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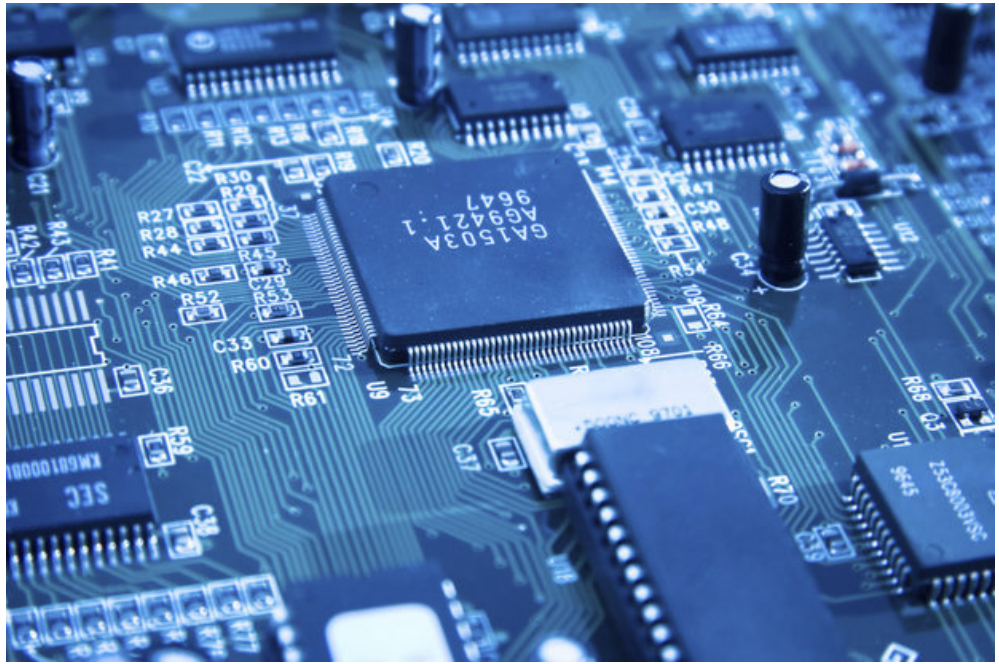
Chips and Circuits,
Heuristieken, UvA 2017

Oplossen van een constraint optimisation problem met een Heatmap gestuurde A* implementatie

Chips and Circuits

- Logische poorten (gates) verbinden voor werking
- Snijden = kortsluiting!
- Minder draad:

  snellere chip
  + lagere productiekosten per chip

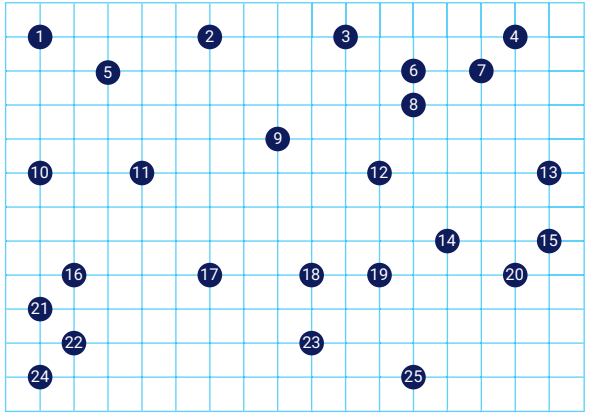


De casus

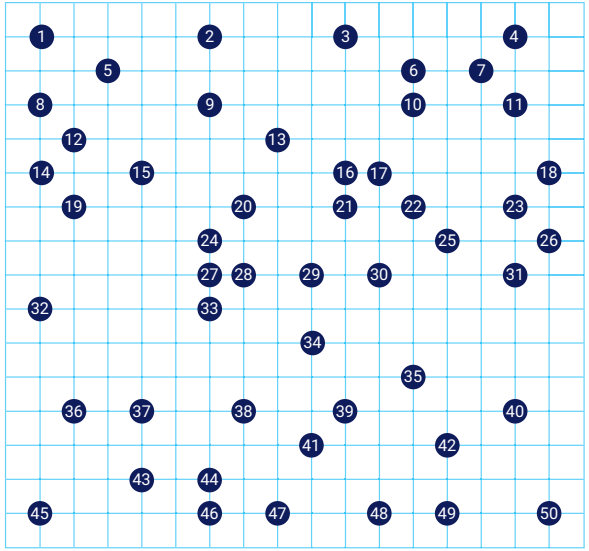
Voorbeeld Netlist:
(1, 11), (2, 8), (17, 6),
(14,20), (23, 25), (22, 13)

- Twee printplaten
- Netlist = voorschrift hoe gates verbonden moeten worden
- 3 netlists per printplaat (6 totaal)
- Manhattan grid + 7 lagen (3D)
- Niet snijden, niet buiten grid, niet door gates
- Constraint optimisation problem

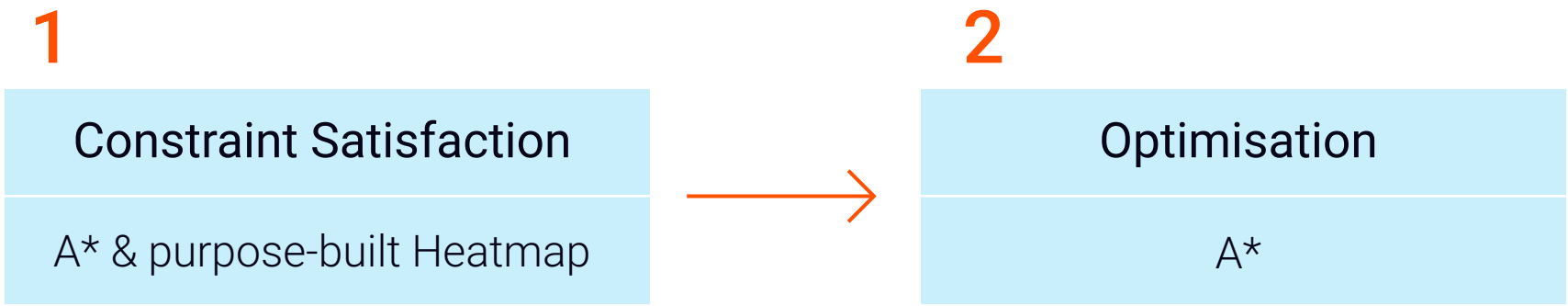
Printplaat 1 17x12x7 25 gates



Printplaat 2 17x16x7 50 gates



Methode overview



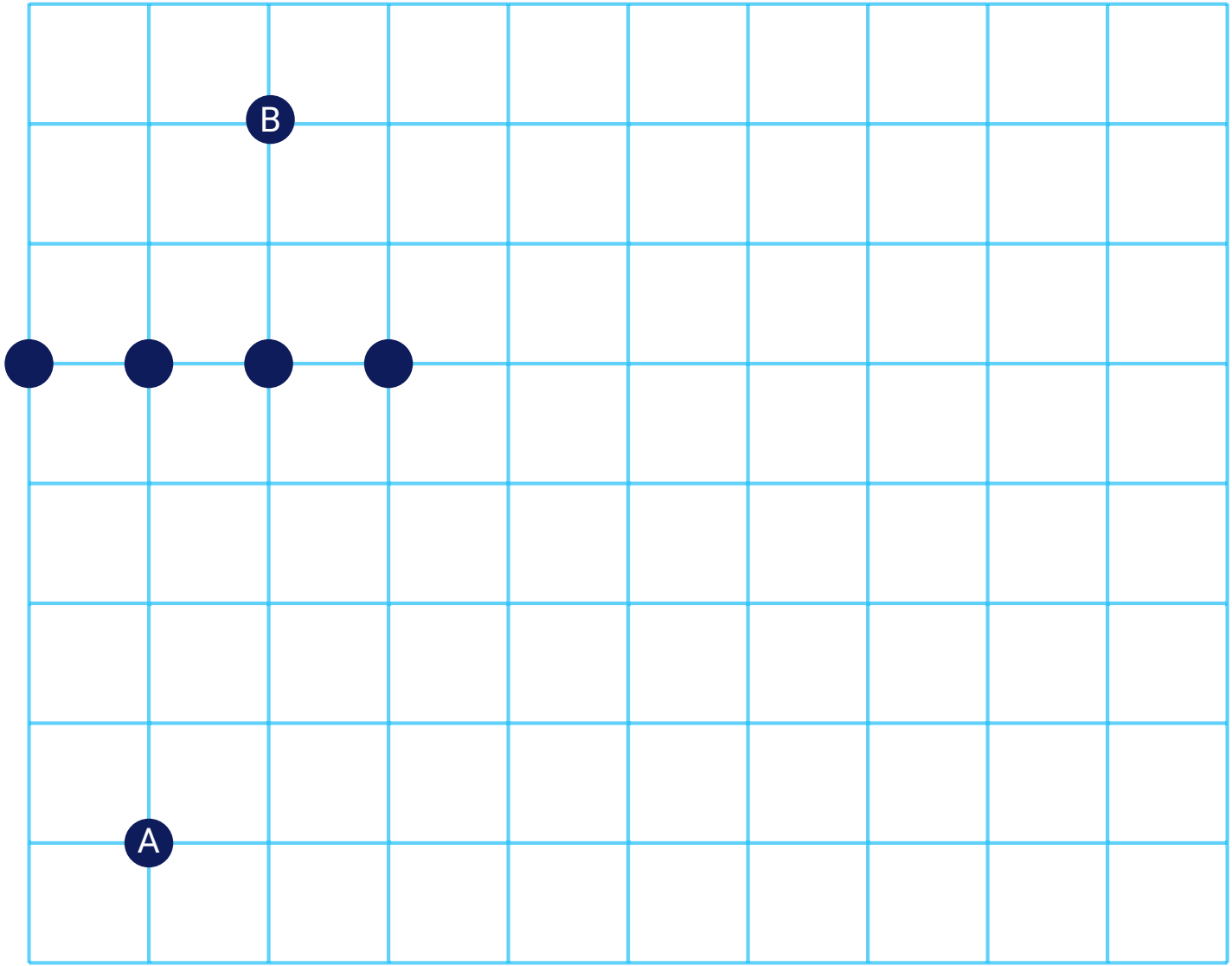
A* Zoek Algoritme

Zoek algoritme om het pad met de laagste kosten te vinden:

1. *Huidige node -> evalueer vervolg states*

2. *Ken prijs toe aan vervolg states:*
   Afgelegd pad + Manhattan distance naar doel (heuristiek).

3. *Kies pad met laagste prijs uit lijst -> stap 1.*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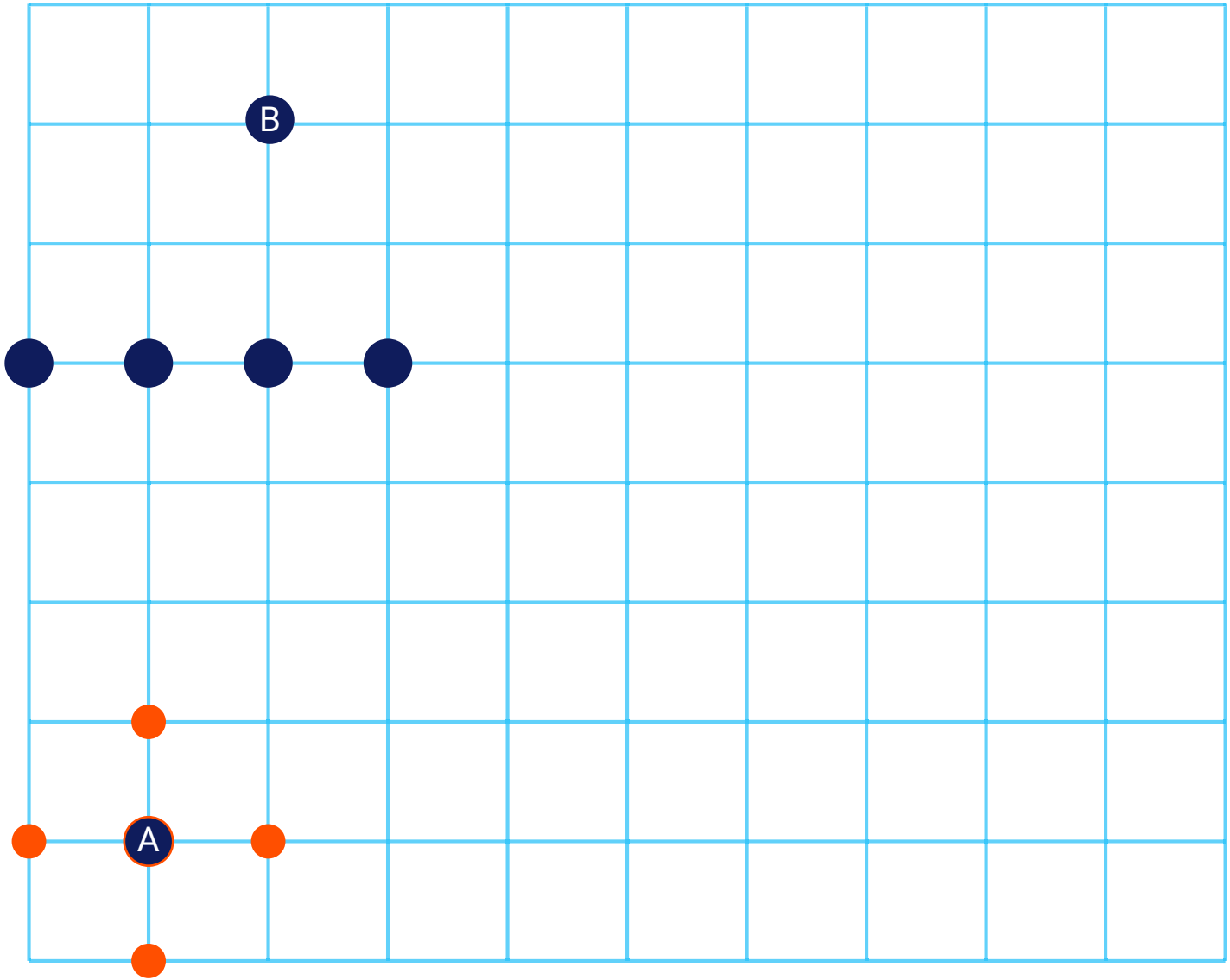
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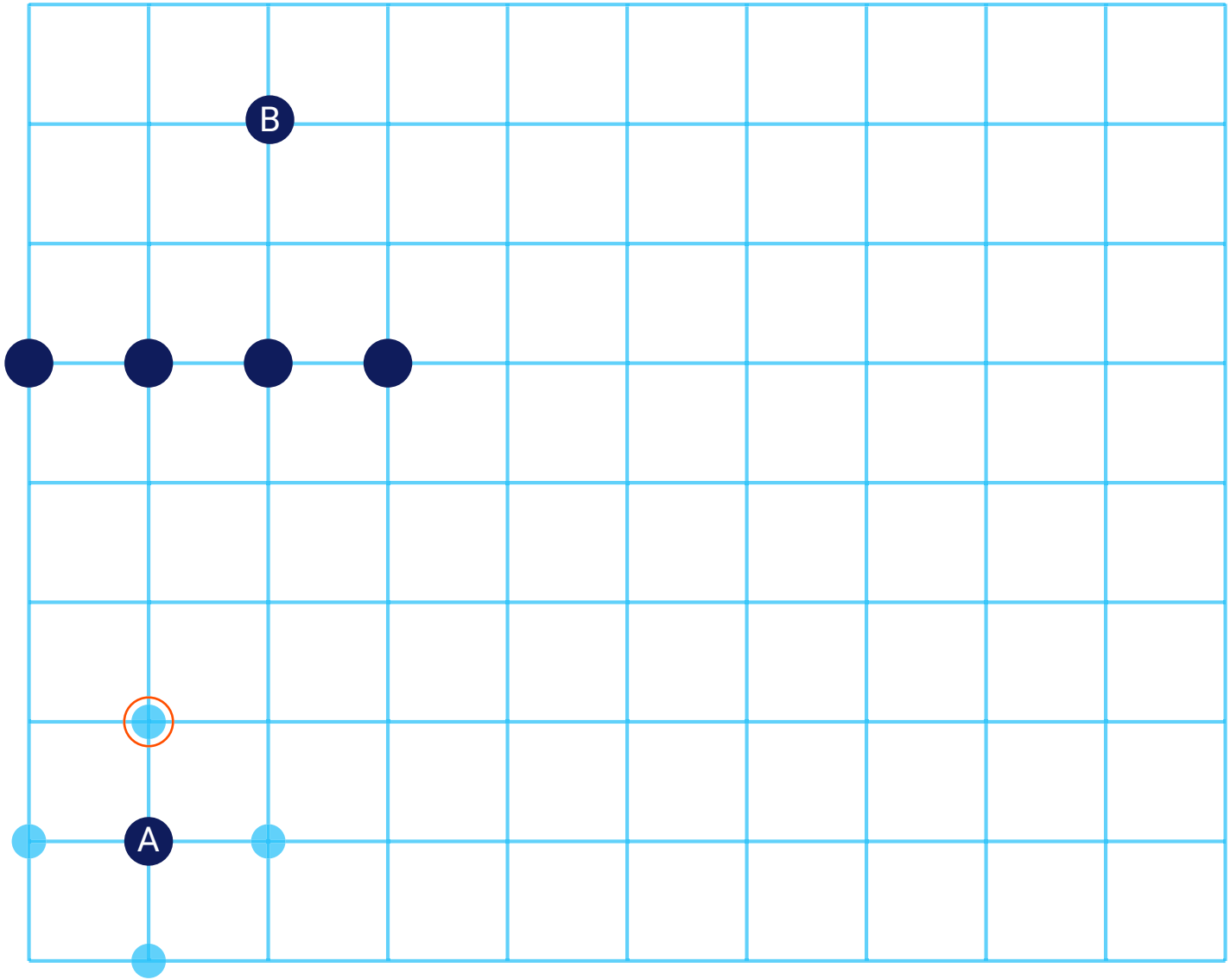
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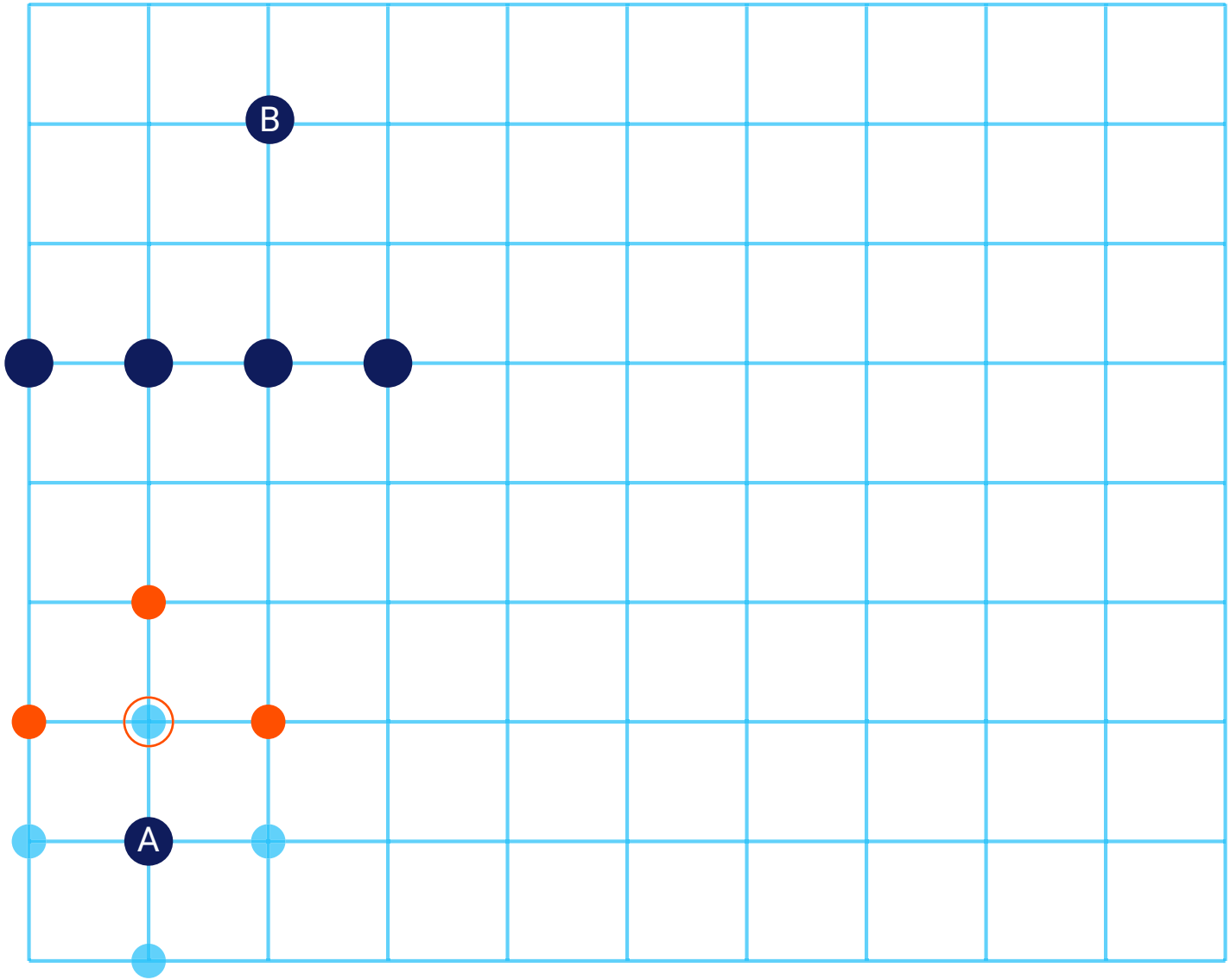
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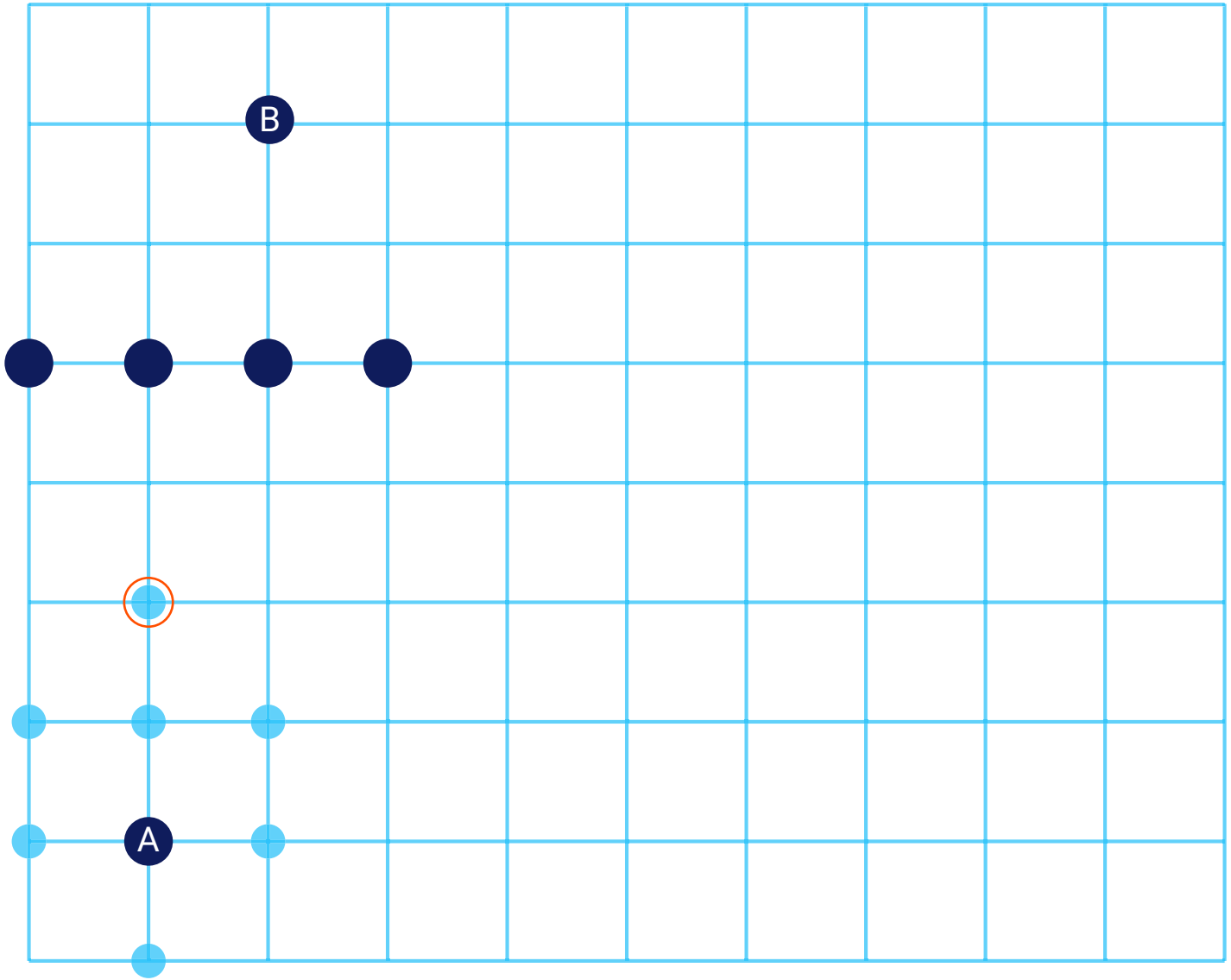
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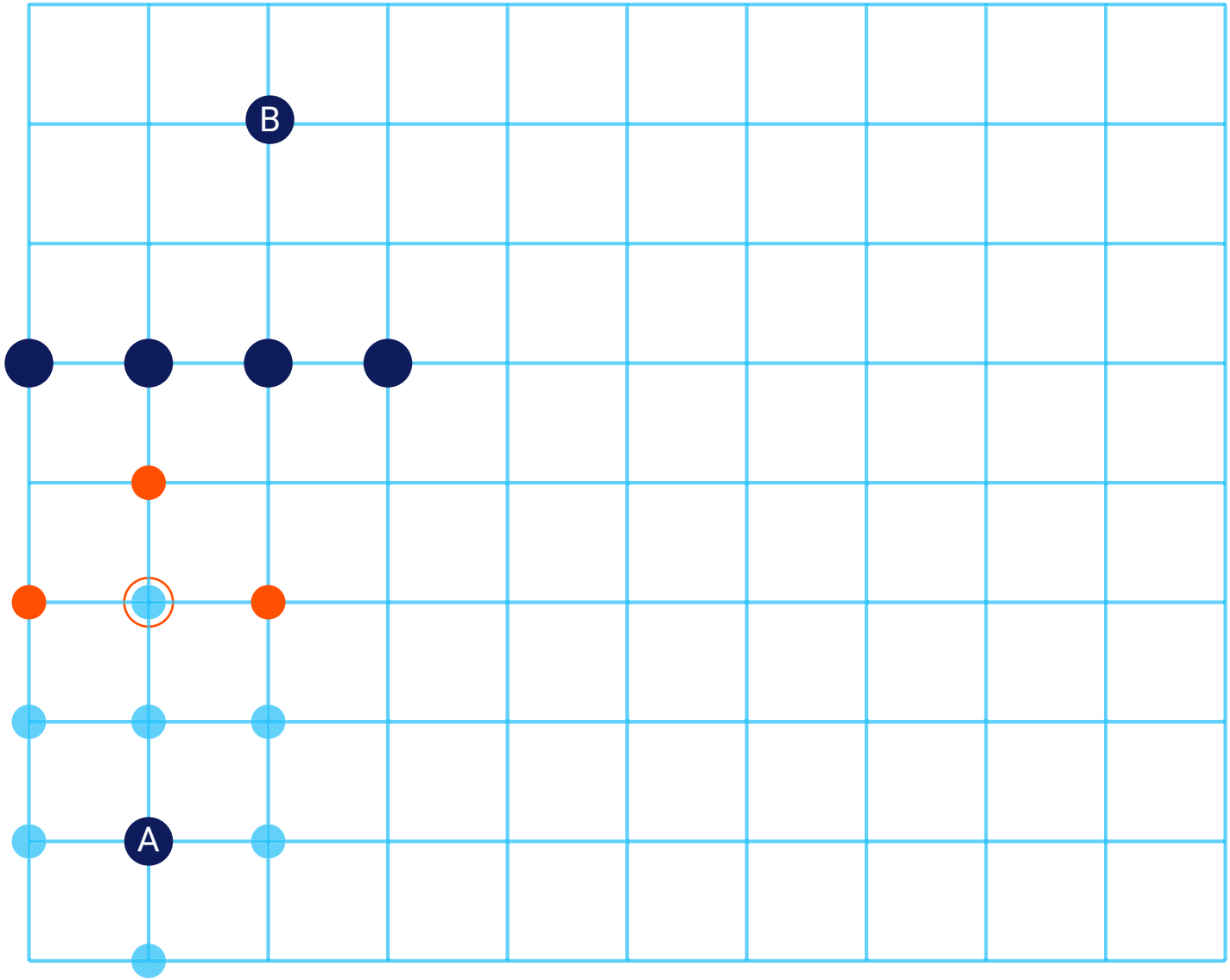
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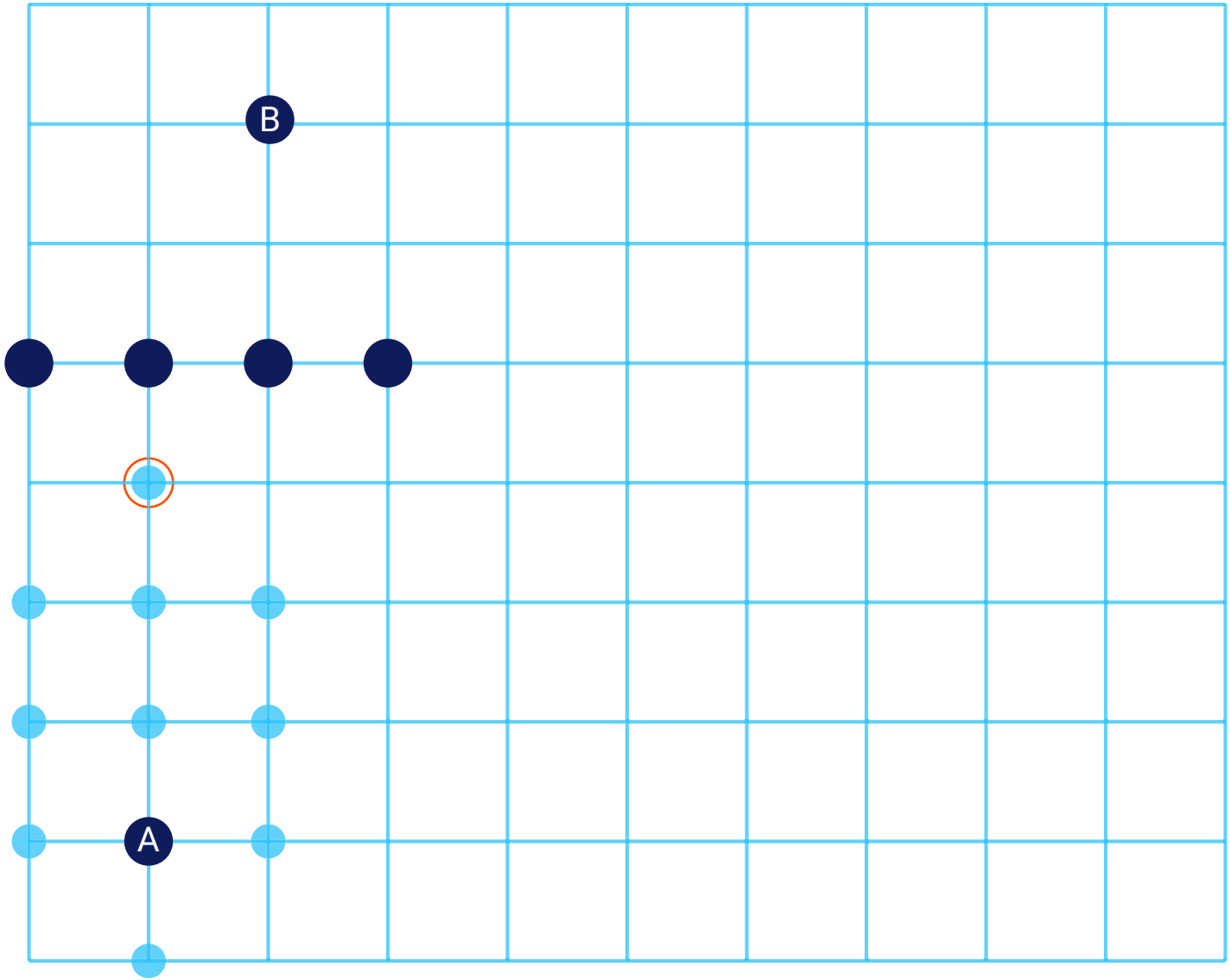
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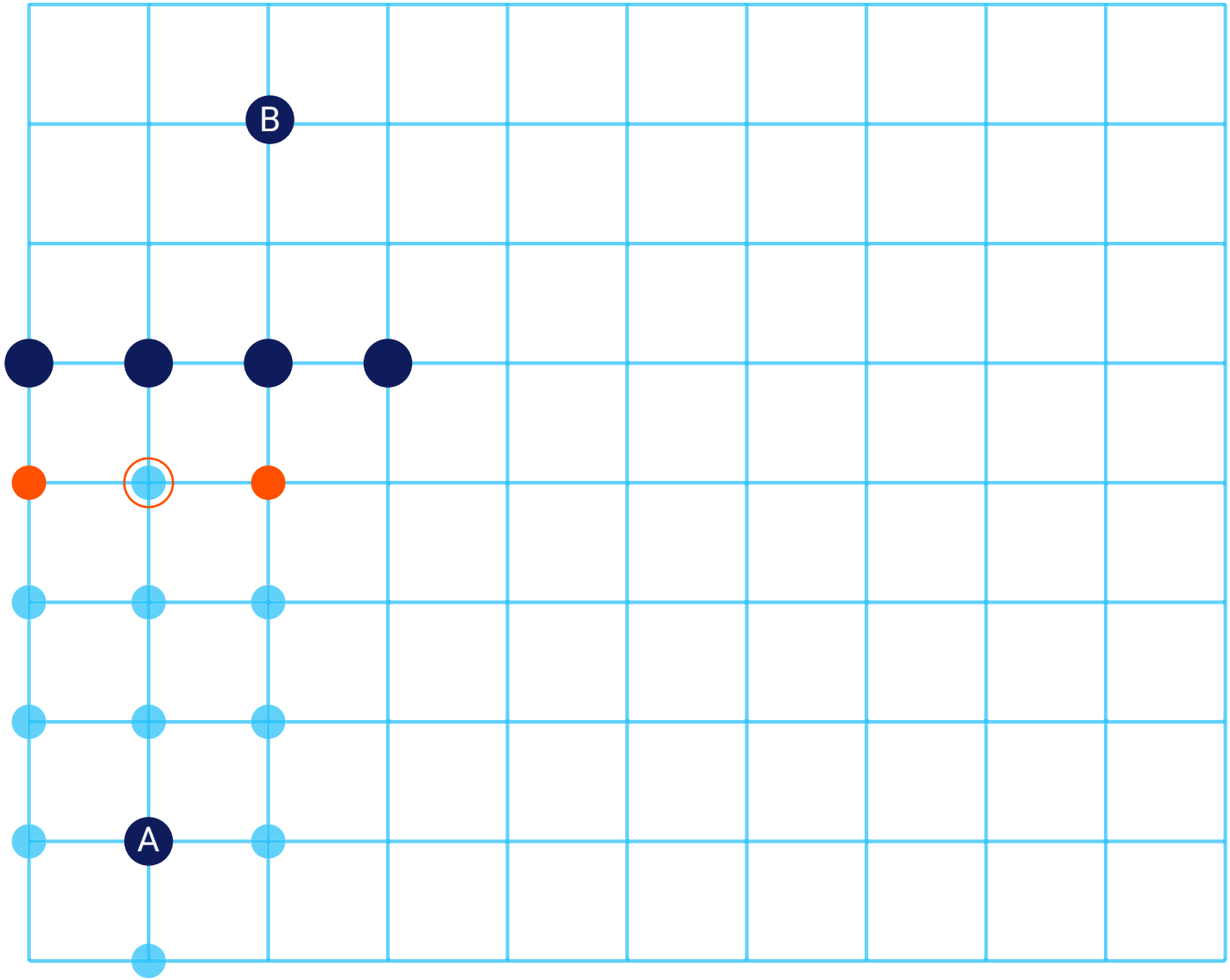
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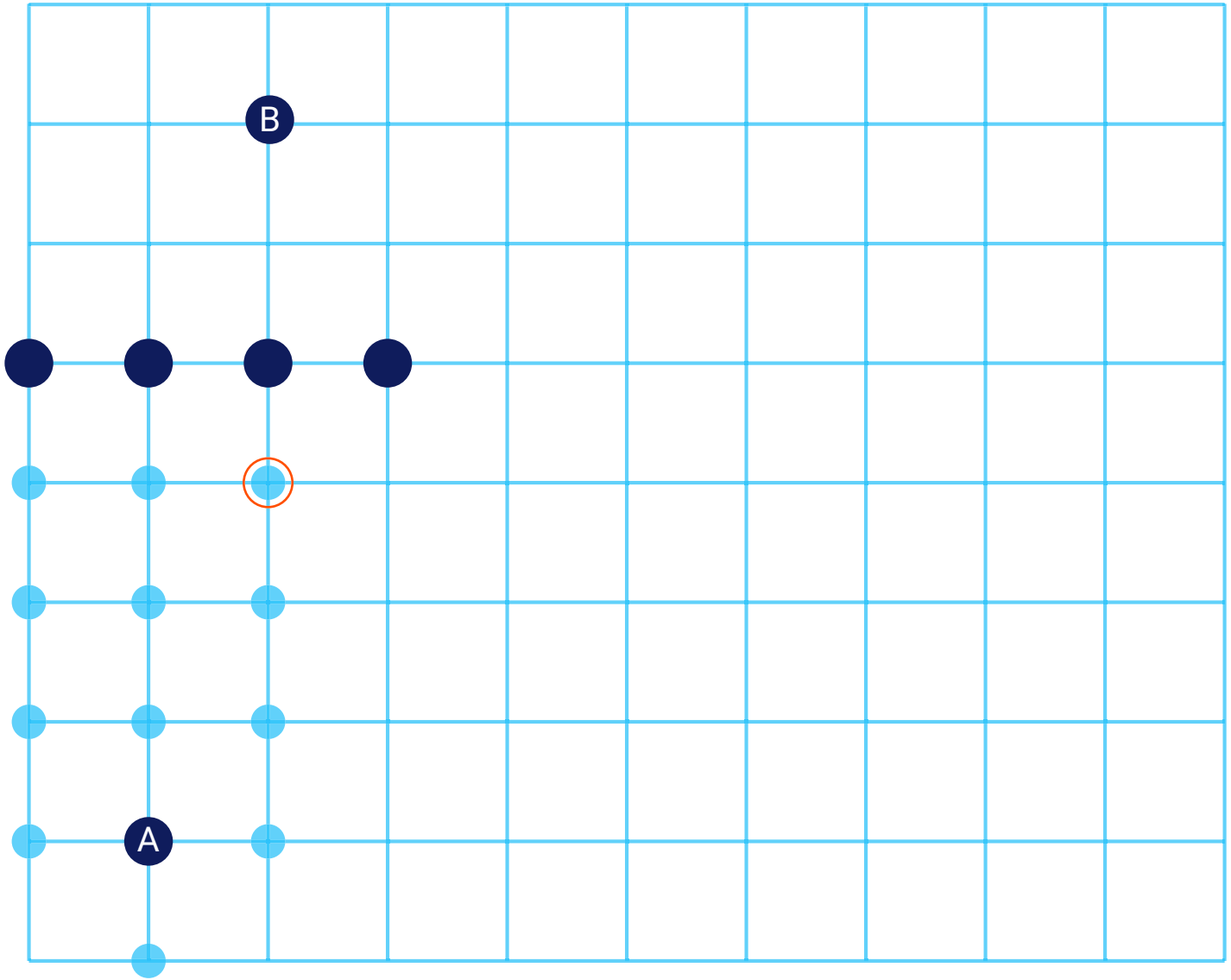
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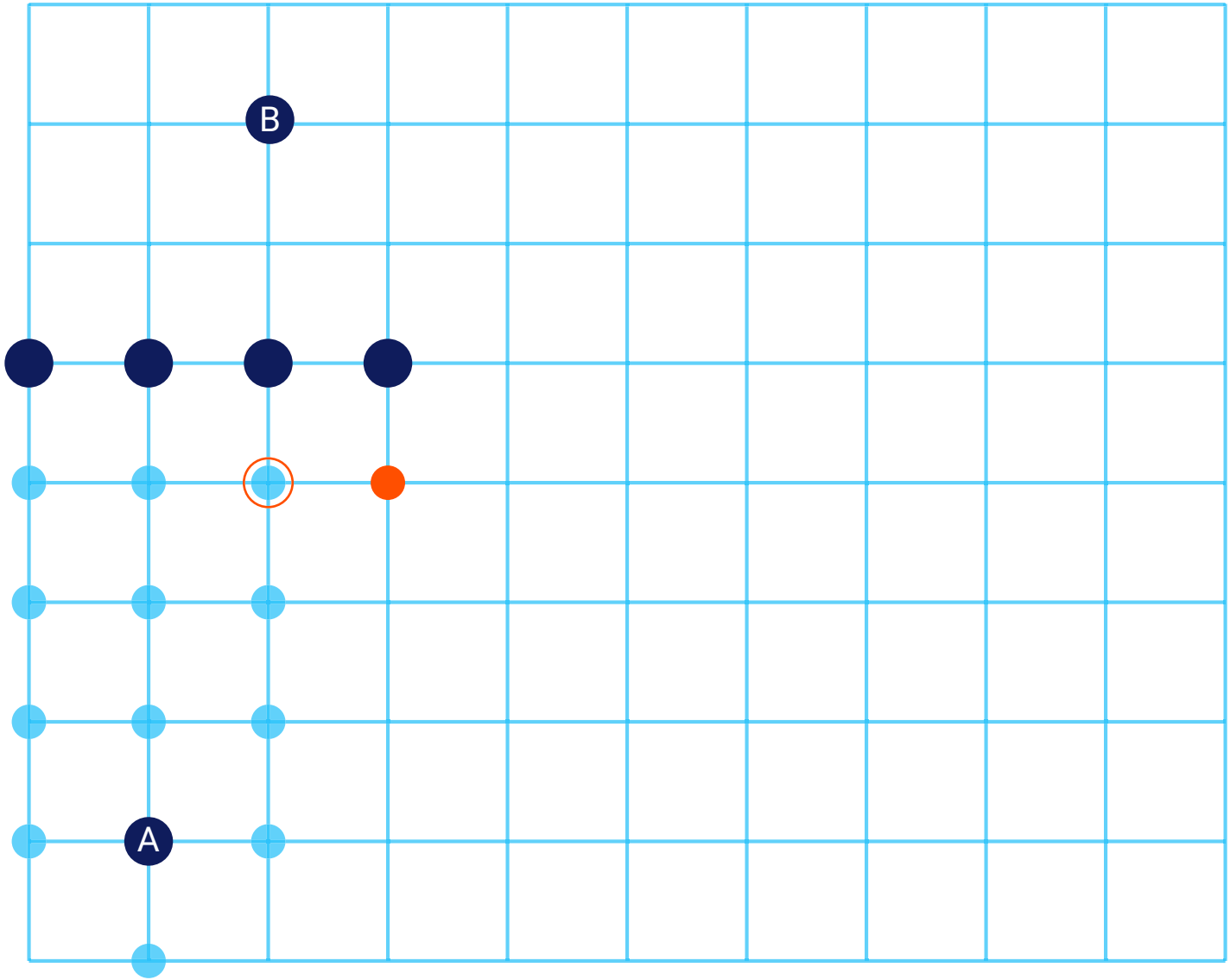
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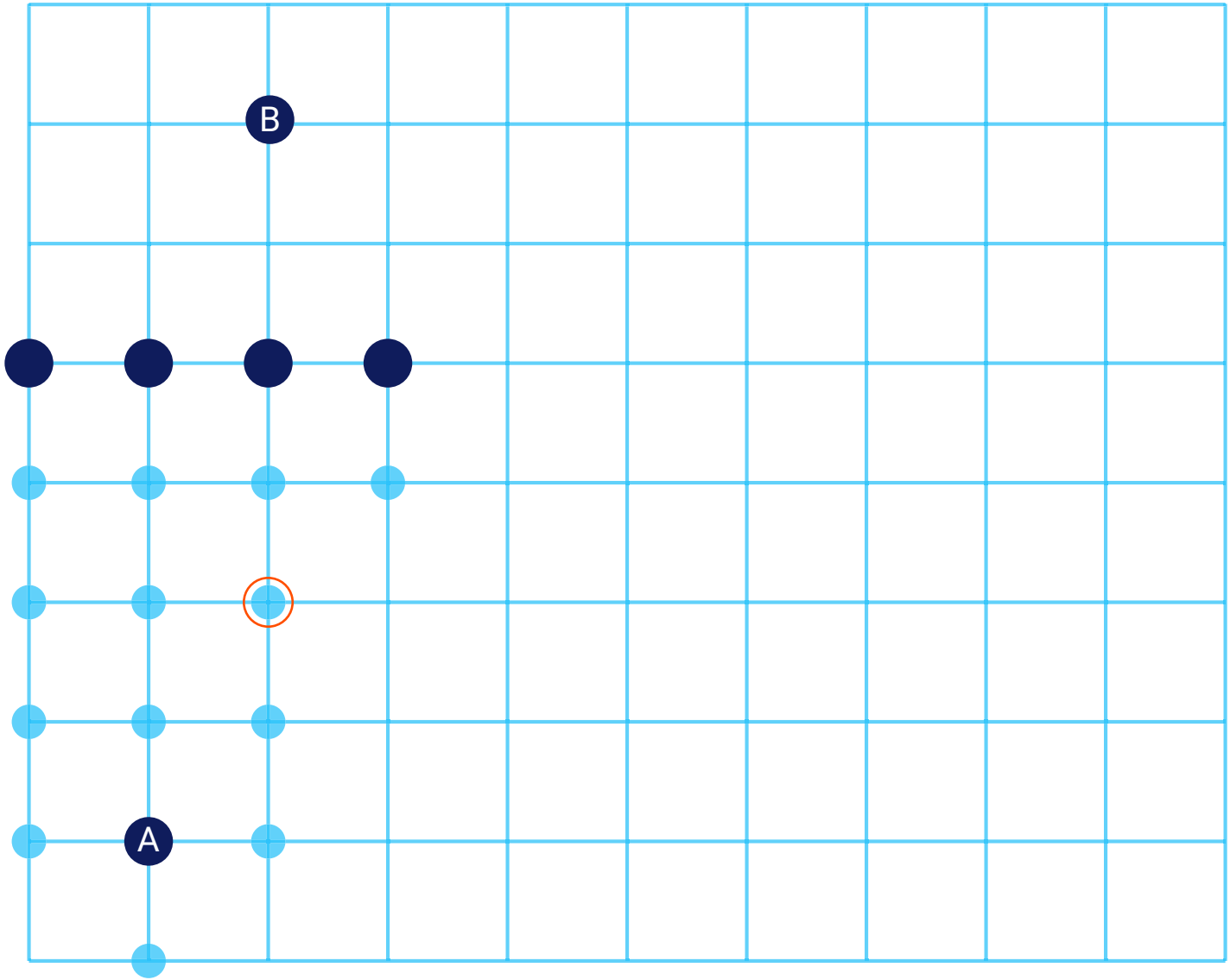
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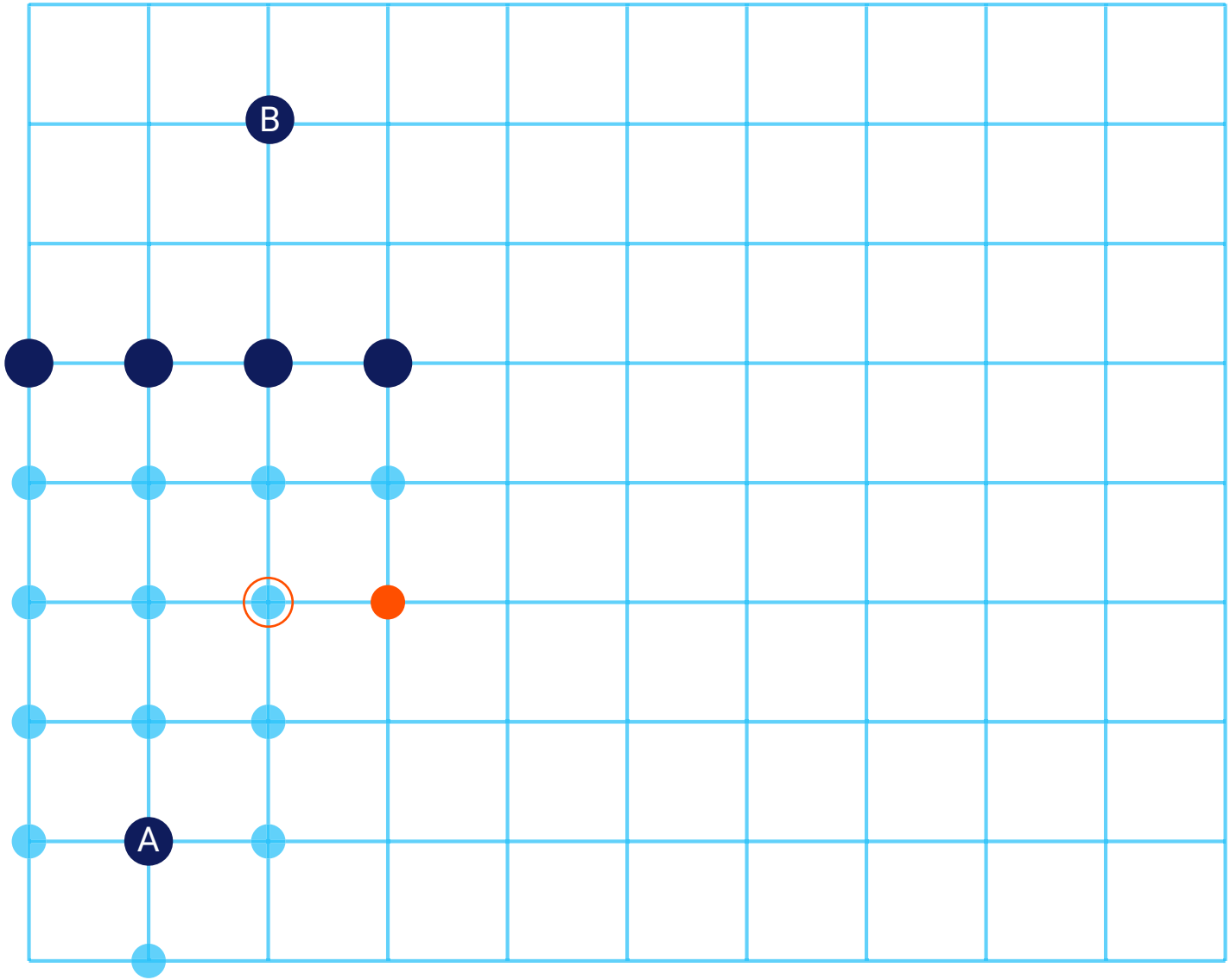
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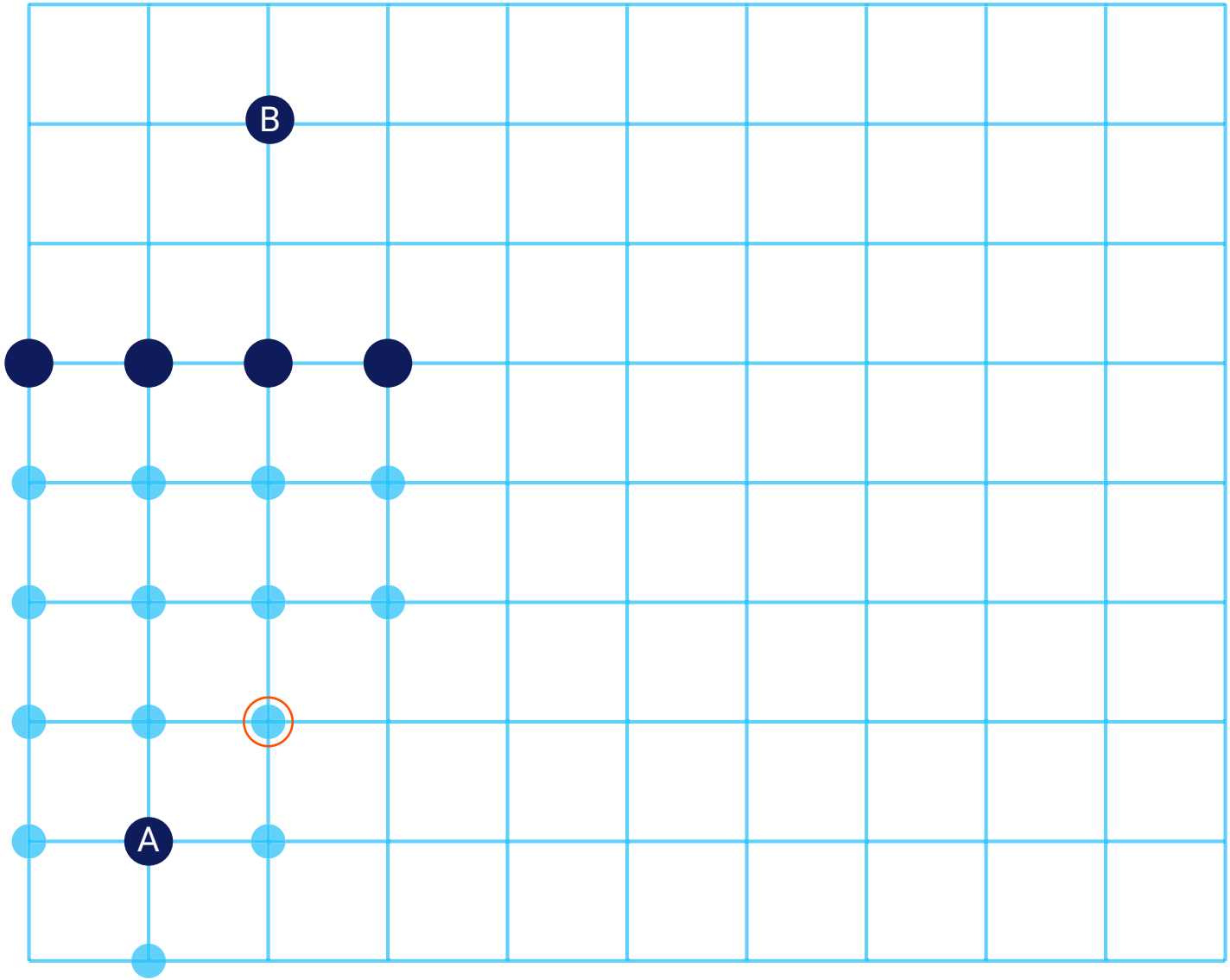
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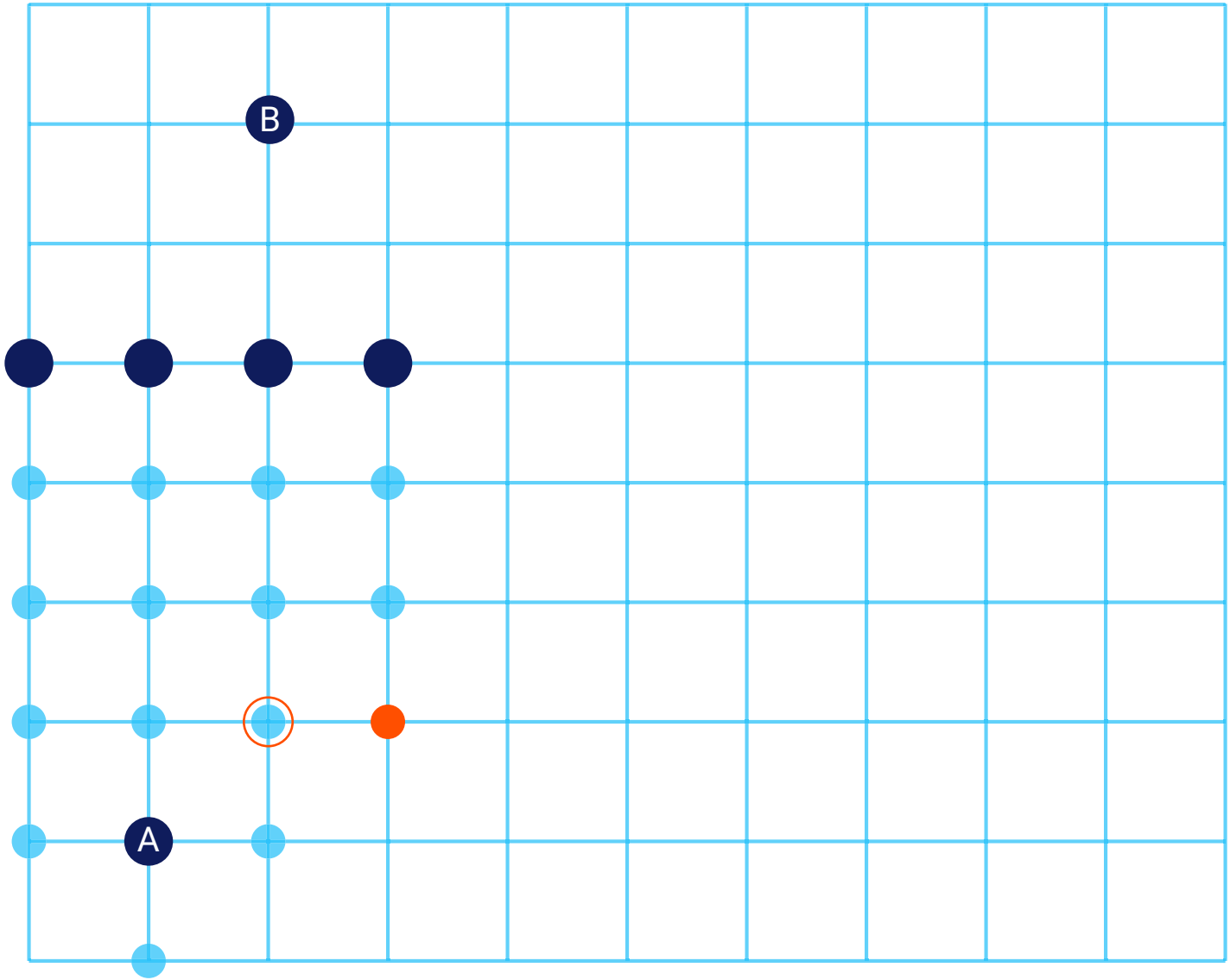
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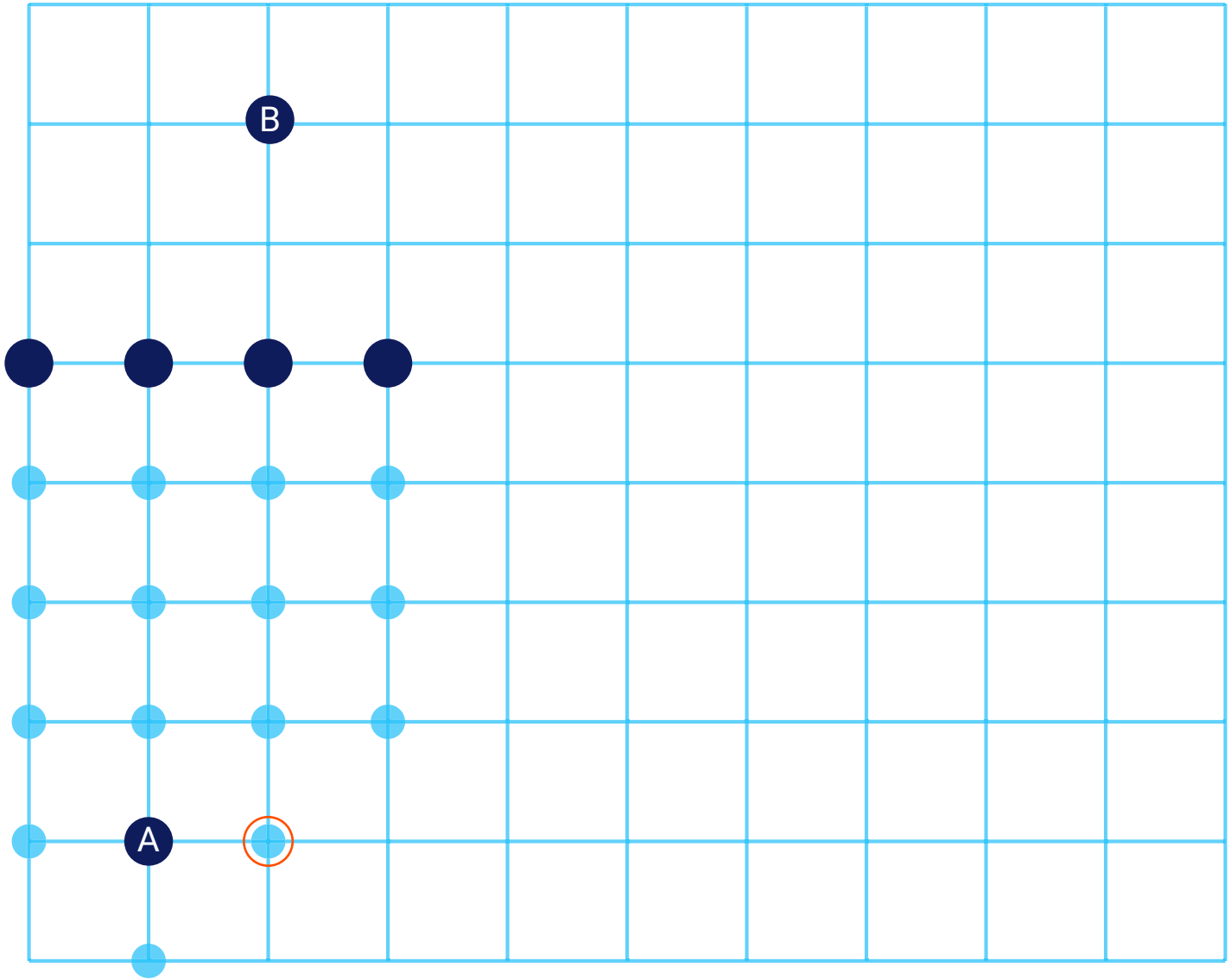
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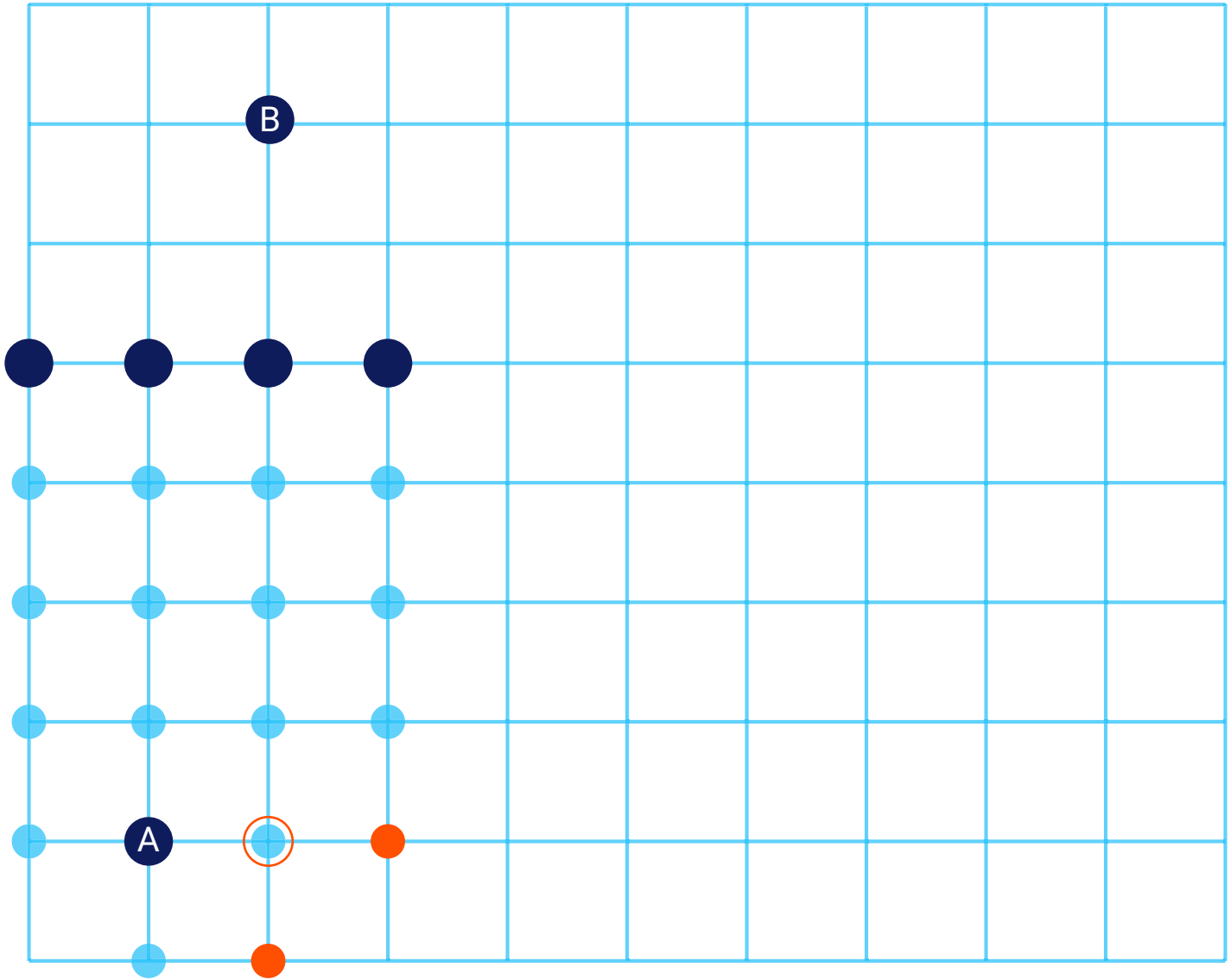
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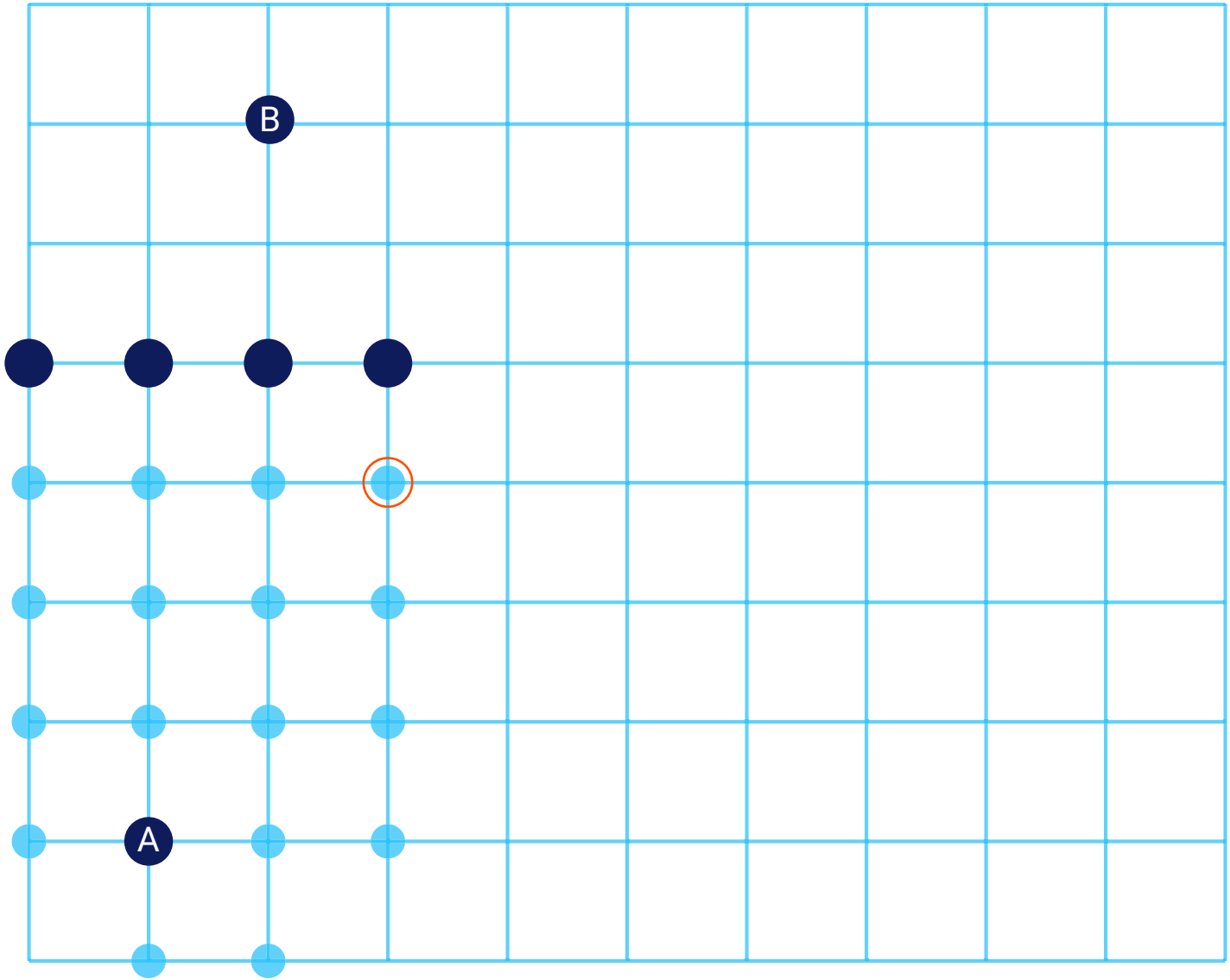
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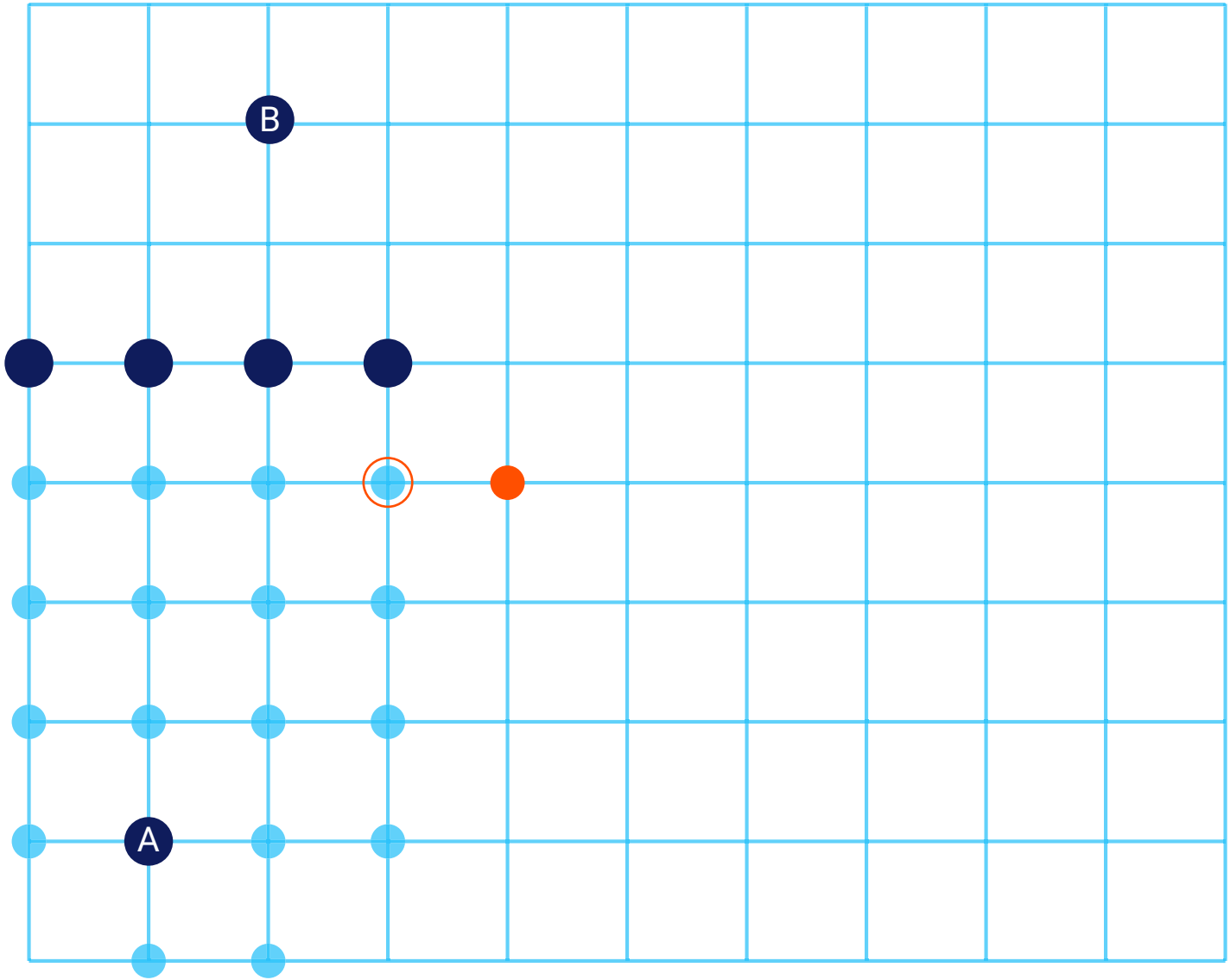
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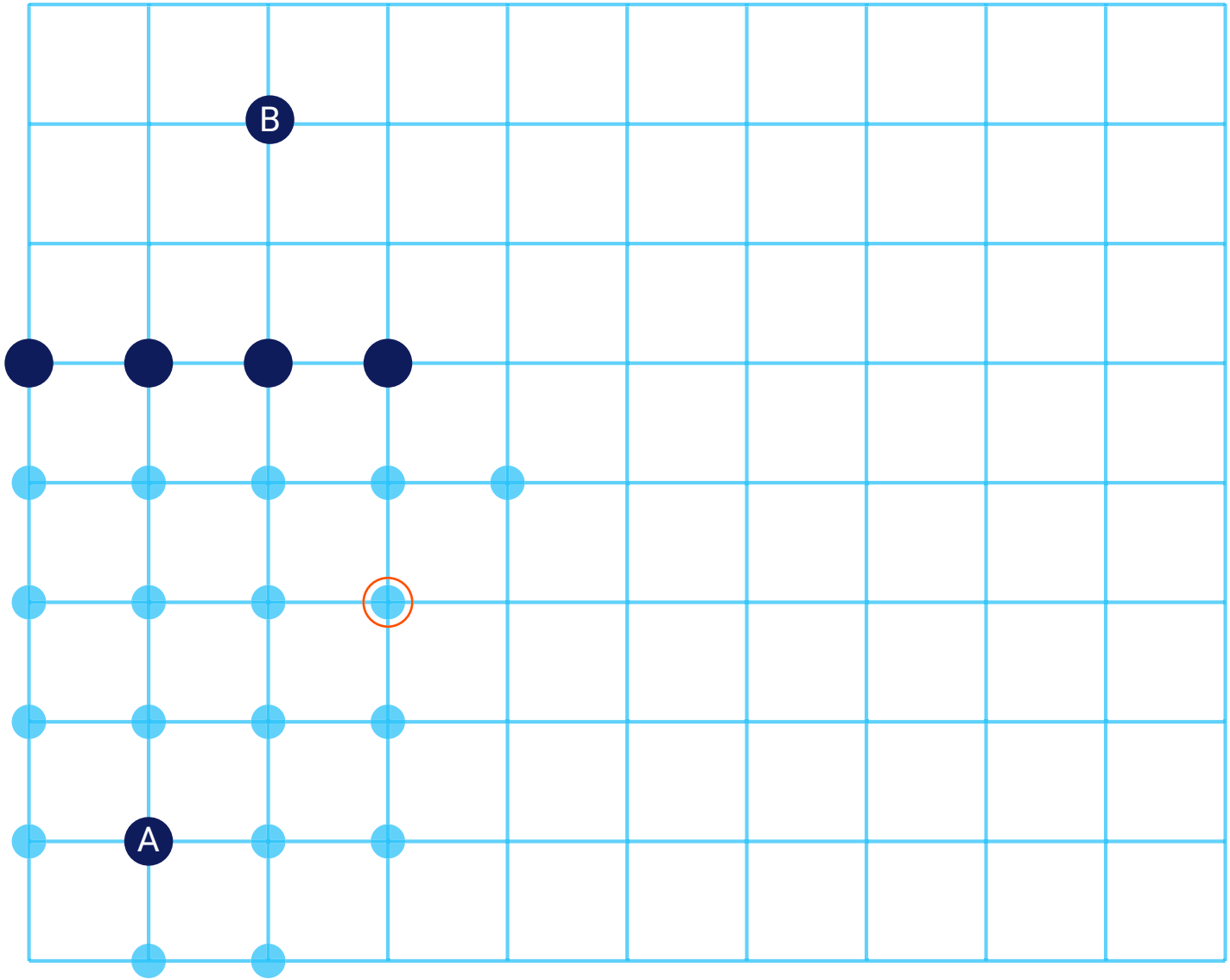
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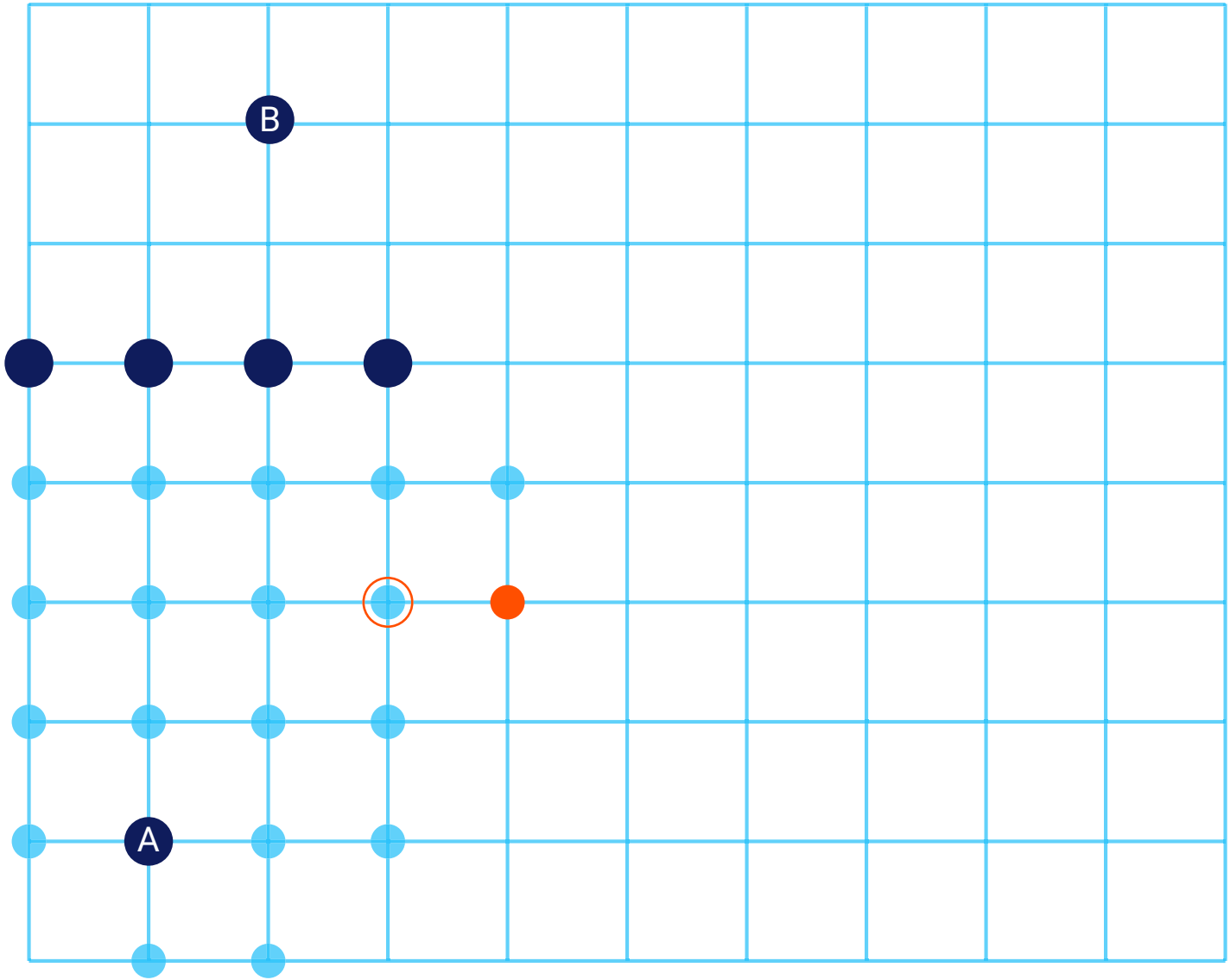
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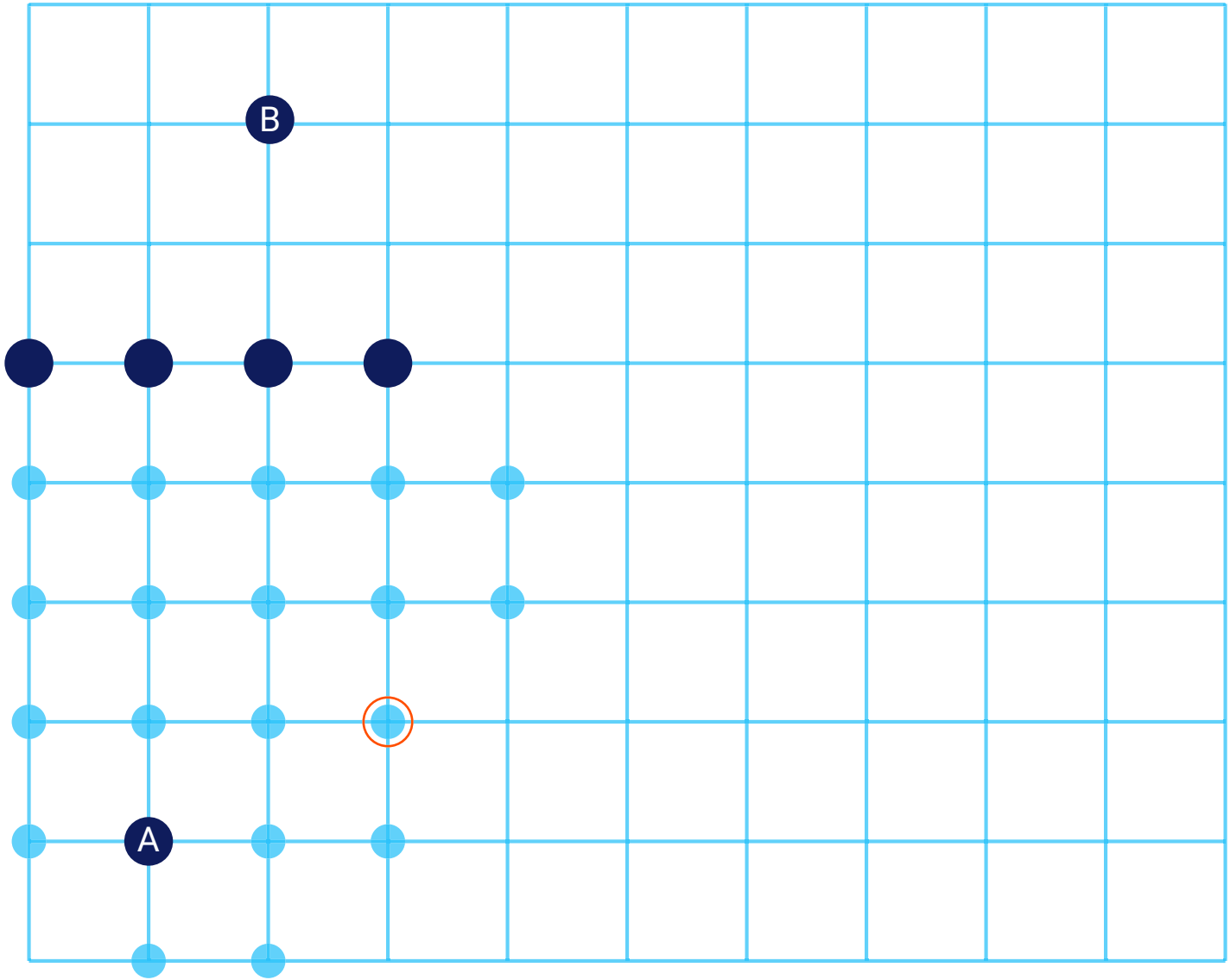
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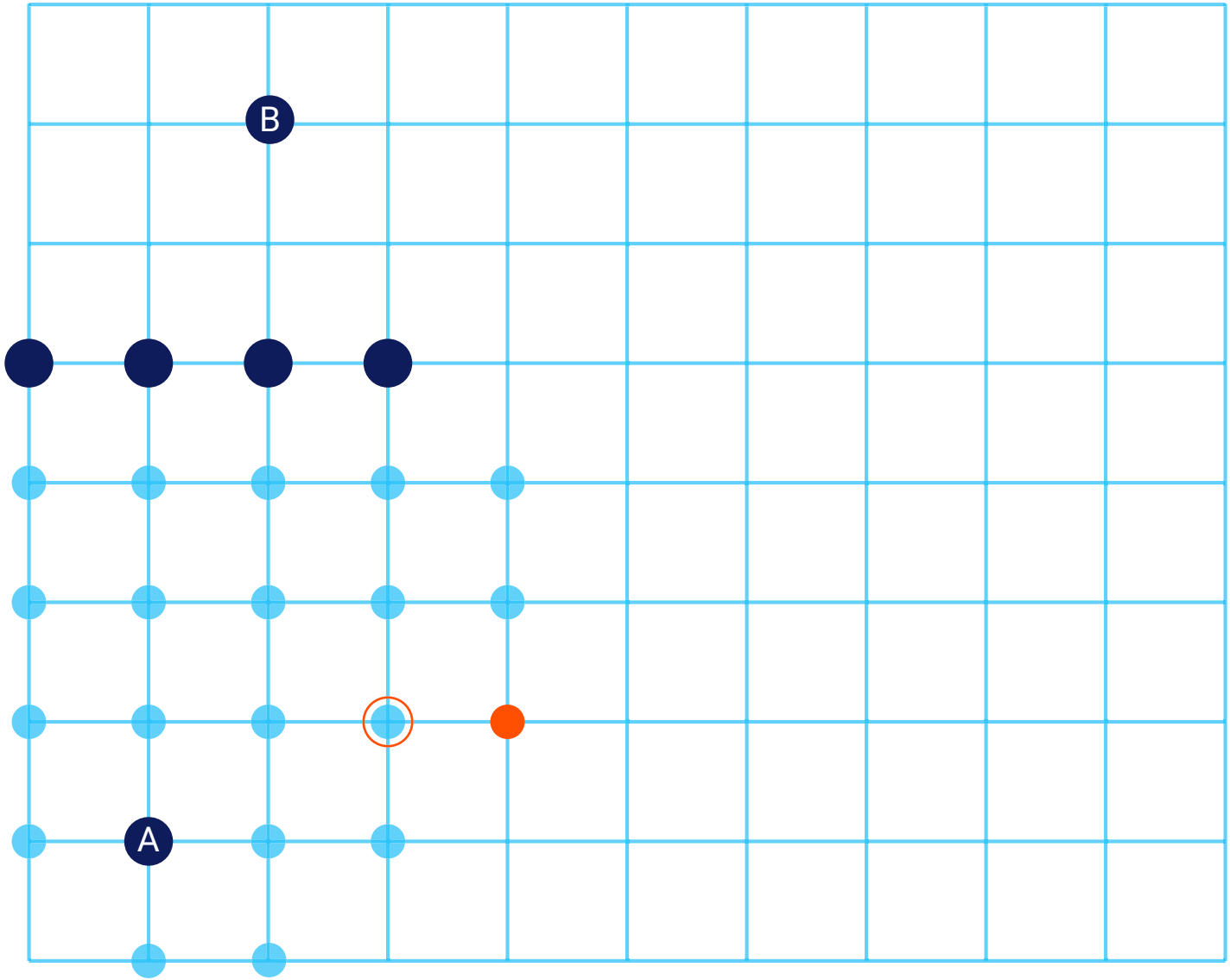
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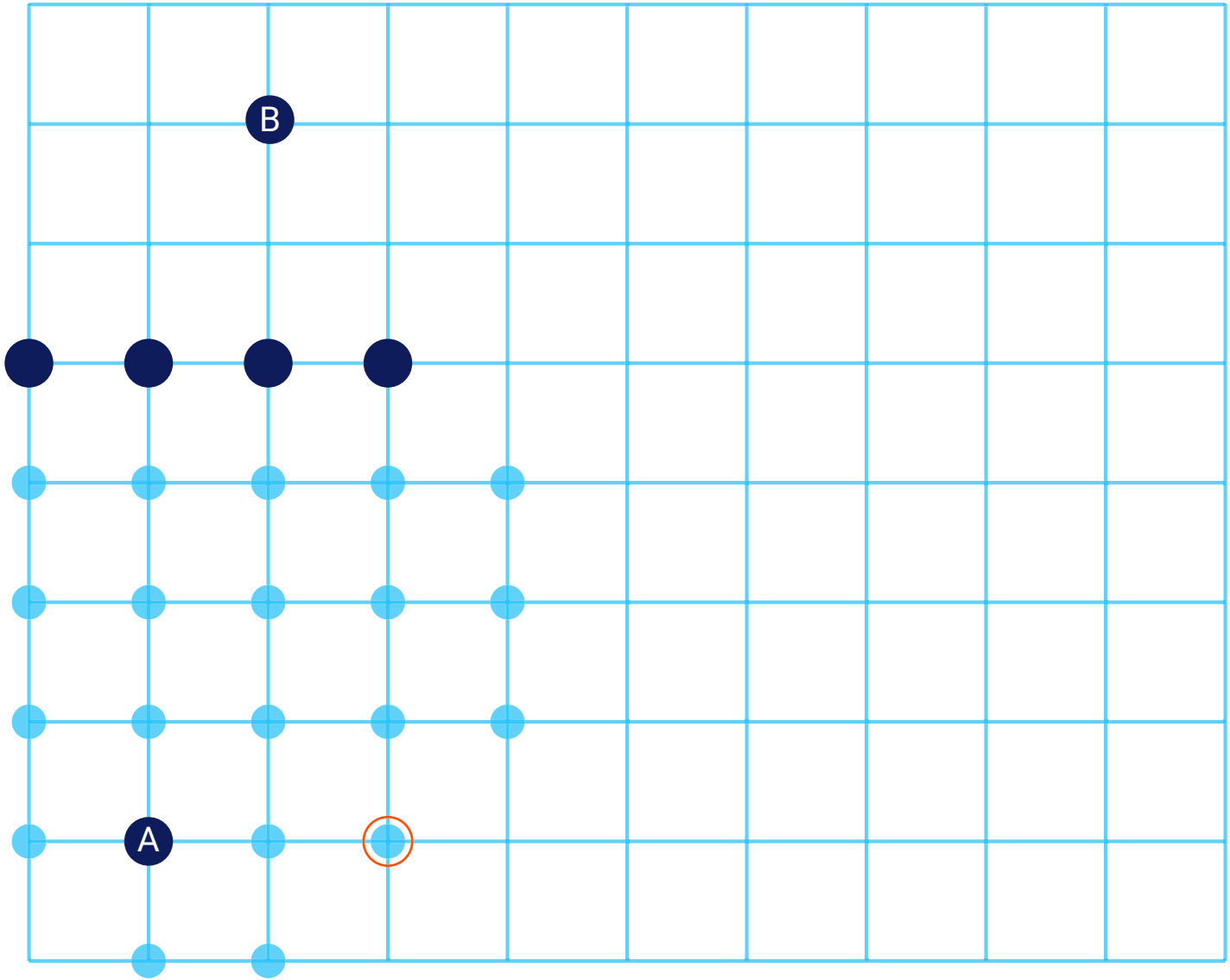
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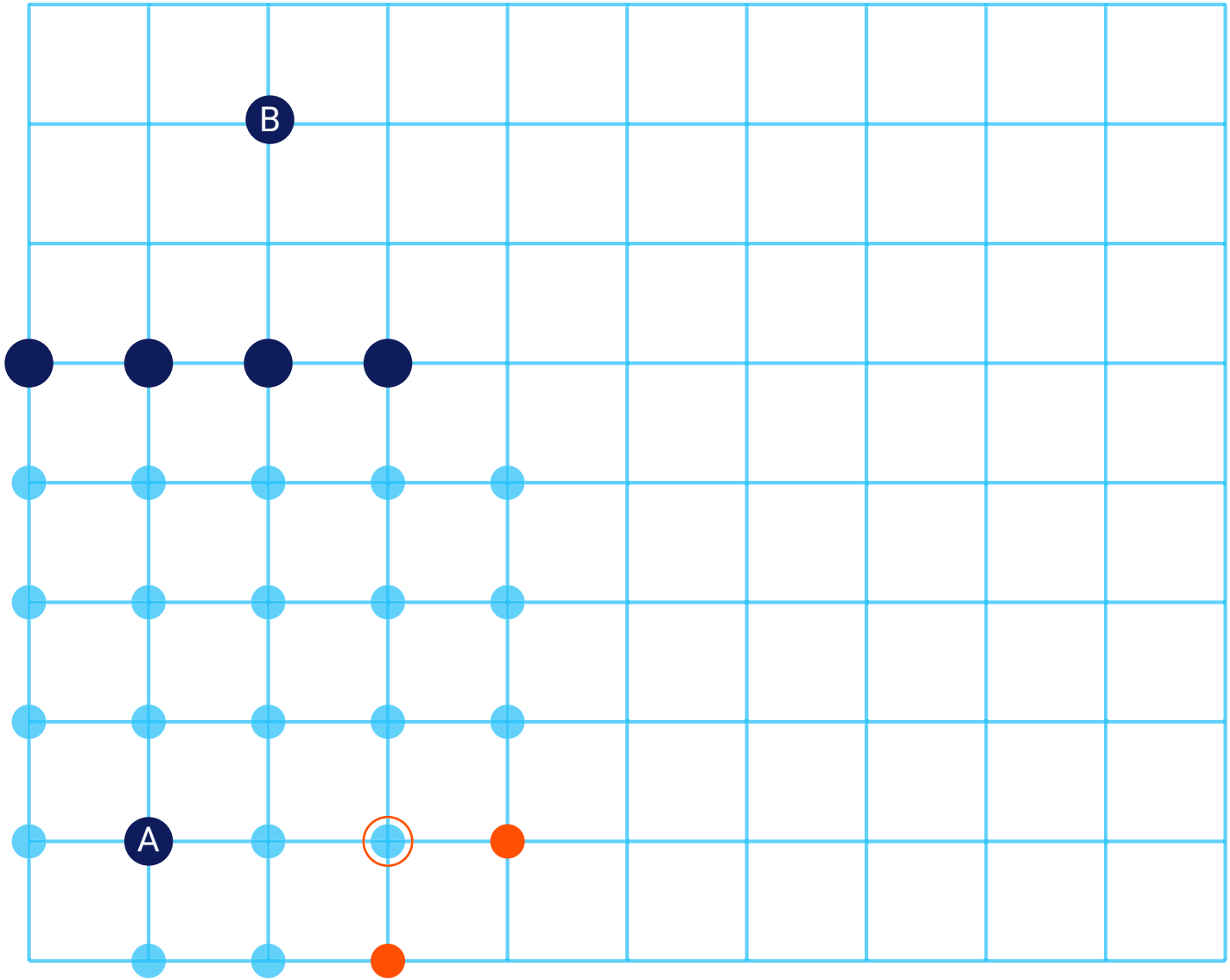
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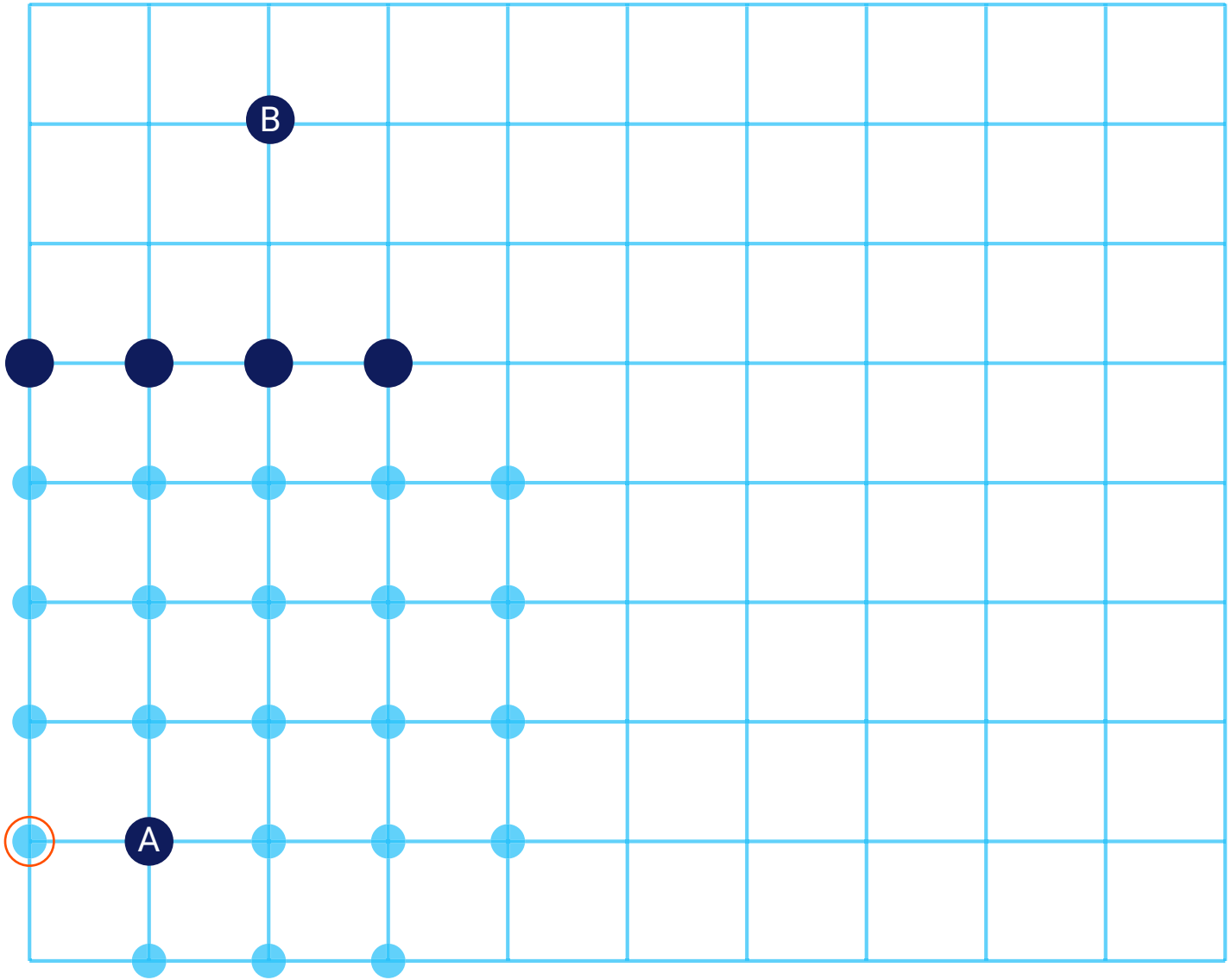
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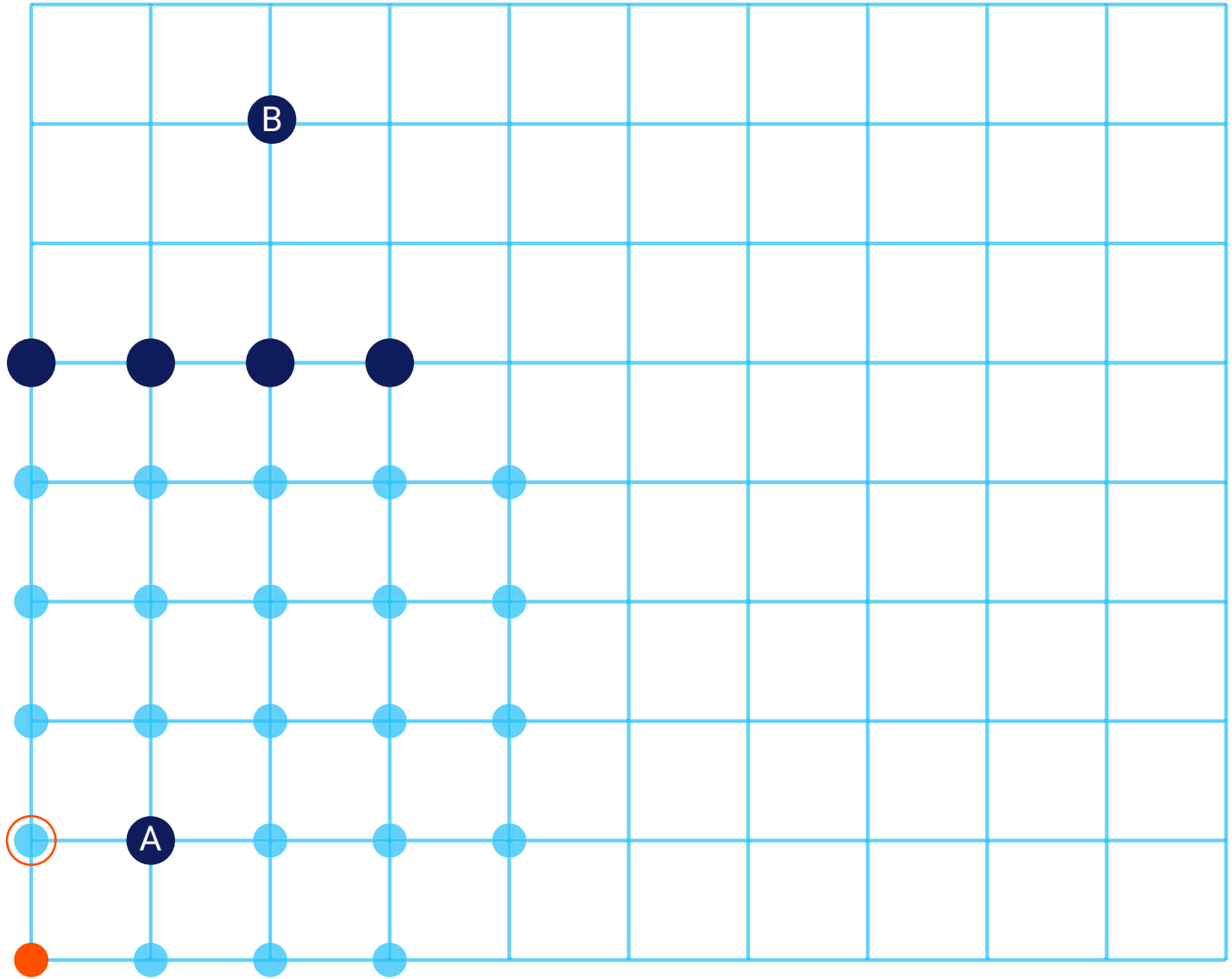
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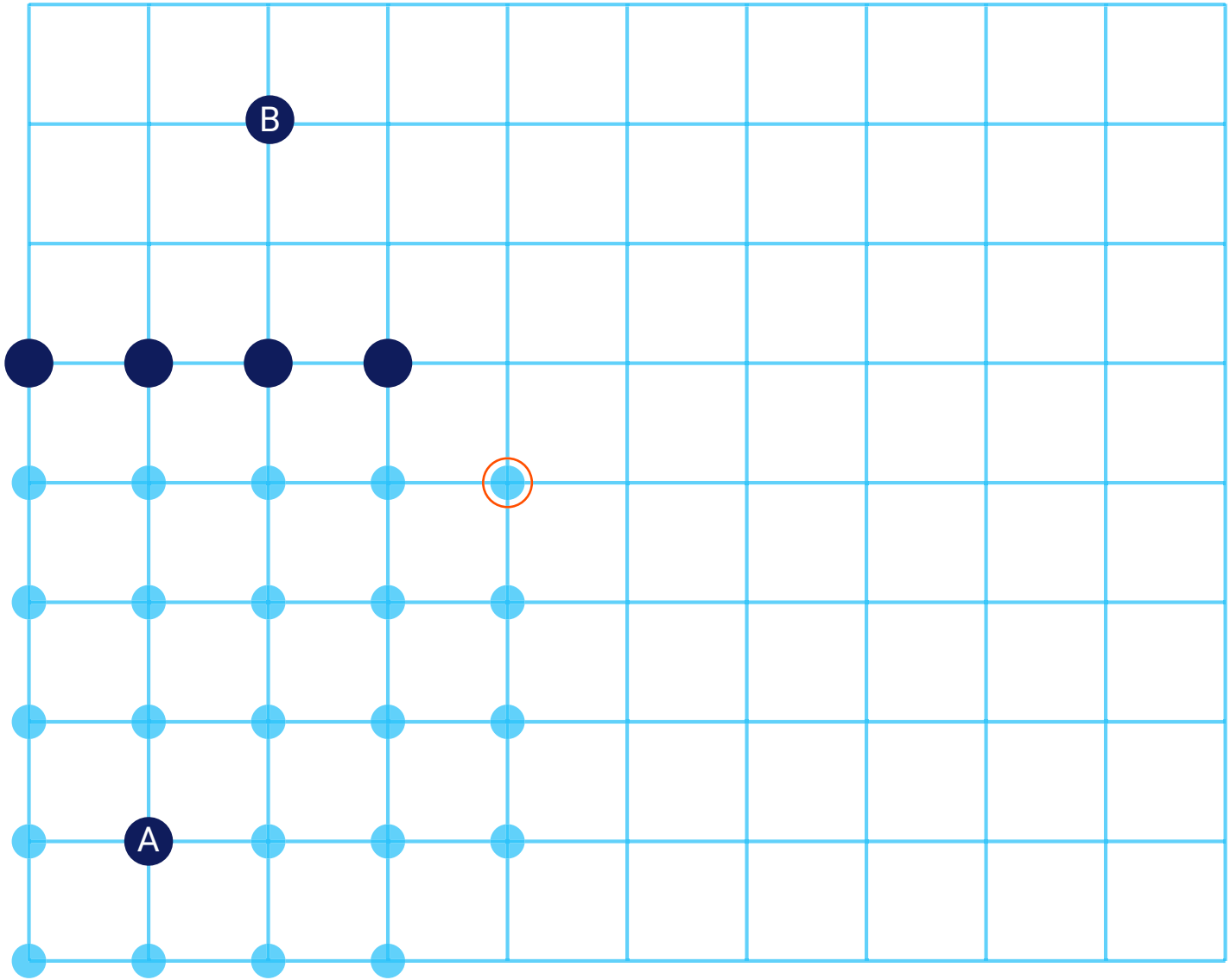
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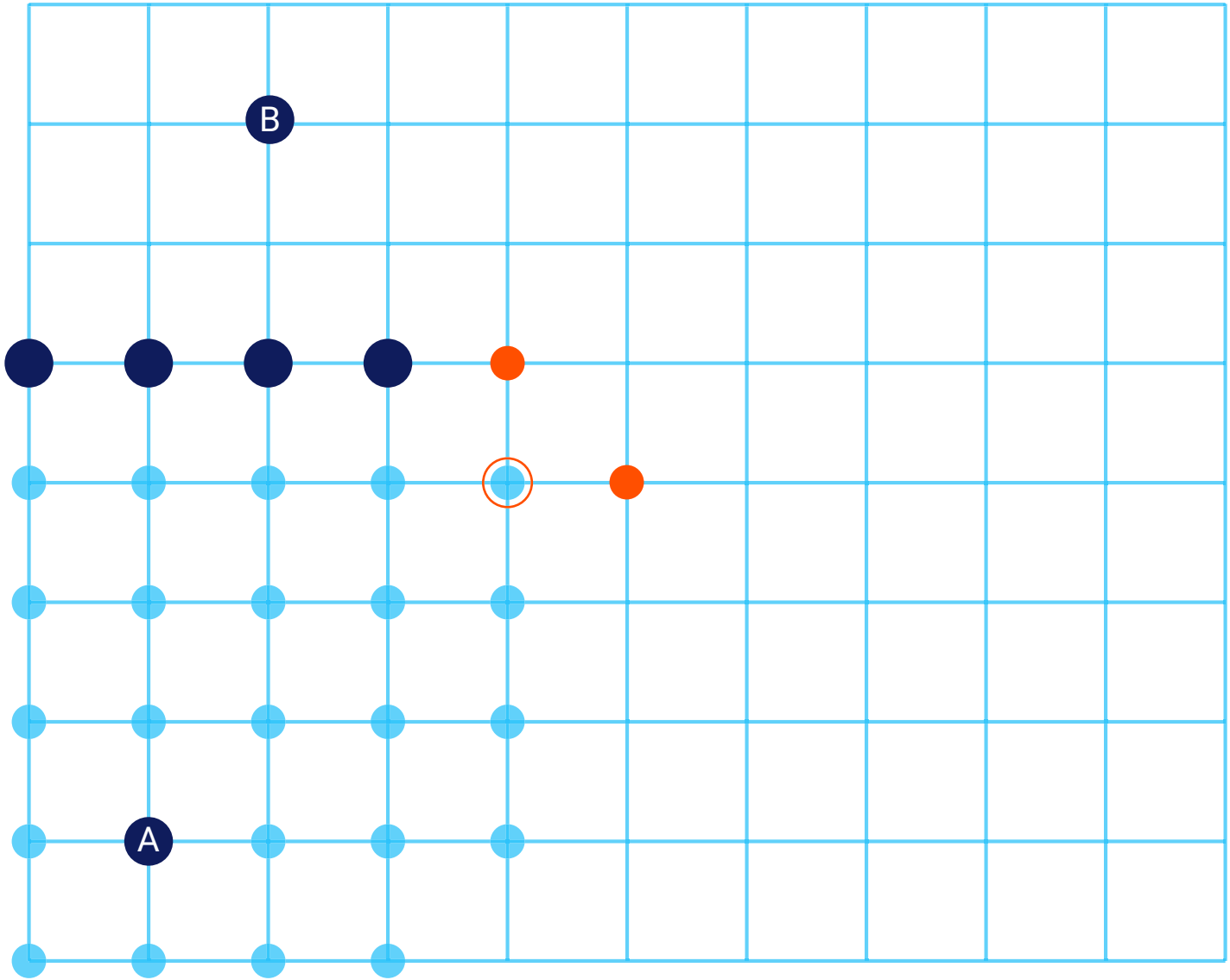
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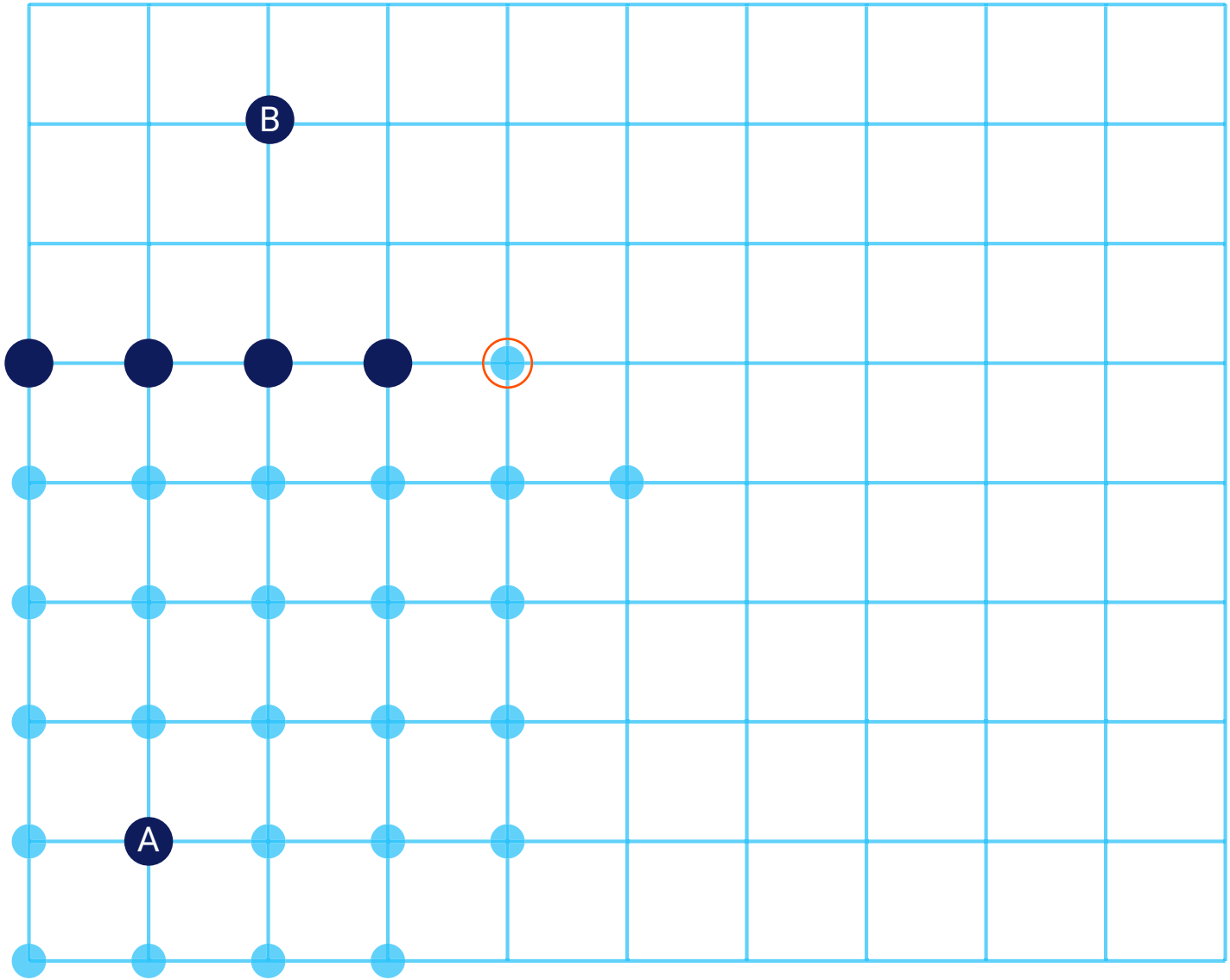
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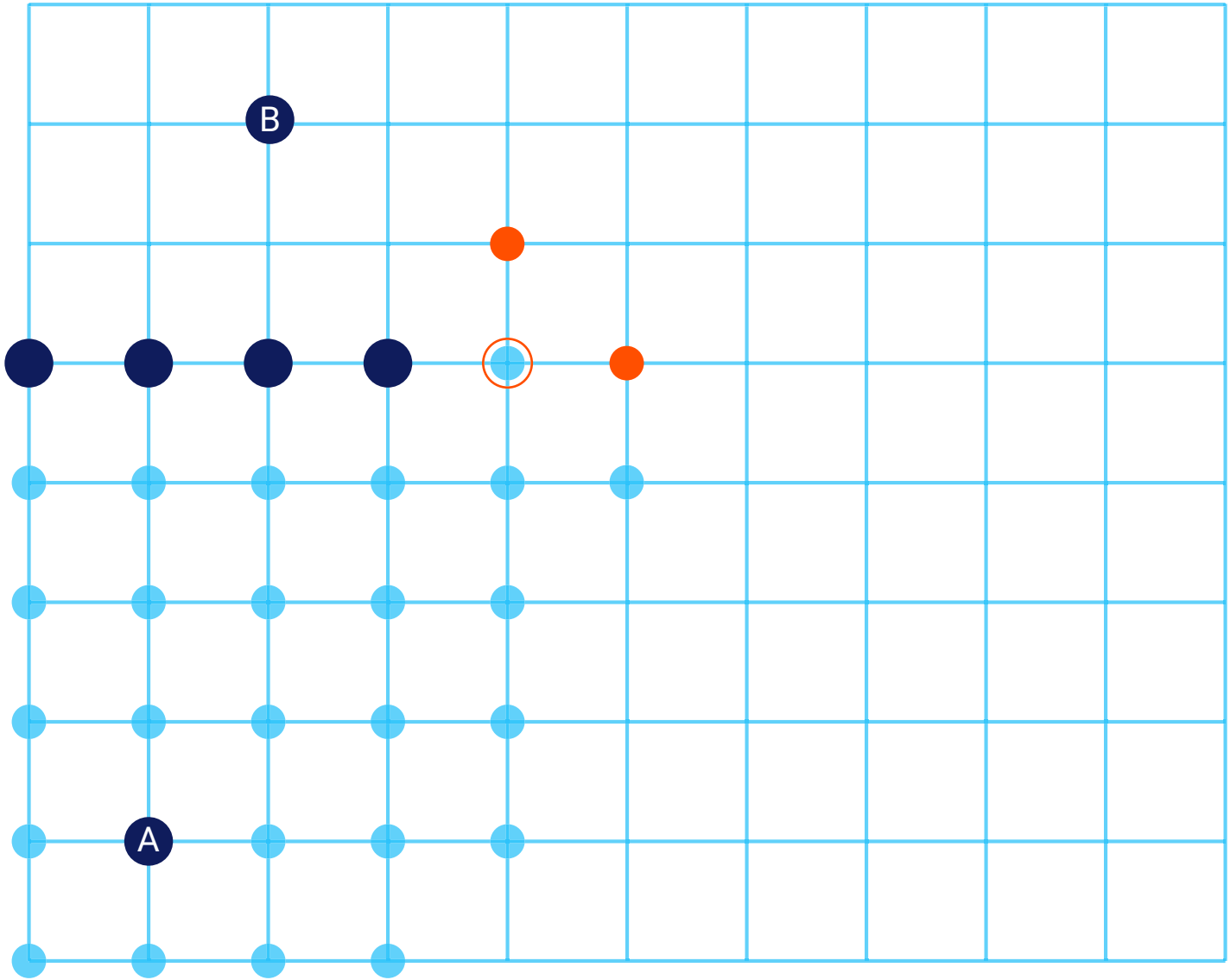
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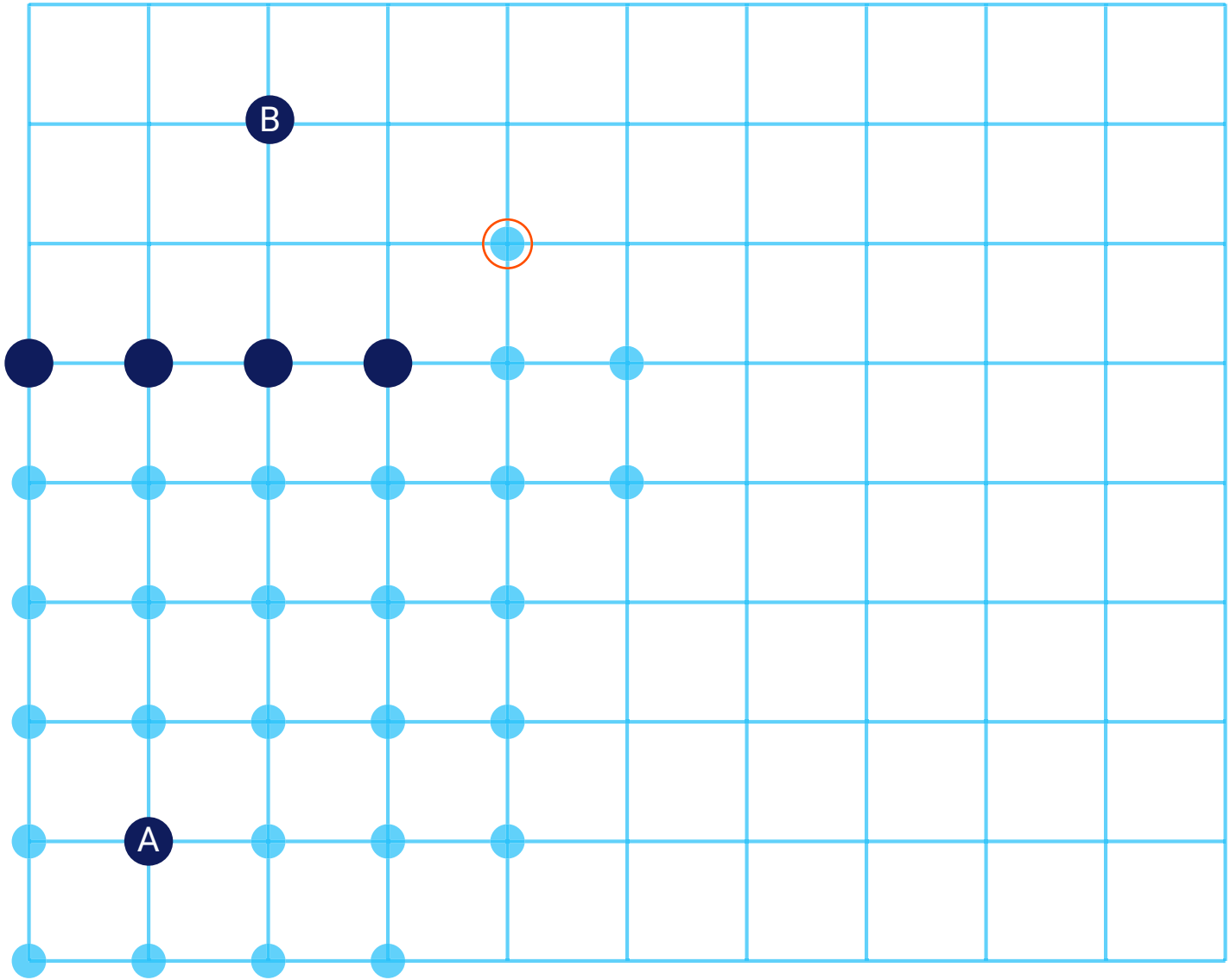
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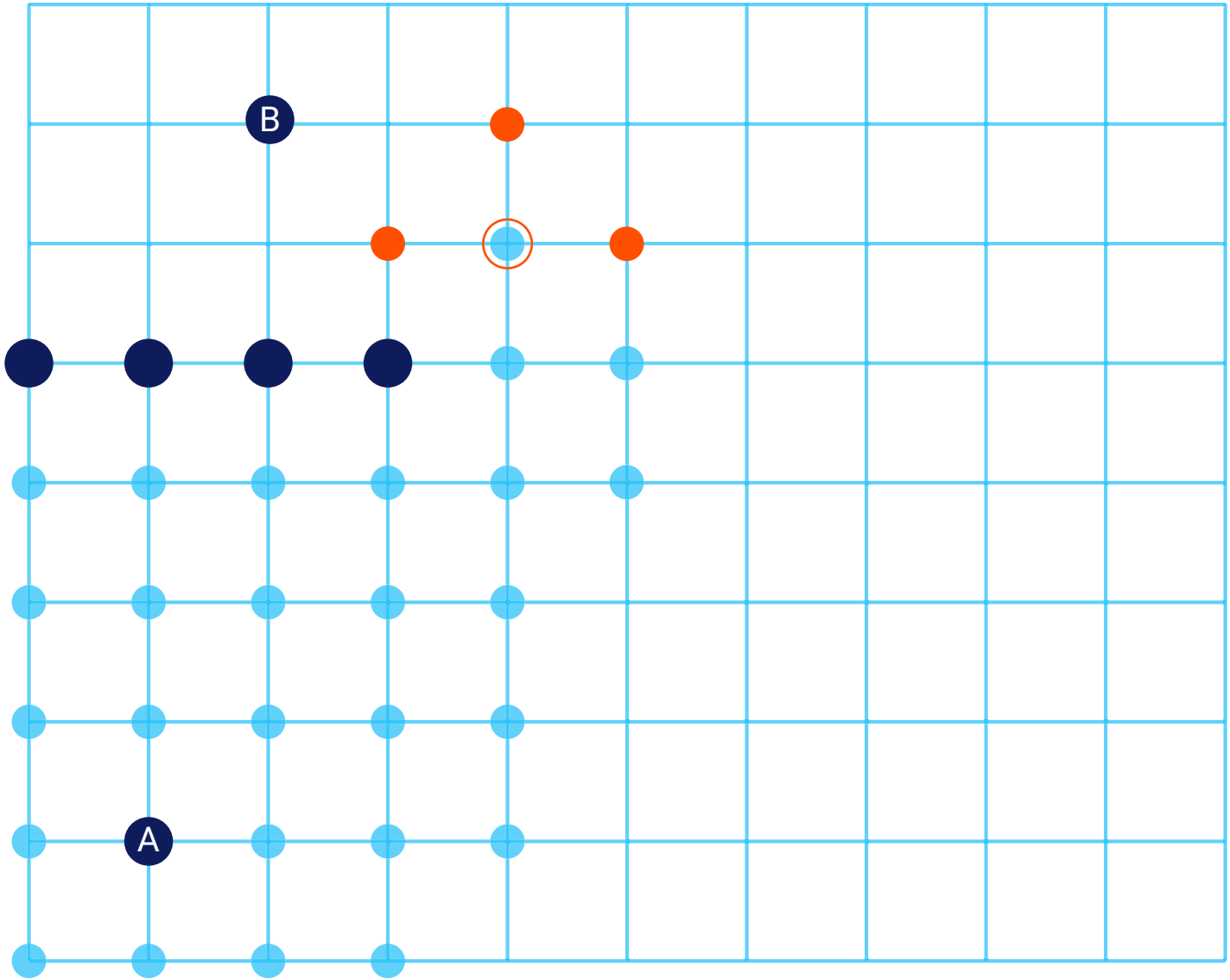
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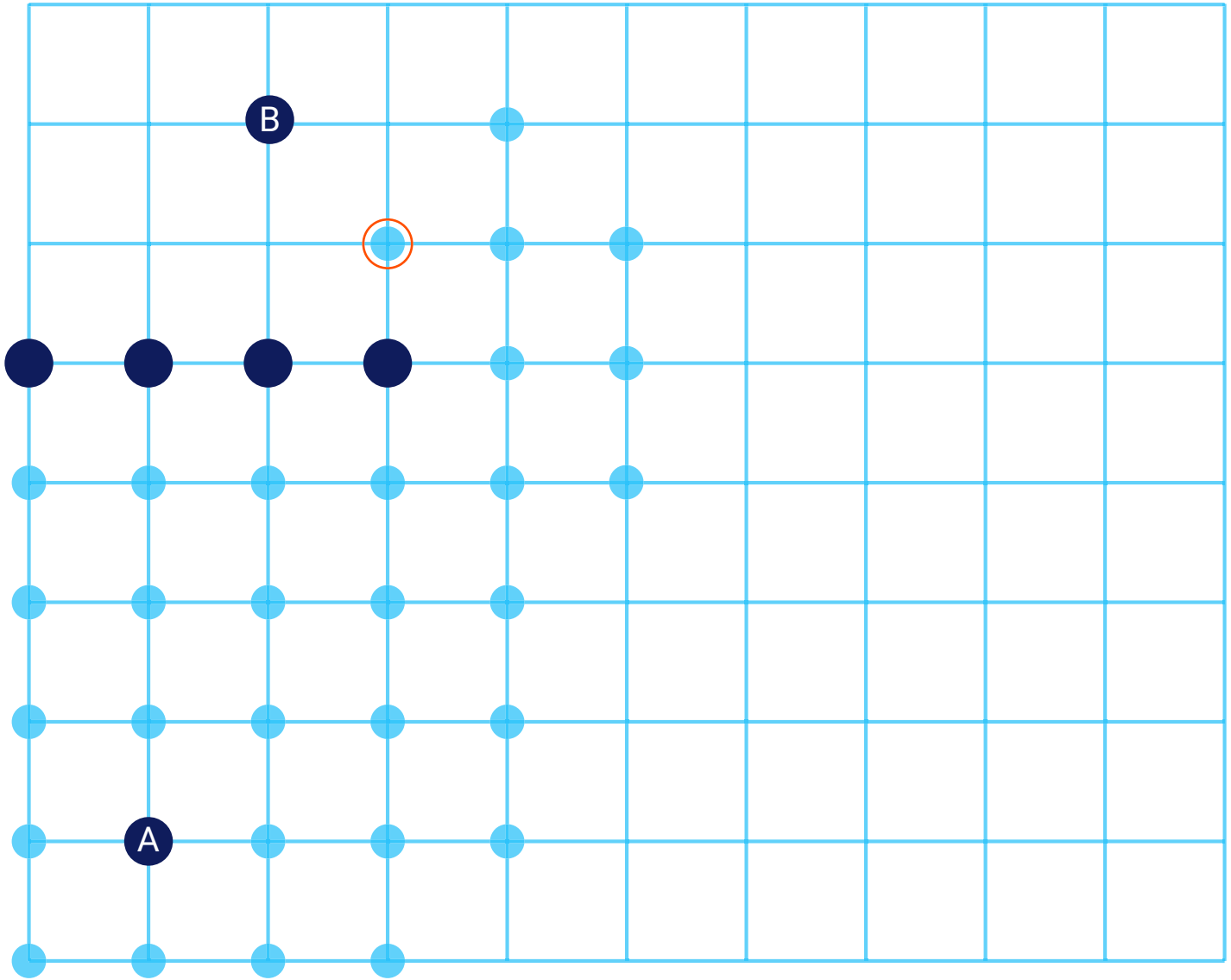
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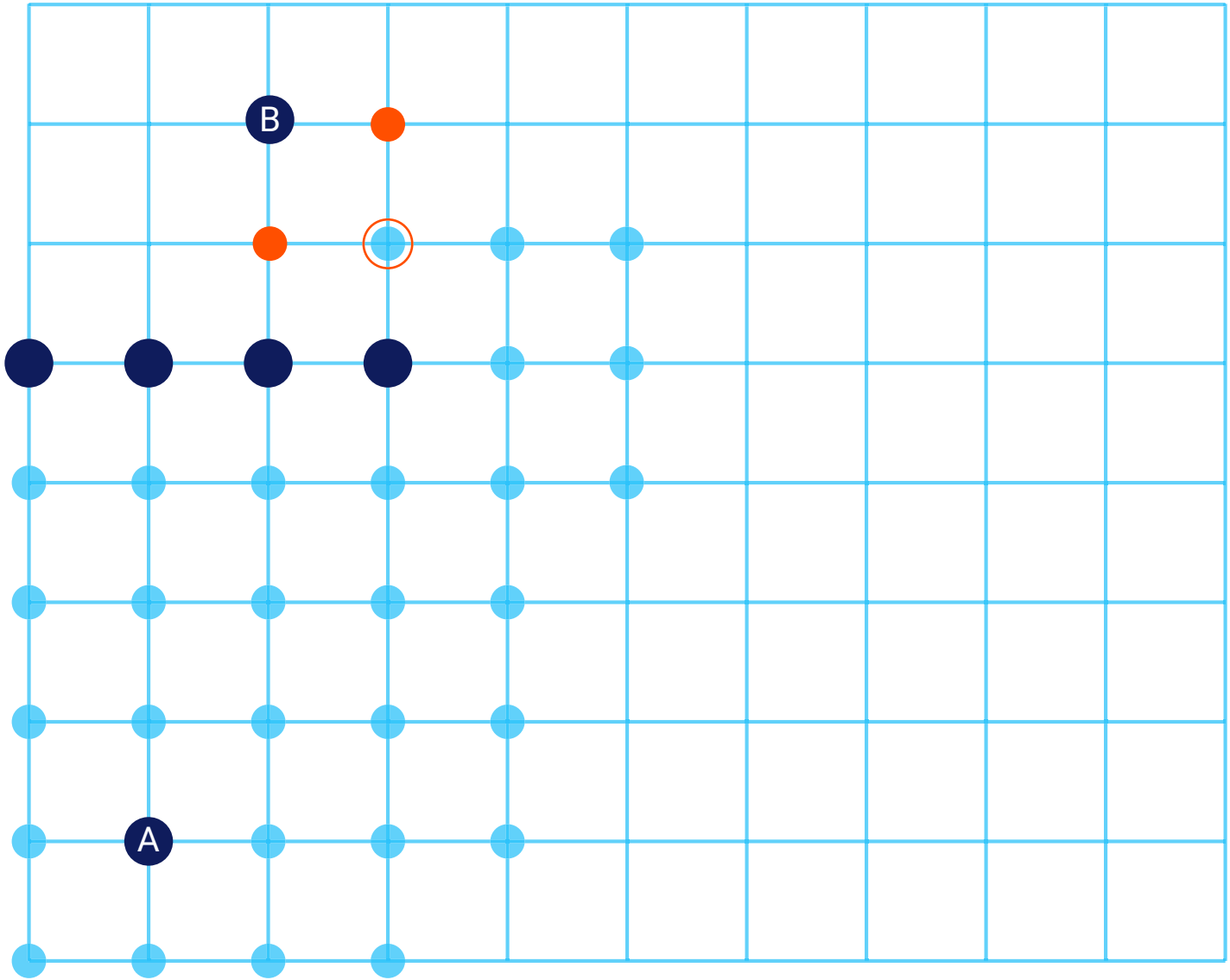
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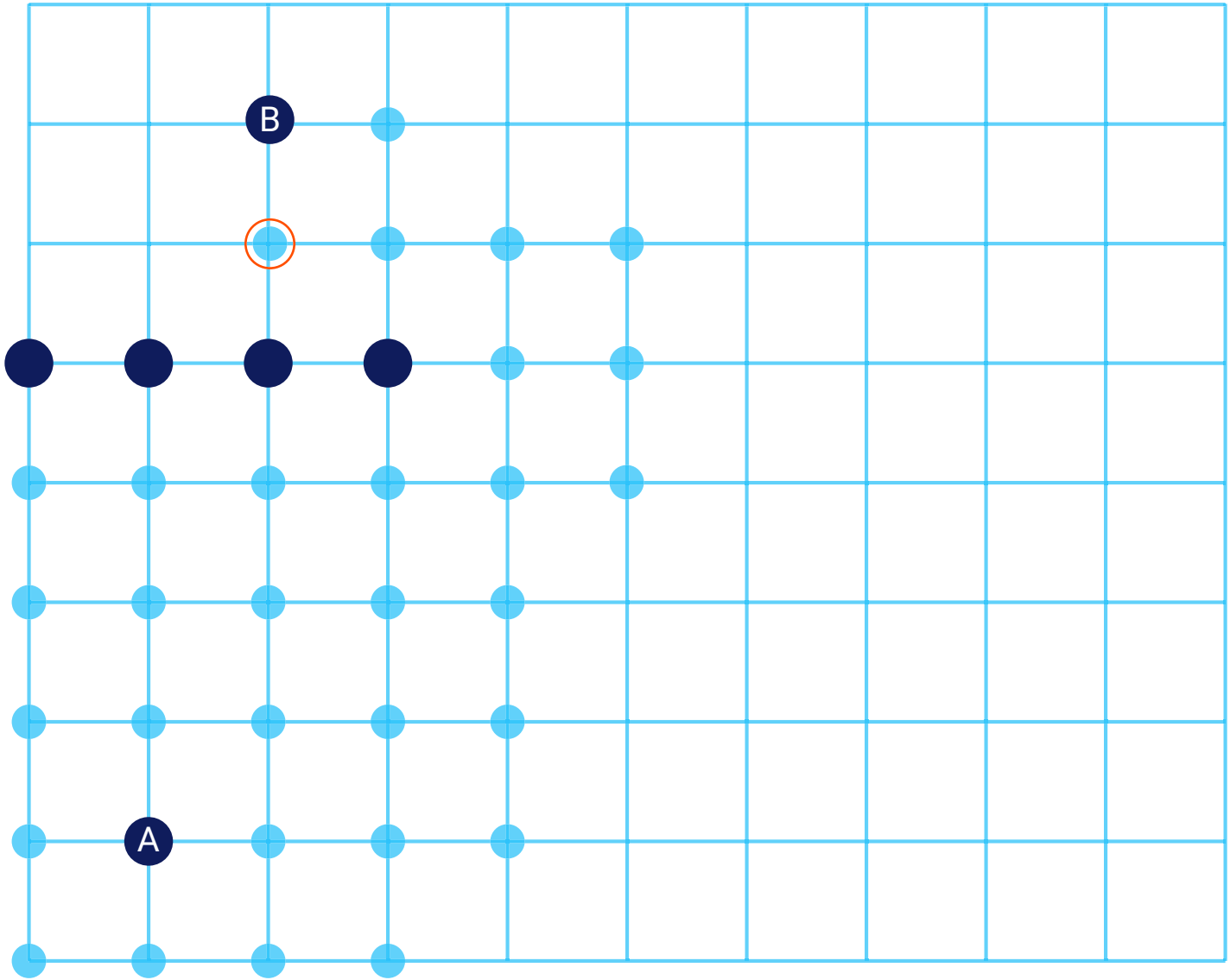
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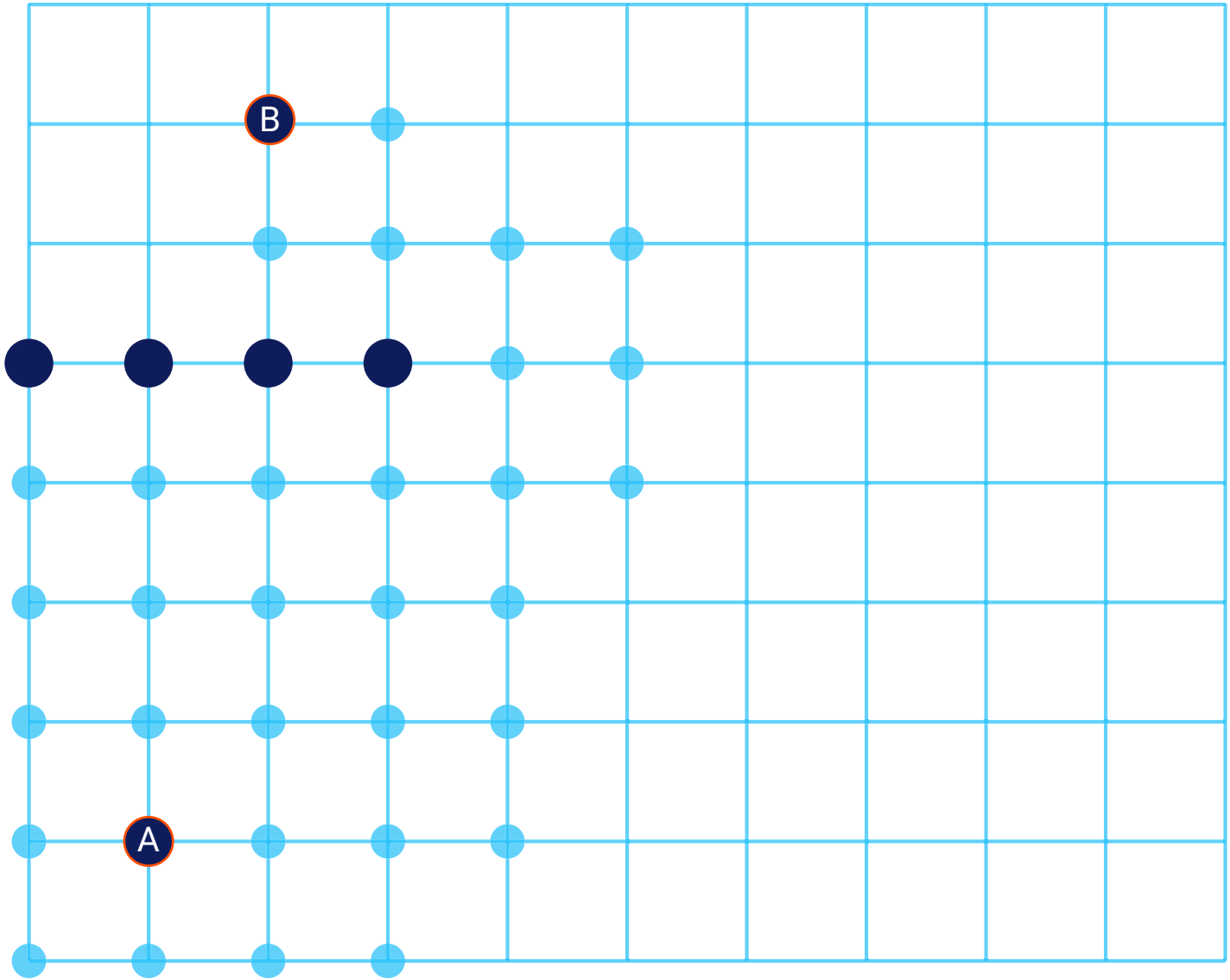
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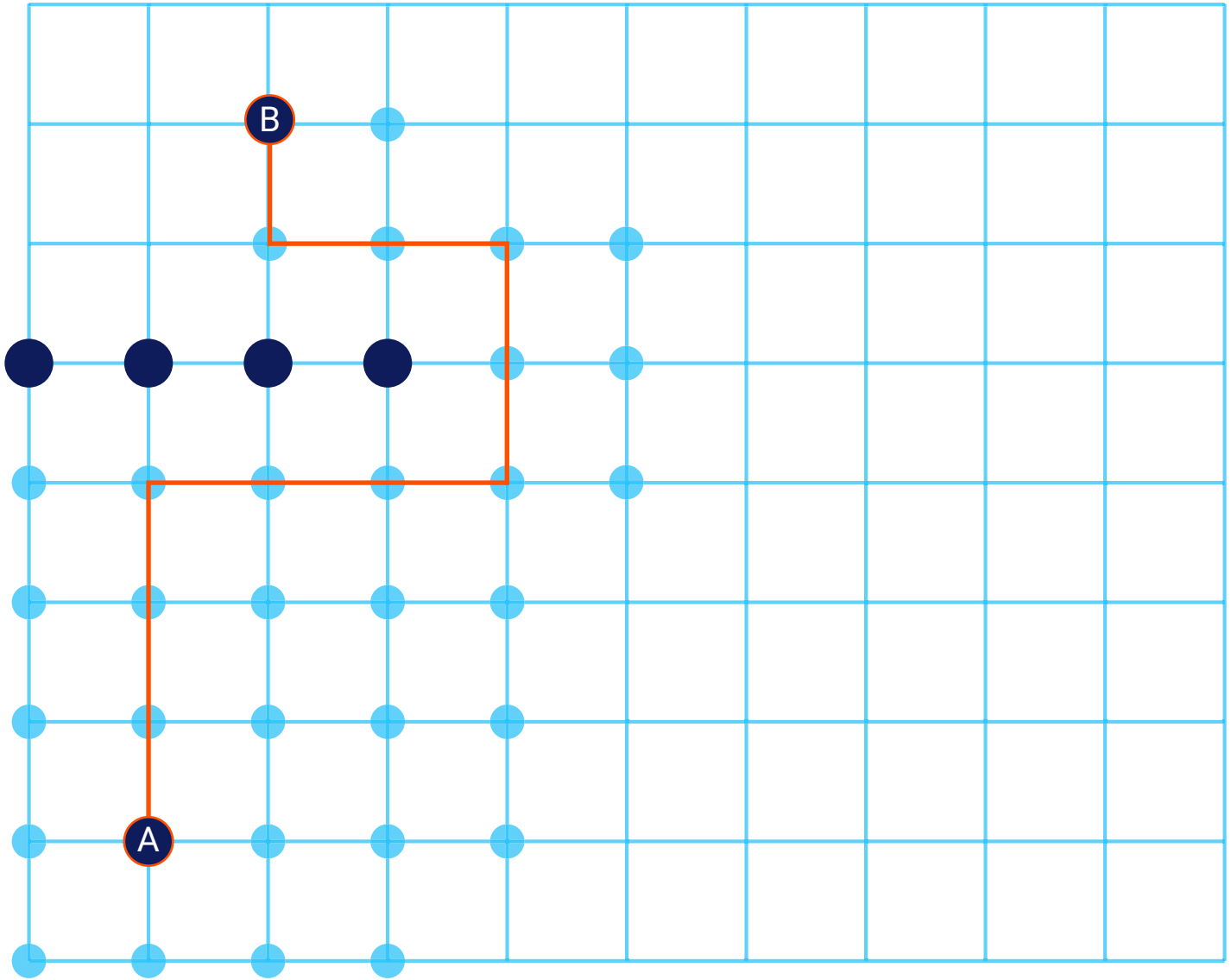
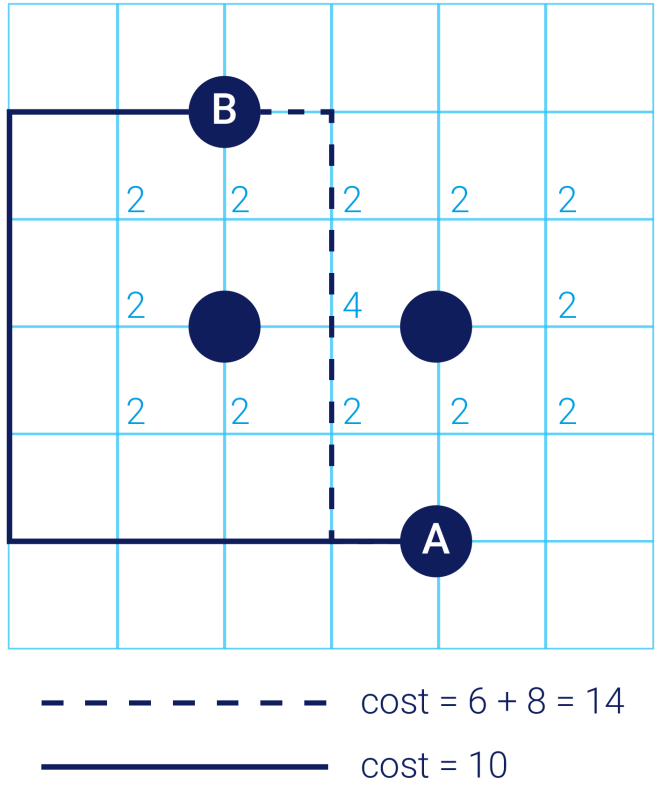

B
A

Heatmap

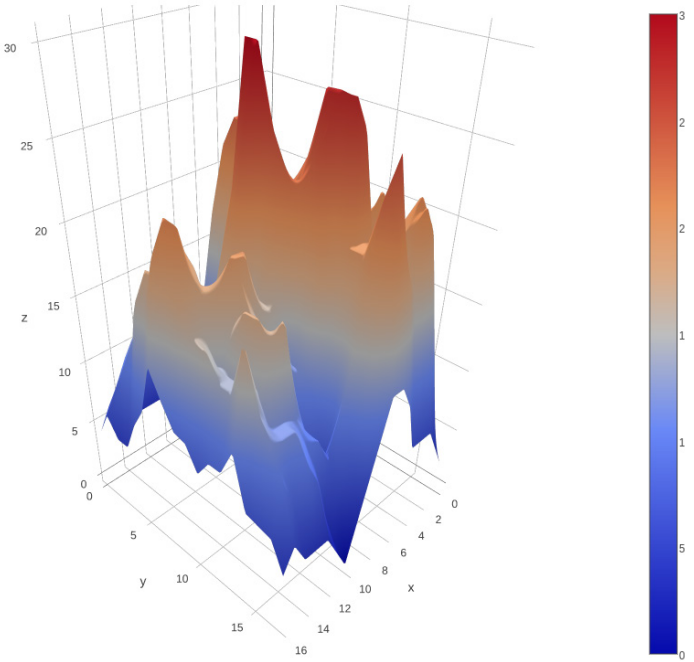
Pad met laagste kosten ≠ kortste pad

Heat penalty =
Heat constant - (2 • Manhattan distance to gate)



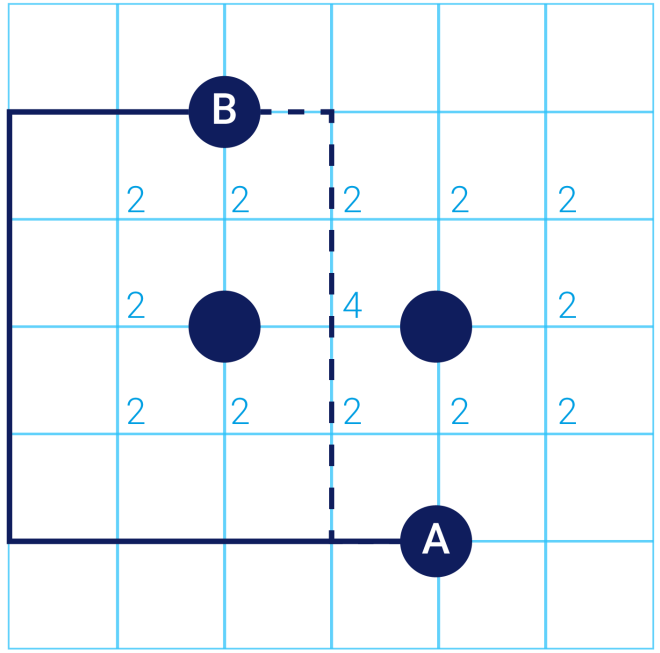
Heatmap

Pad met laagste kosten ≠ kortste pad



Heat penalty =

Heat constant - (2 • Manhattan distance to gate)

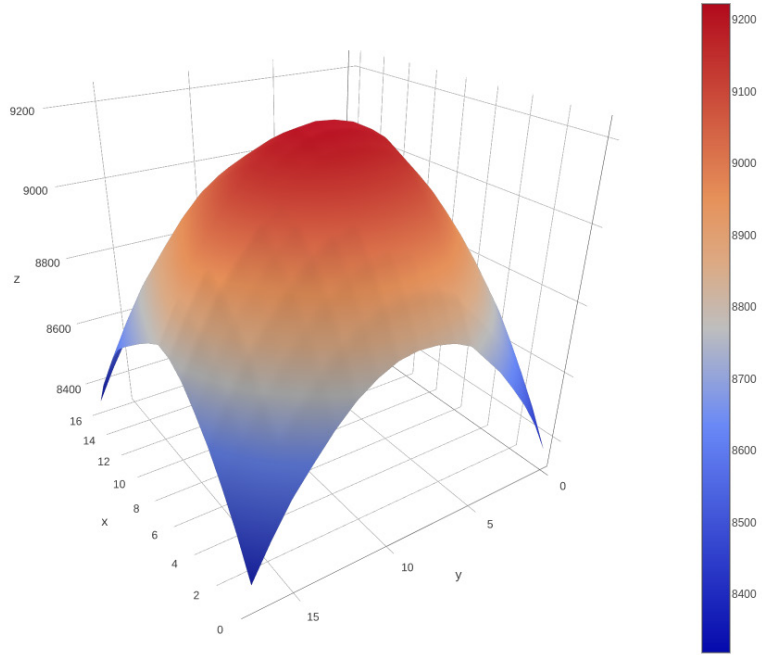


cost = 6 + 8 = 14

cost = 10

Heat range

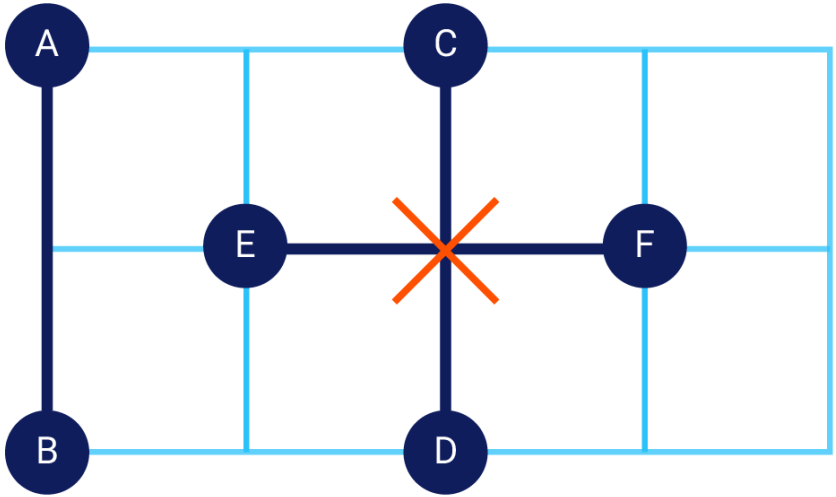
Pilot study: heat constant 5 - 30



Heat 2000, printplaat 2

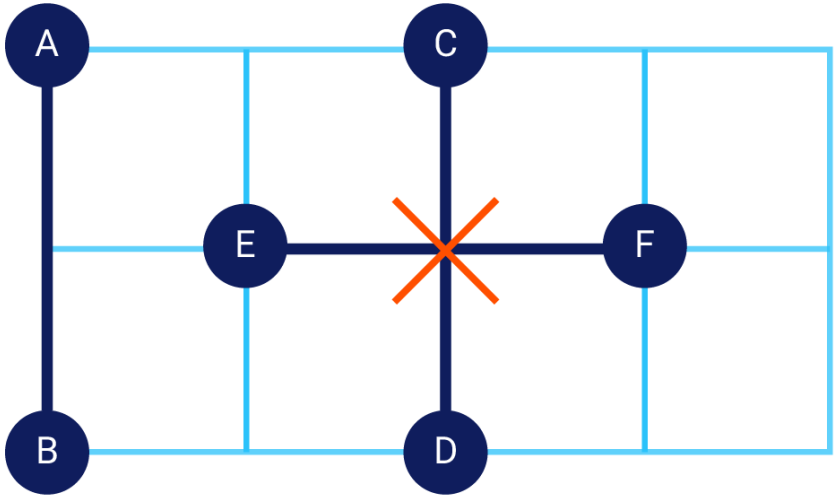
Permutaties

Netlist: [[A, B], [C, D], [E,F]]

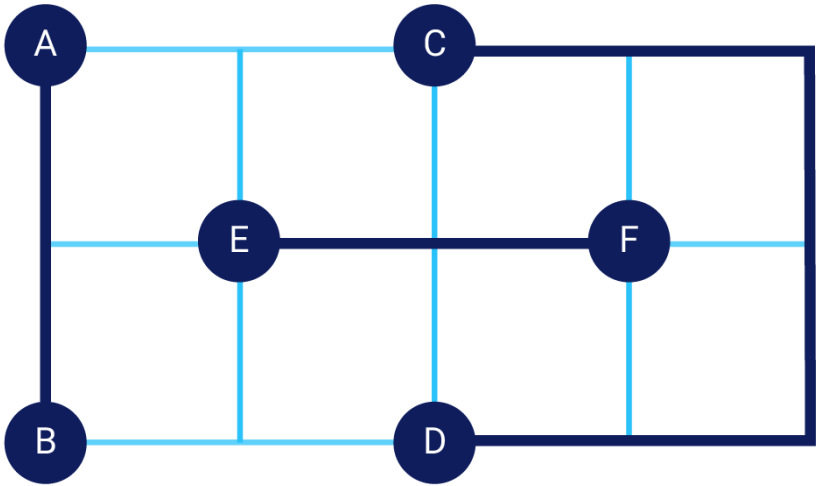


Permutaties

Netlist: [[A, B], [C, D], [E,F]]

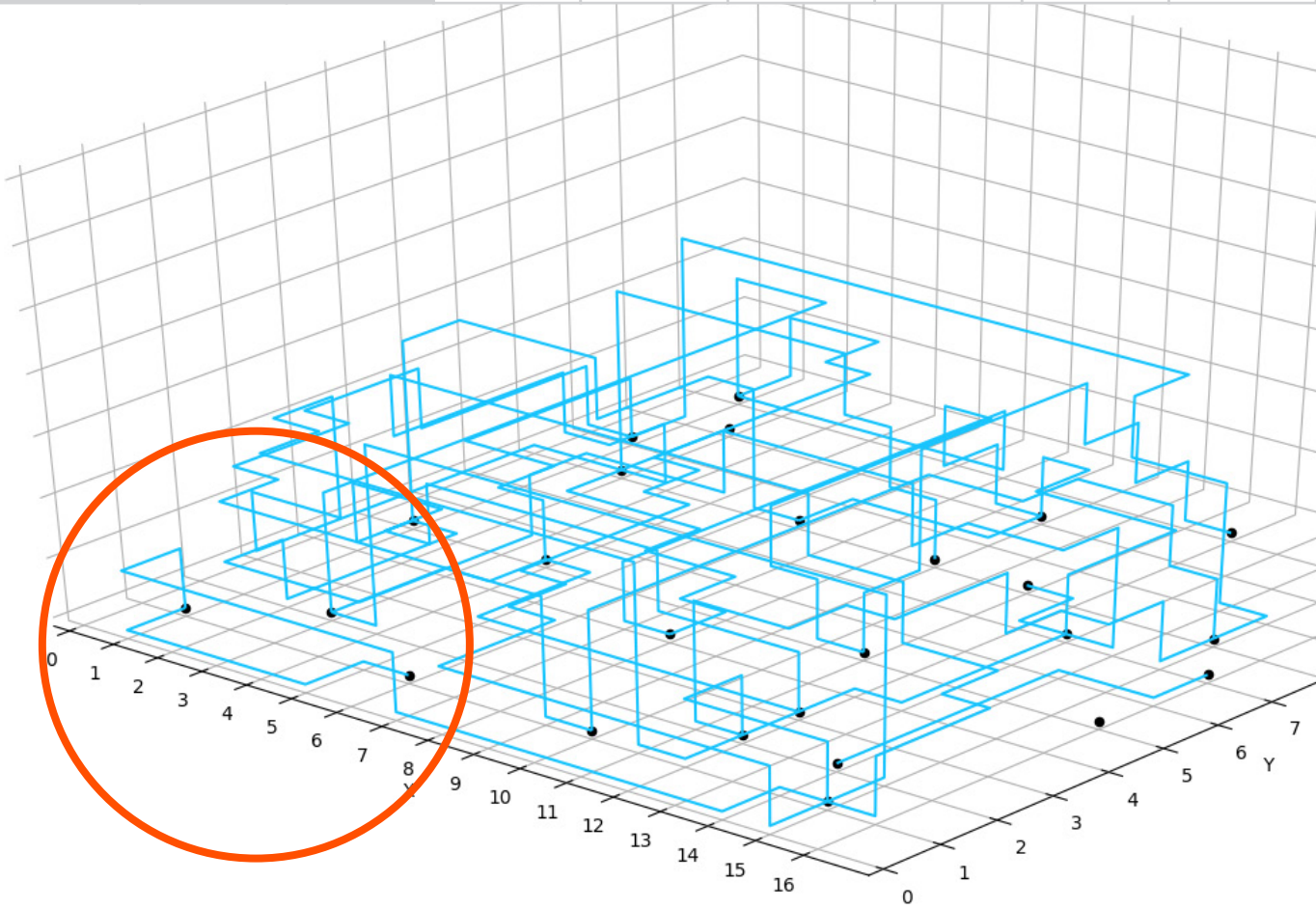


Netlist: [[A, B], [E, F], [C, D]]



Optimalisatie

*A**



Resultaten

*Alleen A**

500 permutations

	Circuit board 1			Circuit board 2		
Netlist	1	2	3	4	5	6
Number of nets laid down	27/30	32/40	37/50	40/50	45/60	47/70

Resultaten

A + Heatmap*

500 permutations

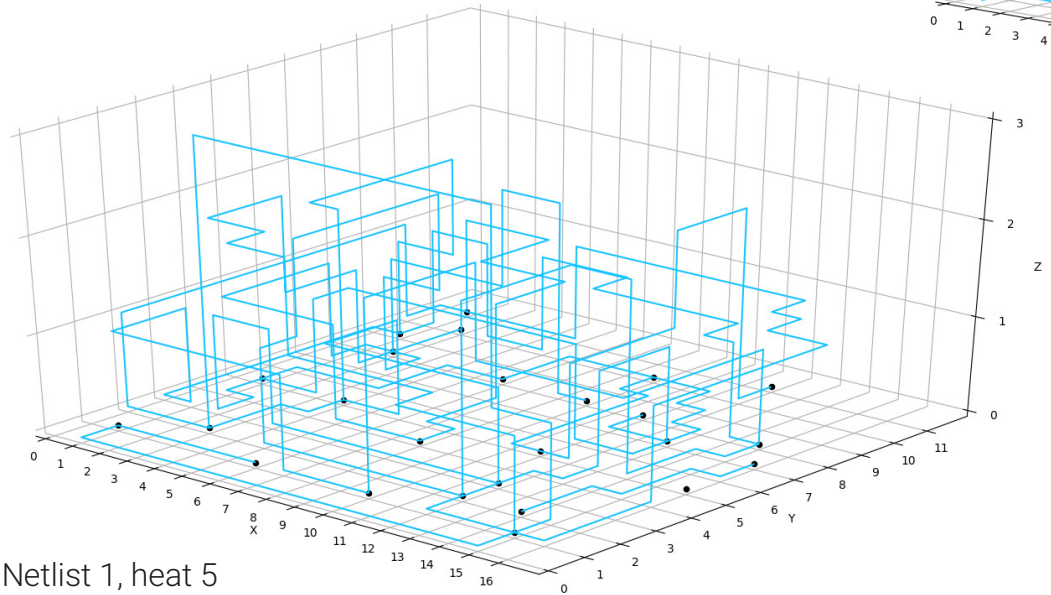
Heat constant:
5-30

totaal: 12500 iteraties per netlist

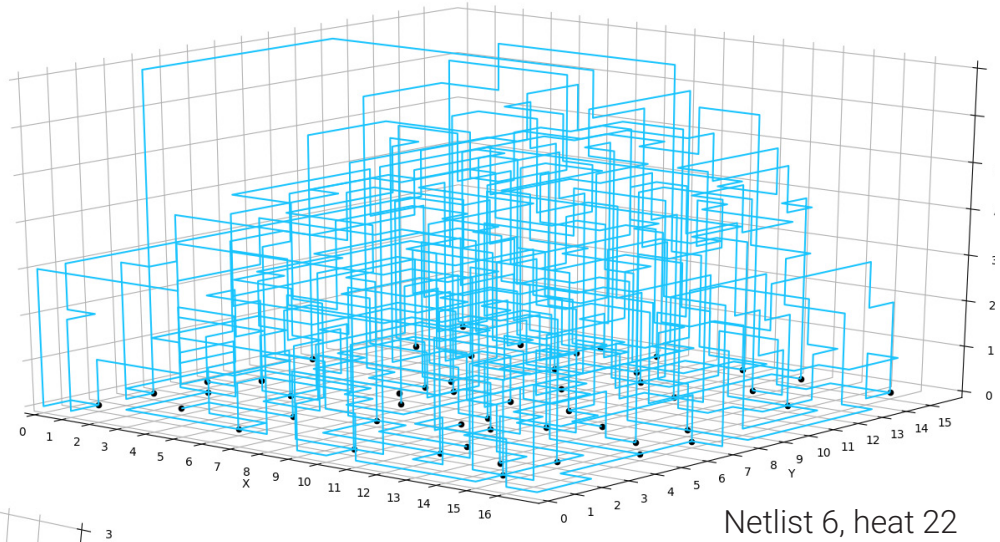
	Circuit board 1			Circuit board 2		
Netlist	1	2	3	4	5	6
Number of nets laid down	30/30	40/40	50/50	50/50	60/60	70/70
Heat constant	5	19	14	29	18	22
Total length before optimisation	409	765	1003	1096	1416	1615
Total length after optimisation	**359**	**455**	**743**	**818**	**910**	**1341**
Decrease in total length after optimisation	12,2%	40,5%	25,9%	25,4%	35,7%	17,0%
Lower bound total length	291	341	475	600	578	761
Percentage of optimised total length exceeding the lower bound	23,4%	33,4%	56,4%	36,3%	57,4%	76,2%

Resultaten

3D Plot



Netlist 1, heat 5



Netlist 6, heat 22

Conclusie

- Alle netlists zijn oplosbaar
- Heatmap was essentieel
- Geen universele optimale heat constant
- Volgorde van nets in de netlist cruciaal in deze methode

Discussie

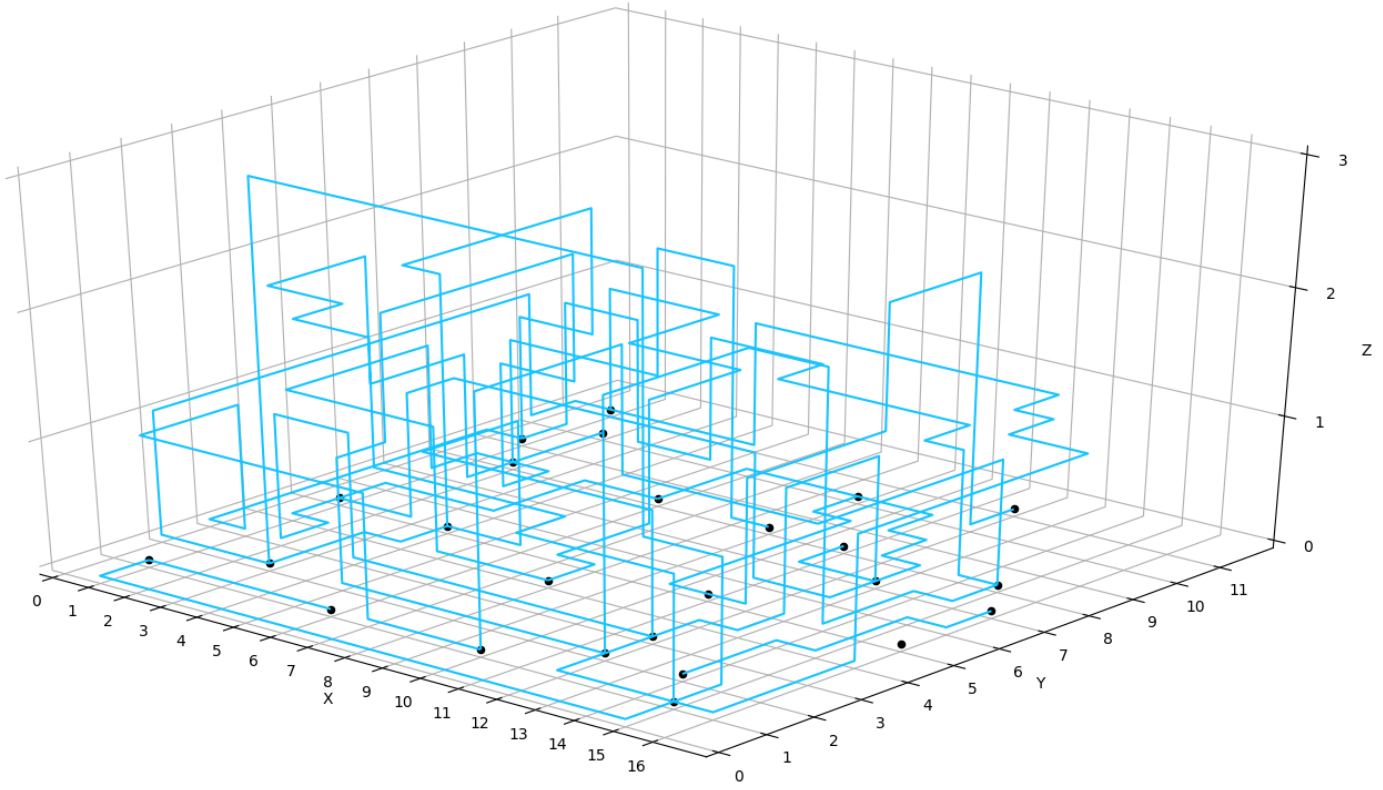
- Optimaal?
  Lower bound,
  Random permutations: alle permutaties (n!)

- 6e meest complex

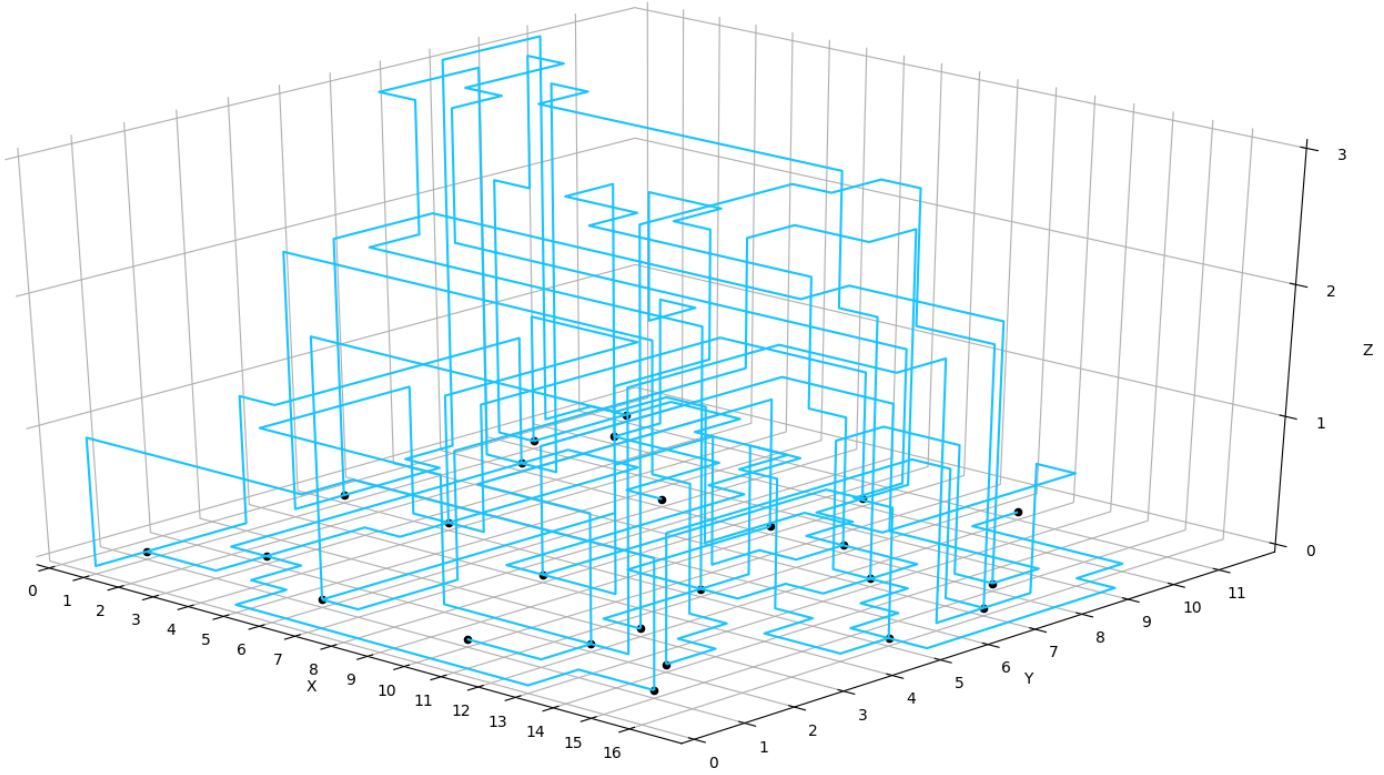
- Vervolgonderzoek:
  permutations + effectievere Heatmaps
  + volgorde optimalisatie

Vragen?

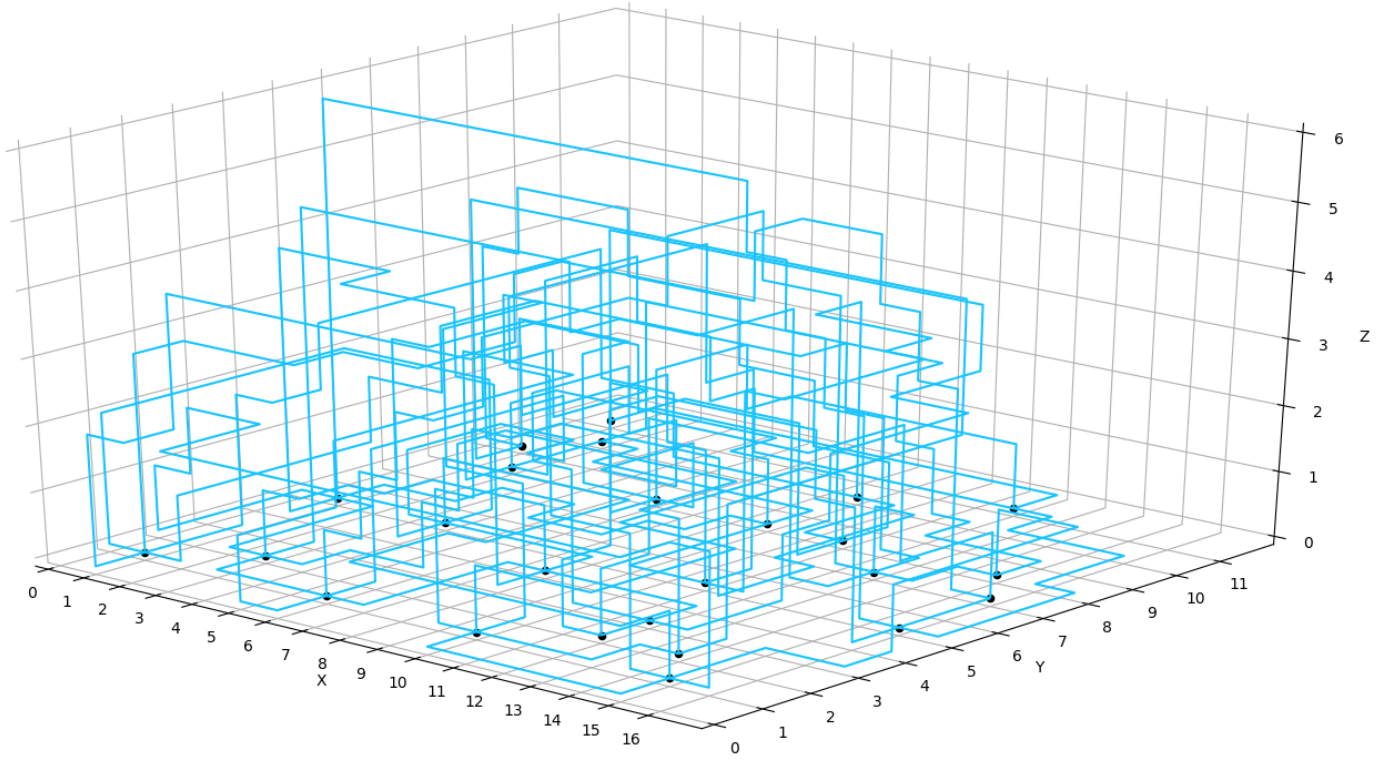
Netlist 1



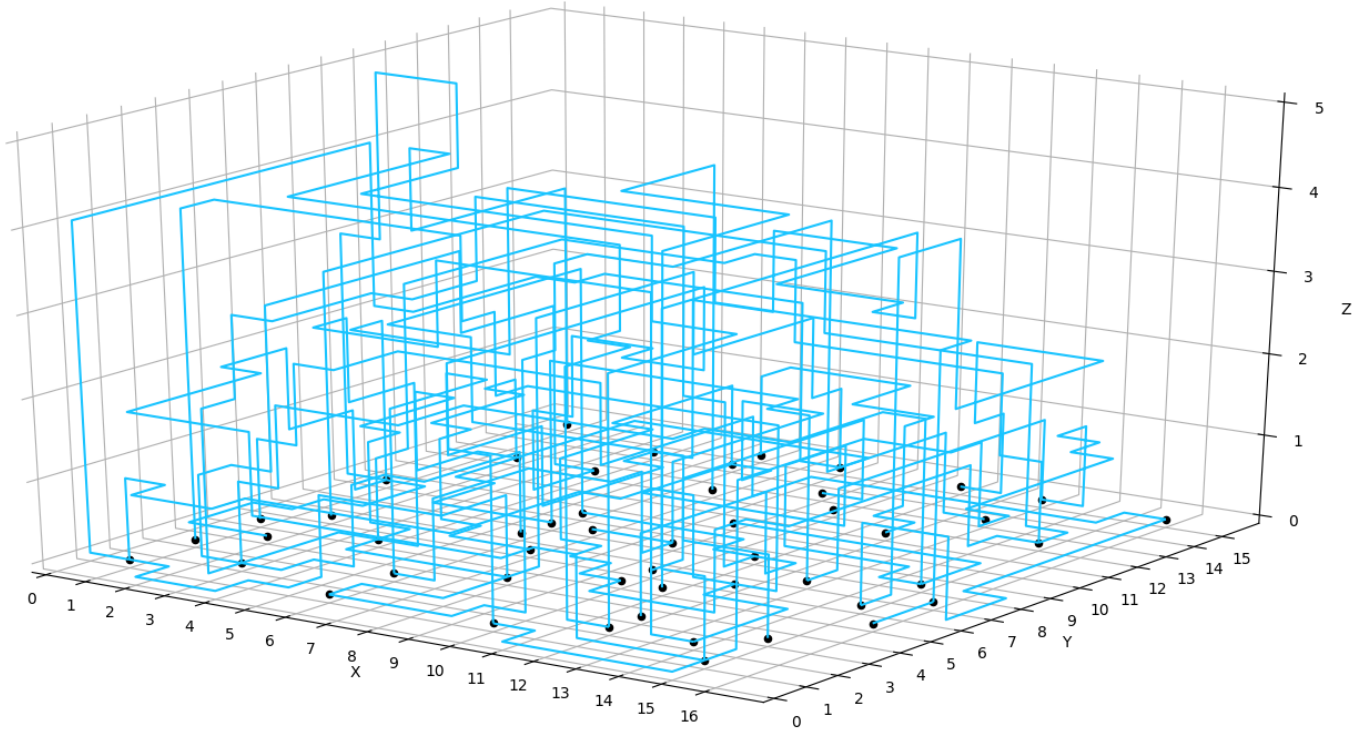
Netlist 2



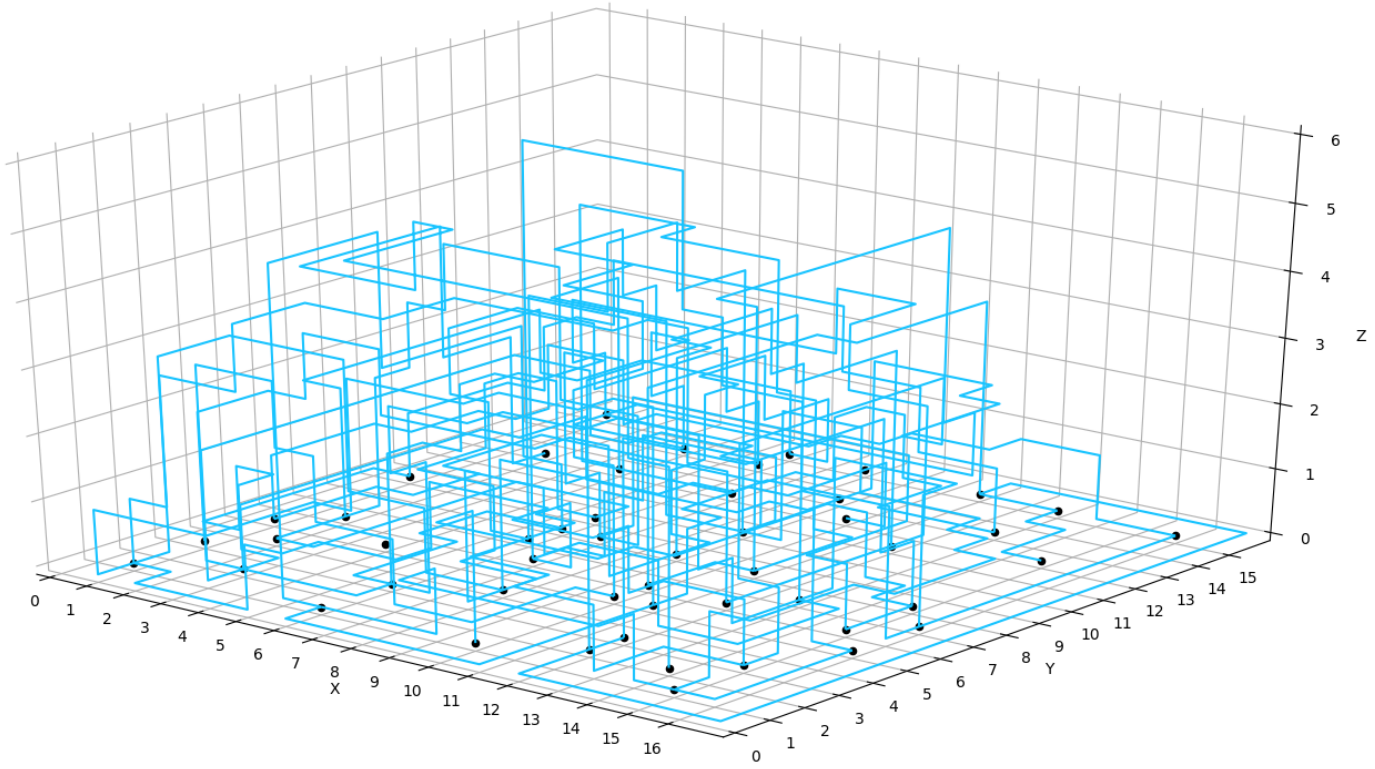
Netlist 3



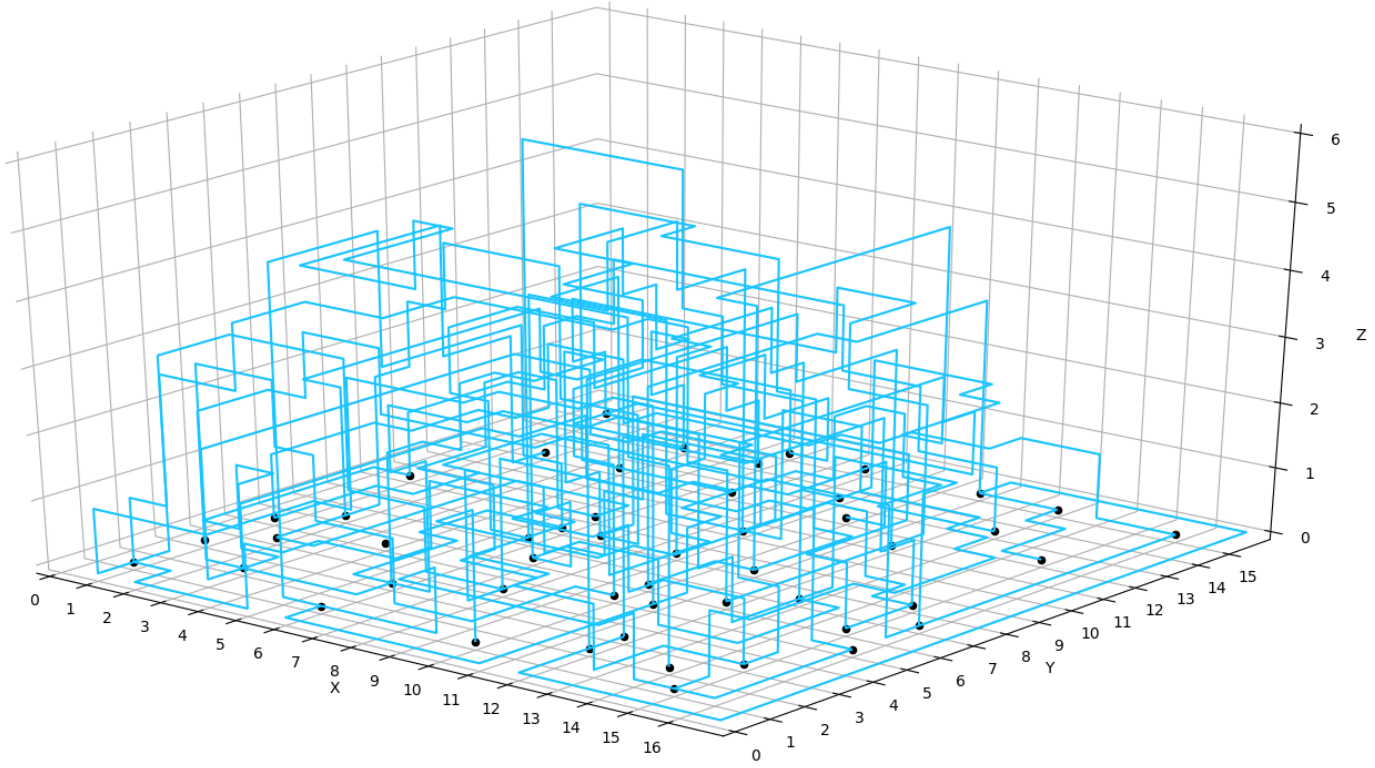
Netlist 4


X
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Y
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Z
0 1 2 3 4 5

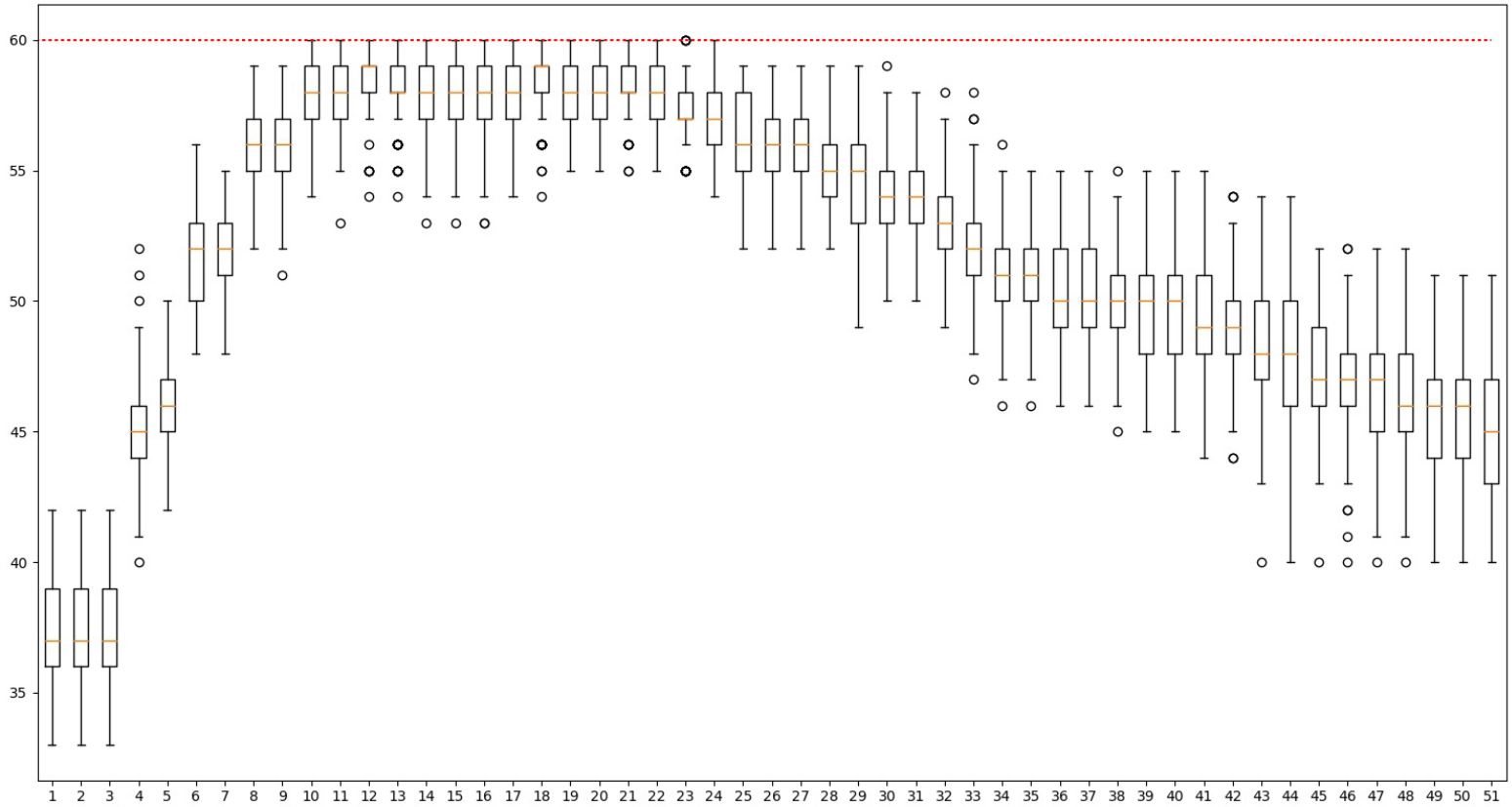
Netlist 5

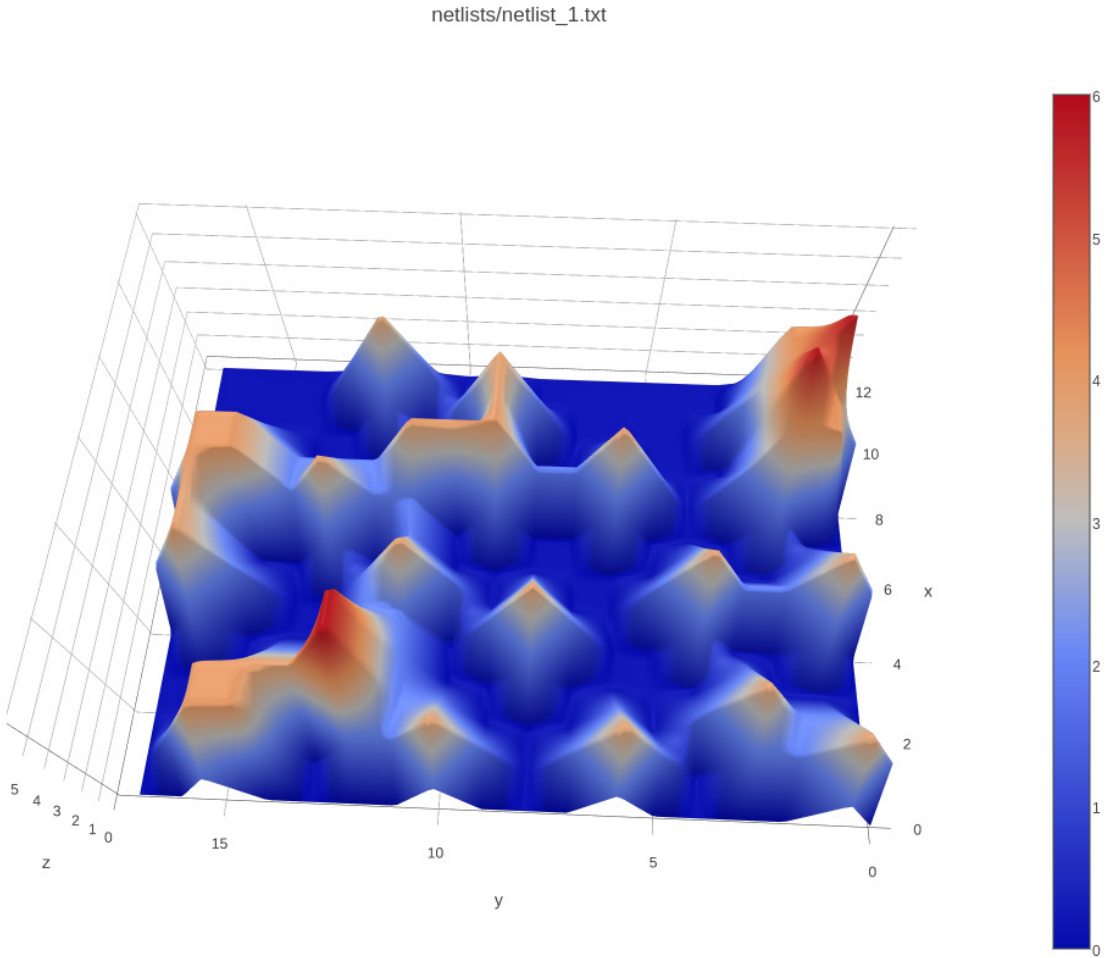

X
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Y
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Z
0 1 2 3 4 5 6

Netlist 6


X
Y
Z
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
0 1 2 3 4 5 6

Netlist 5, 100 iteraties




netlists/netlist_1.txt
x
y
z
0
2
4
6
8
10
12
0
5
10
15
0
1
2
3
4
5
6