Metro Maps on Octilinear Grid Graphs

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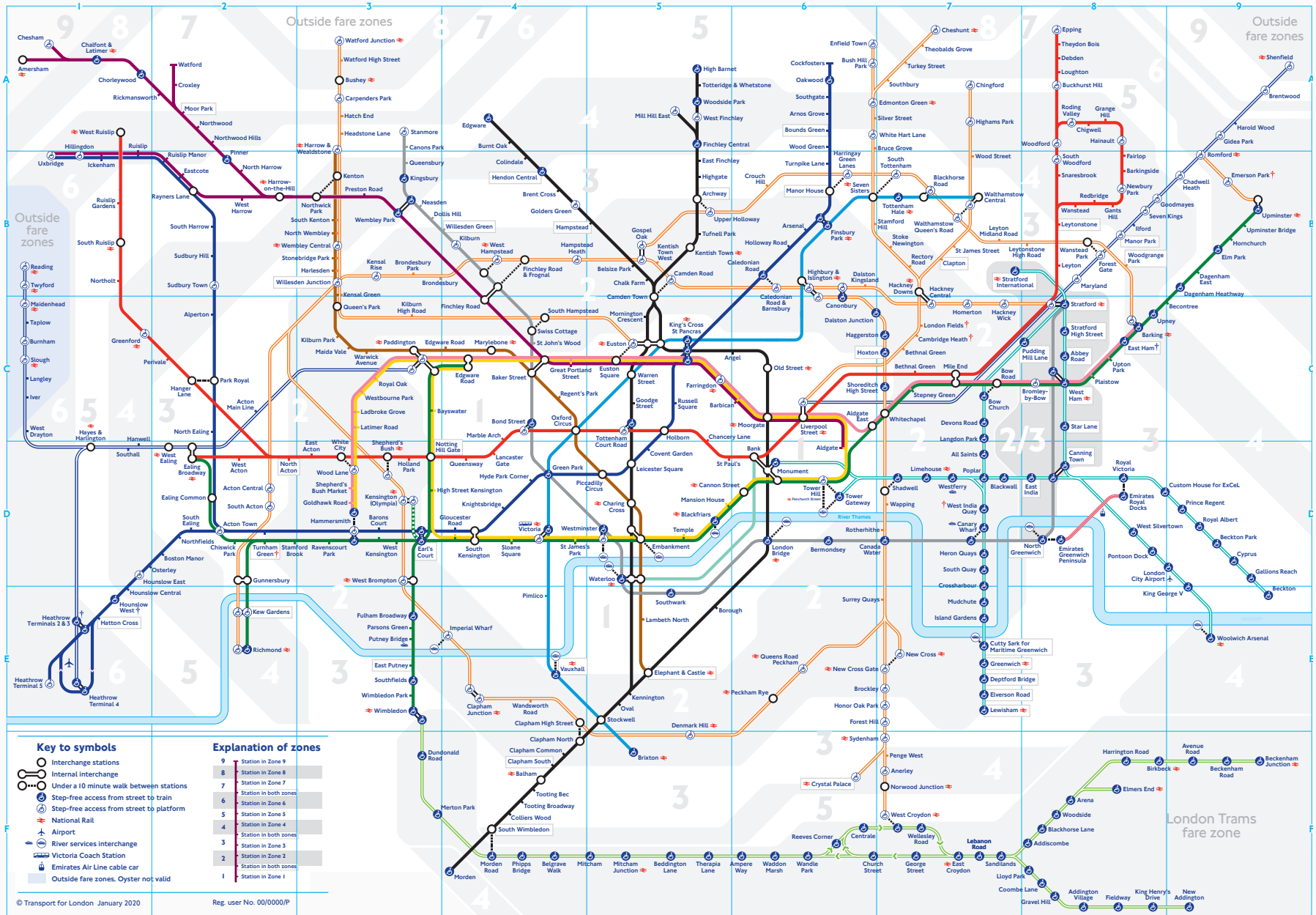
EuroVis 2020 - Norrköping, Sweden

Motivation - Official London Tube Map



Goals

Given an input line graph $G = (V, E, L)$ with edge lines $L(e)$, render an **octilinear** drawing of G automatically and fast

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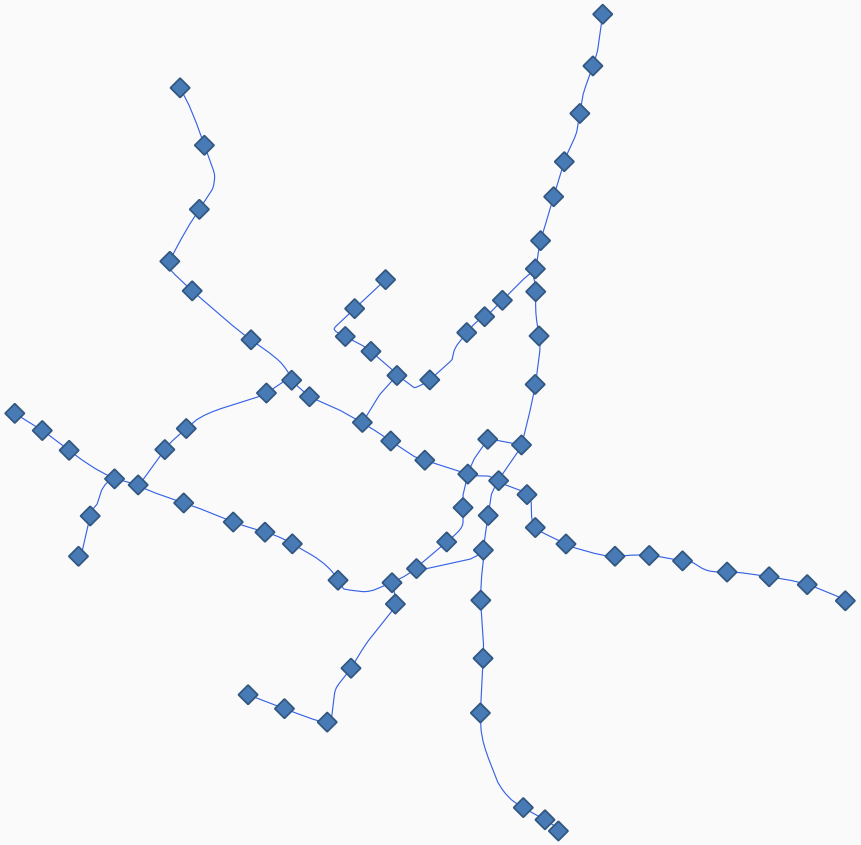

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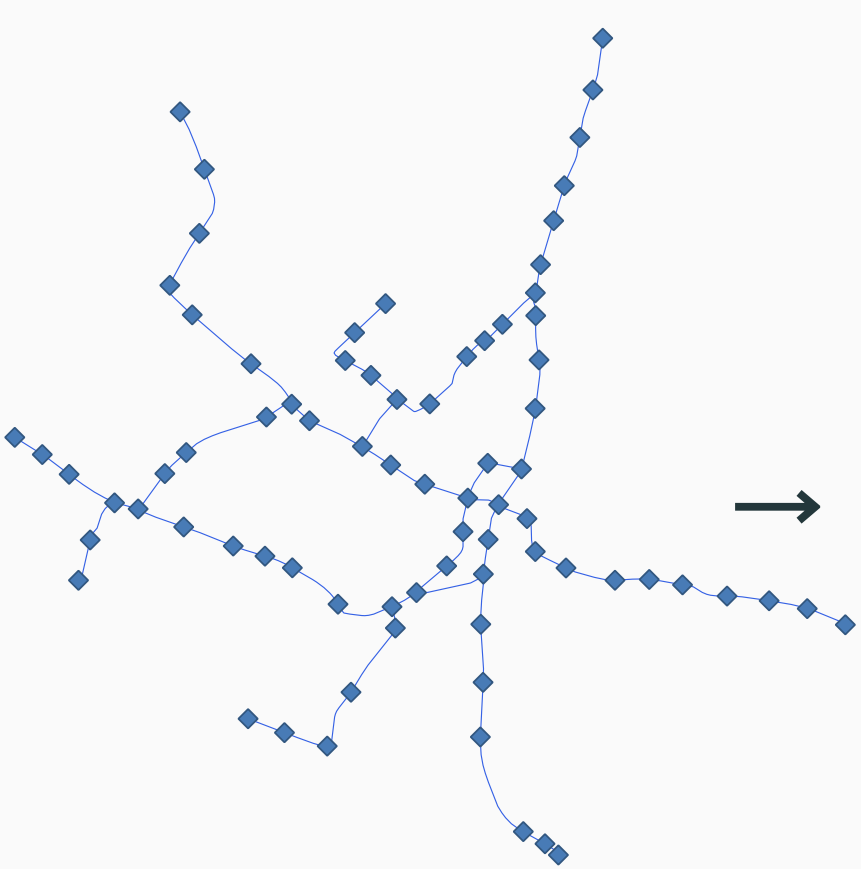

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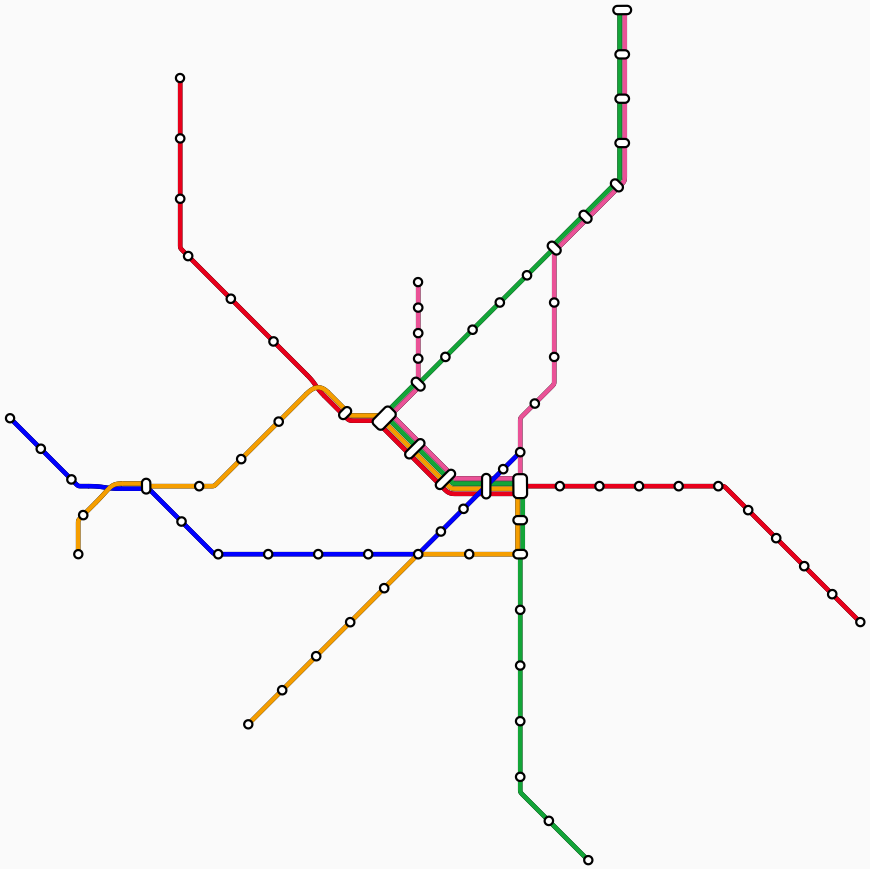

Octilinear drawing of G

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Allow arbitrary (but optimal) number of edge bends to circumvent obstacles and approximate geographical courses

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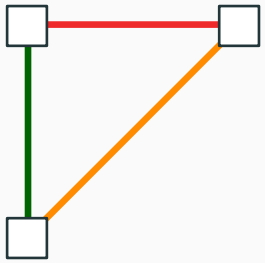

Octilinear embedding

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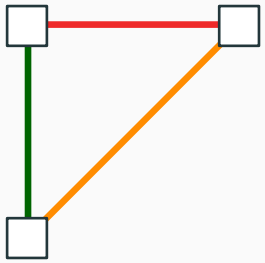
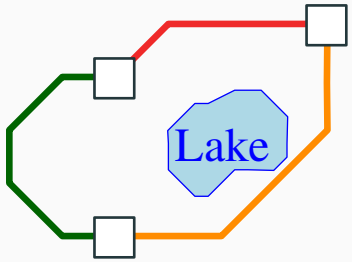


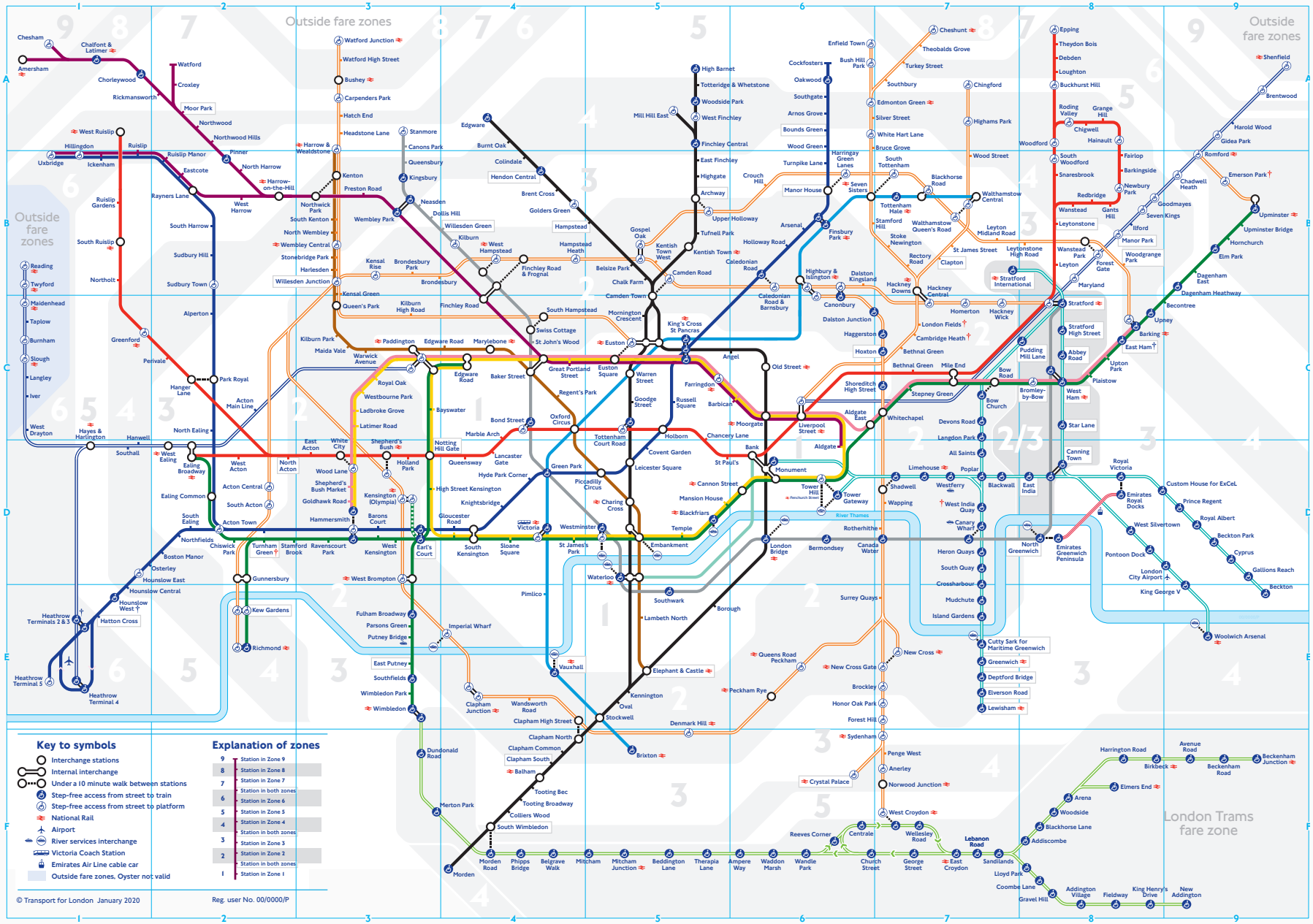
Octilinear embedding

vs.



Octilinear drawing

Octilinear Embedding vs. Octilinear Drawing



Octilinear Embedding vs. Octilinear Drawing

Excerpt of regional train map of southwestern Germany

Existing Approaches

1. Local search / Hill climbing (Stott 2004)

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- Octilinearity not guaranteed [1]

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Problems:

- Octilinearity not guaranteed [1]
- Produce octilinear embeddings, so no bends along edges (can be mitigated by adding explicit bend nodes) [1, 2, 3]
- Are often too slow for practical purposes (on-demand maps, editors) [1, 2]

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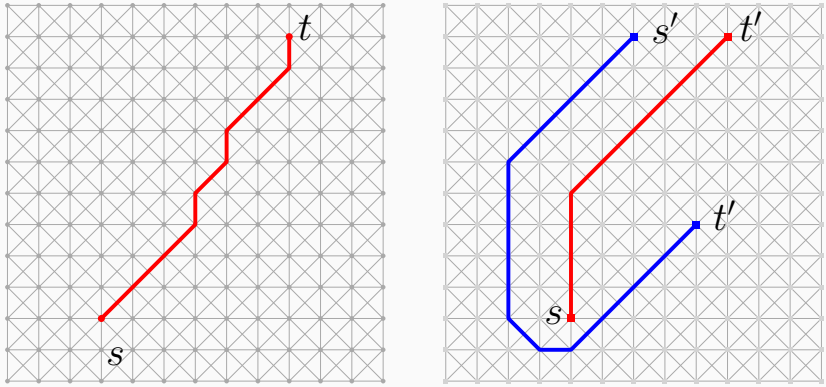

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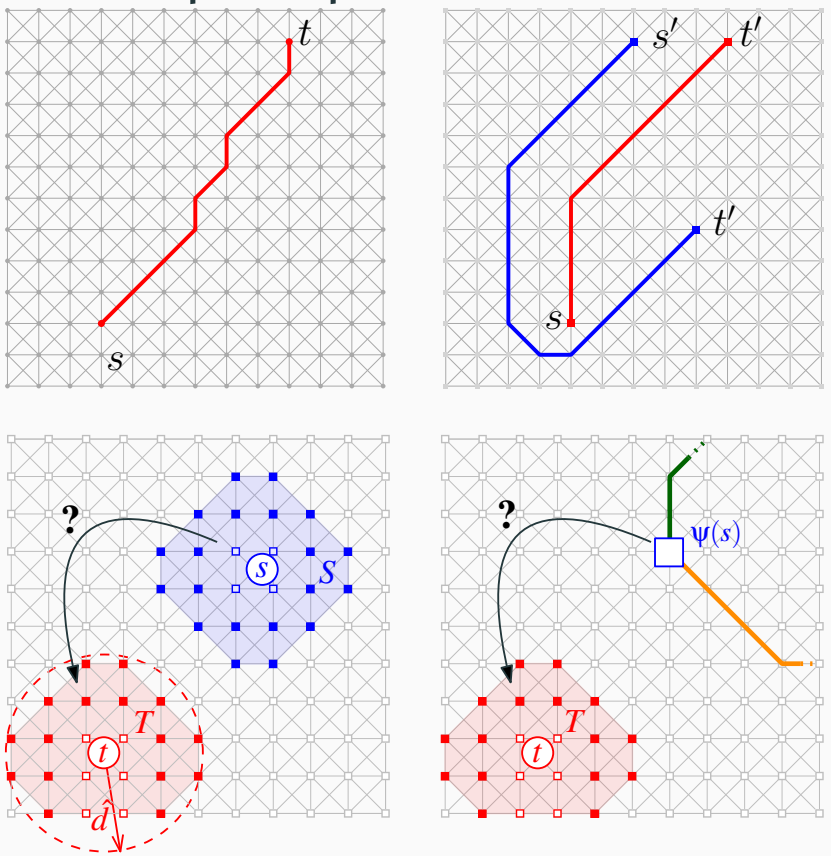
2. For each $e \in E$, $e = (s, t)$: define start and target grid nodes S, T and find the shortest path from S to T. Make path an obstacle.



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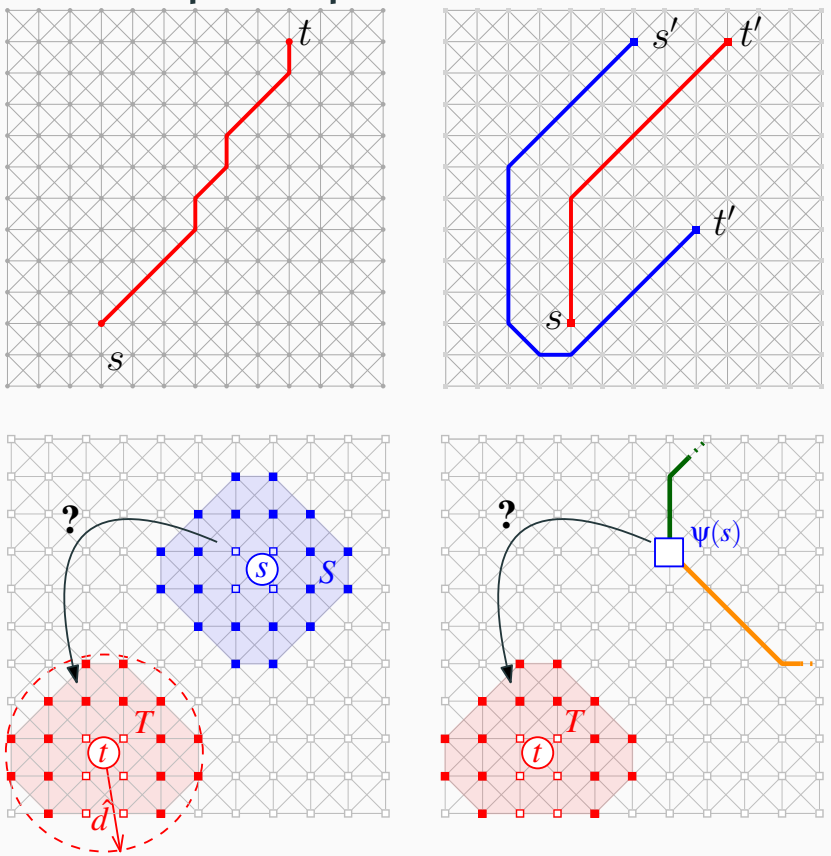

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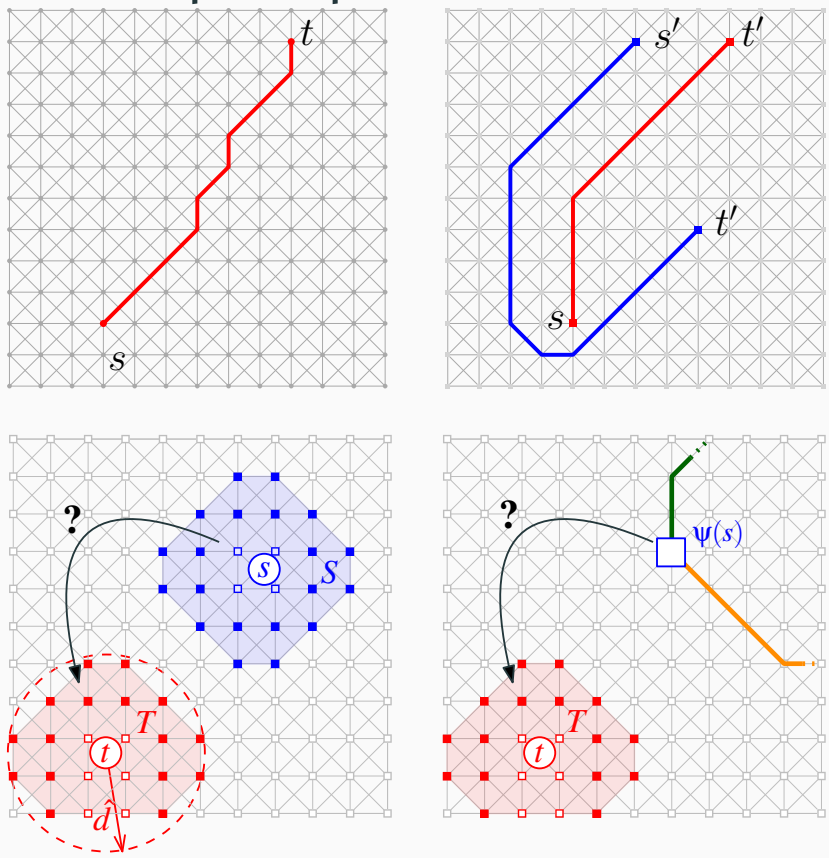
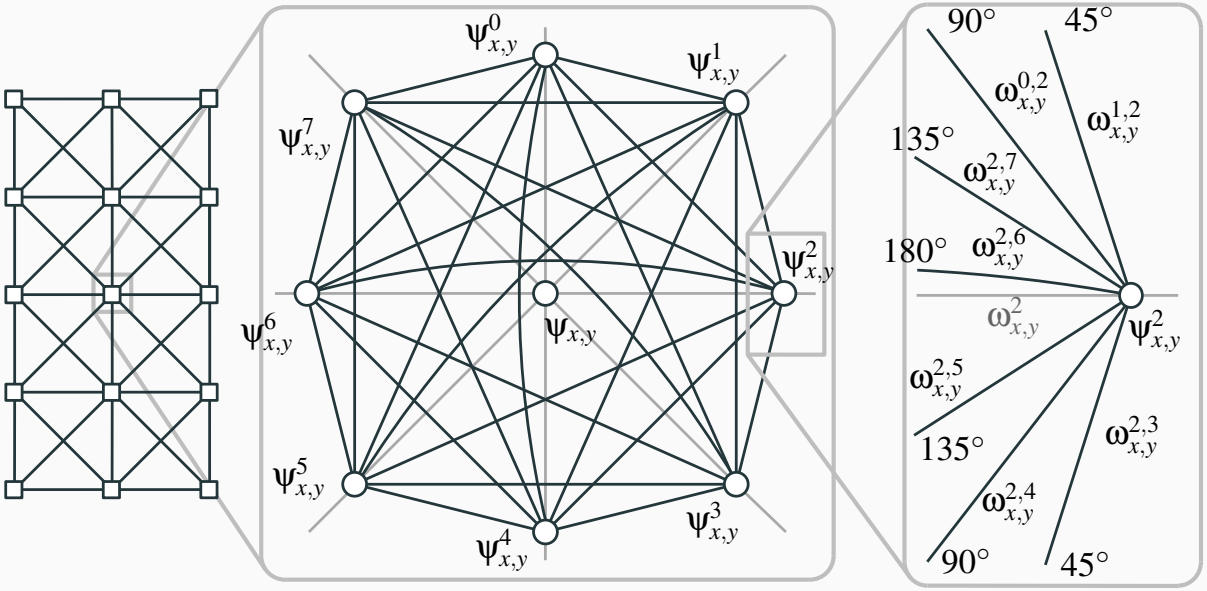


Key question: Should the shortest paths be determined simultaneously or iteratively (then: in which order)?

Graph Modeling - Detail



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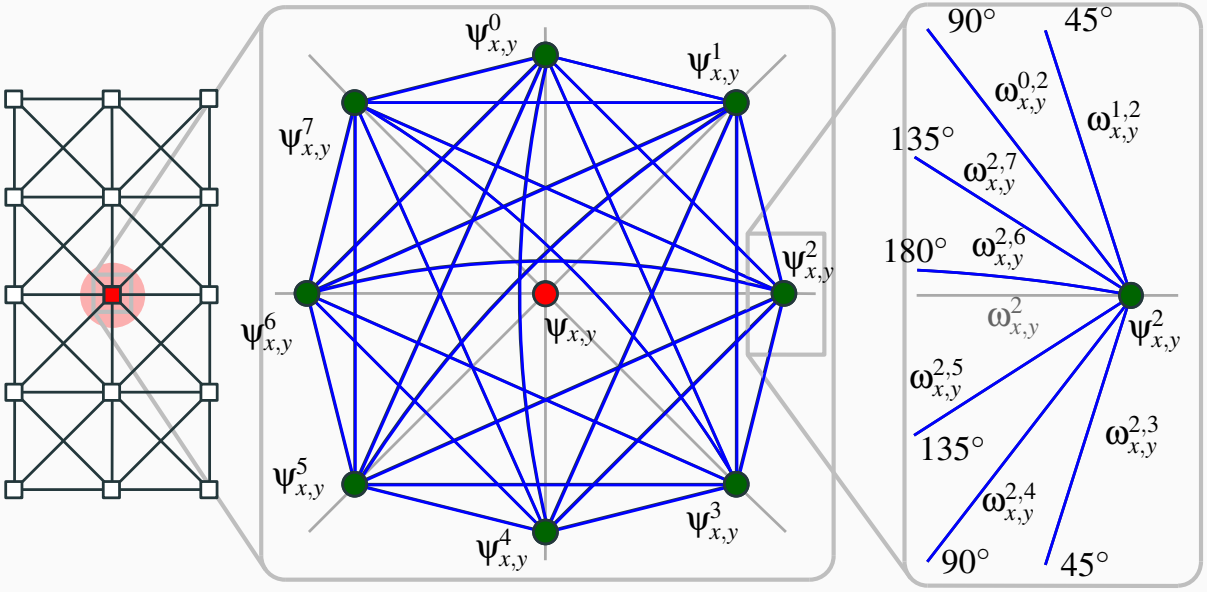

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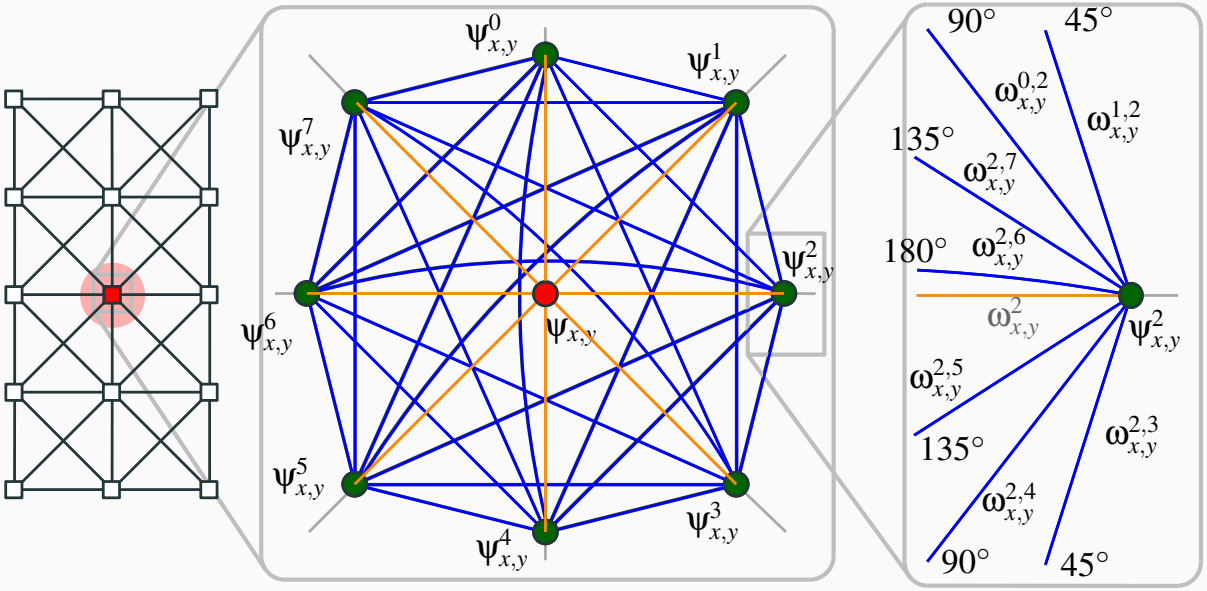

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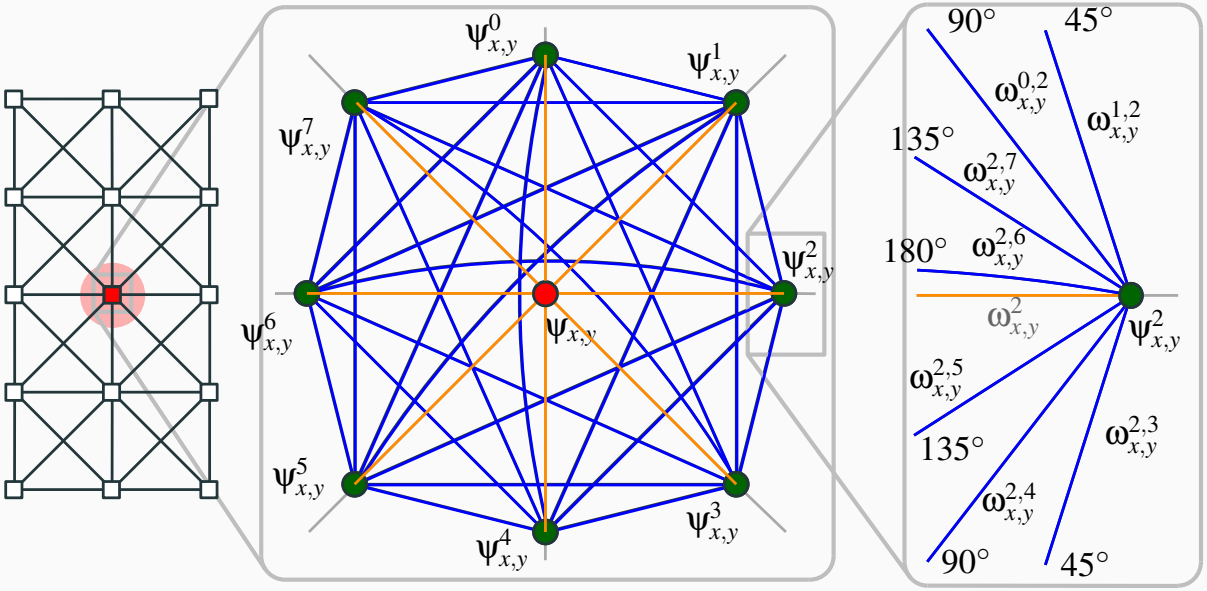
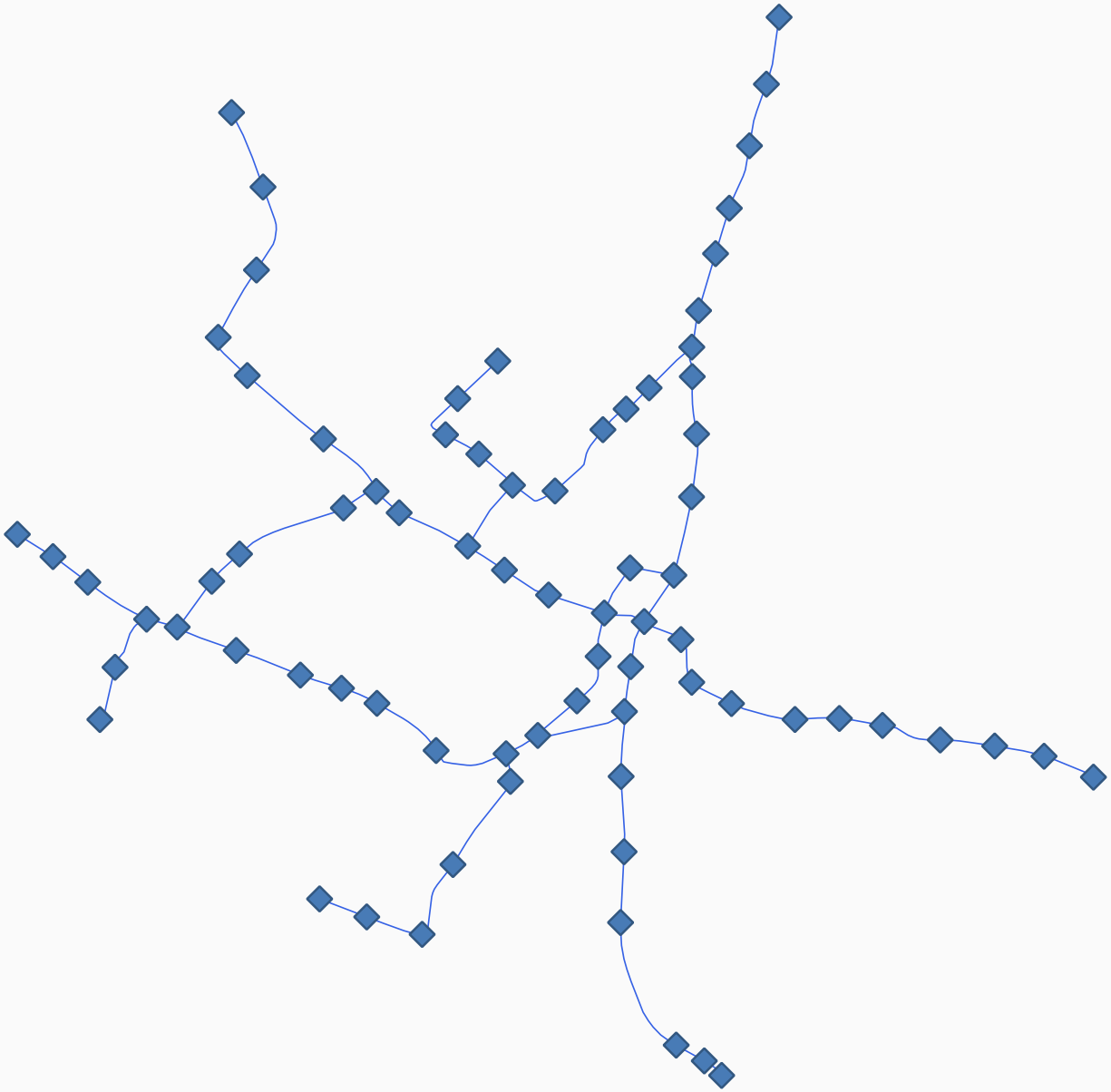


- Each grid node is extended by explicit bend edges between port nodes. Edge costs reflect the angle
- To arrive at a grid node, we add sink edges
- Sink edge costs reflect (1) the angle between the sink and continued lines on already settled sinks and (2) a node move penalty

Iterative Calculation



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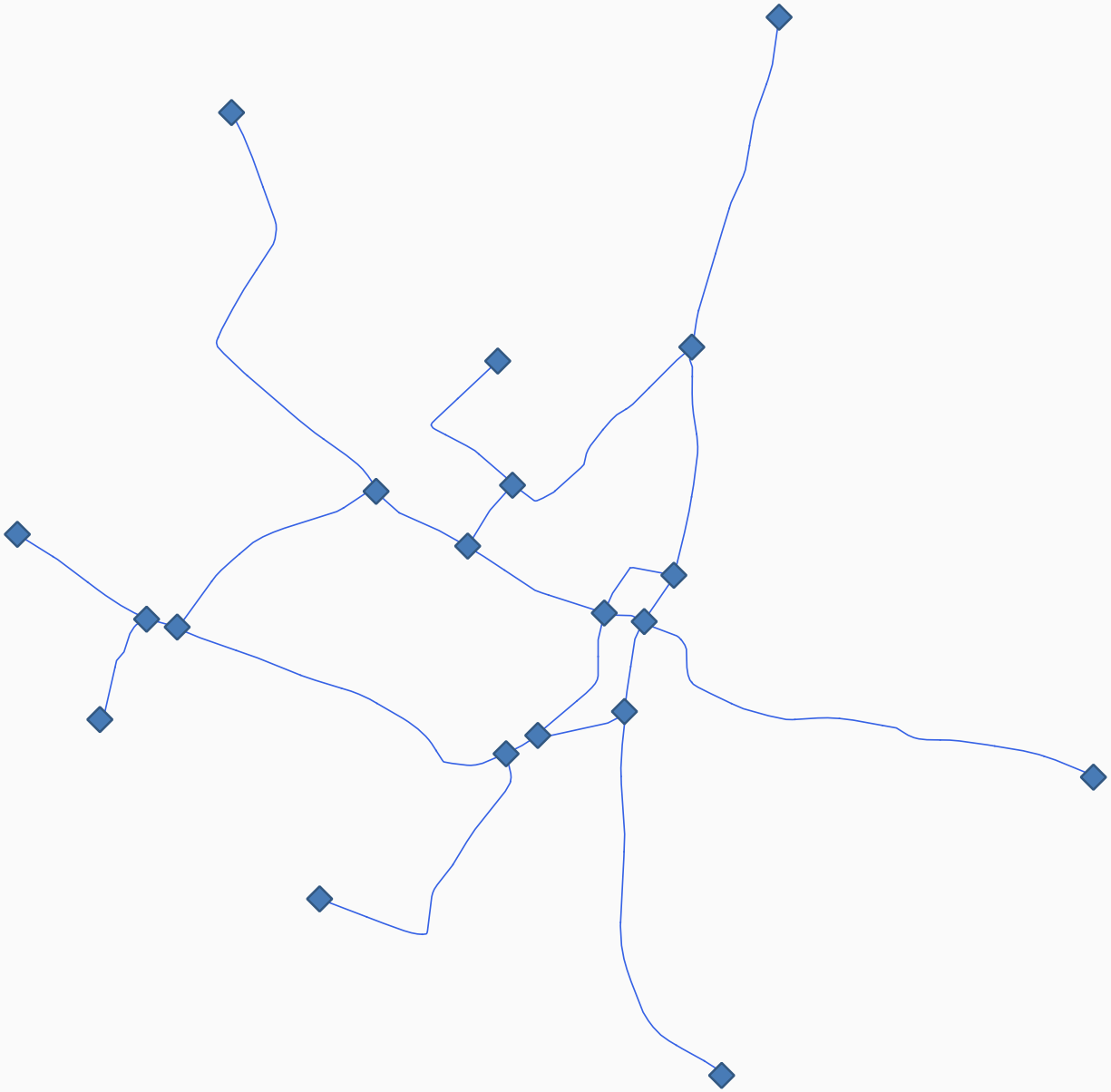

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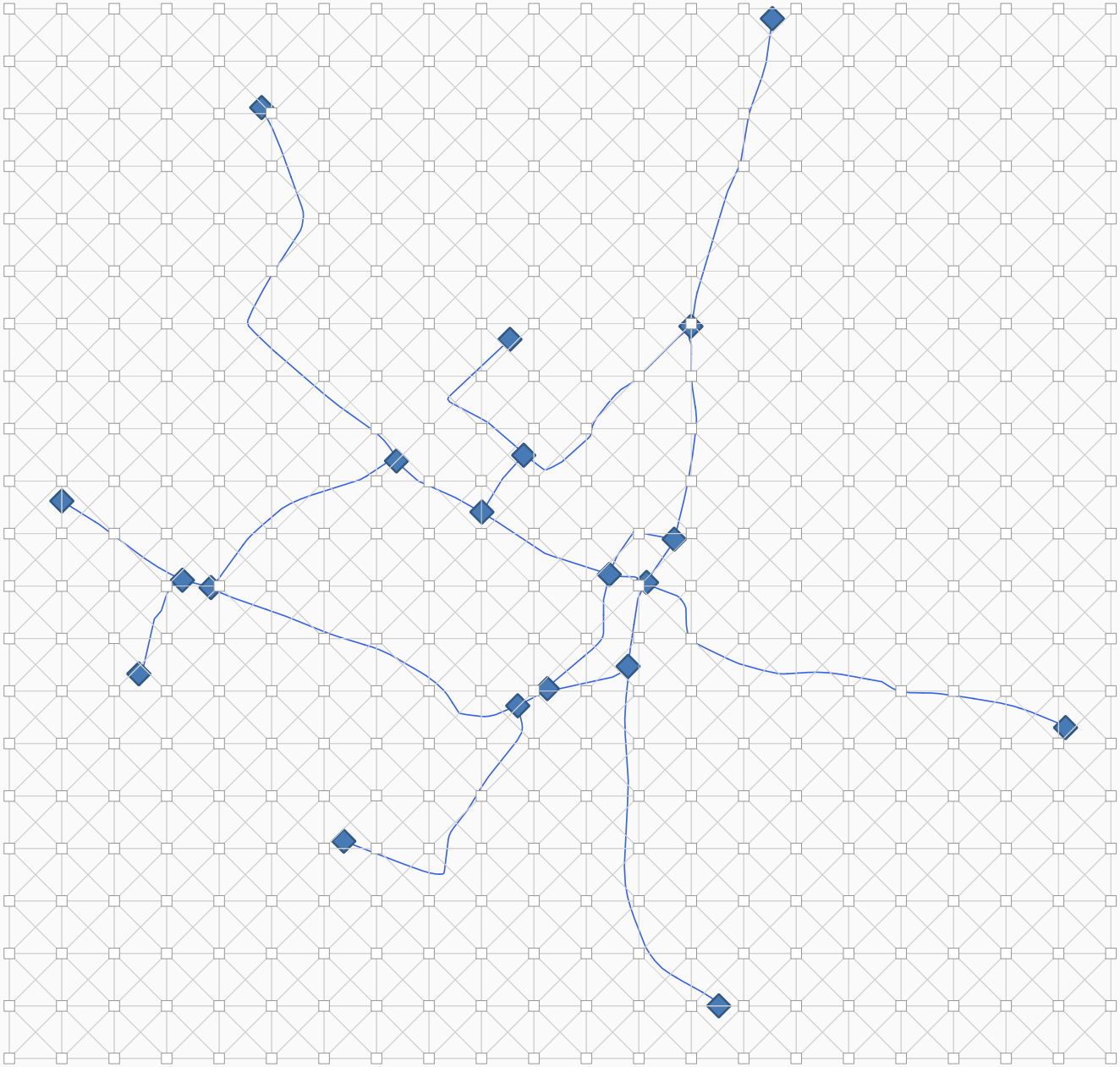

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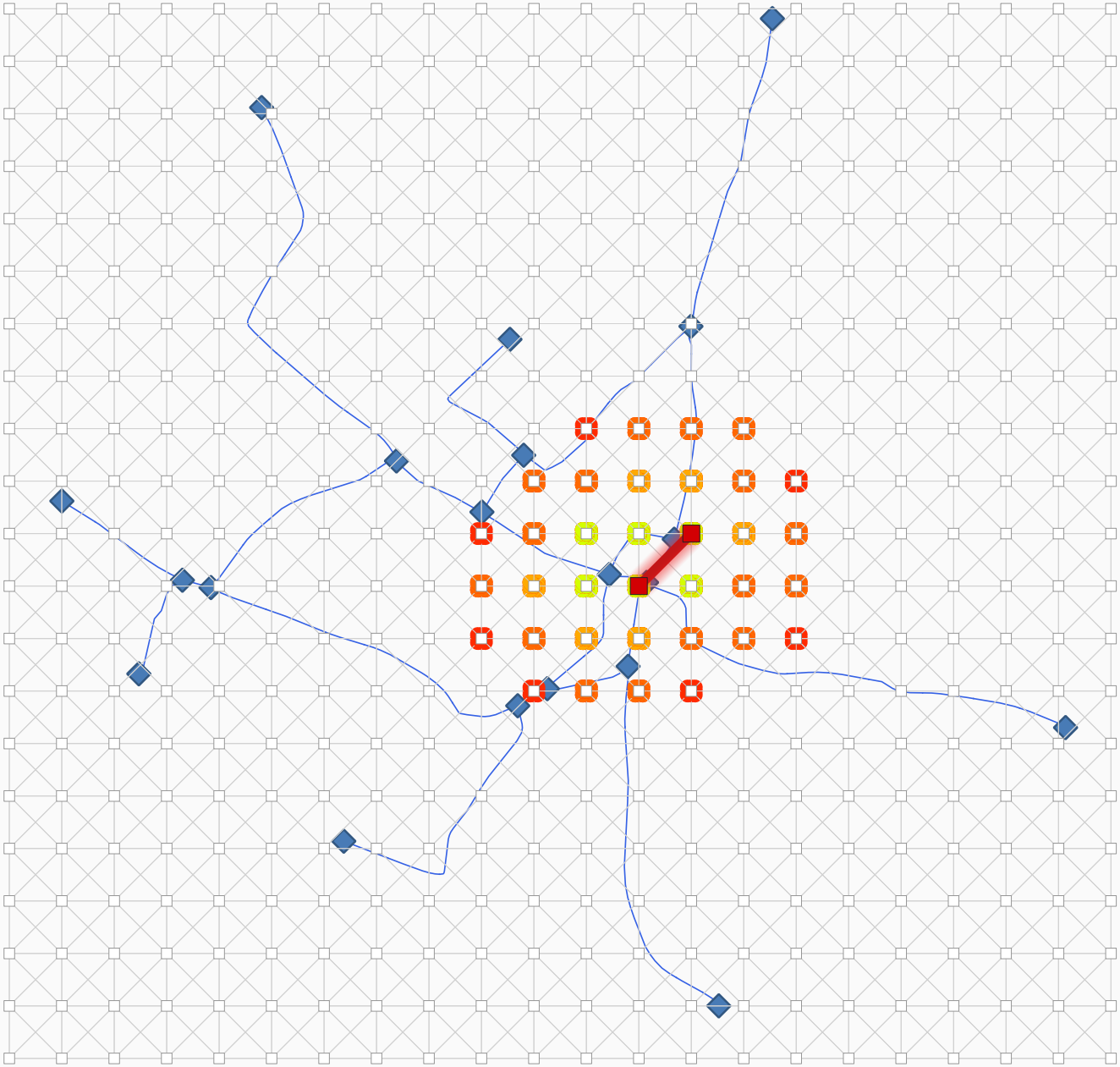

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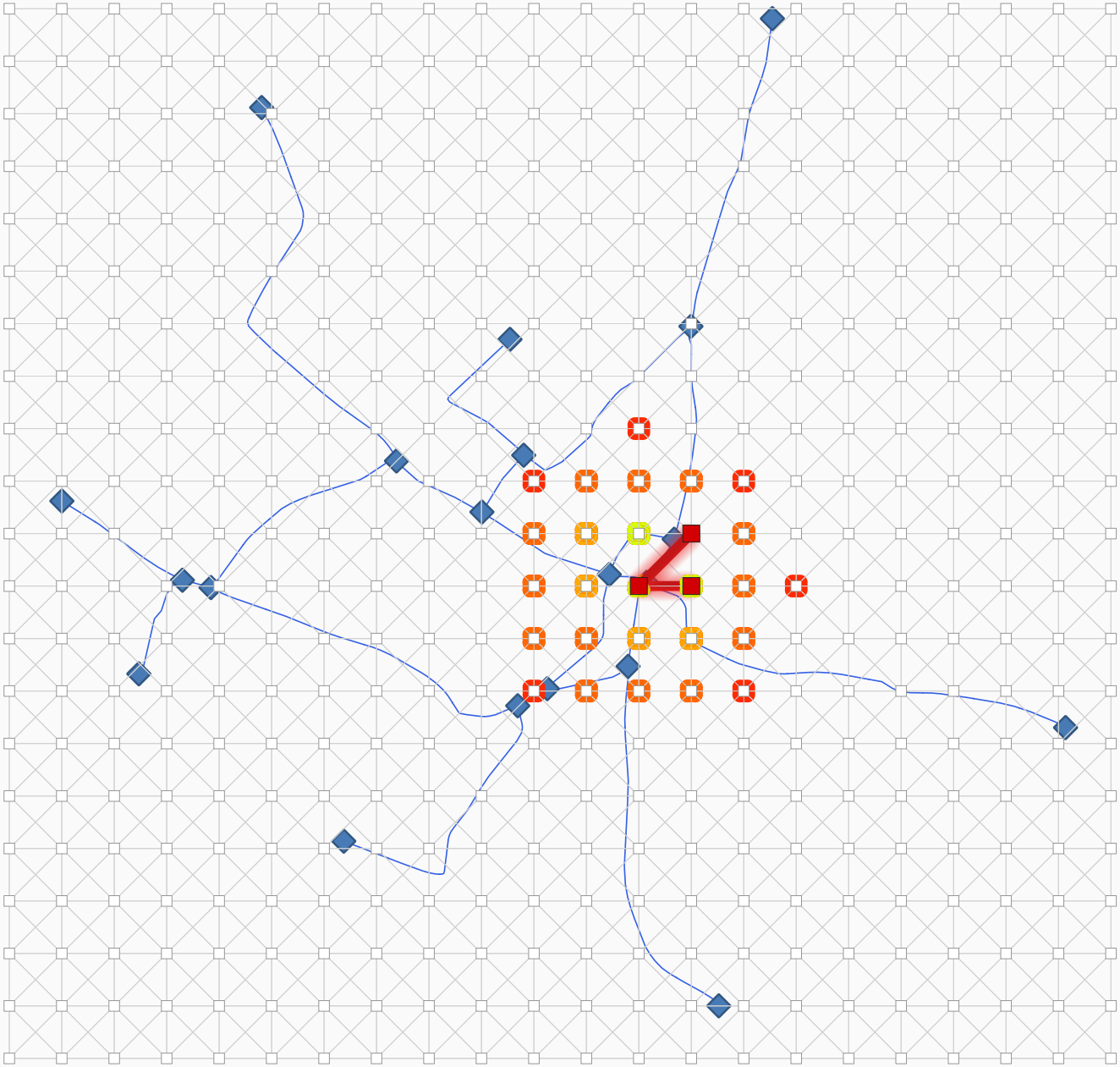

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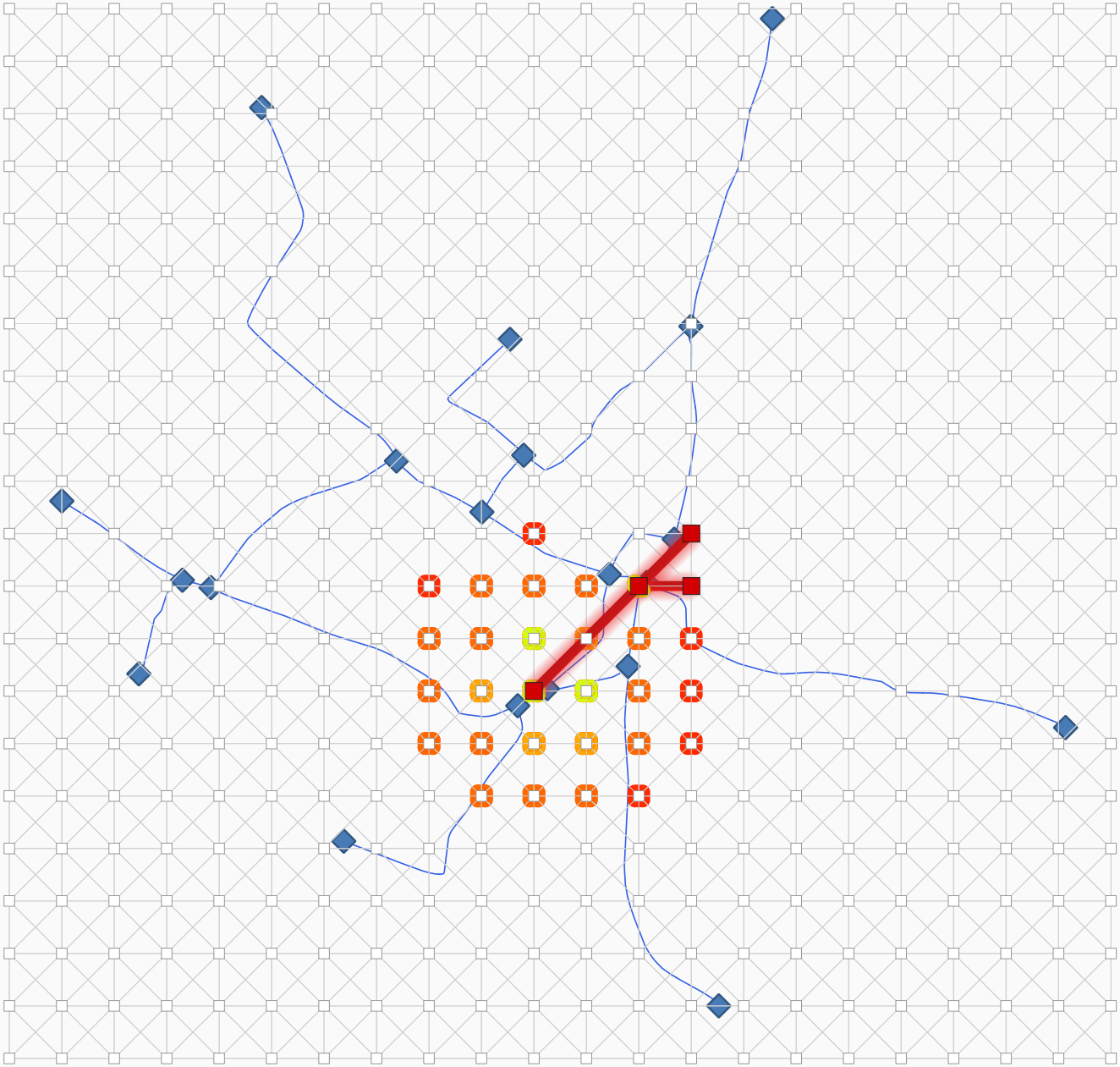

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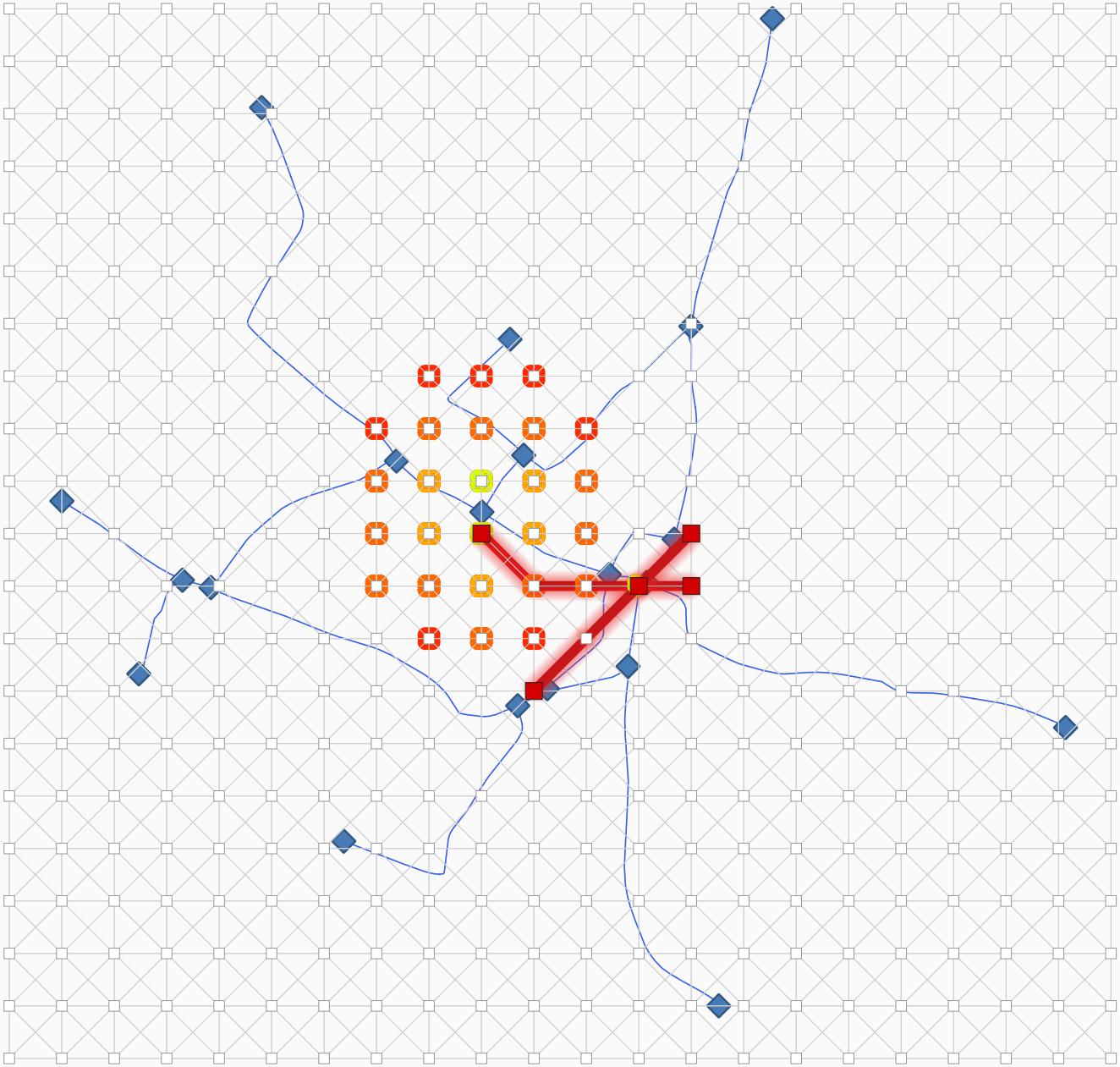

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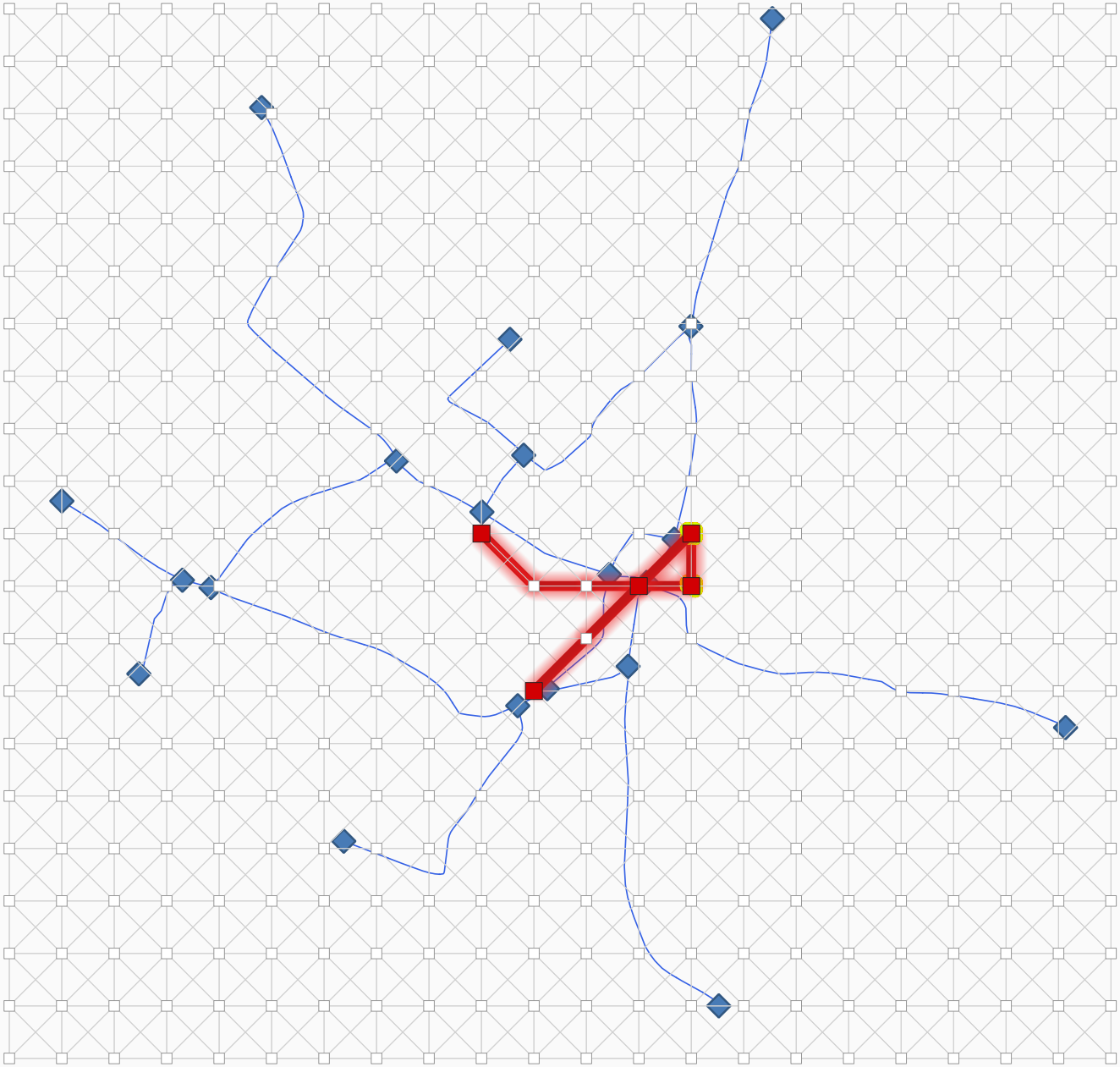

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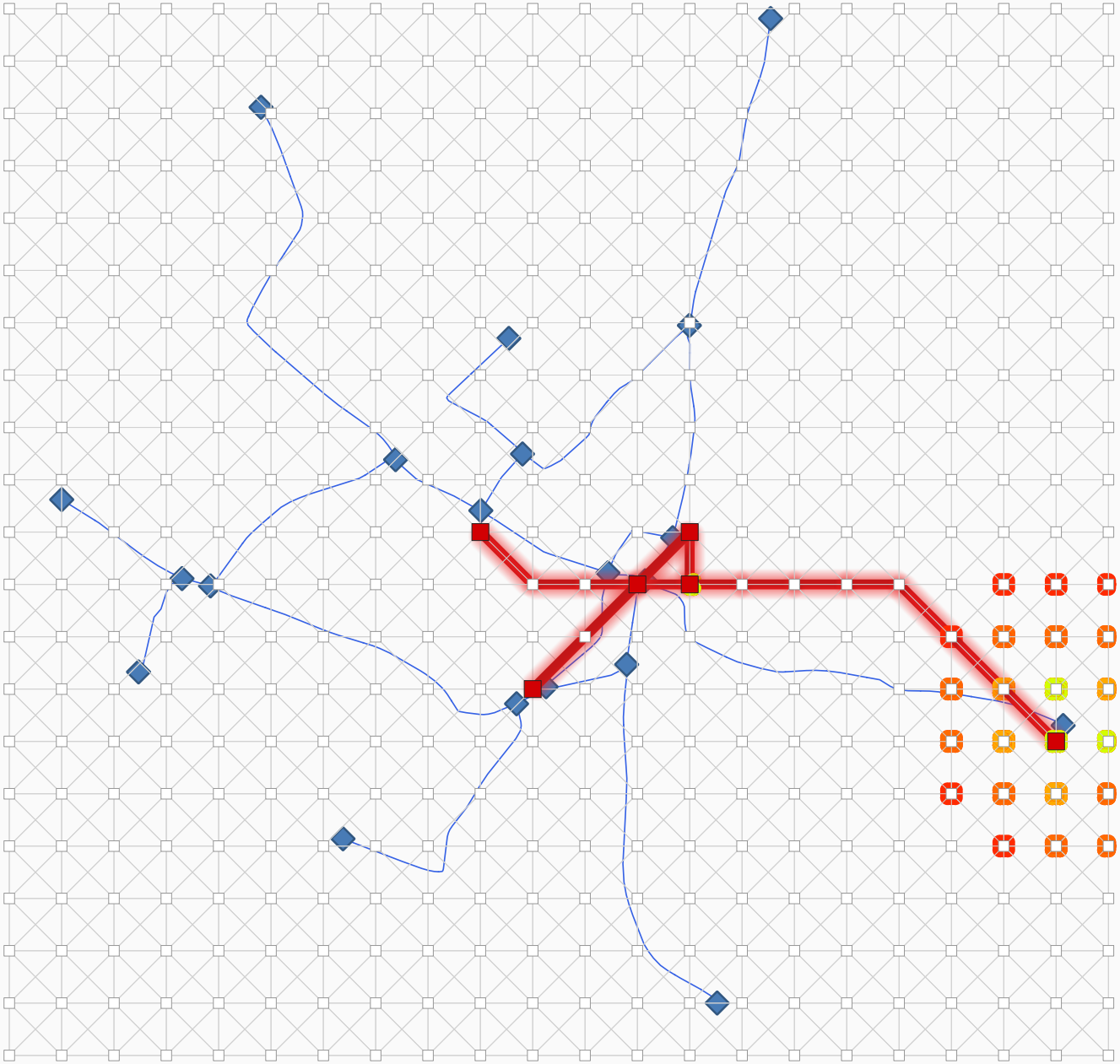

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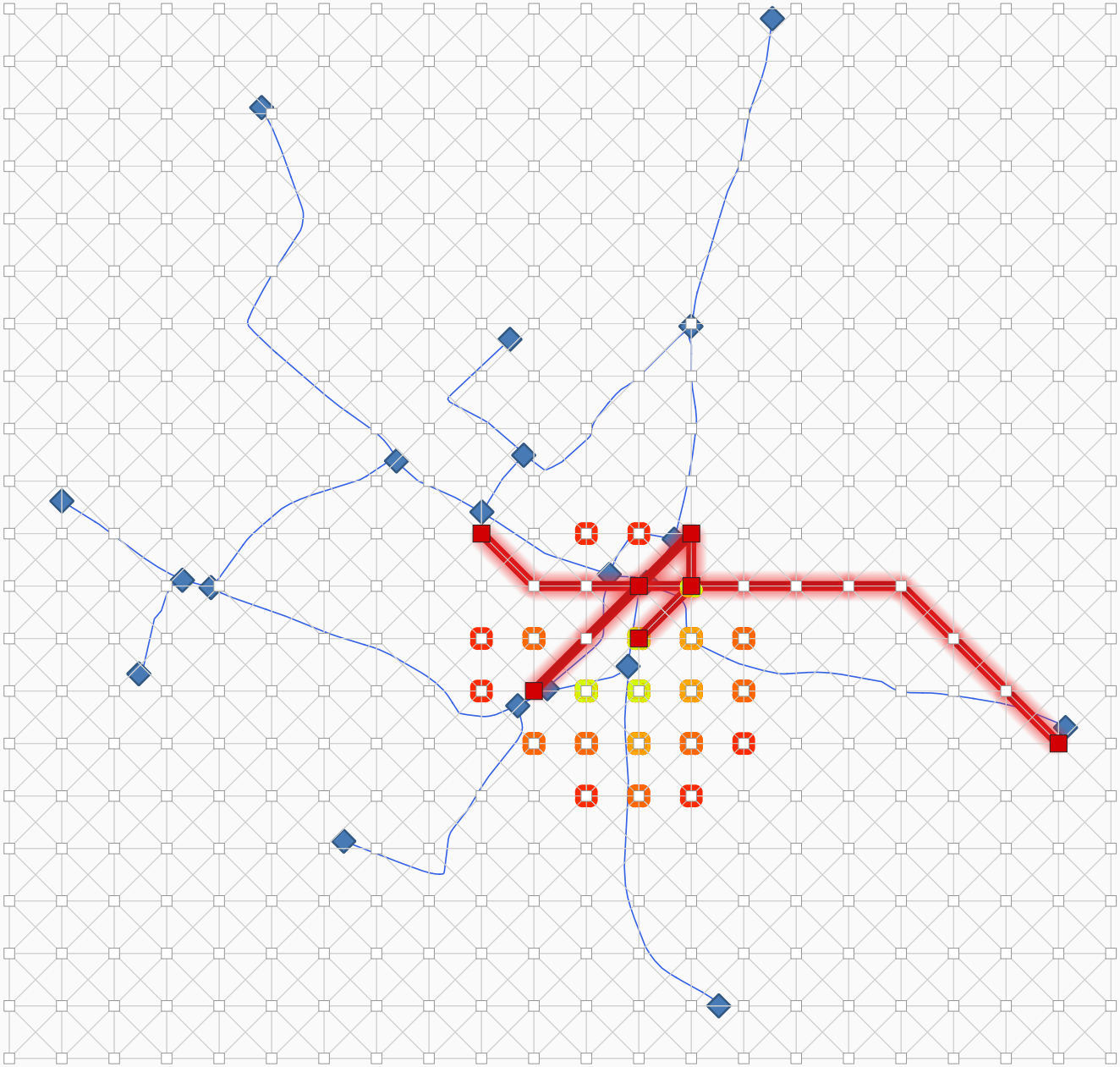

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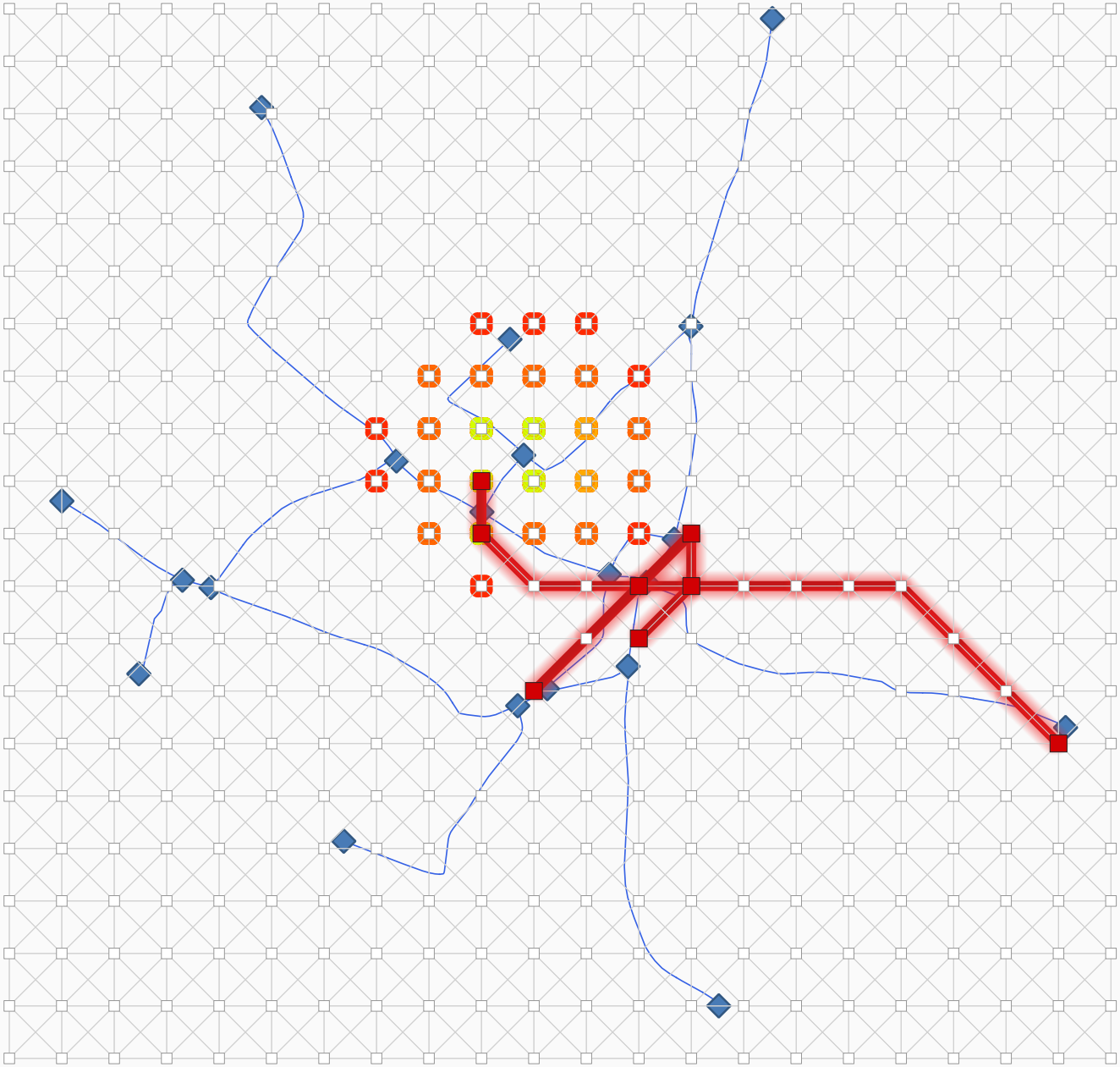

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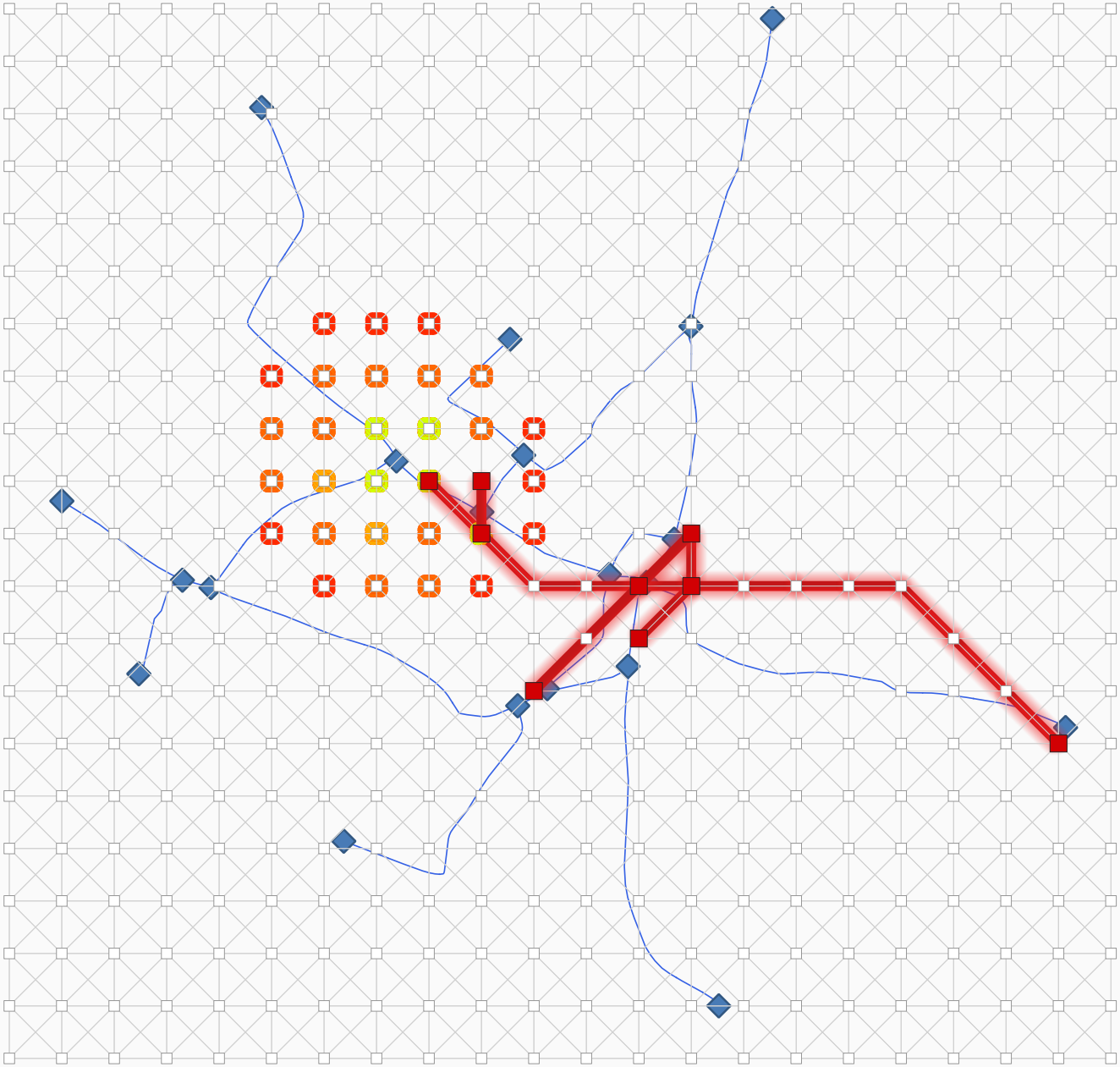

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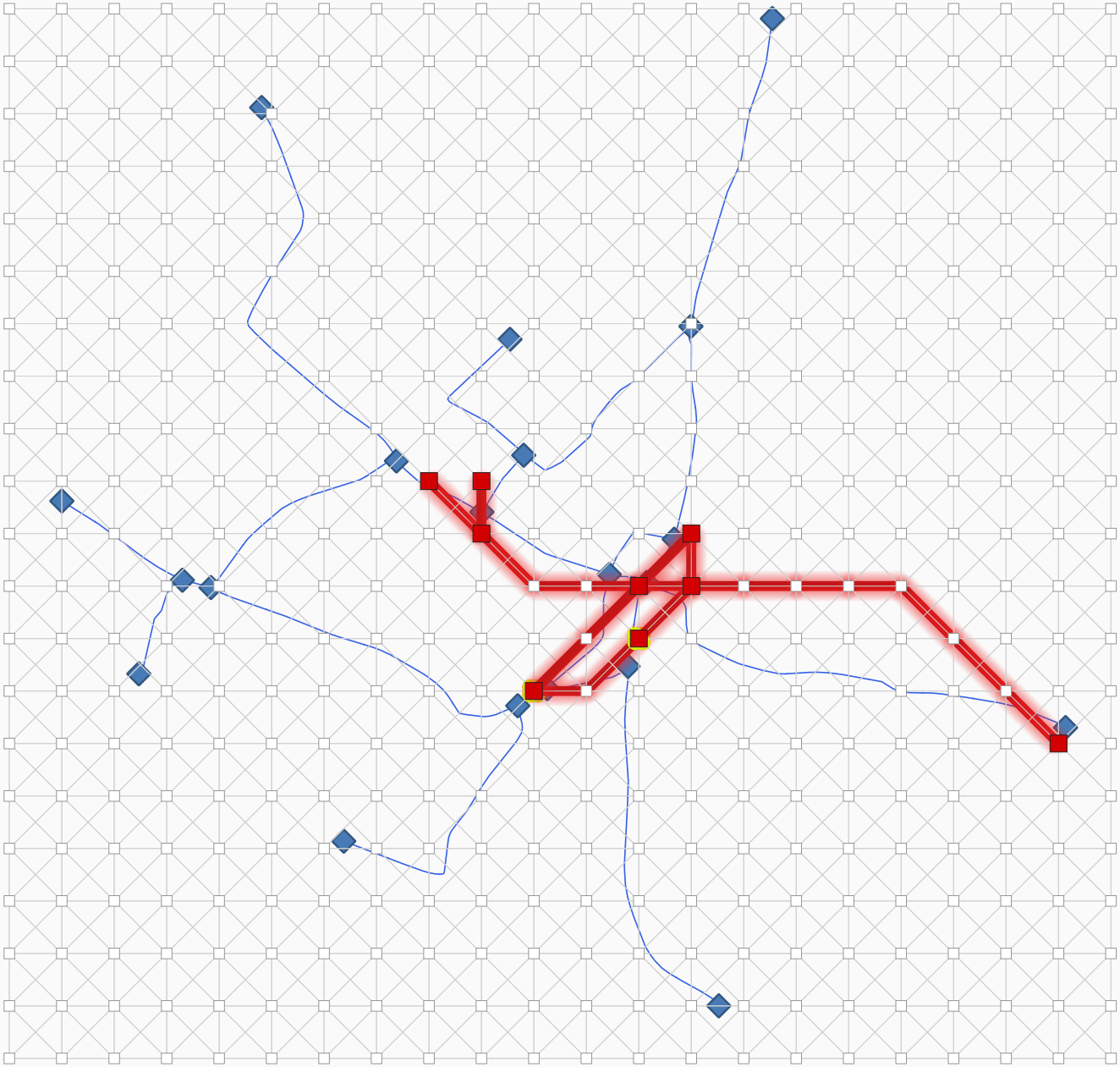

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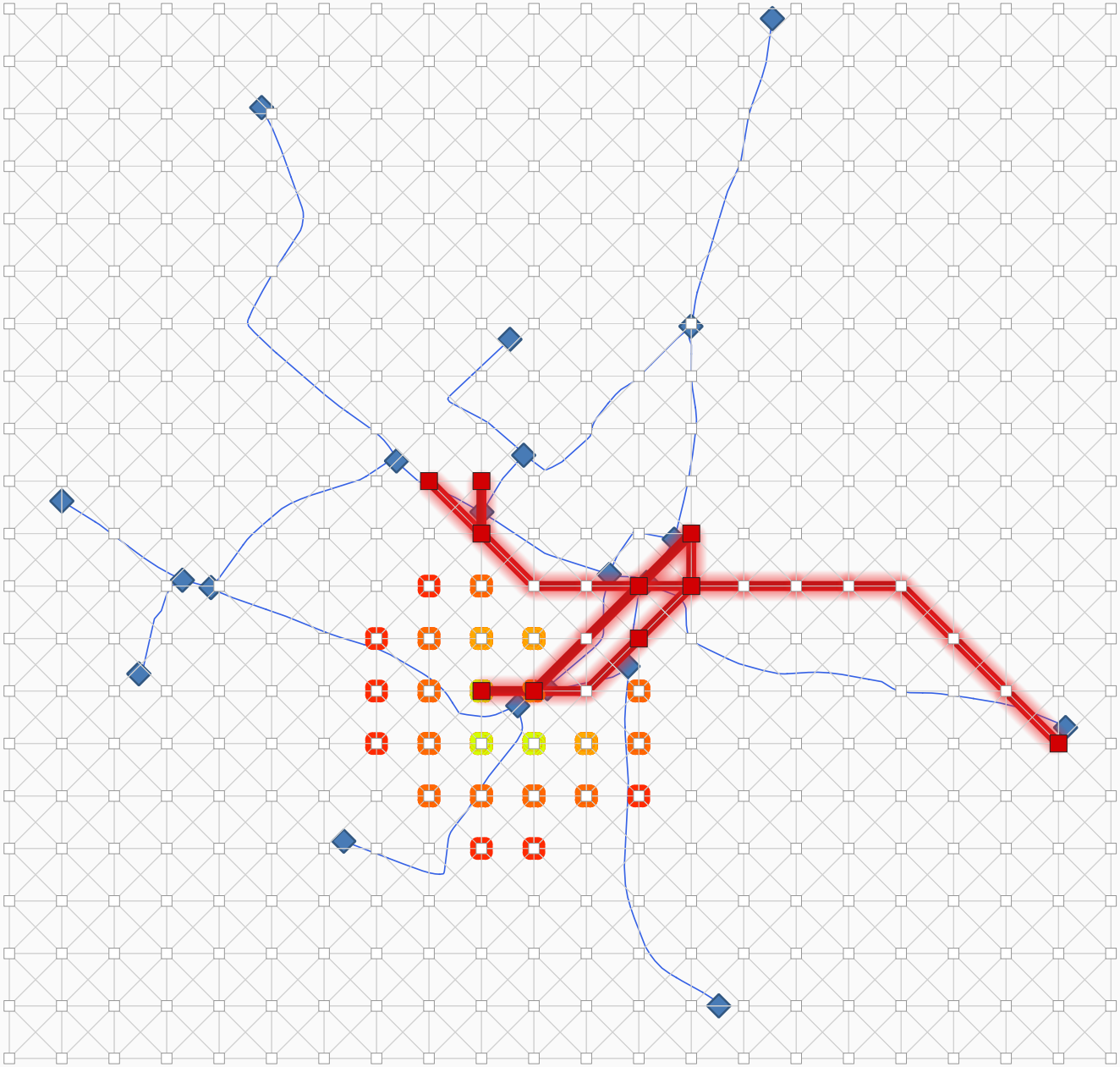

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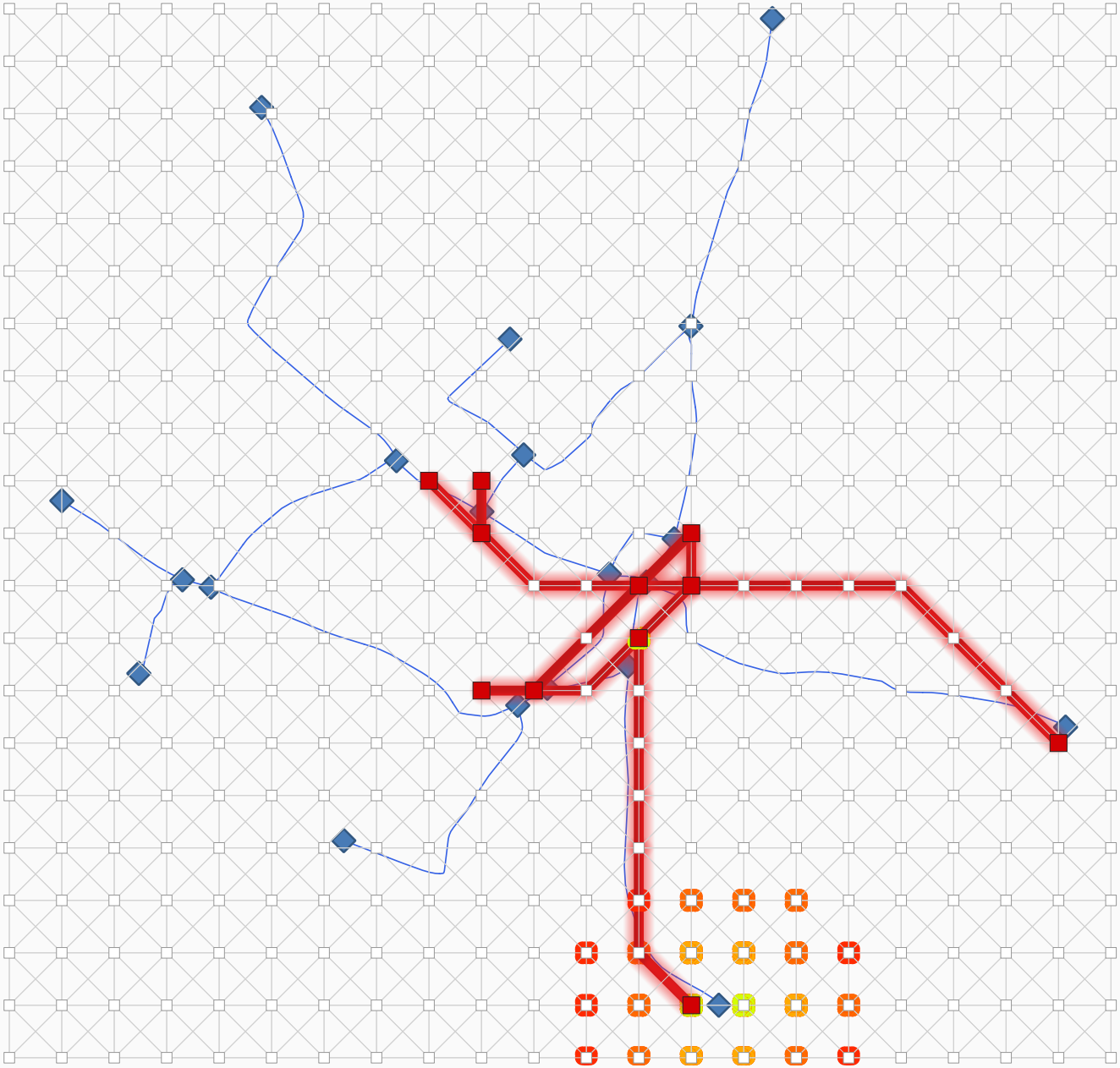

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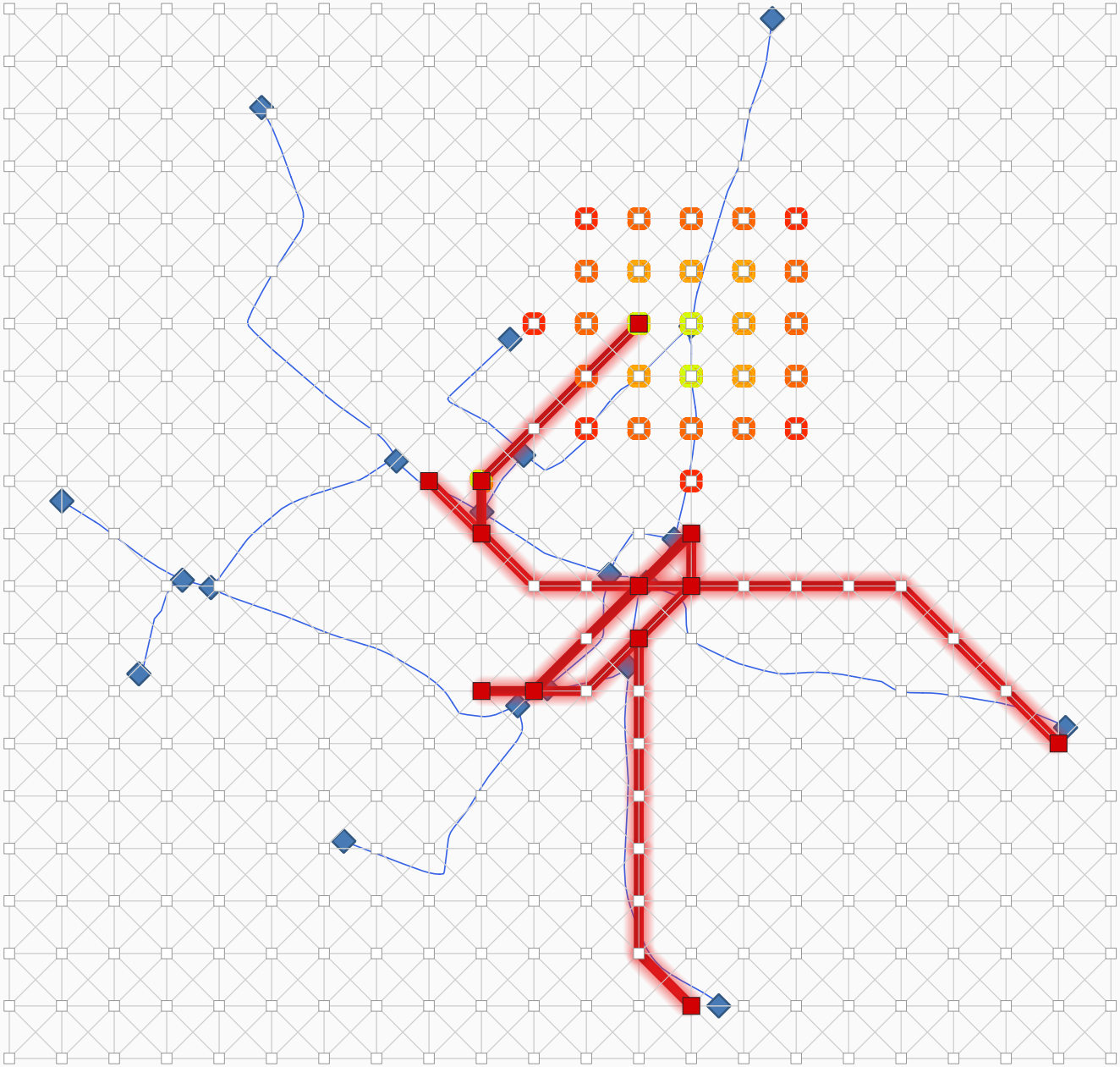

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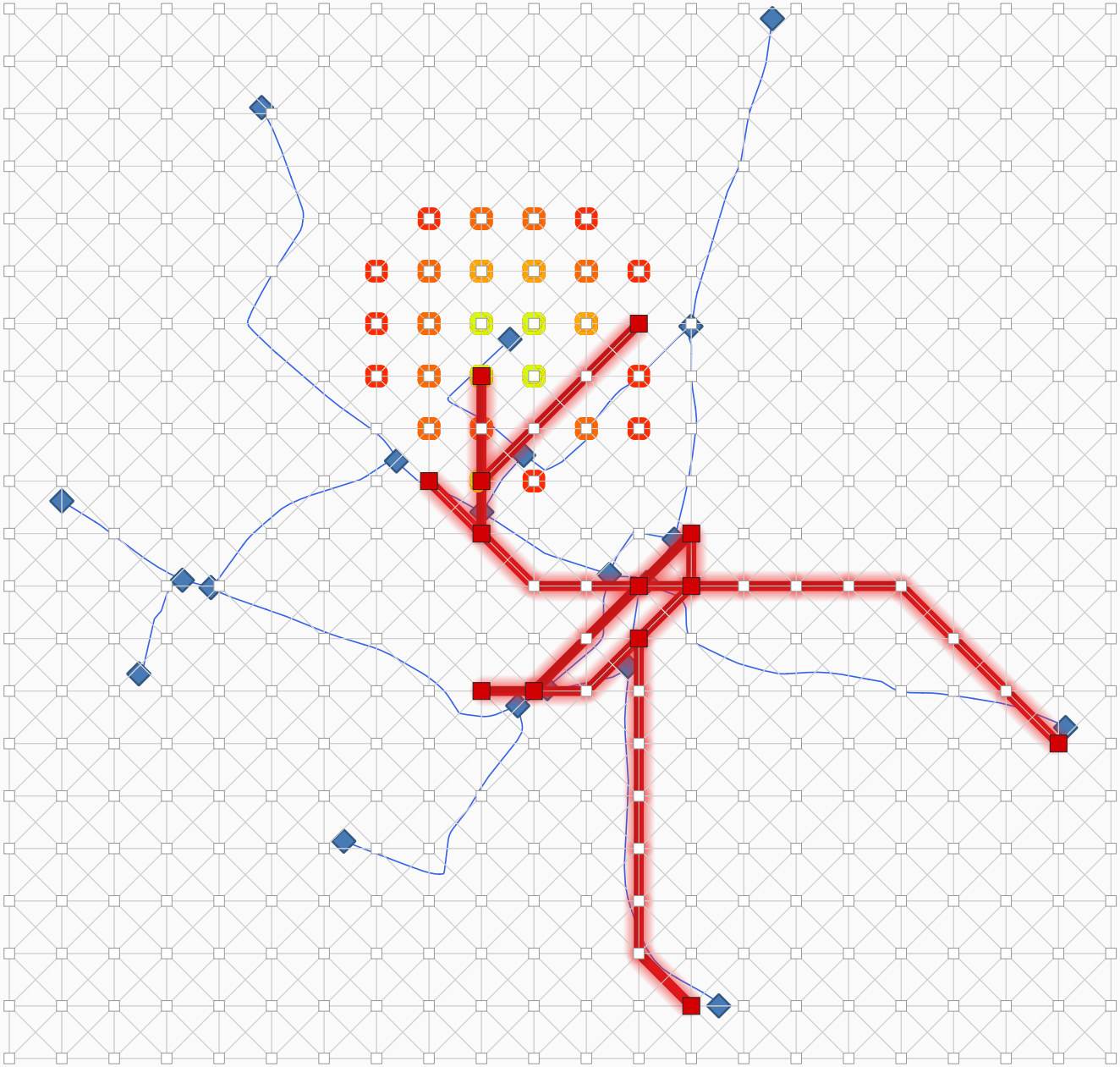

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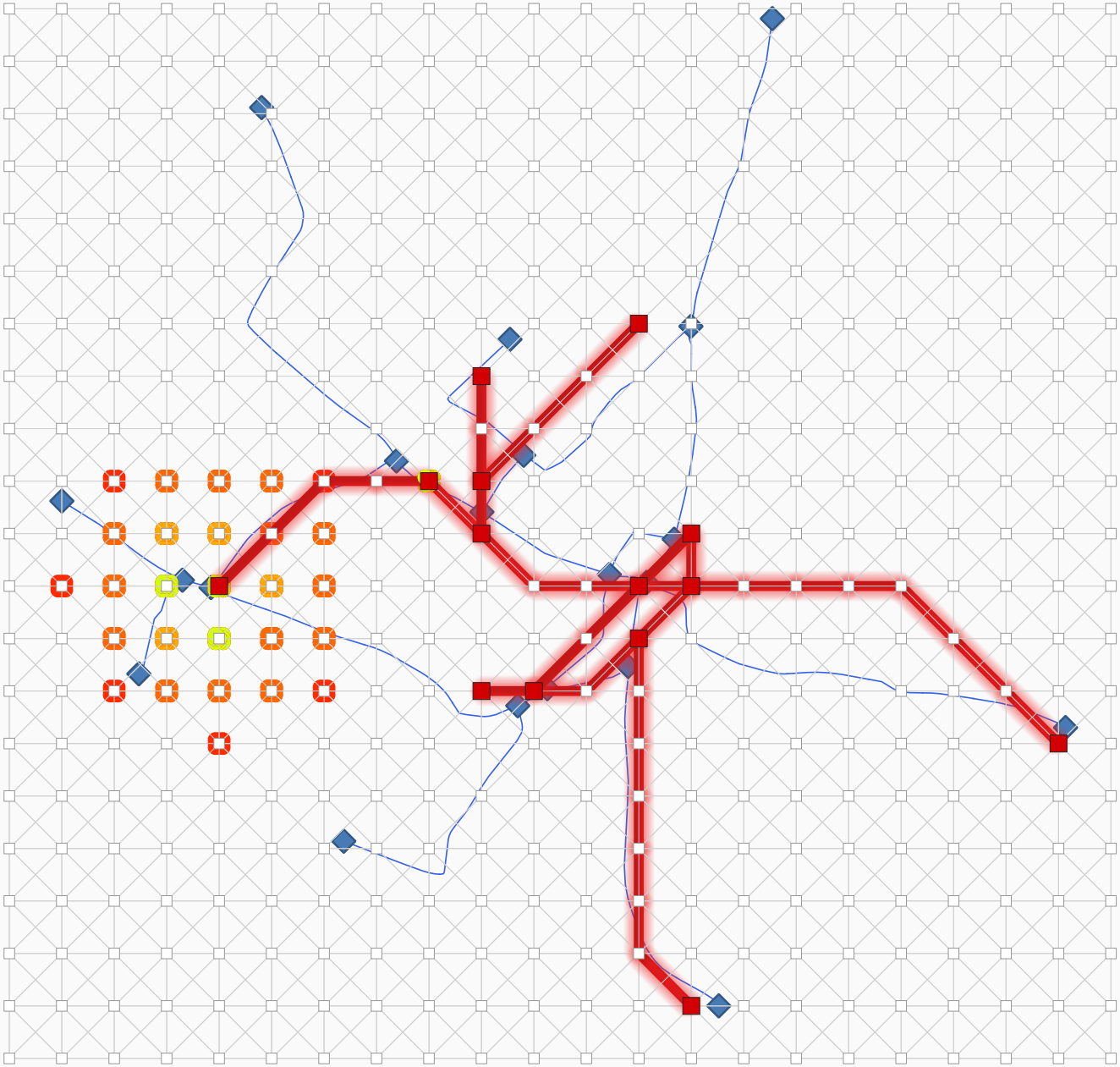

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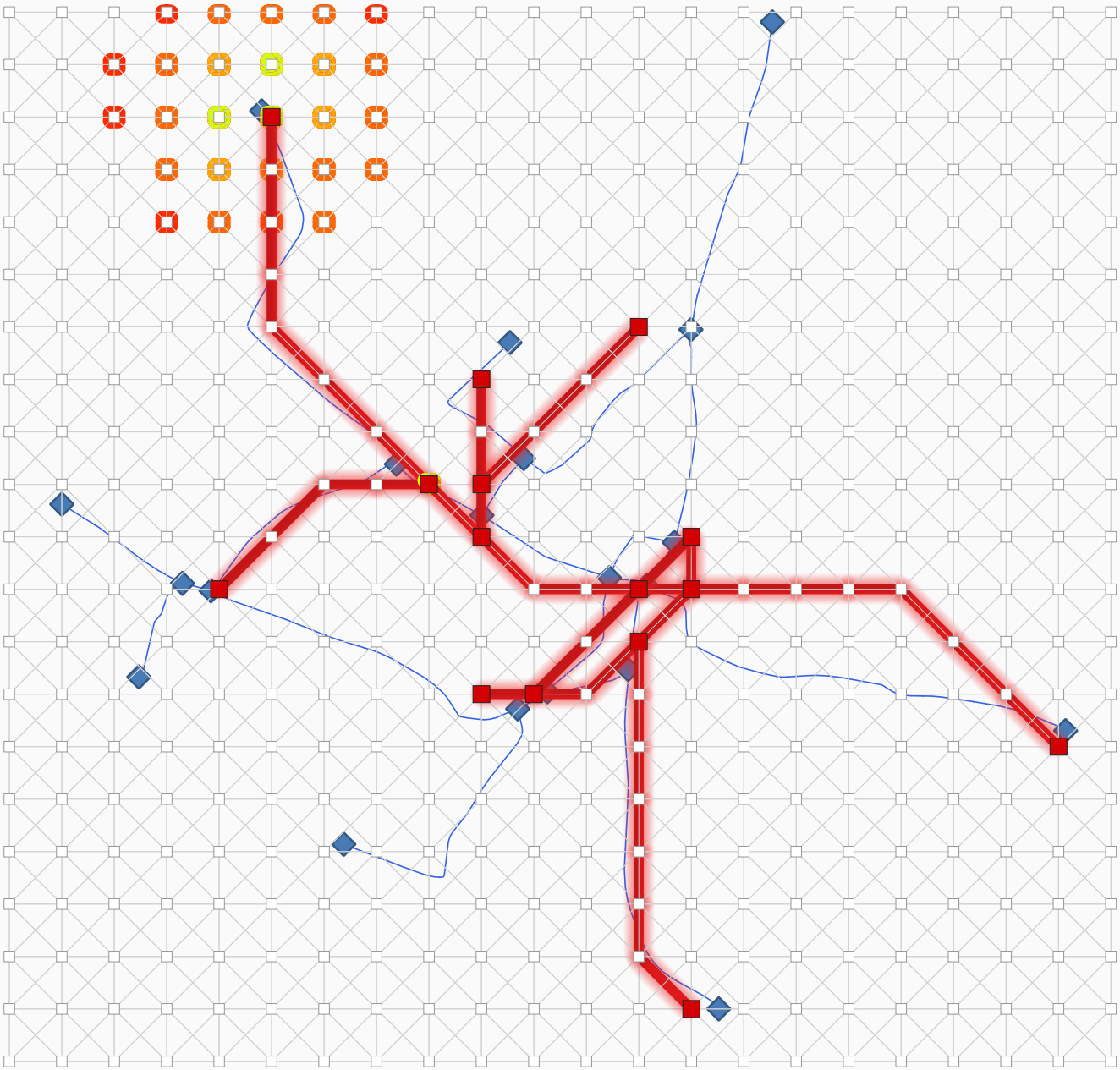

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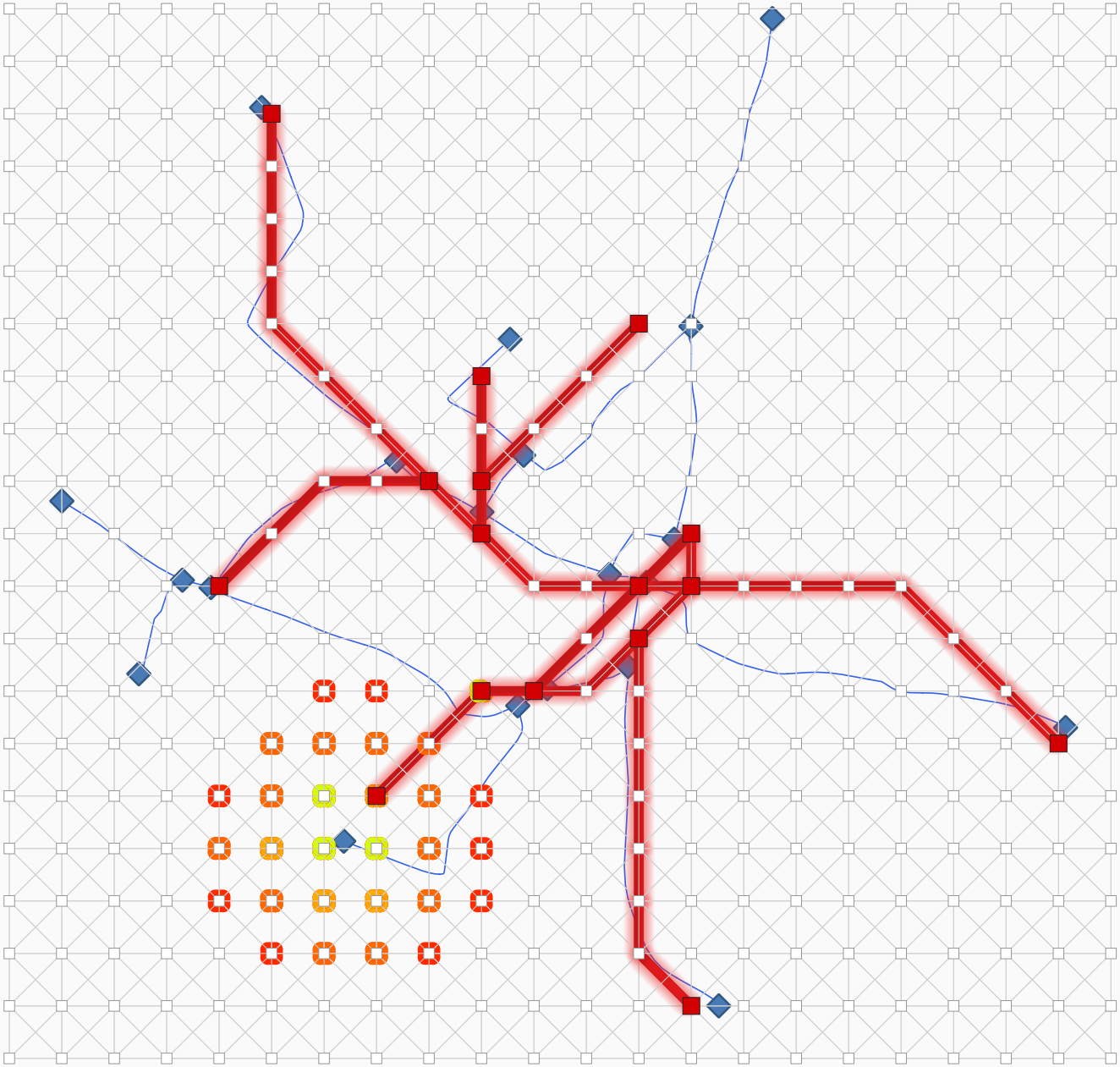

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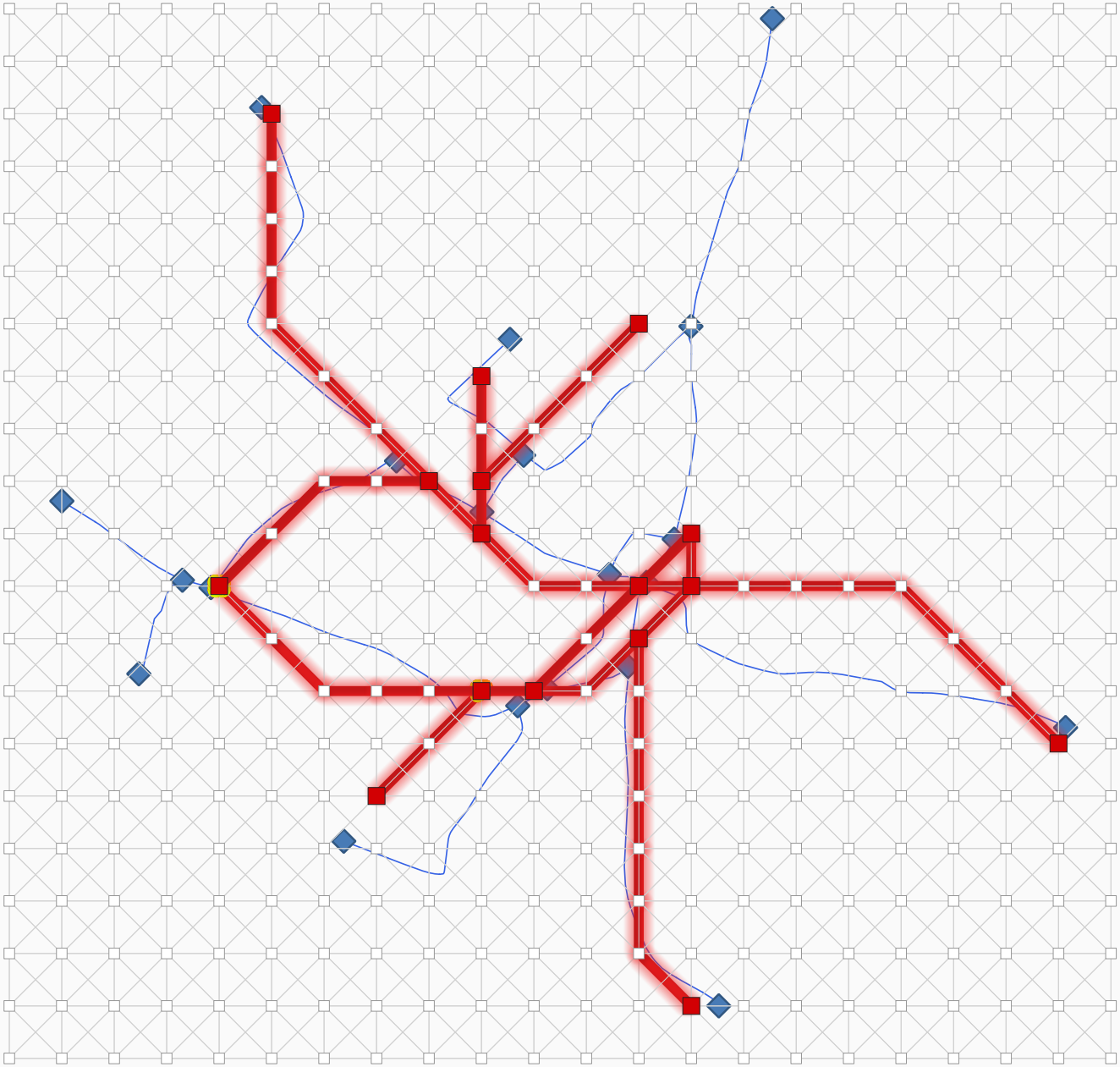

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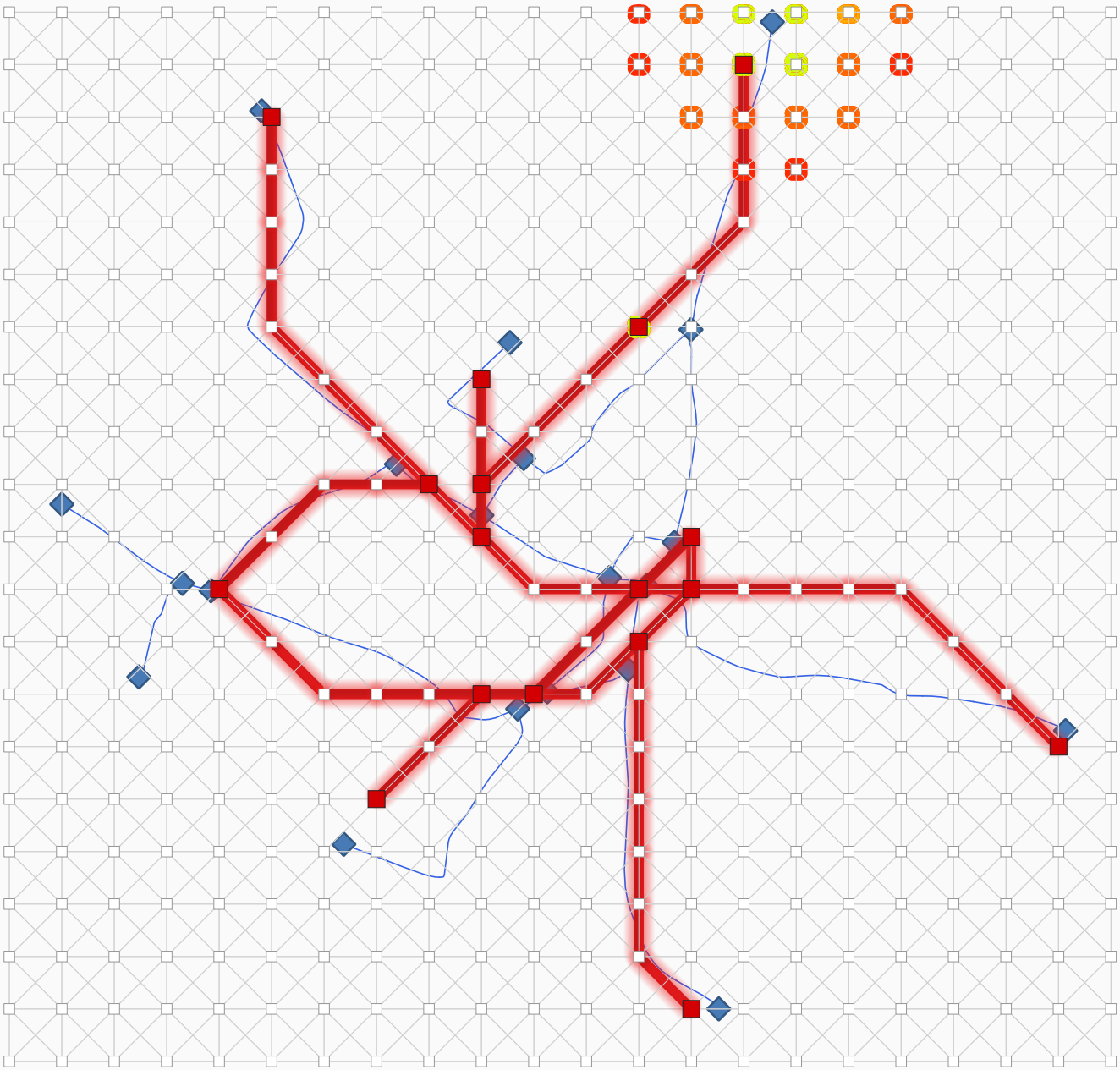

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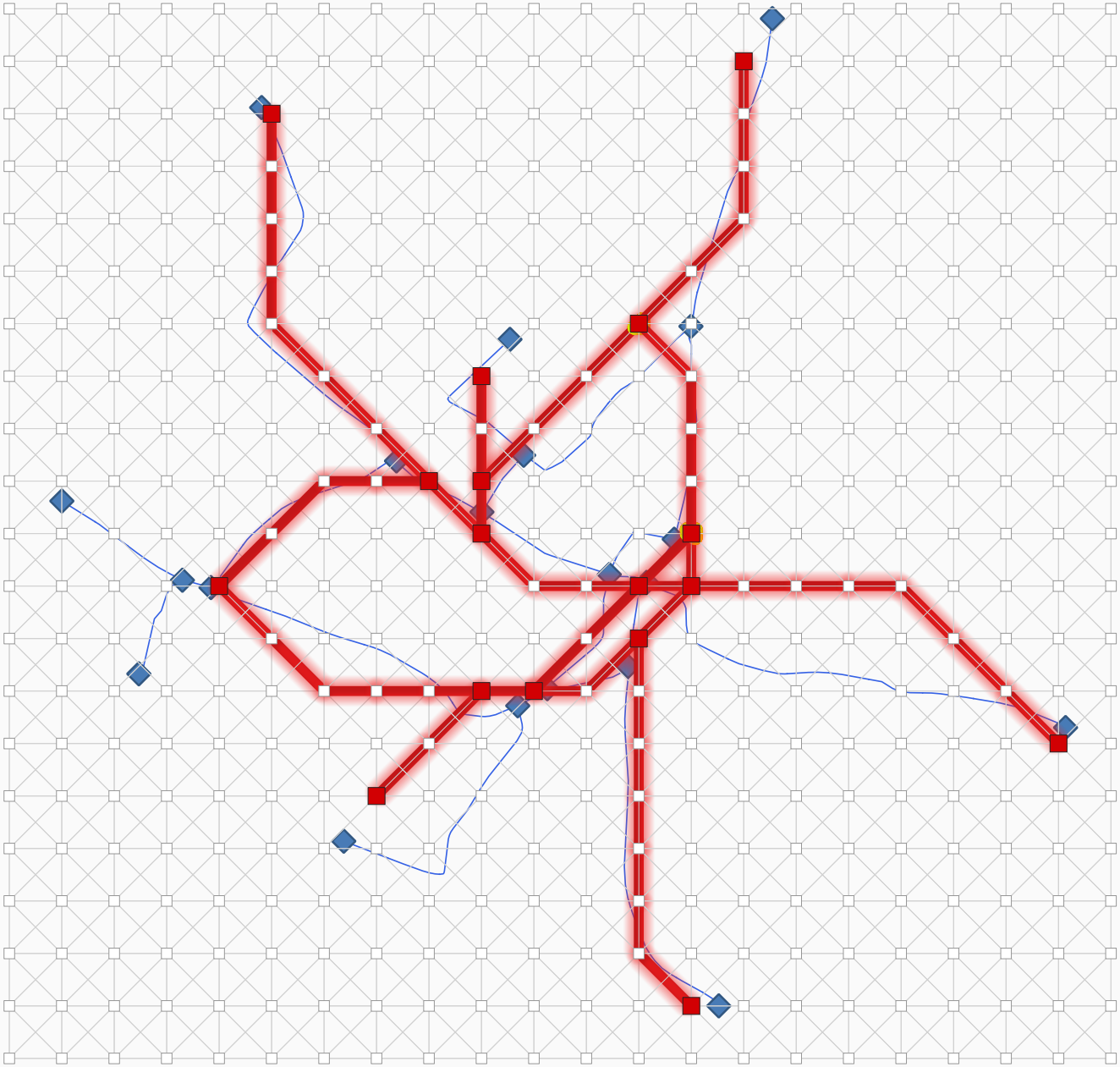

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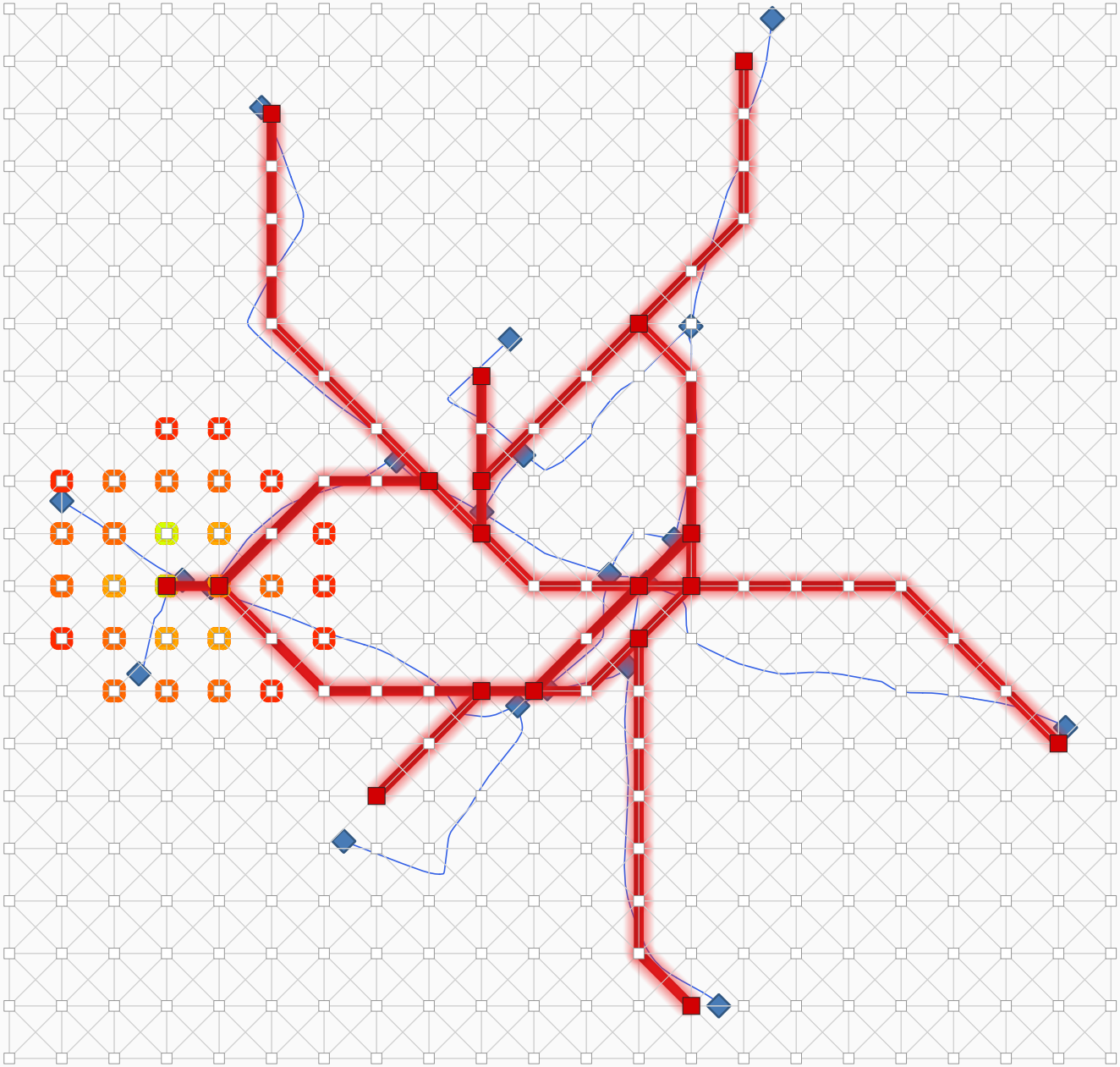

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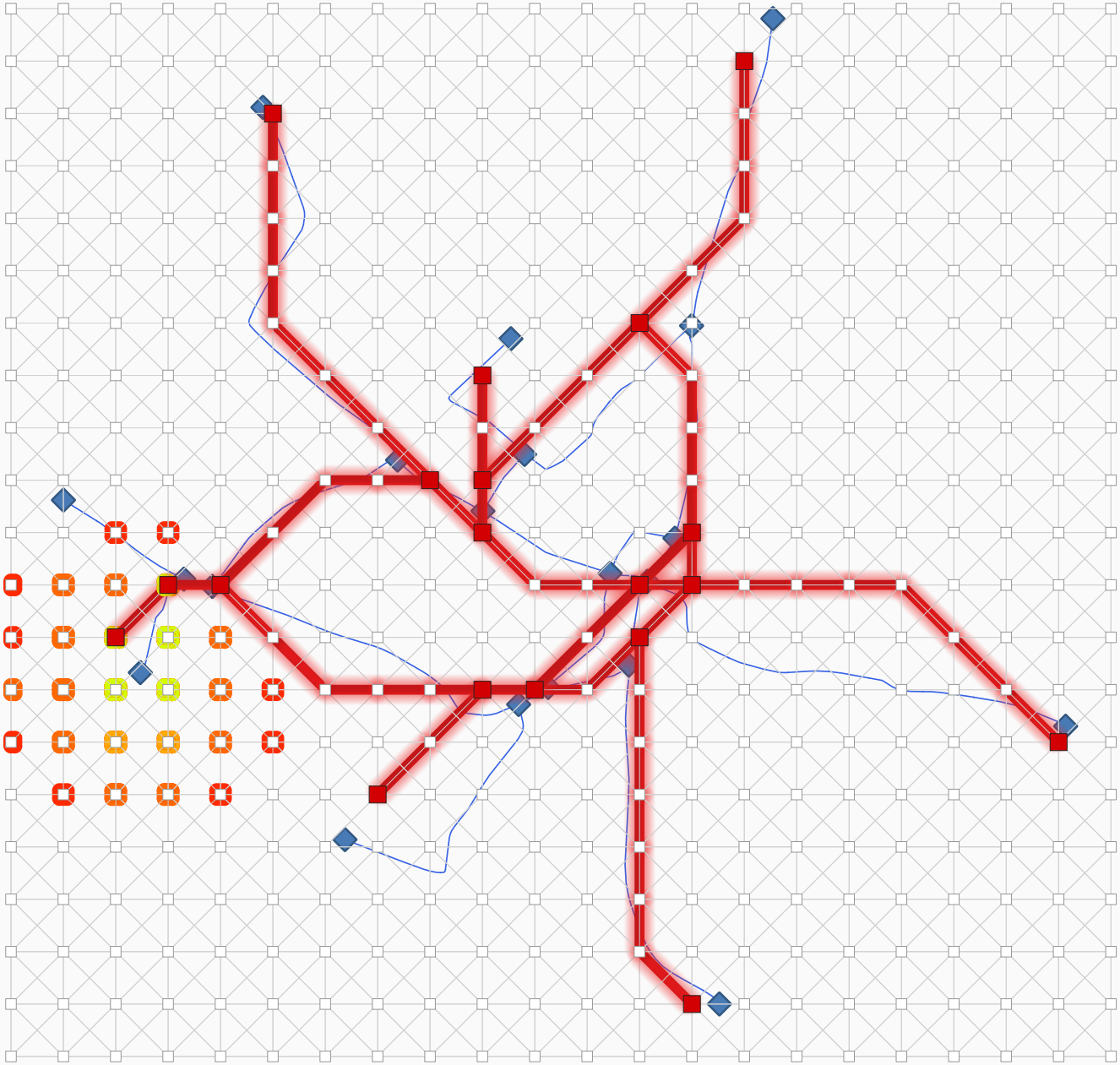

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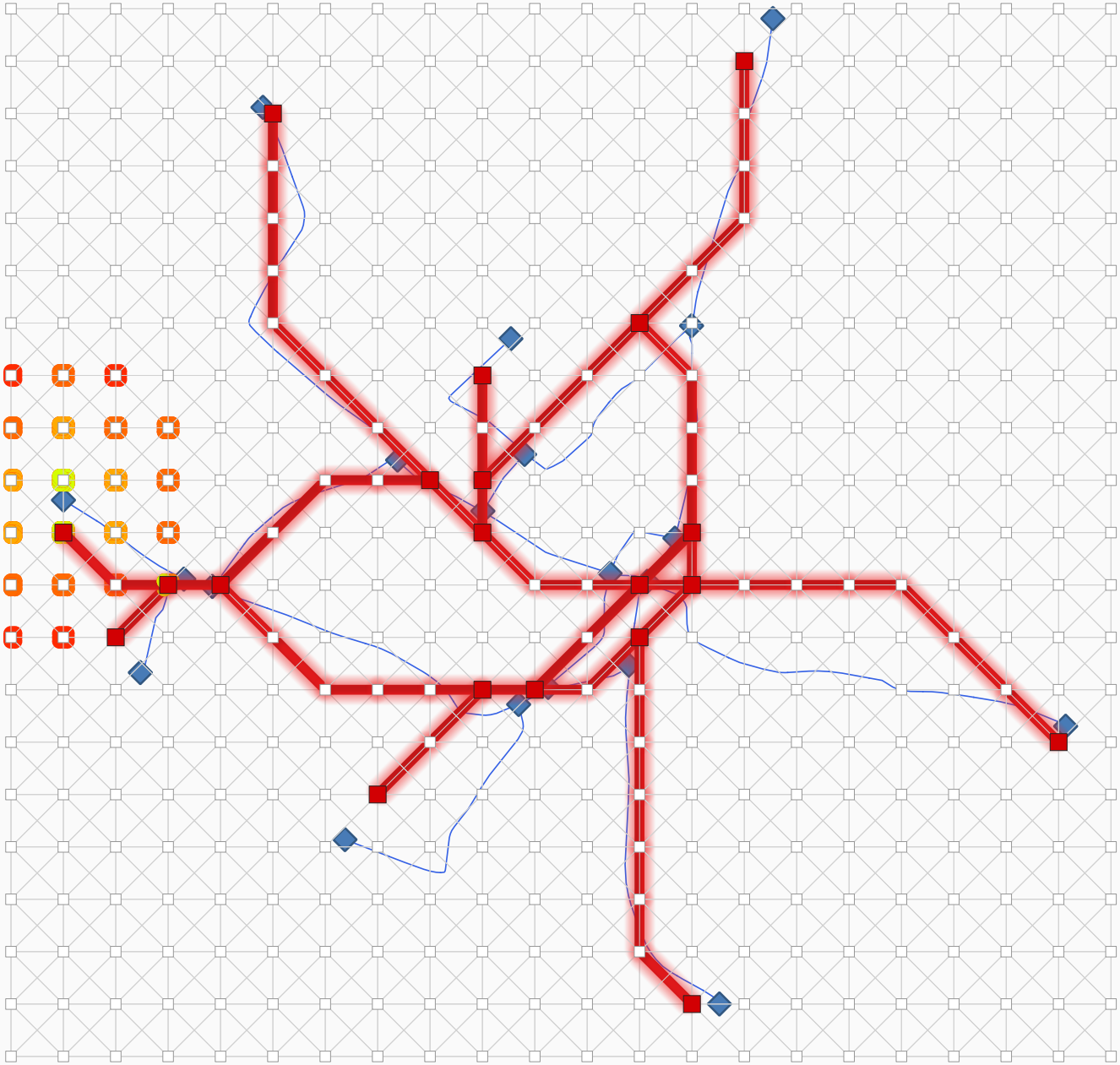

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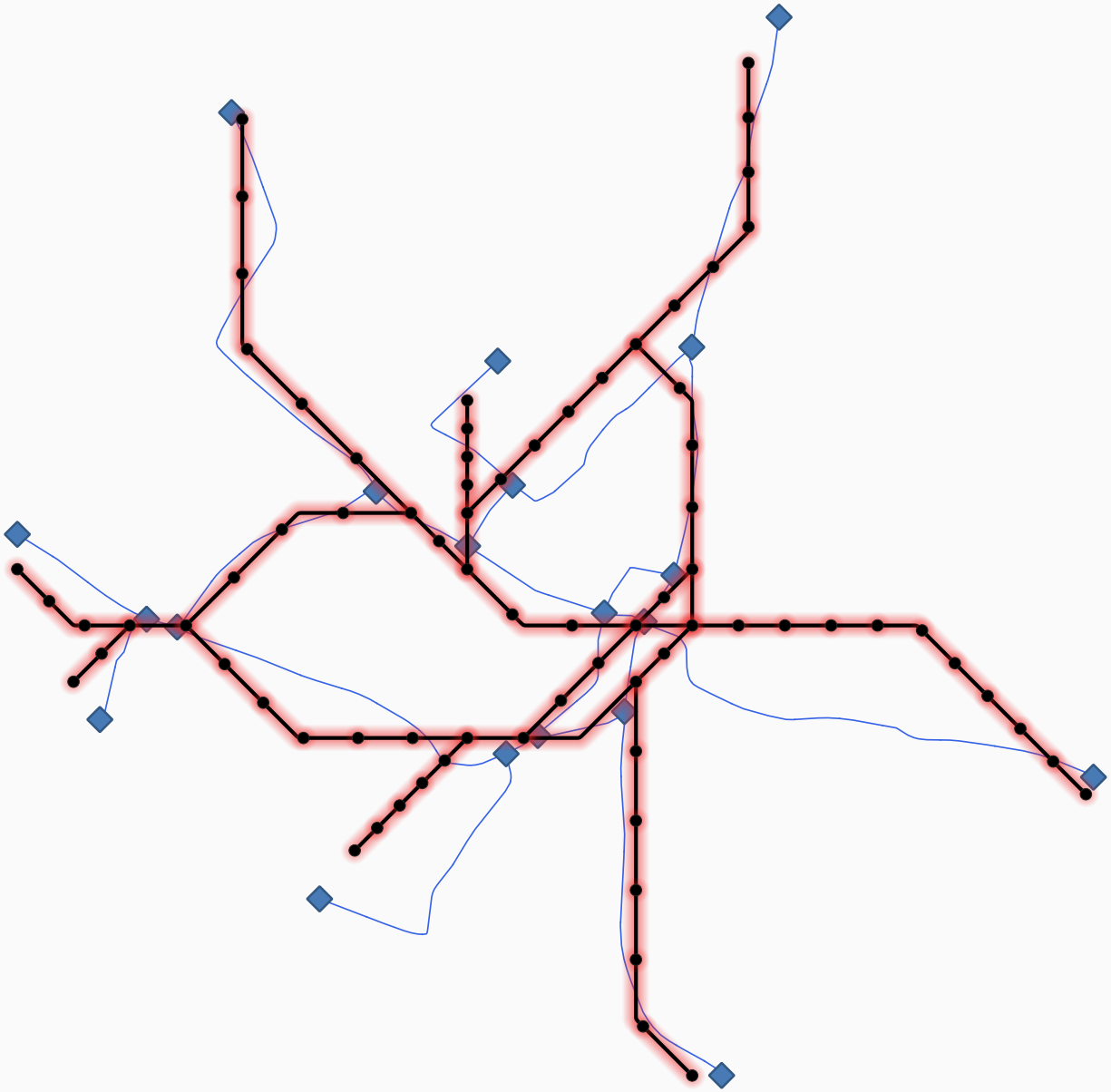

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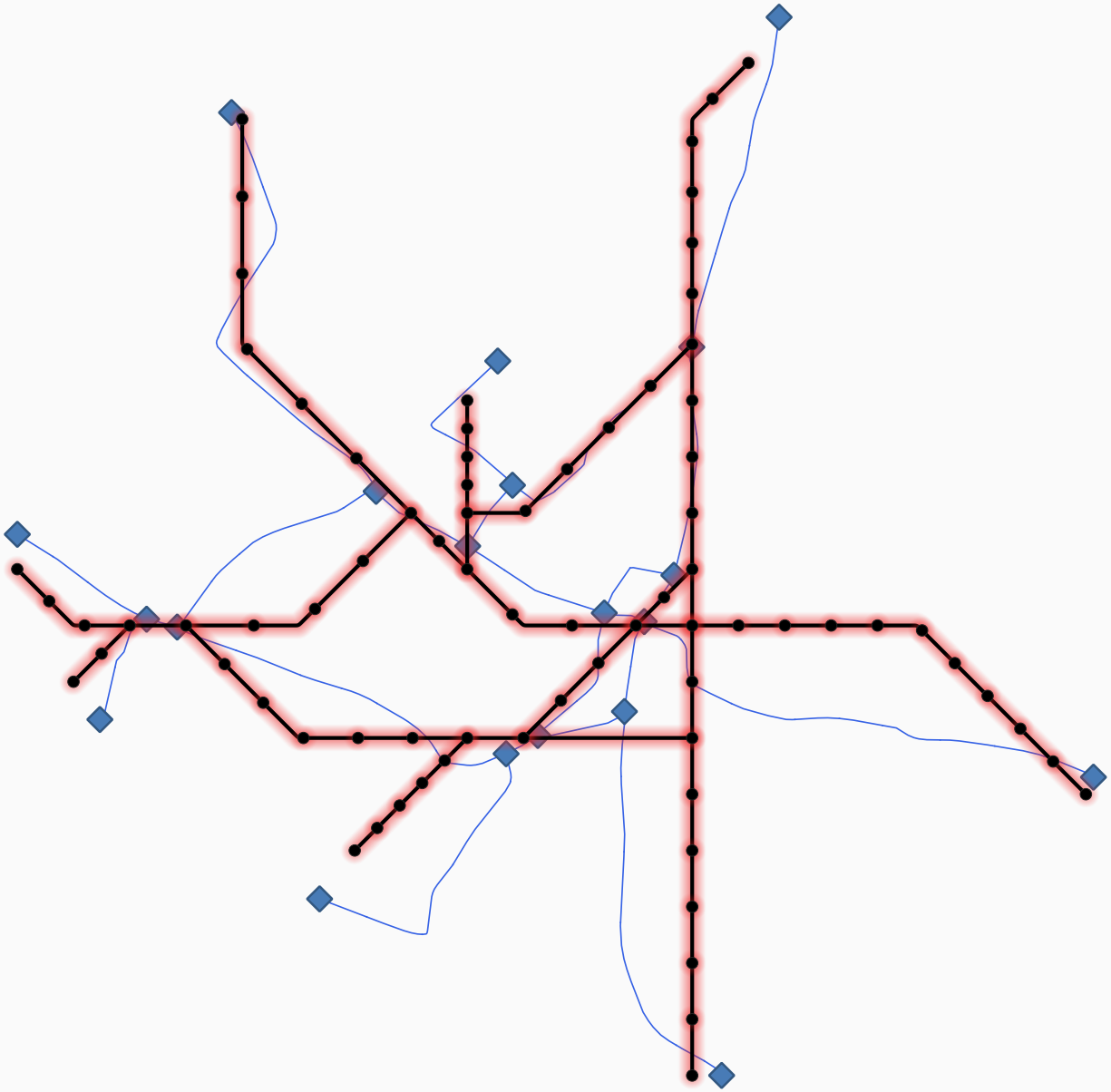

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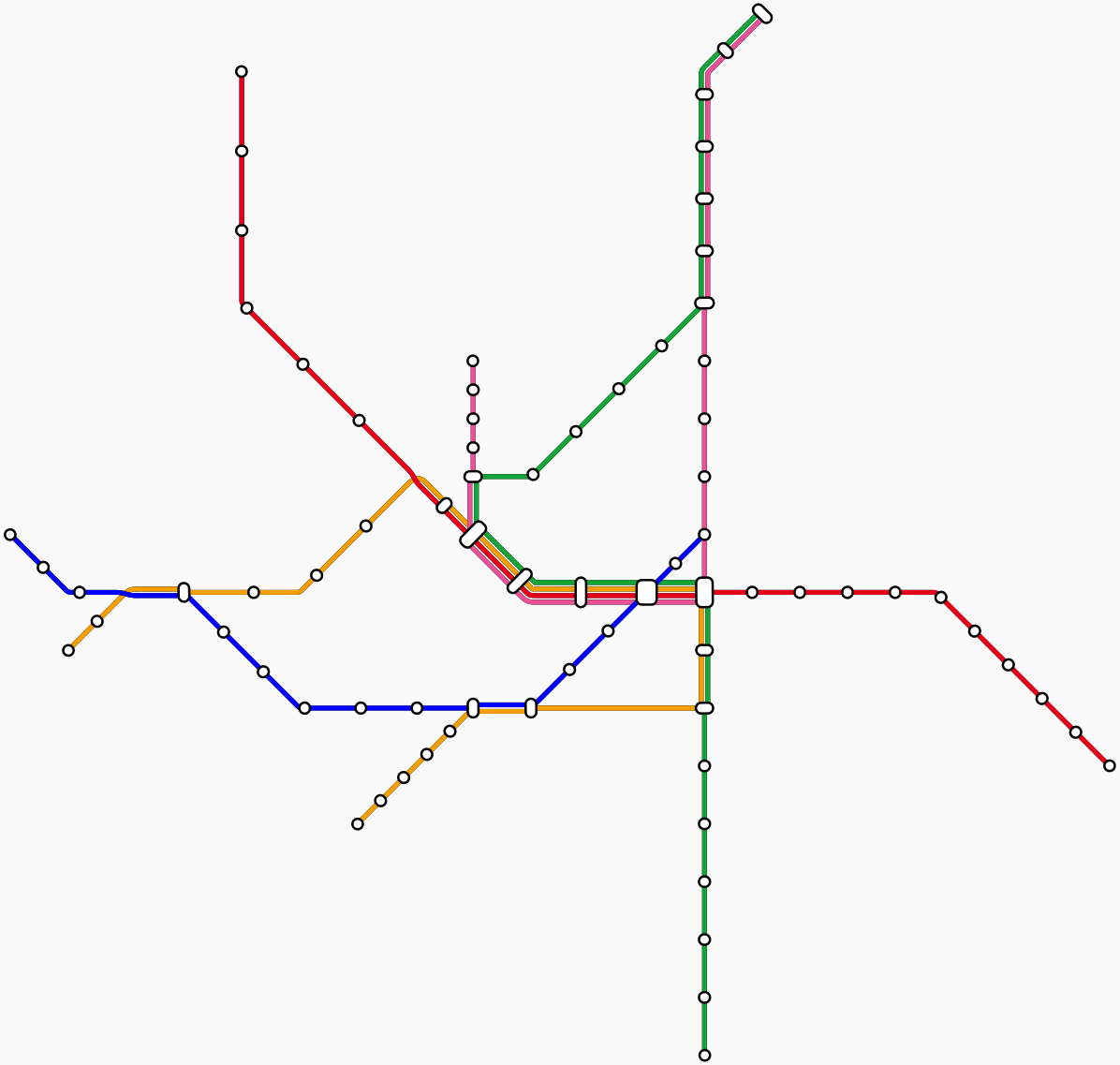

Linear Program (LP) or Approximate Approach (A)?

Final target values and approximation error δ of linear program (LP-2) and approximate approach (A-2) when degree 2 nodes where contracted first

	LP-2	t	A-2	t	δ
Freiburg	144.6	11m	146.5	73ms	**1.3%**
Vienna	170.5	13h	175.1	171ms	**2.7%**
Stuttgart	383.2	12h	399.2	510ms	**4.1%**
Berlin	315.4	20h	326.0	513ms	**3.4%**
Sydney	360.6	7h	361.4	250ms	**0.2%**
London	$\geq$669.2	—	758.3	2.1 s	$\leq$**14%**

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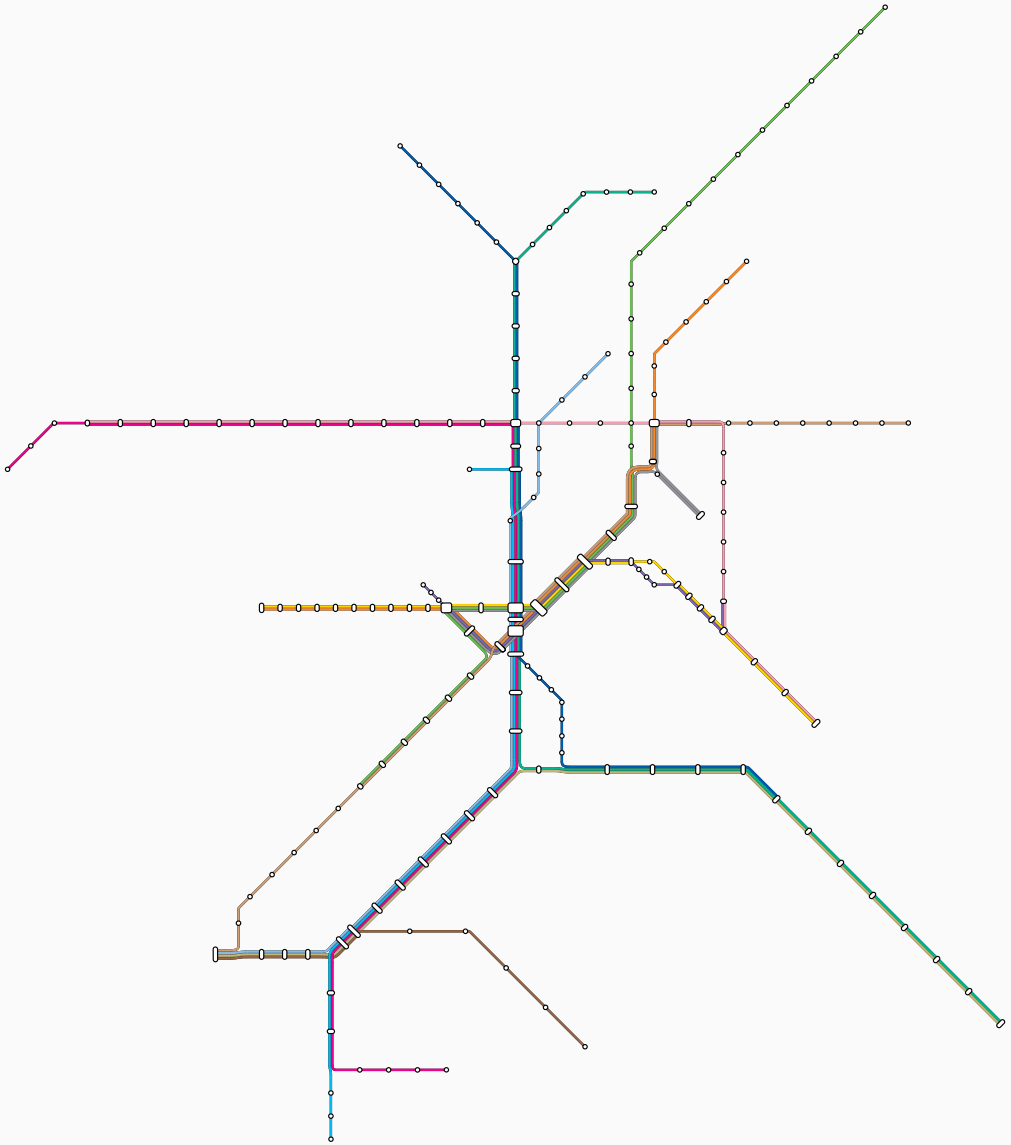

Linear Program (LP)

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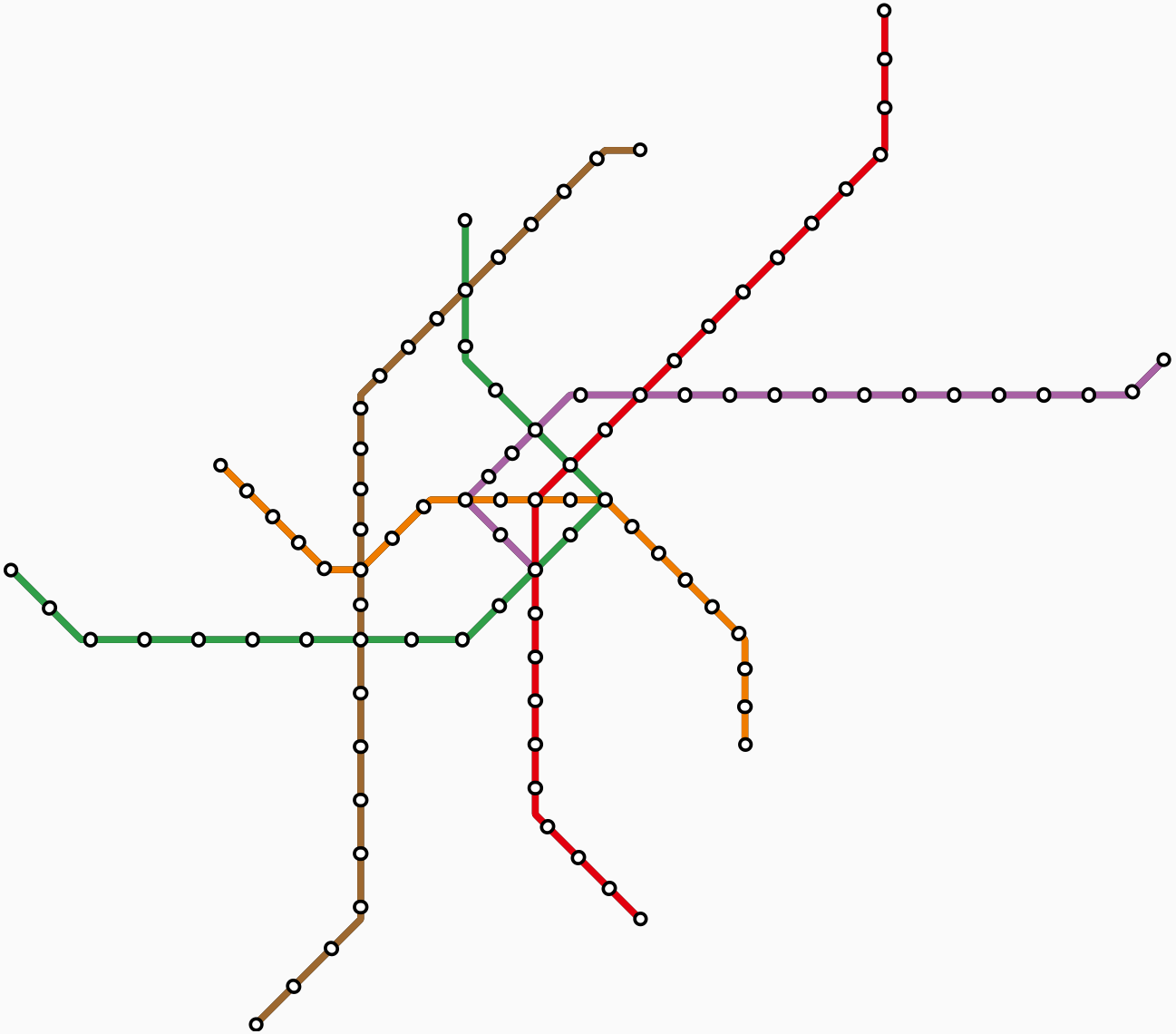
Linear Program (LP)

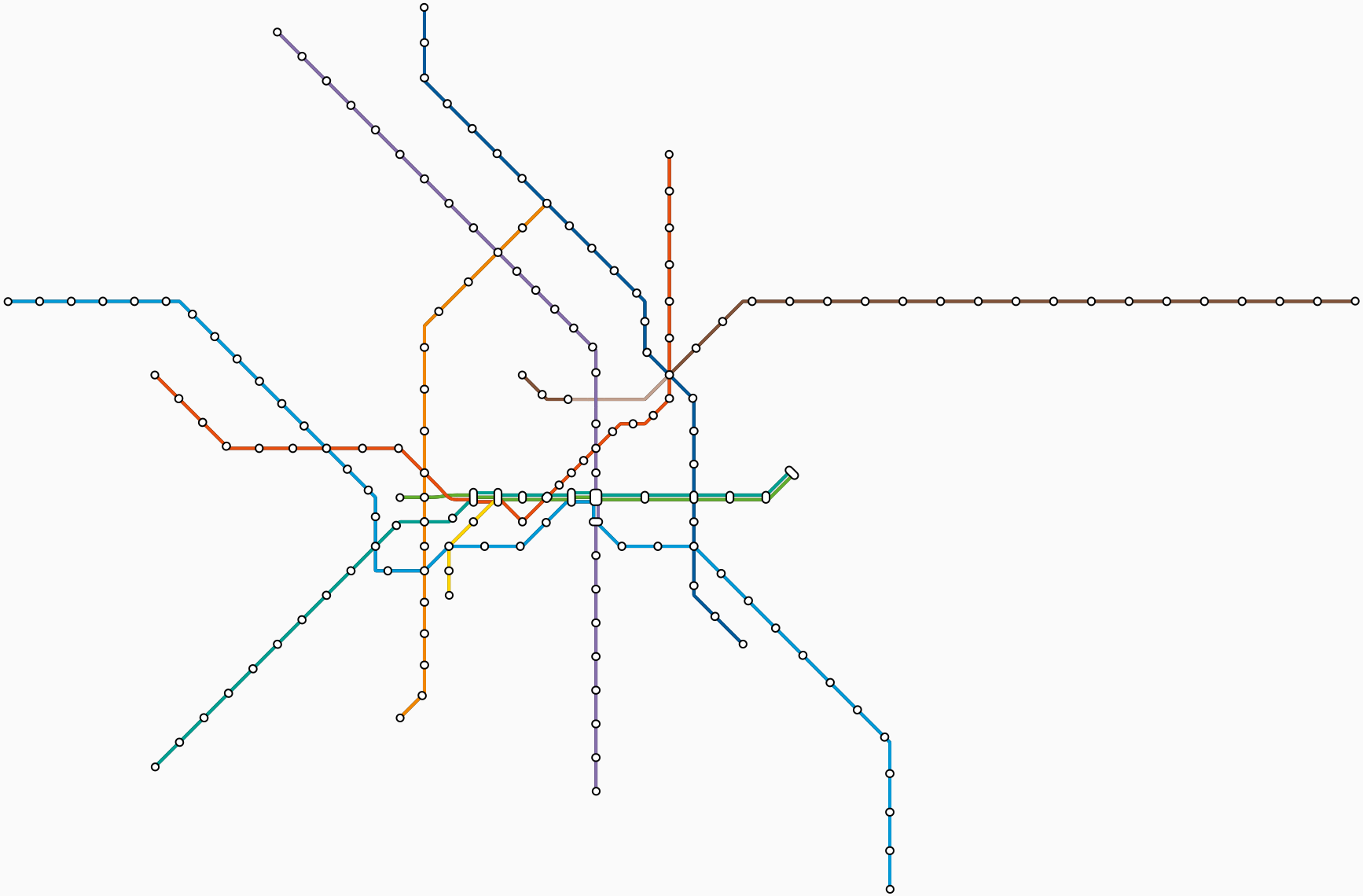
Approximate Approach (A)

Results



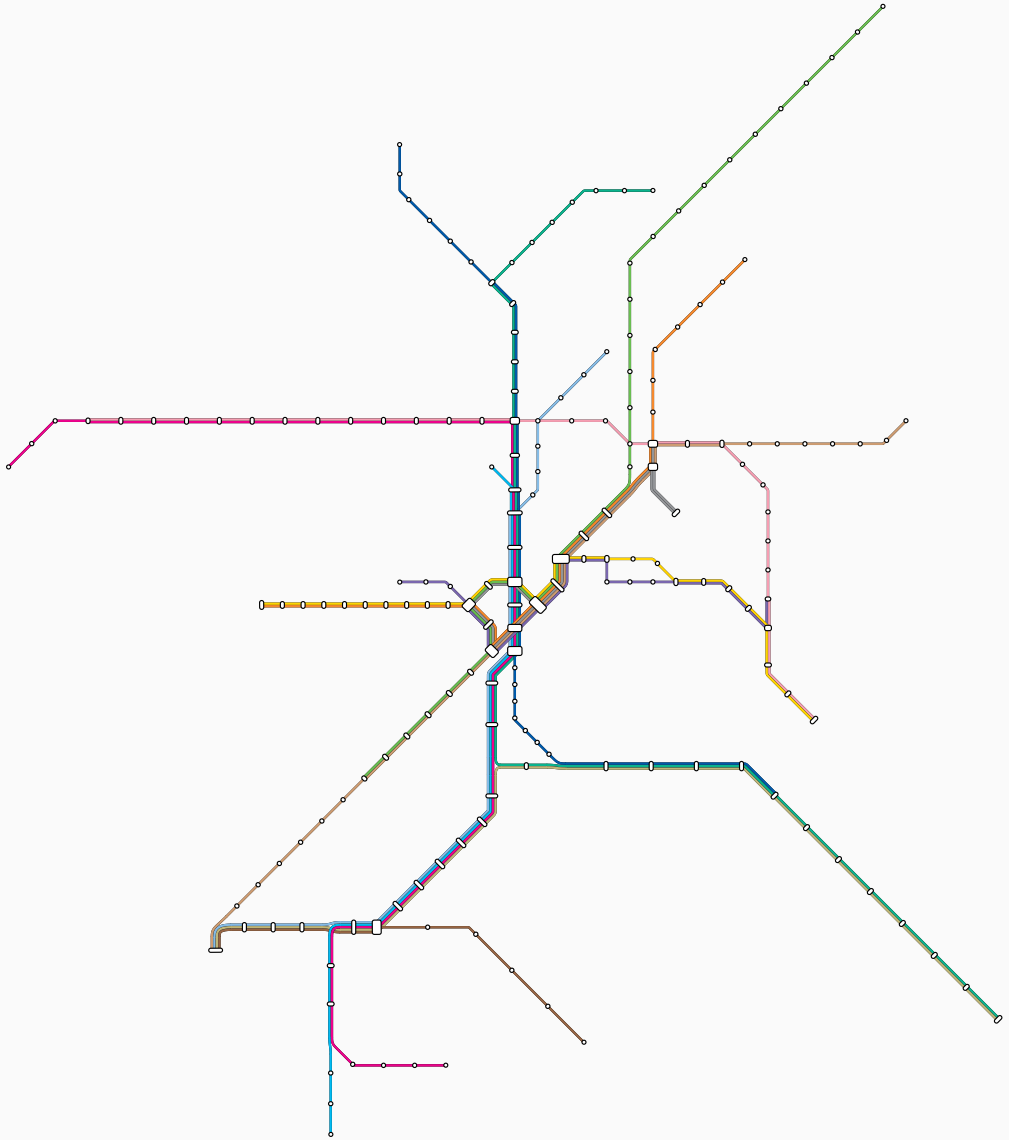
Vienna, drawn with approx. approach in **202 ms**.

Results



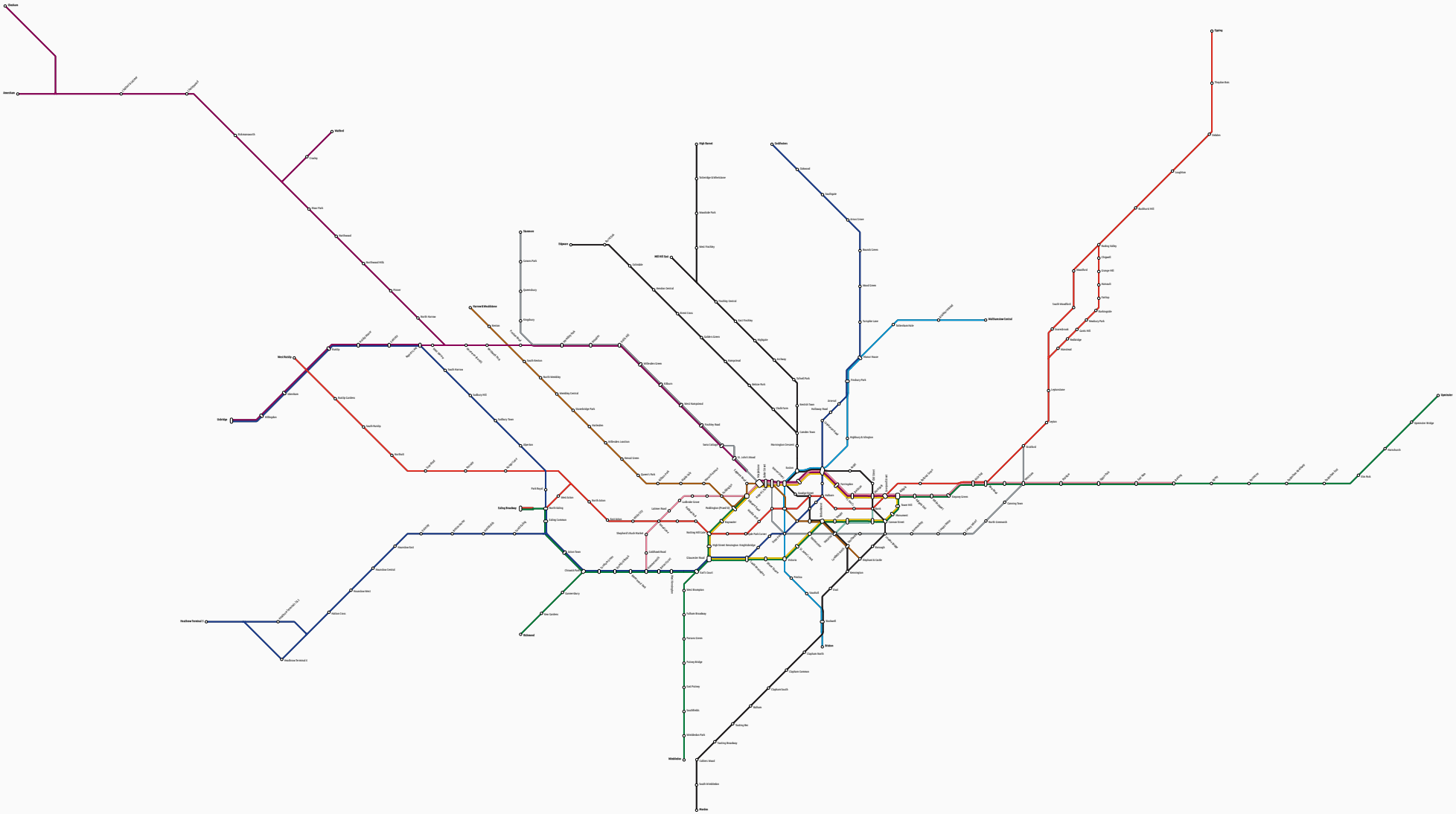
Berlin, drawn with approx. approach in **764 ms**.

Results



Stuttgart, drawn with approx. approach in **843 ms**.

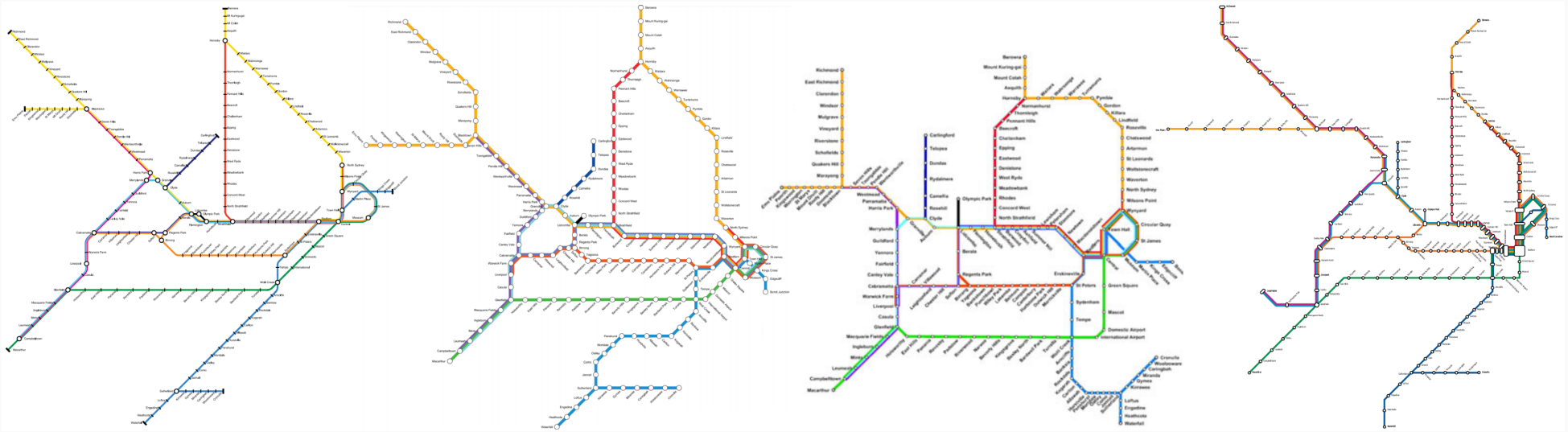
Results



London (labeled), drawn with approx. approach in **2.7 s**.

Comparison to other work

Sydney light rail network



Nöllenburg et al.
$t = 23\text{m}$

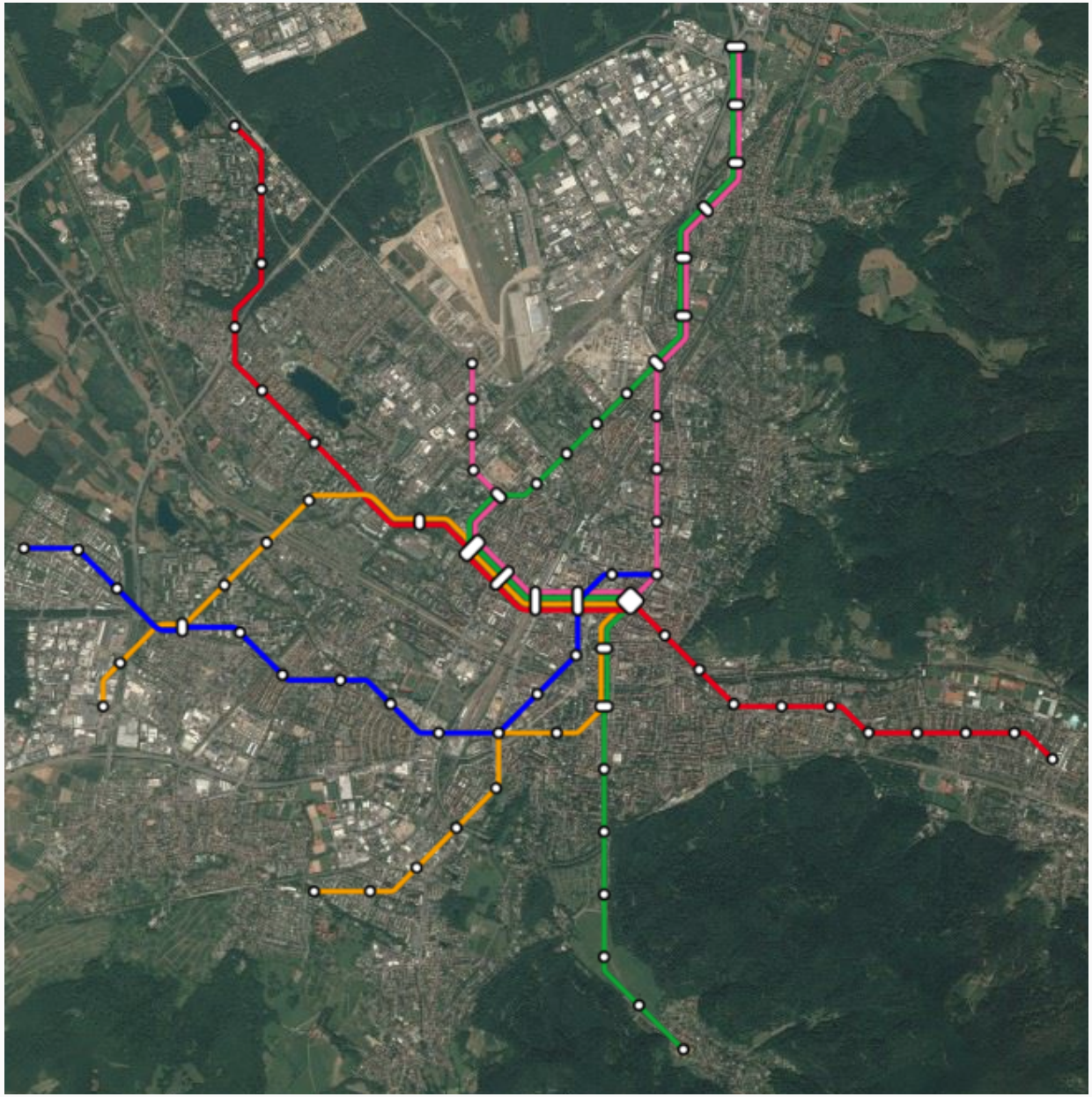
Wang et al. (2011)
$t = 816\text{ms}$

Wang et al. (2016)
$t \approx 150\text{ms}$ *

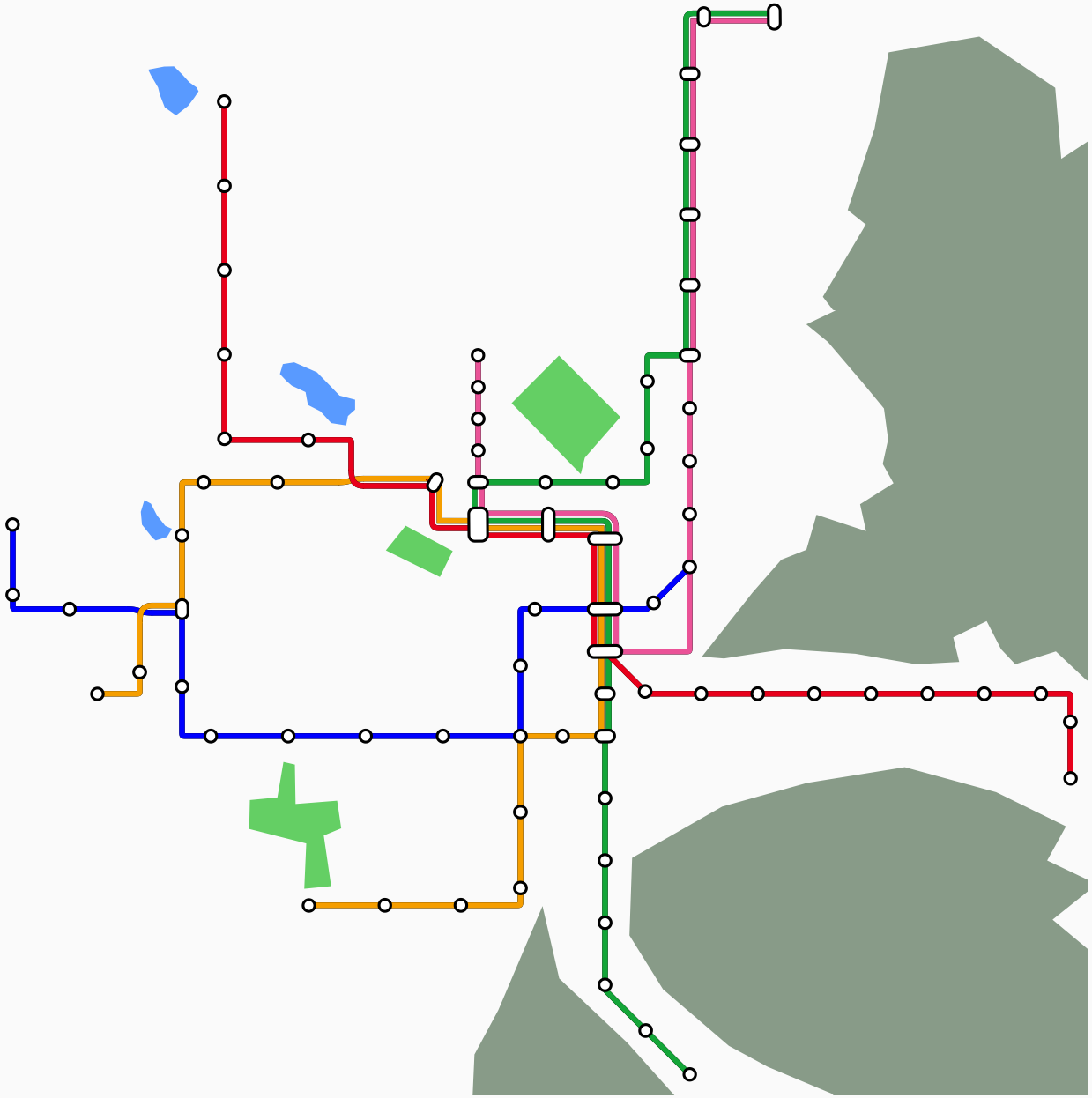
Our approach
$t = 370ms$

* No time was reported, given time is for a network of similar size (Berlin)

Results



Results



Future Work

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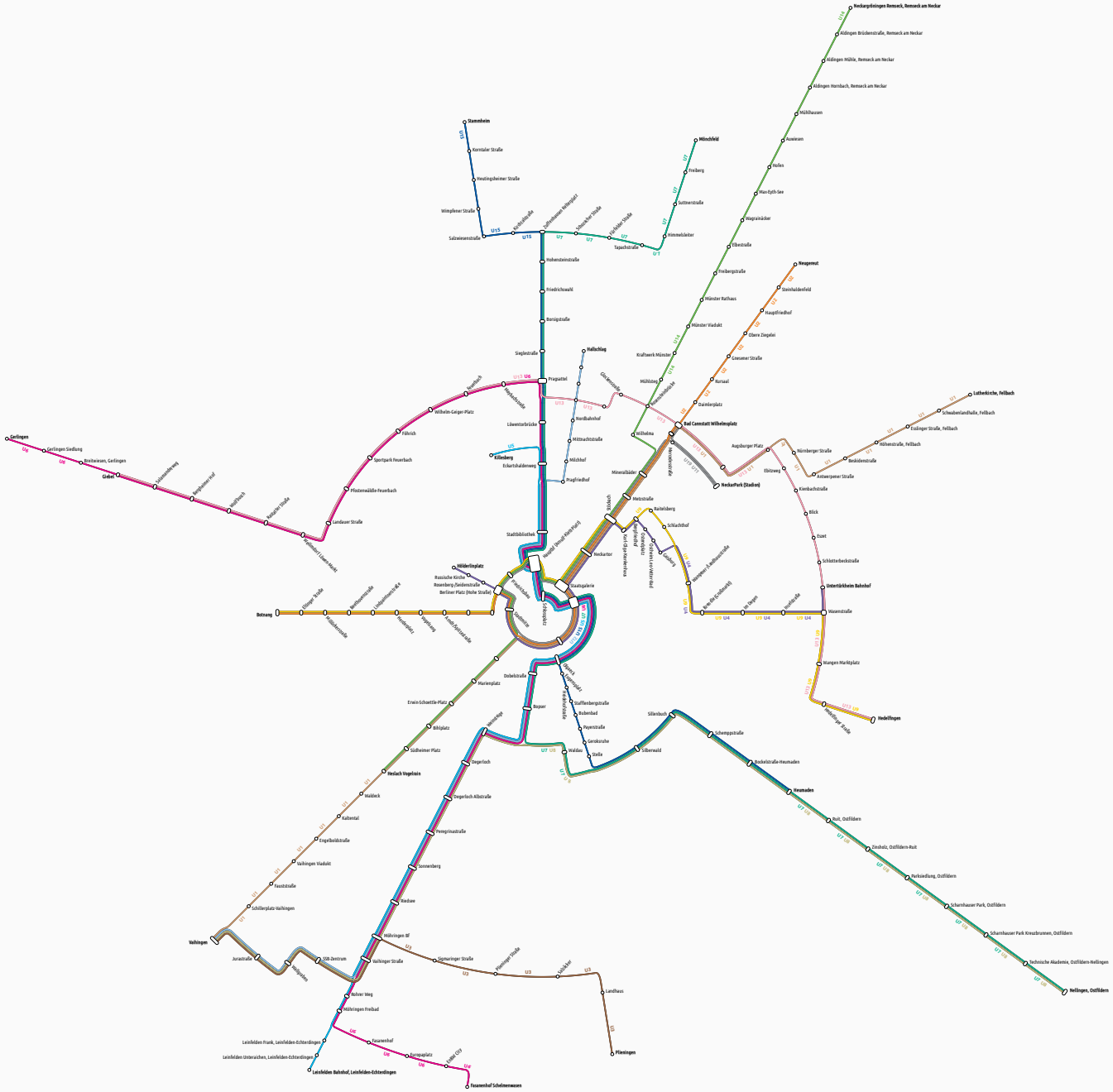
- Include previously developed clustering techniques for local search
- Use different base grids

Outlook: Orthoradial Base Grids



Thank you!

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