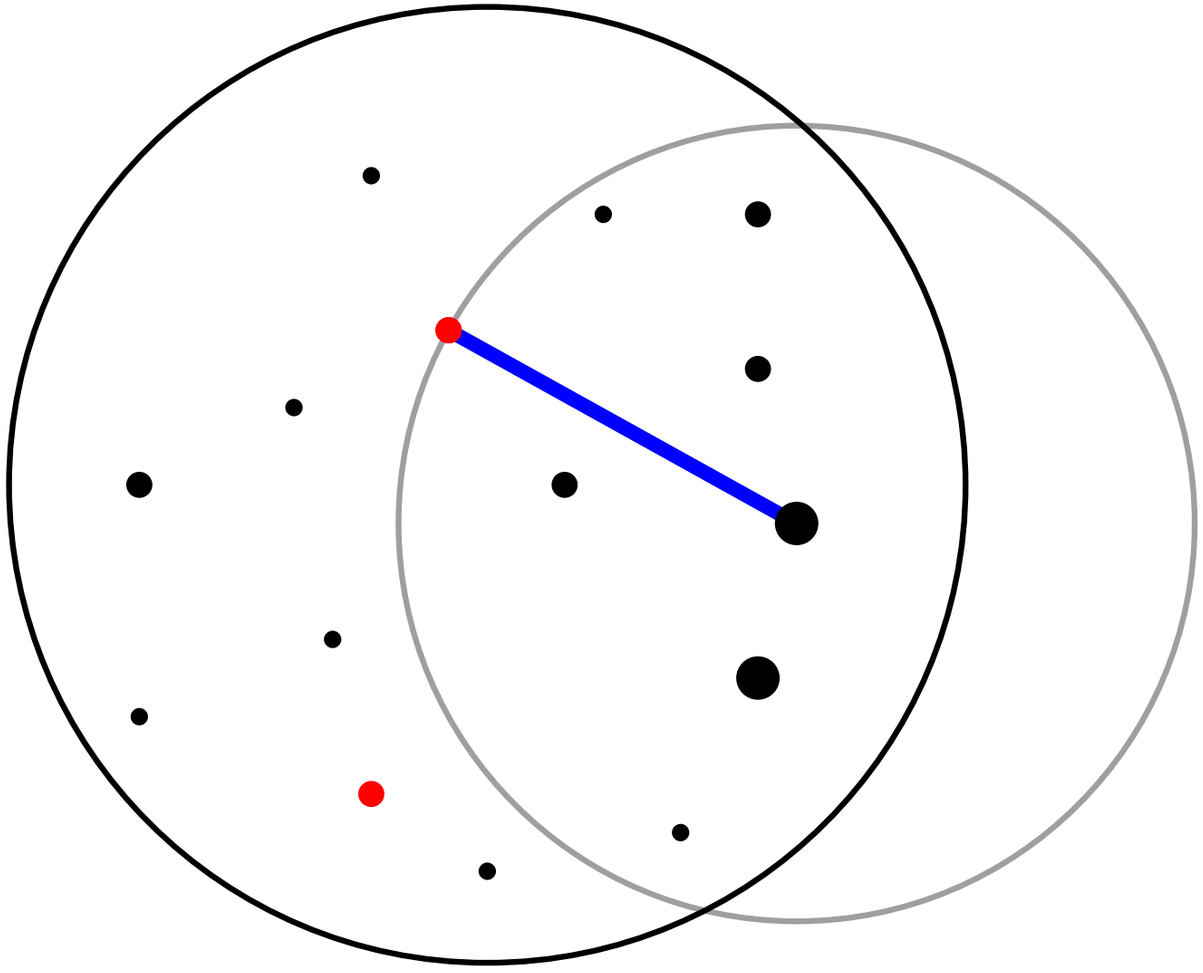

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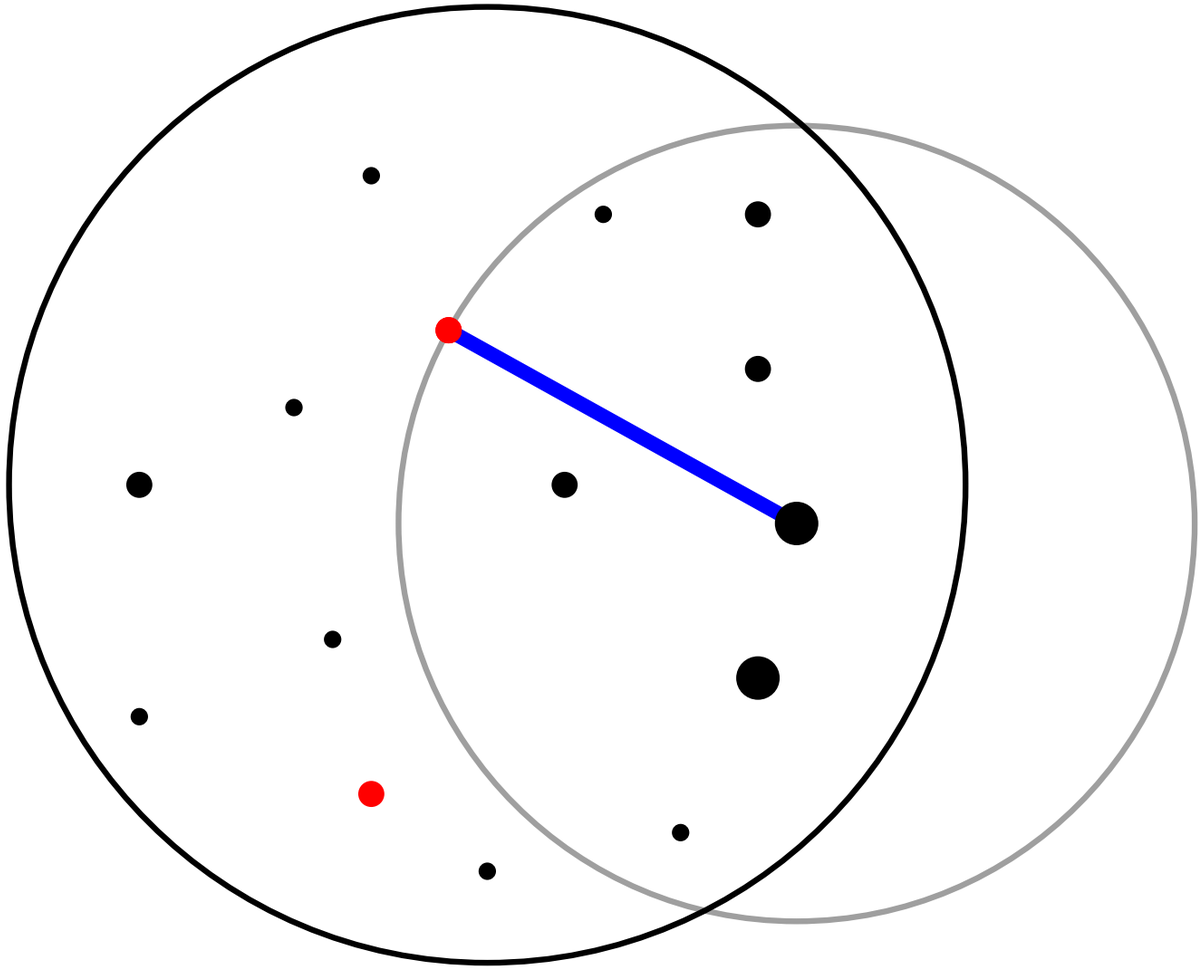
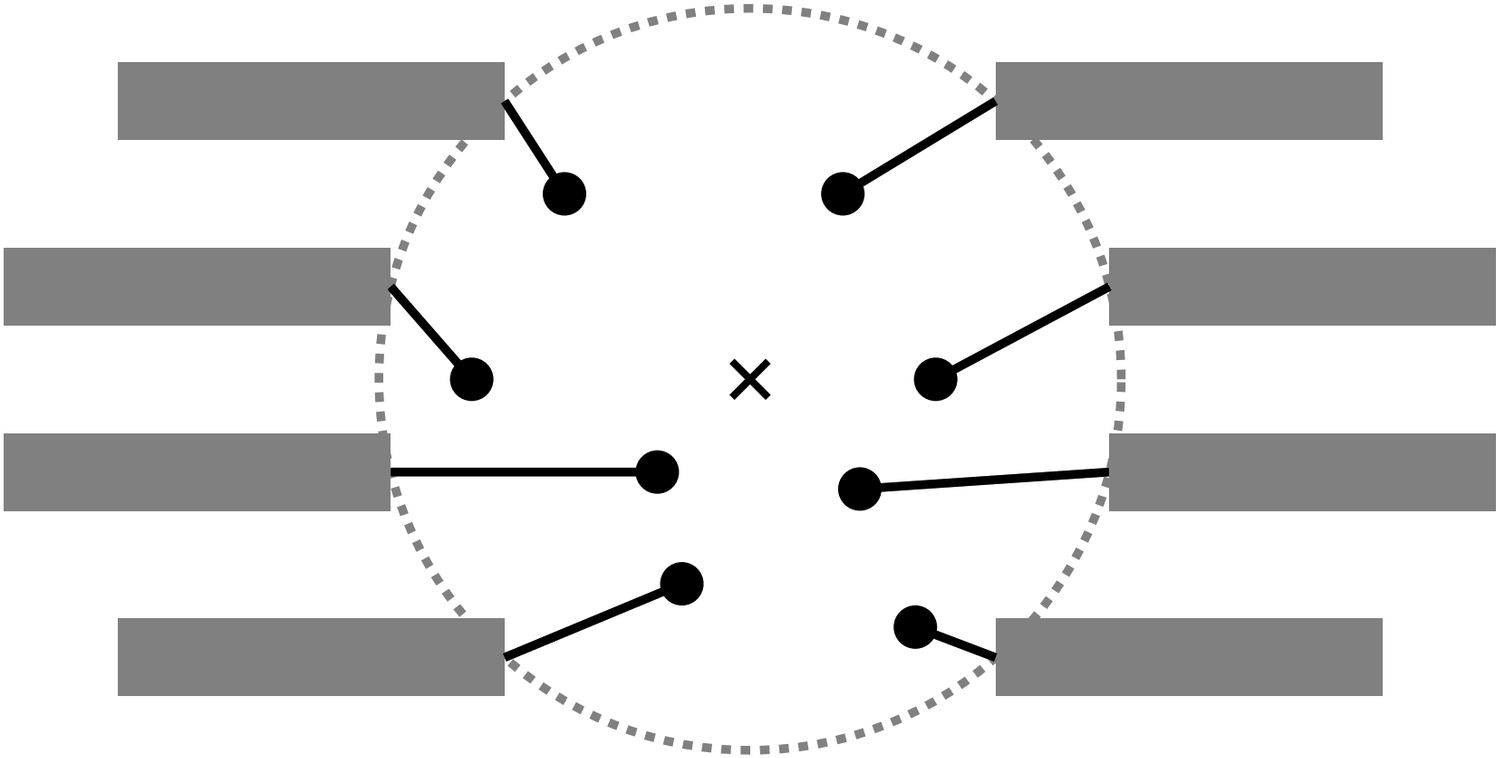


- Randomized initialization heuristic for k-median/k-means [Arthur and Vassilvitski, 2007]
- probability $\approx distance^d$
- Clustering: assign to closest labeled site

  – much better than uniform random selection
  – fast

Bézier Curves as Leaders



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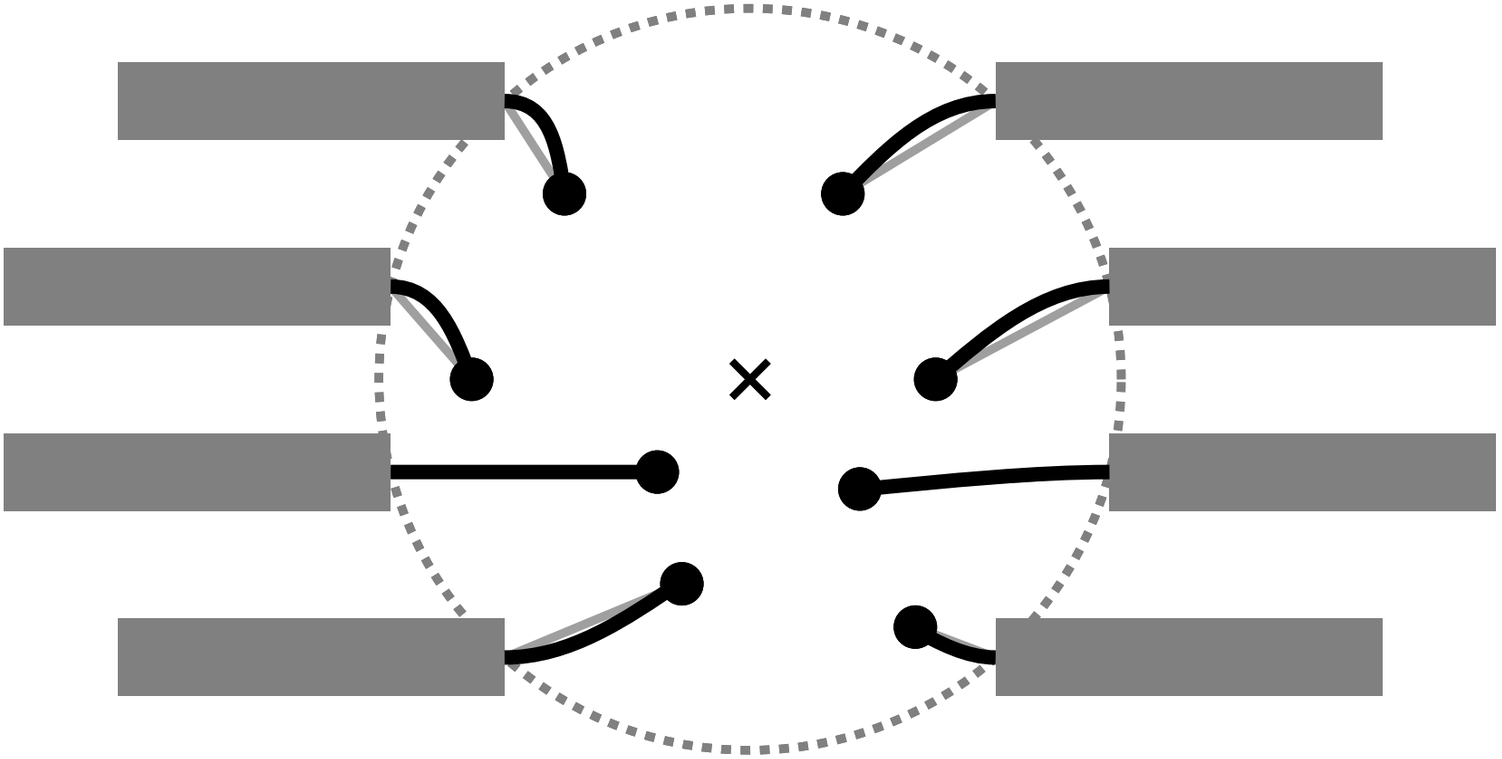

- post-processing:

Bézier Curves as Leaders

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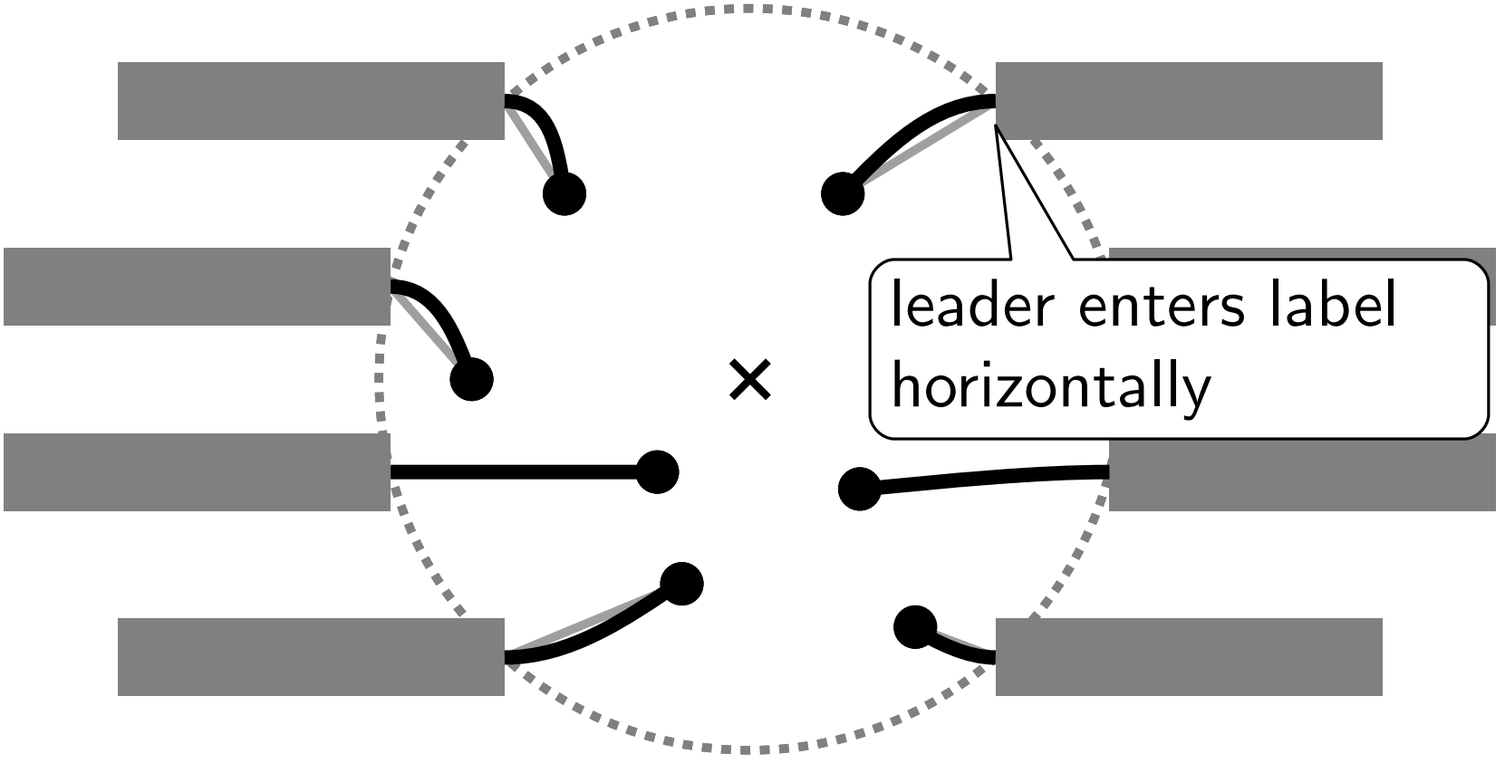

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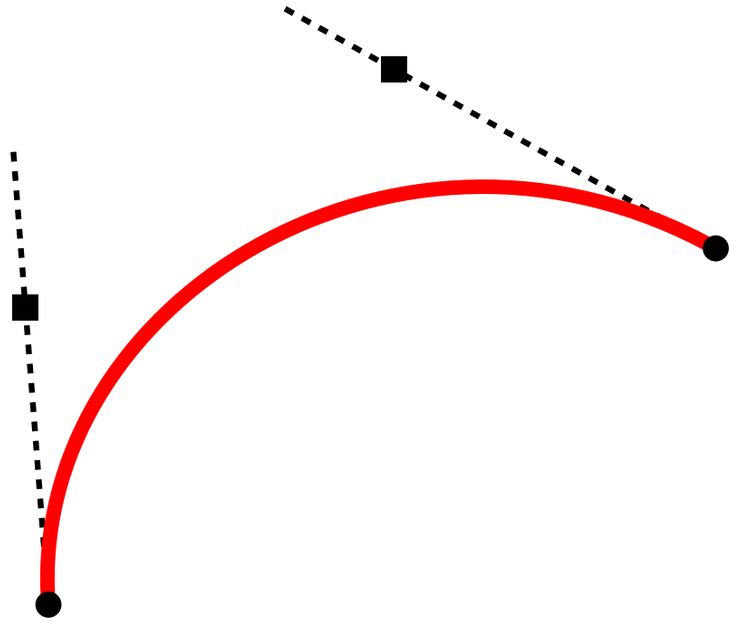
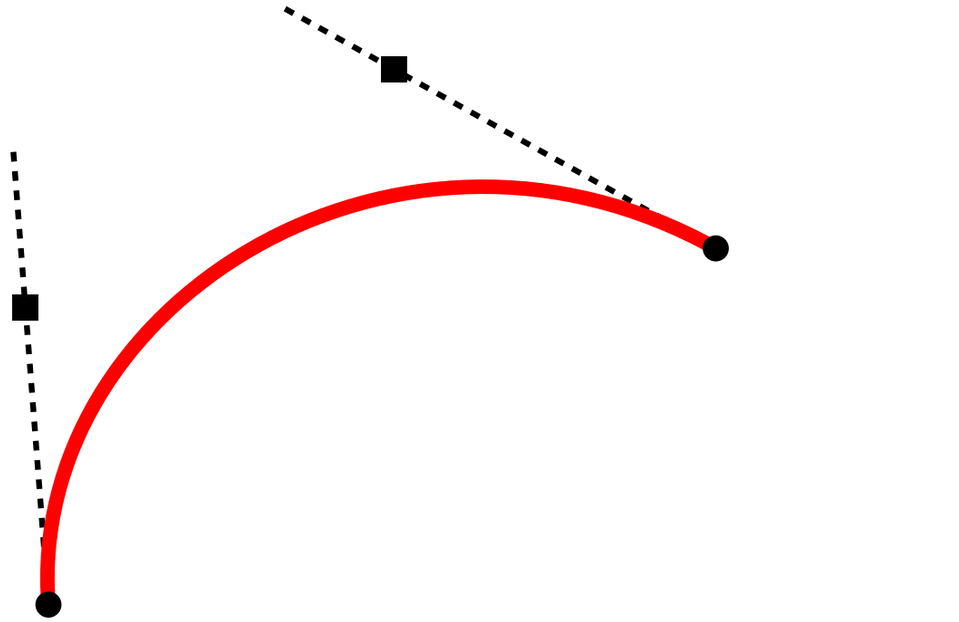
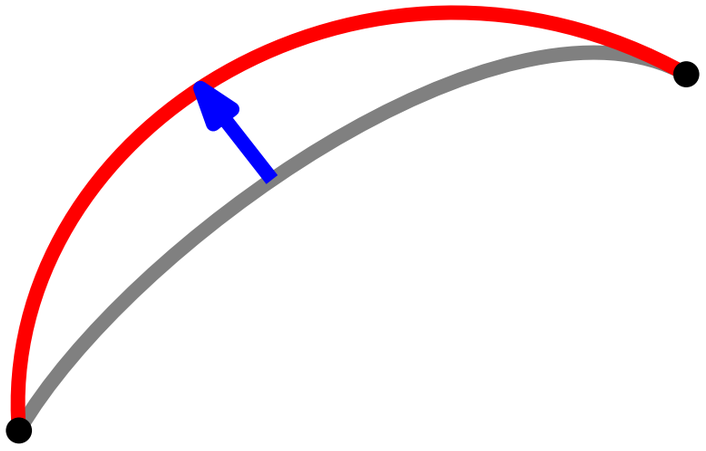


- post-processing:
  - (cubic) Bézier curves

Bézier Curves as Leaders





- post-processing:
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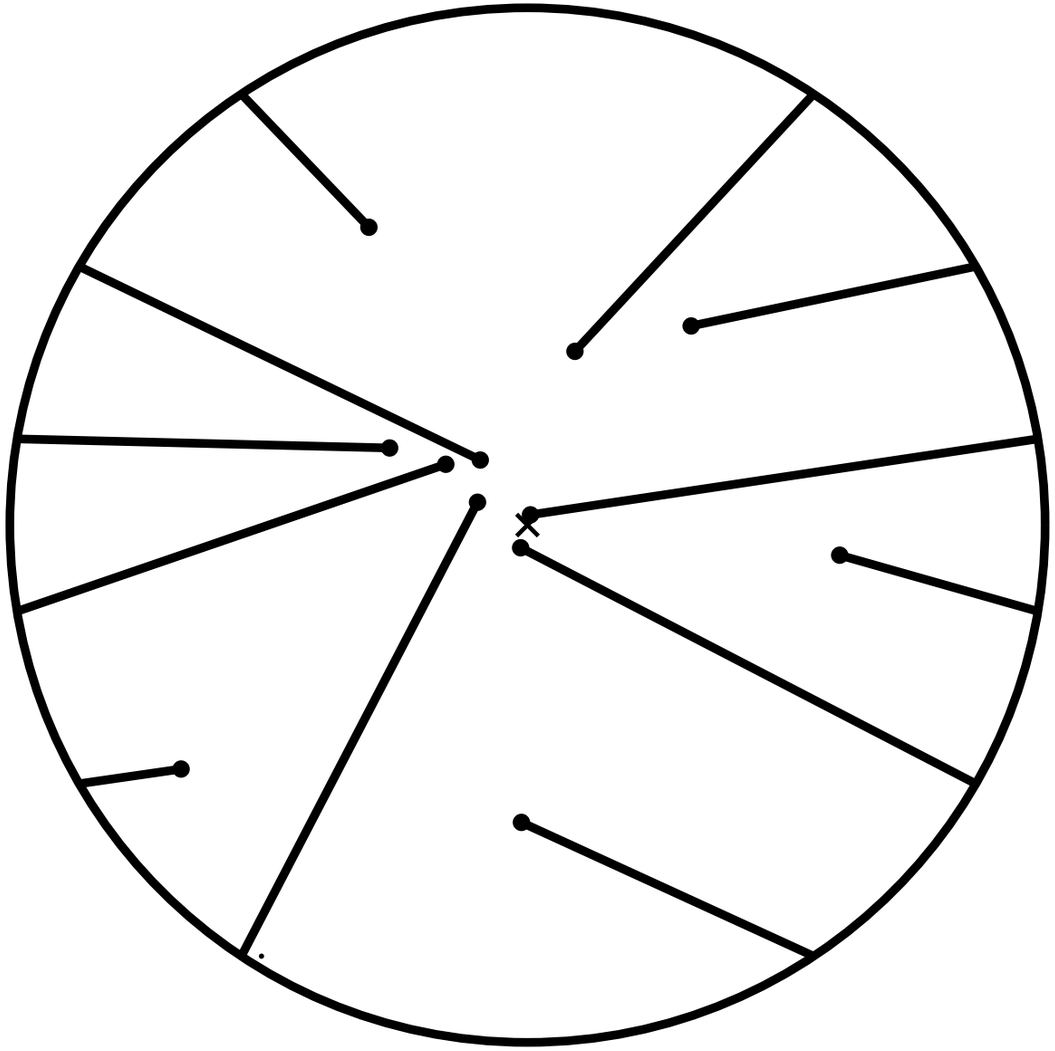
  - force-directed approach

Bézier Curves as Leaders



- post-processing:
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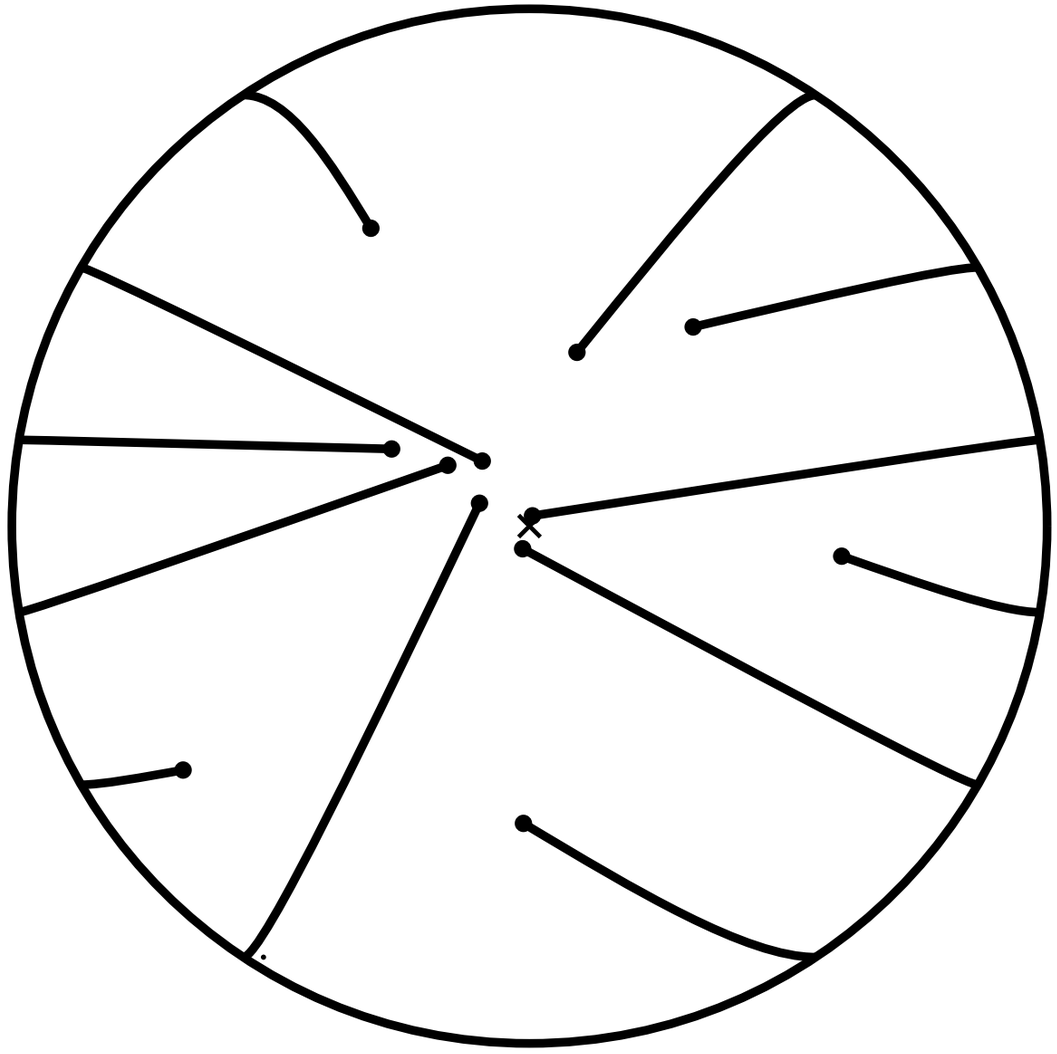
- gradually improve drawing according to desired changes (*forces*)

Bézier Curves as Leaders



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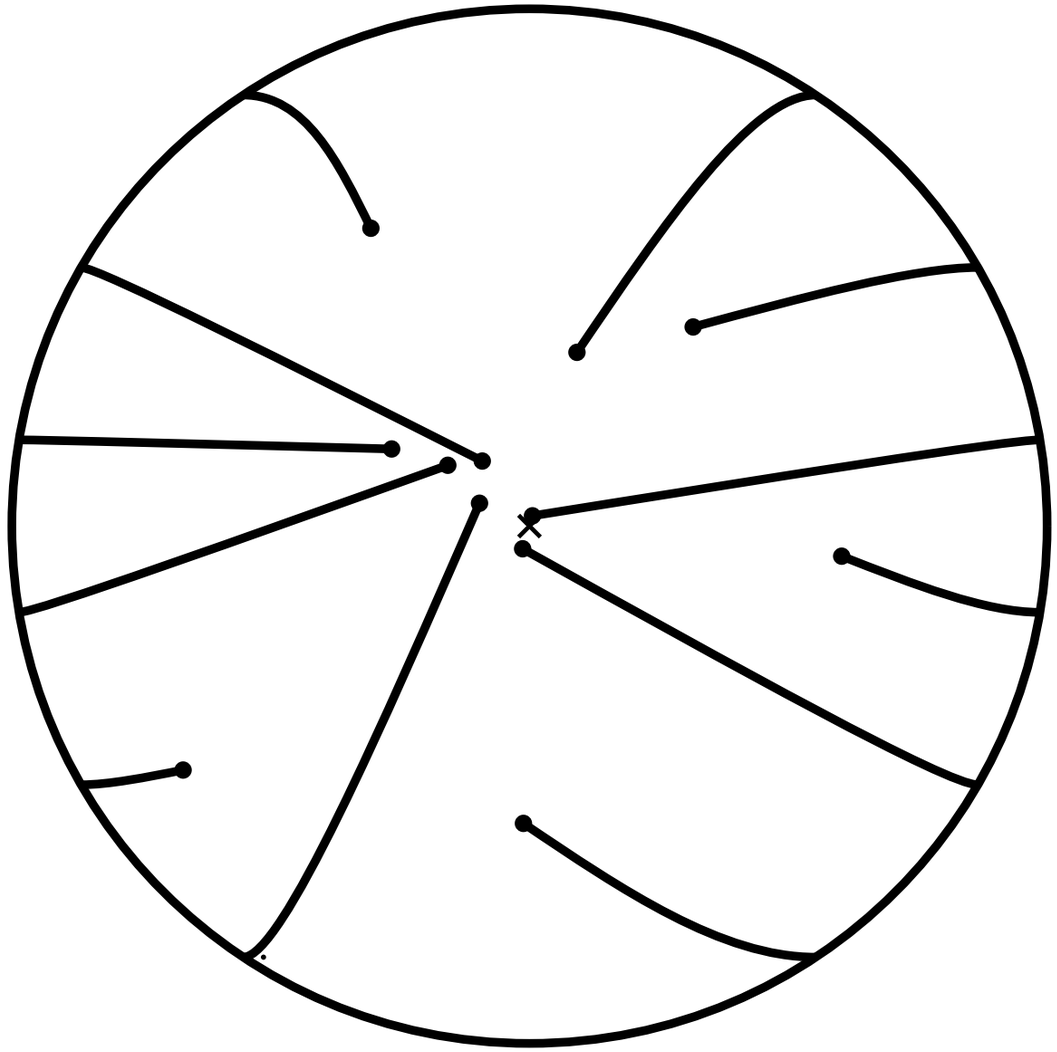

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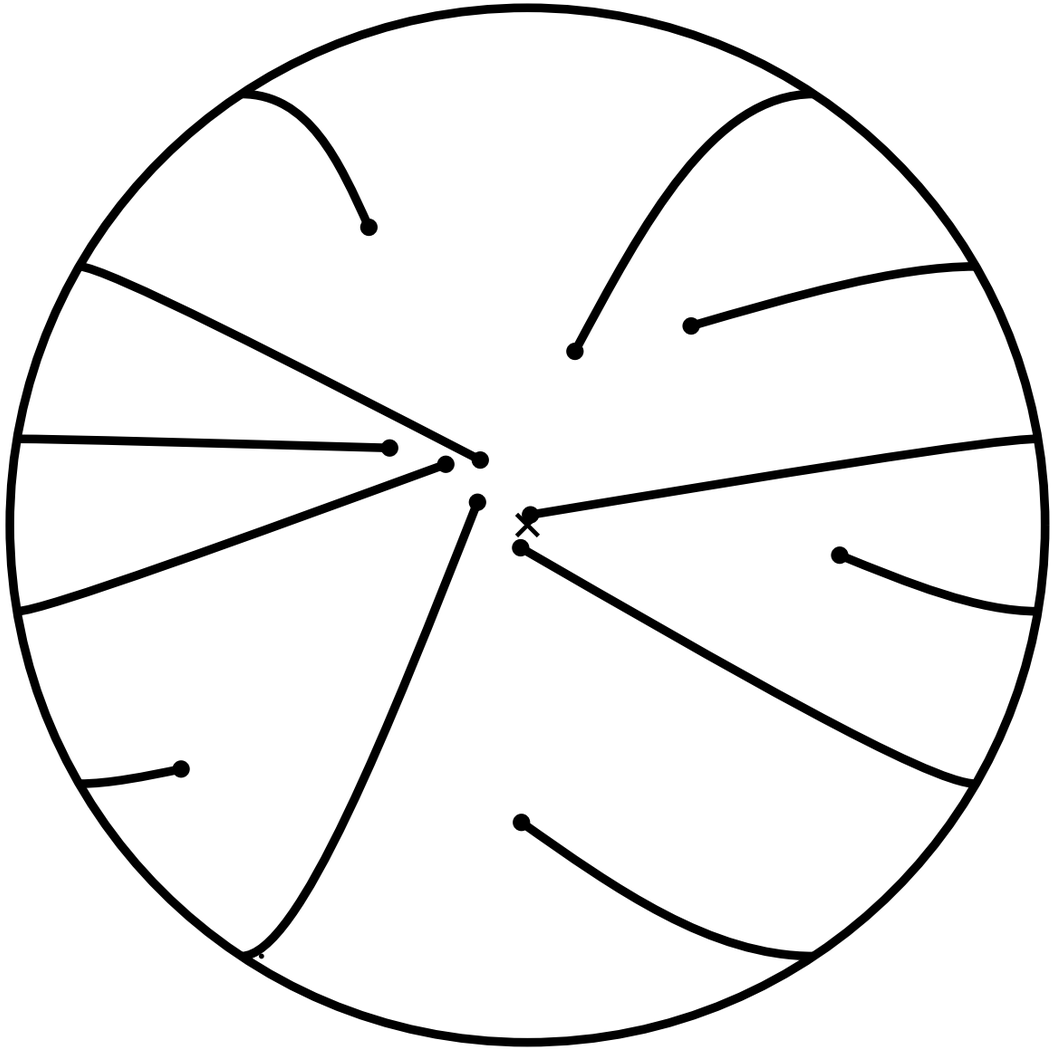

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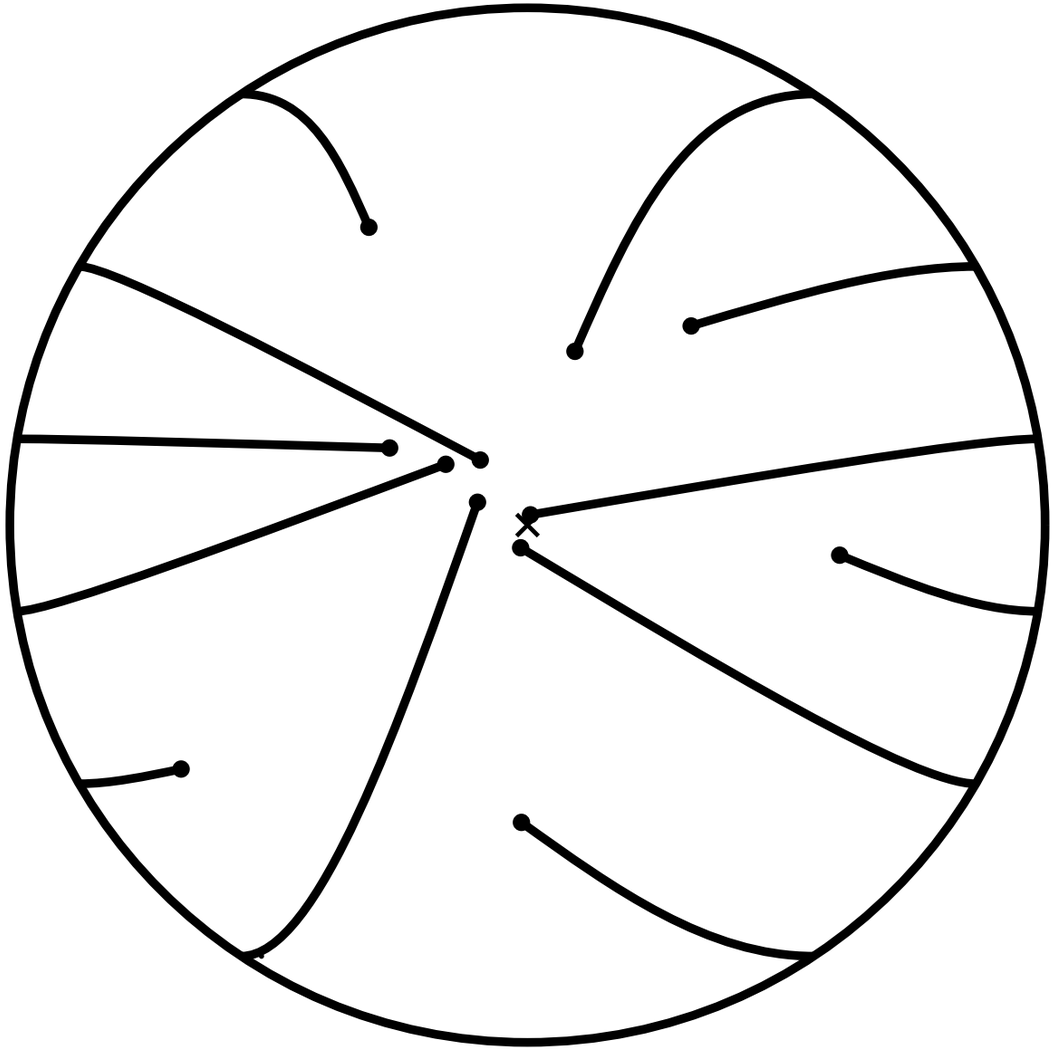

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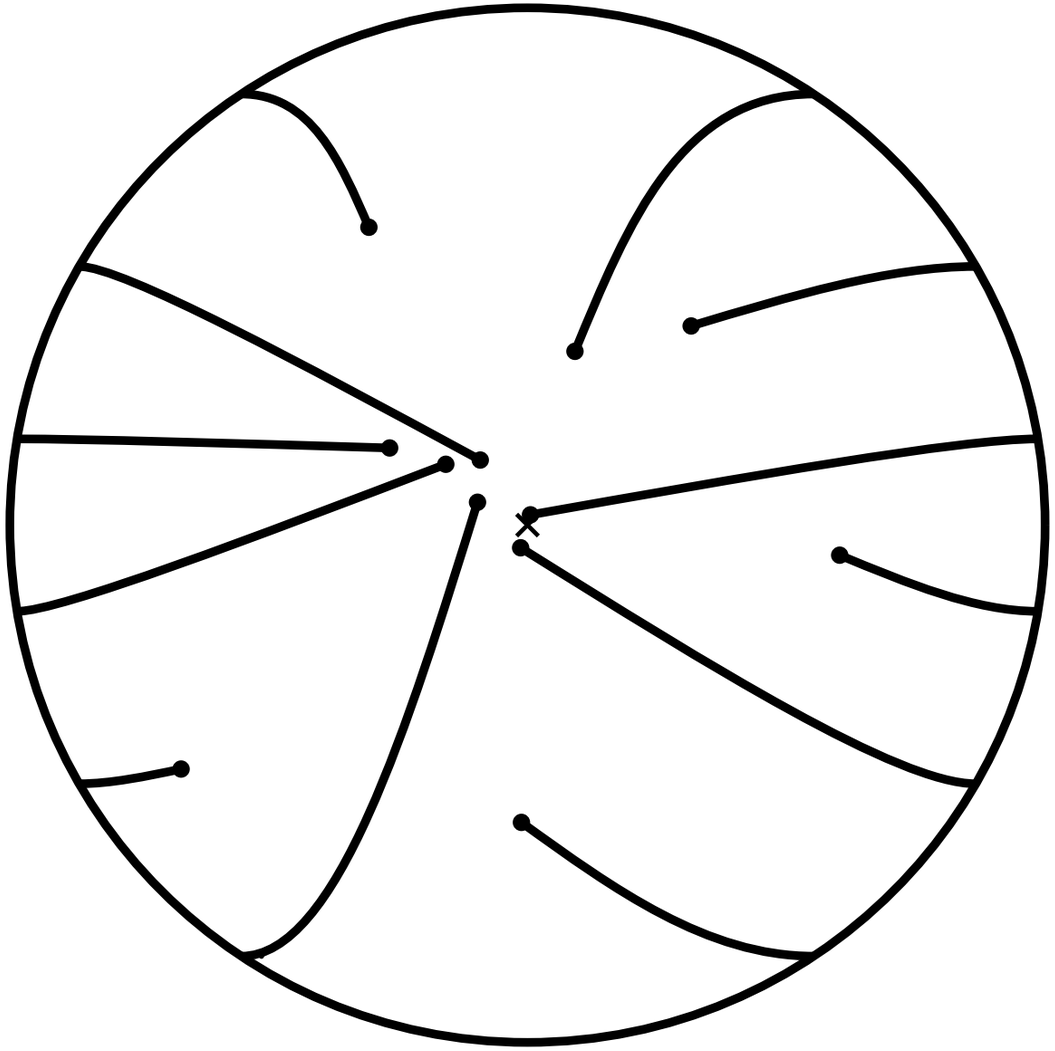

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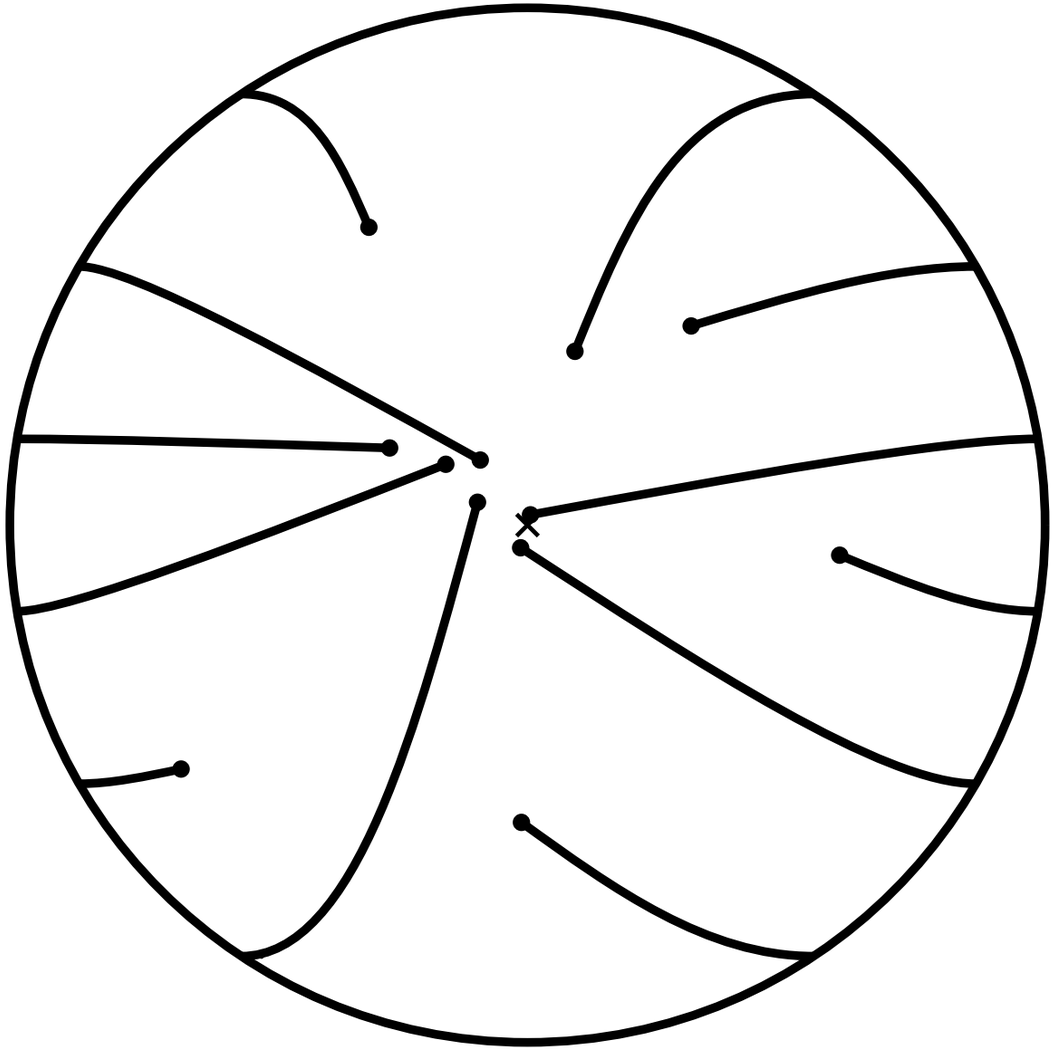

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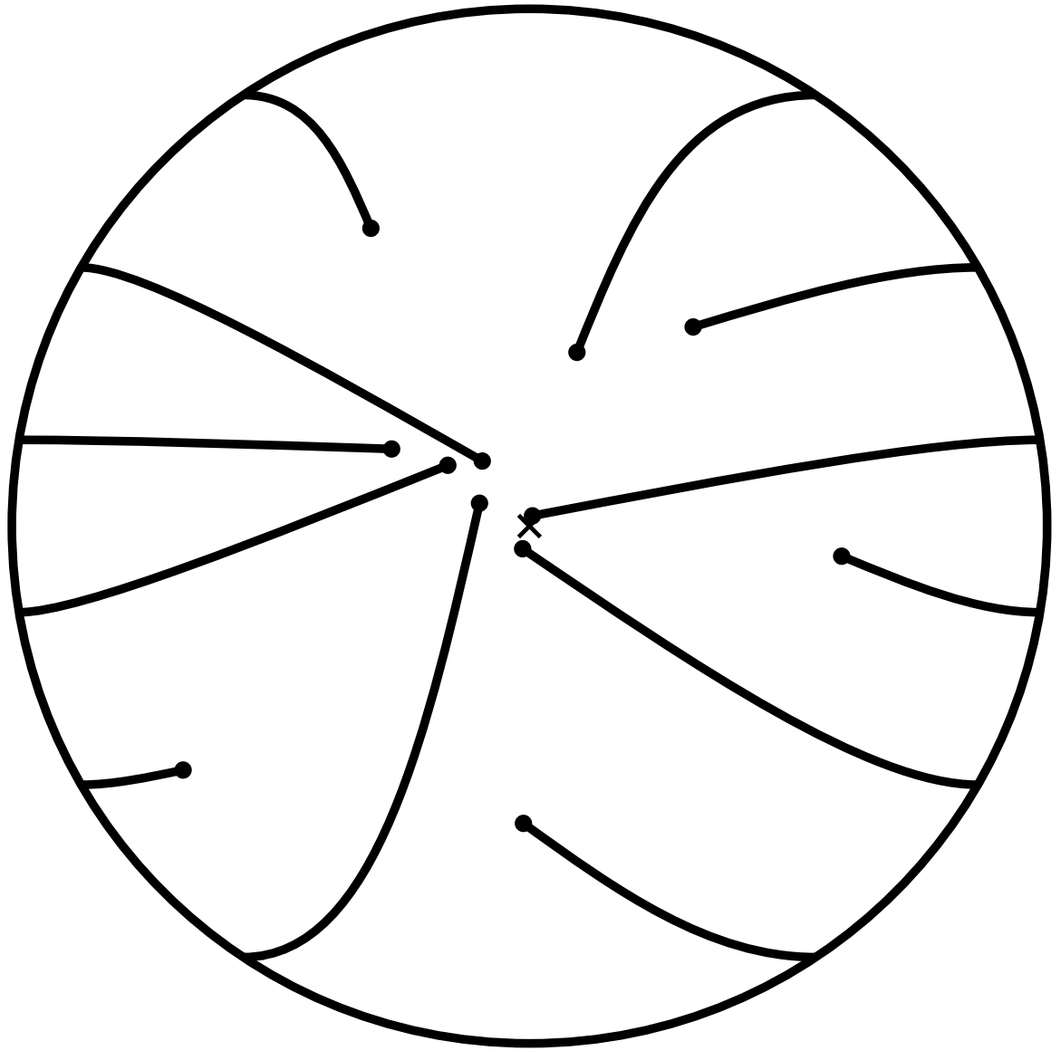

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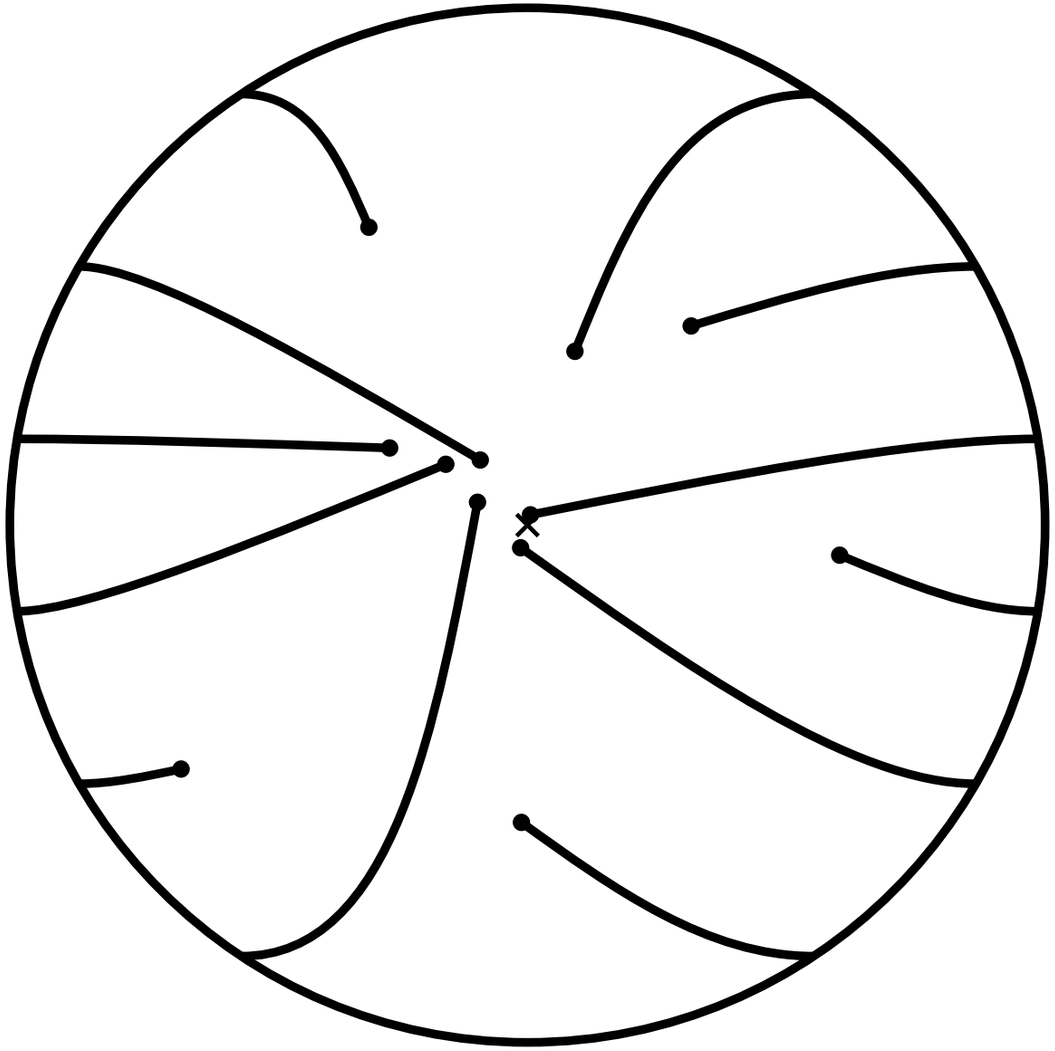

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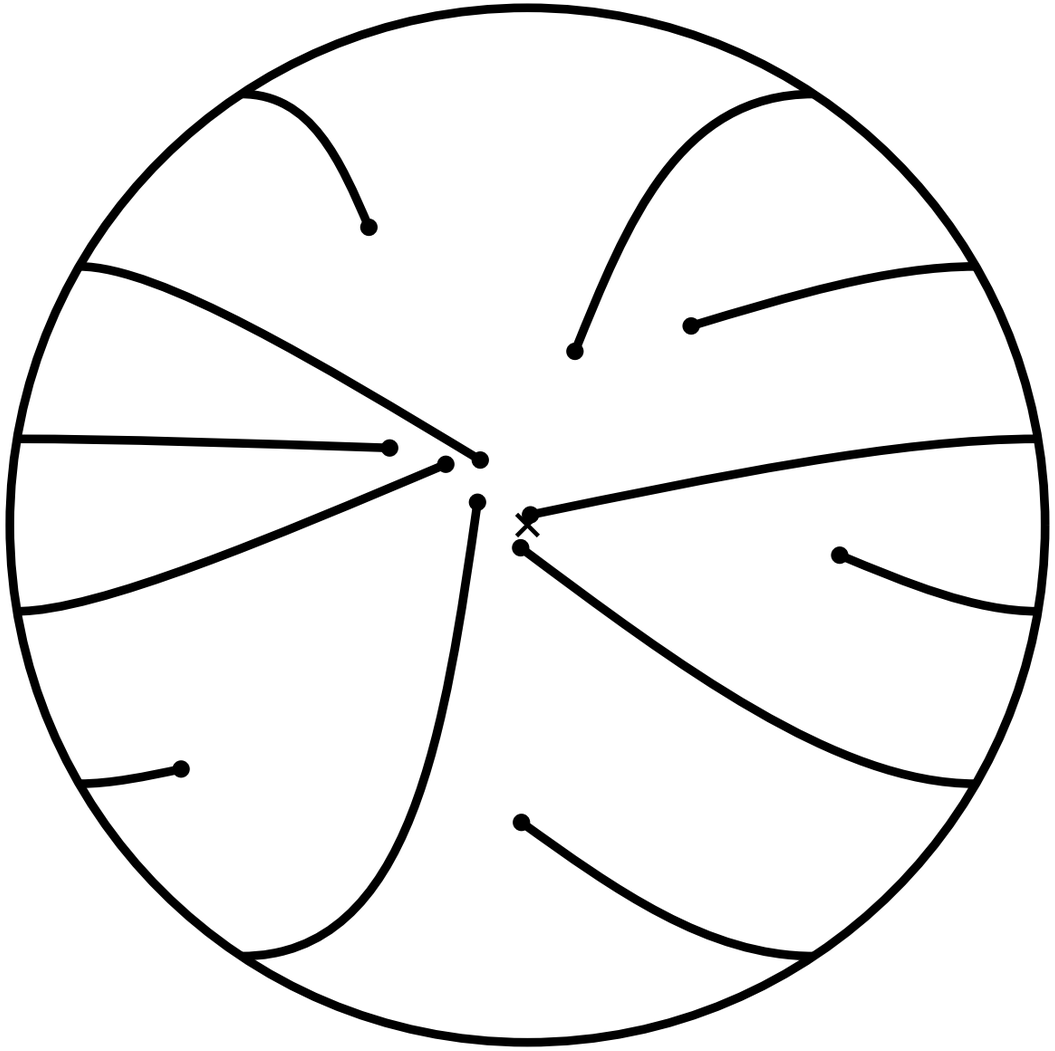

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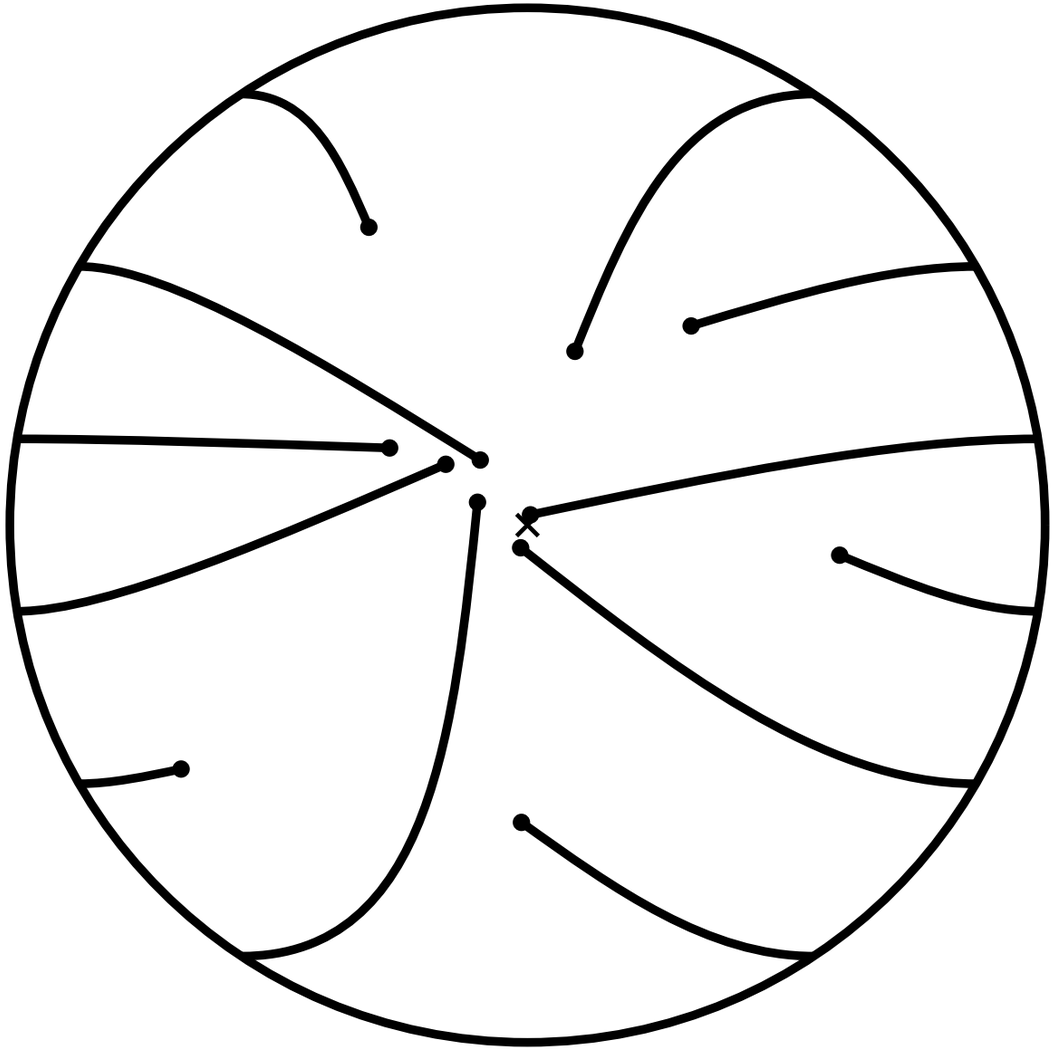

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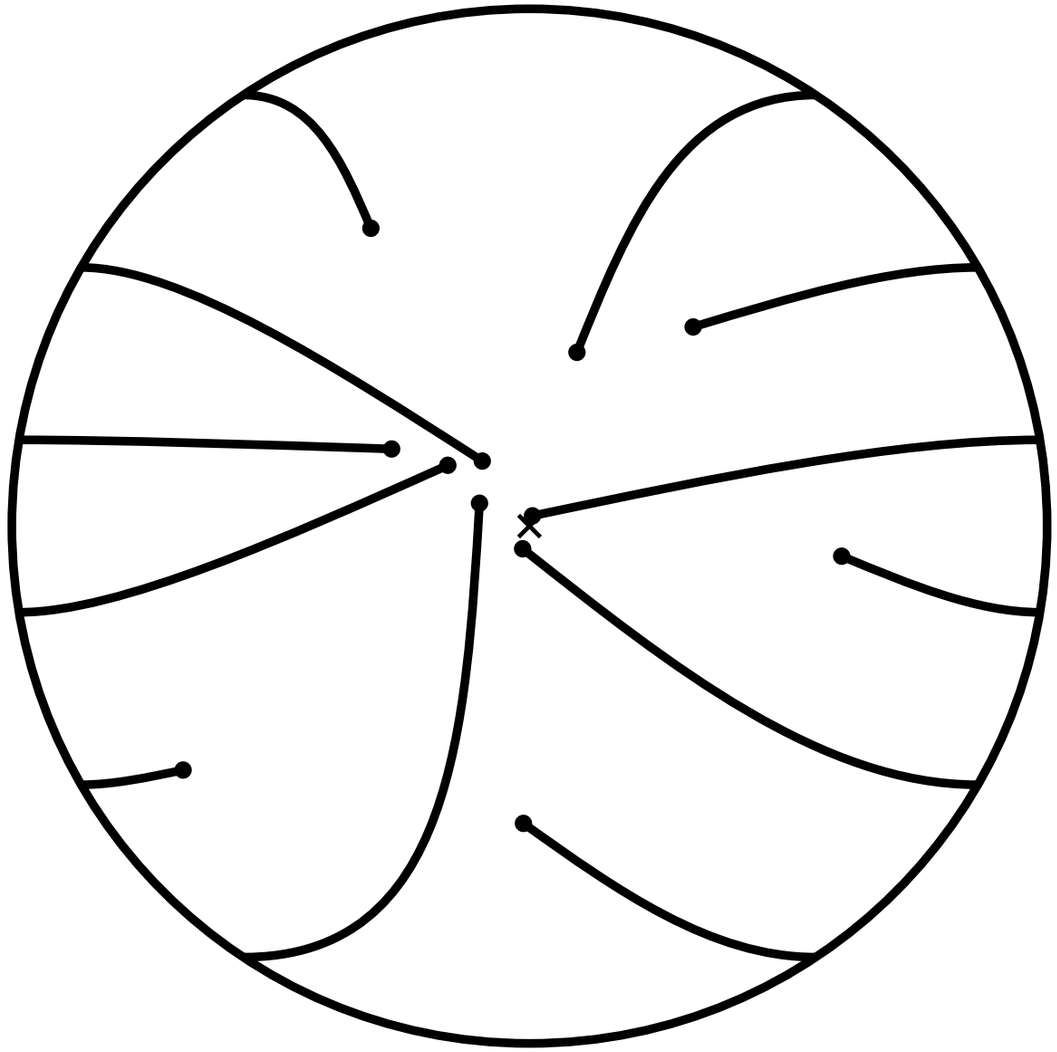

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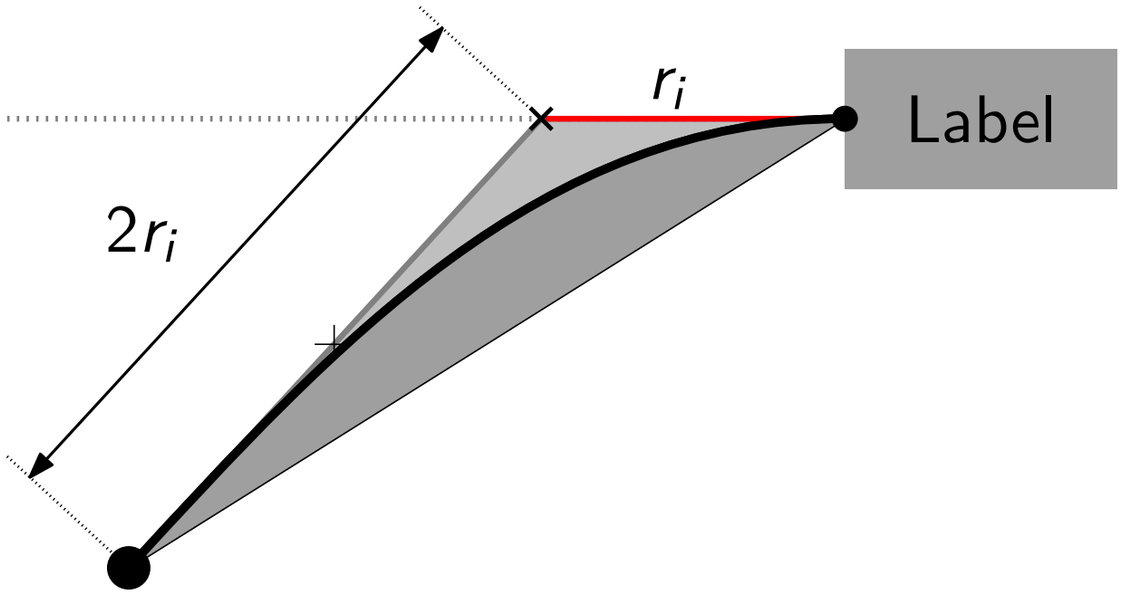

- post-processing:
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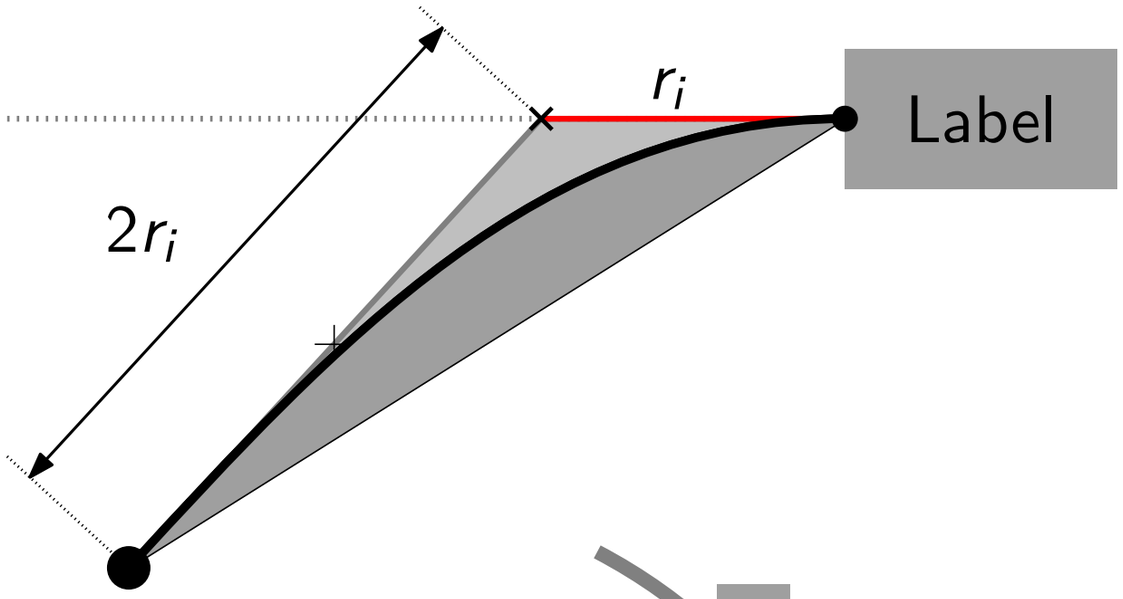
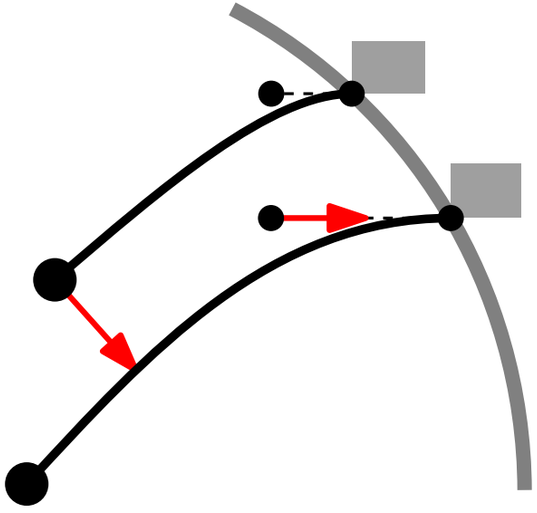
  - move towards desired shape

Bézier Curves as Leaders





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  - avoid other leaders

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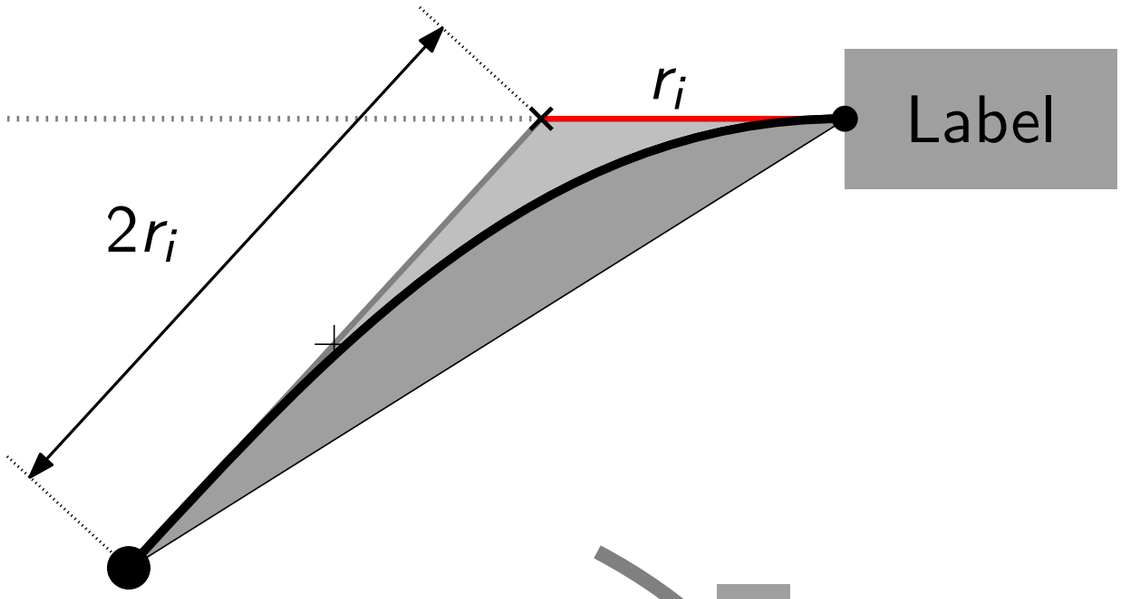

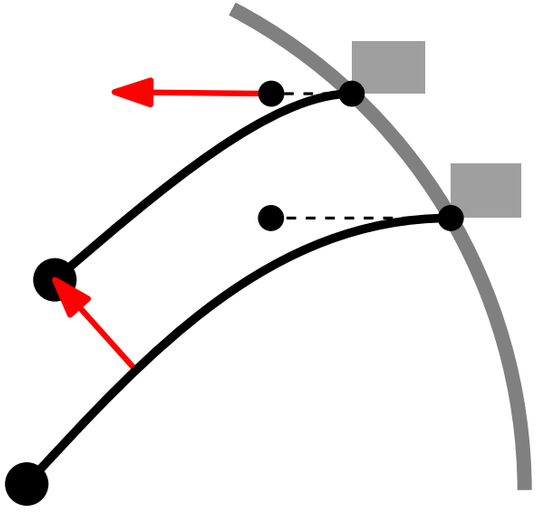

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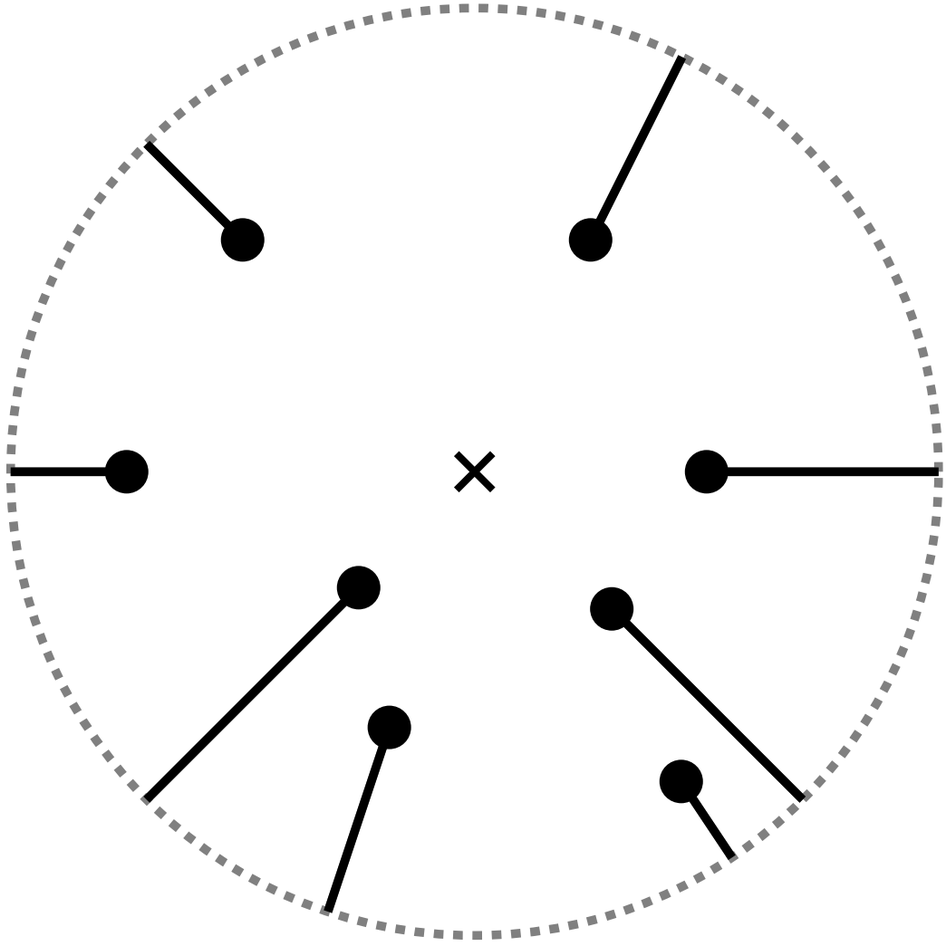
Curvy Leaders in the Radial Model



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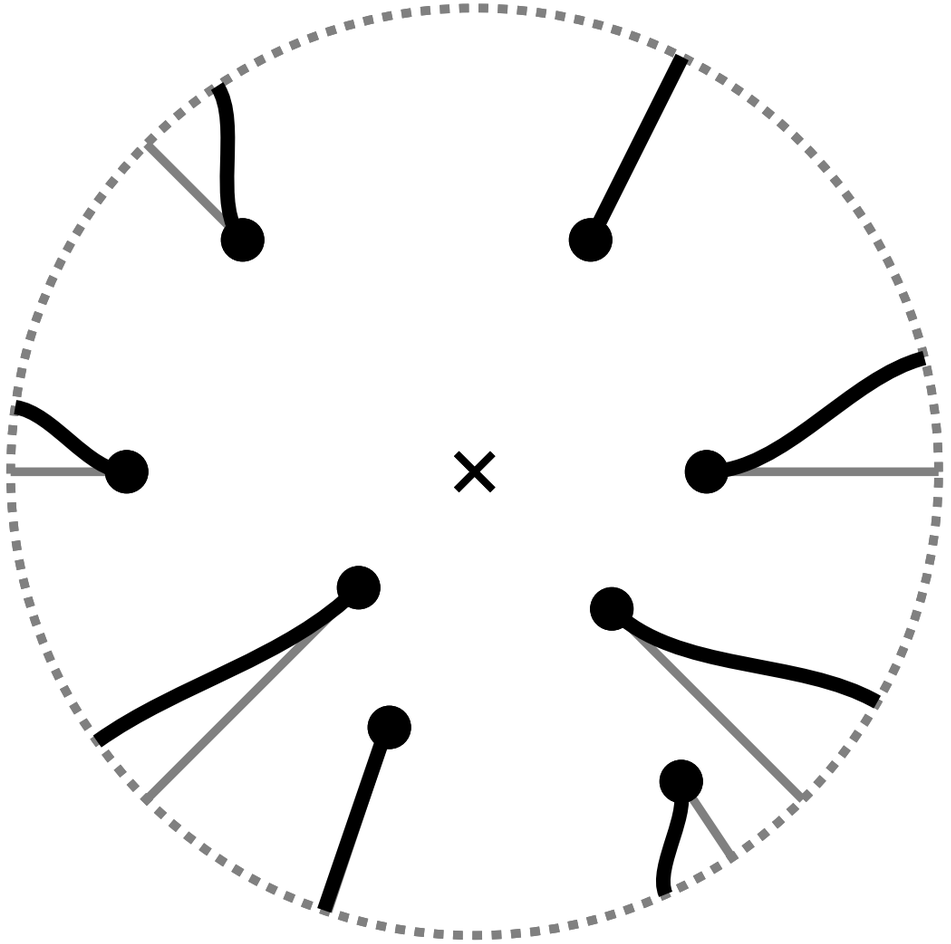

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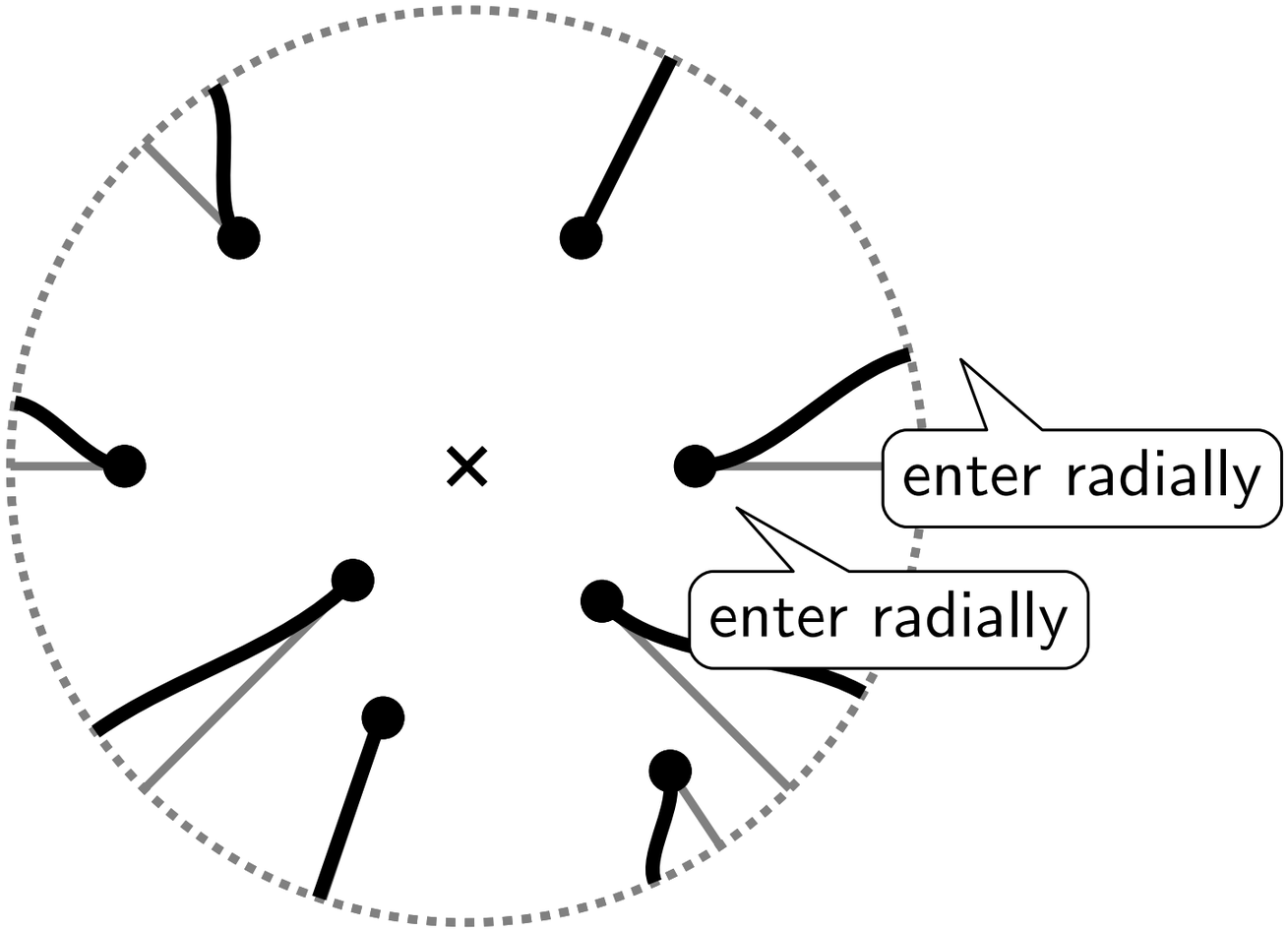

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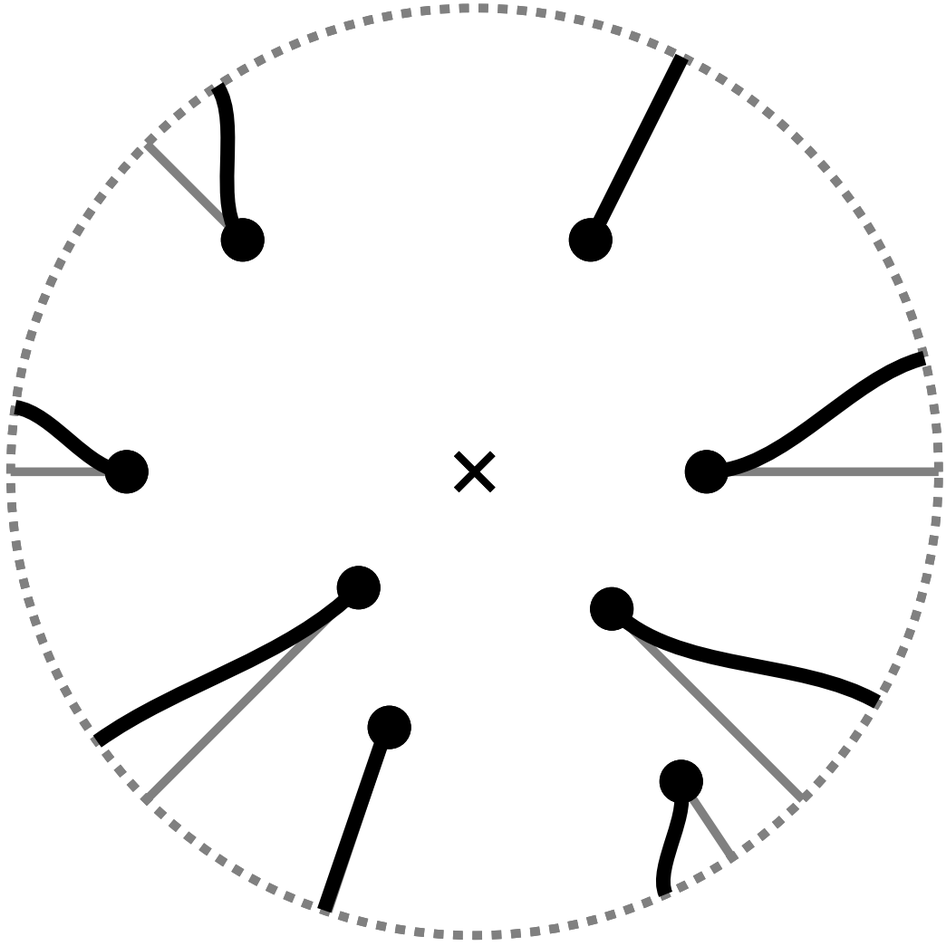

- move label positions on boundary
- improve angle

Conclusion and Open Problems

- Free leader model prefered for smaller numbers of labeled sites
- Radial model for many short labels

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  Idea: Weights changing over time