Implementierung eines N-Queens-Solvers mit koronaler Vorbesetzung

Presentation zum Lehrstuhlseminar

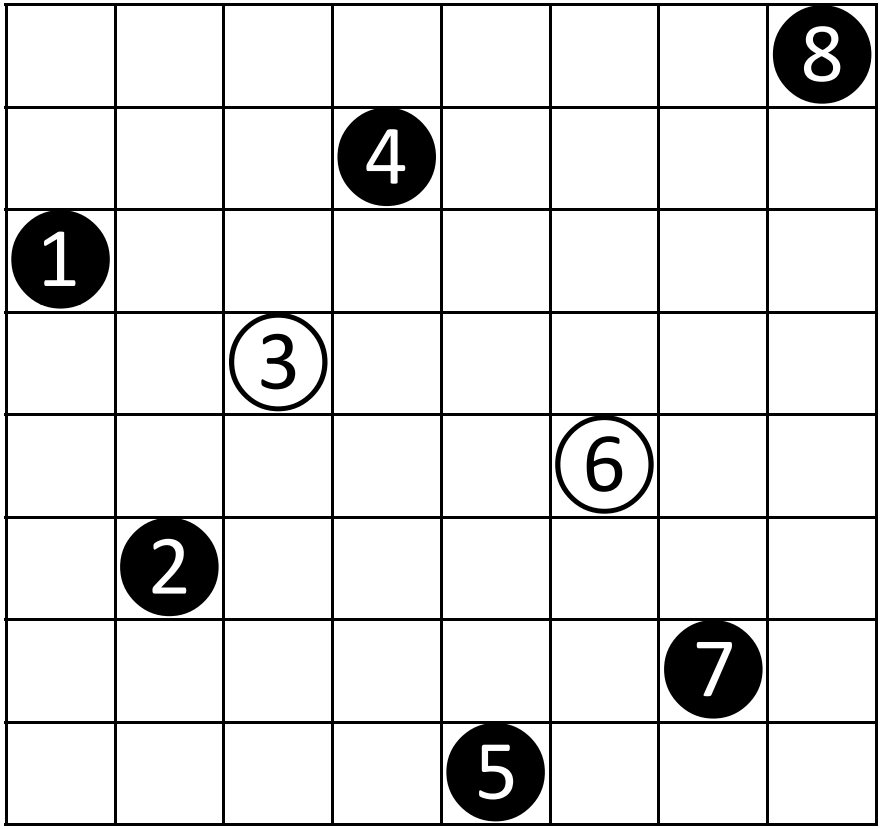
Benedikt Reuter

Dresden, 08.02.2015

Betreuer:
Dr.-Ing. Thomas B. Preußer

Gliederung

Einleitung


8
4
1
3
6
2
7
5

Bisherige Lösungen

N	Lösungen	N	Lösungen	N	Lösungen
1	1	10	724	19	4968057848
2	0	11	2680	20	39029188884
3	0	12	14200	21	314666222712
4	2	13	73712	22	2691008701644
5	10	14	365596	23	24233937684440
6	4	15	2279184	24	227514171973736
7	40	16	14772512	25	2207893435808352
8	92	17	95815104	26	22317699616364044
9	352	18	666090624	27	?

TECHNISCHE UNIVERSITÄT DRESDEN

Queens@TUD

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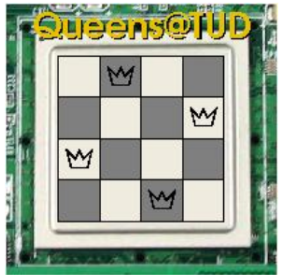

QUEENS@TUD

Mit FPGAs zum Weltrekord!

Q(26)=22.317.699.616.364.044

Queens@TUD ist ein massiv paralleler, FPGA-basierter Ansatz zur Suche und Zählung aller Lösungen zu einem gegebenen →N-Damenproblem.
Zu Beginn des Projektes (2008) waren die Lösungszahlen für alle N bis 25 bekannt. Dieses Projekt war das erste, das am **11. Juli 2009** die Lösungszahl für N=26 zu Q(26)=**22317699616364044** bestimmt hat. (mehr)

Wir evaluieren zur Zeit die Fortsetzung des Projektes zur Berechnung von Q(27). Ein zeitnaher Abschluss dieses Problems wird definitiv sowohl *weitere methodische und algorithmische Verbesserungen* als auch *verstärktes FPGA-Sponsoring* erfordern. Für nützliche Hinweise und interessierte *Kooperationspartner* wären wir sehr dankbar.

SPONSORS

→SIGNALION

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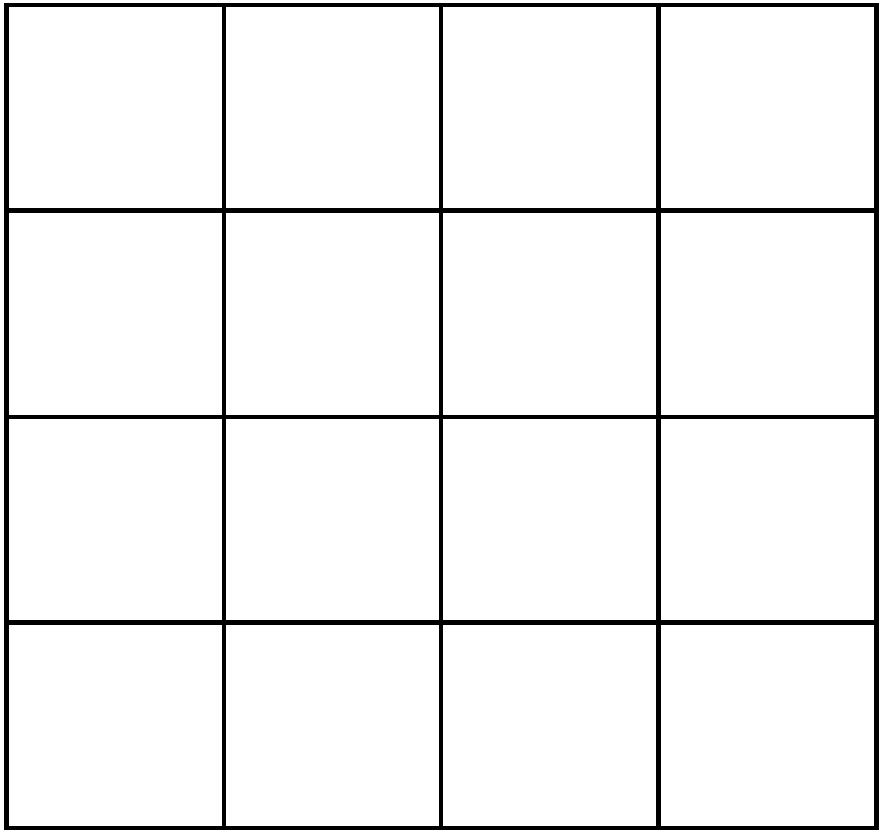
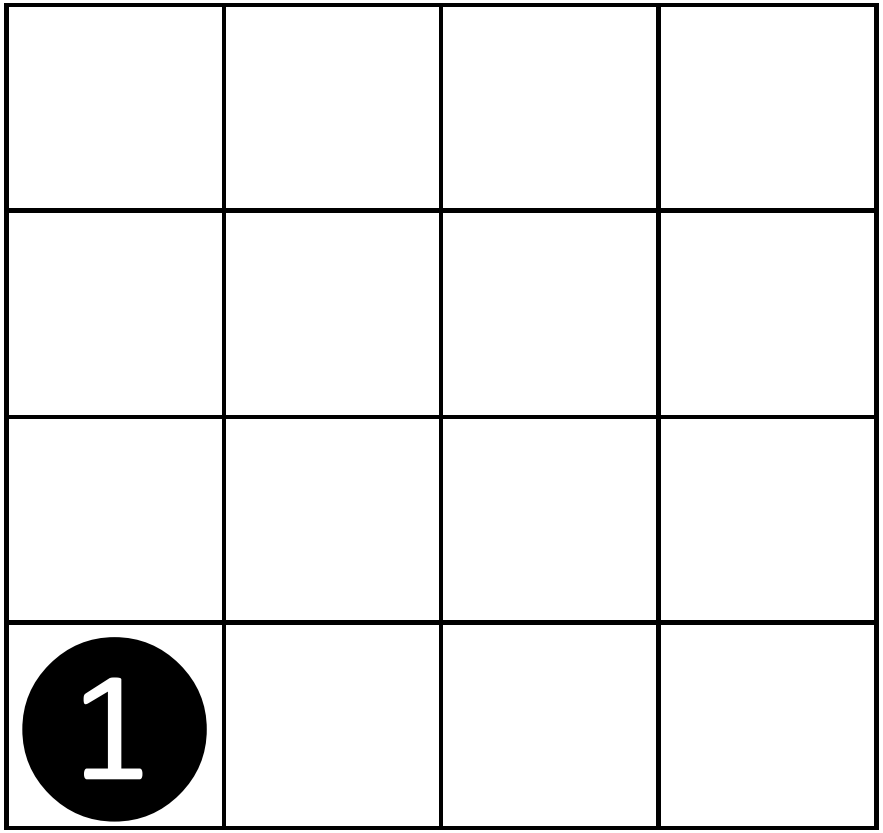
Fakultät Informatik
Technische Universität Dresden
D-01062 Dresden

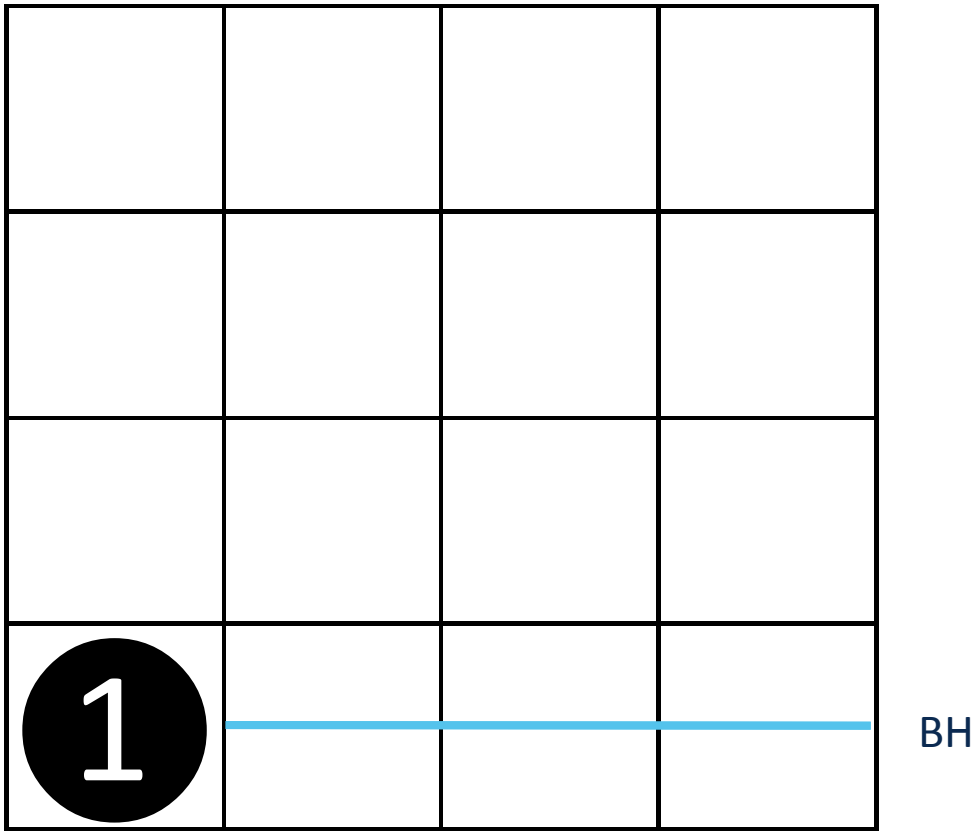
http://queens.inf.tu-dresden.de/ (03.02.2015)

Algorithmus



Algorithmus

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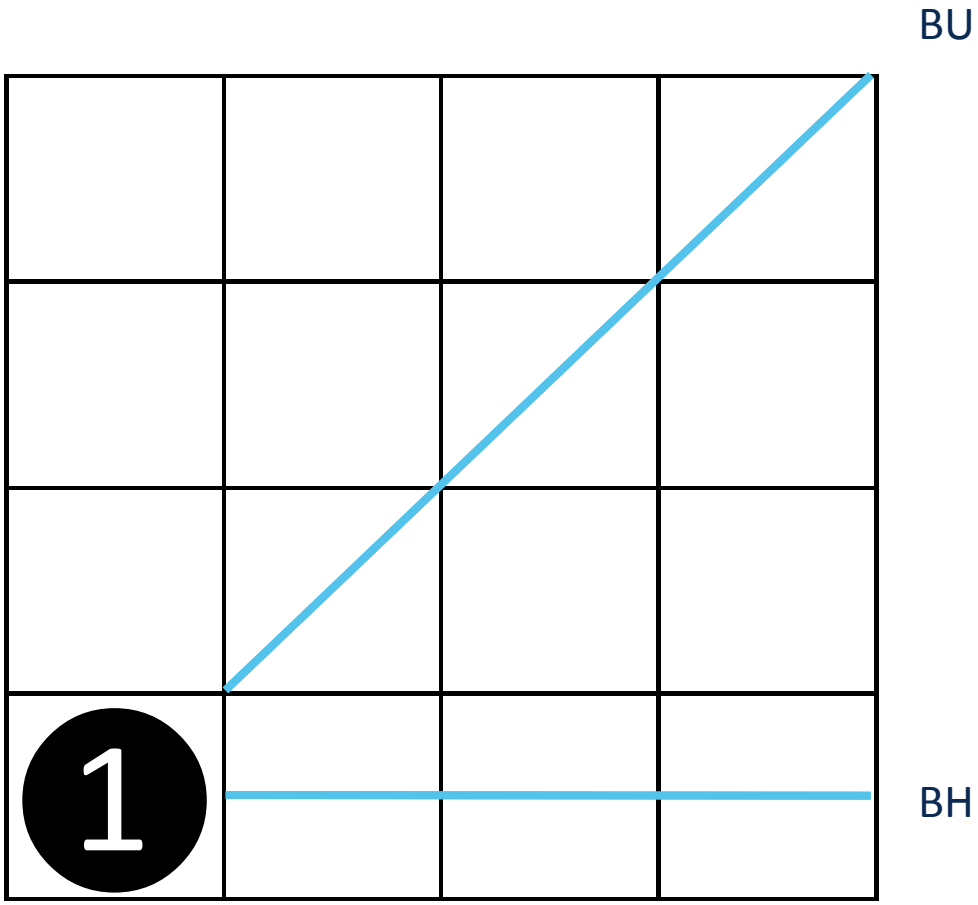
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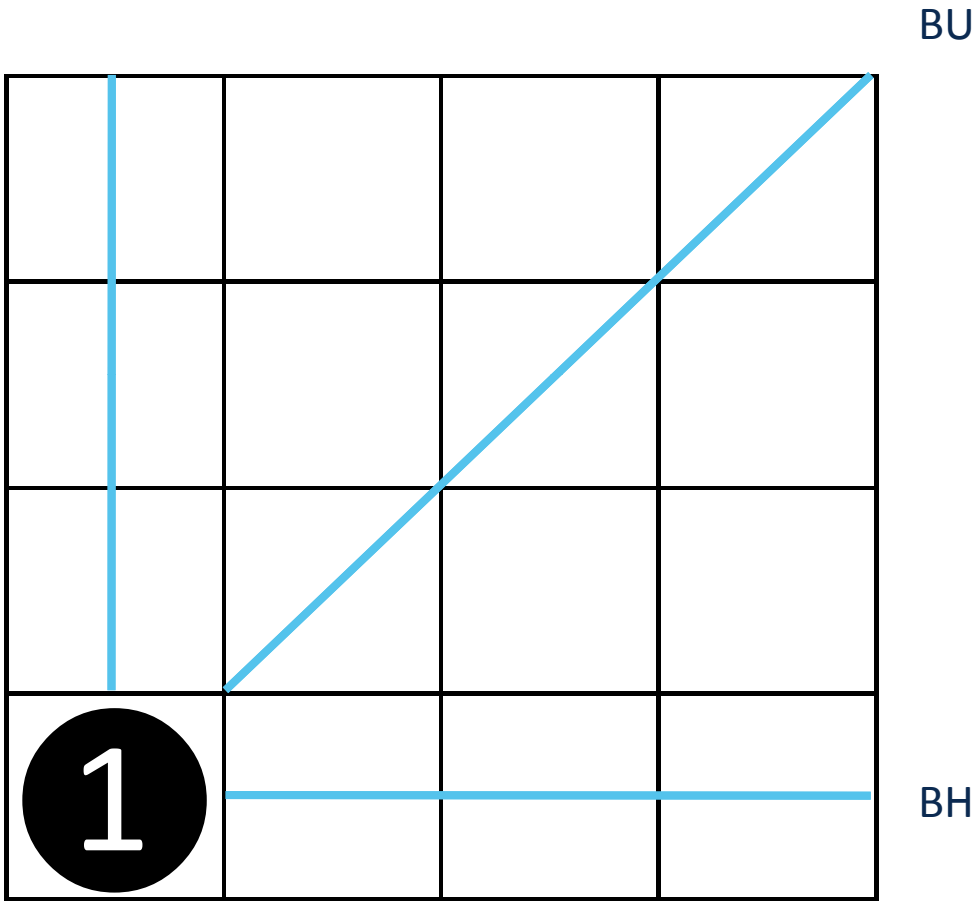
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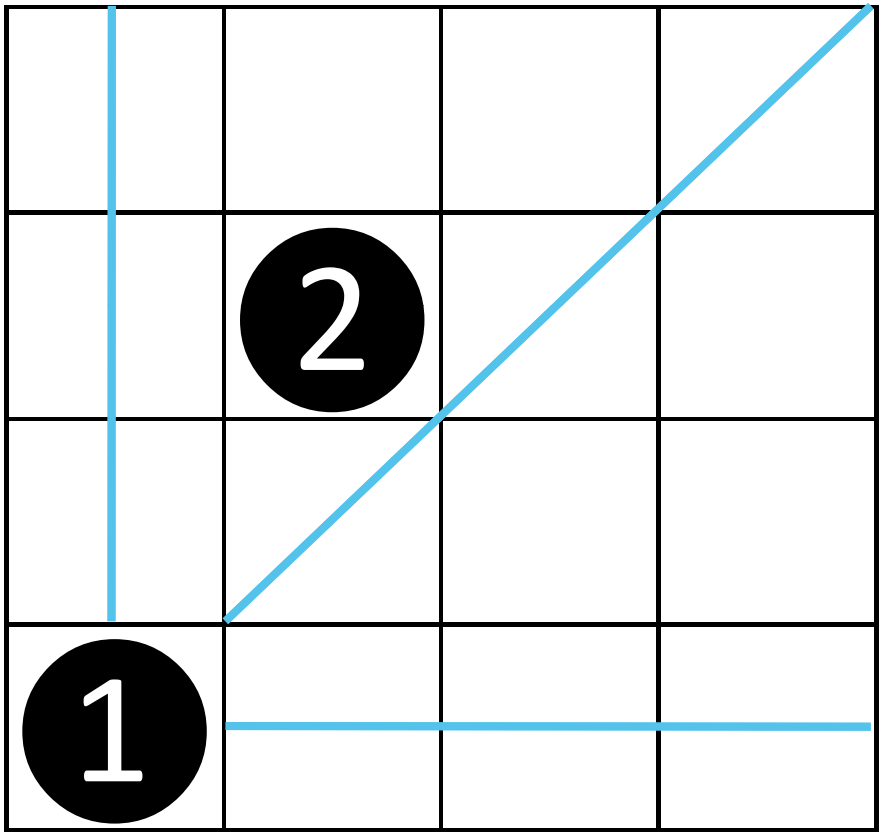
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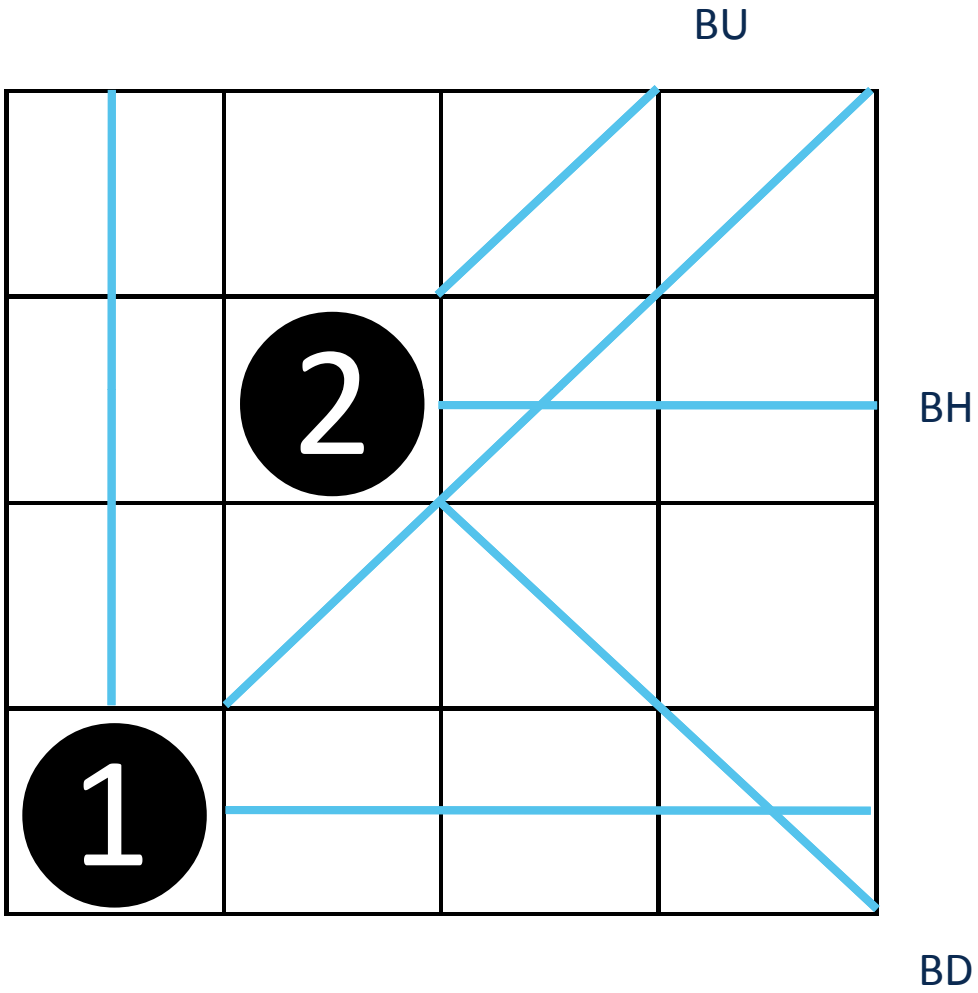
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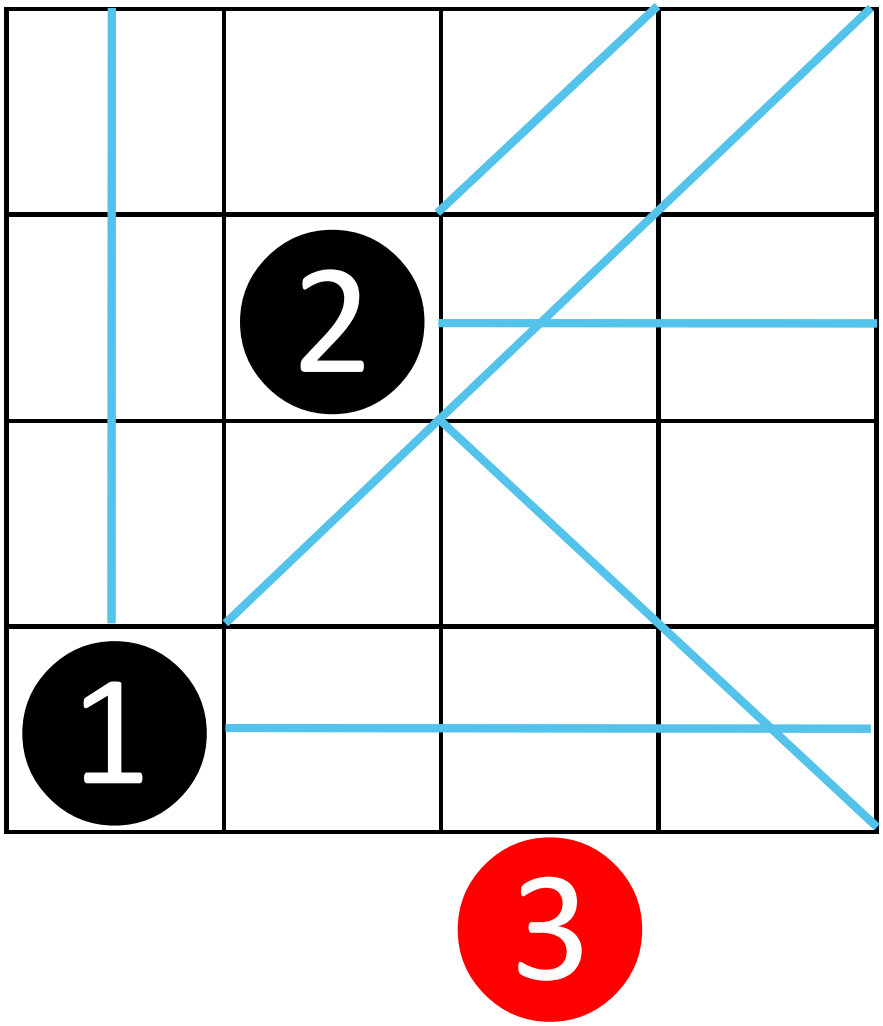
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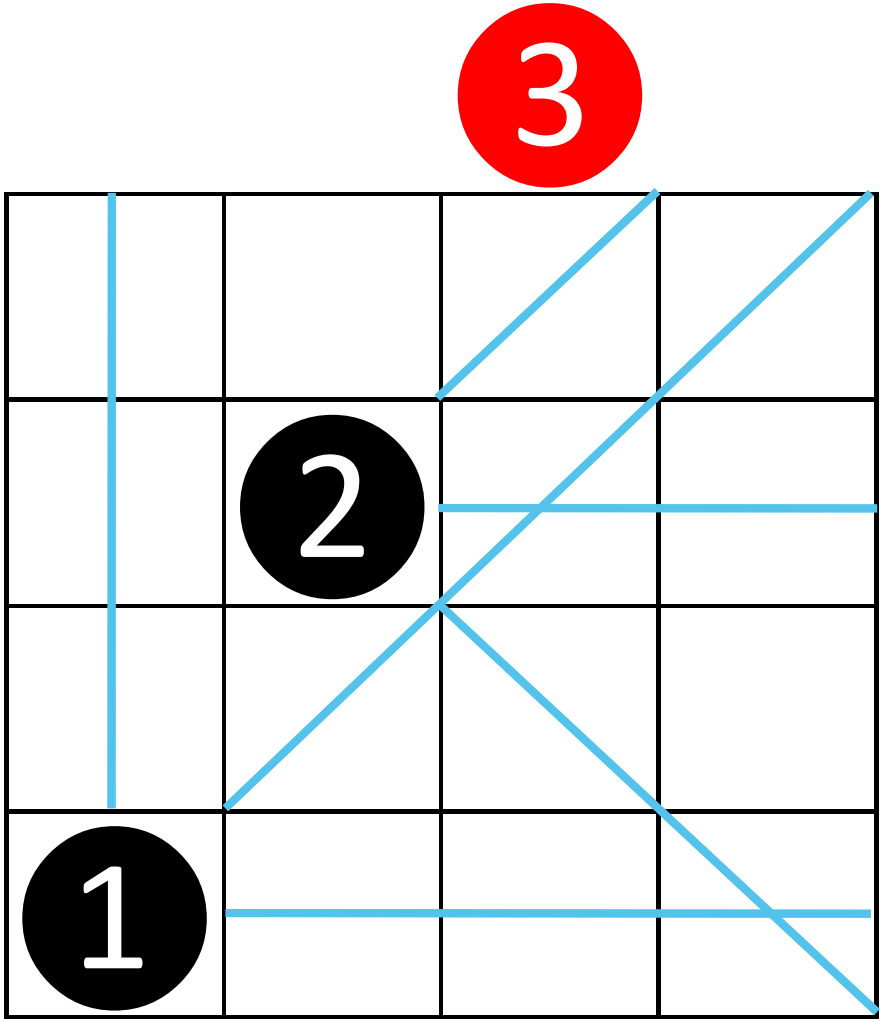

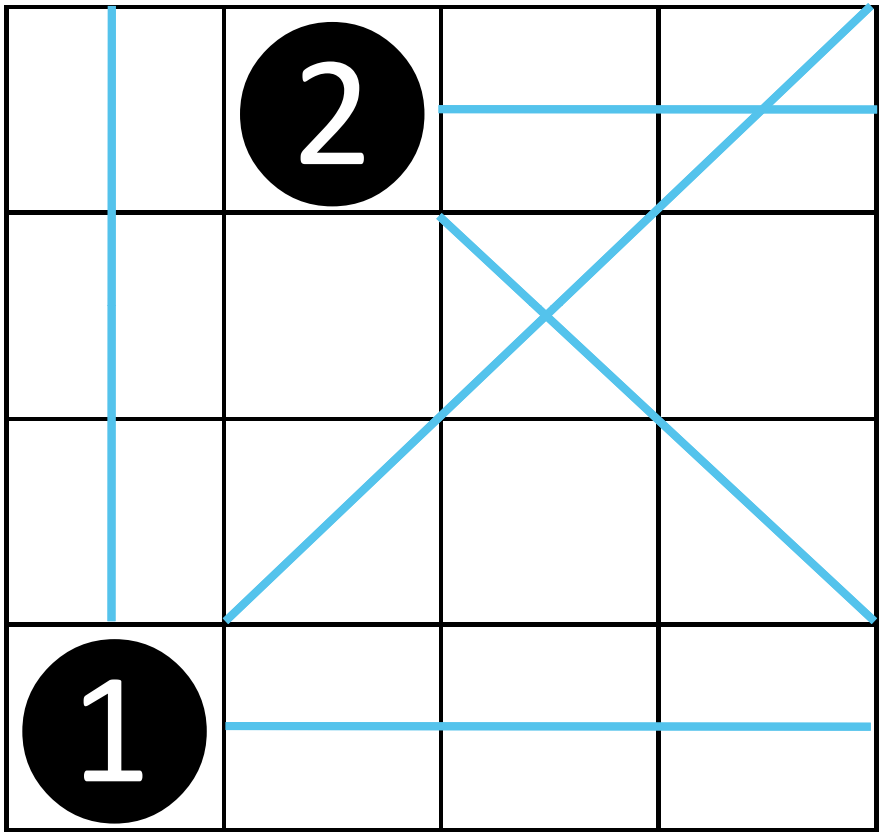
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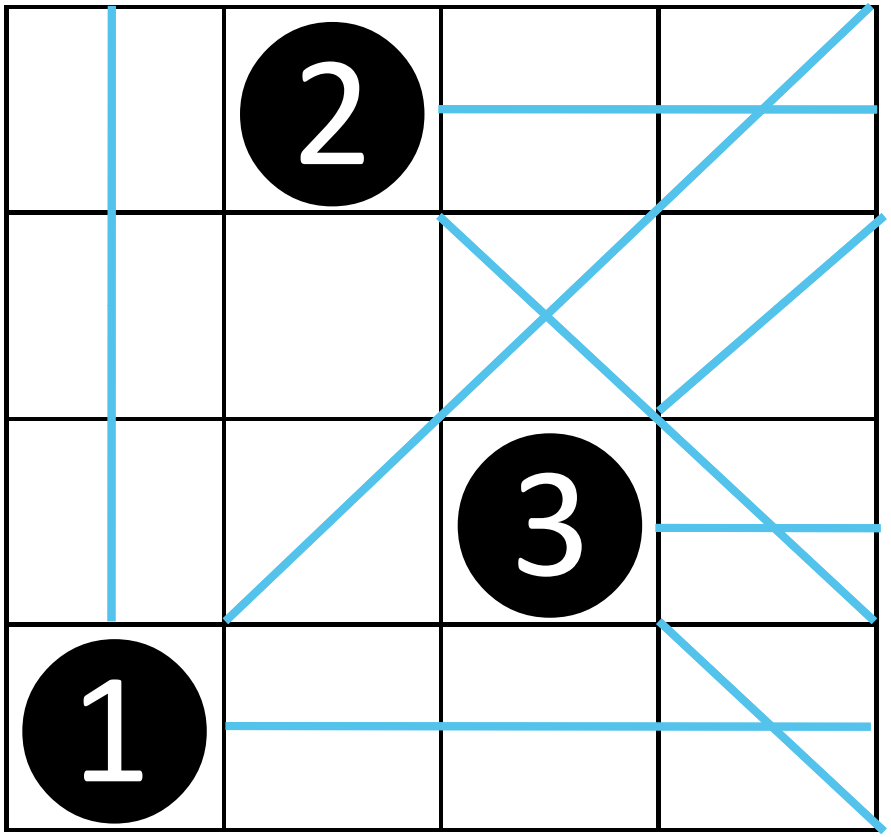
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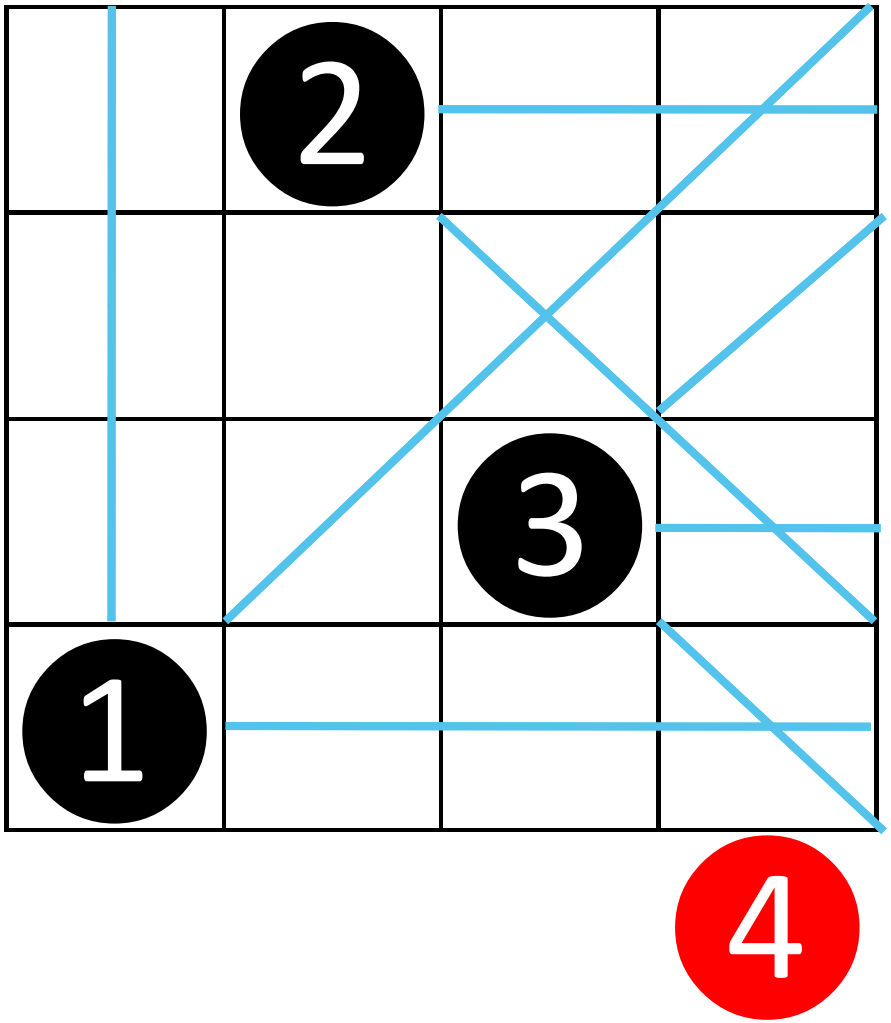
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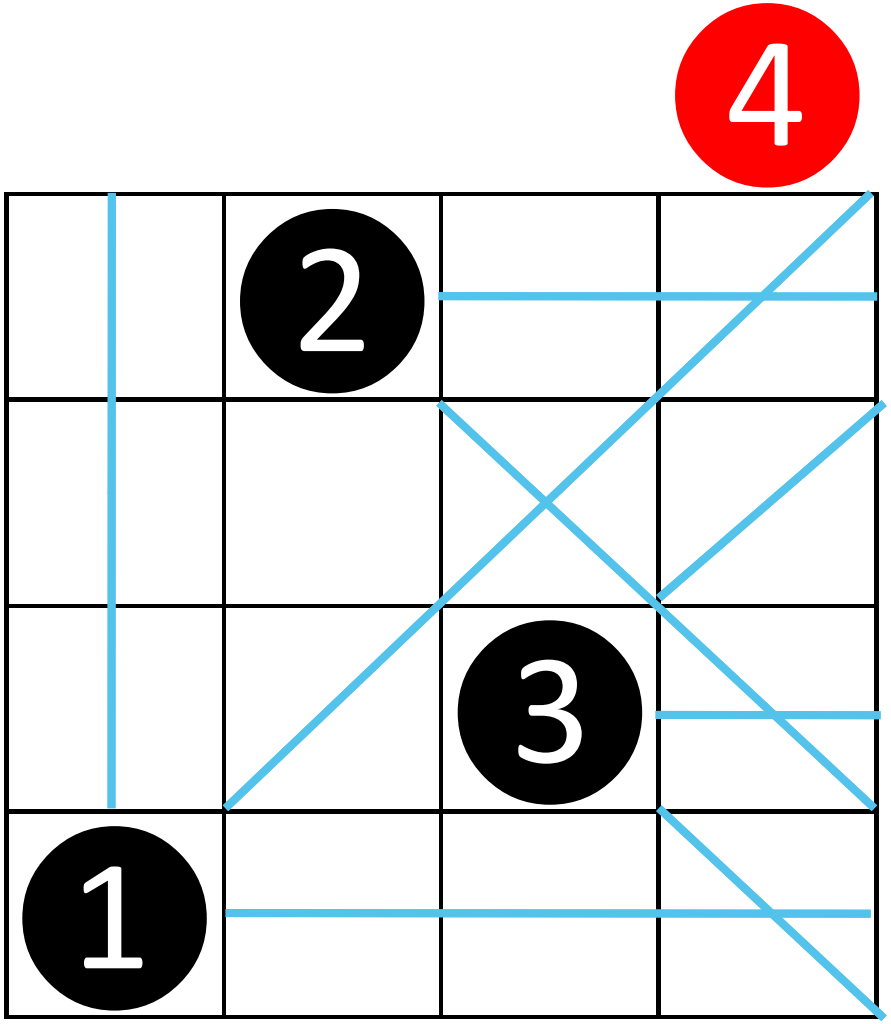
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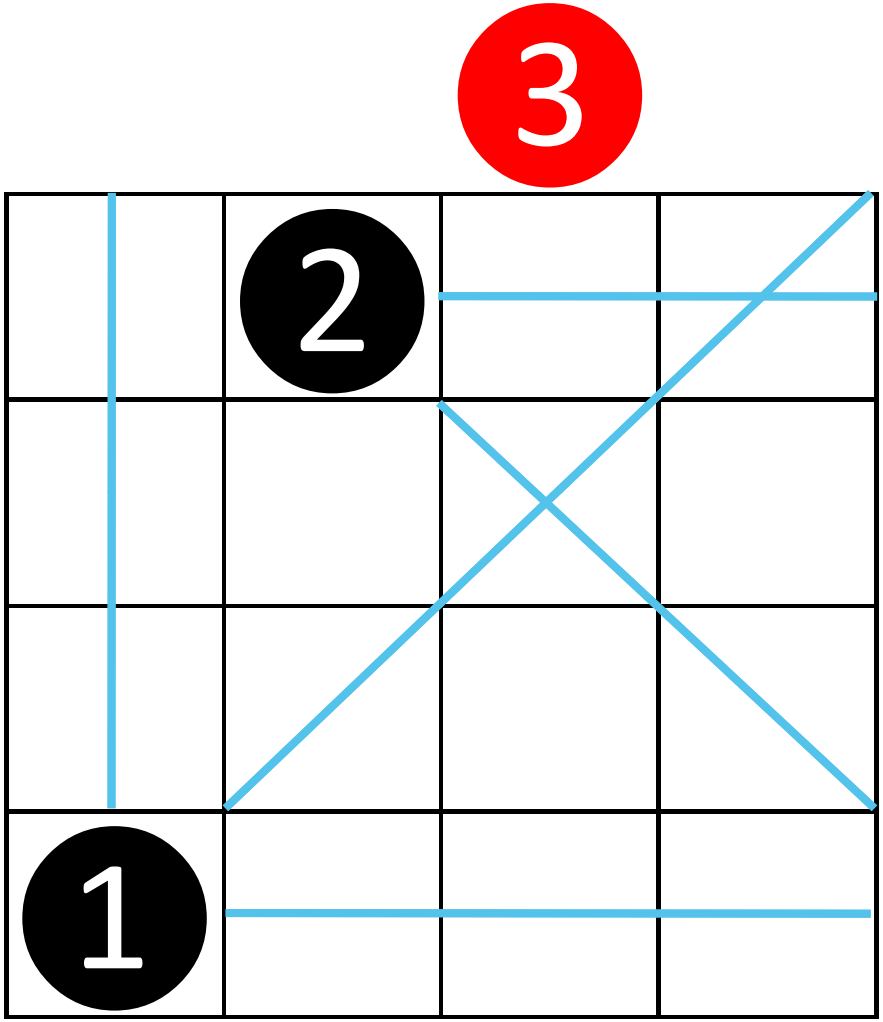
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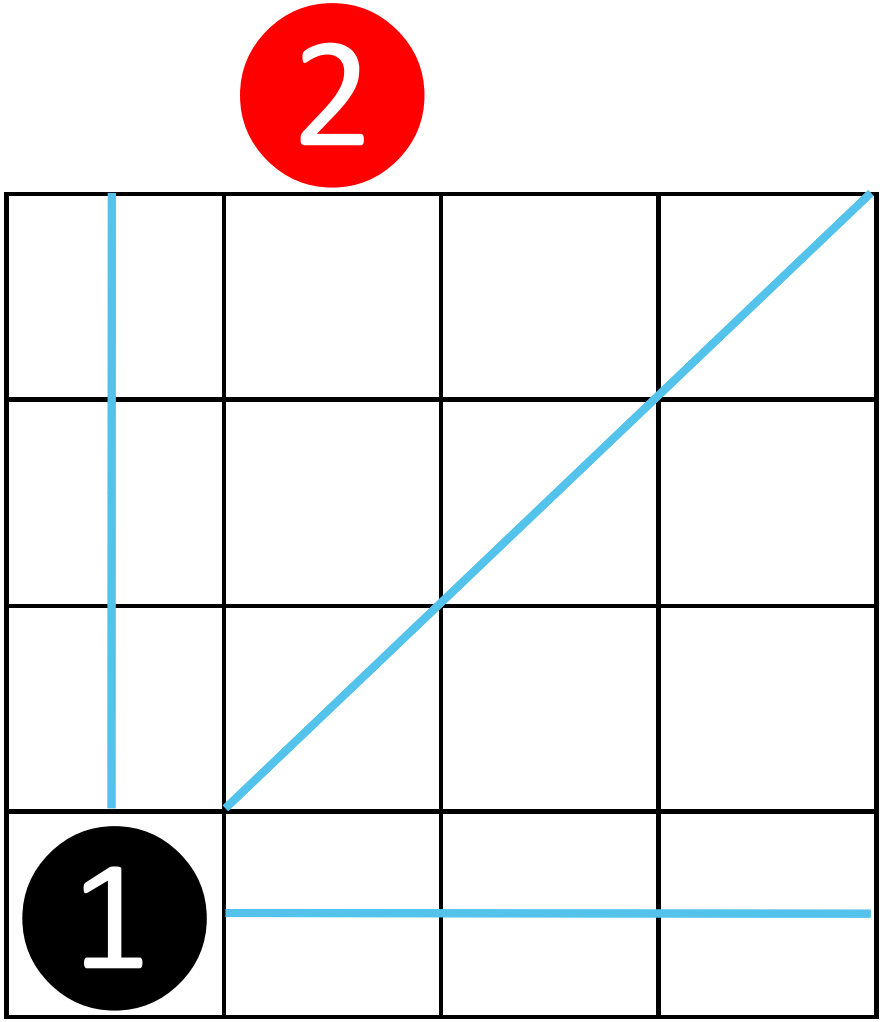
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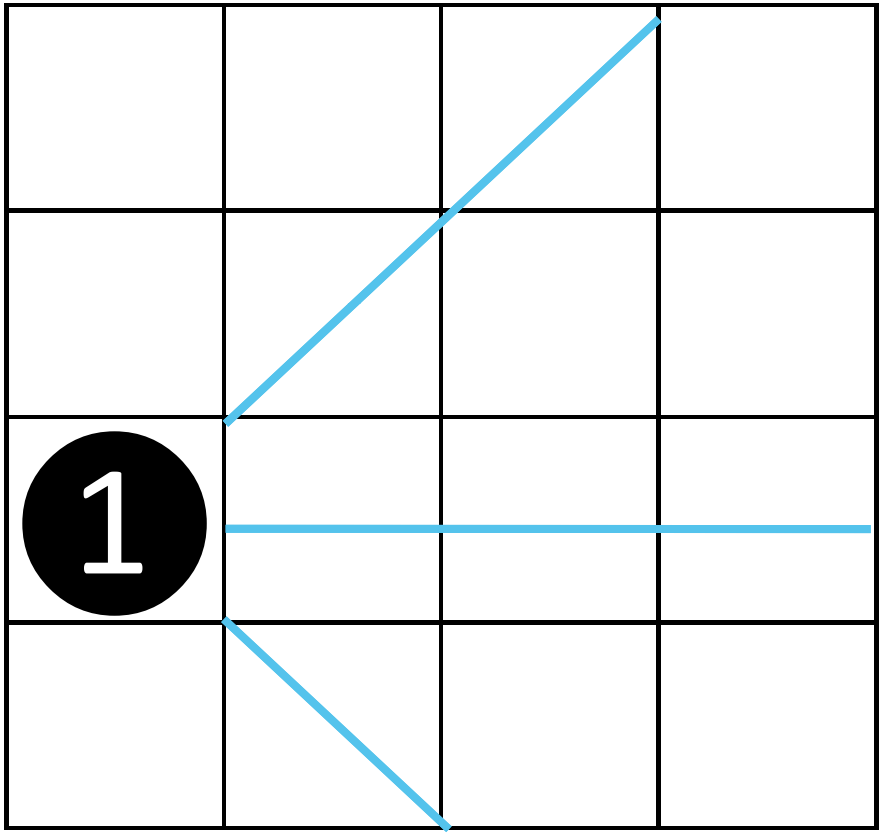
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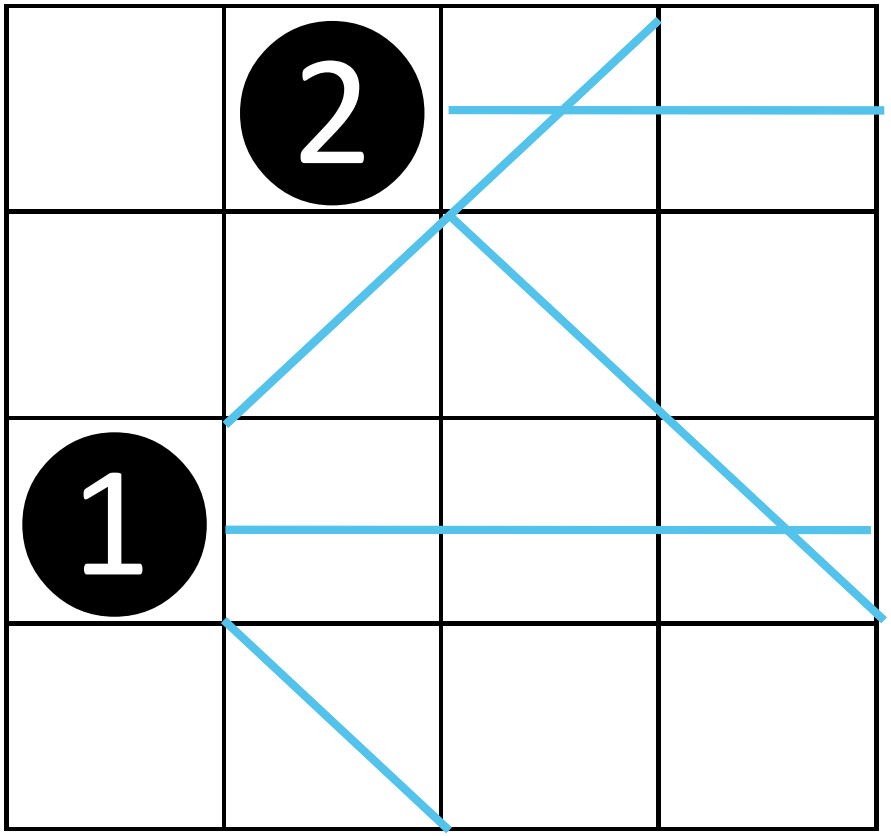
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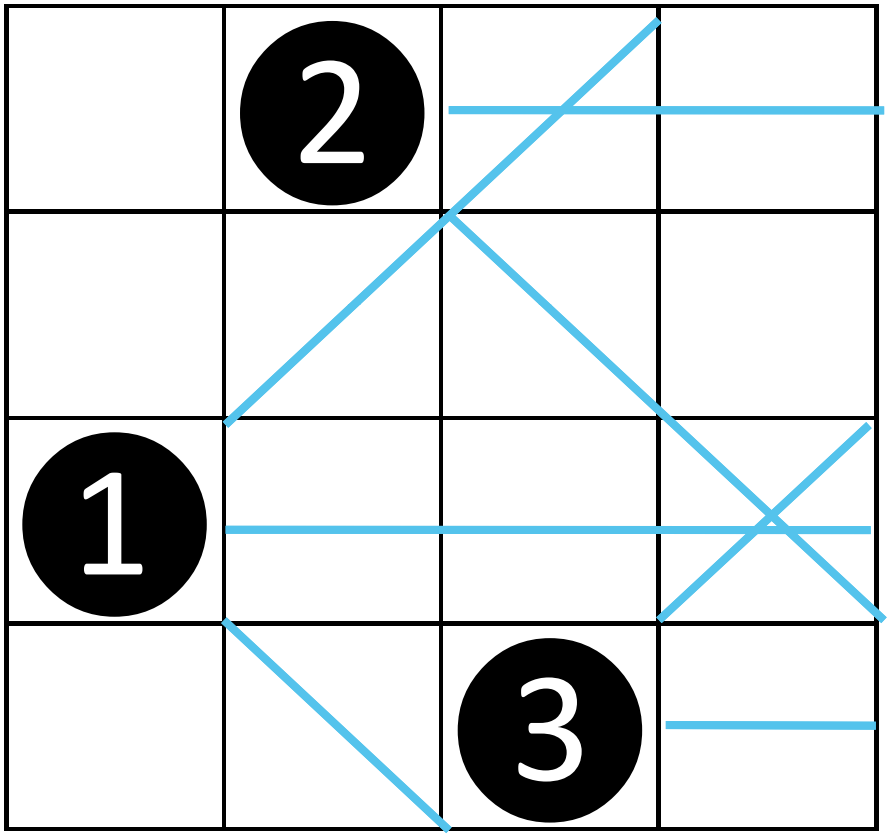
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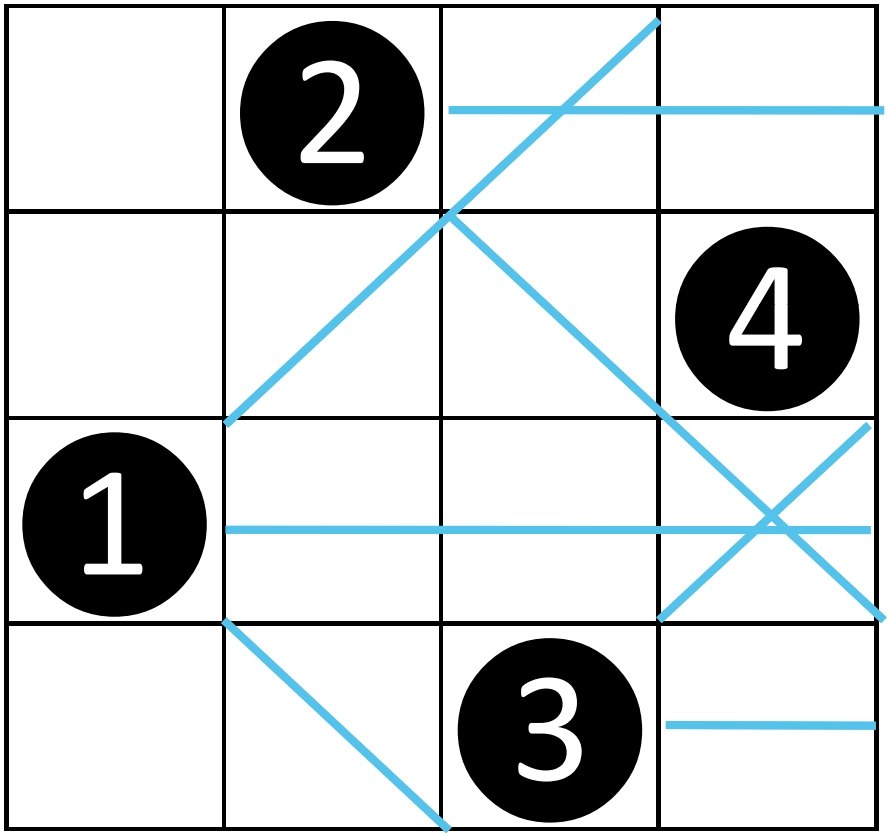

1. Lösung gefunden

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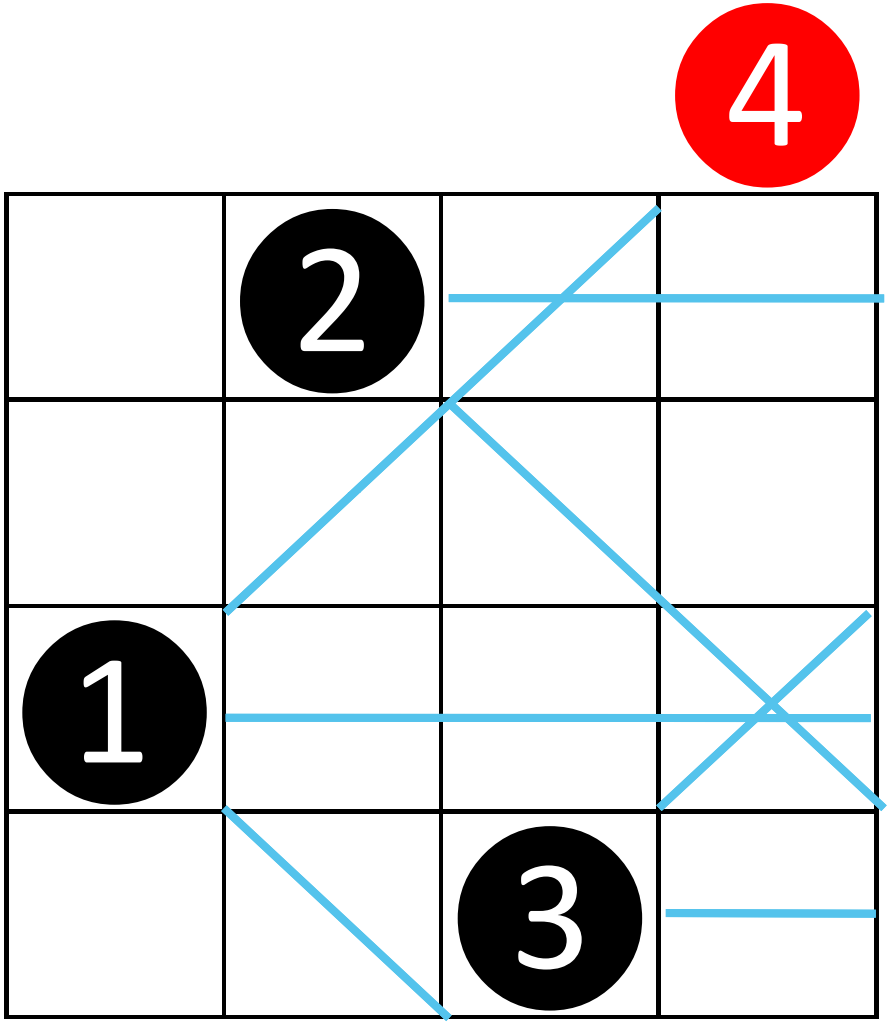

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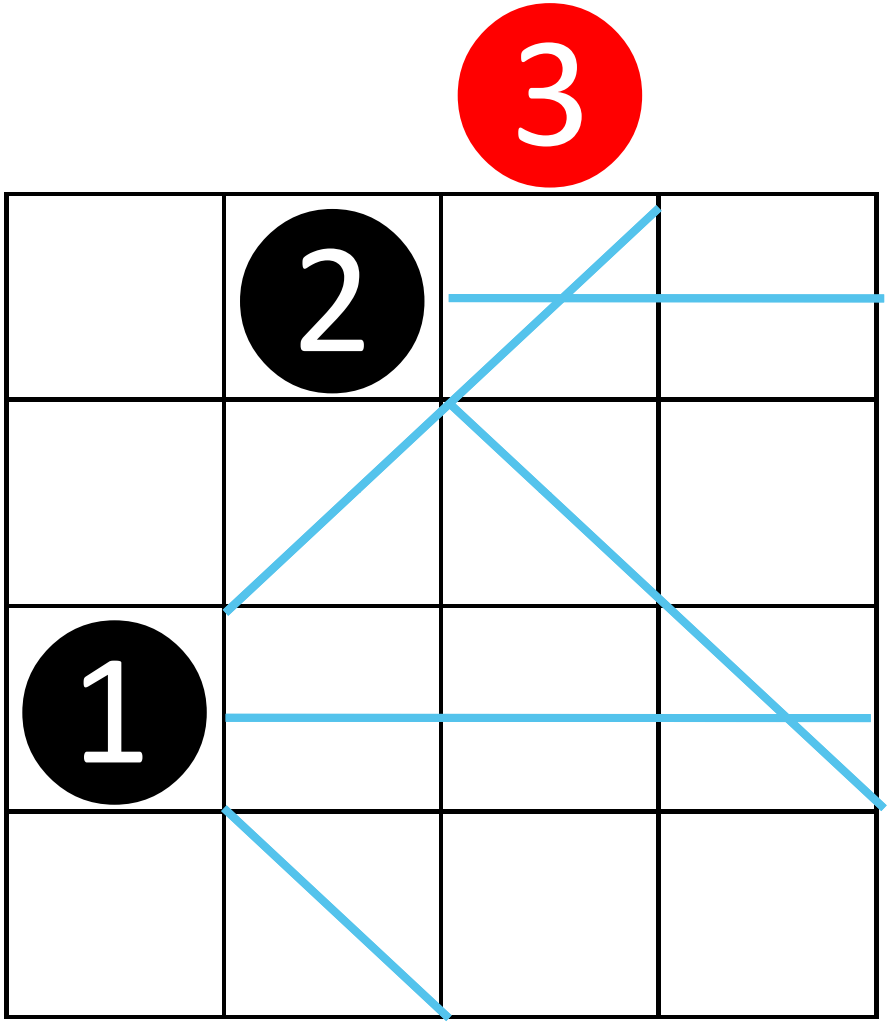

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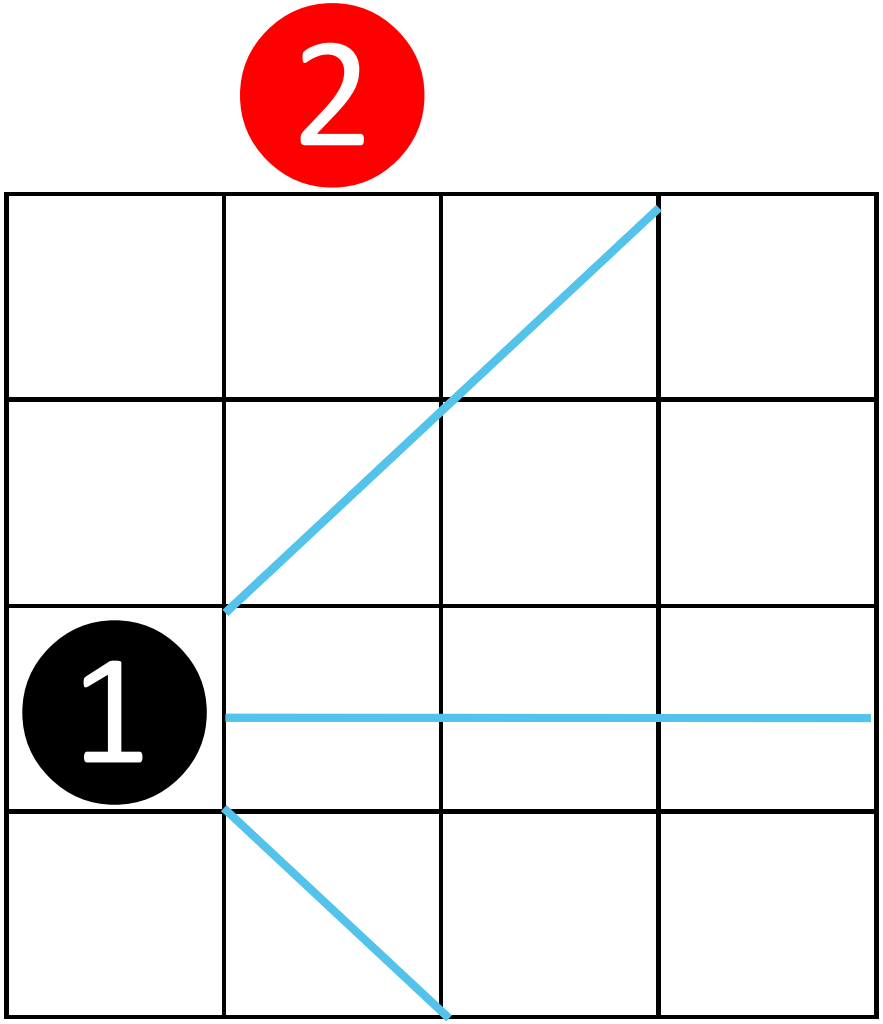

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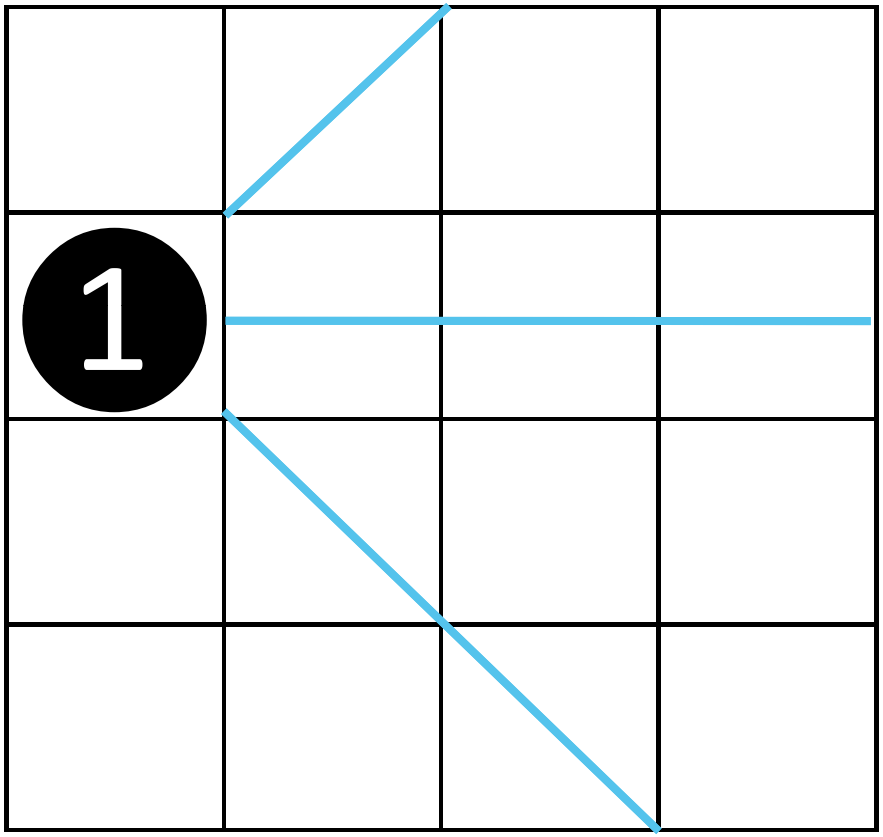

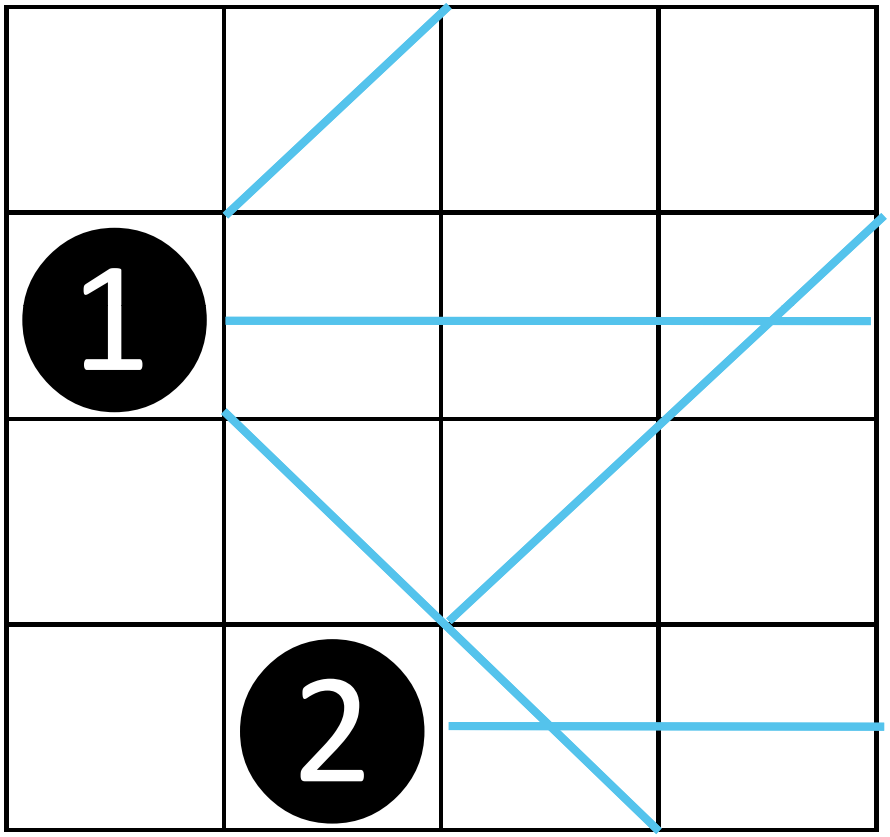
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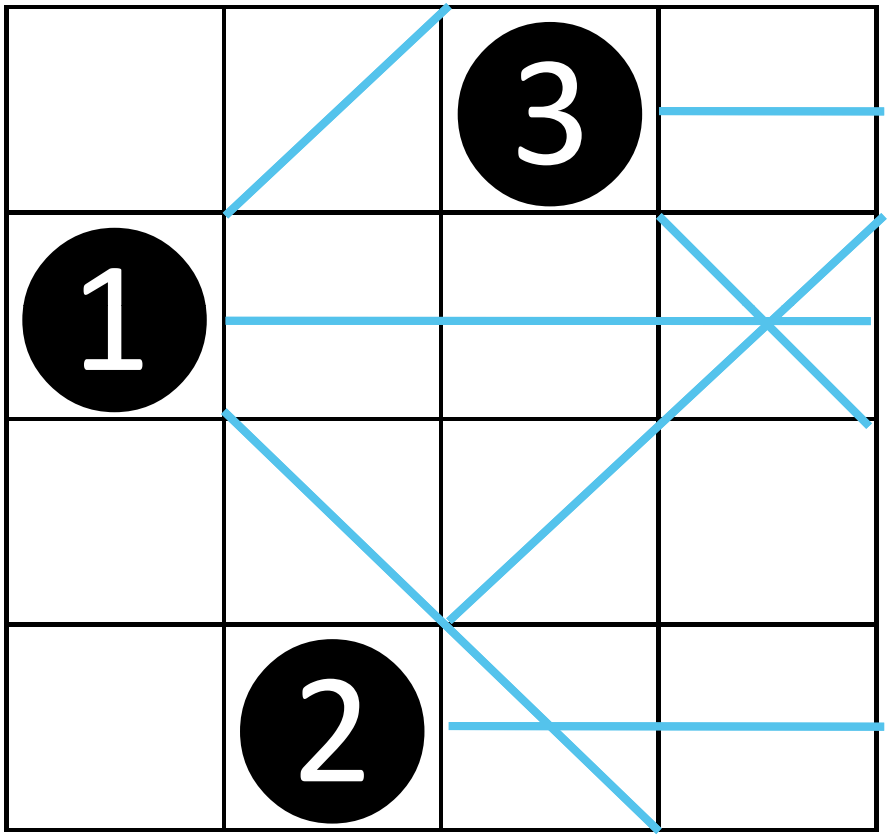
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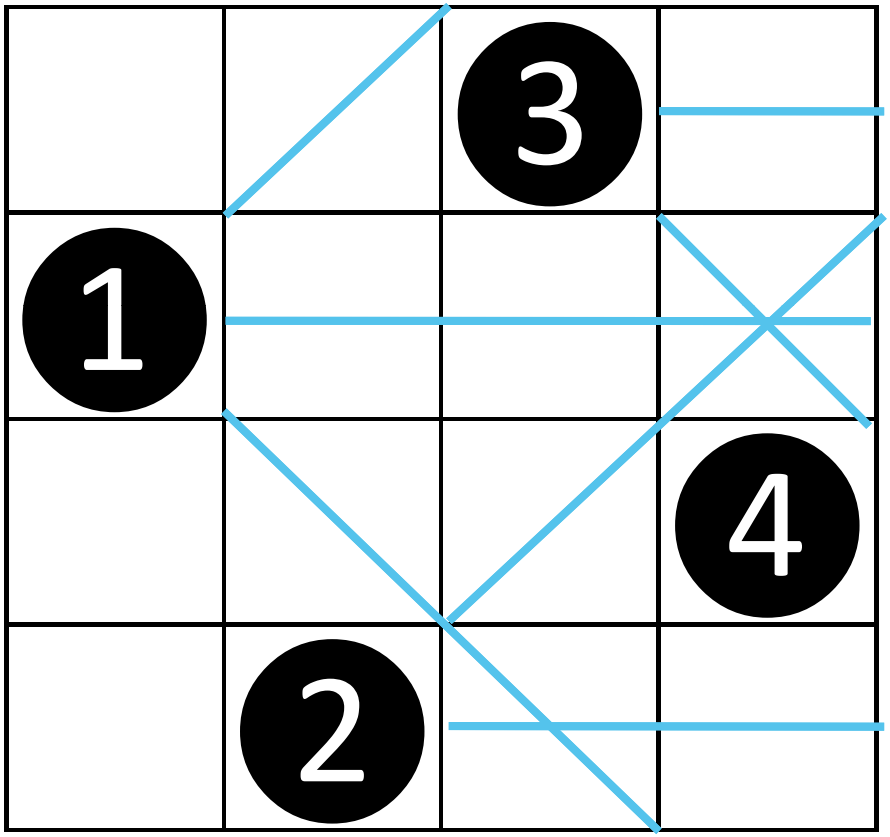

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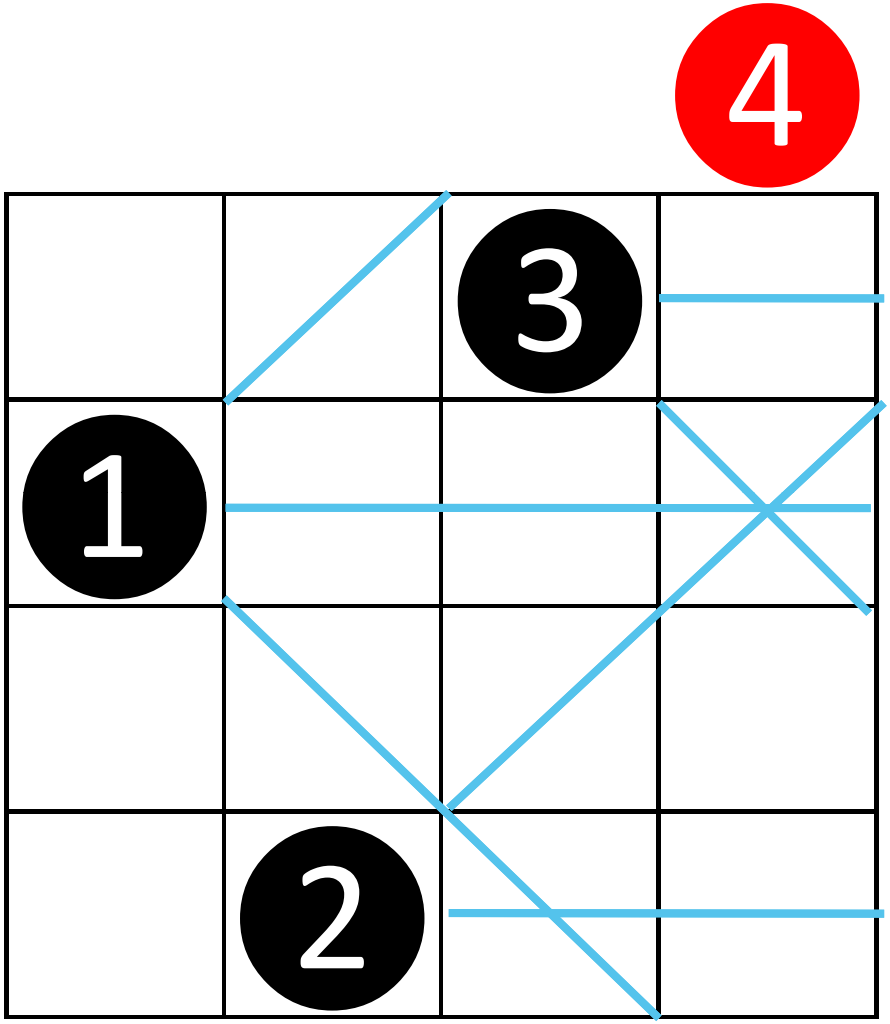

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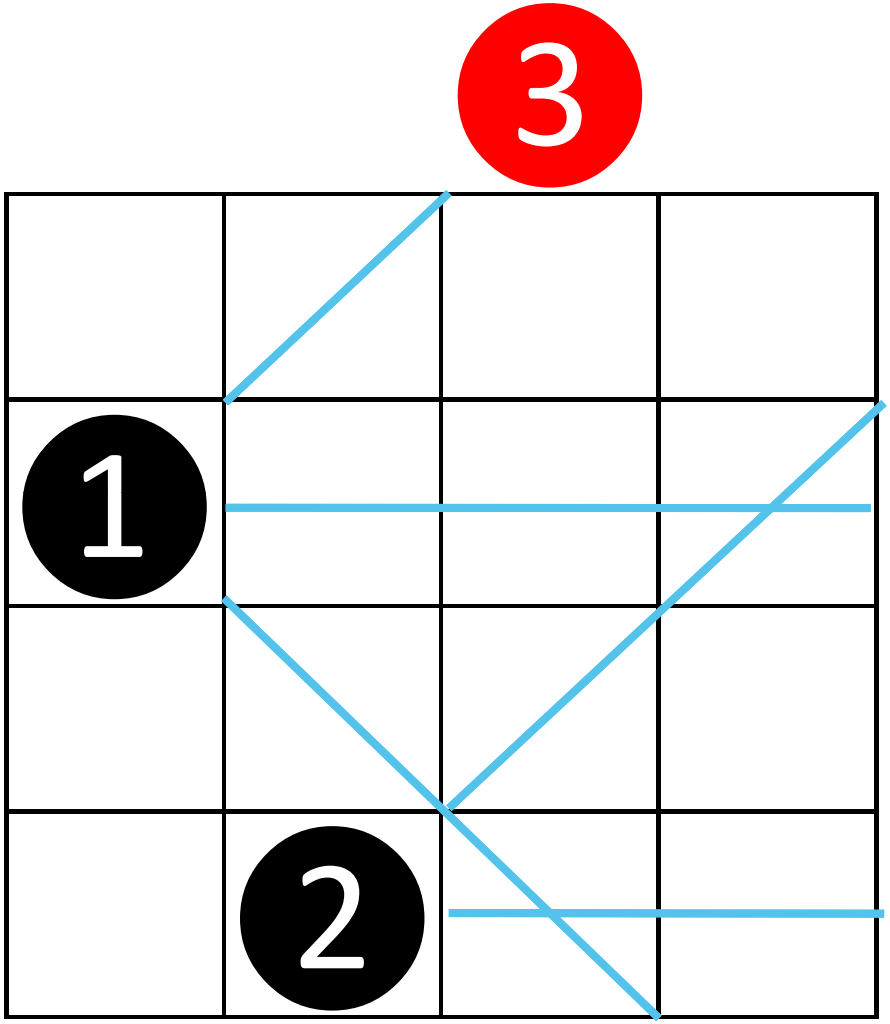

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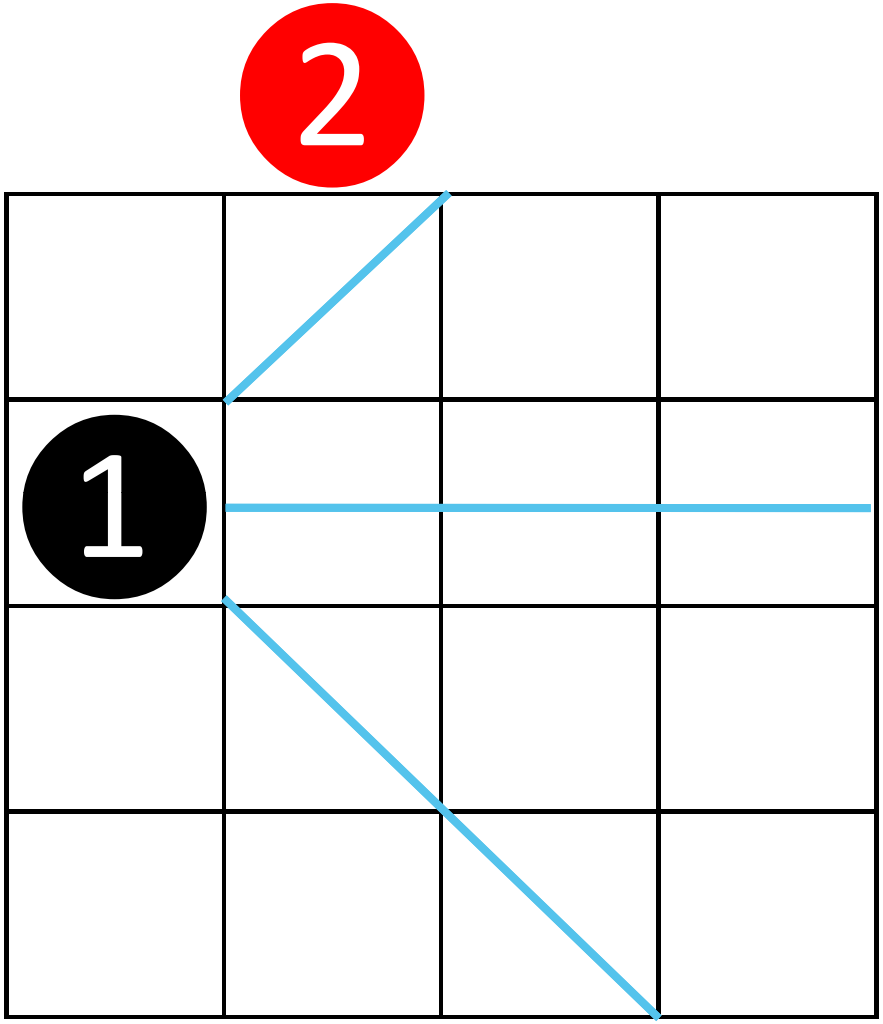

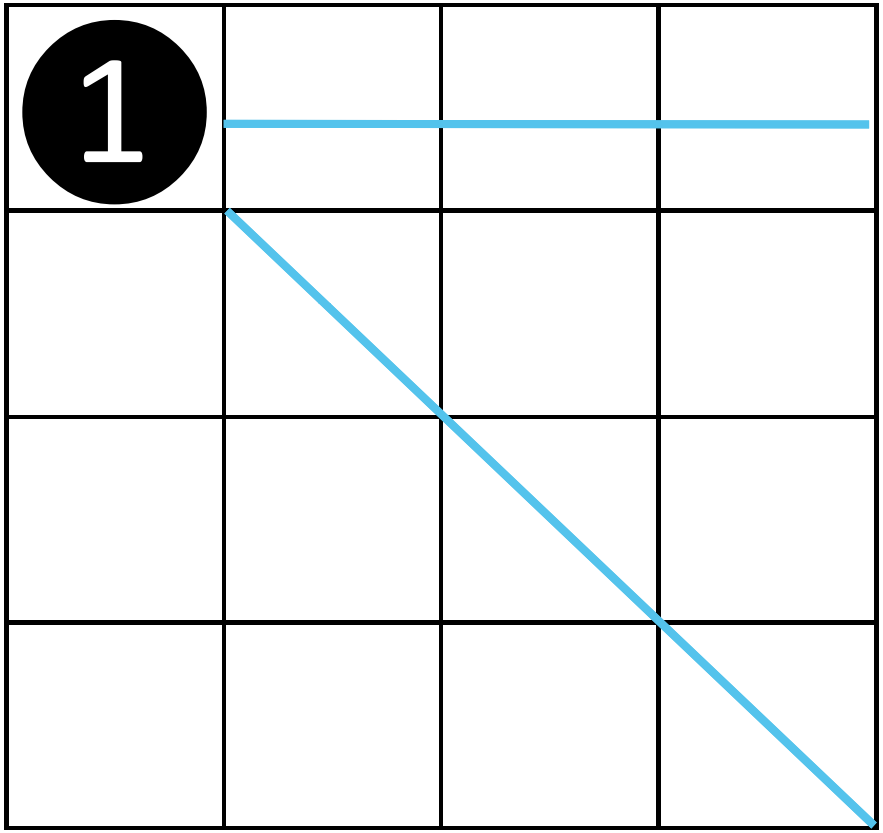
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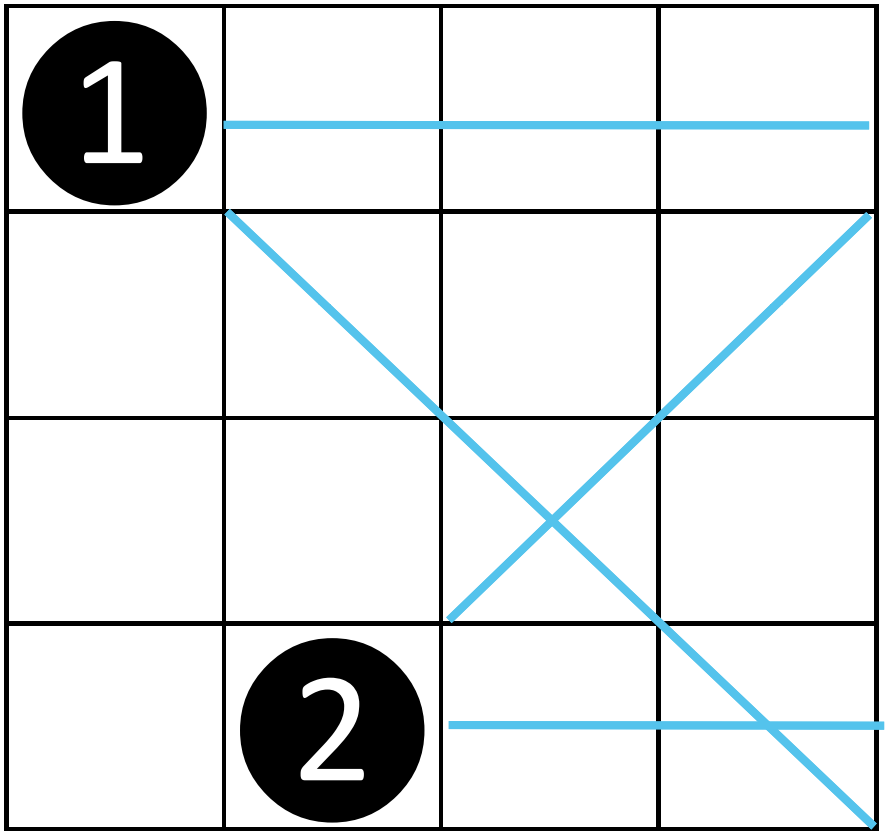
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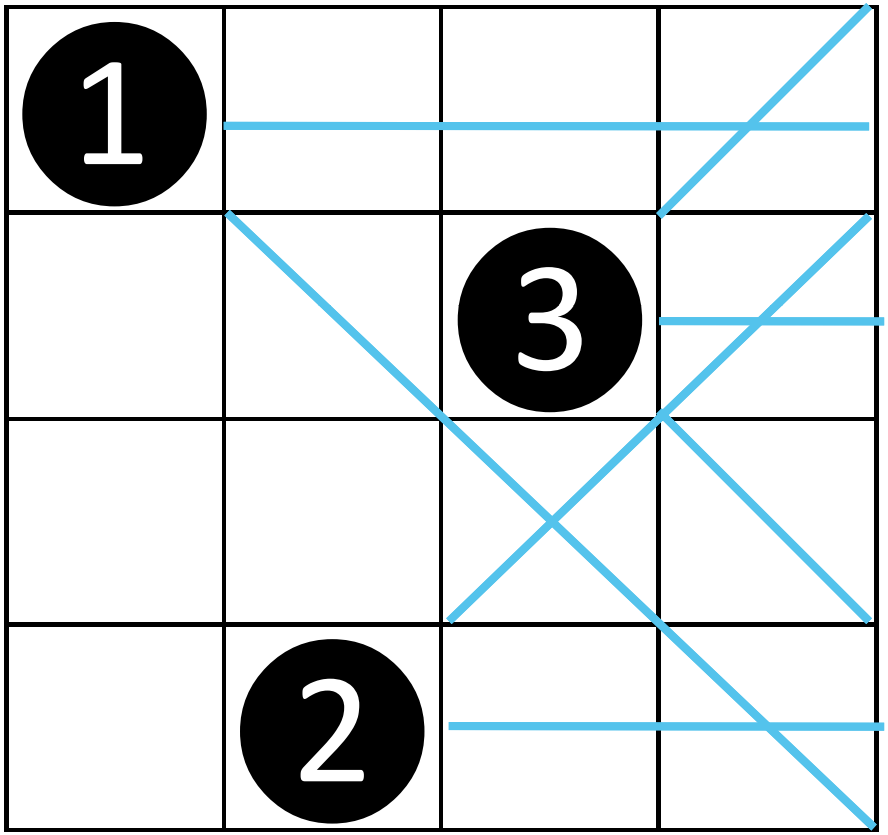
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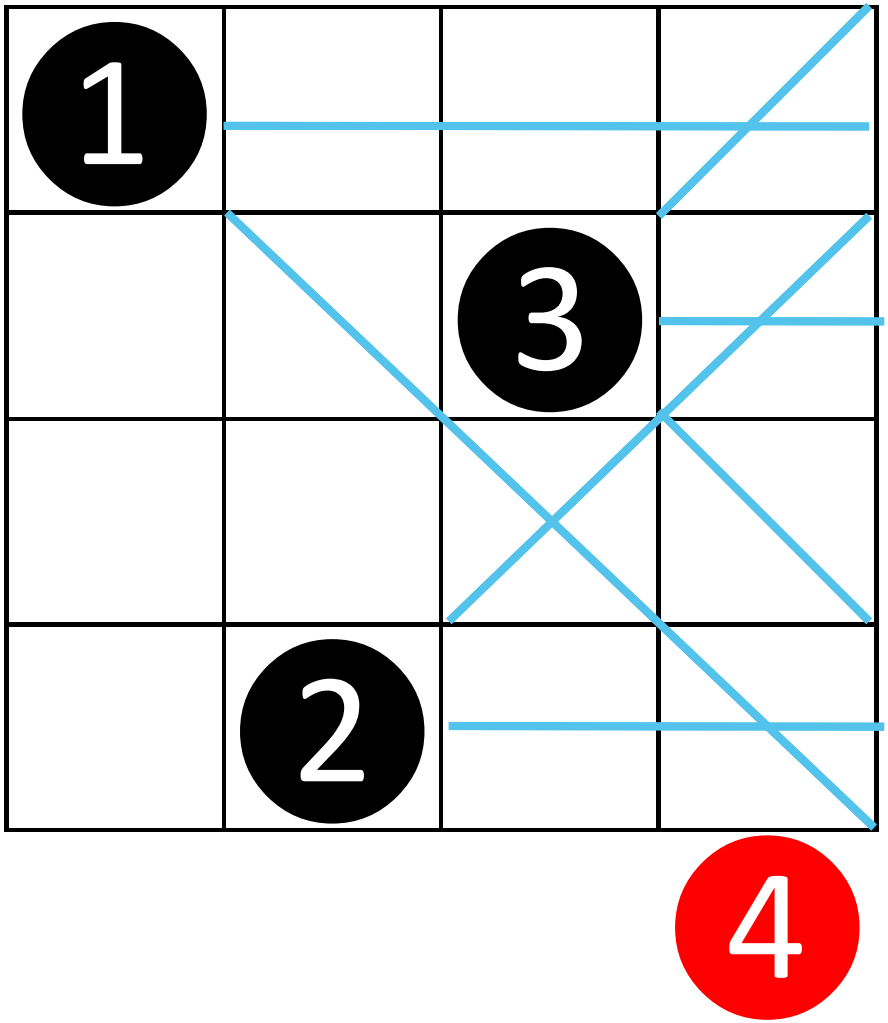
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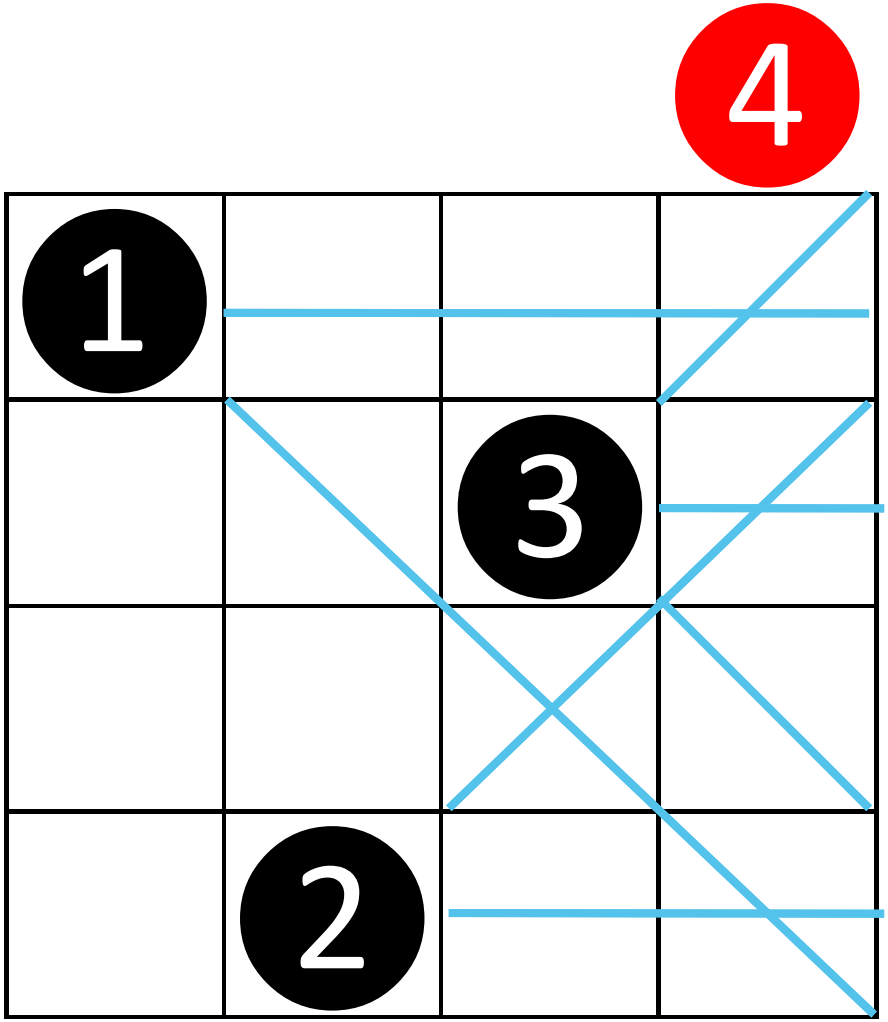

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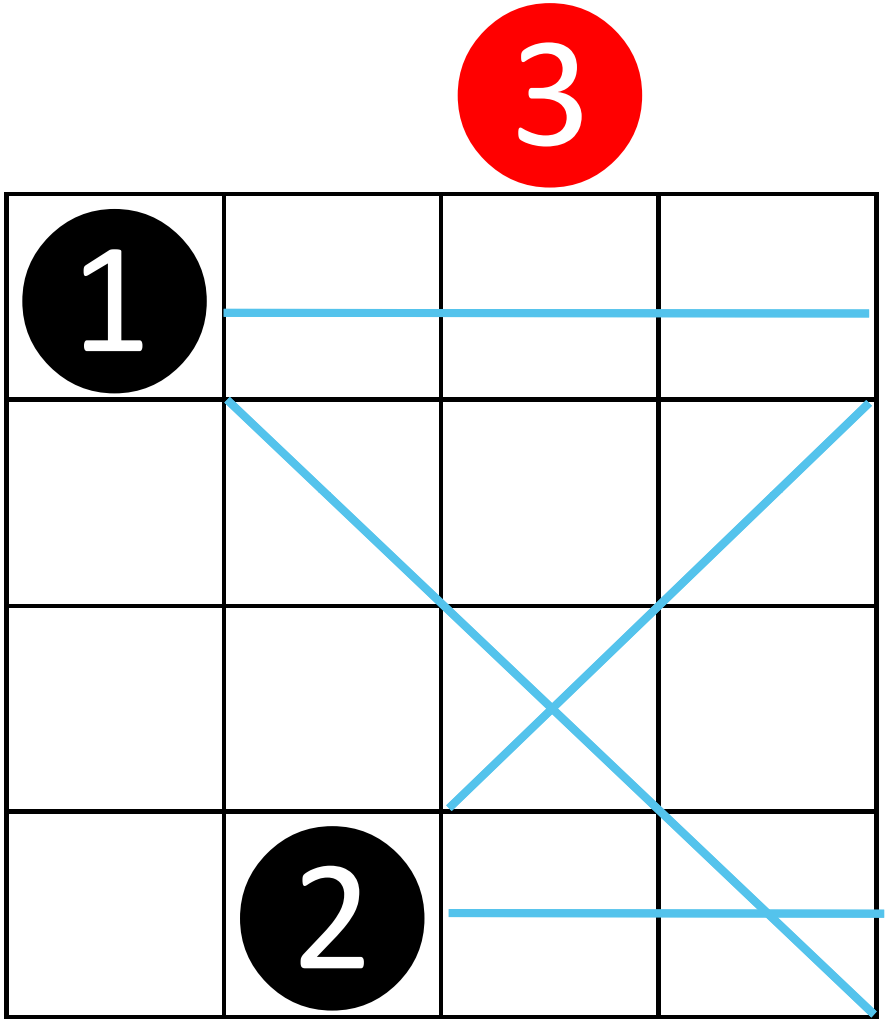

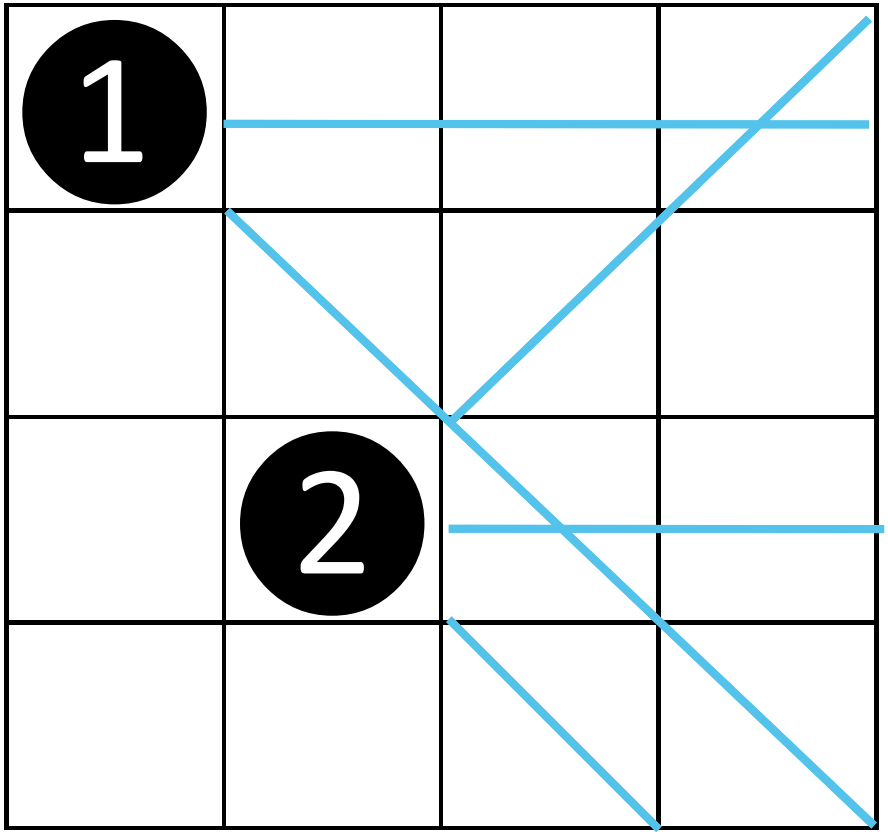
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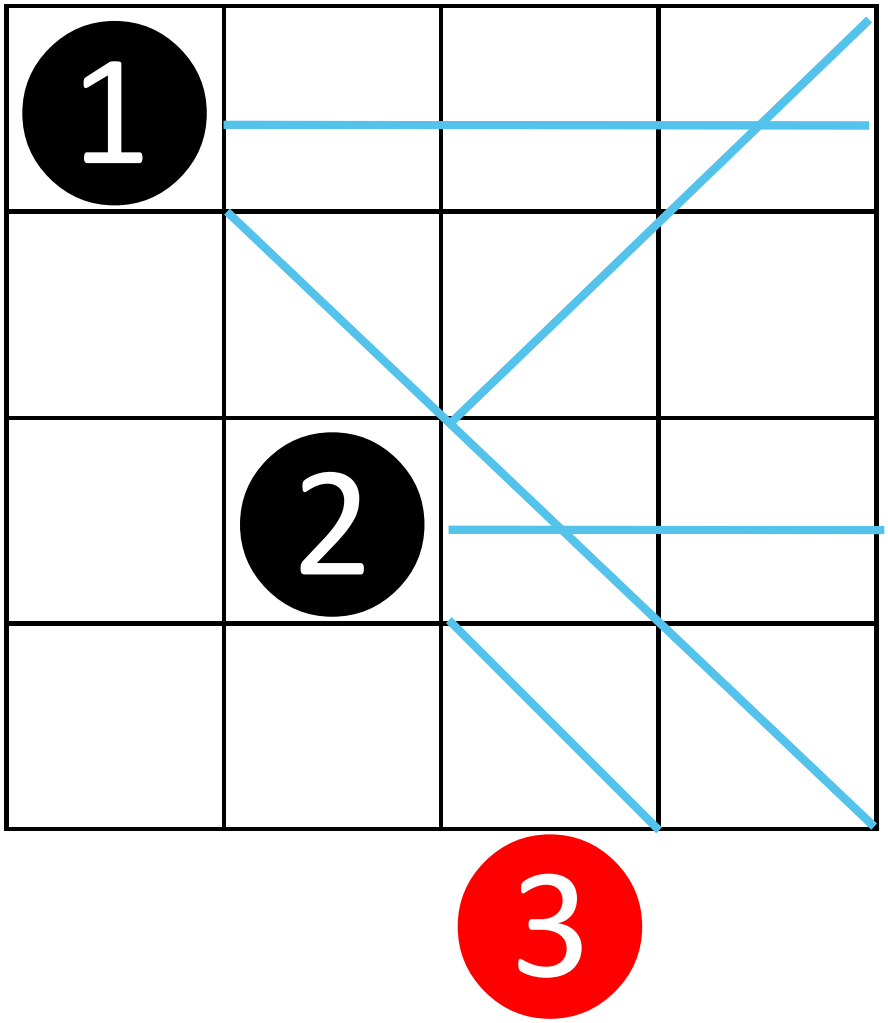
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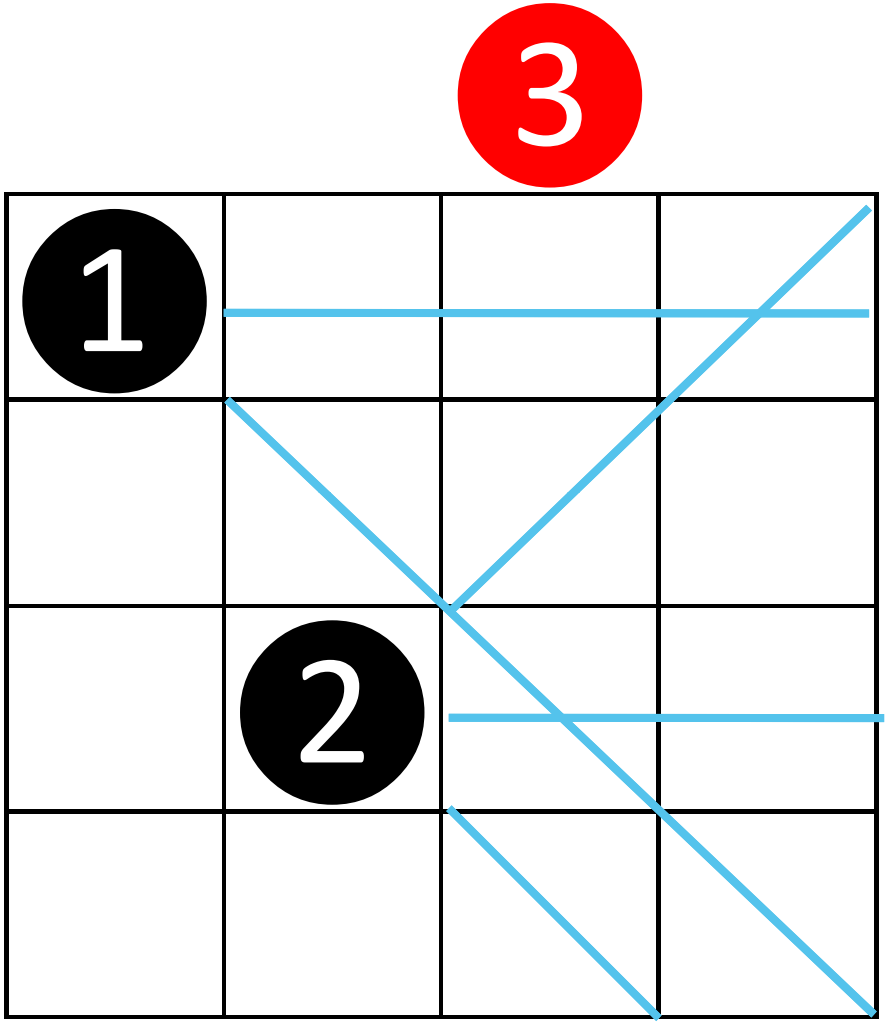

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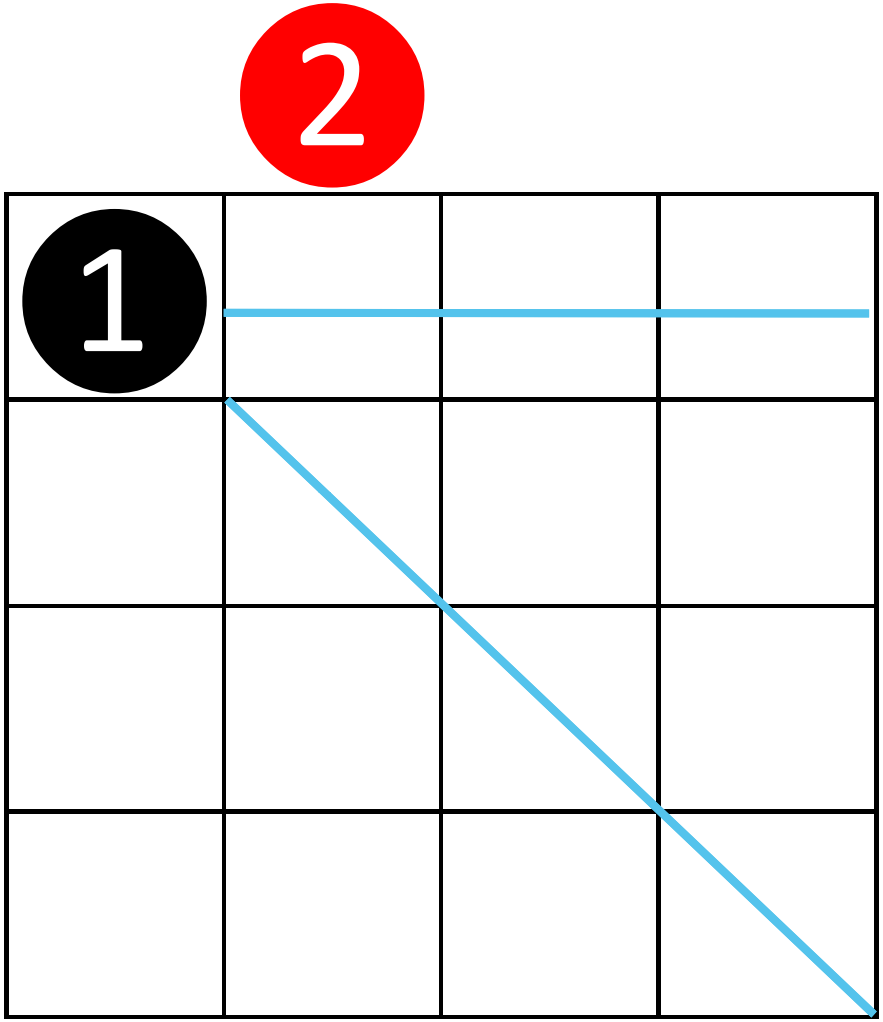

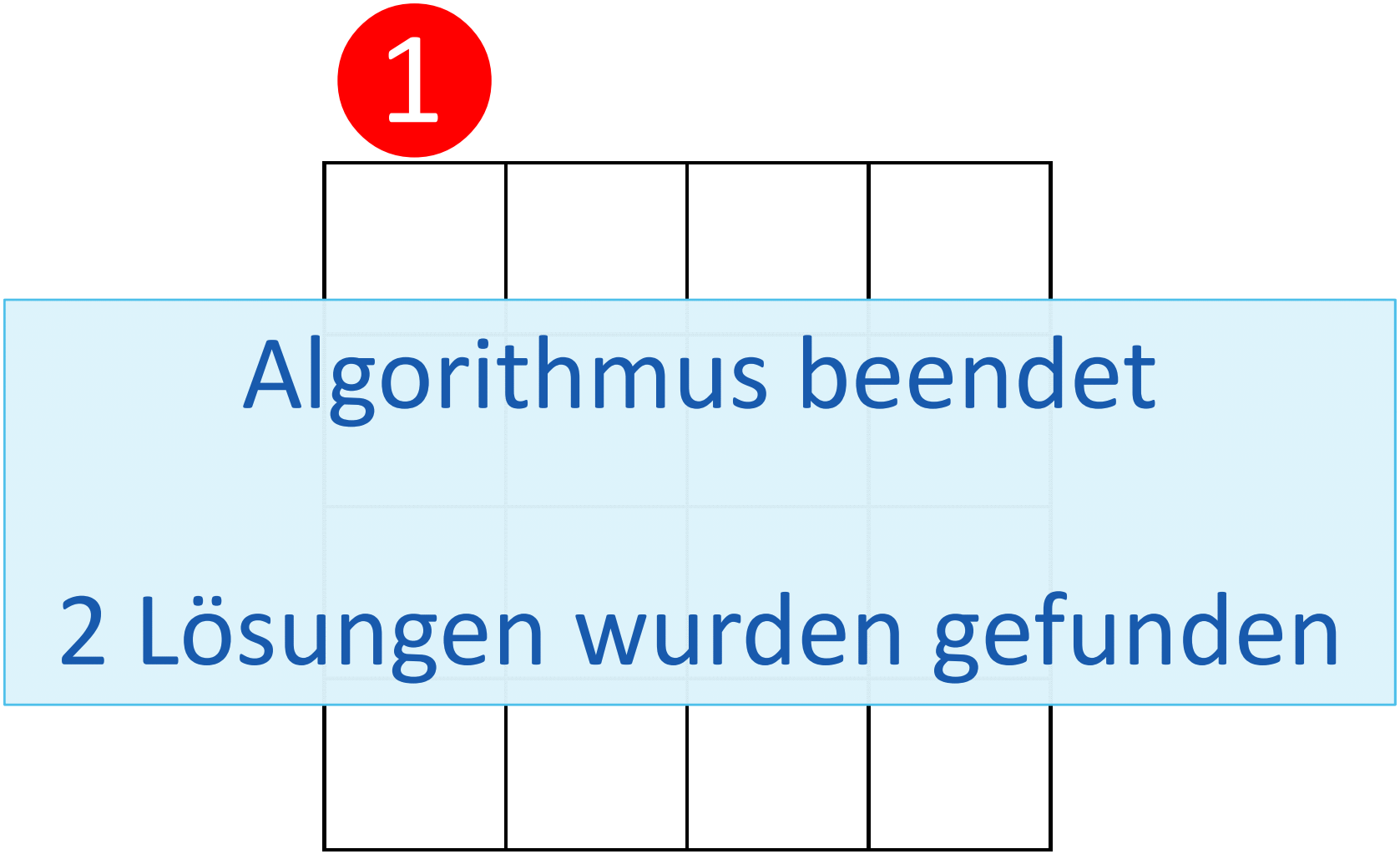
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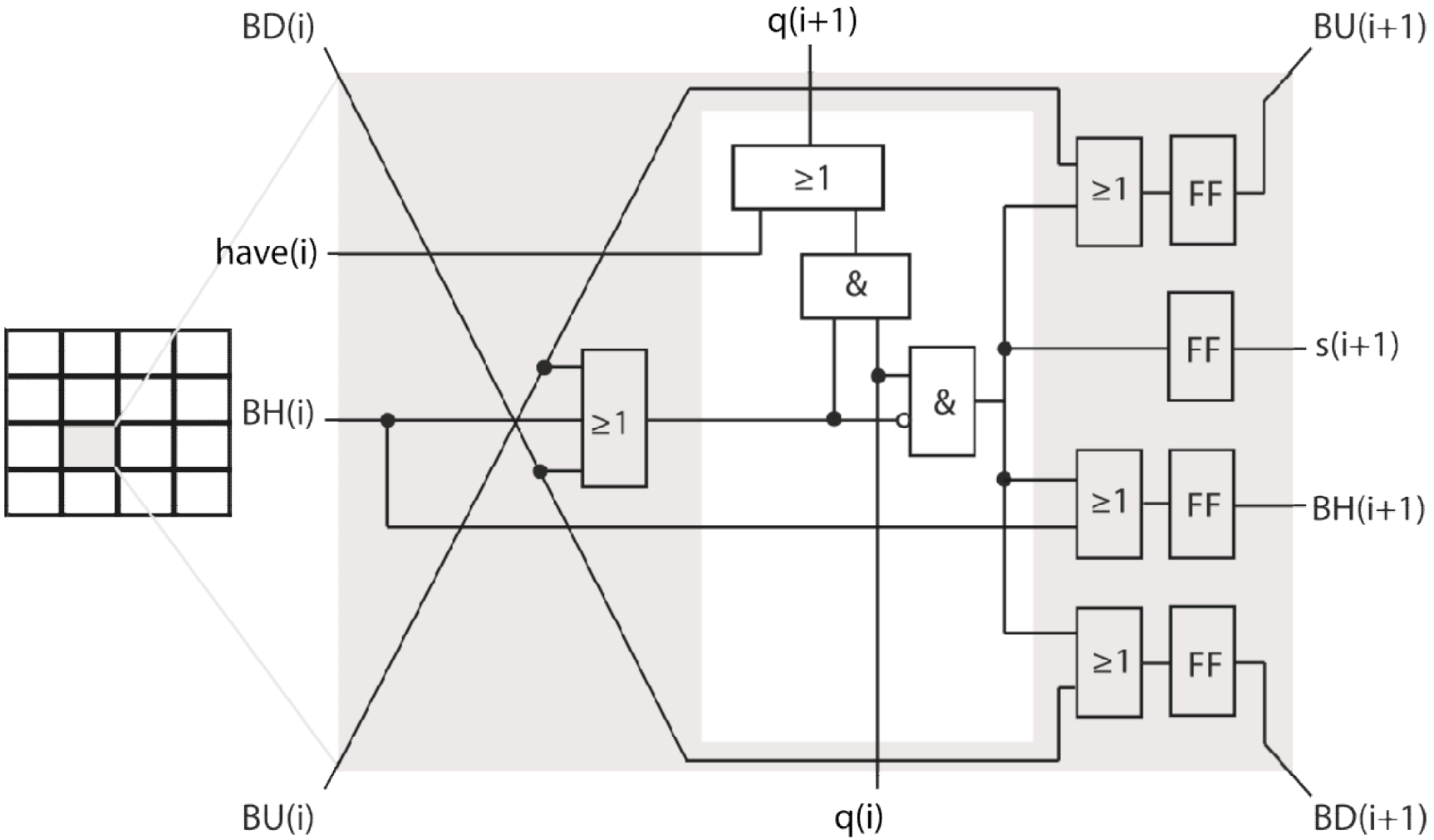
Algorithmus beendet
2 Lösungen wurden gefunden

Algorithmus



Frei nach einer Abbildung aus dem Paper (siehe Quellen)

Optimierung

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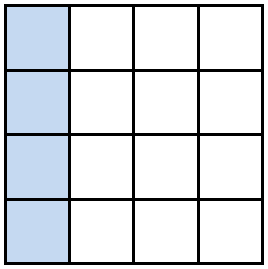

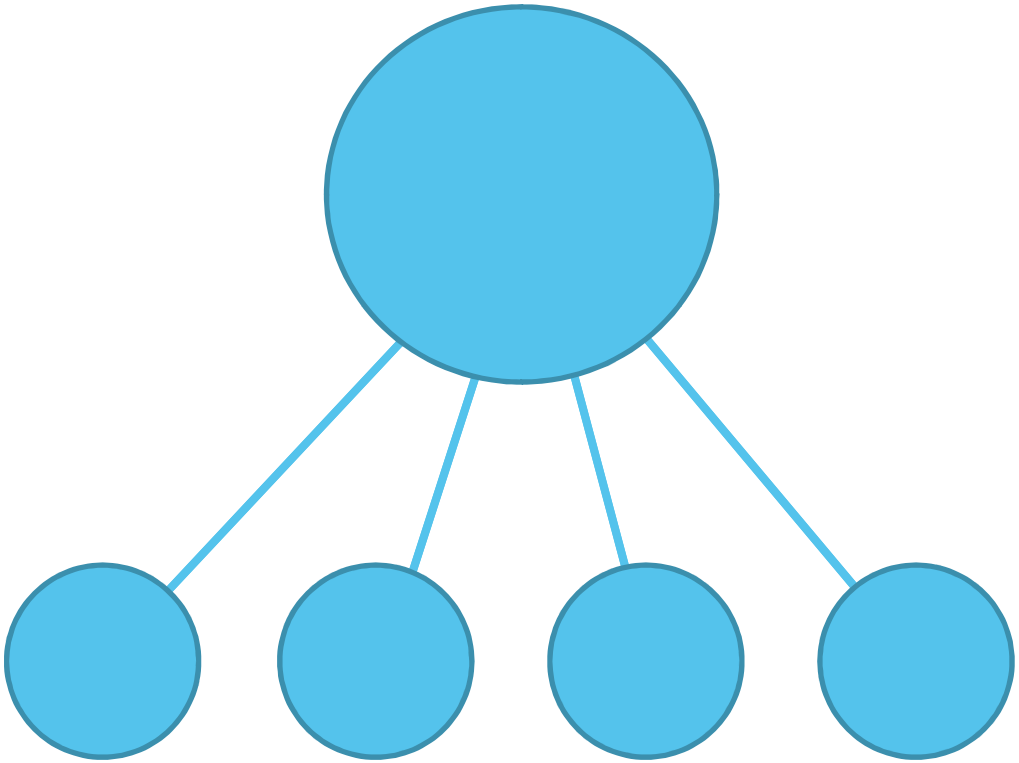

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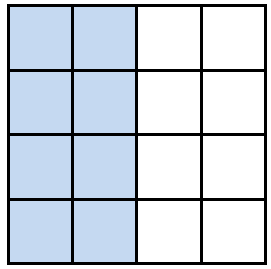

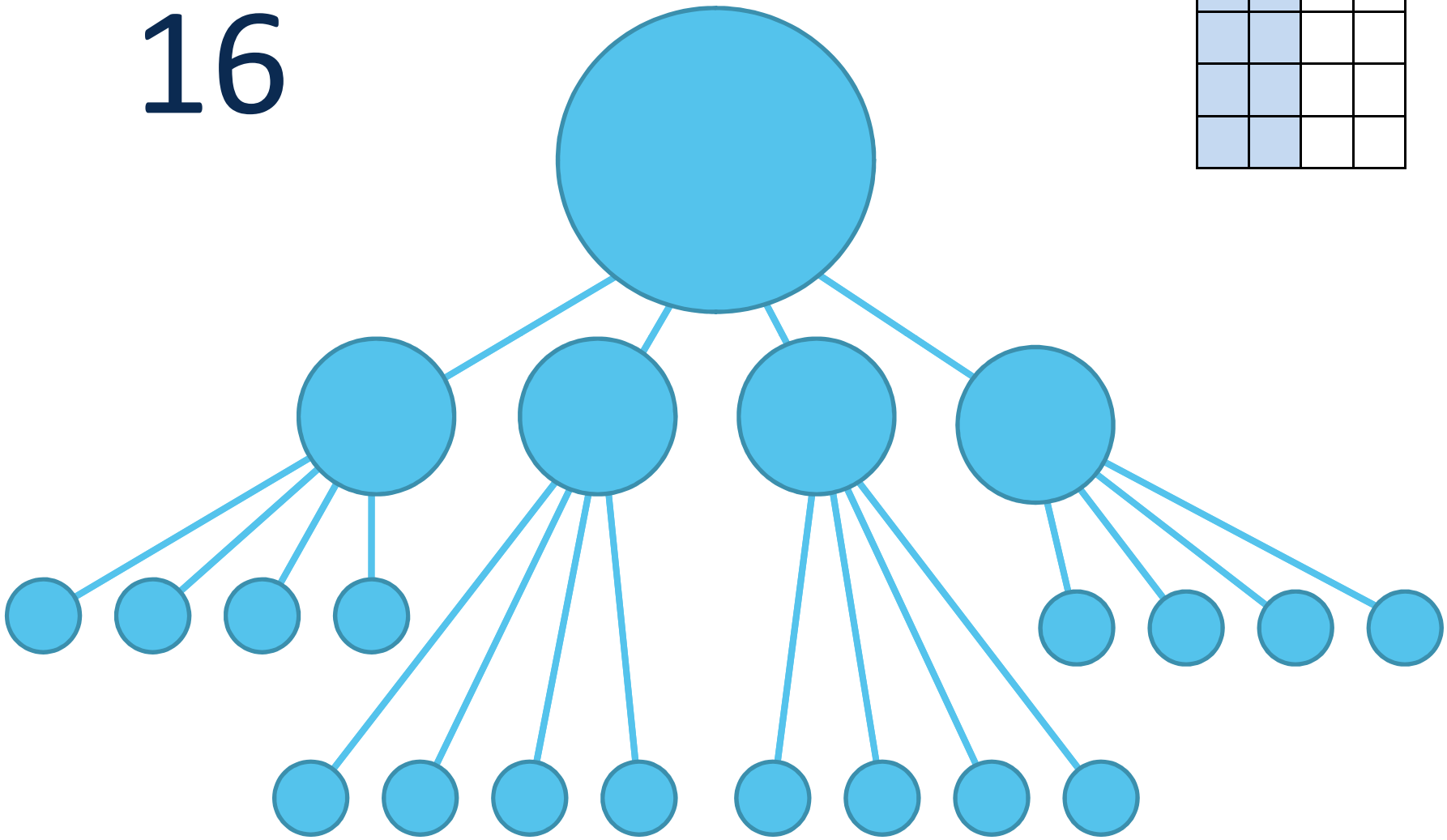

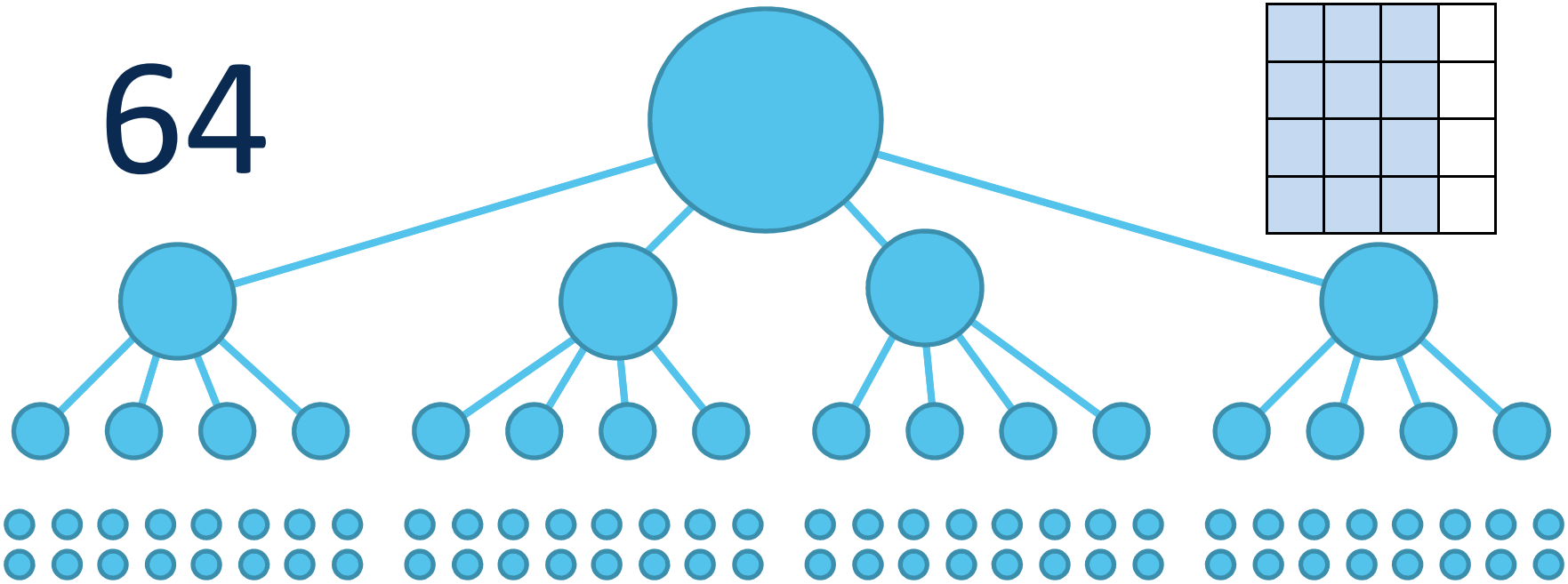
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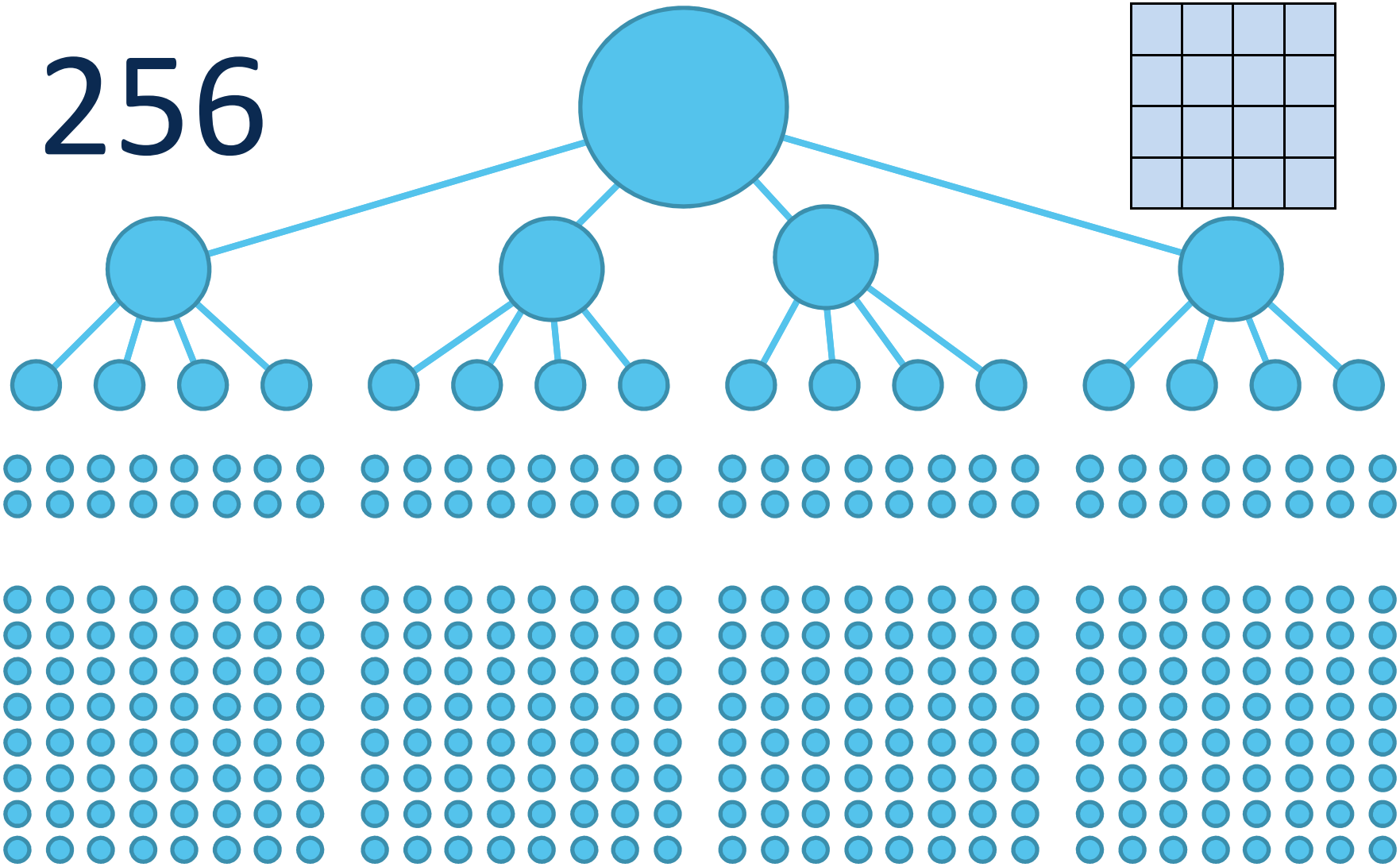

256

Anzahl an möglichen Damenpositionierungen = n^n

4x4 Matrix ➔ 256

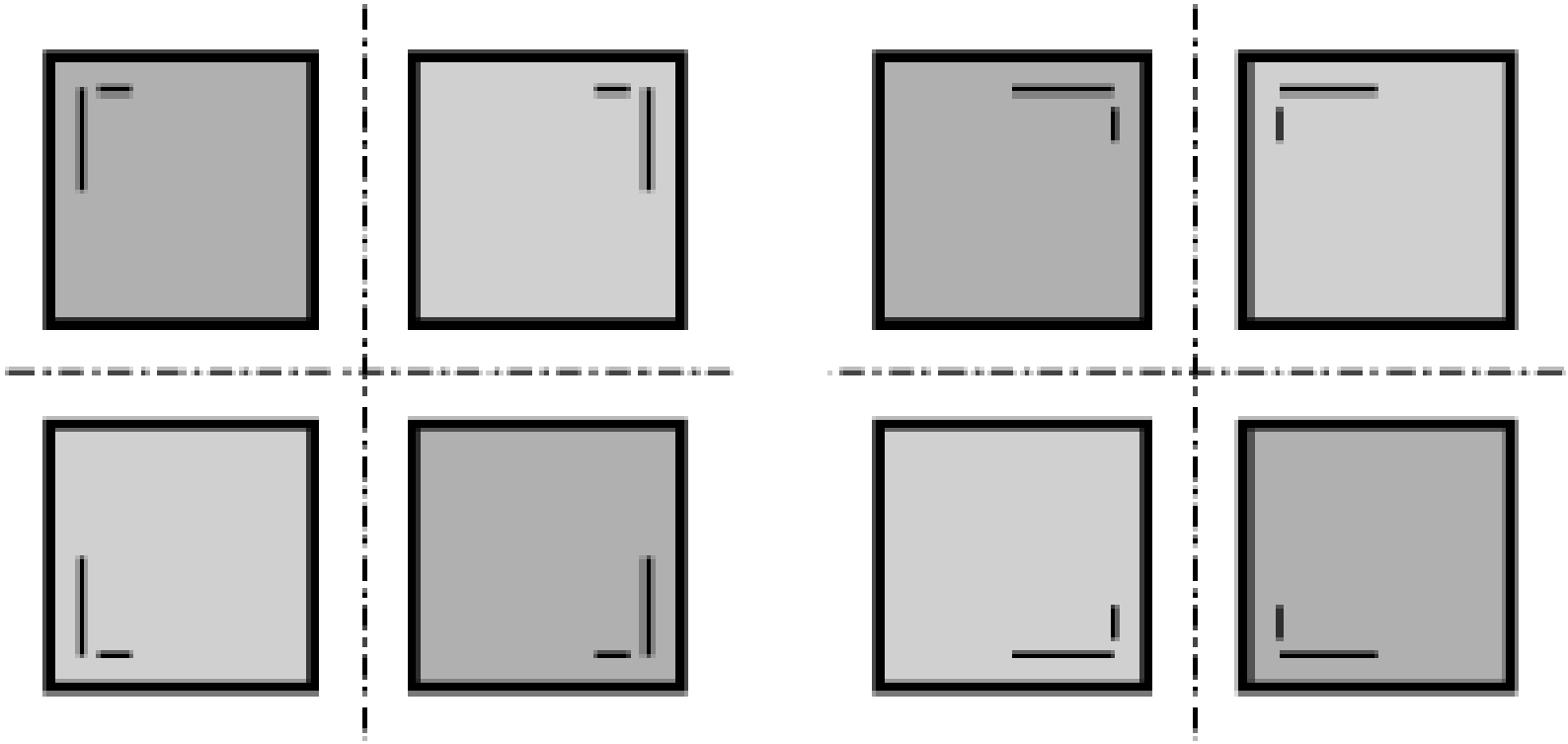
5x5 Matrix ➔ 3125

8x8 Matrix ➔ 16777216

26x26 Matrix ➔ $6{,}156 * 10^{36}$

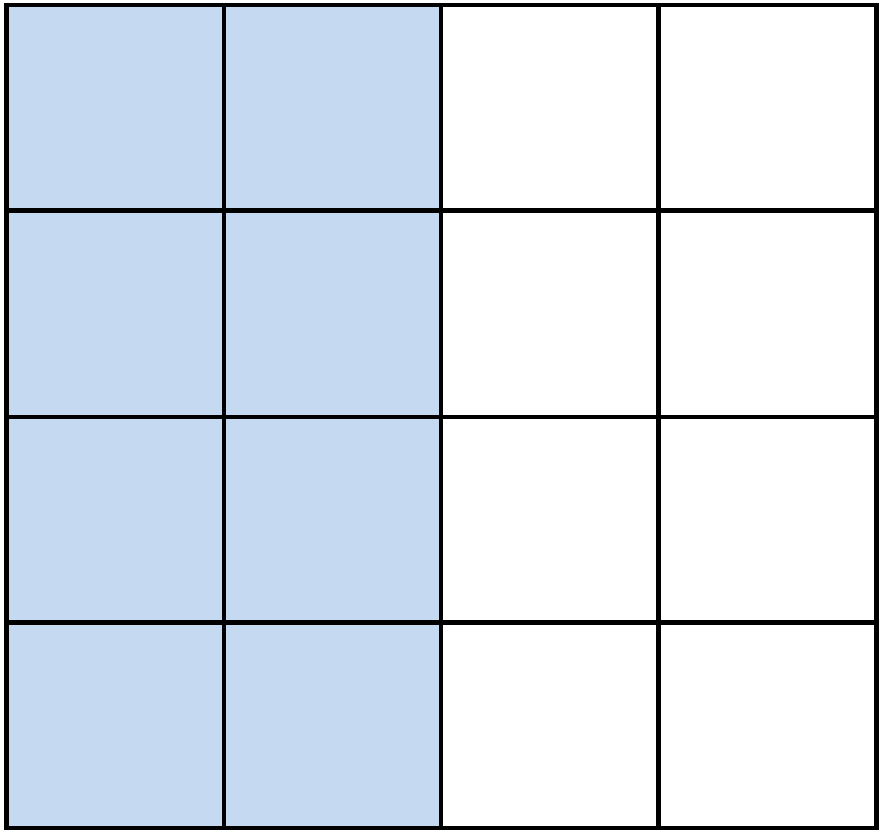
27x27 Matrix ➔ $4{,}434 * 10^{38}$

Optimierung
Symmetrie

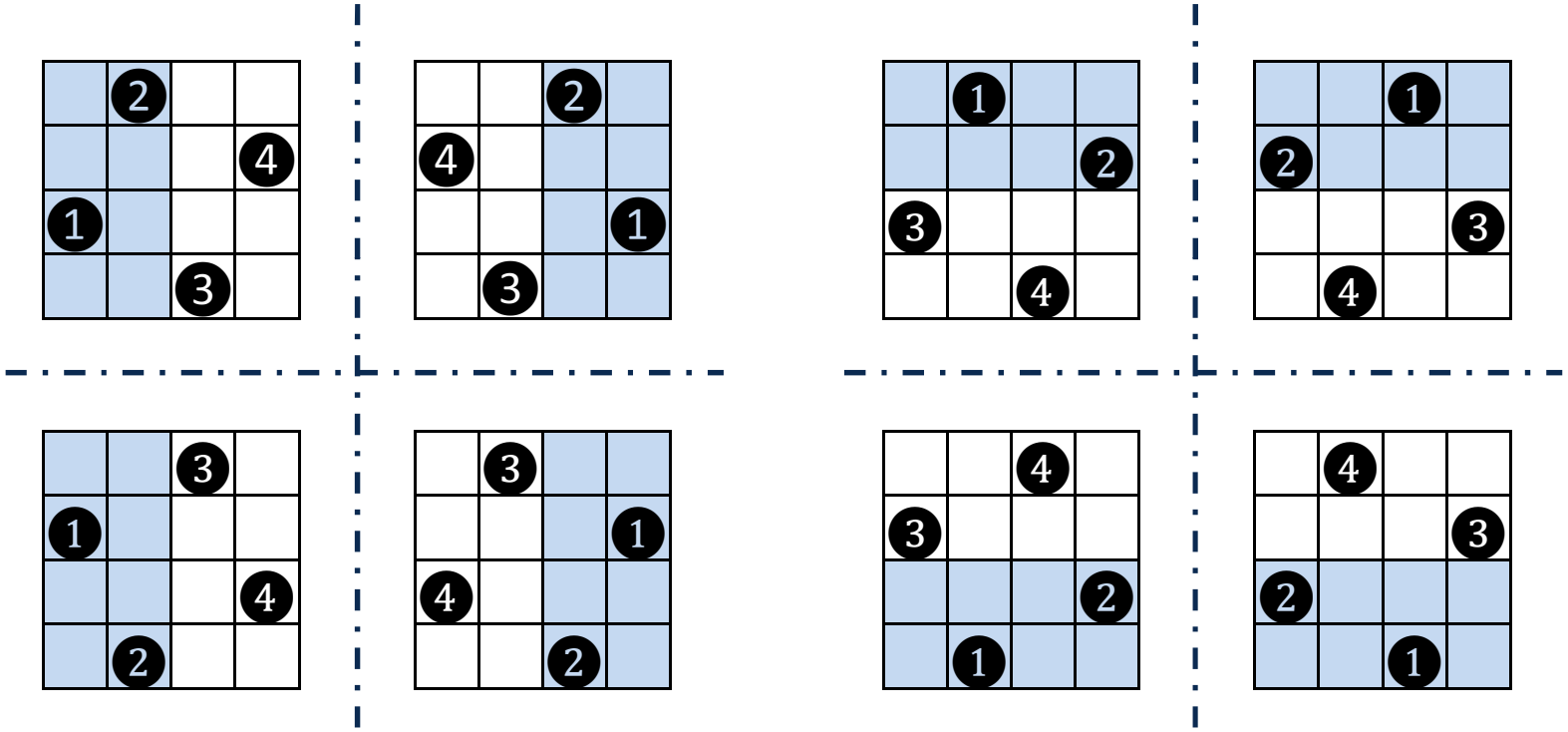


Quelle: http://queens.inf.tu-dresden.de/?n=f&ln=de (03.02.2015)

Optimierung
Ansatz mit 2-Spalten Vorbelegung

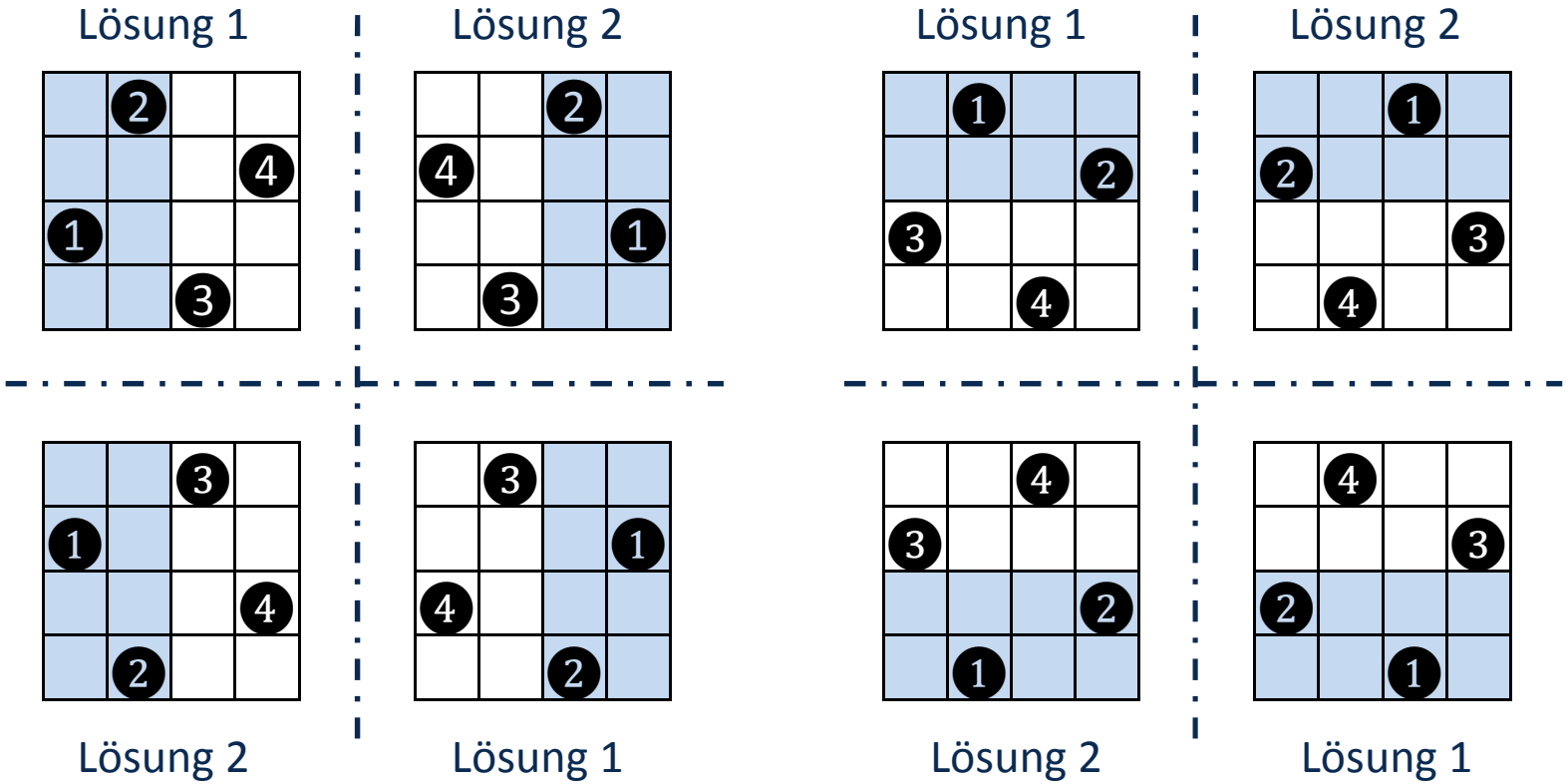


Symmetrie

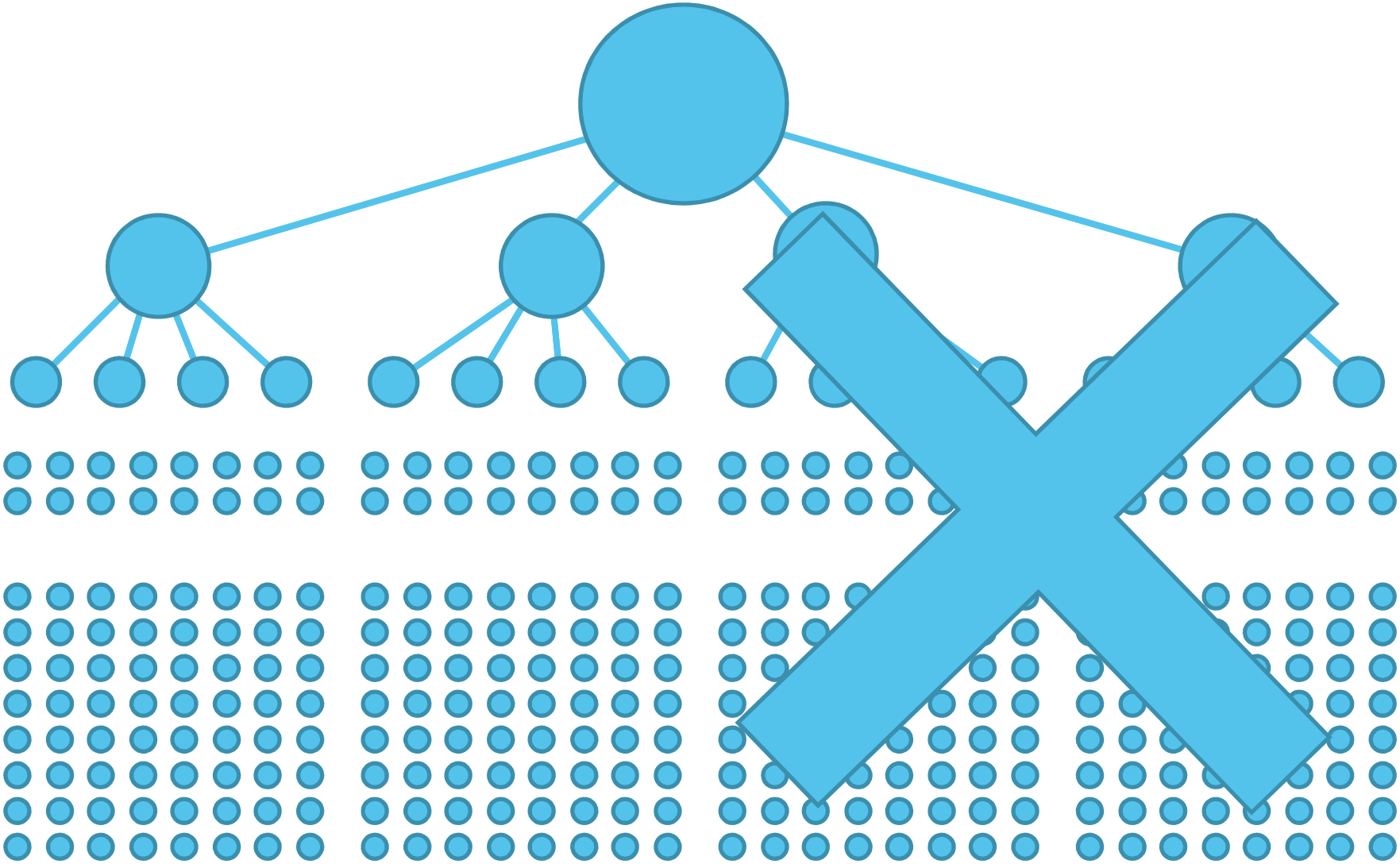


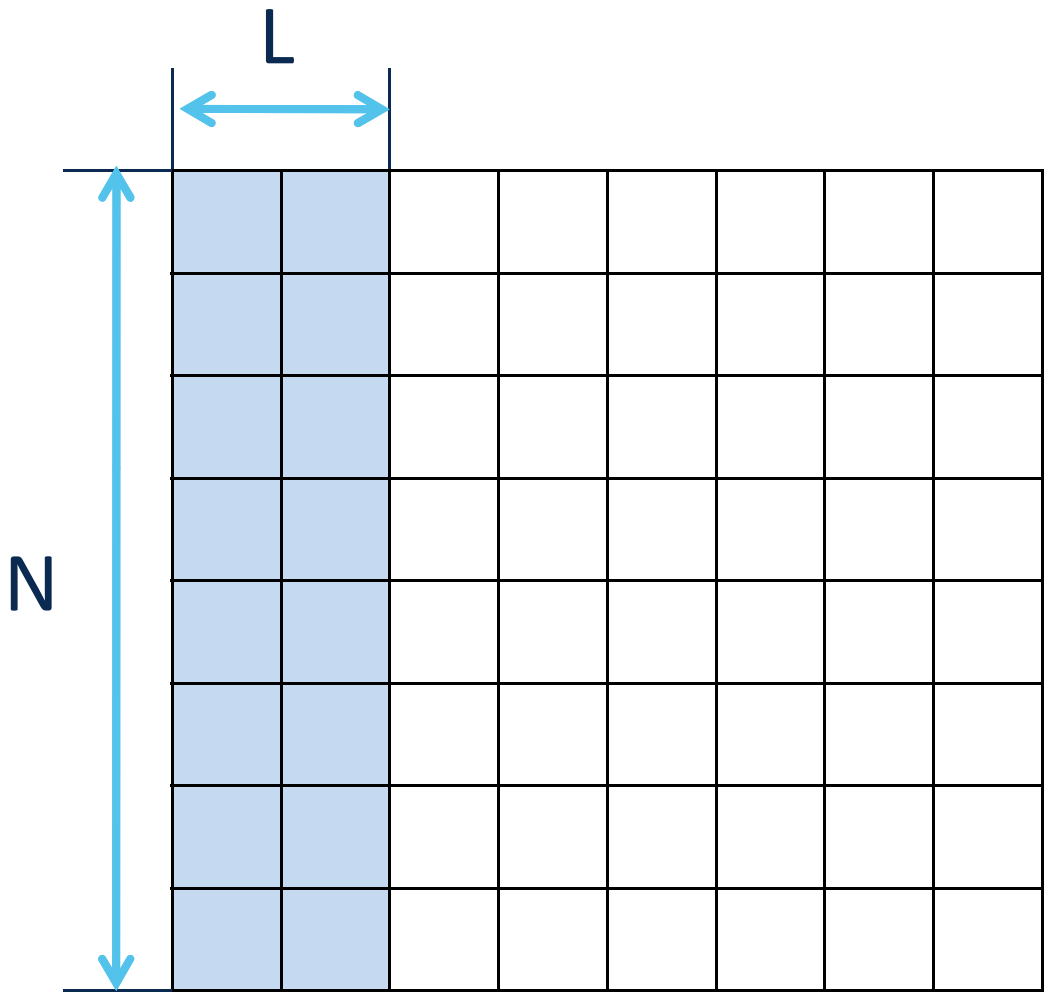
Frei nach: http://queens.inf.tu-dresden.de/?n=f&ln=de (03.02.2015)

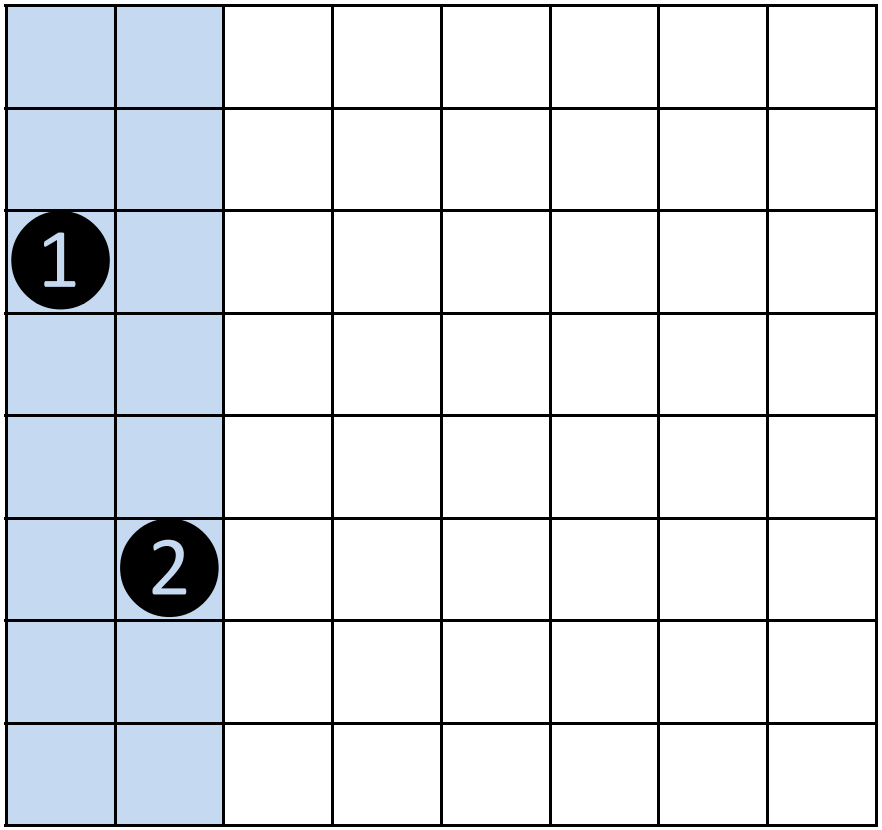
Symmetrie

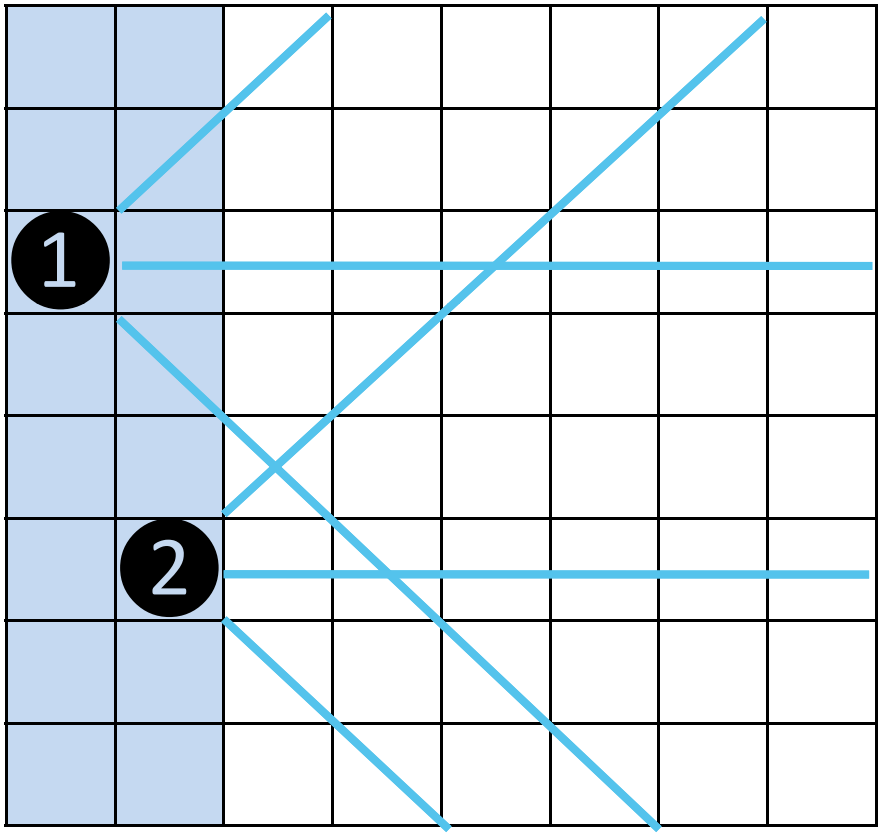


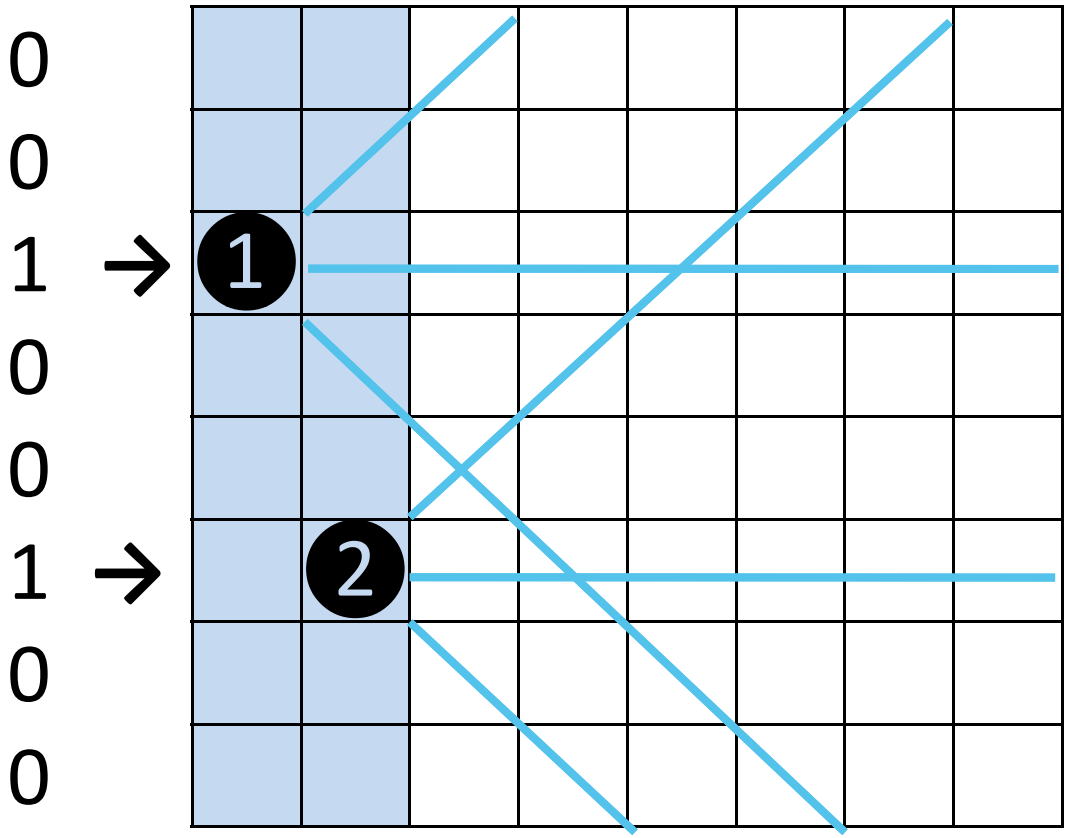
Frei nach: http://queens.inf.tu-dresden.de/?n=f&ln=de (03.02.2015)



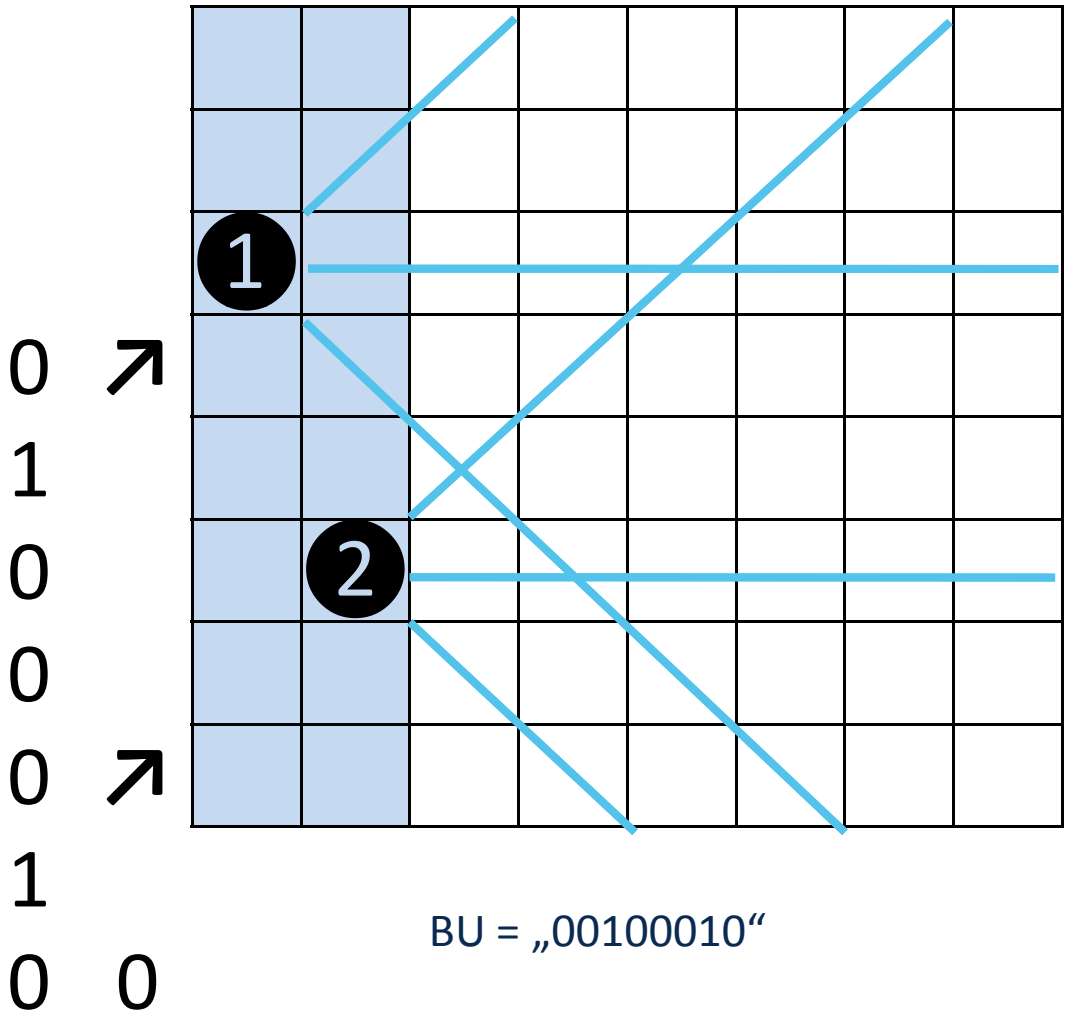

L
N


1
2

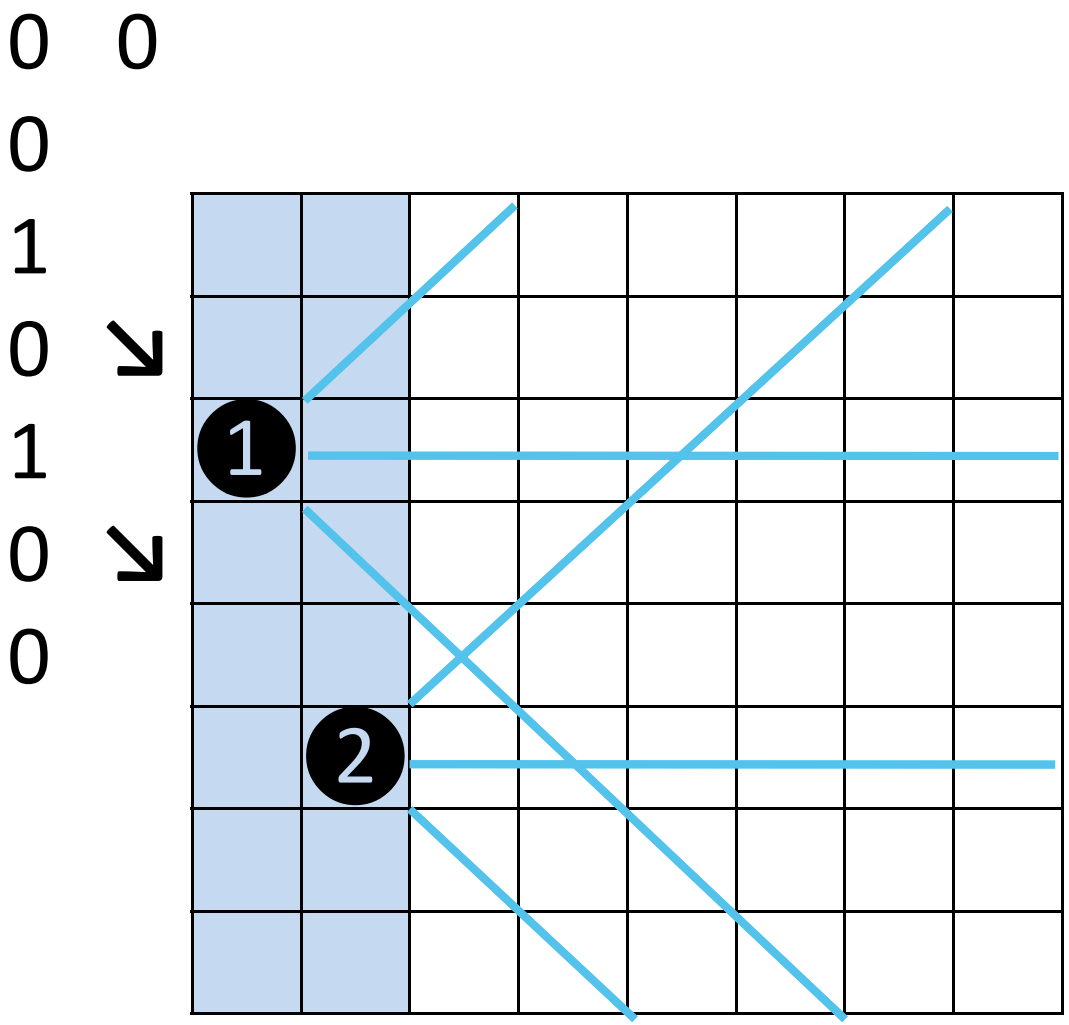

1
2



BH = „00100100“



BU = „00100010“



BD = „00101000“

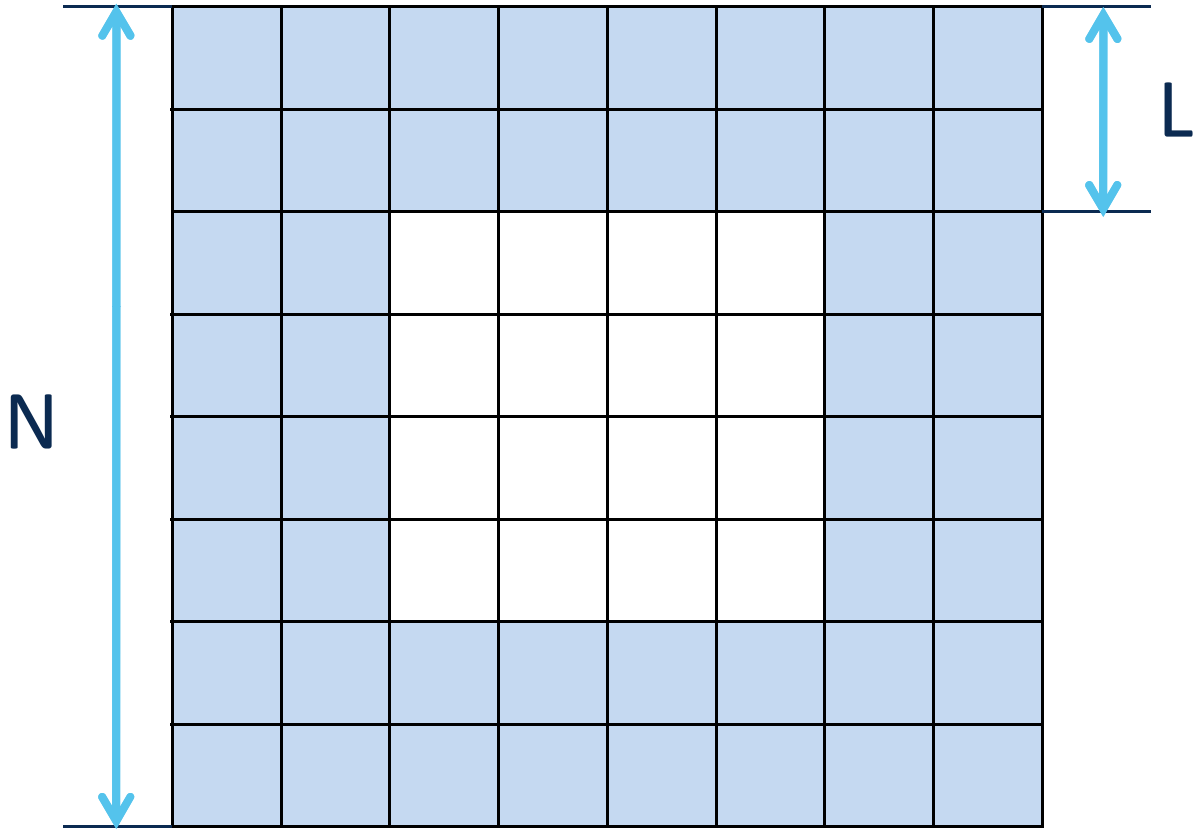
Kodierung

BH = „00100100“

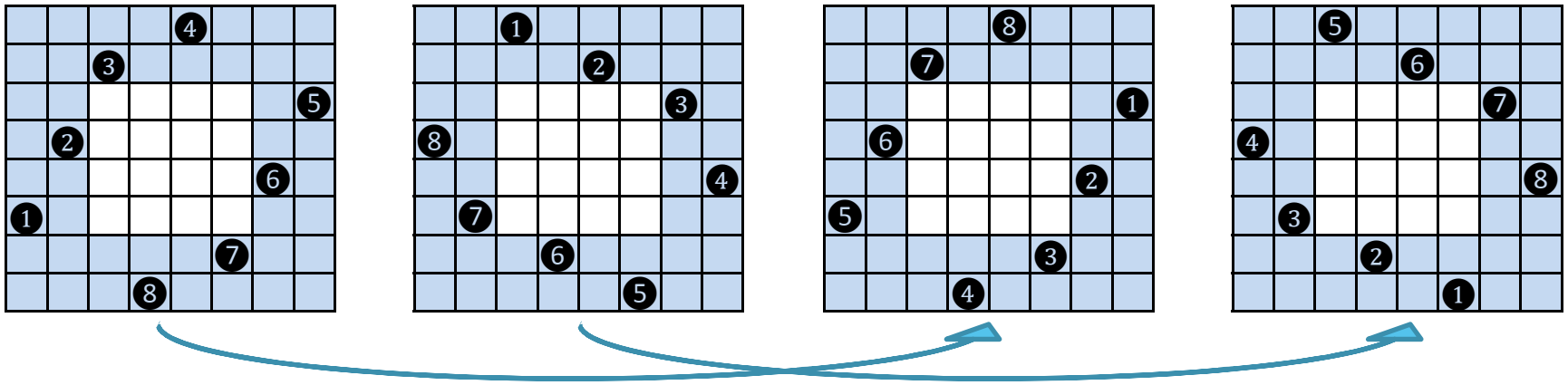
BU = „00100010“

BD = „00101000“

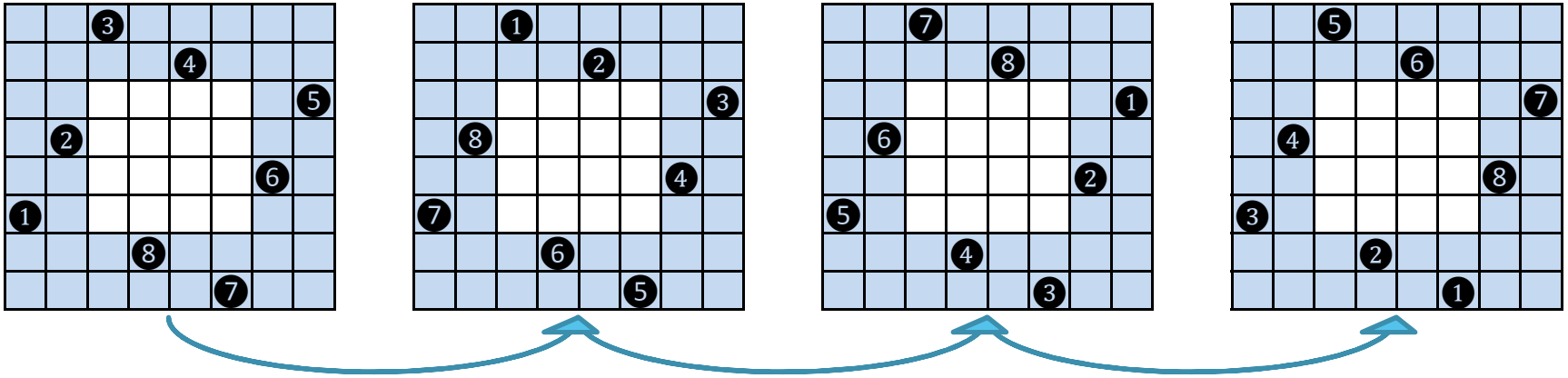
Optimierung
Ansatz mit koronaler Vorbelegung

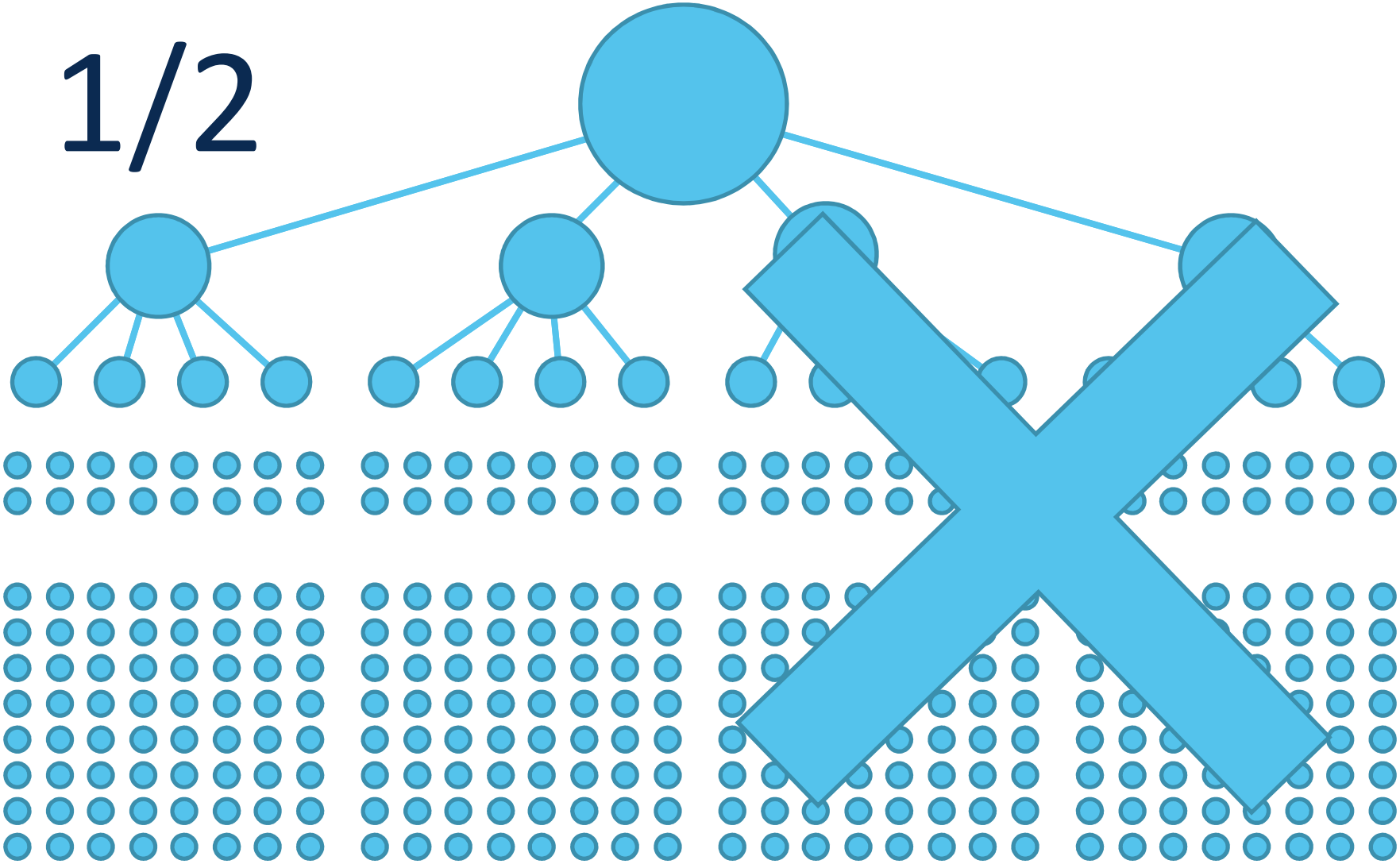

N
L

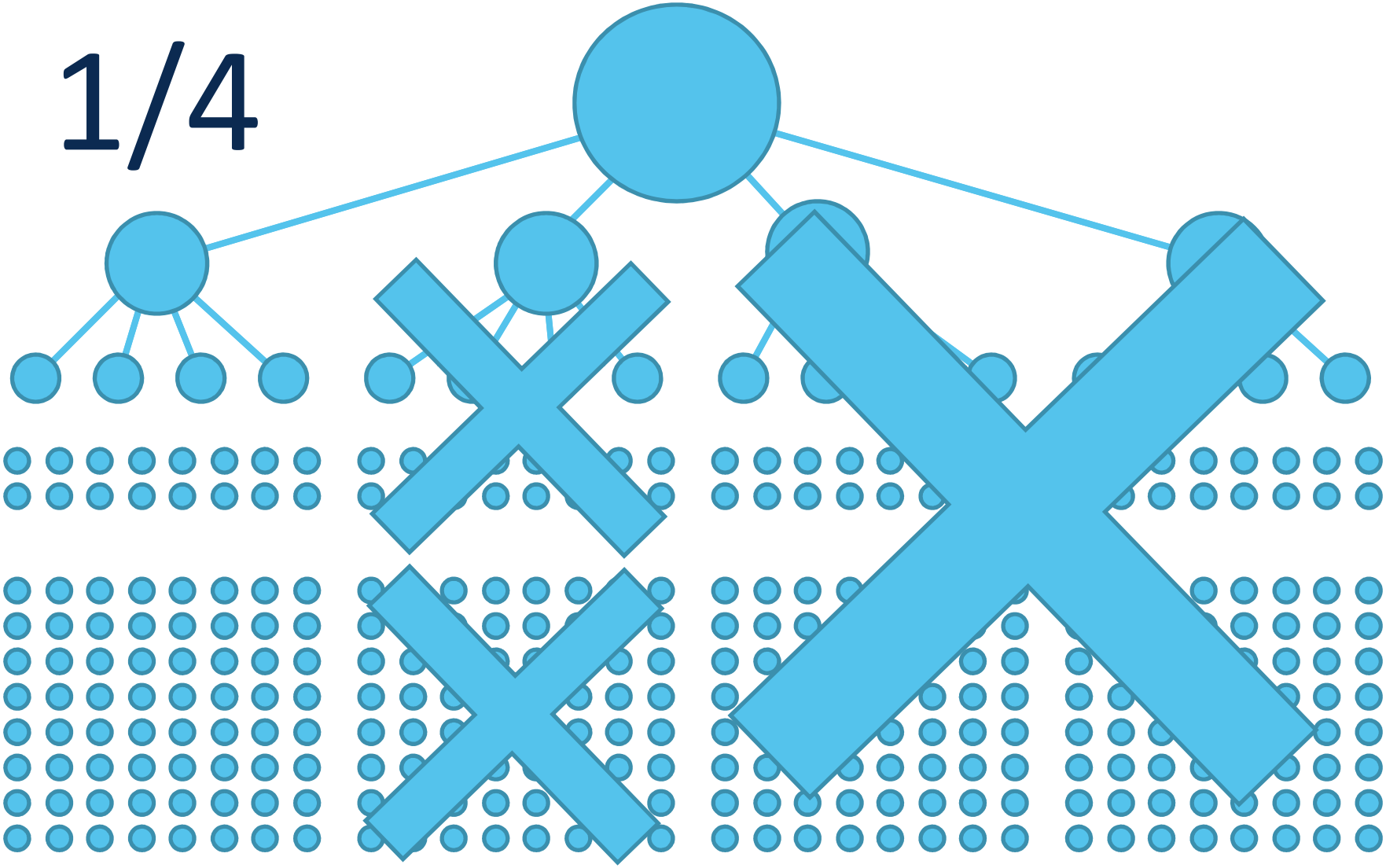
Punktsymmetrie

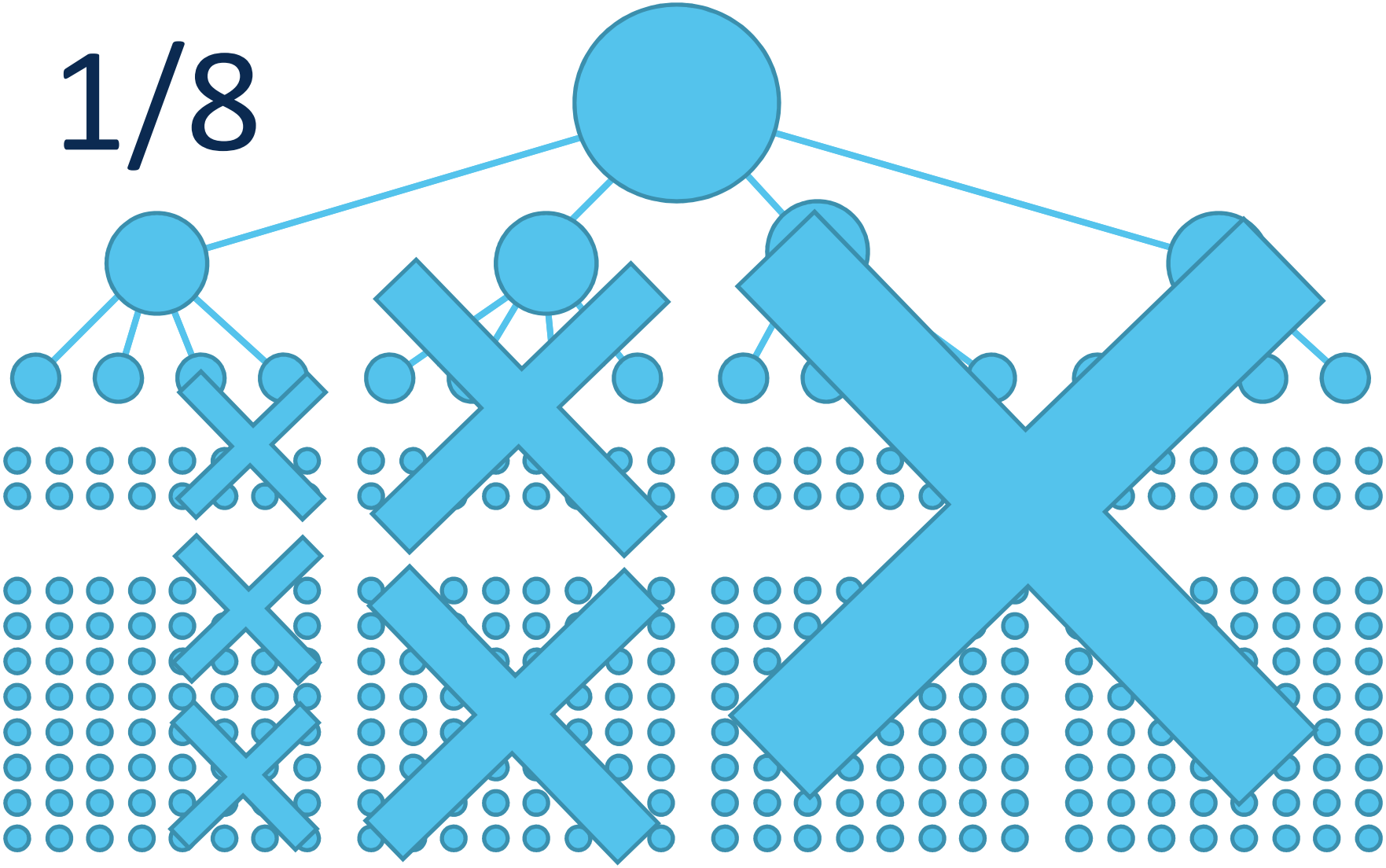


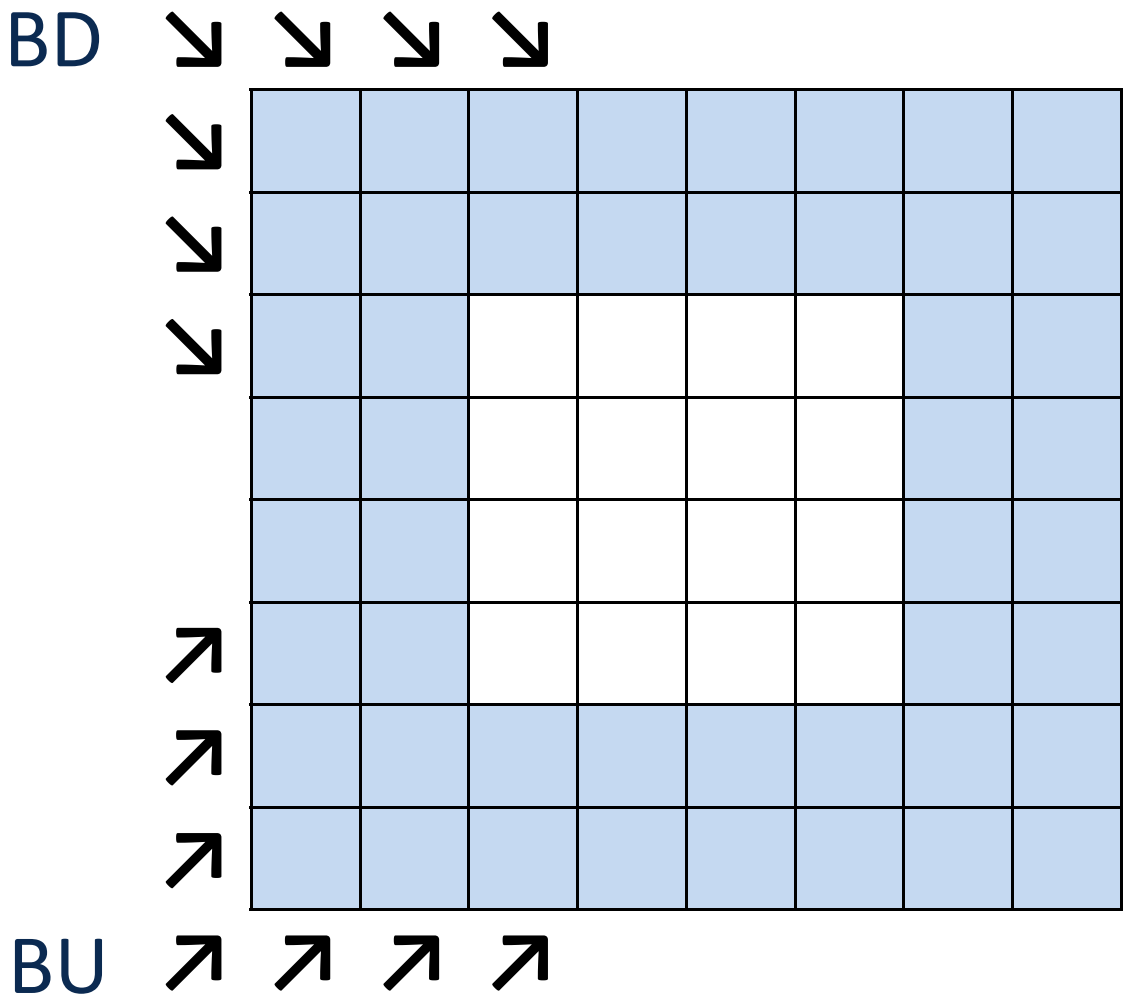
Rotationssymmetrie

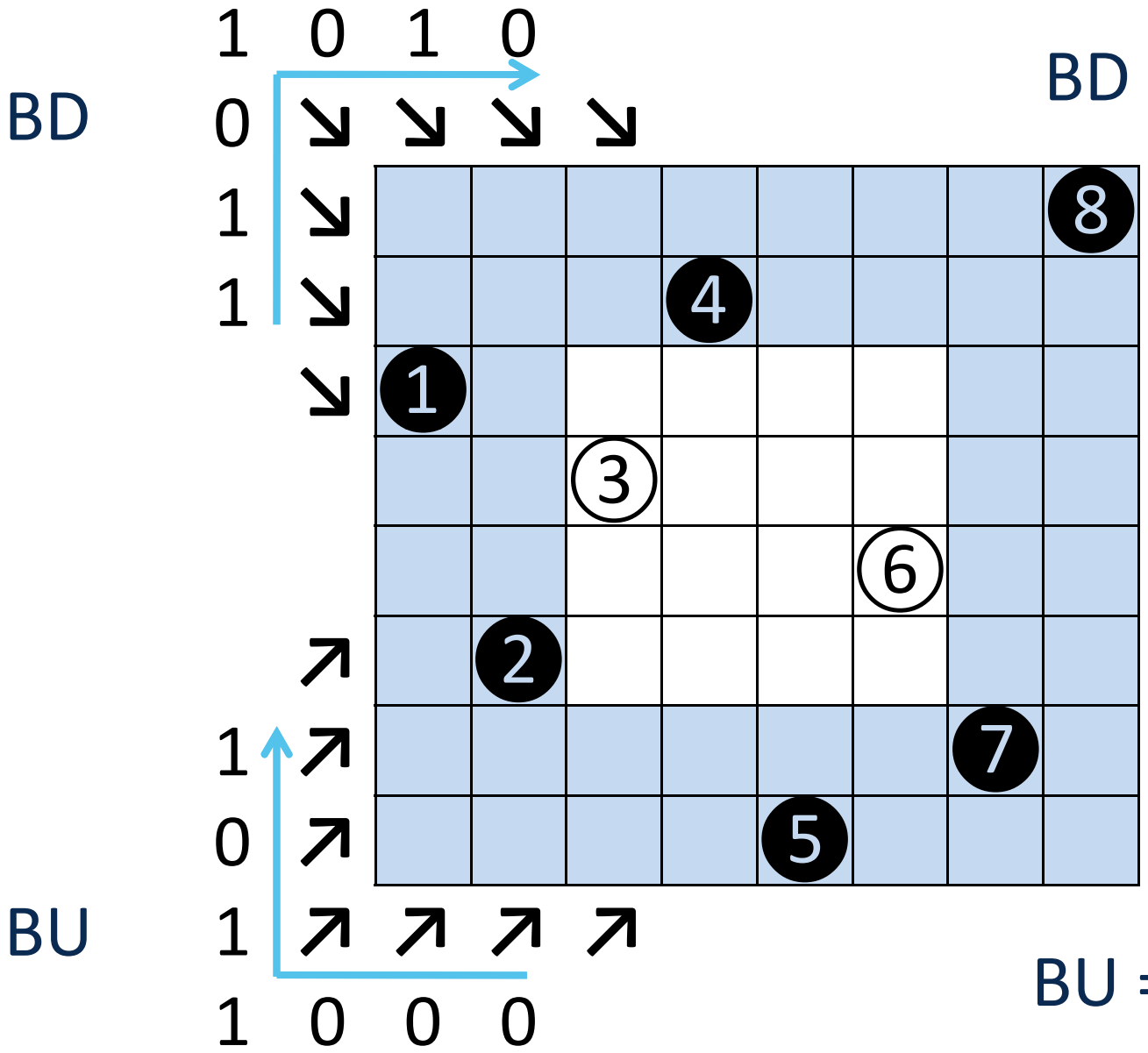



1/2


1/4

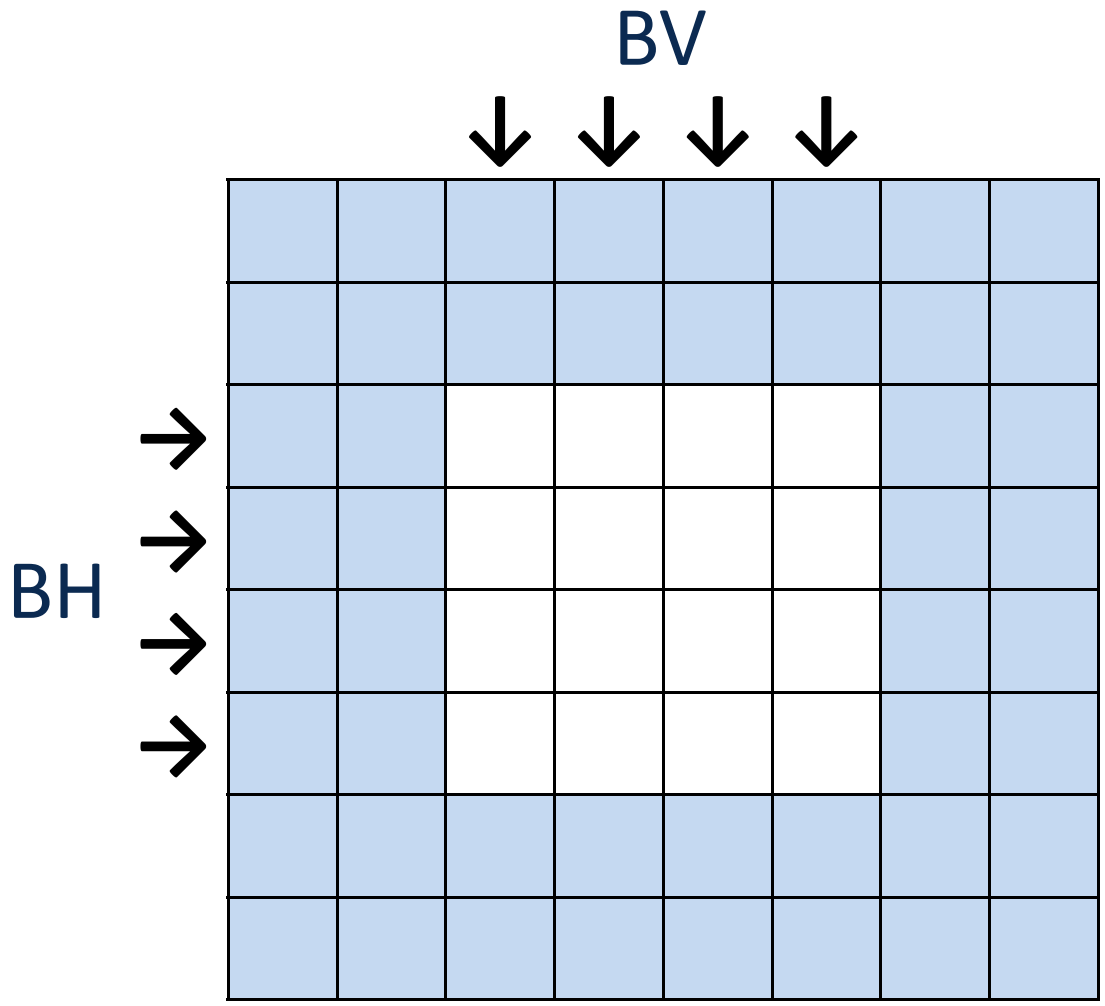

1/8

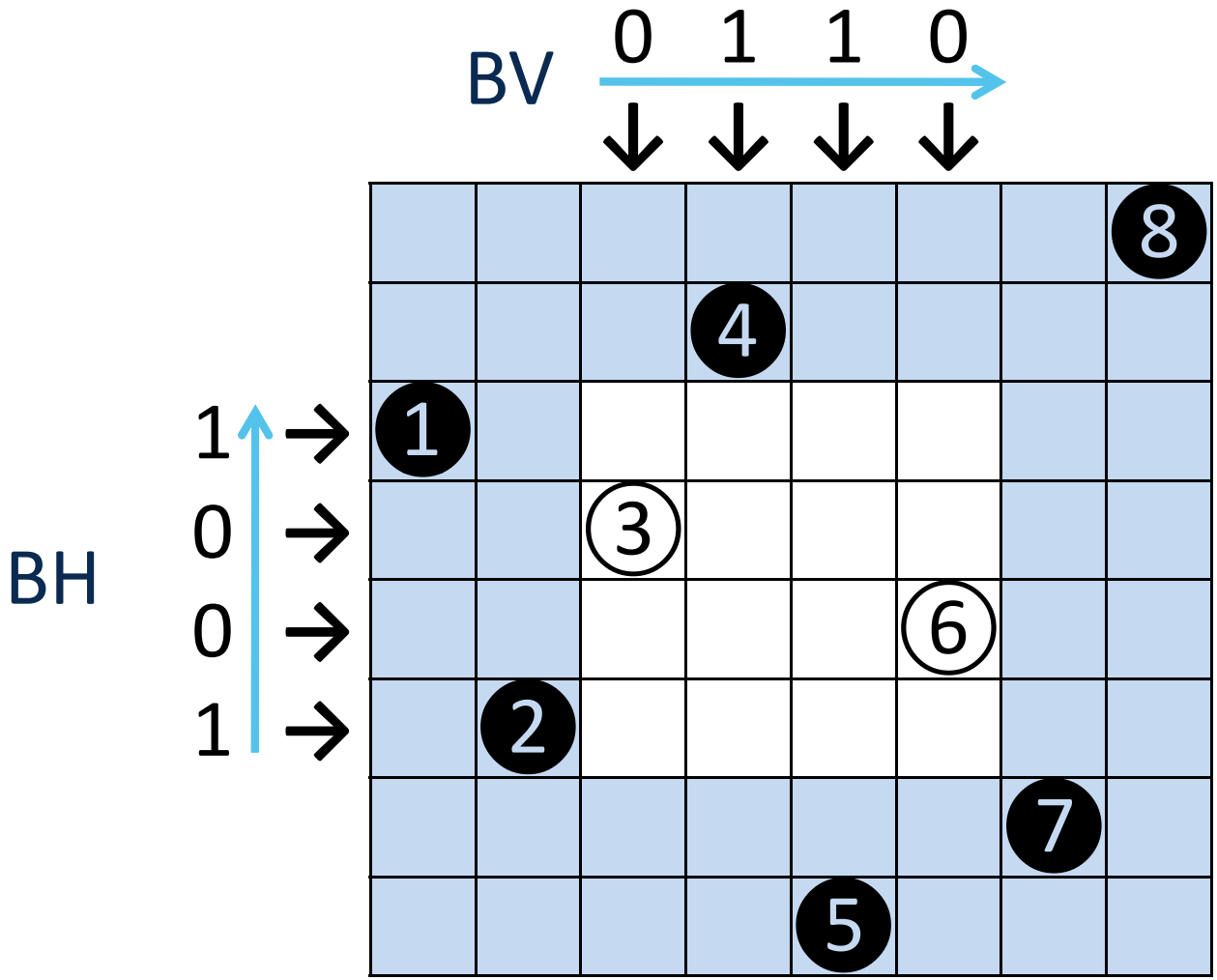

BD
BU



BD = „1101010“

BU = „0001101“

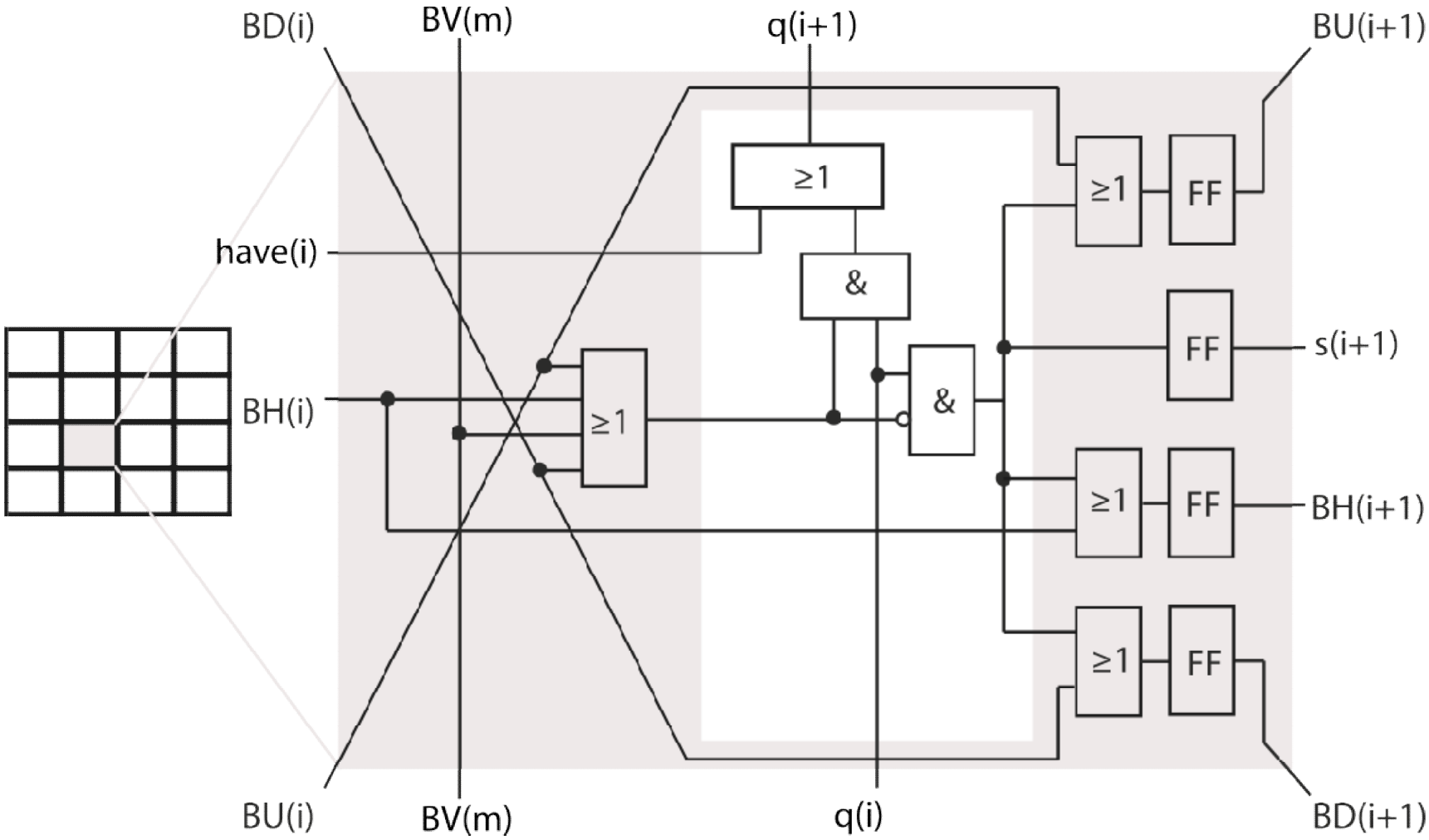

BV
BH



BV = „0110“

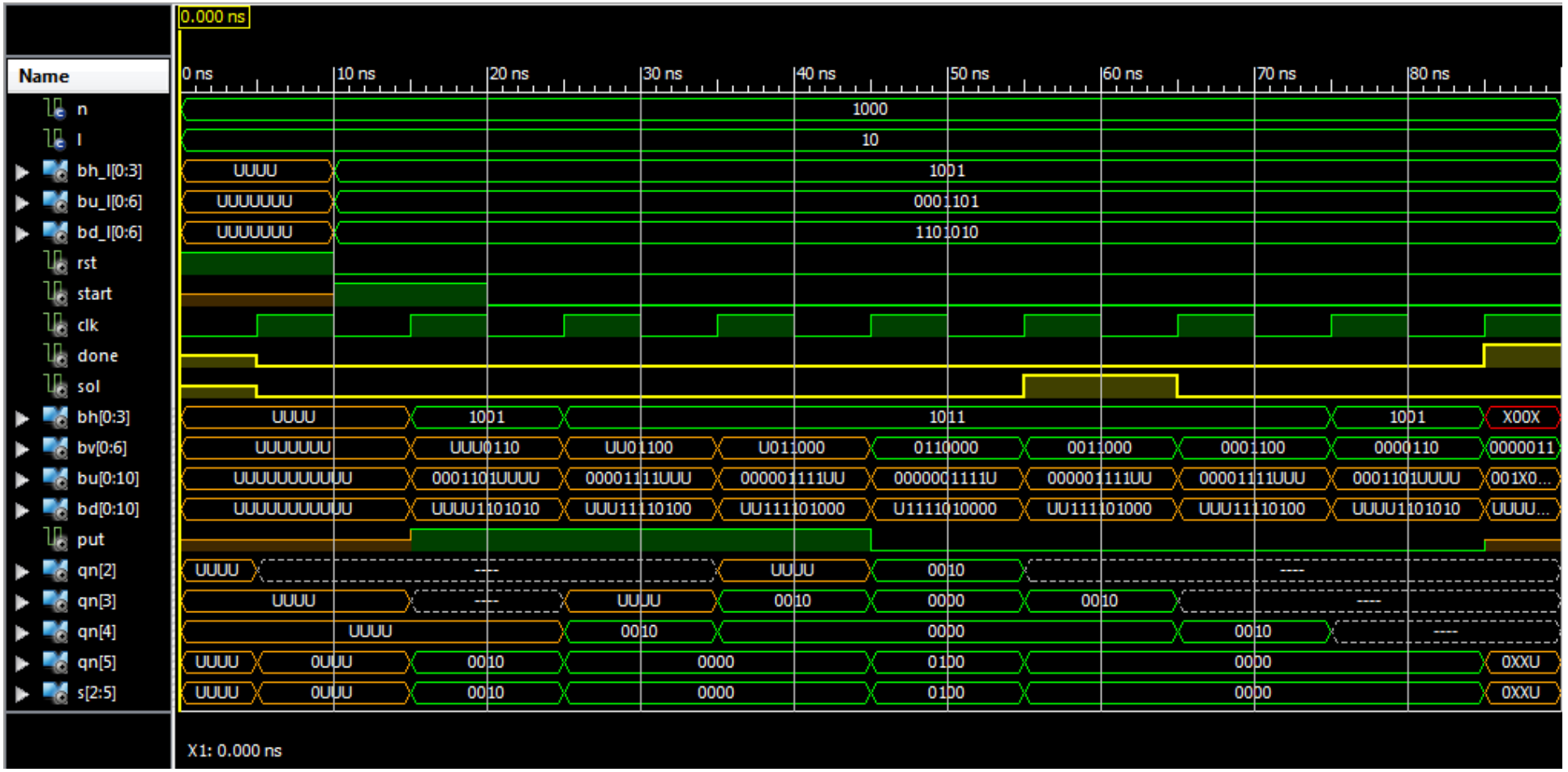
BH = „1001“

Algorithmus



Frei nach einer Abbildung aus dem Paper (siehe Quellen)

Simulation


0.000 ns
Name
0 ns
10 ns
20 ns
30 ns
40 ns
50 ns
60 ns
70 ns
80 ns
n
1000
l
10
bh_l[0:3]
UUUU
1001
bu_l[0:6]
UUUUUUU
0001101
bd_l[0:6]
UUUUUUU
1101010
rst
start
clk
done
sol
bh[0:3]
UUUU
1001
1011
1001
X00X
bv[0:6]
UUUUUUU
UUU0110
UU01100
U011000
0110000
0011000
0001100
0000110
0000011
bu[0:10]
UUUUUUUUUUU
00011010UUU
0000111UUUU
000001111UU
0000001111U
000001111UU
0000111UUUU
00011010UUU
001X0...
bd[0:10]
UUUUUUUUUUU
UUUU1101010
UUU11110100
UU11110100
U1111010000
UU11110100
UUU11110100
UUUU1101010
UUUU...
put
qn[2]
UUUU
UUUU
0010
qn[3]
UUUU
UUUU
0010
0000
0010
qn[4]
UUUU
0010
0000
0010
qn[5]
UUUU
0UUU
0010
0000
0100
0000
0XXU
s[2:5]
UUUU
0UUU
0010
0000
0100
0000
0XXU
X1: 0.000 ns

Quellen

- Putting Queens in Carry Chains by Thomas B. Preußer, Bernd Nägel and Rainer G. Spallek, Department of Computer Science, Technische Universität Dresden, Germany
- http://queens.inf.tu-dresden.de/ (03.02.2015)