

Comparatively Ordered Crack Algorithm in Nominal Elements

Damon Chow and Vishal Shah

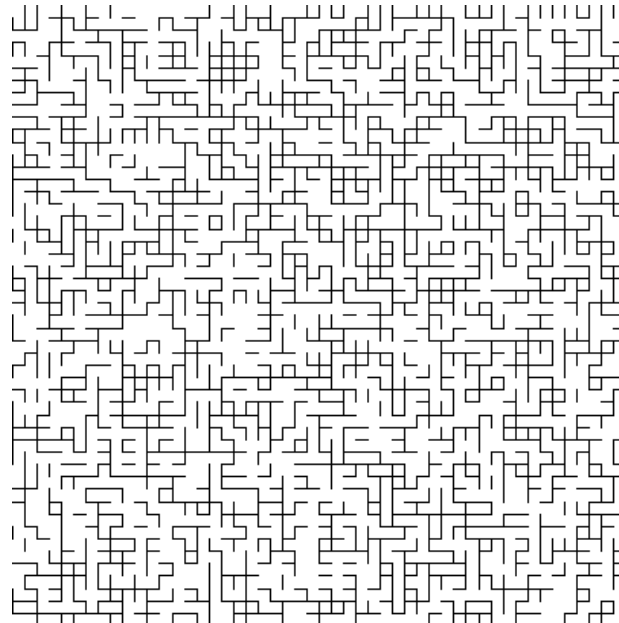
Crack Propagation

- Will a crack propagate from one plane of a material to another?



Modeling

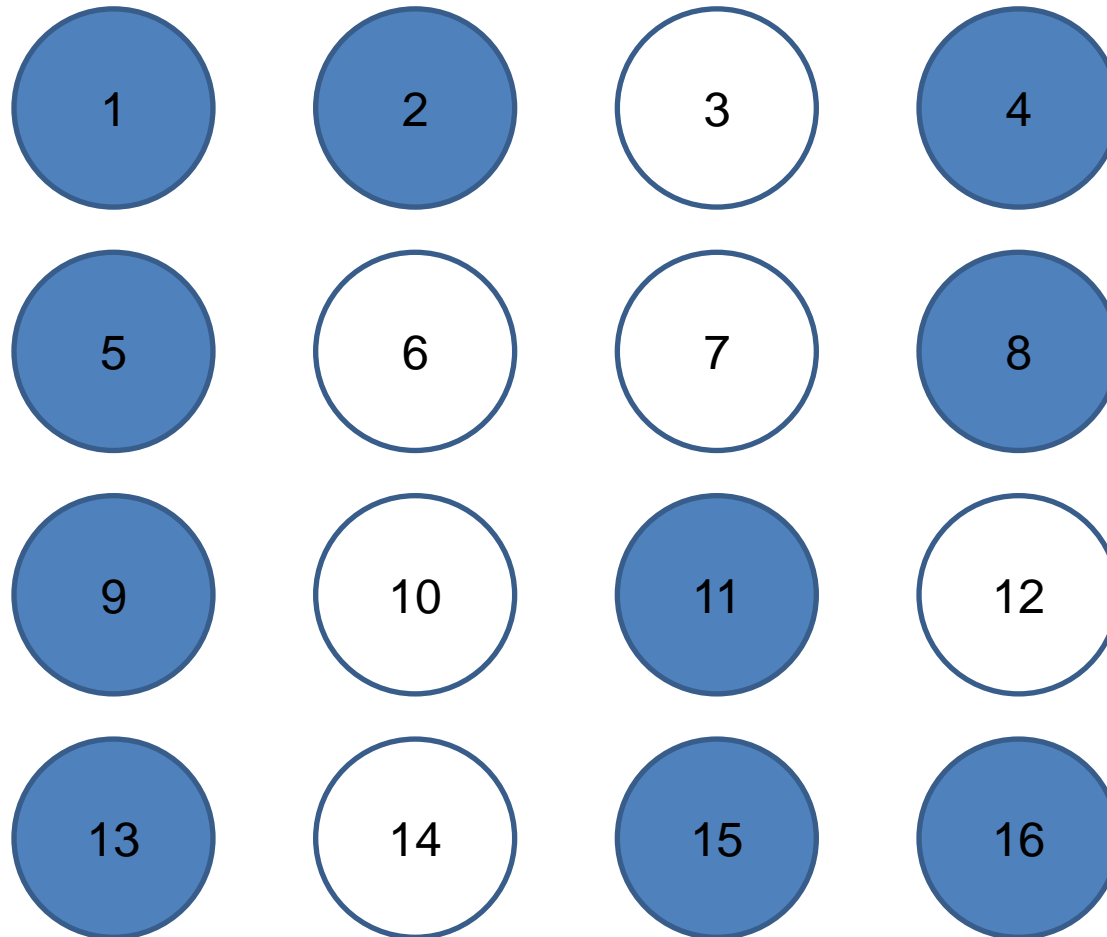
- Create a matrix containing N sites
- Have a percentage of faulty sites (ρ)
- Each ρ represents a different compound
- Test whether a faulty site on one plane of the matrix connects to a faulty site on the opposite plane

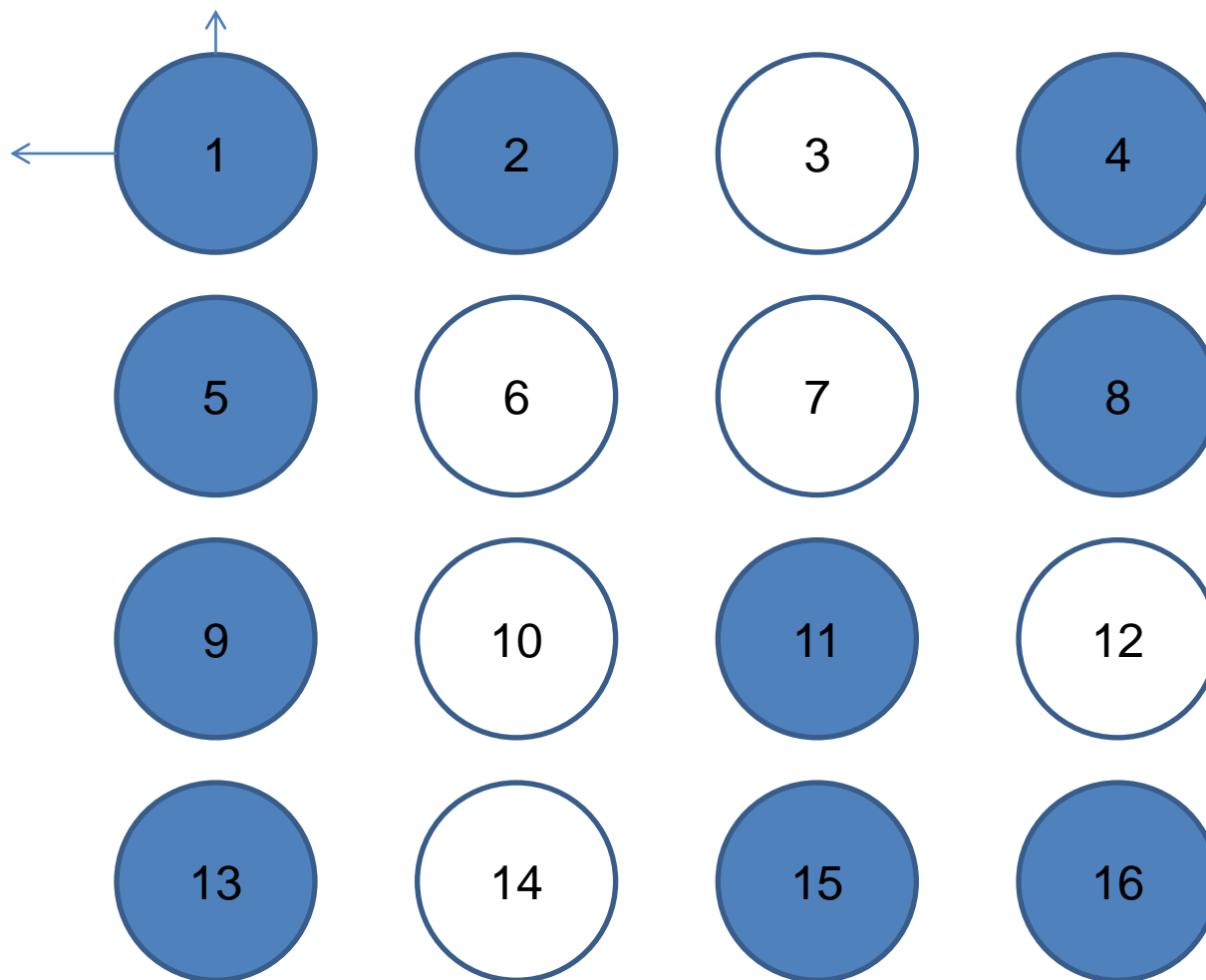


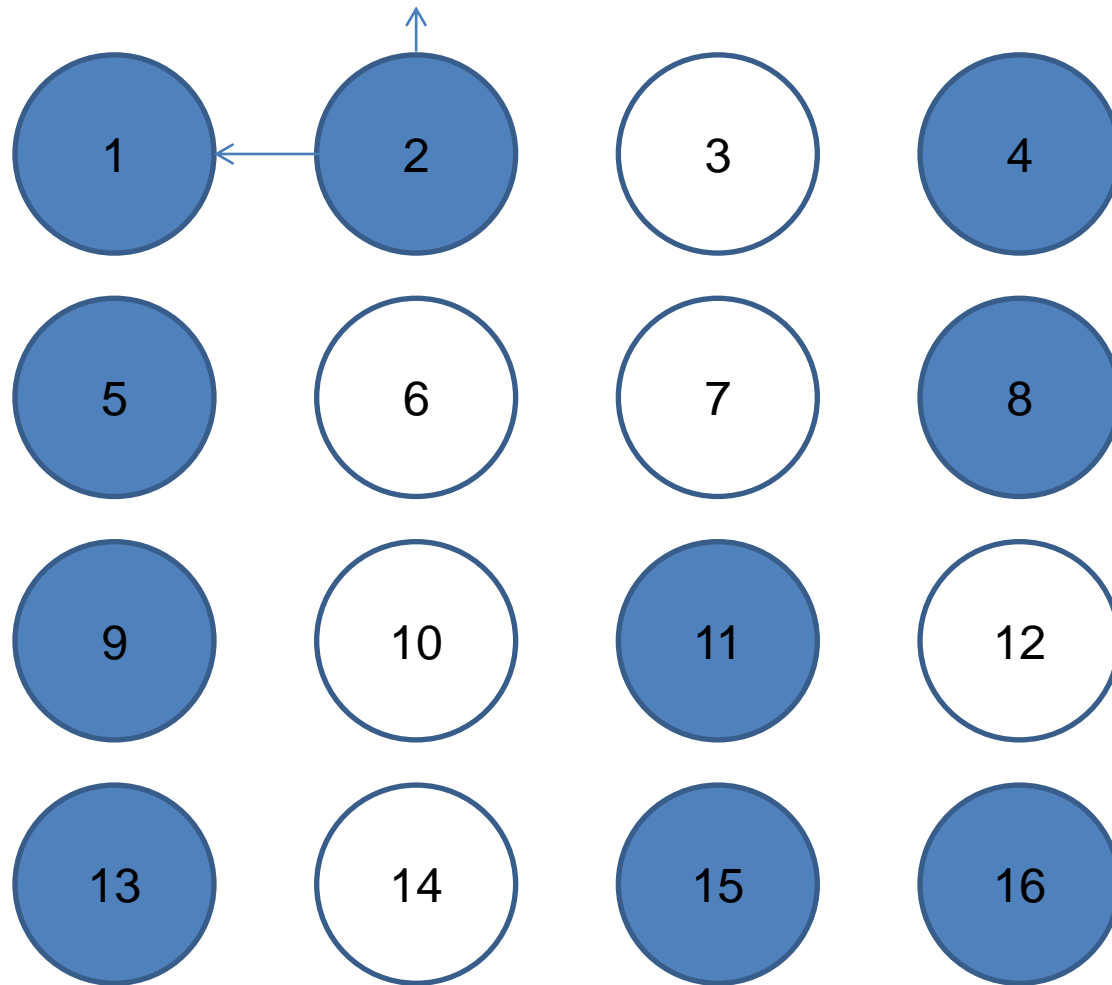
Algorithms

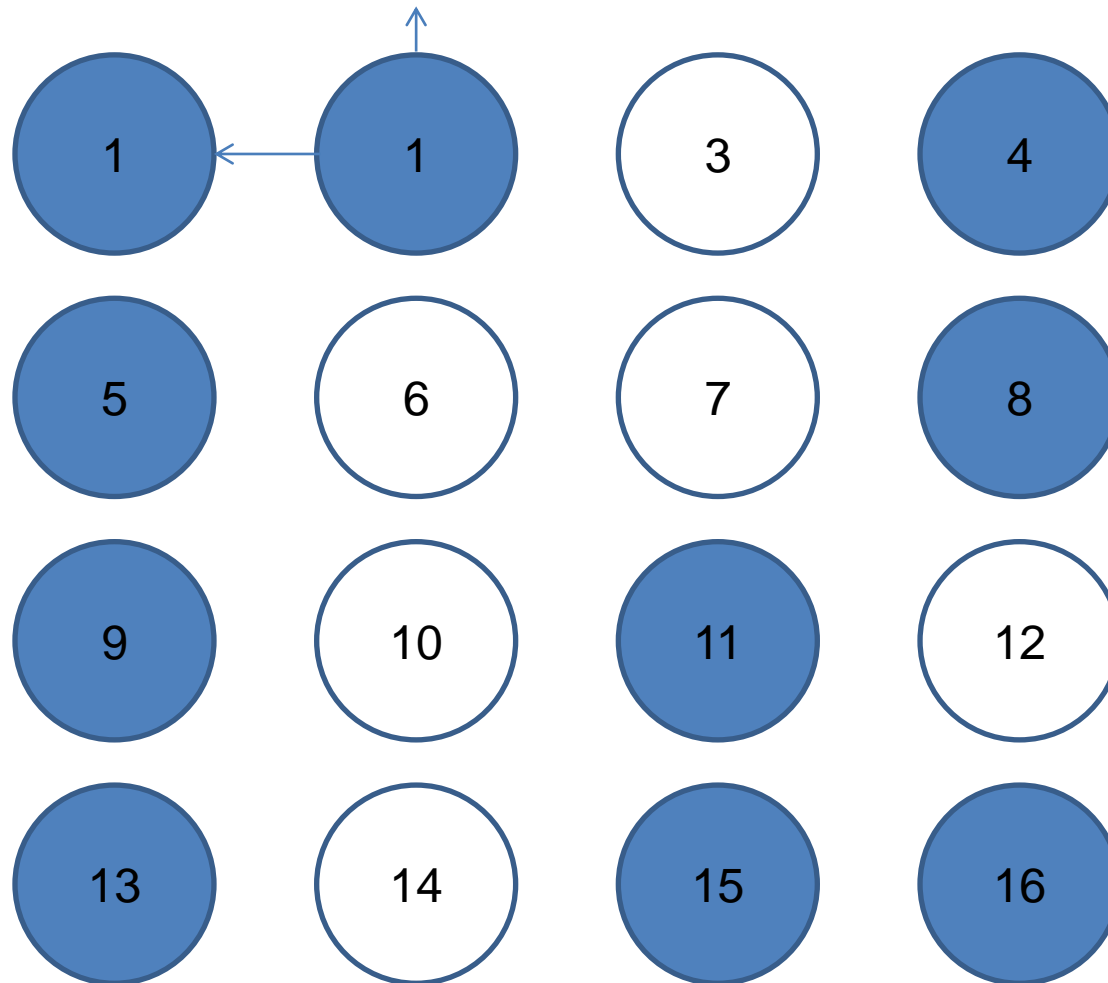
- Hoshen-Kopelman
 - J. Hoshen and R. Kopelman, 1996
 - Cluster labeling
- Newman-Ziff
 - M.E.J. Newman and R.M. Ziff, 2001
 - “Fast” Monte Carlo Algorithm

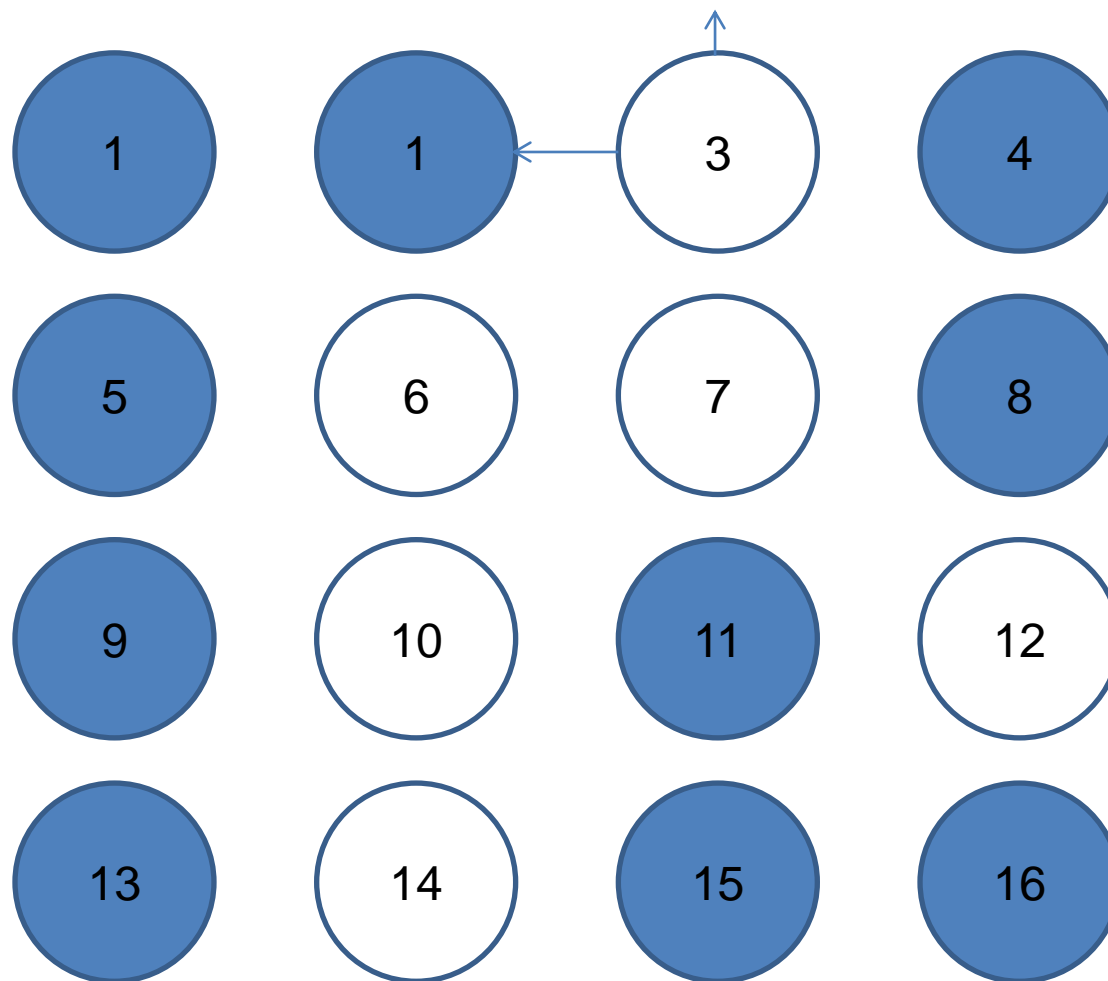
Hoshen-Kopelman (HK)

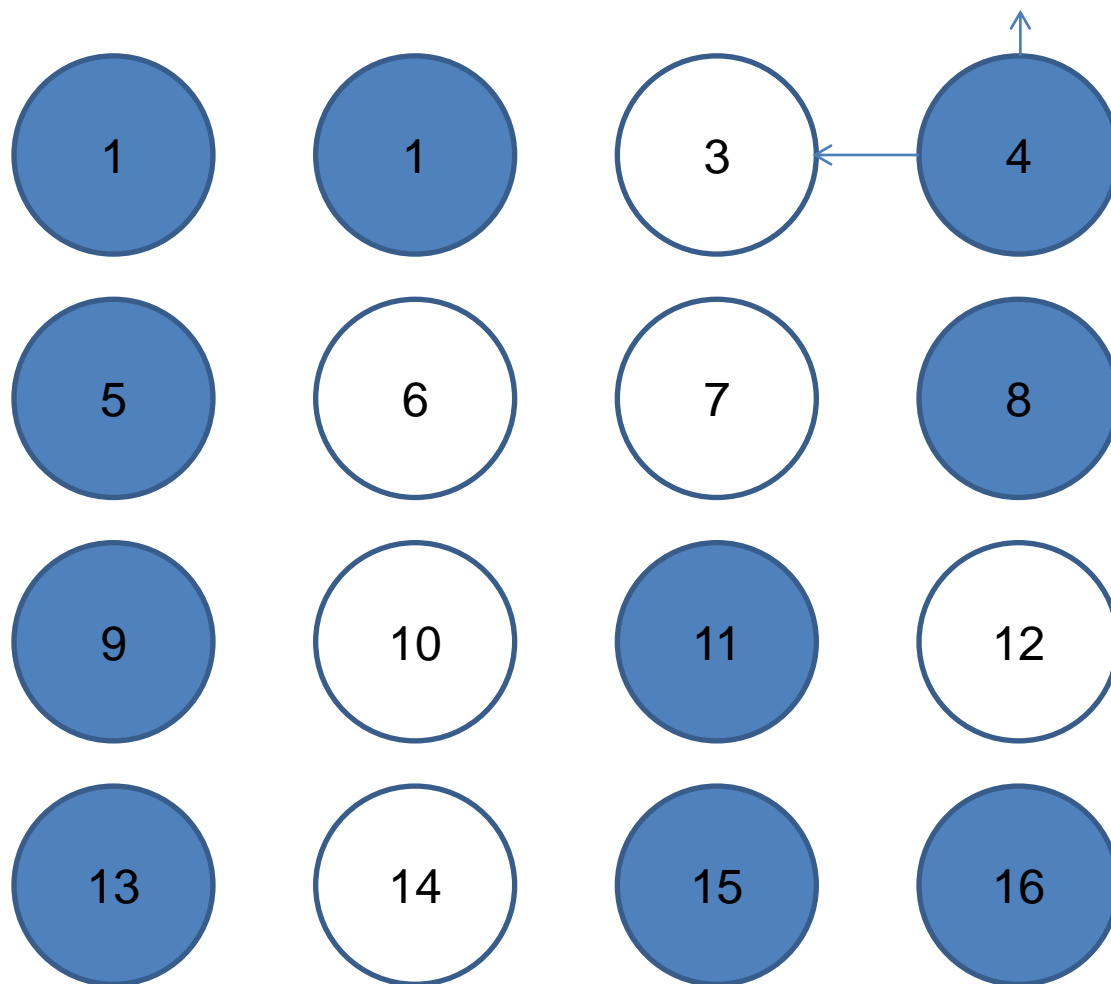


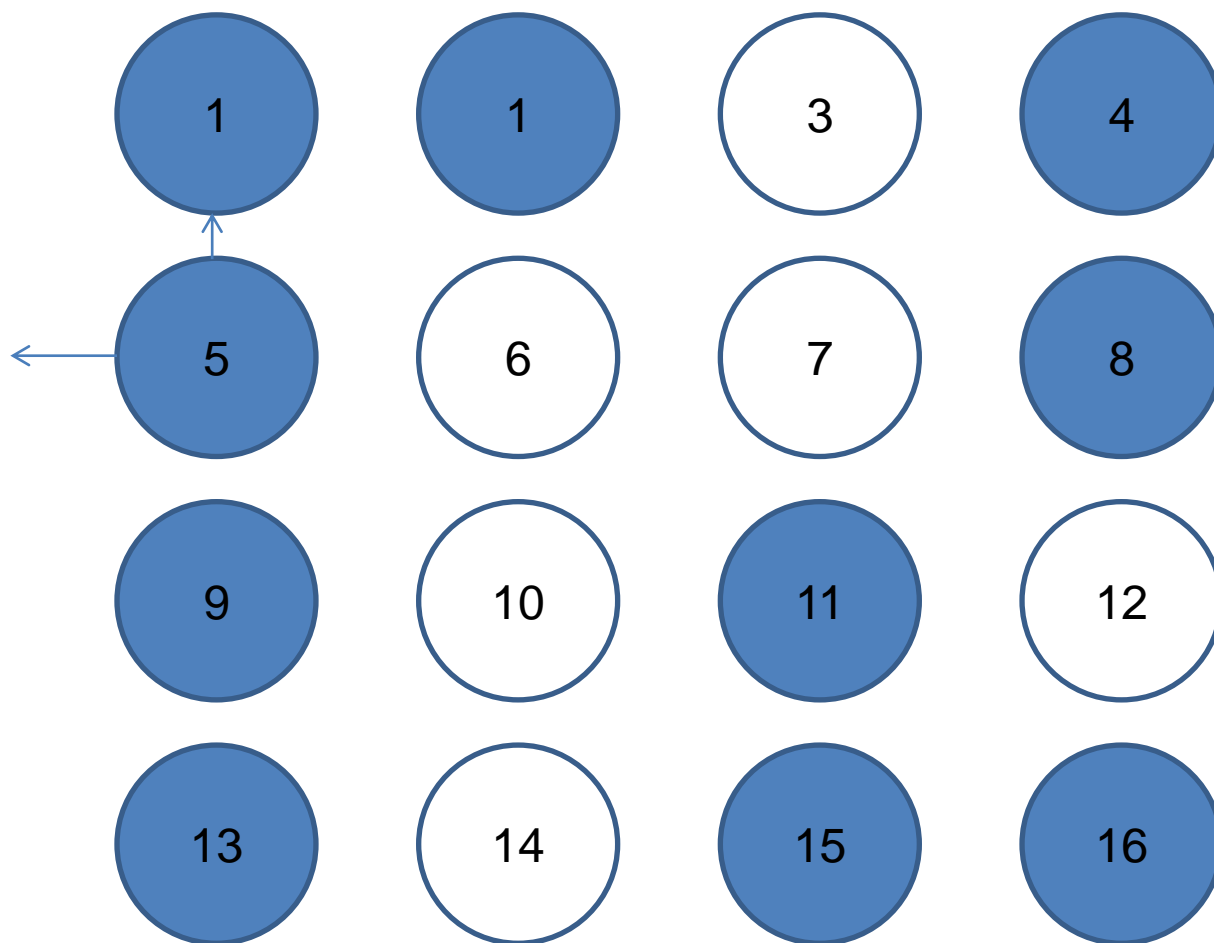


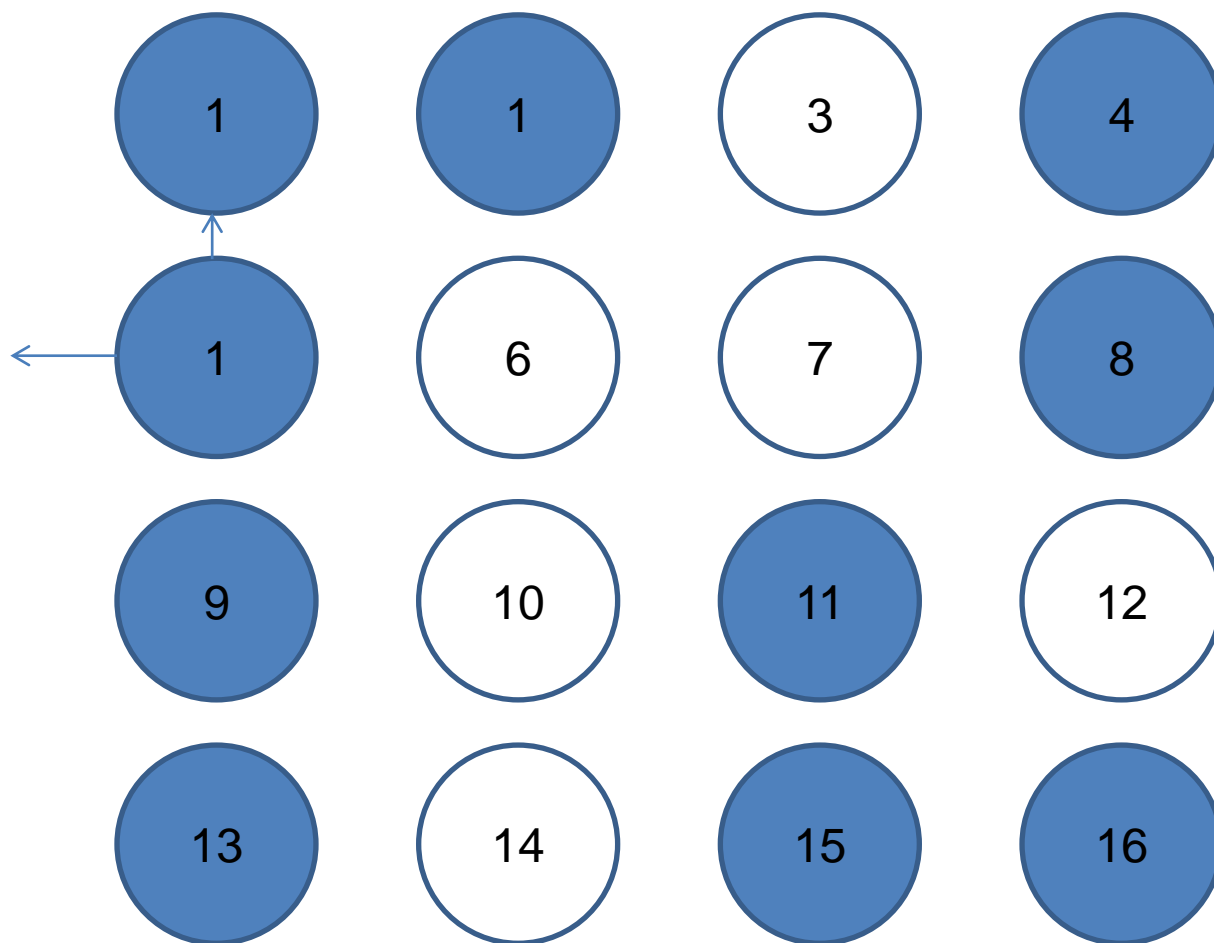


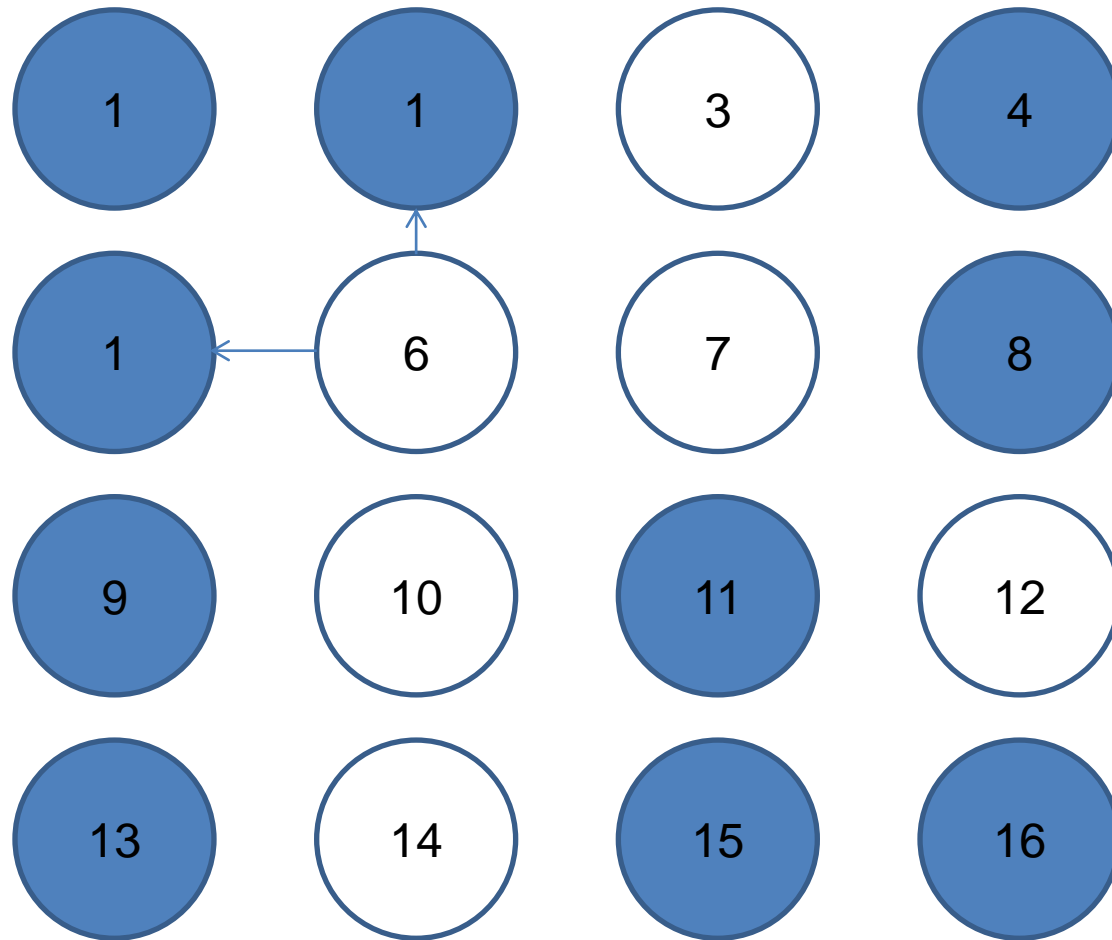


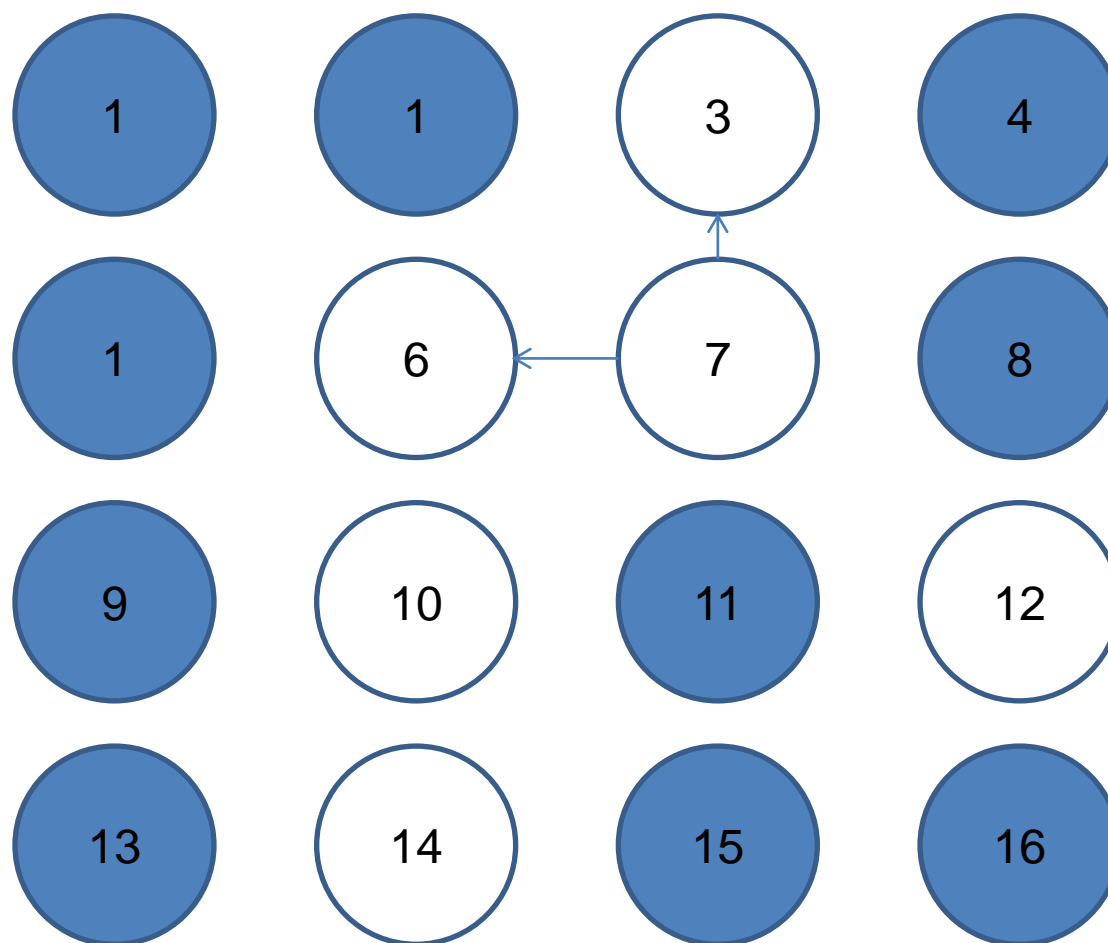


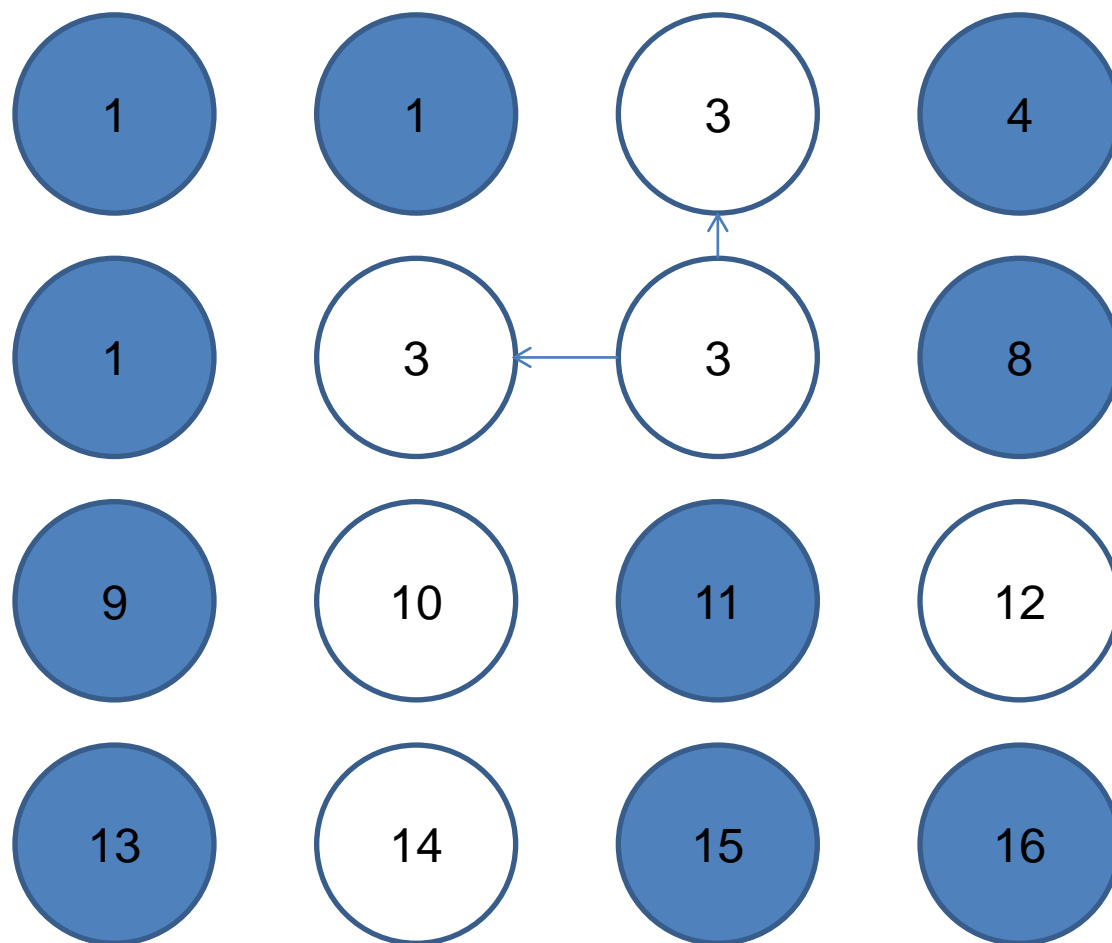


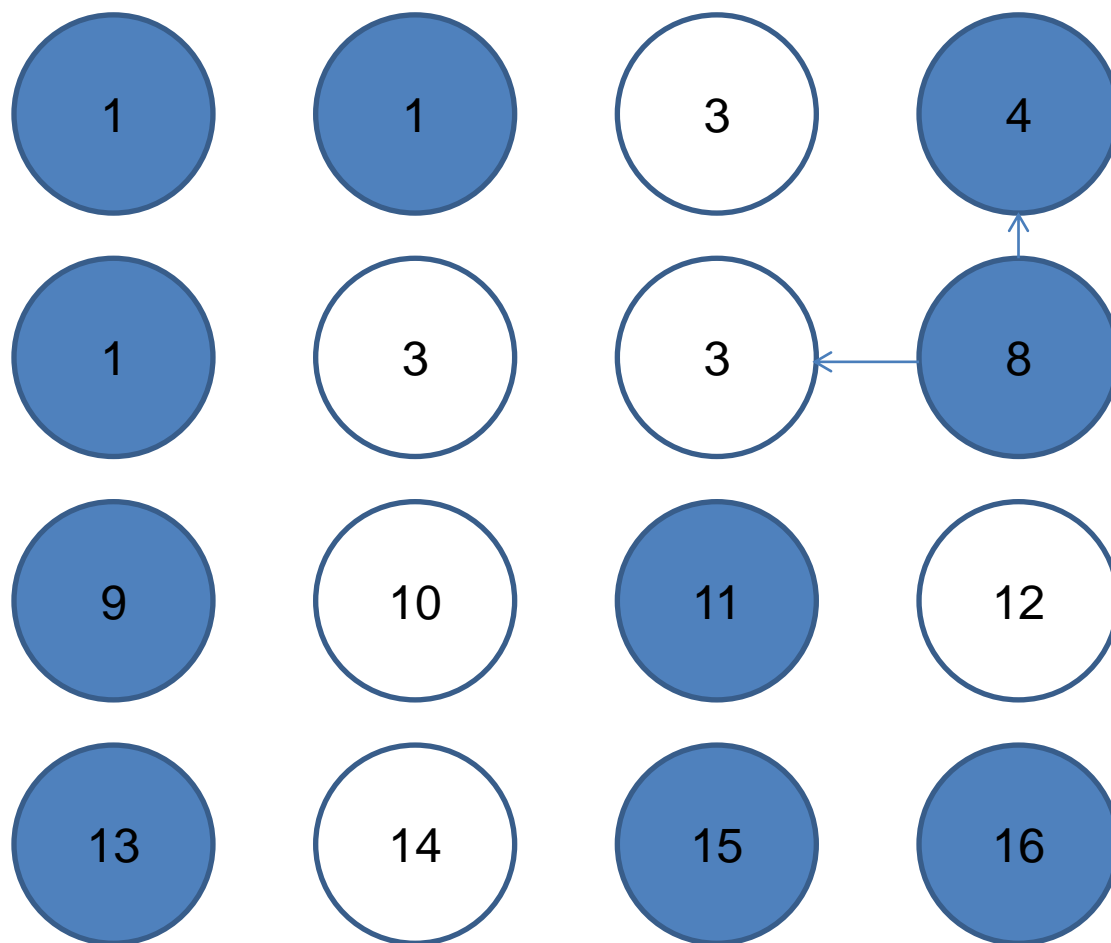


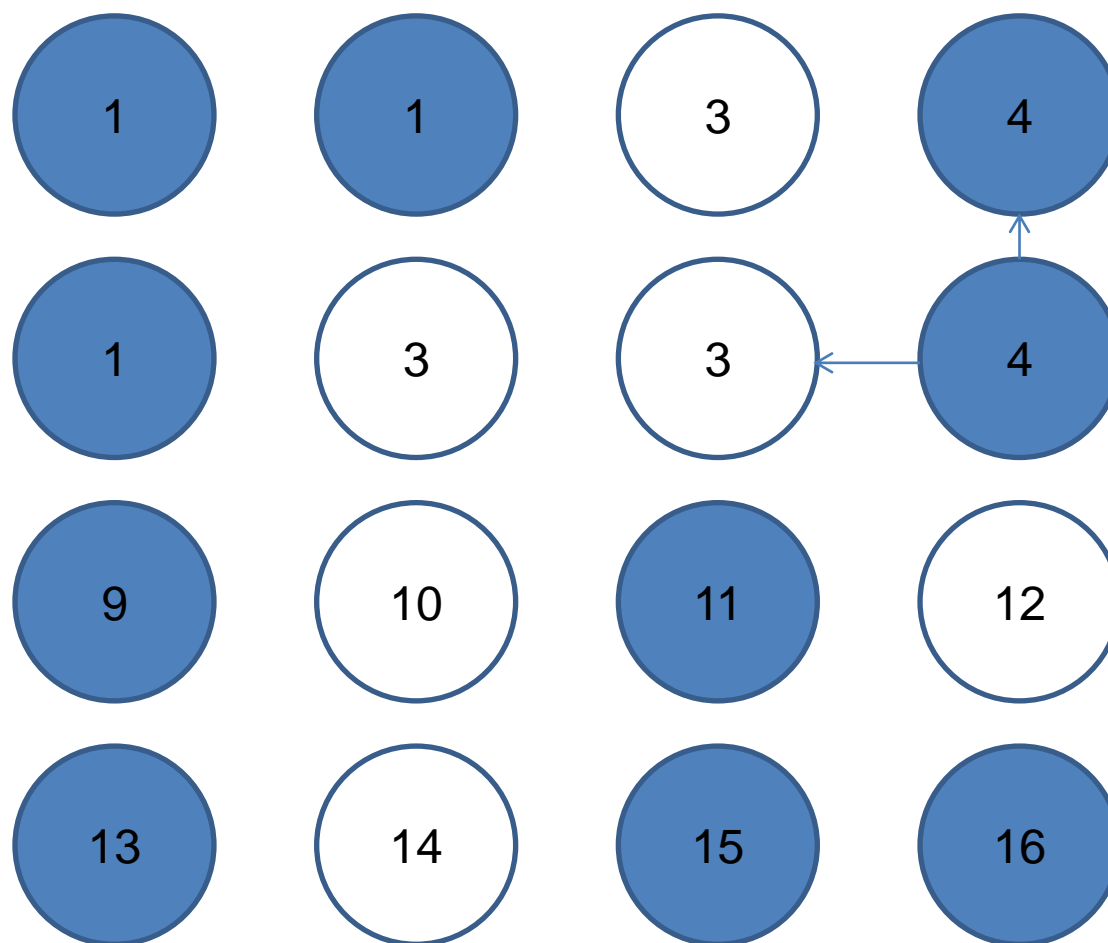


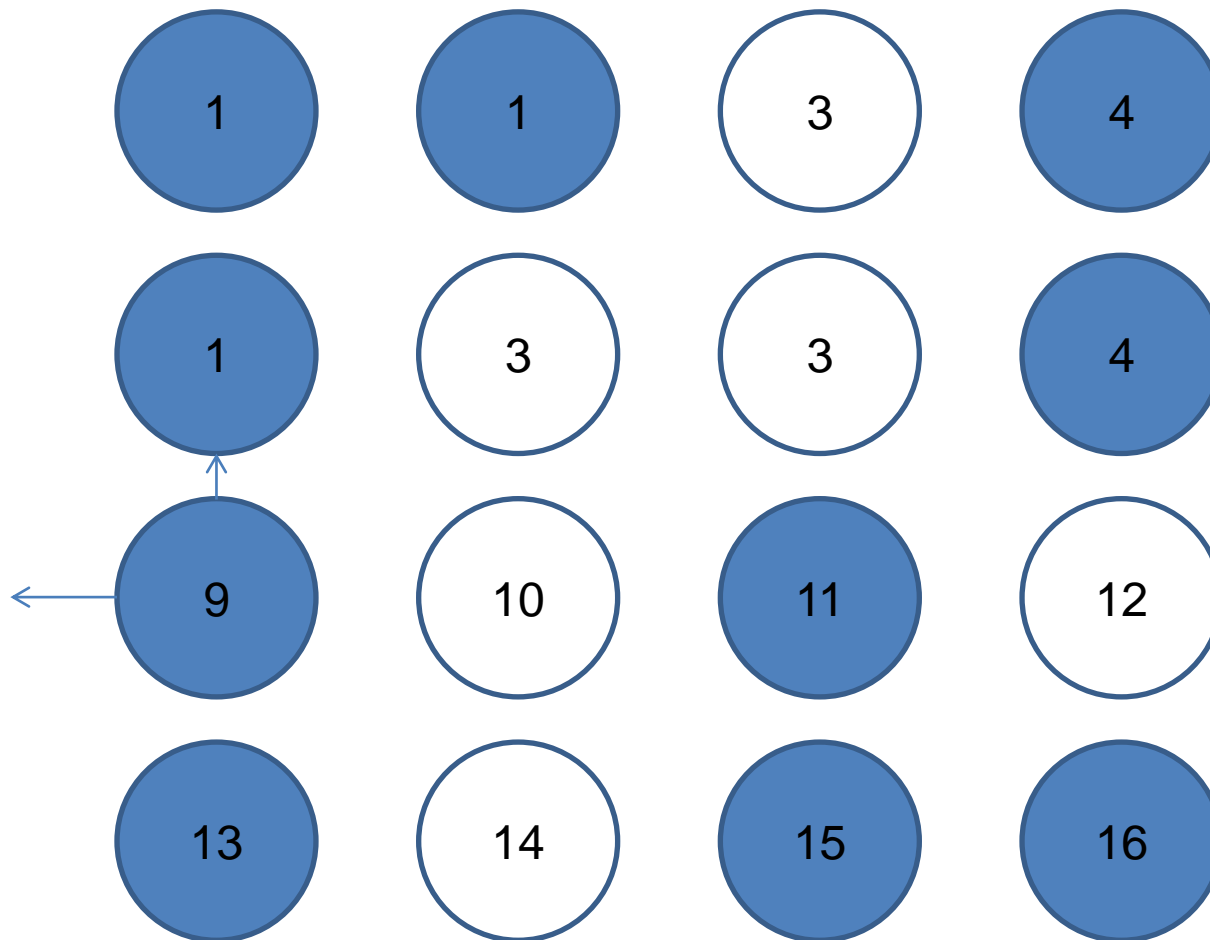


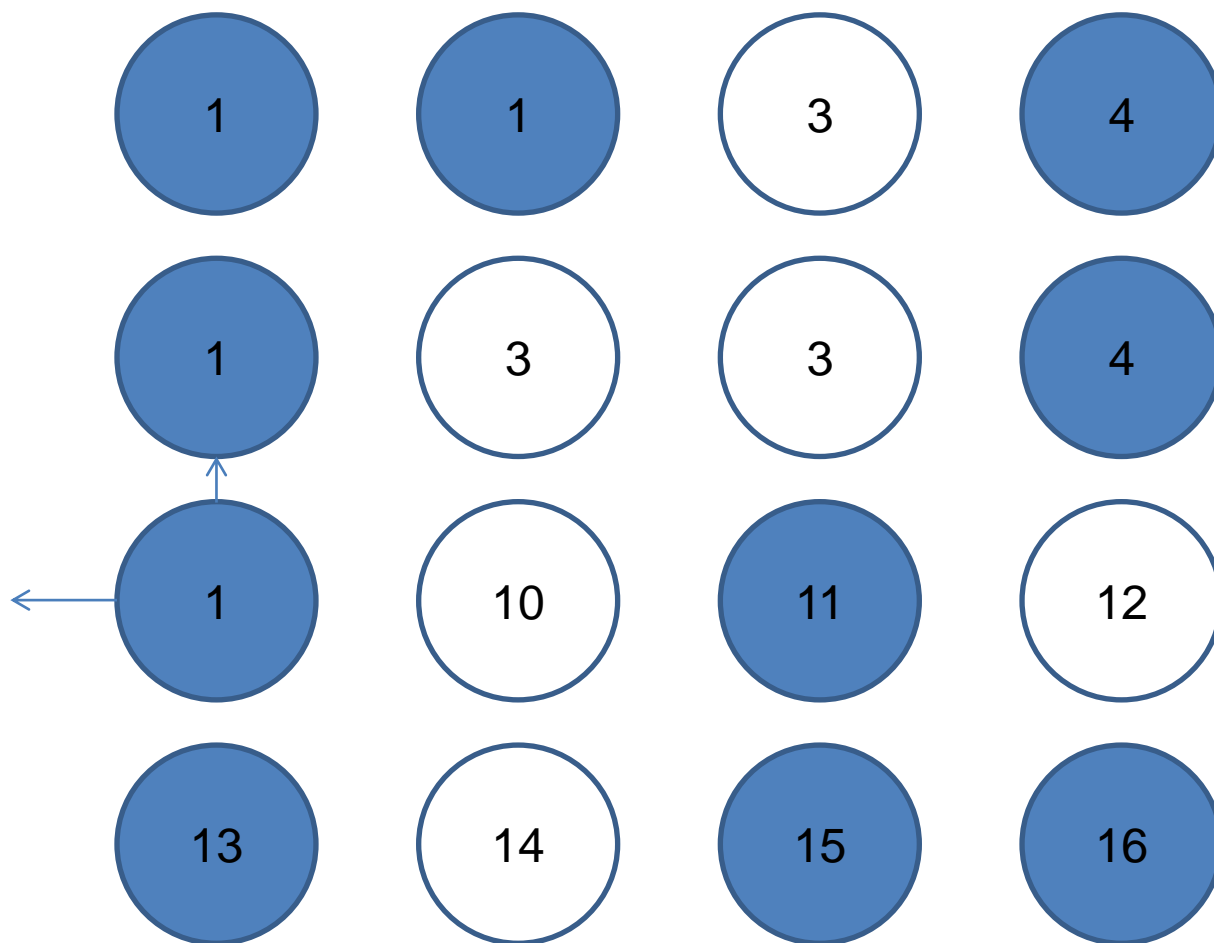


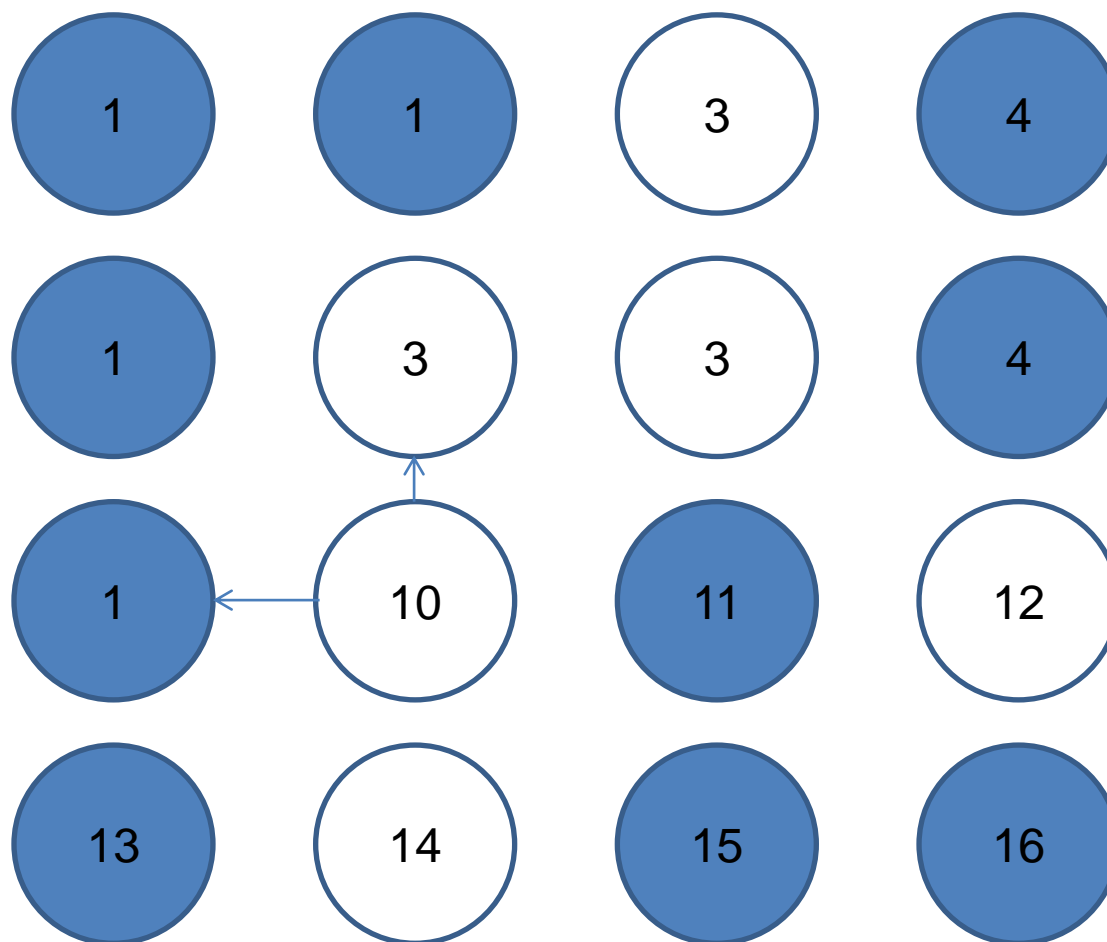


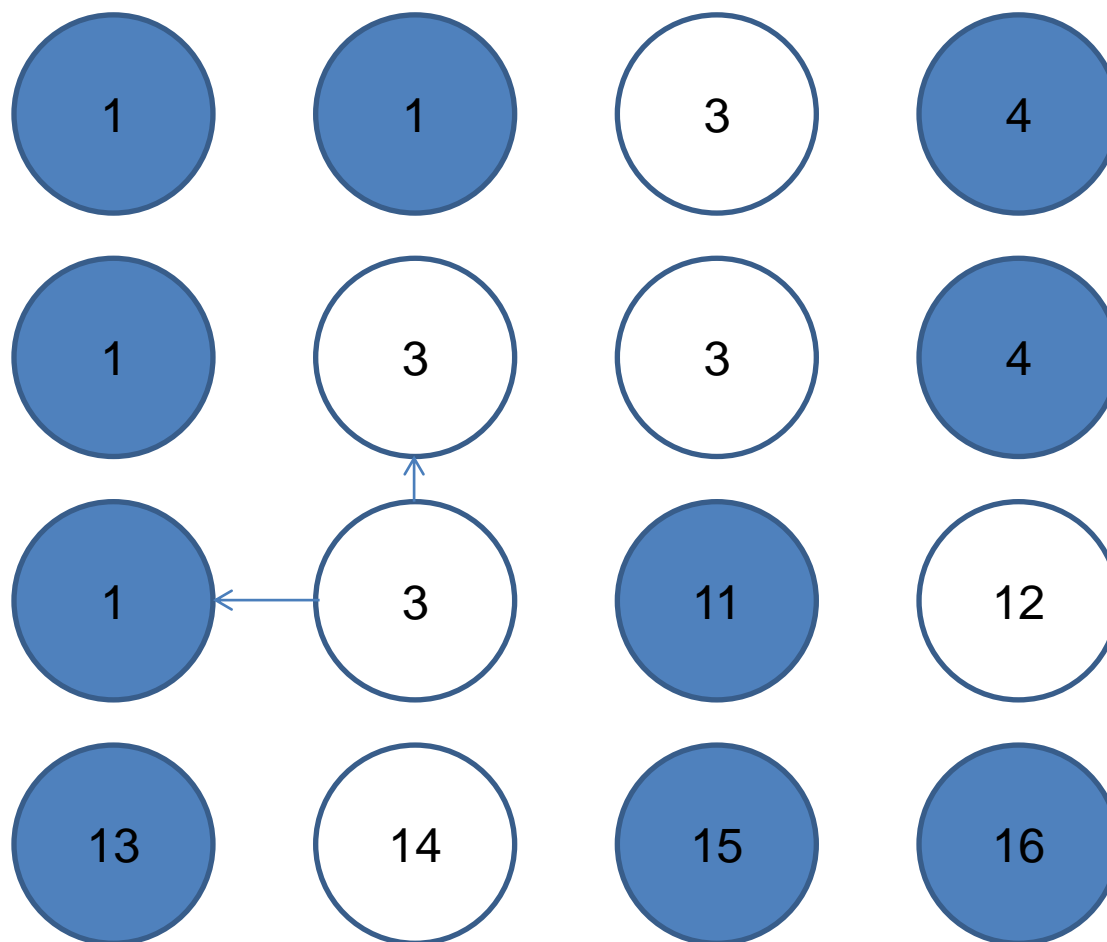


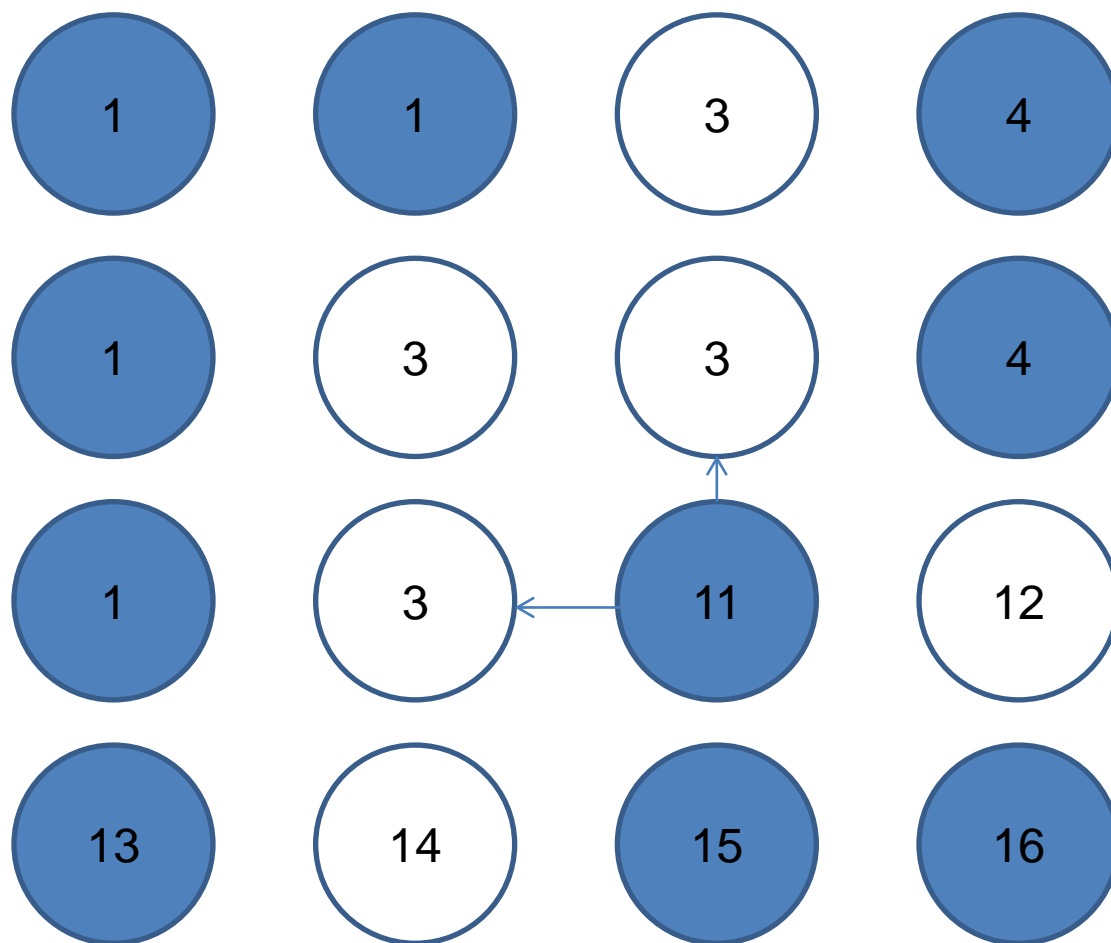


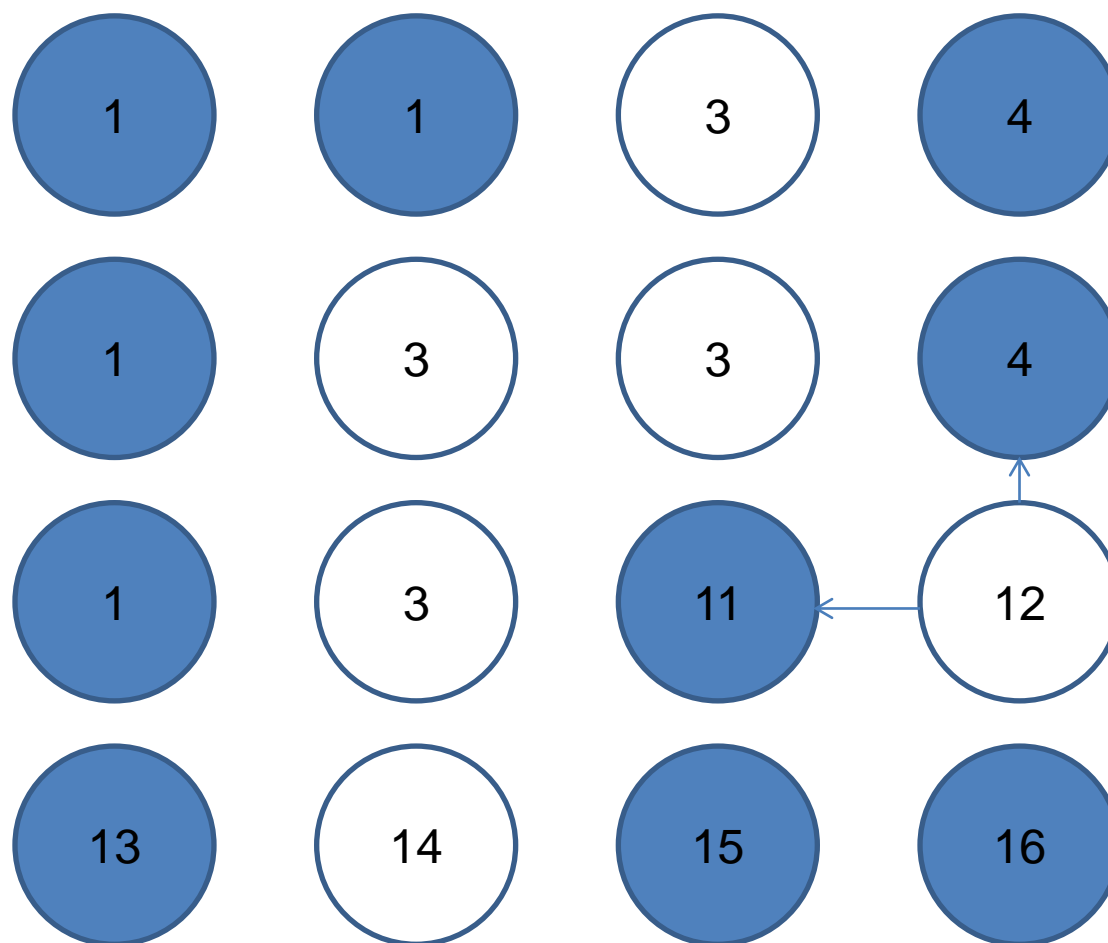


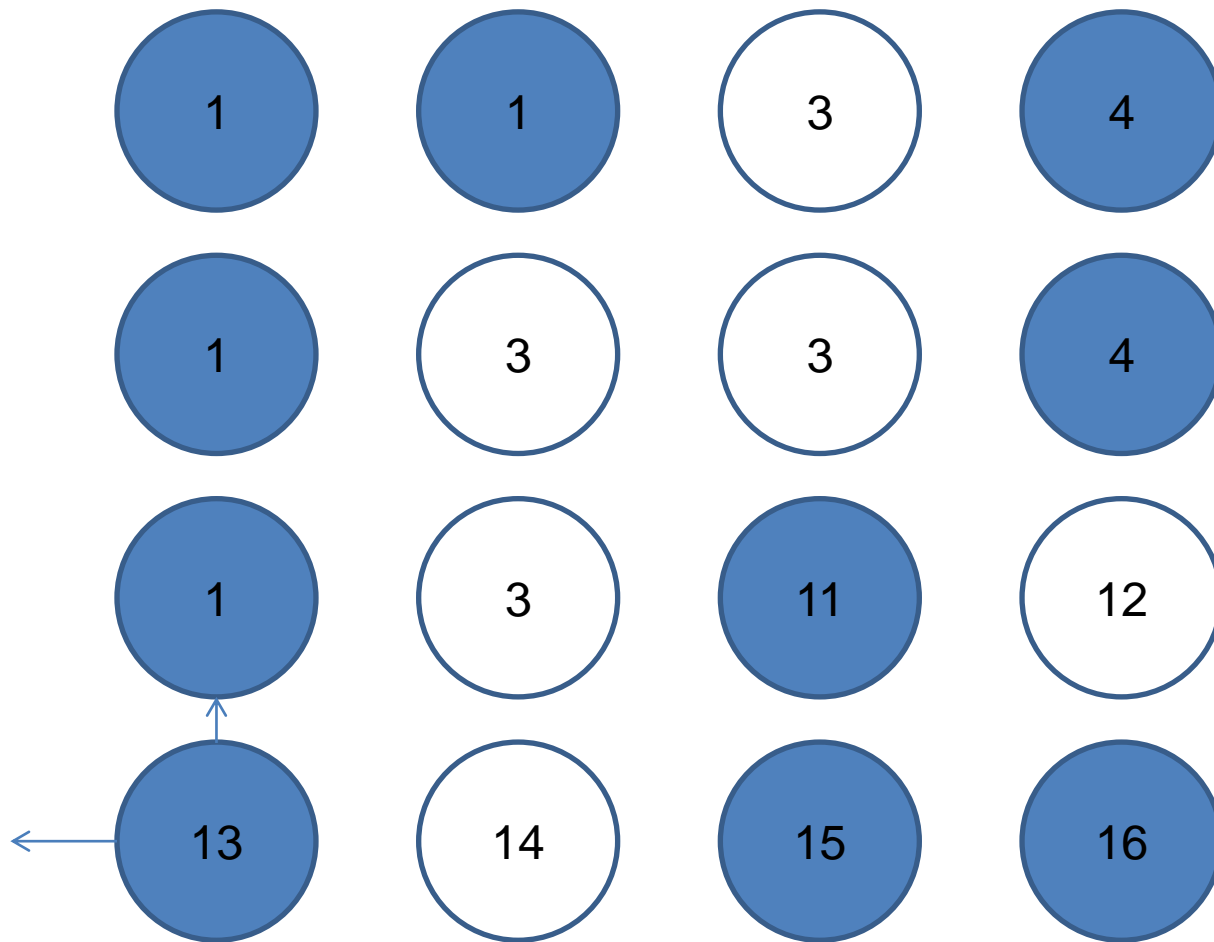


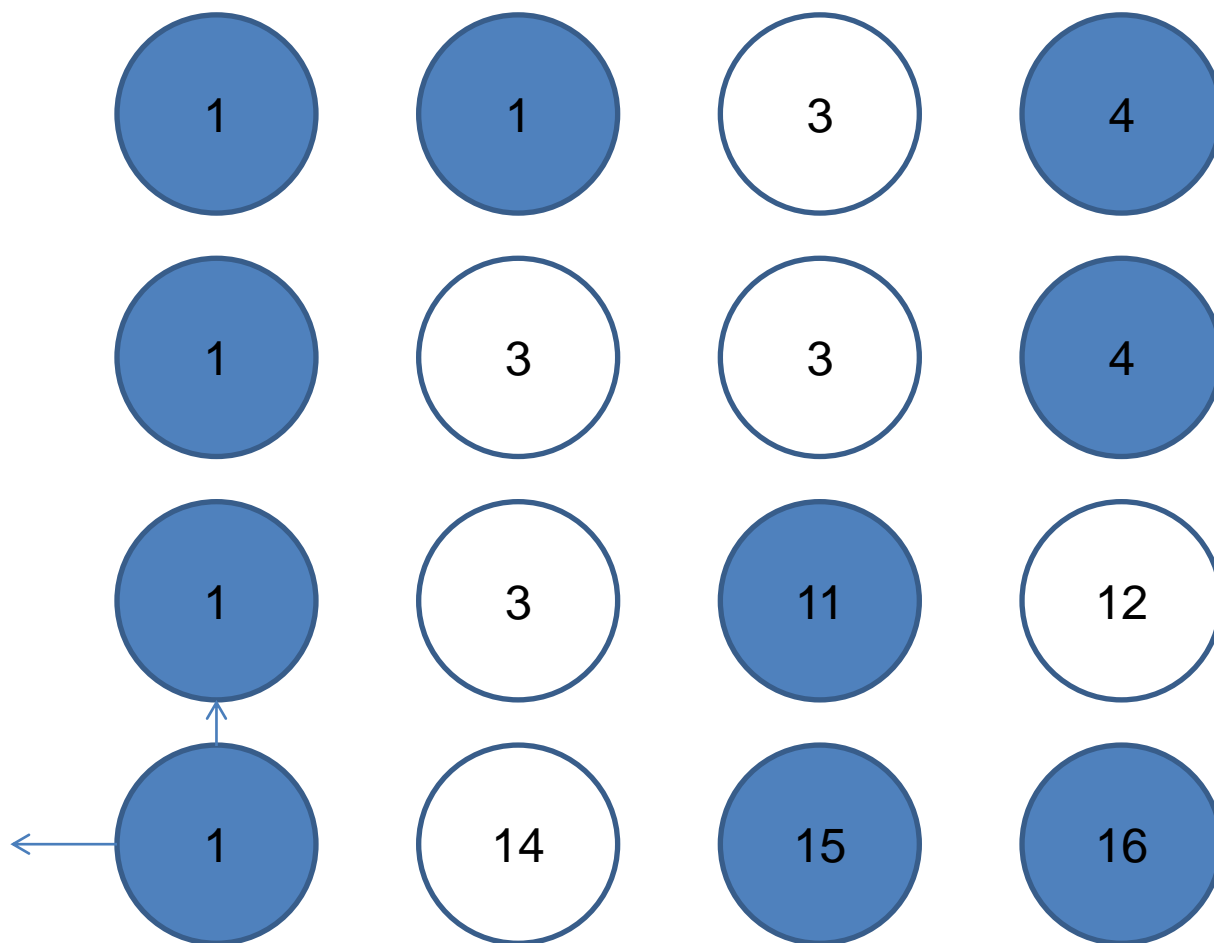


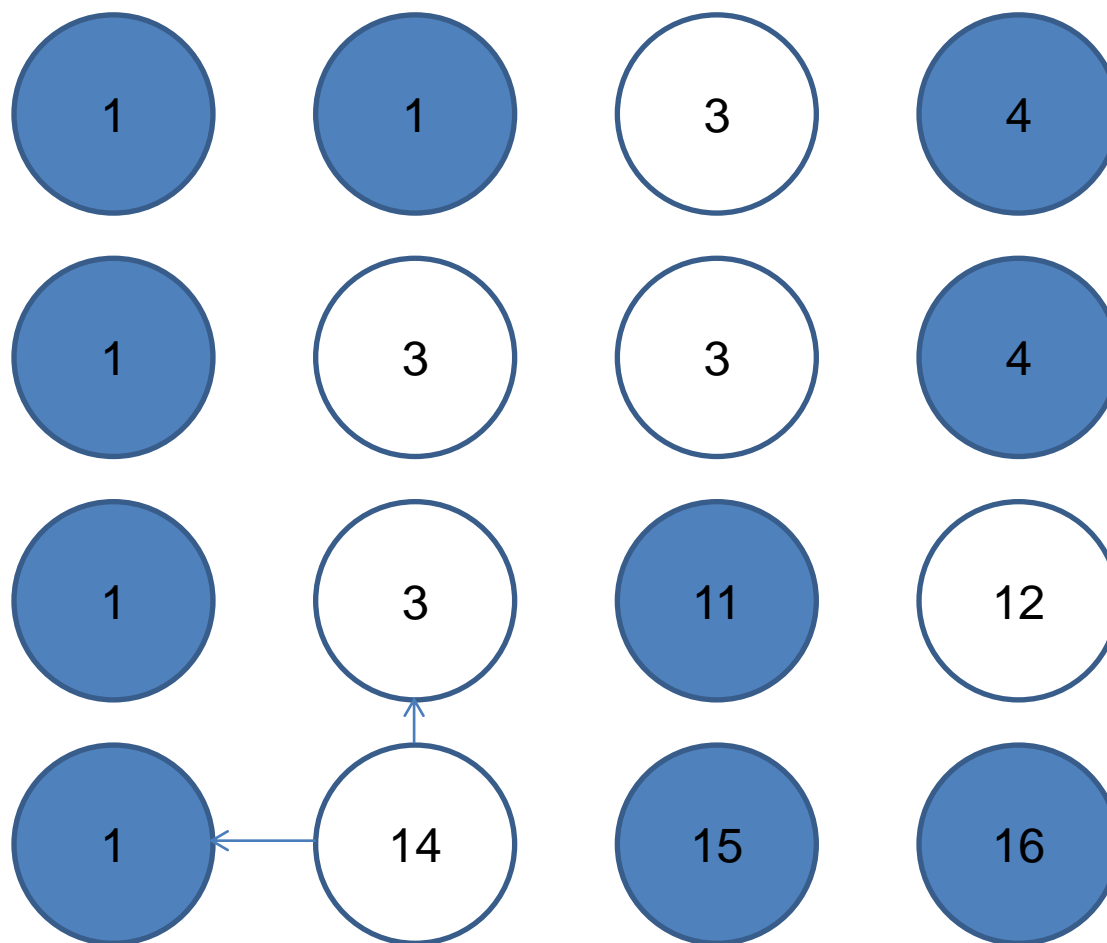


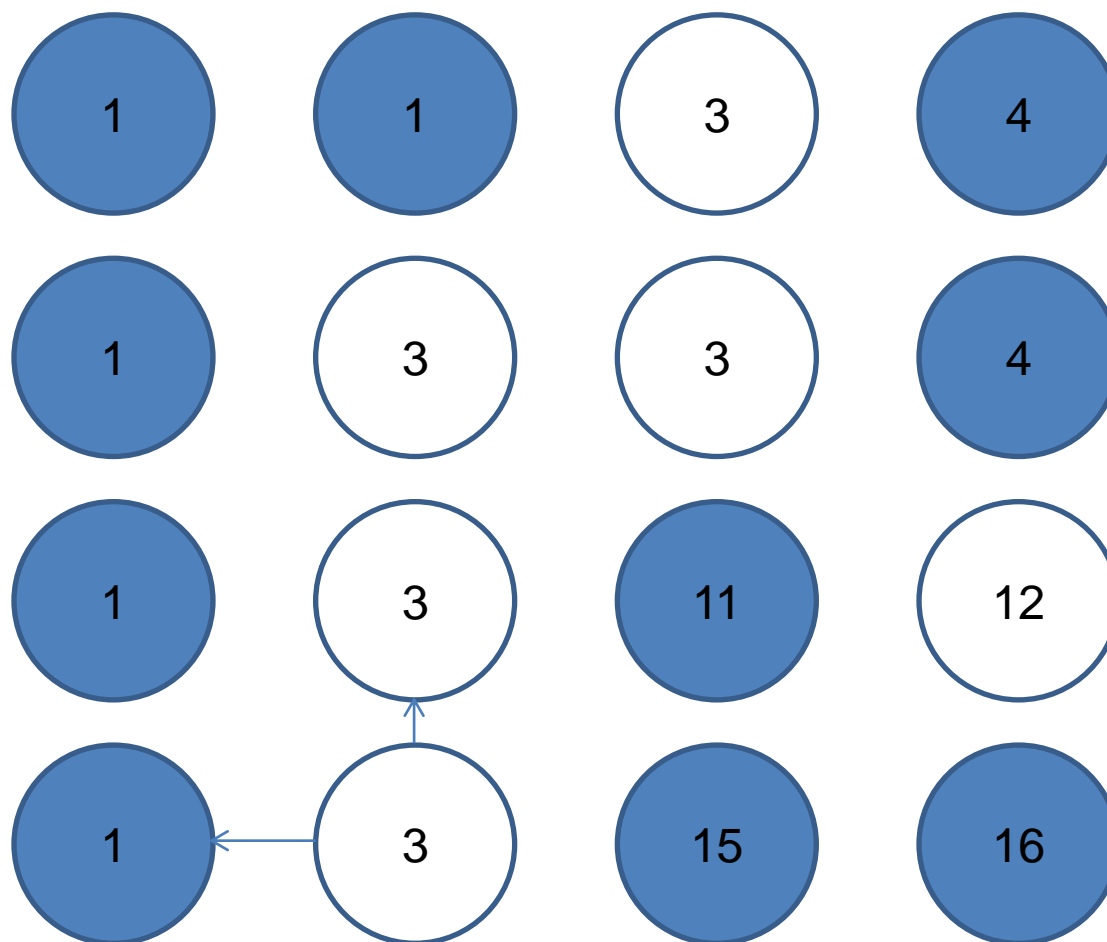


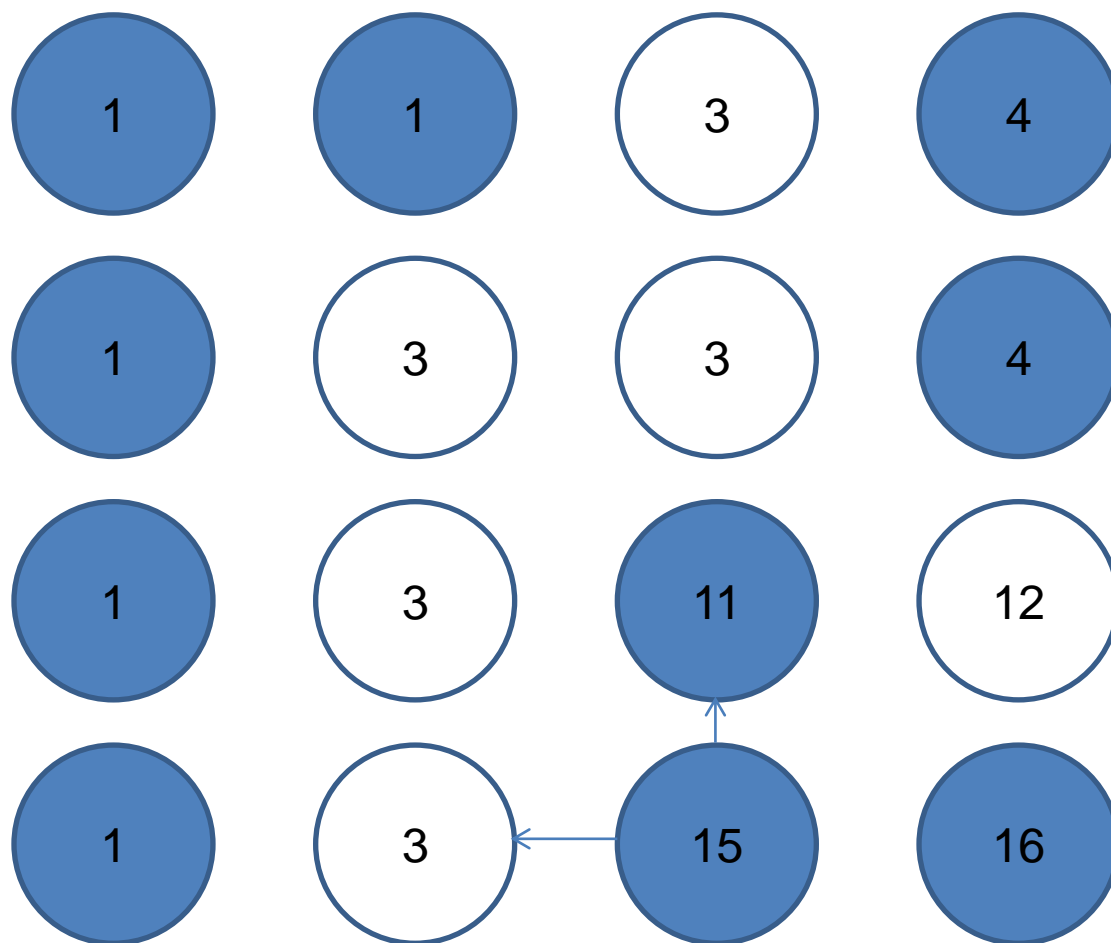


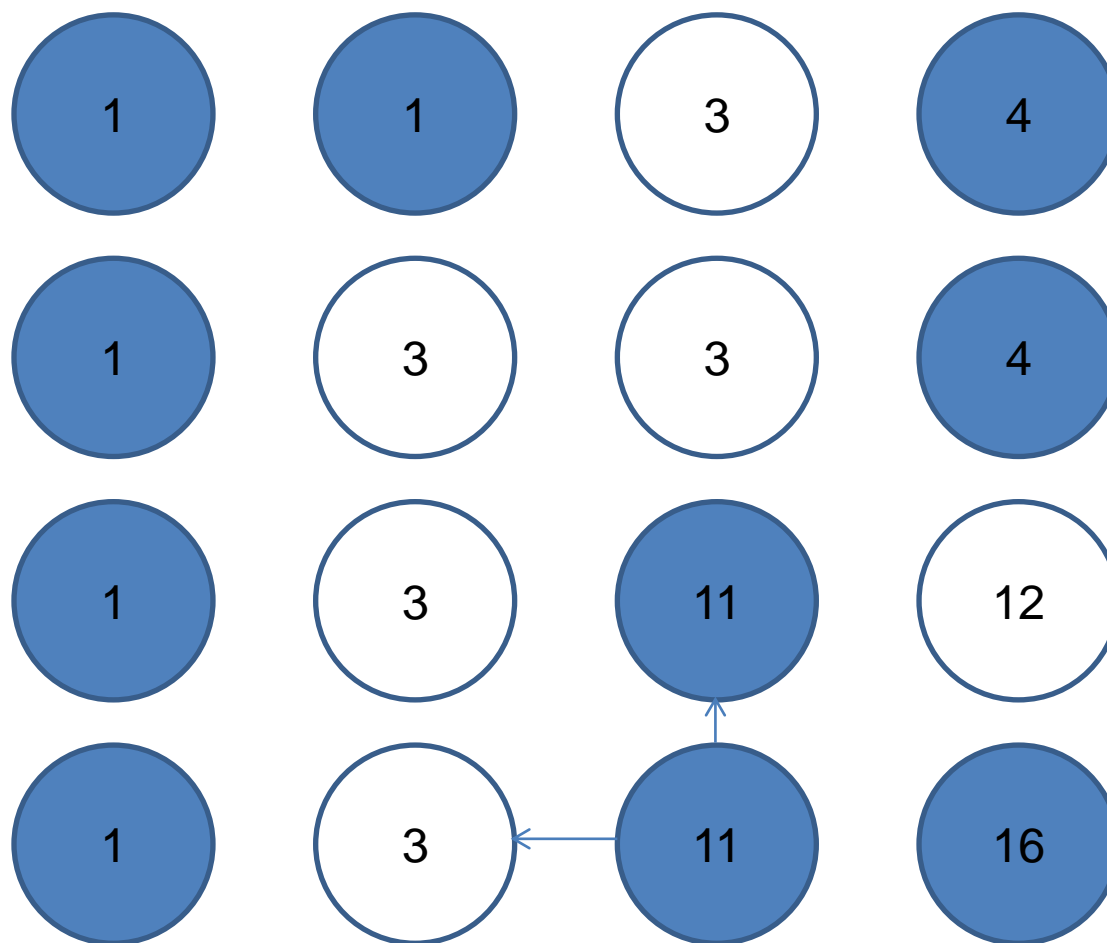


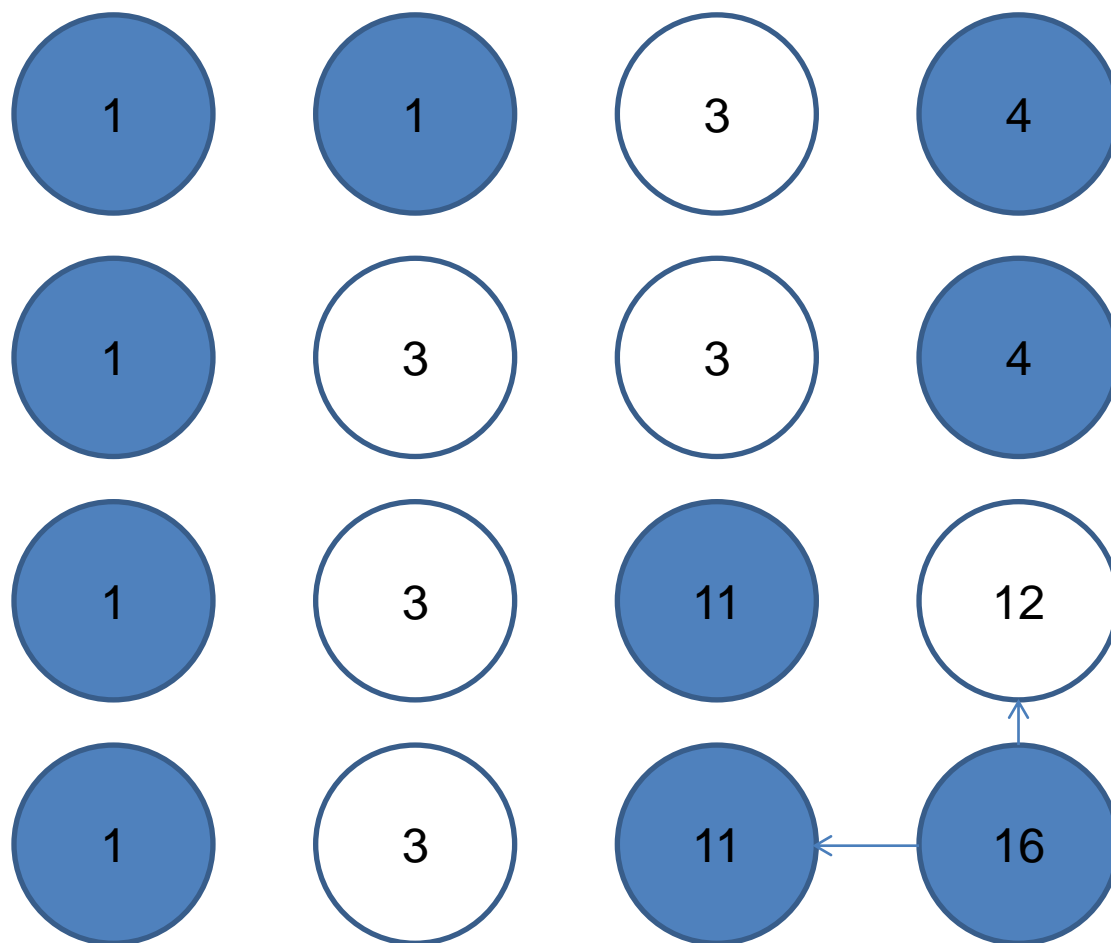


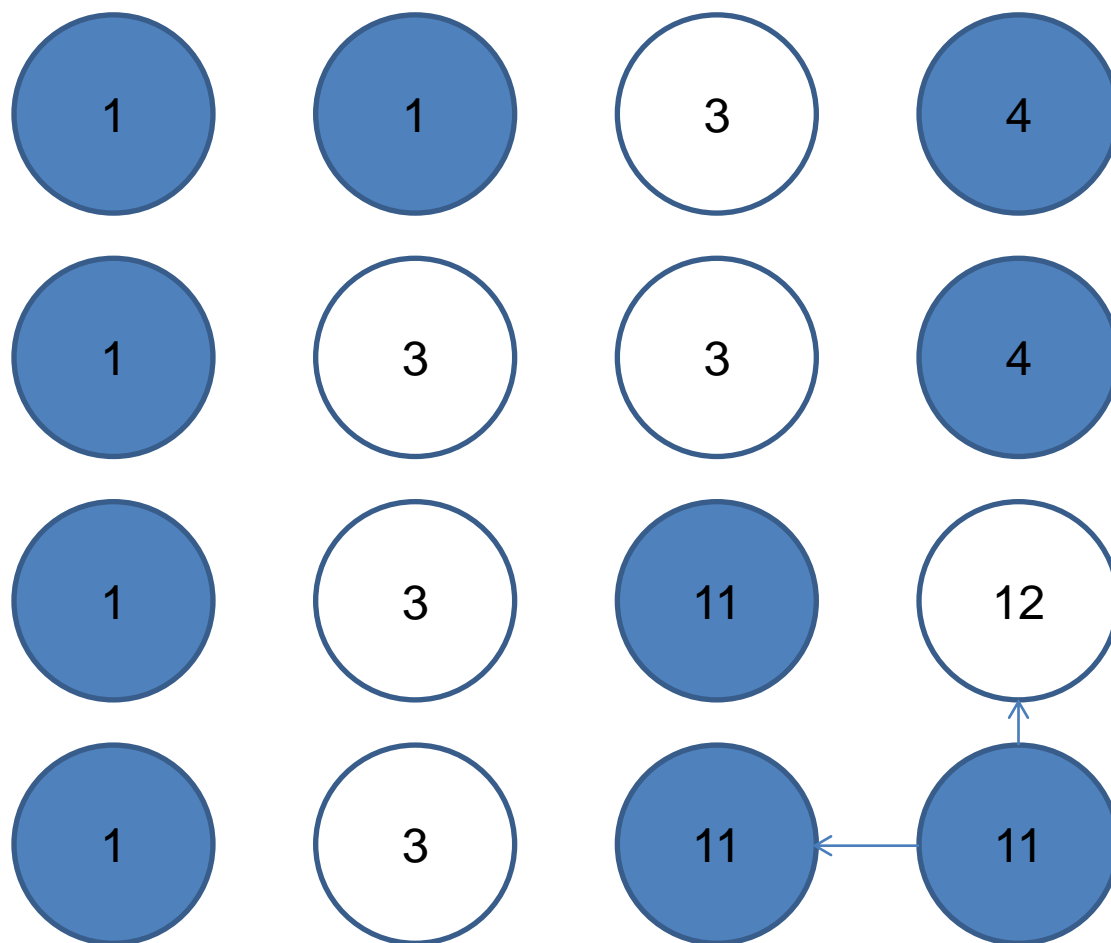


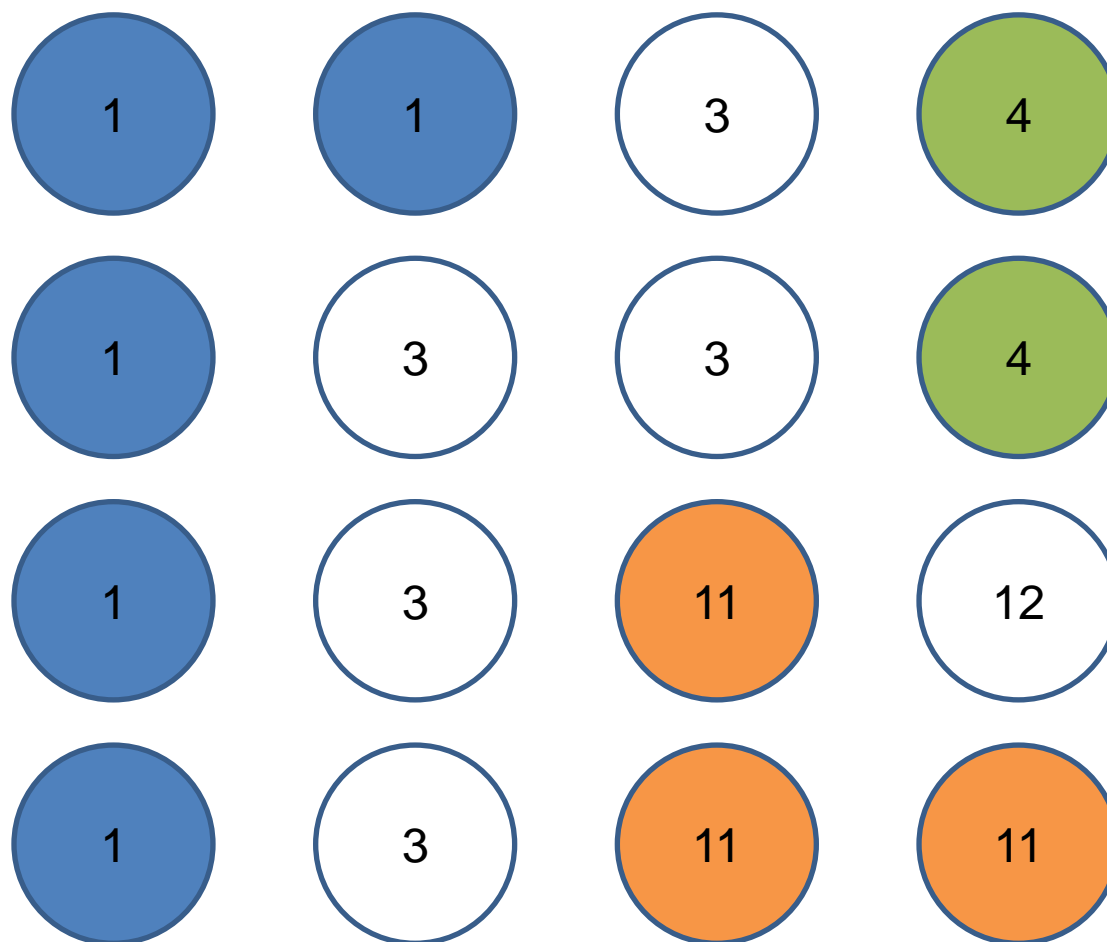




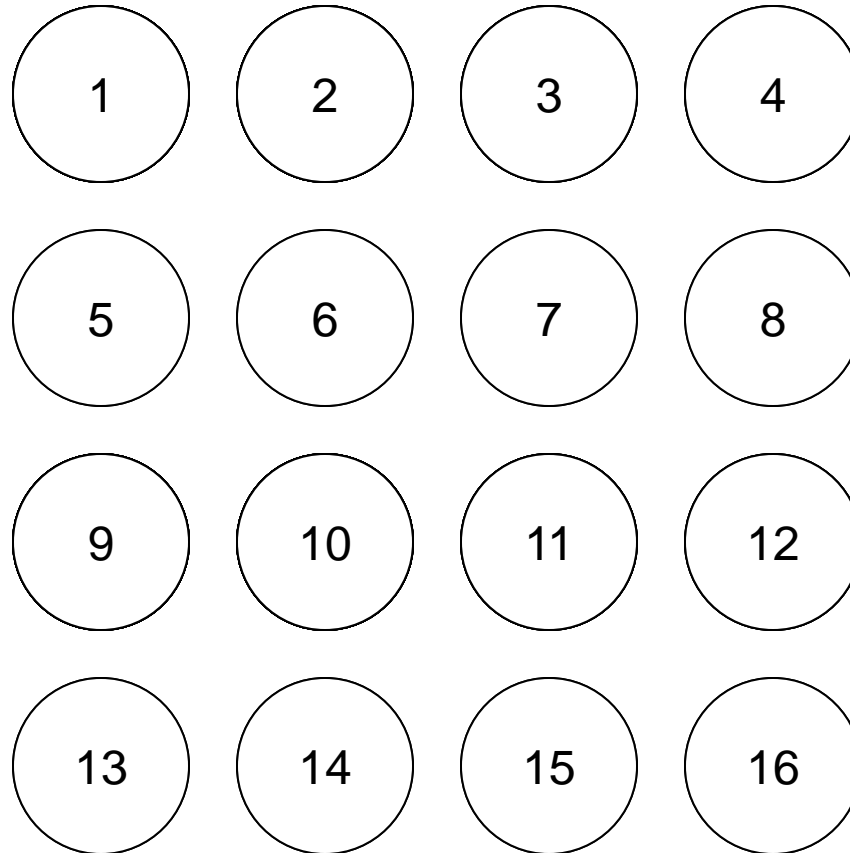


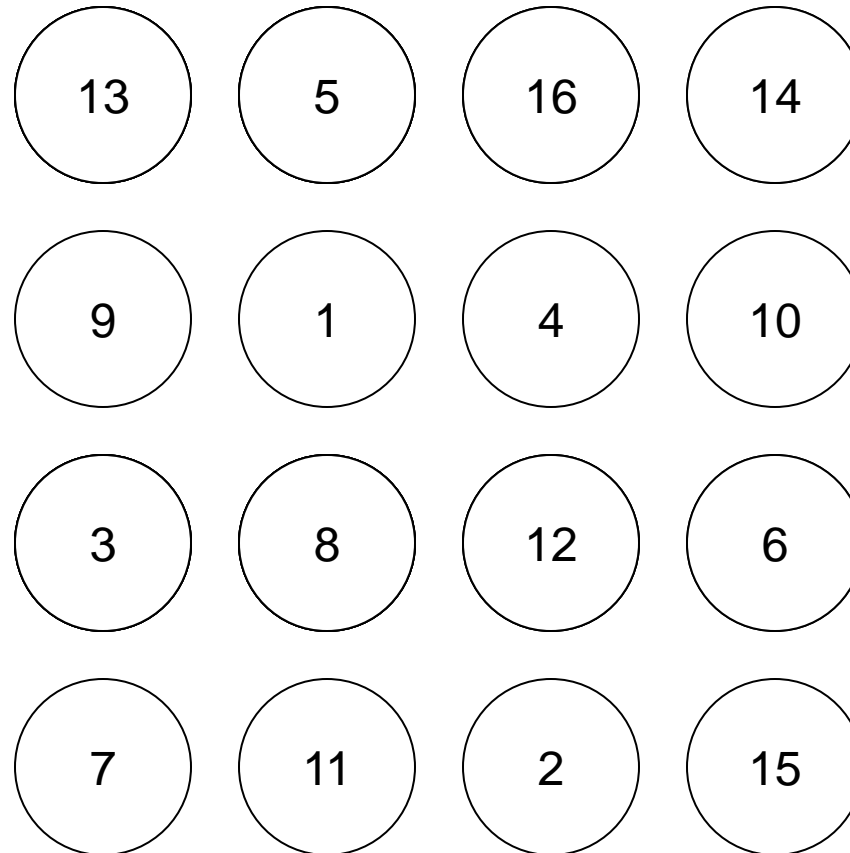






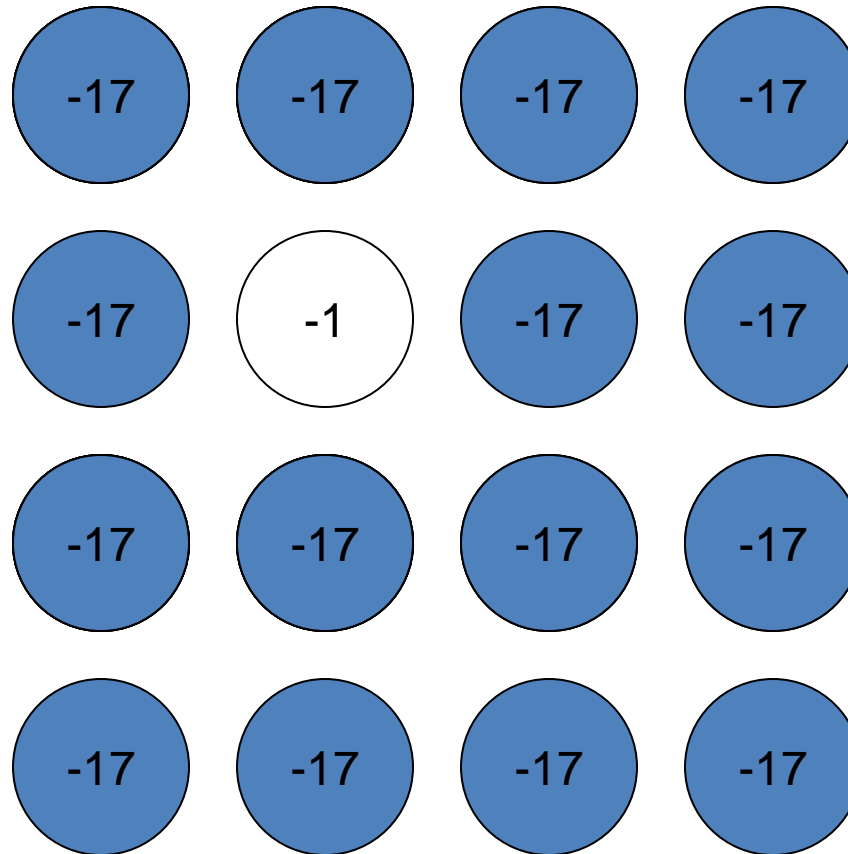
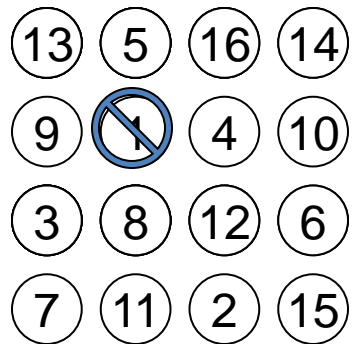
Newman-Ziff (NZ)

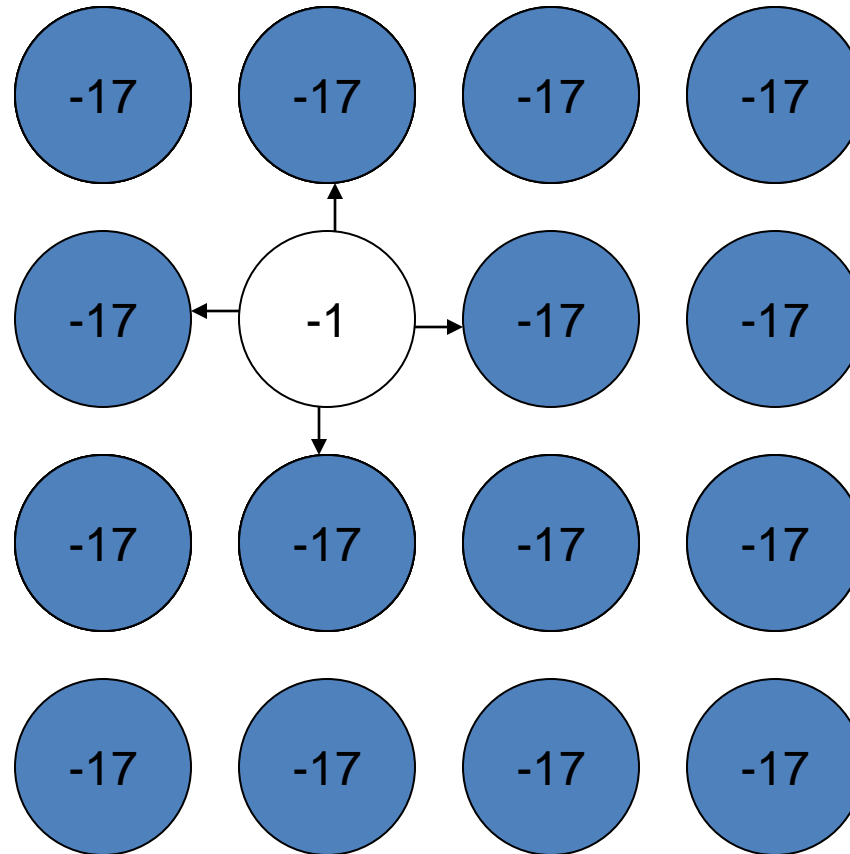
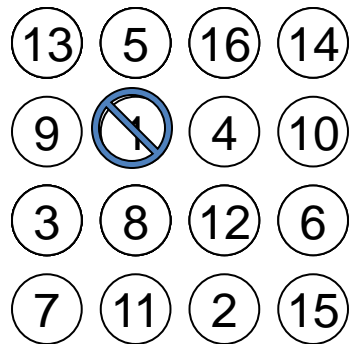


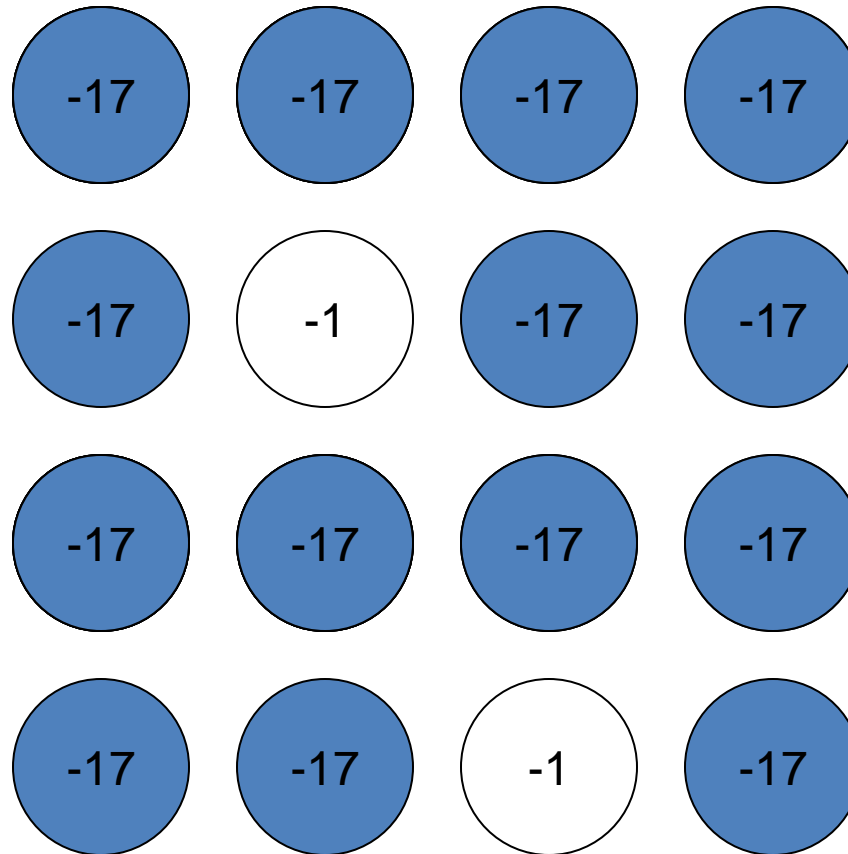
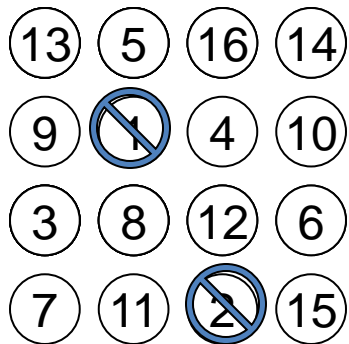


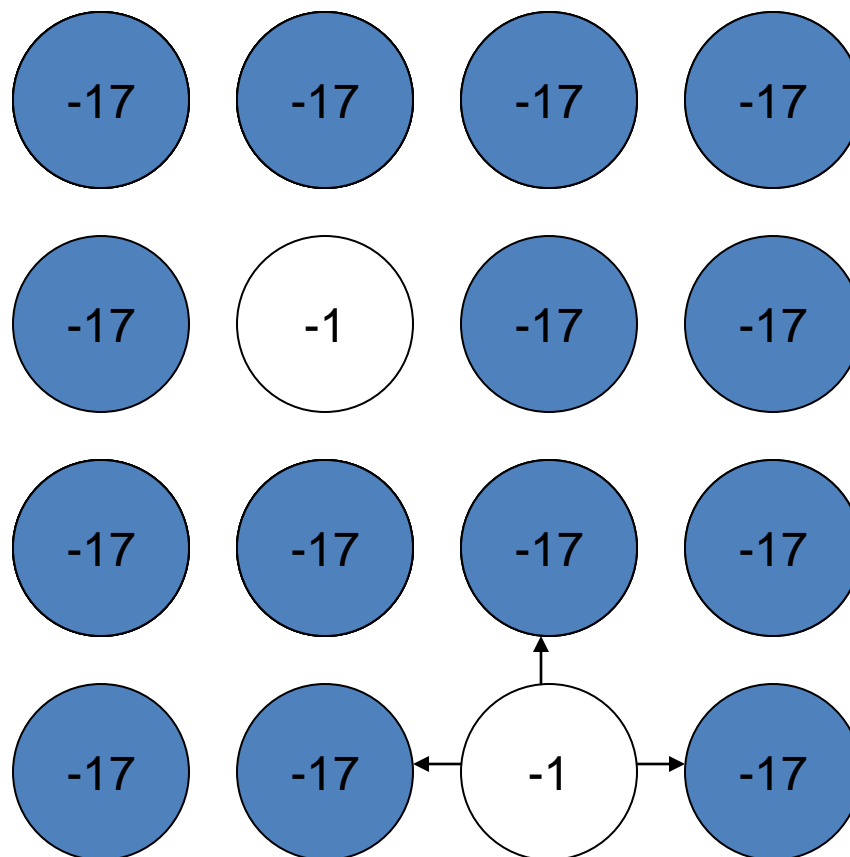
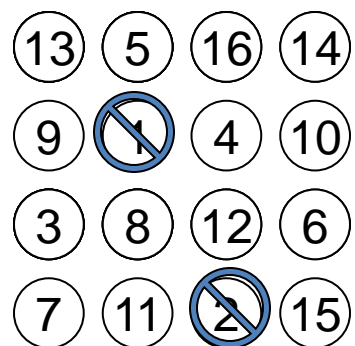
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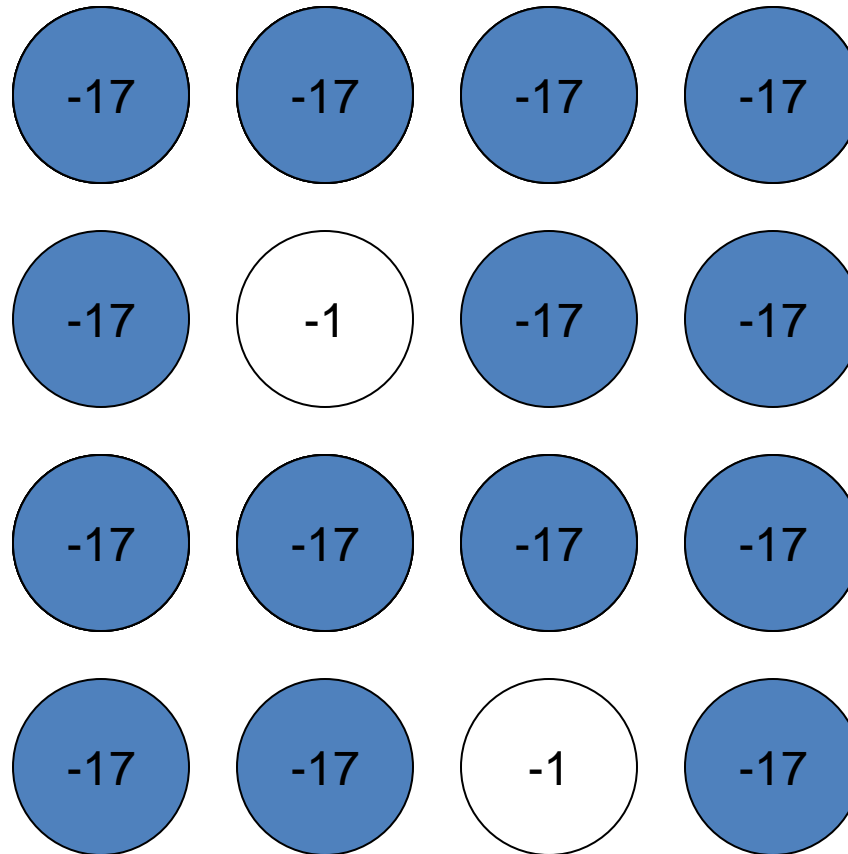
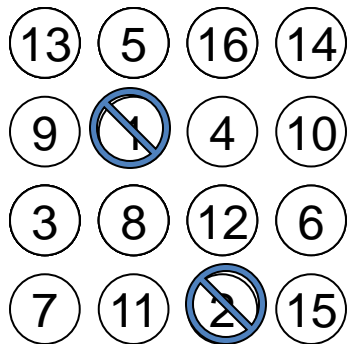
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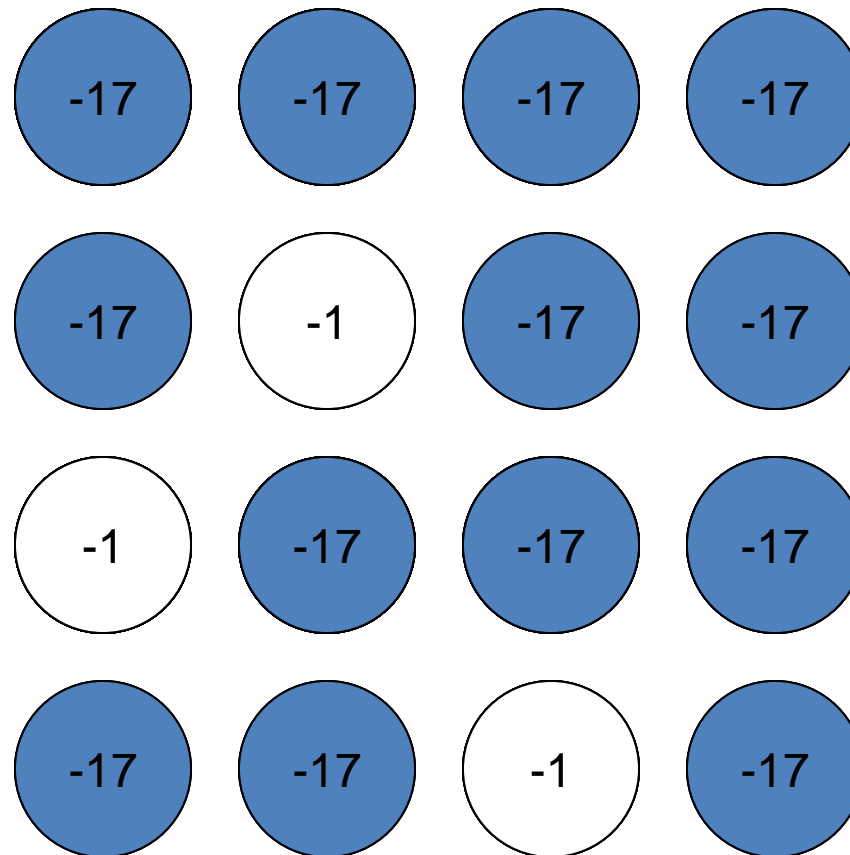
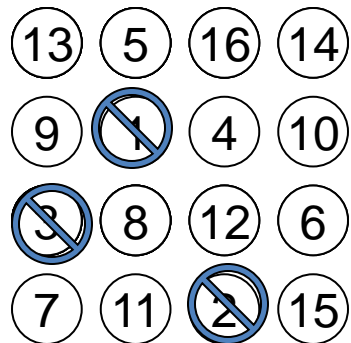


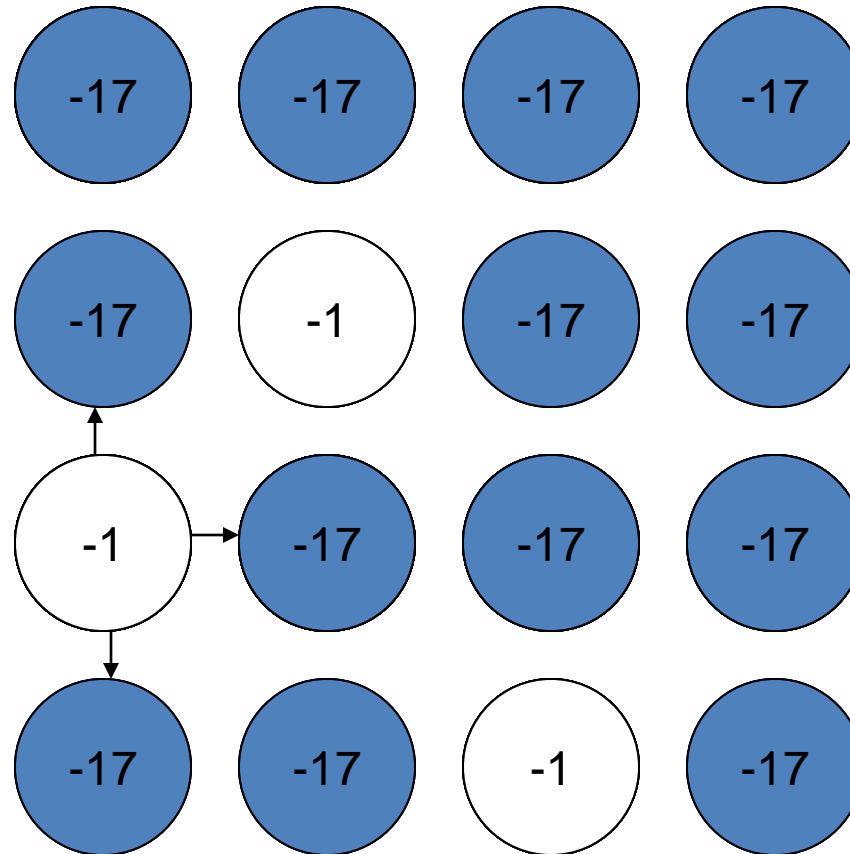
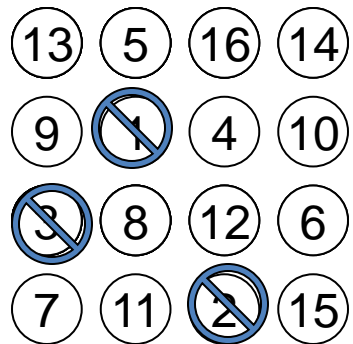


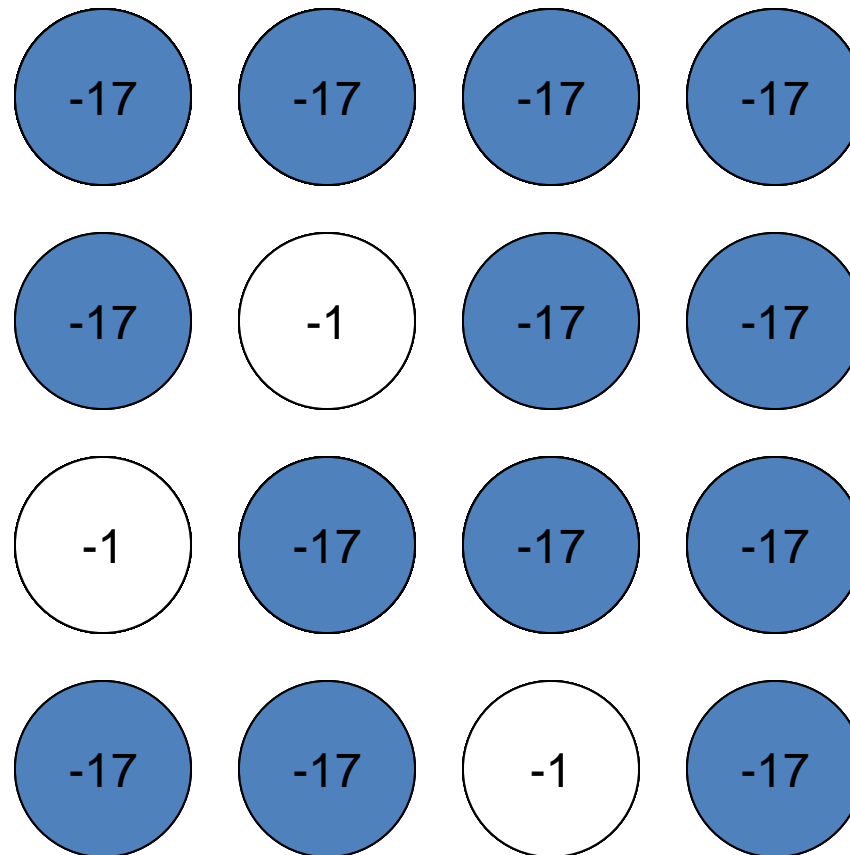
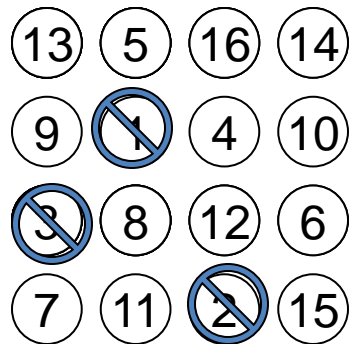


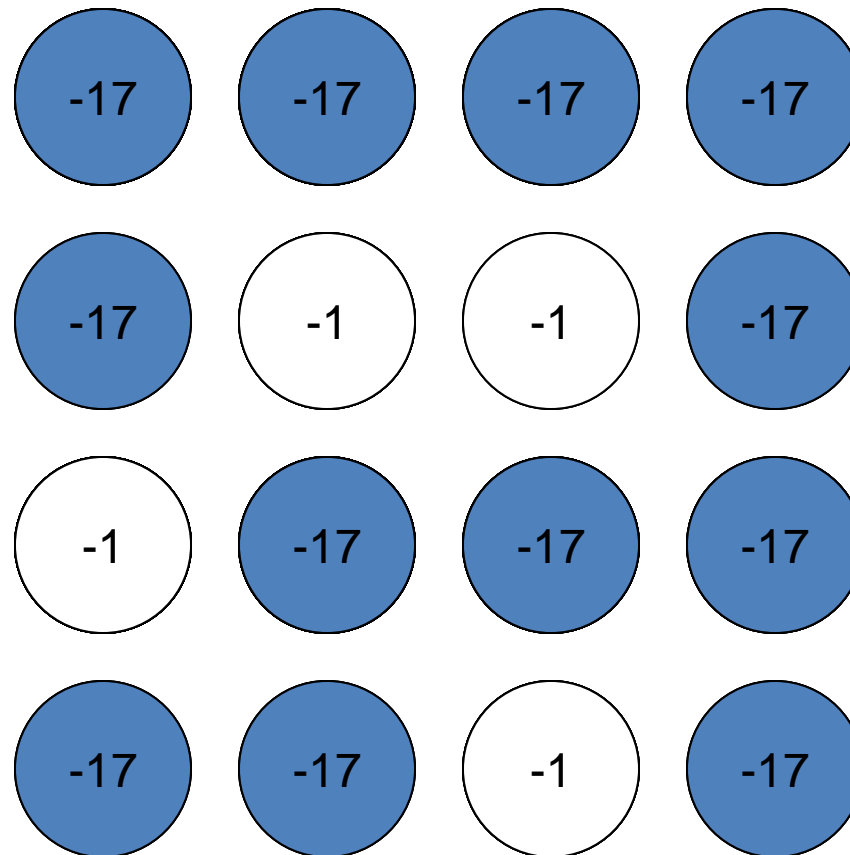
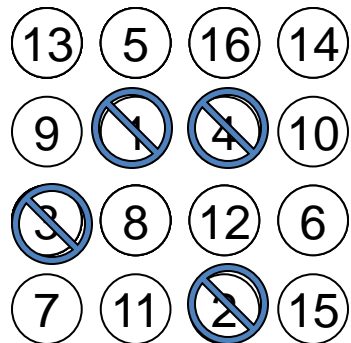


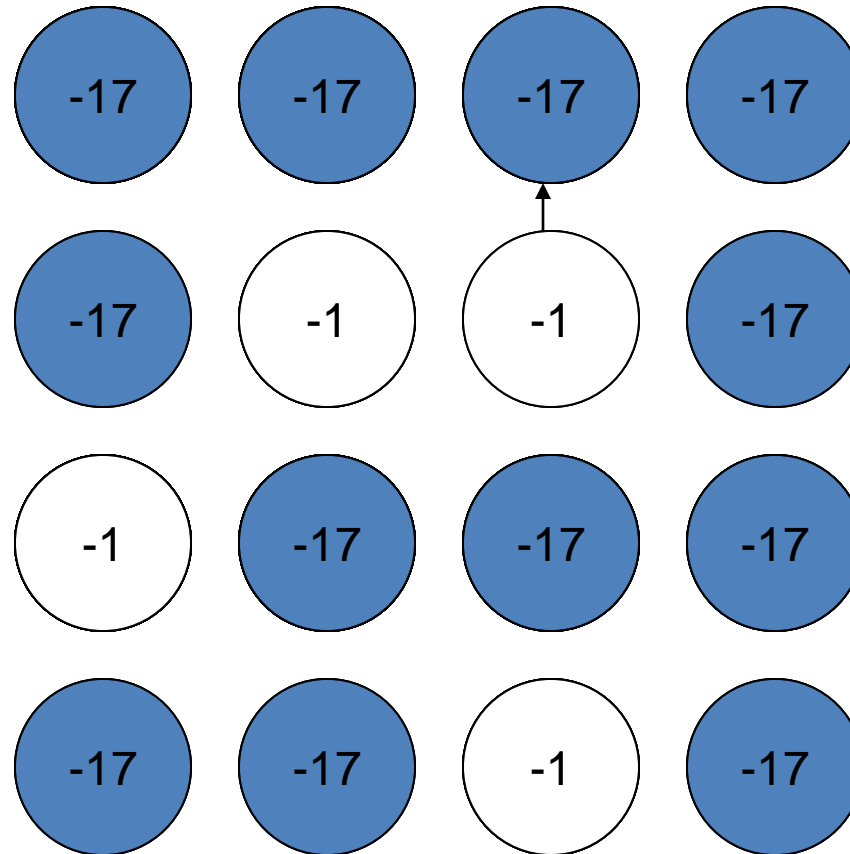
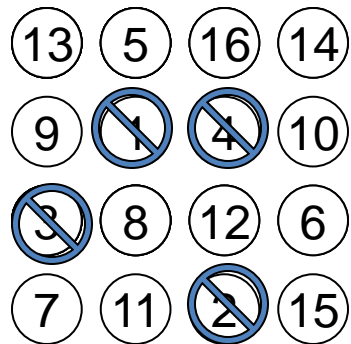


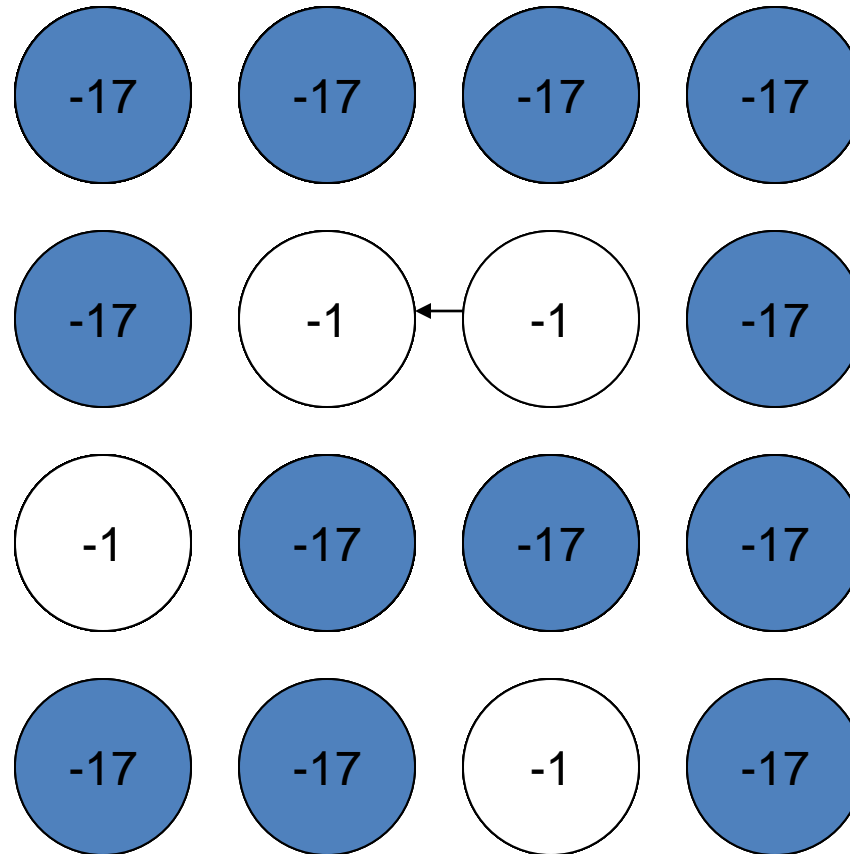
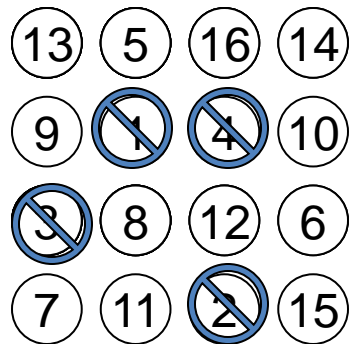


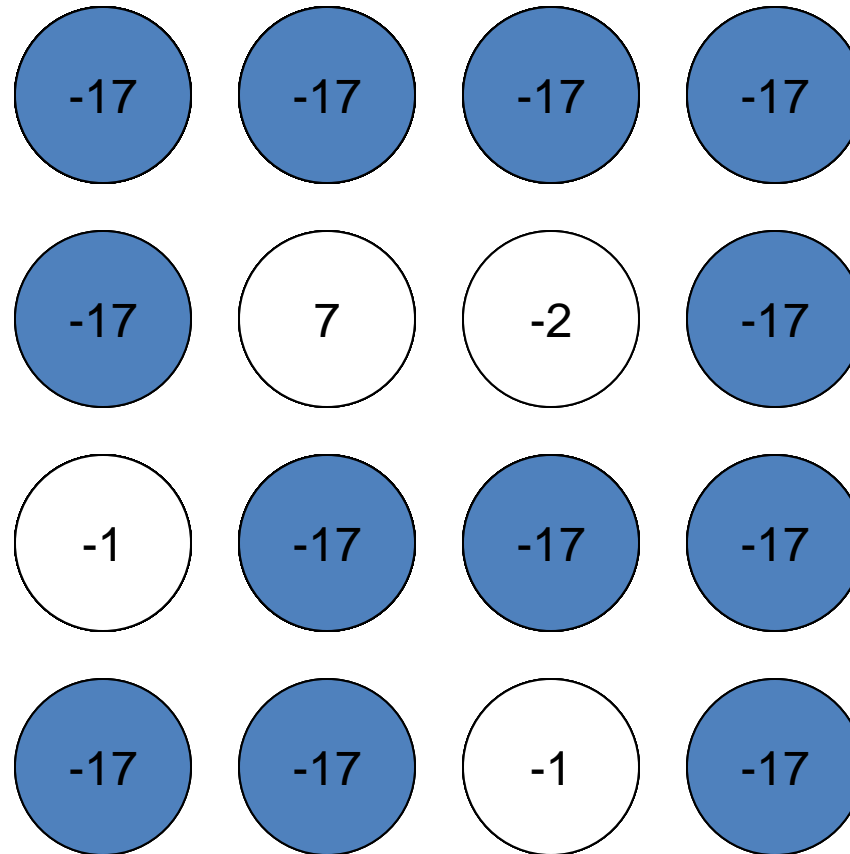
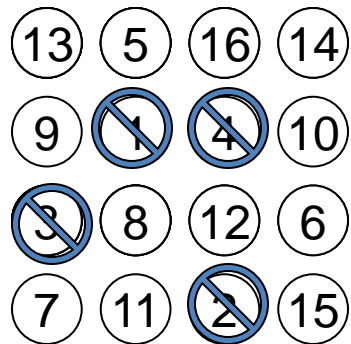


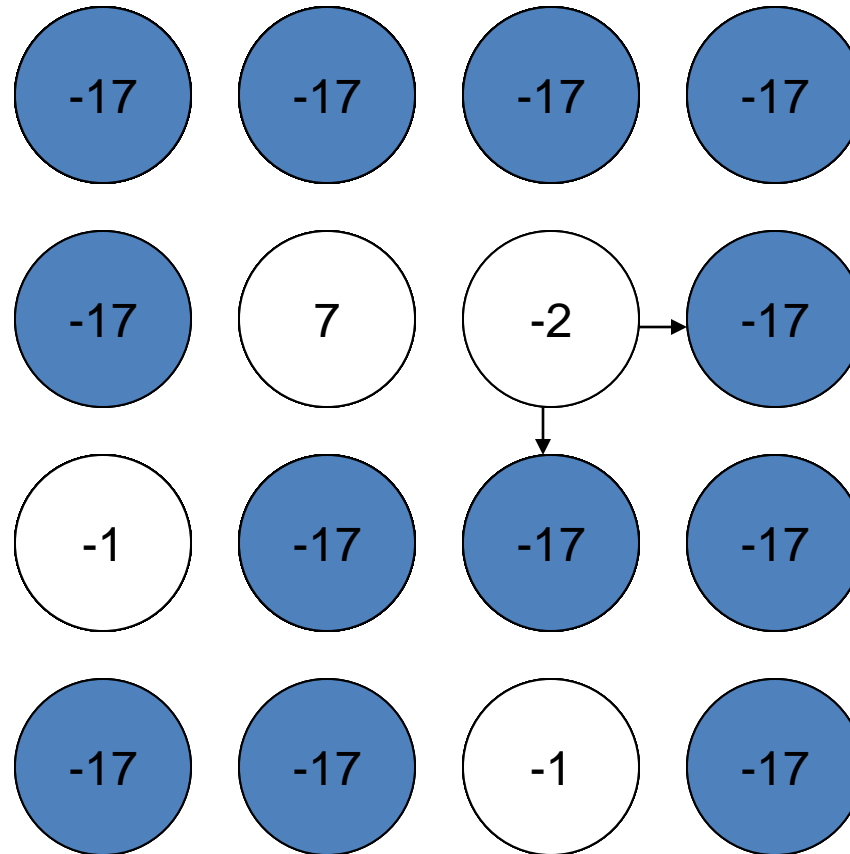
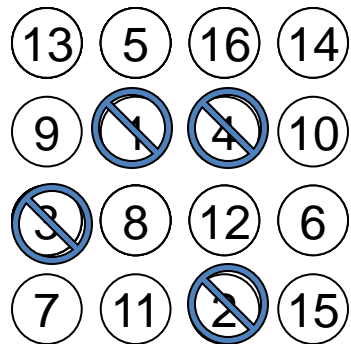


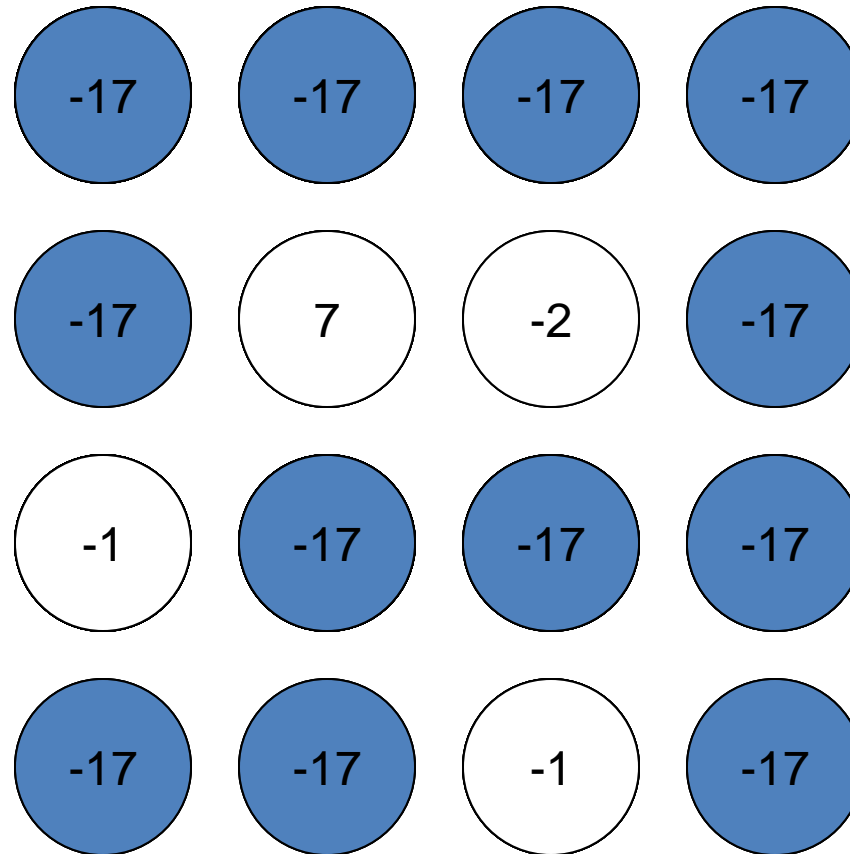
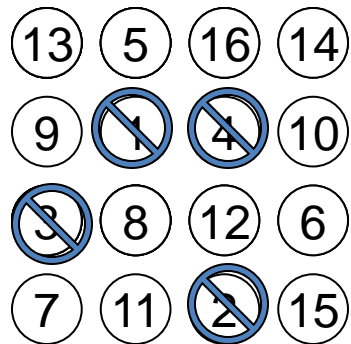


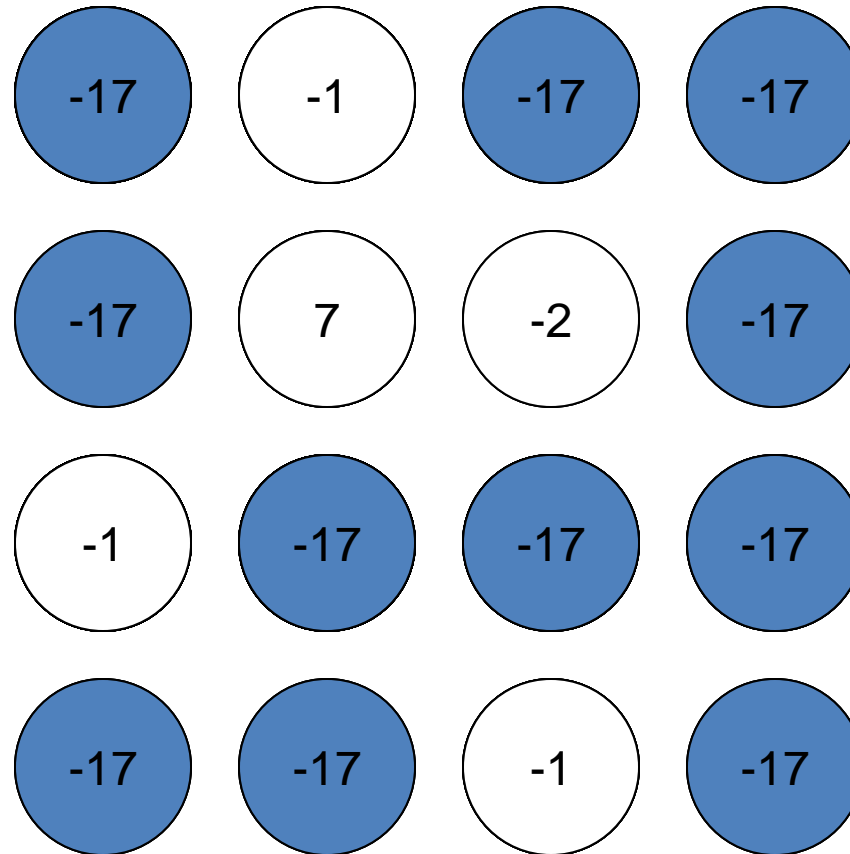
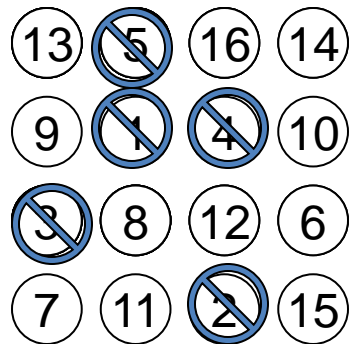


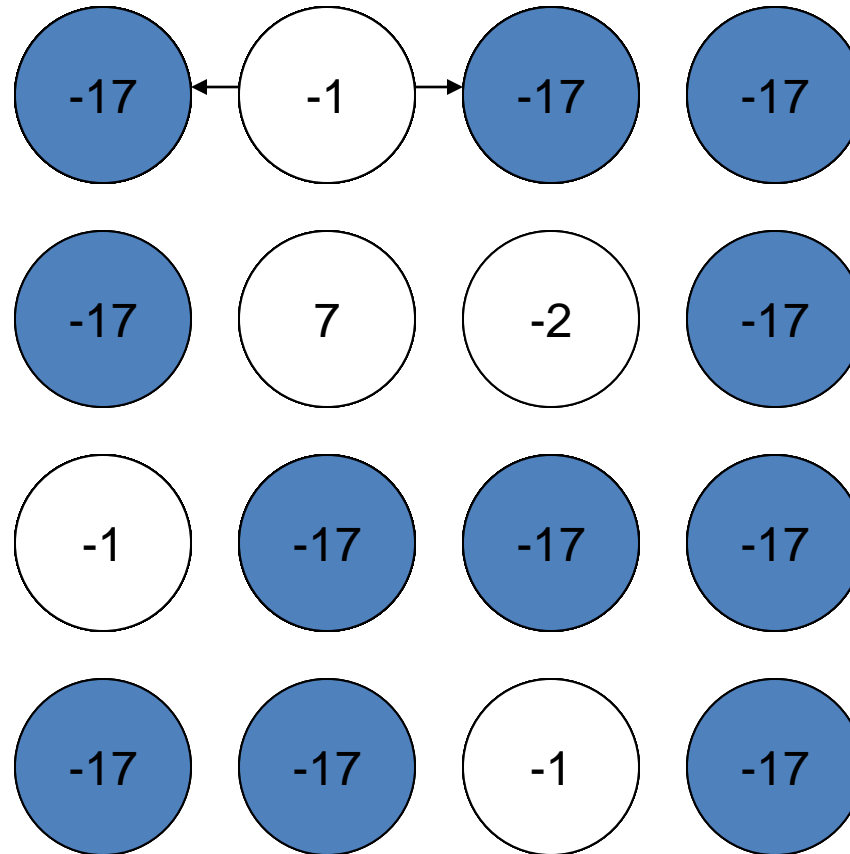
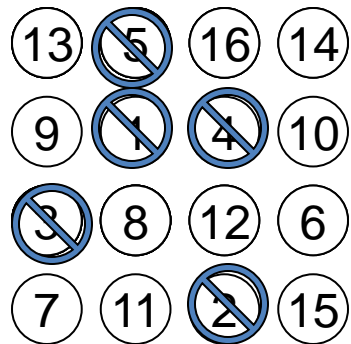


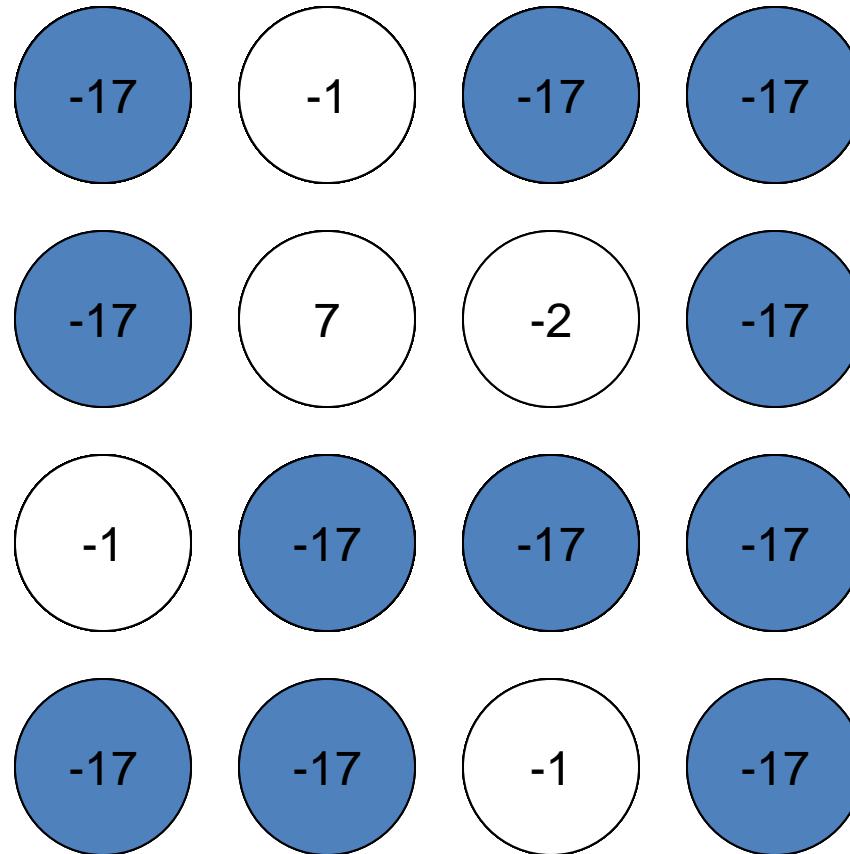
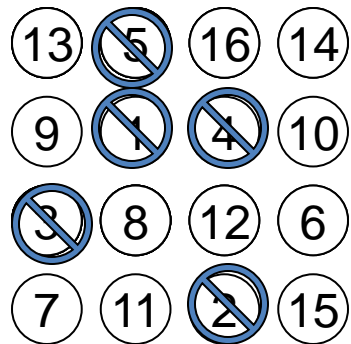


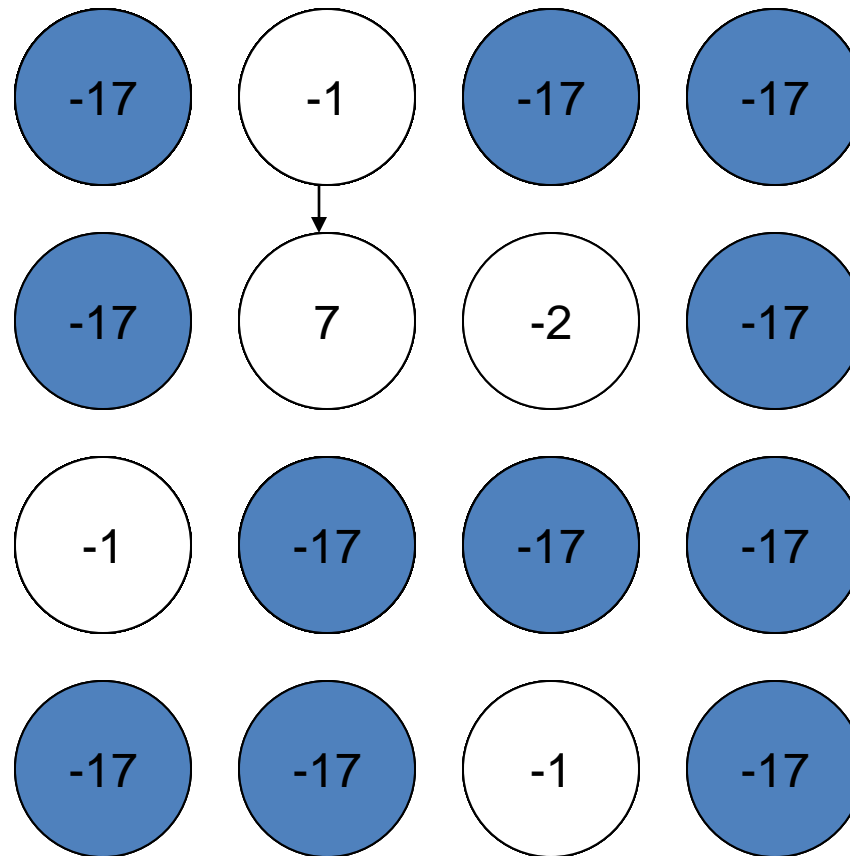
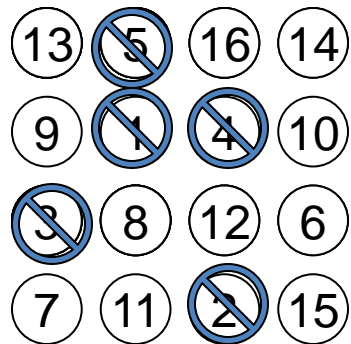


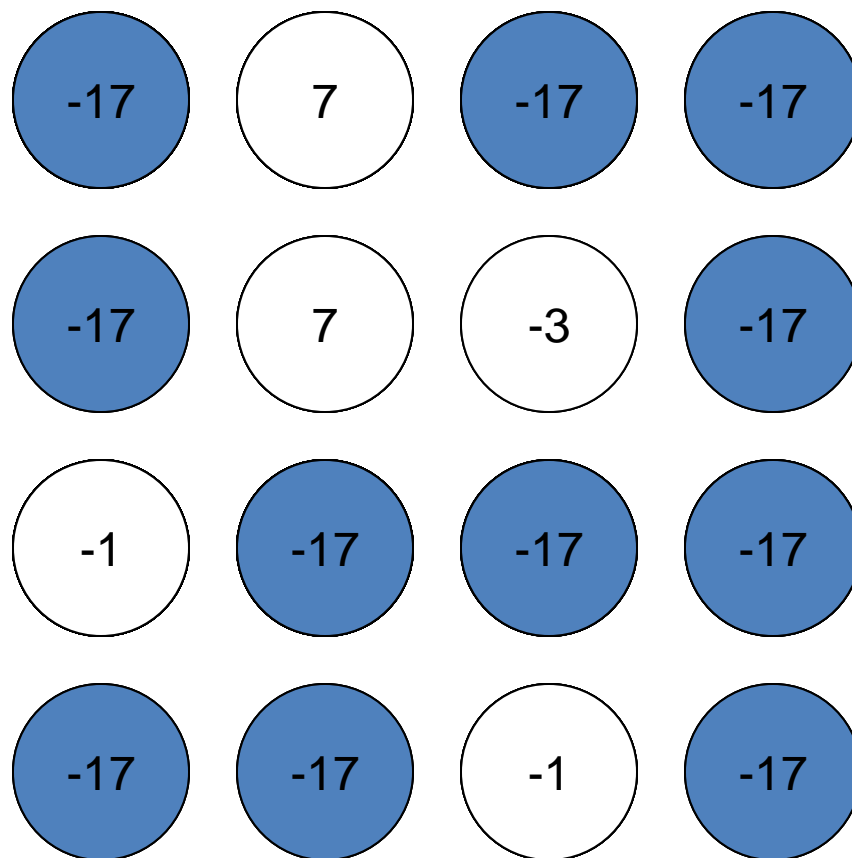
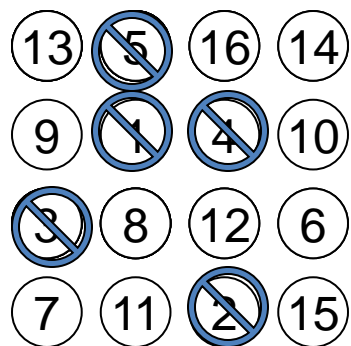


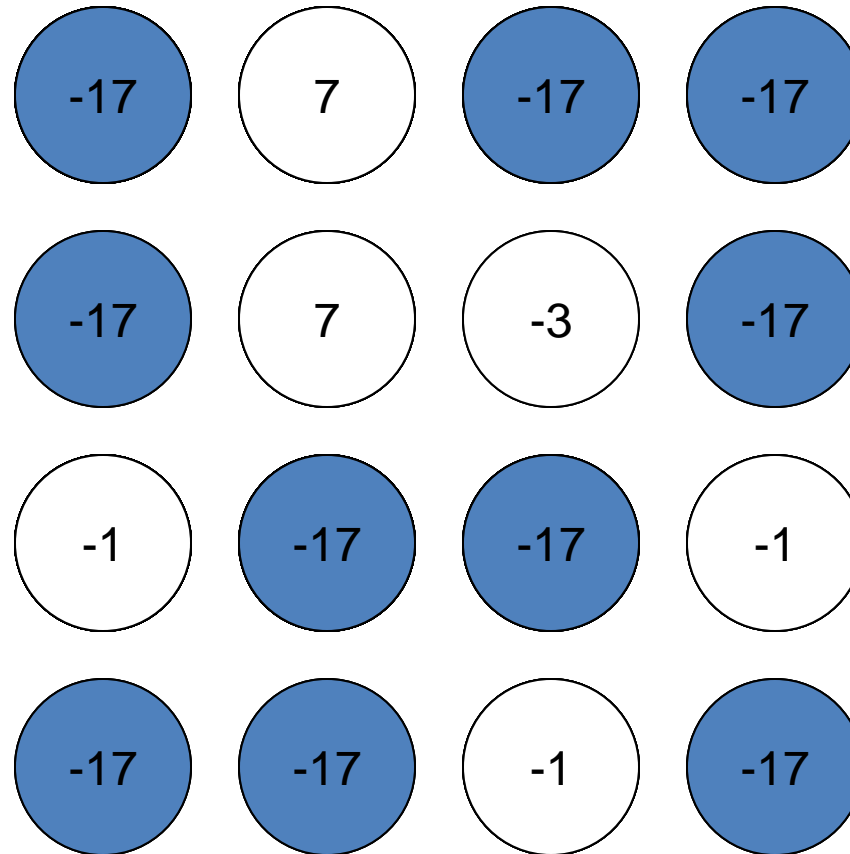
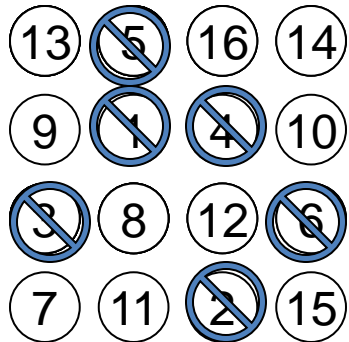


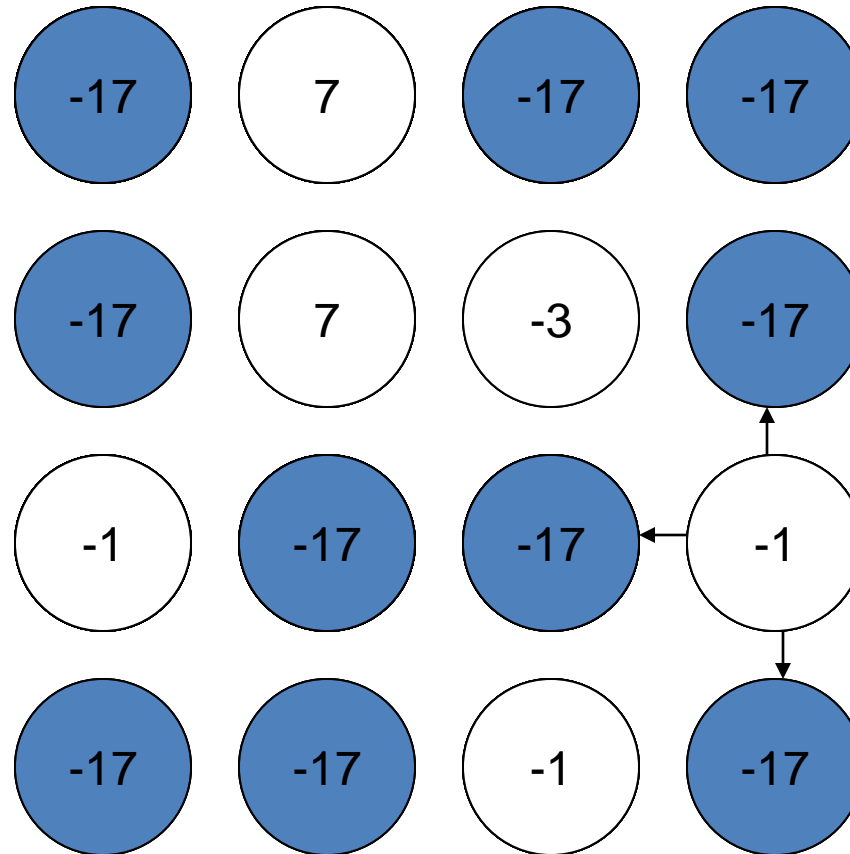
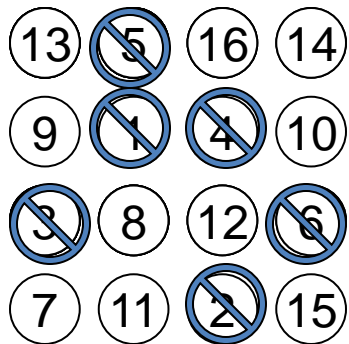


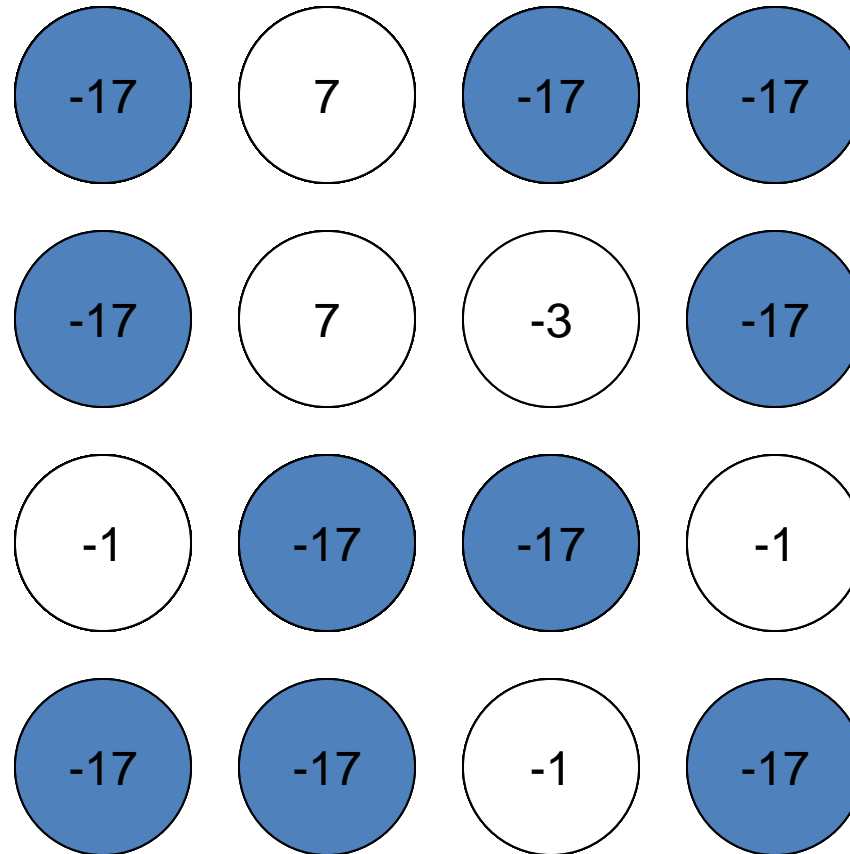
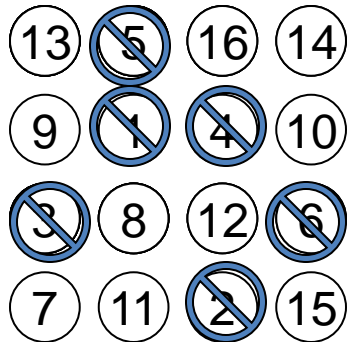


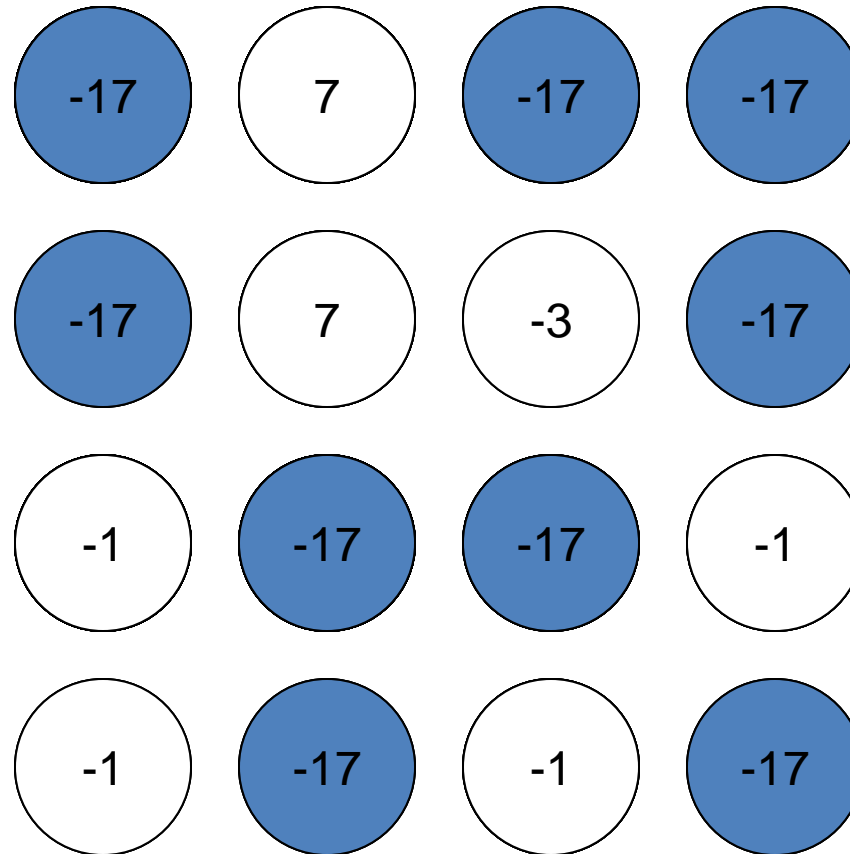
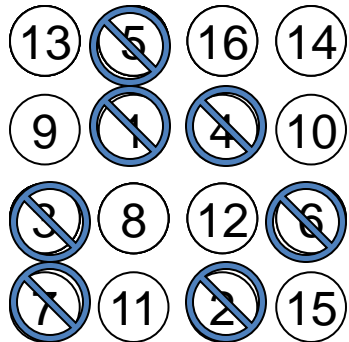


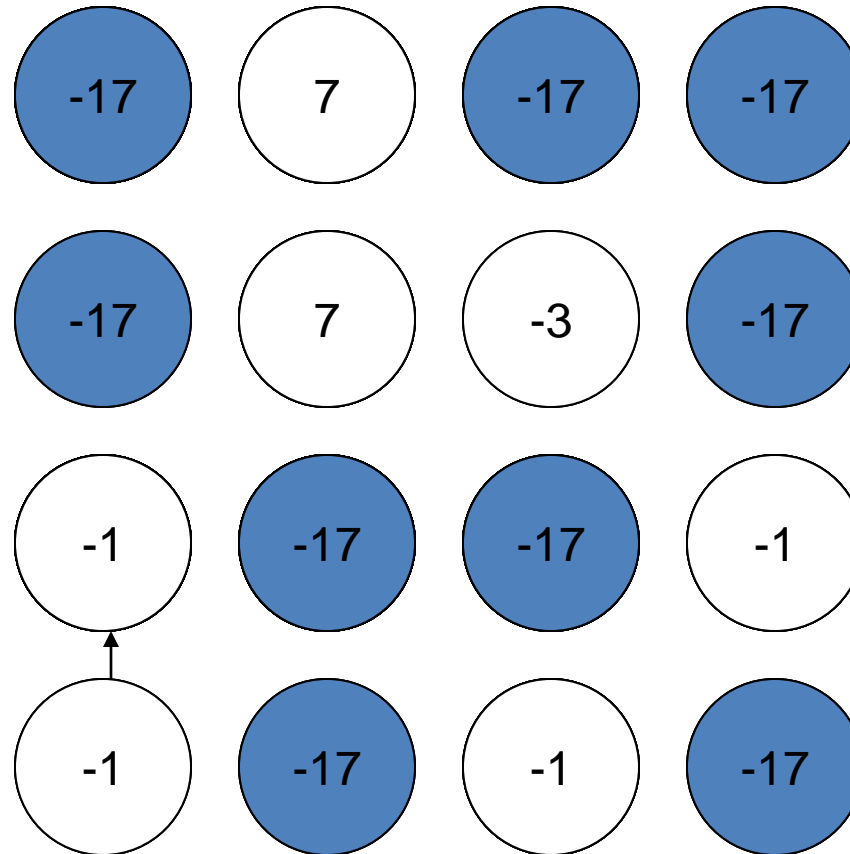
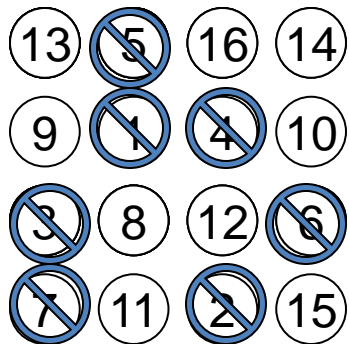


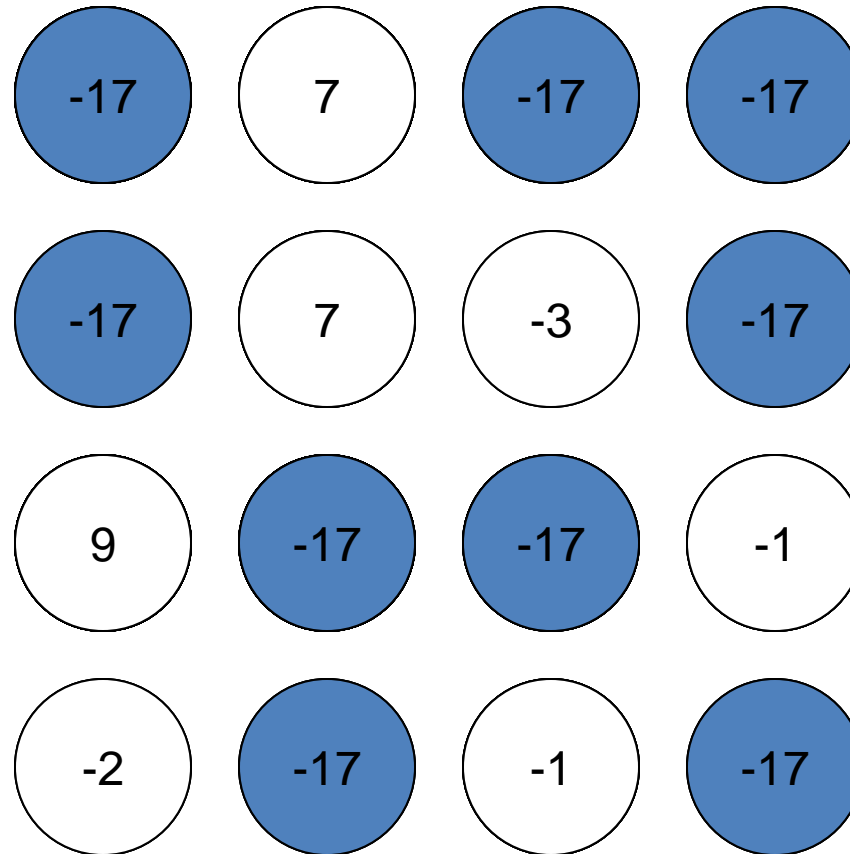
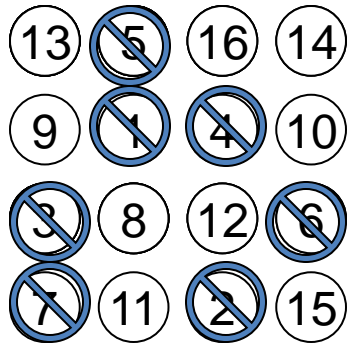


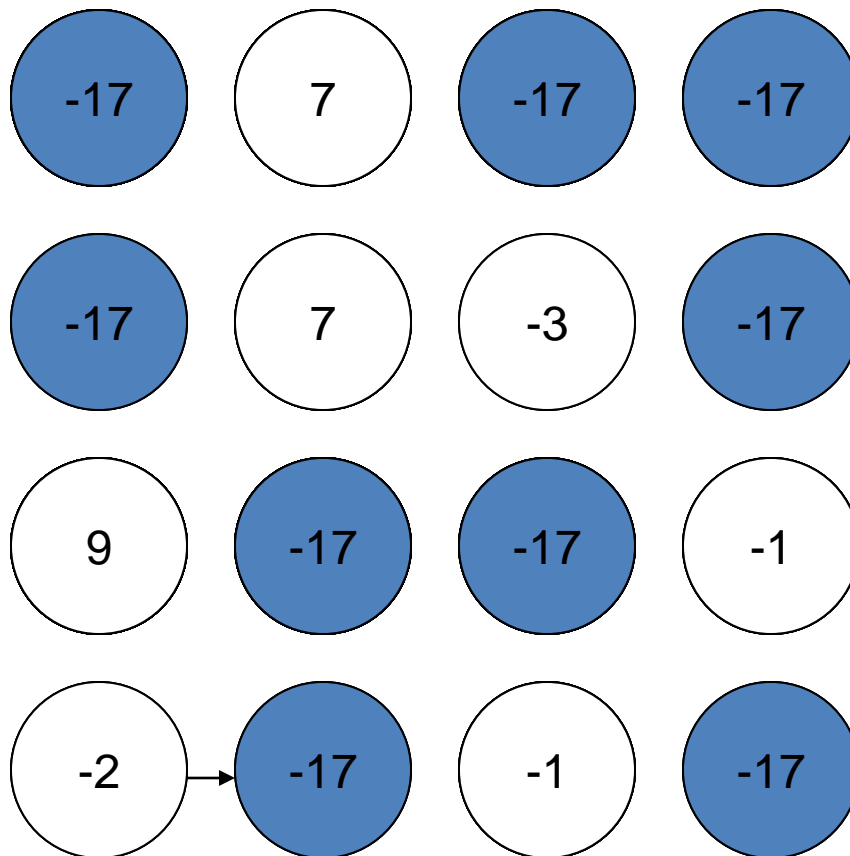
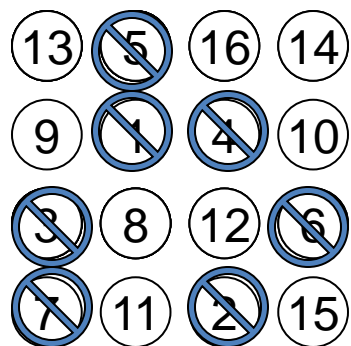


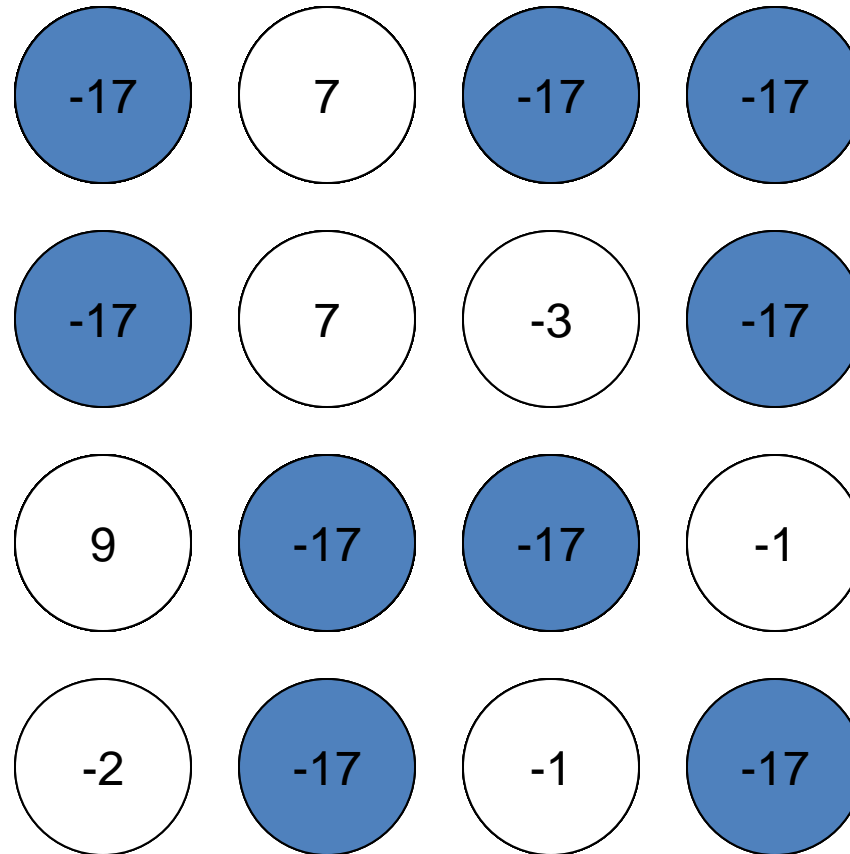
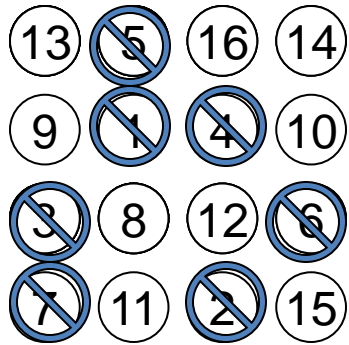


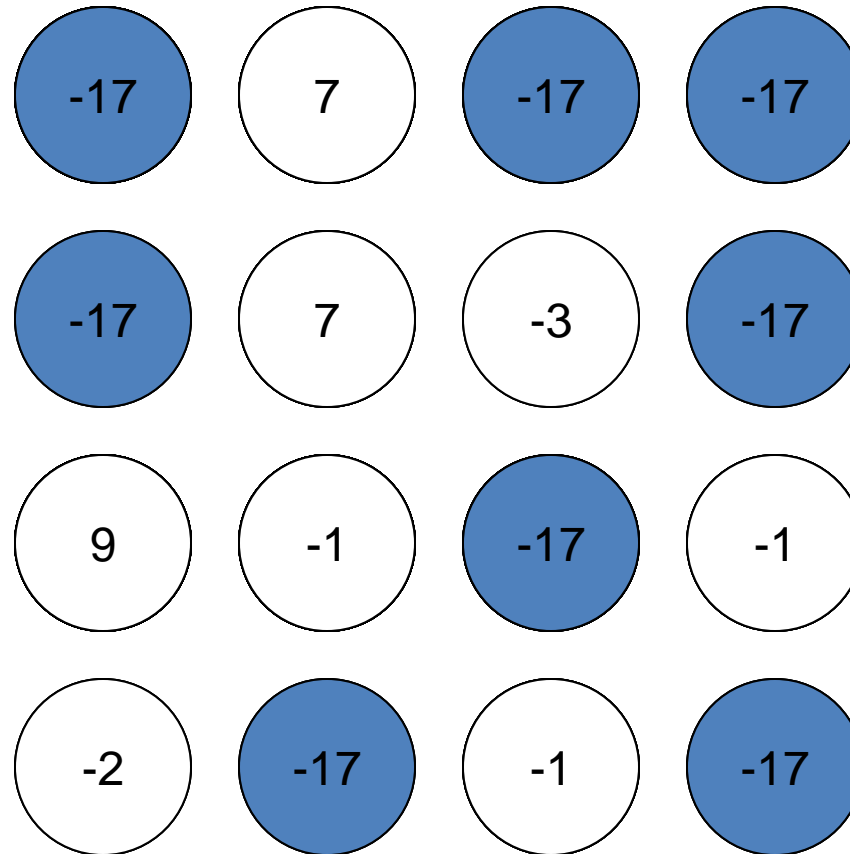
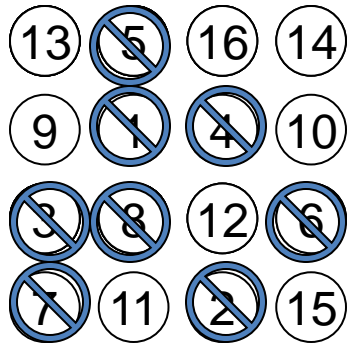


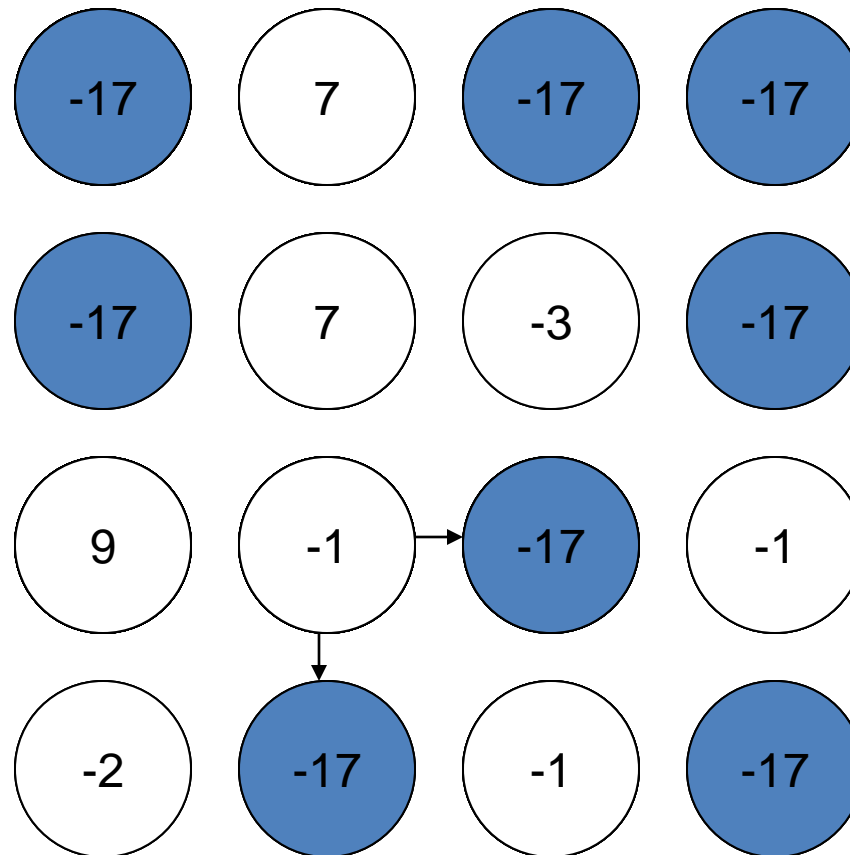
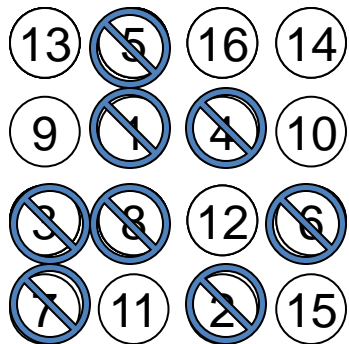


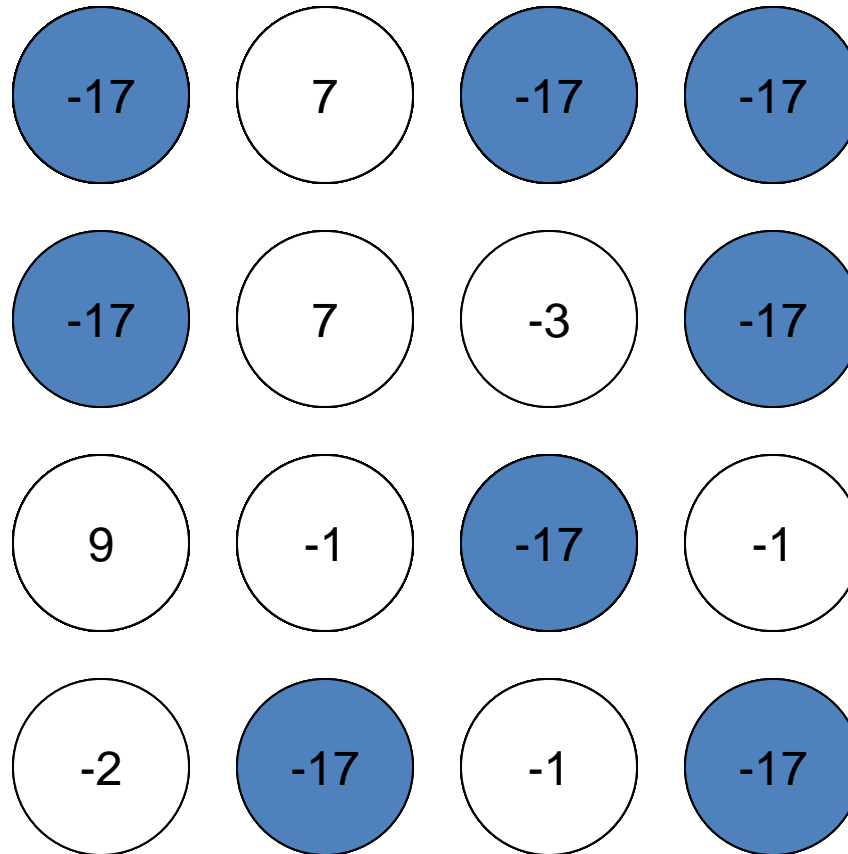
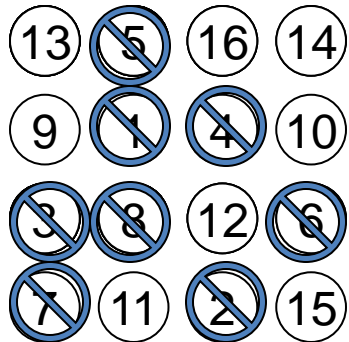


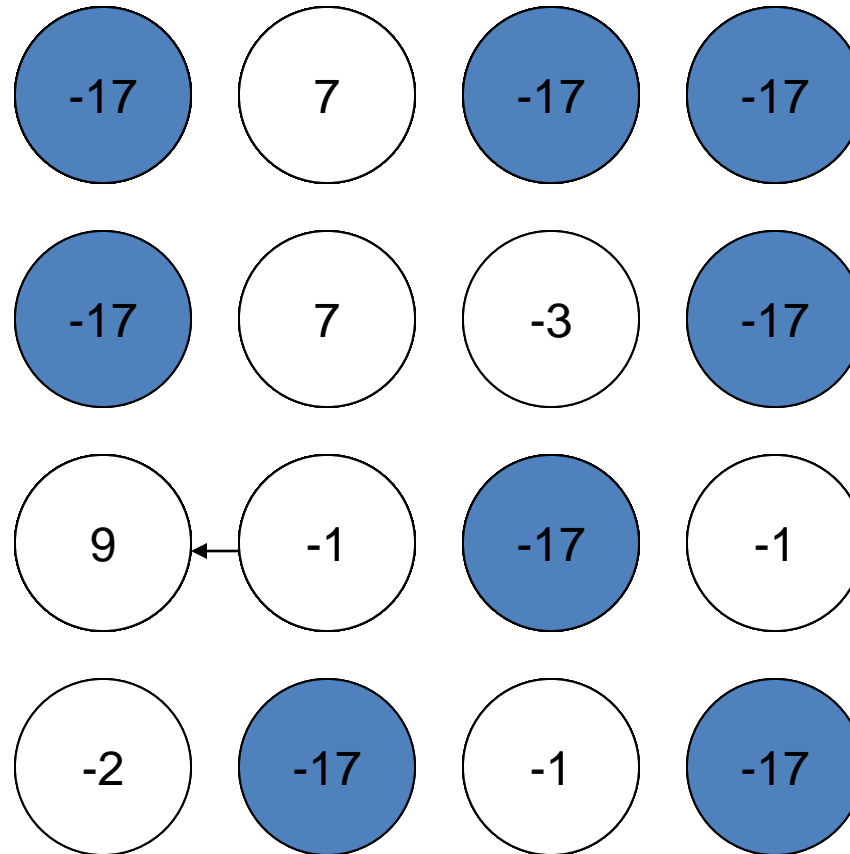
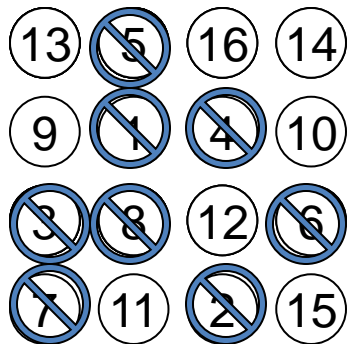


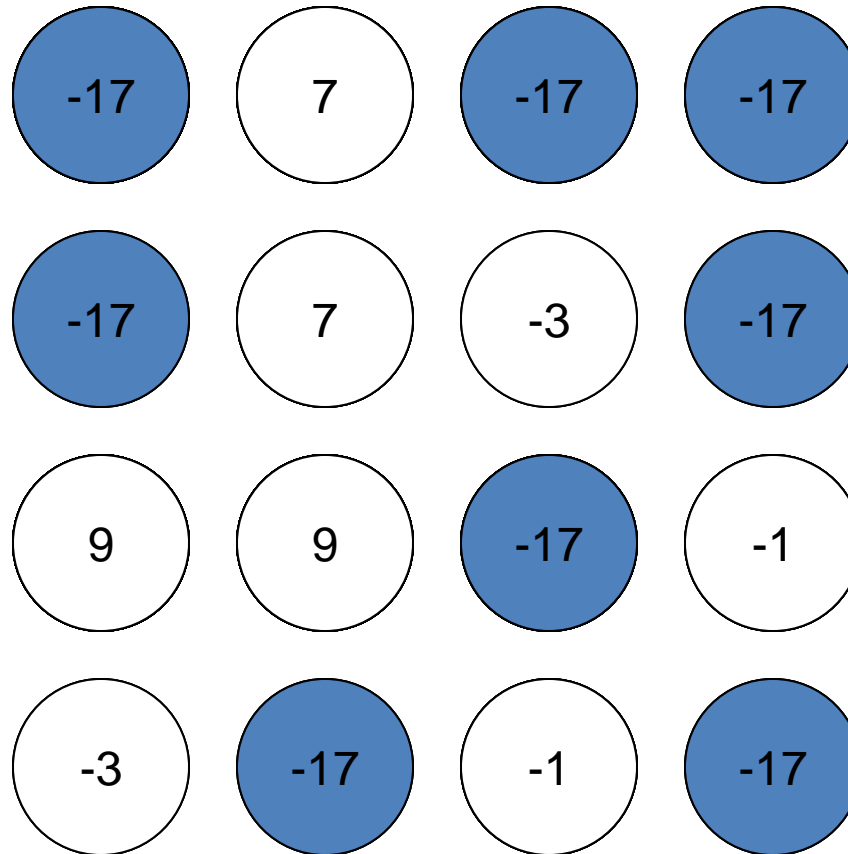
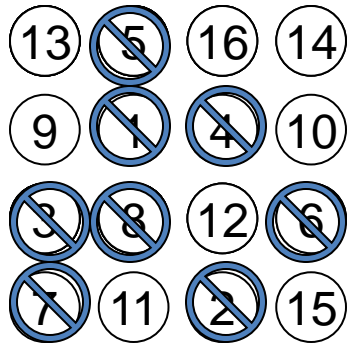


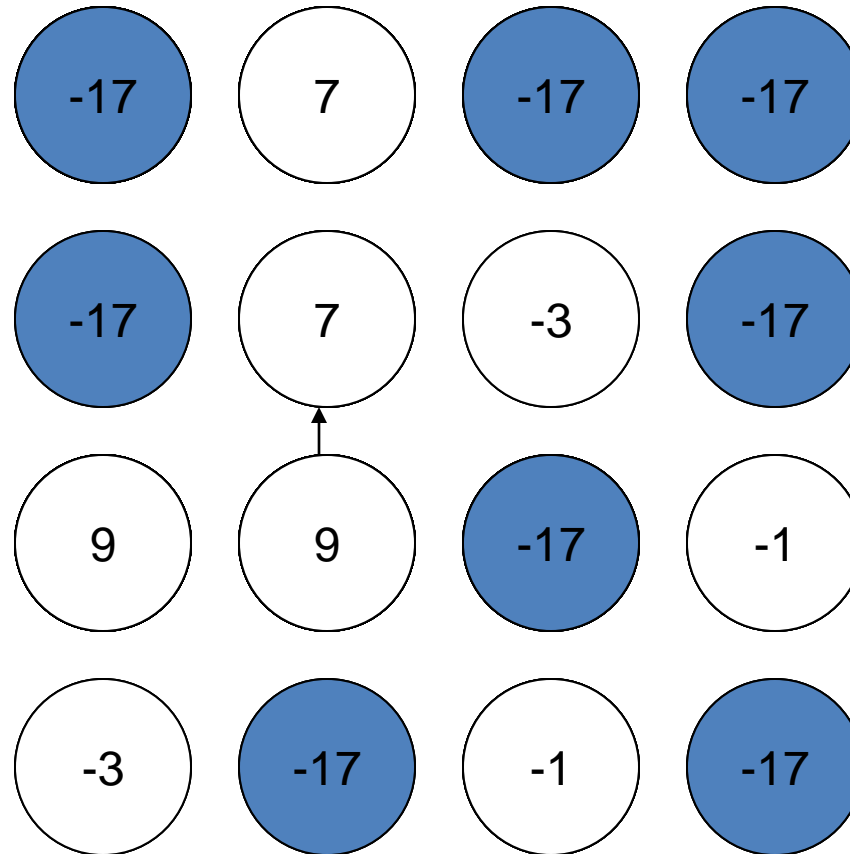
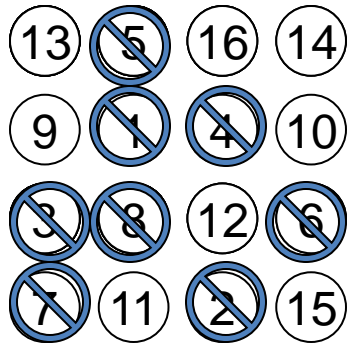


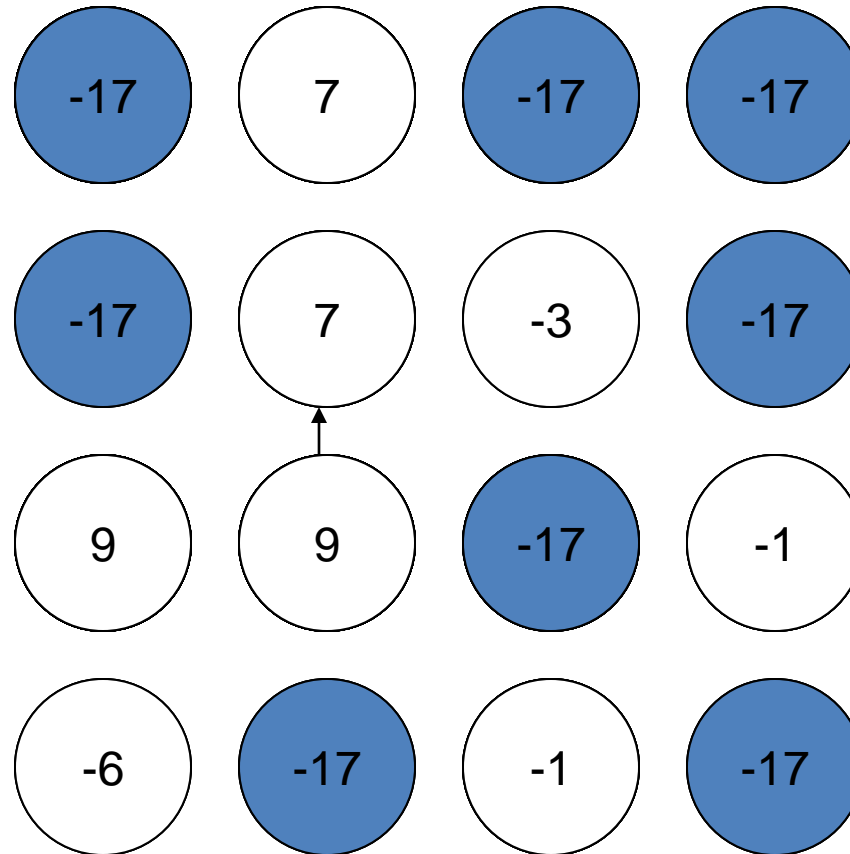
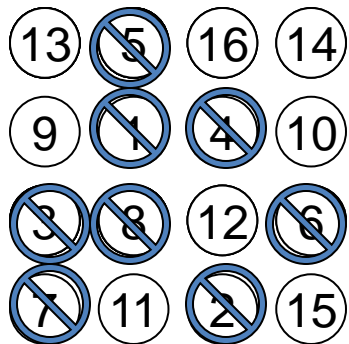


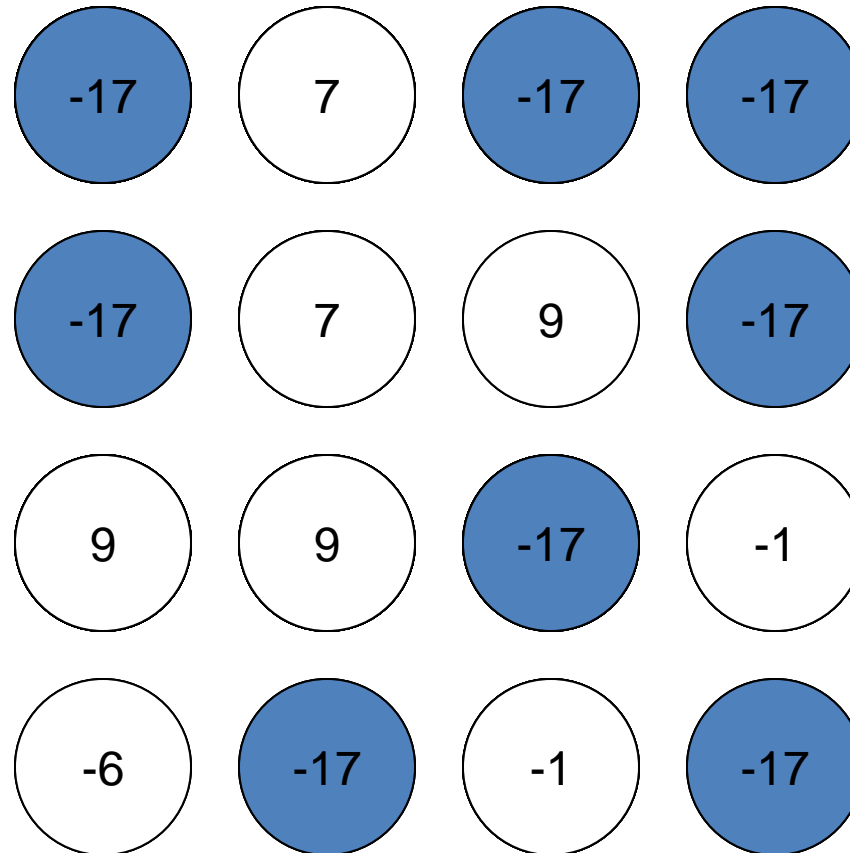
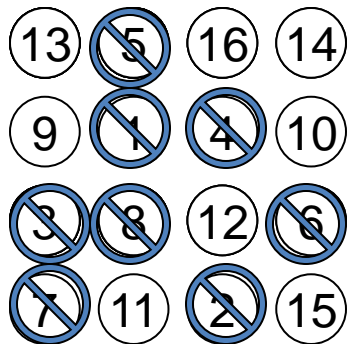


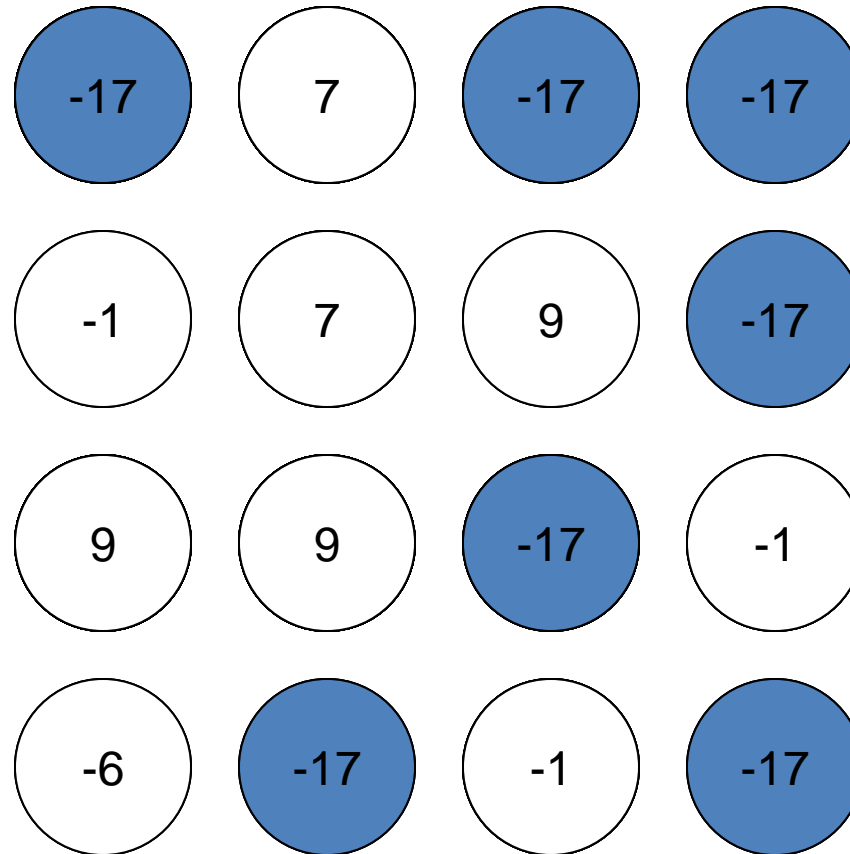
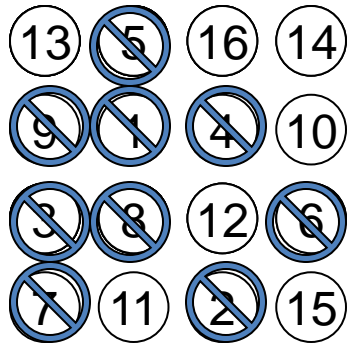


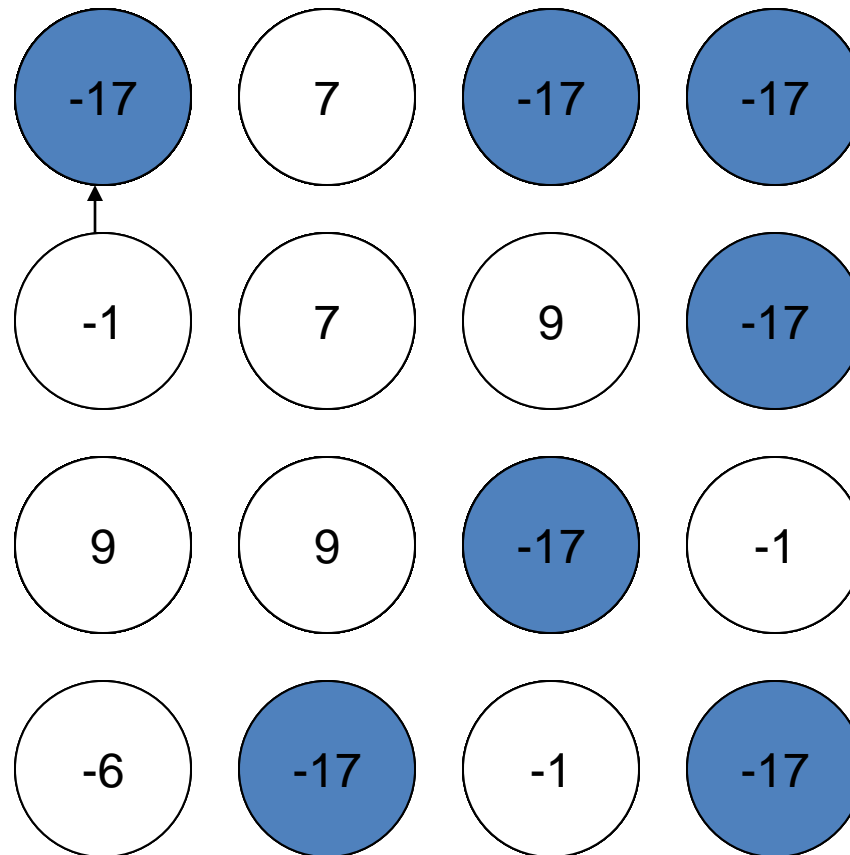
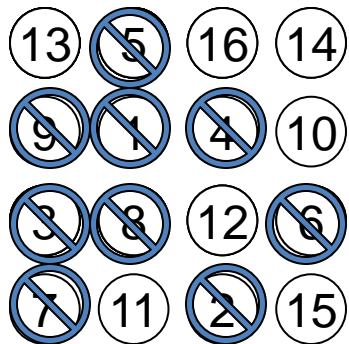


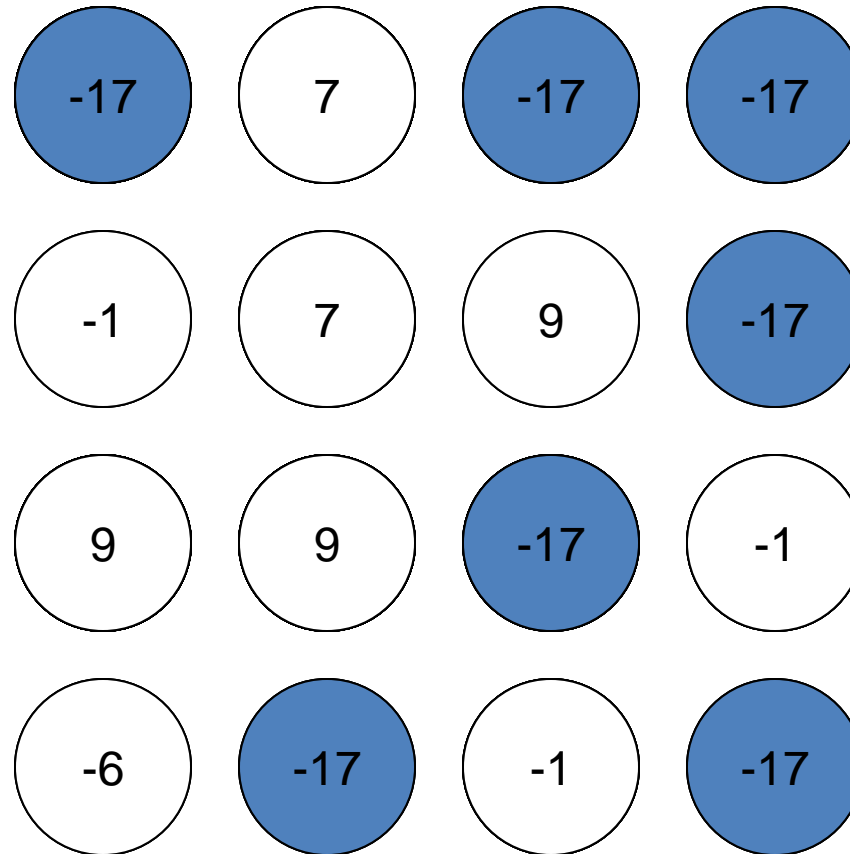
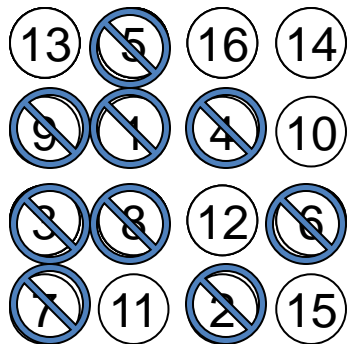


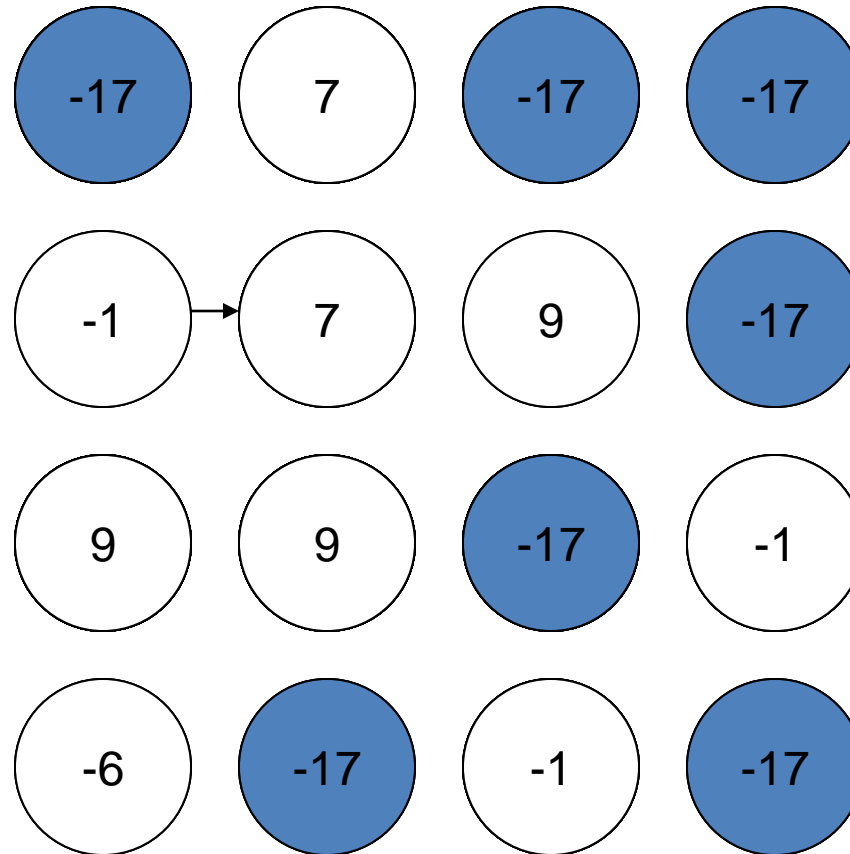
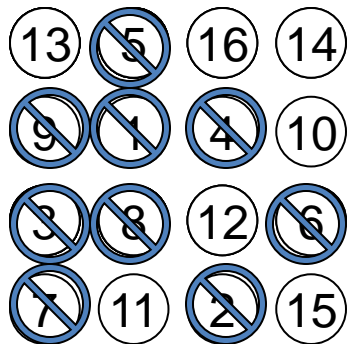


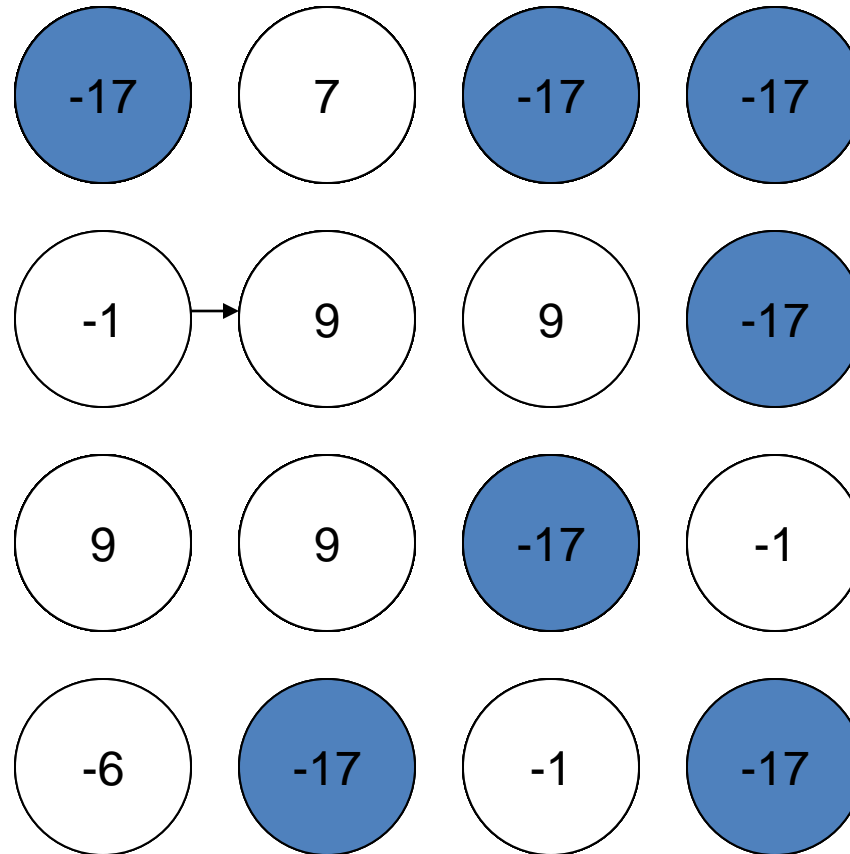
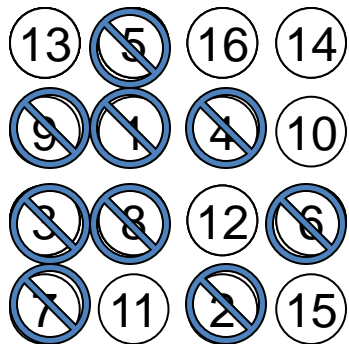


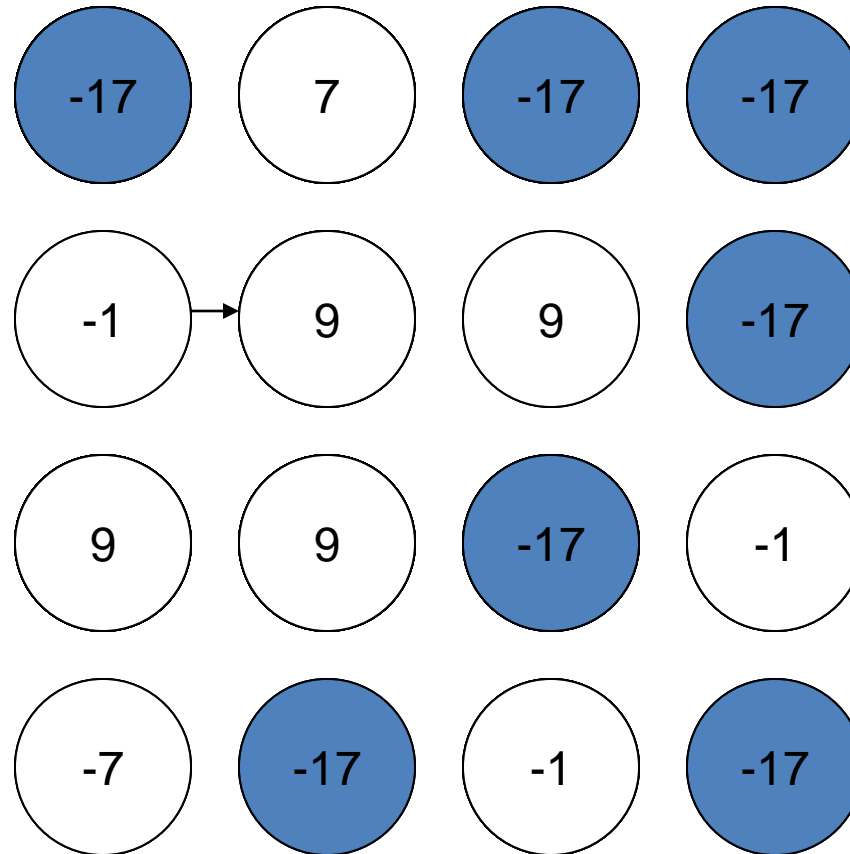
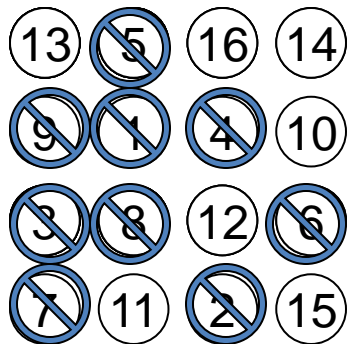


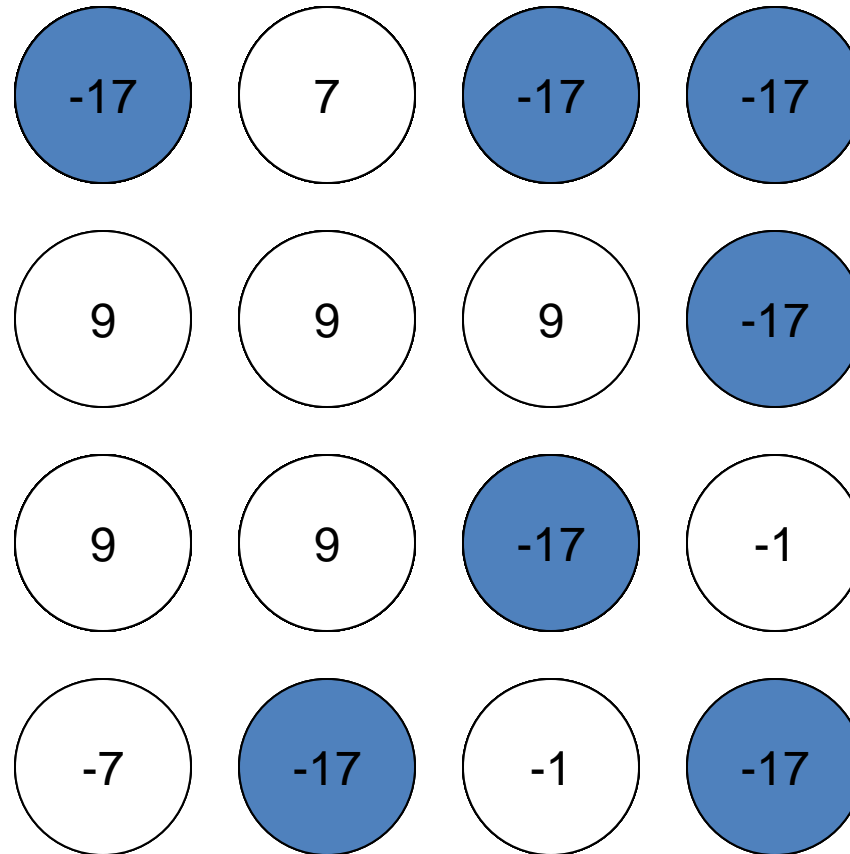
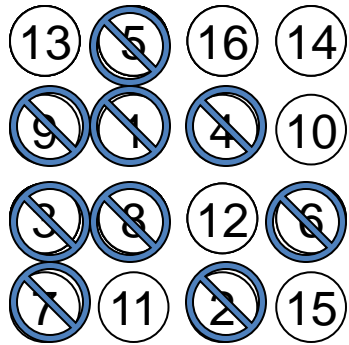


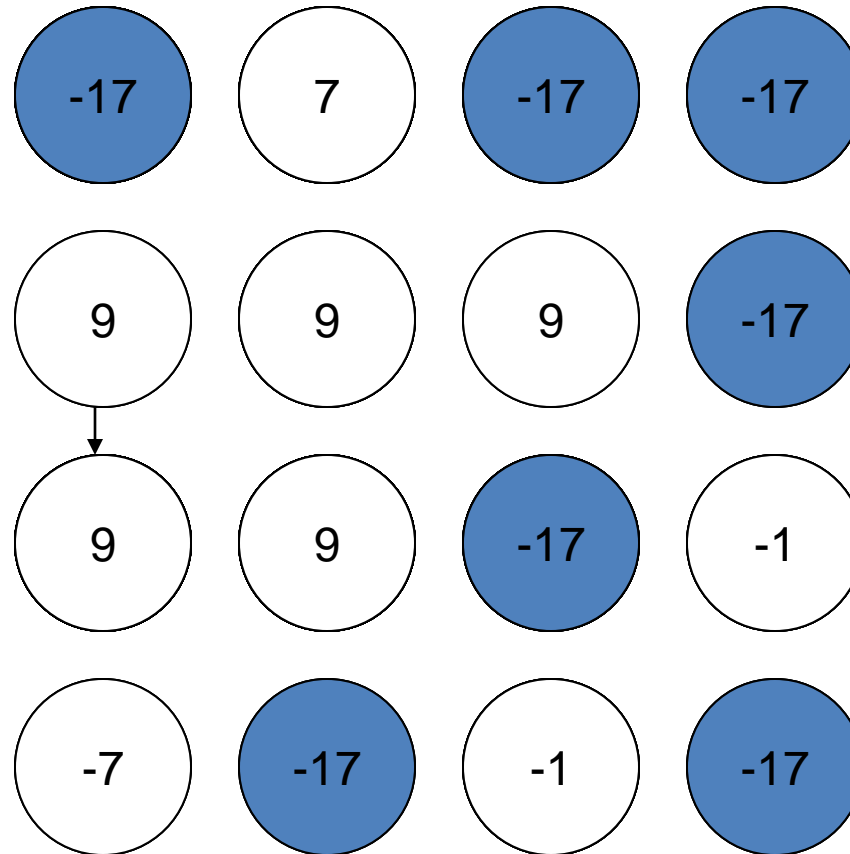
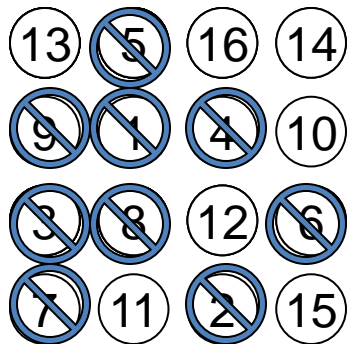


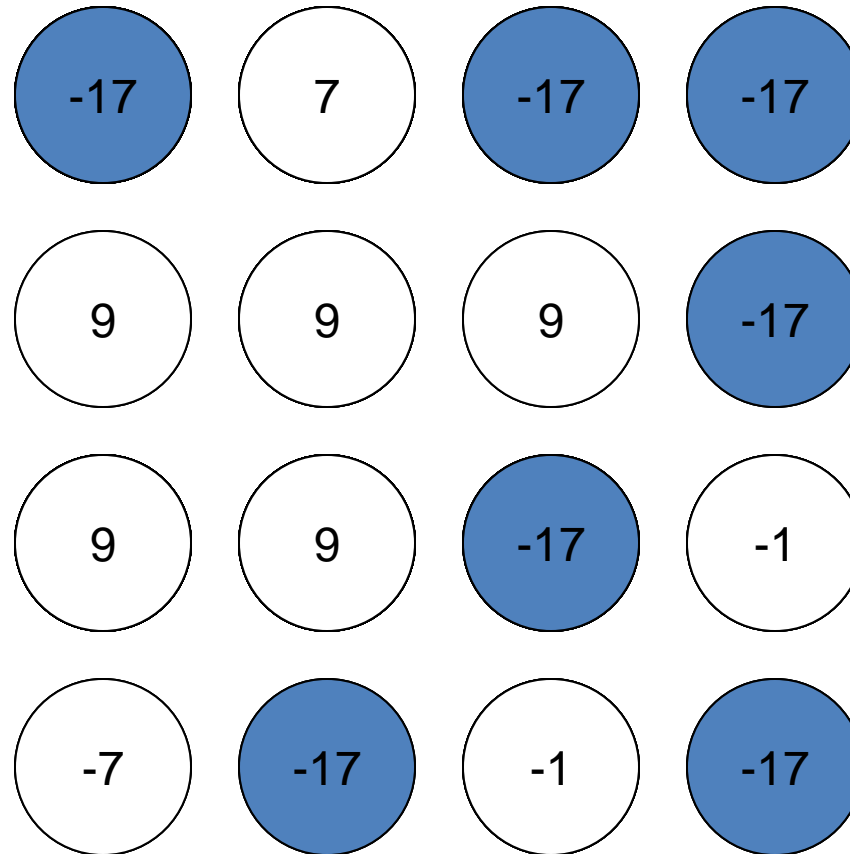
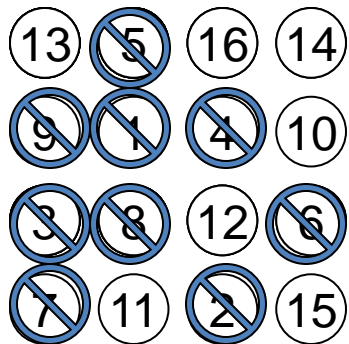








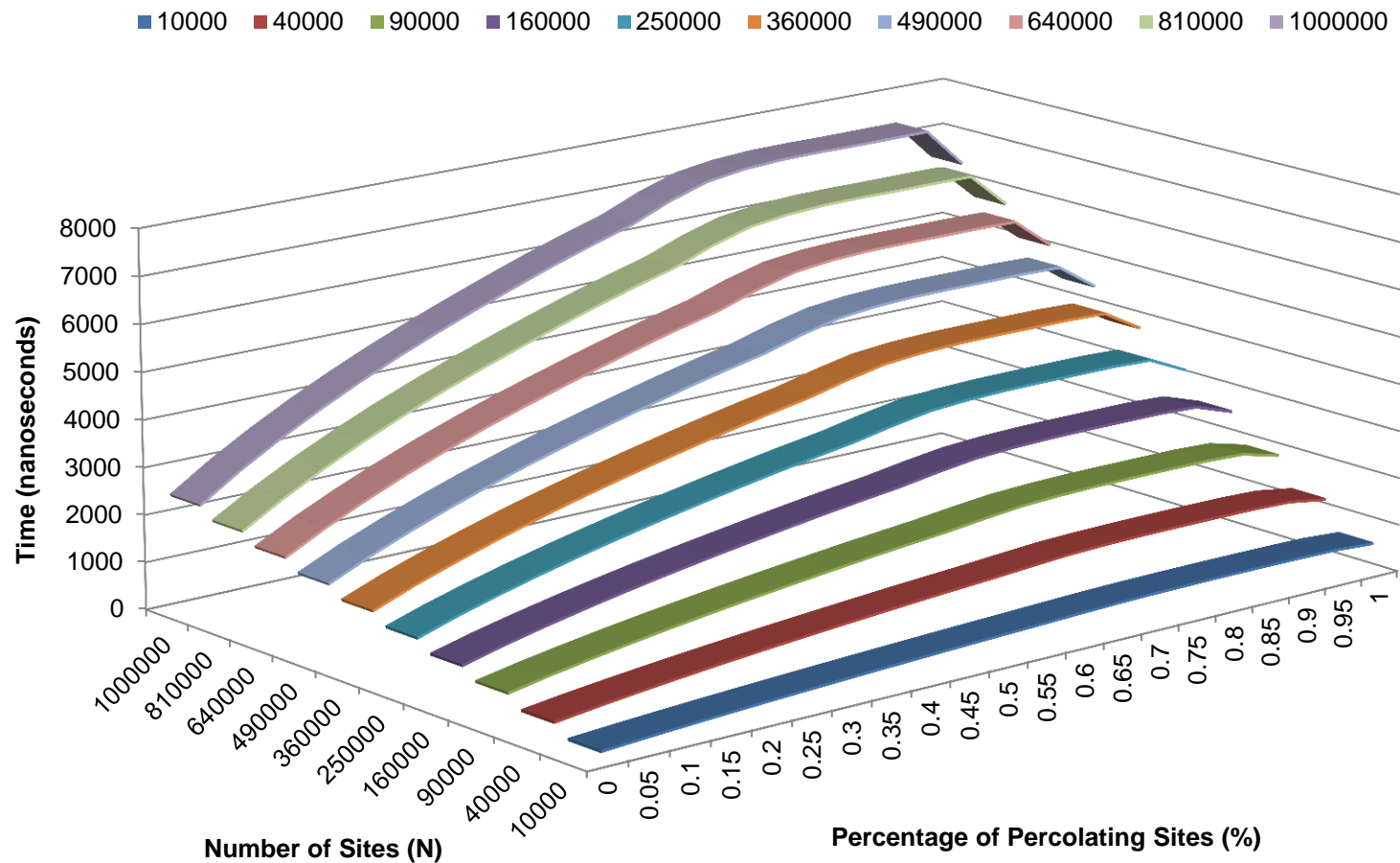




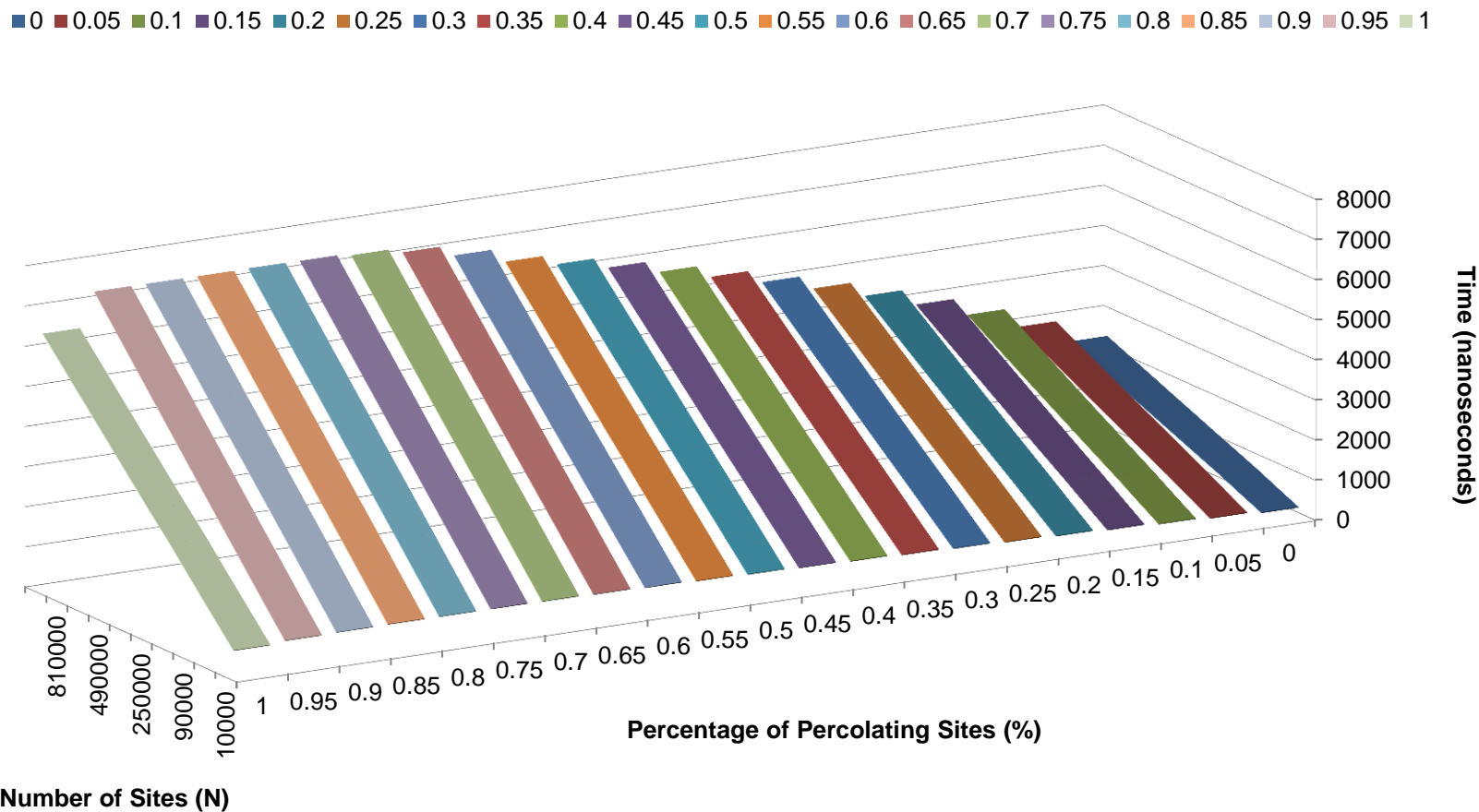
Experimental Configuration

- ρ ranging from 0 to 1
- N ranging from 10^4 to 10^6
- 10^4 trials for each combination of ρ and N
- Same configuration used for both algorithms

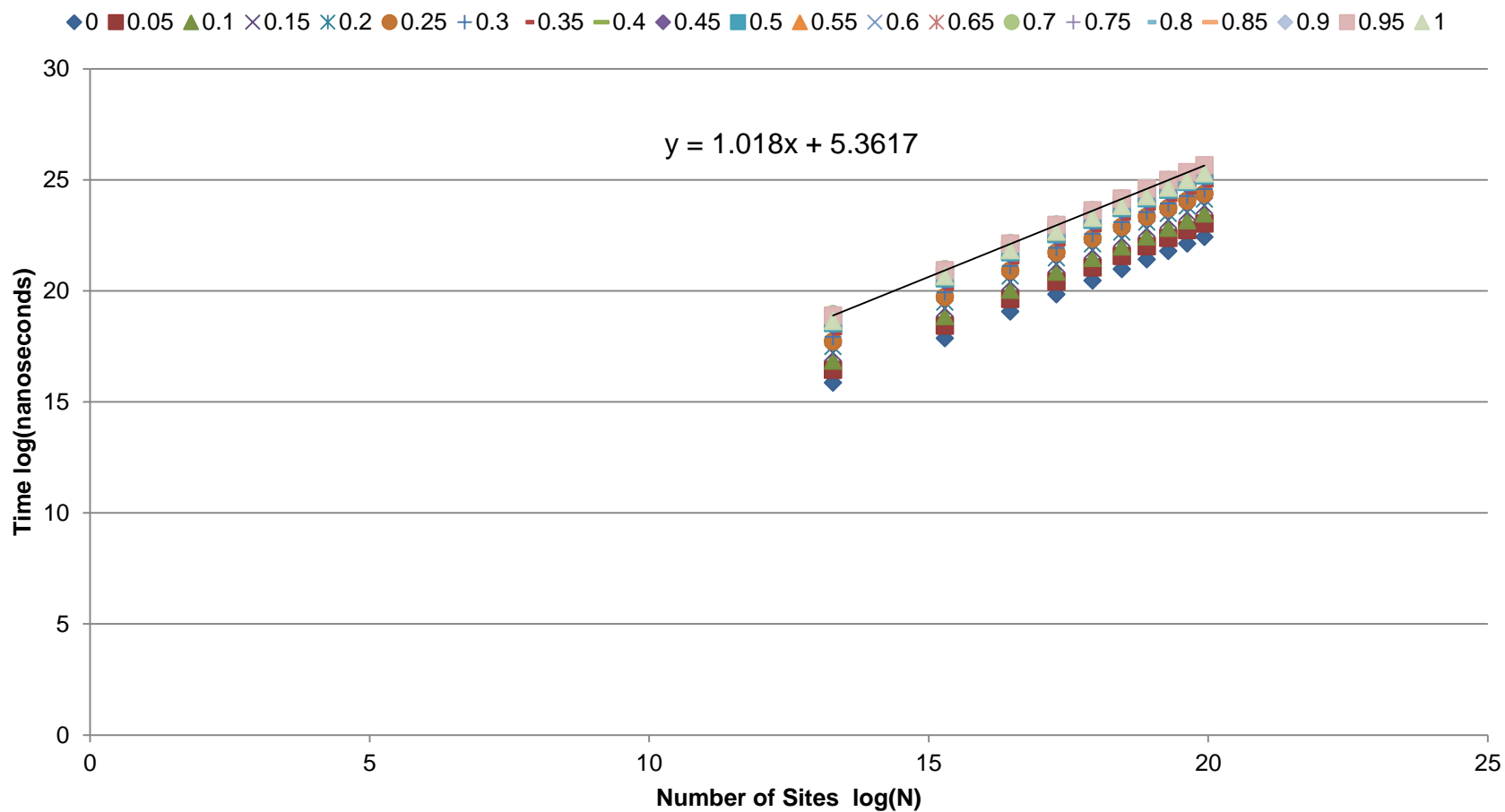
Hoshen-Kopelman Rho vs Time vs Size



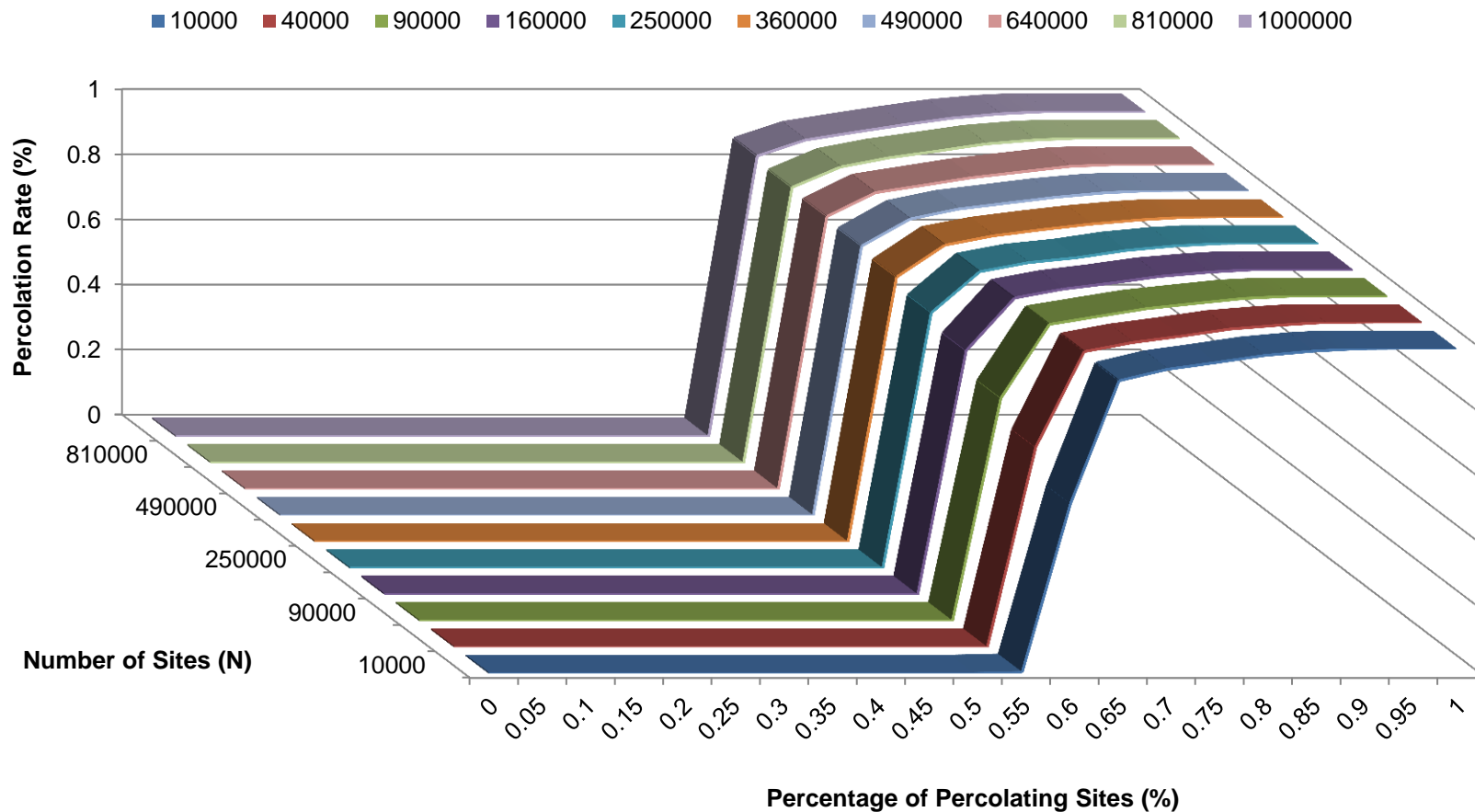
Hoshen-Kopelman Size vs Time vs Rho



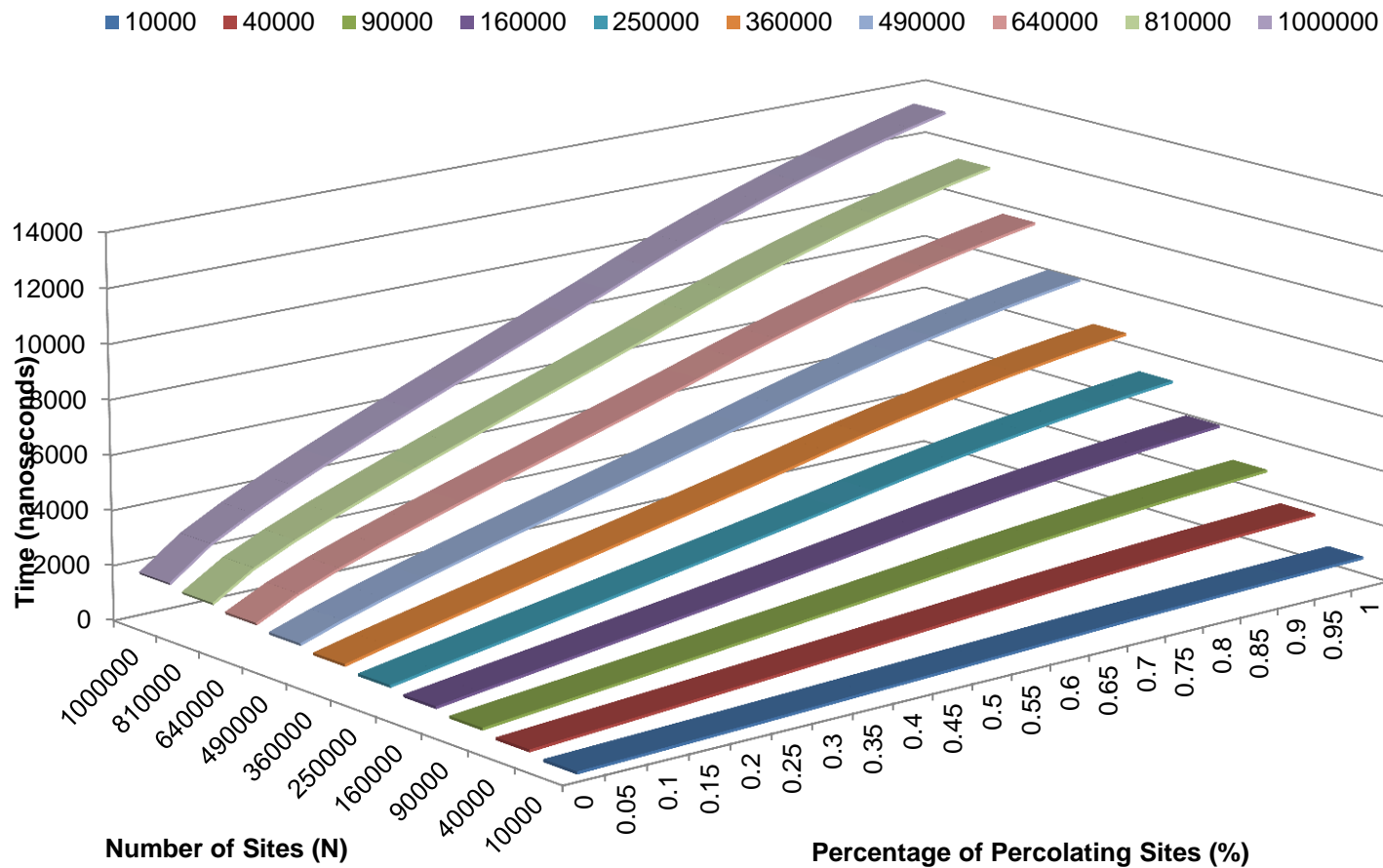
Hoshen-Kopelman Log-Log



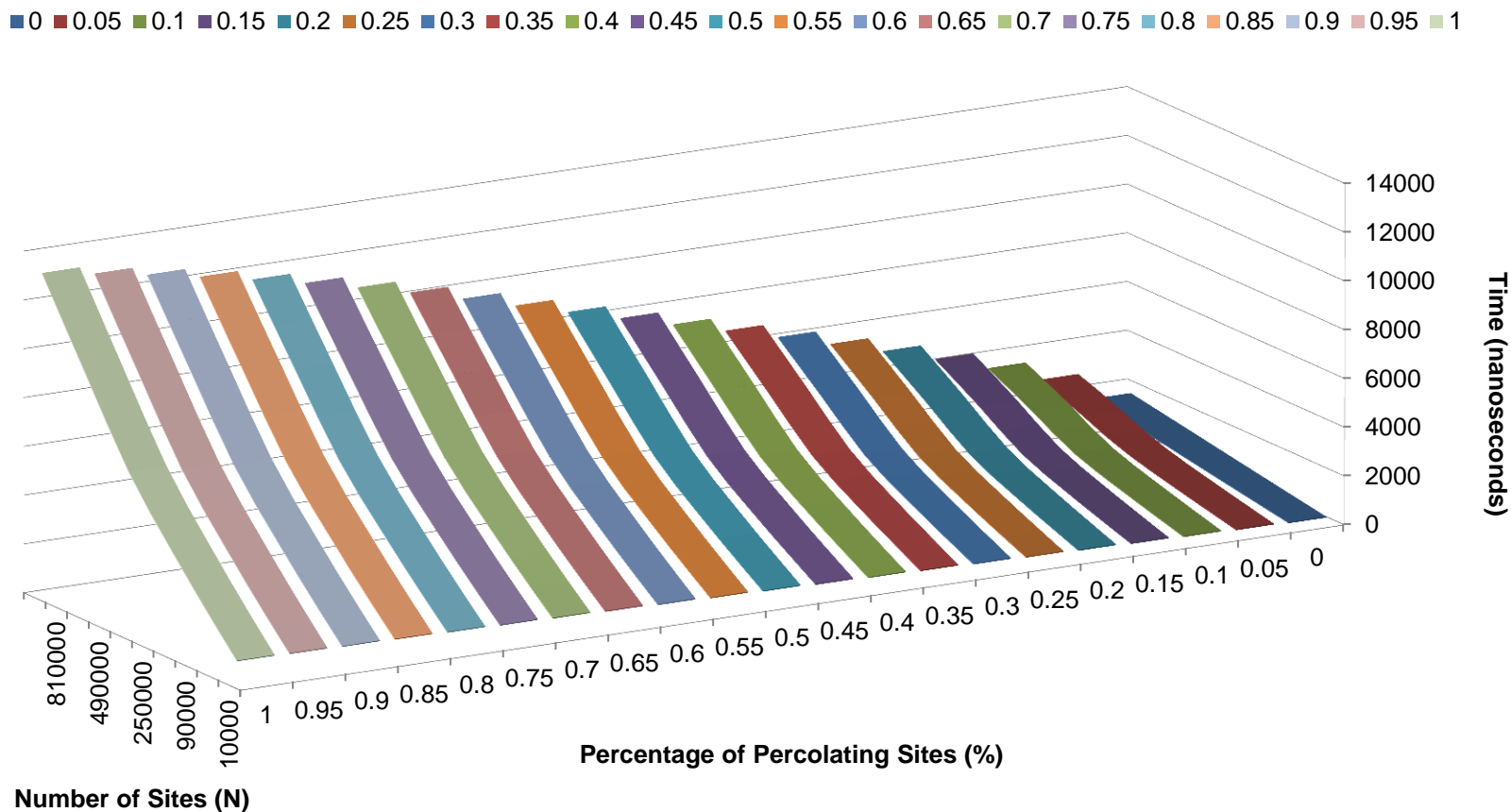
Hoshen-Kopelman Rho vs Size vs Percolation Rate



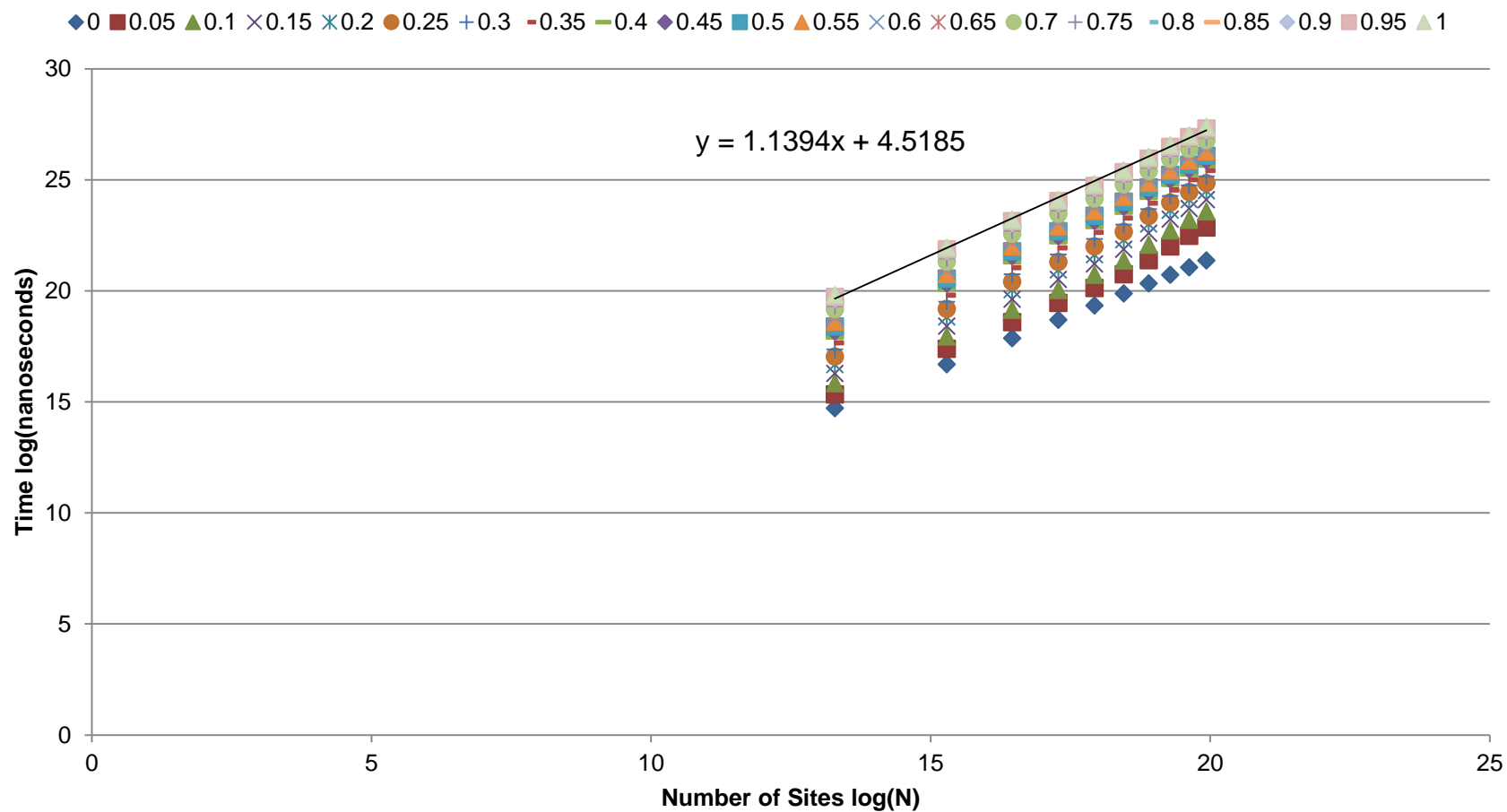
Newman-Ziff Rho vs Time vs Size



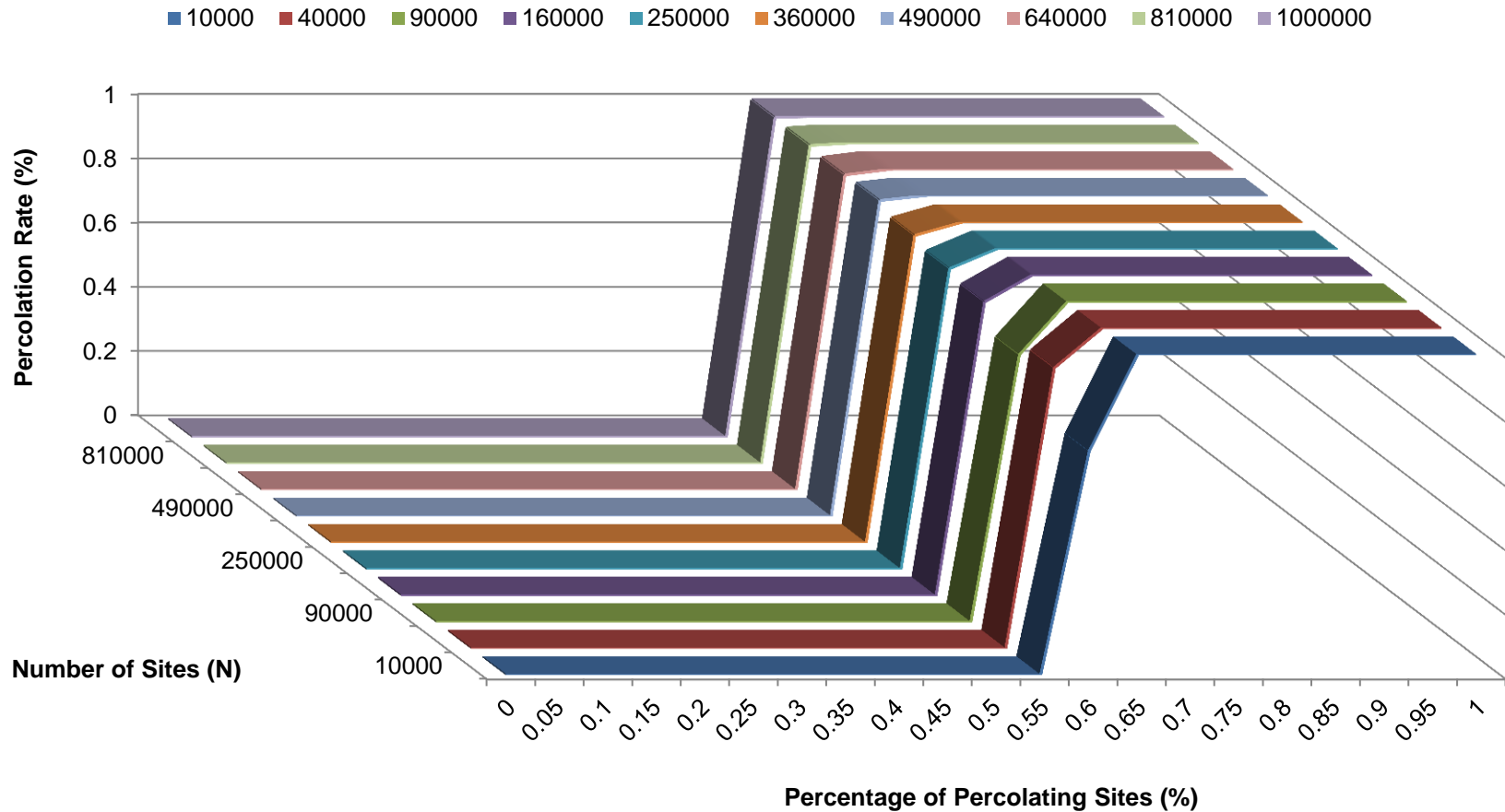
Newman-Ziff Size vs Time vs Rho



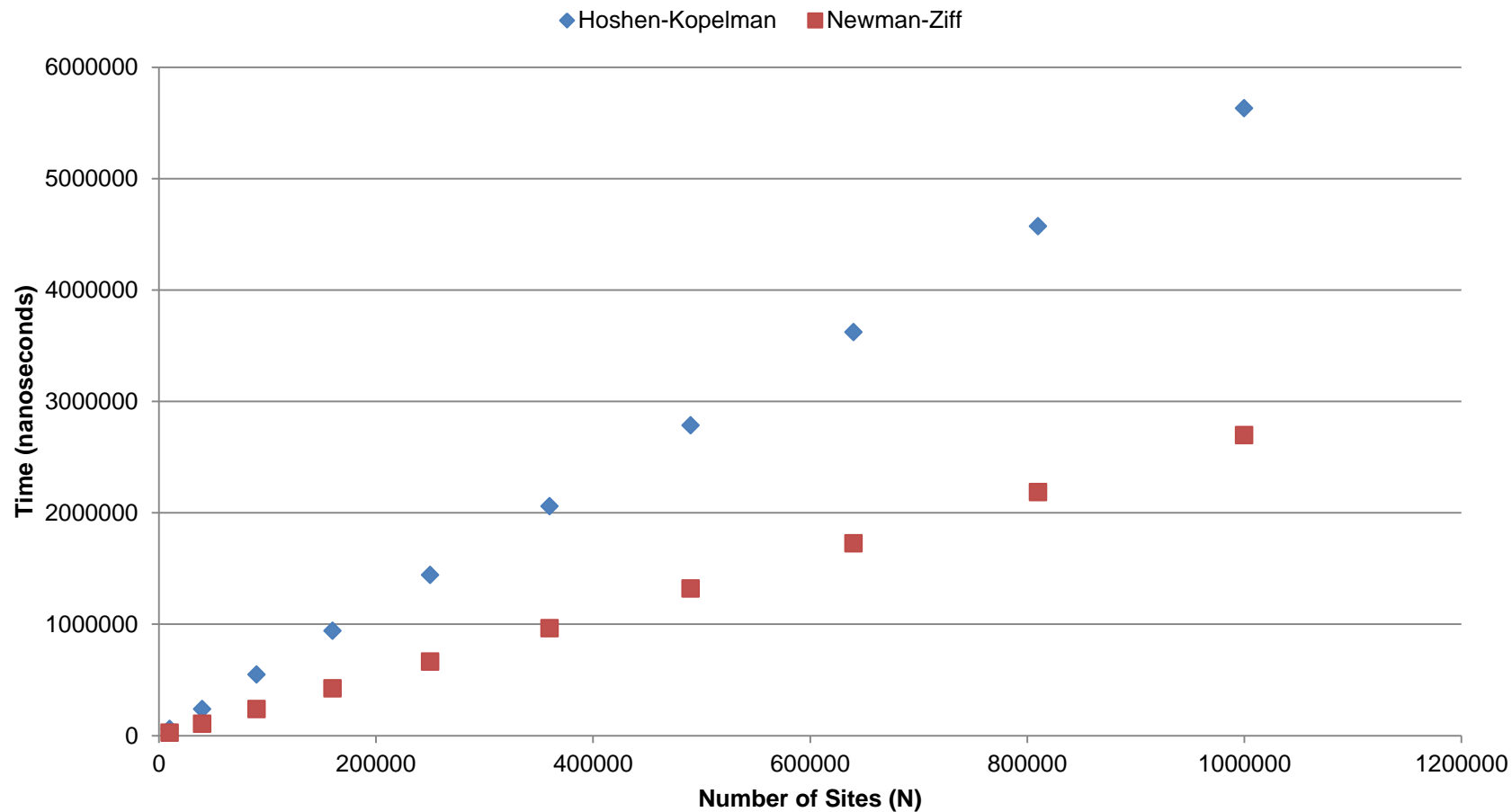
Newman-Ziff Log-Log



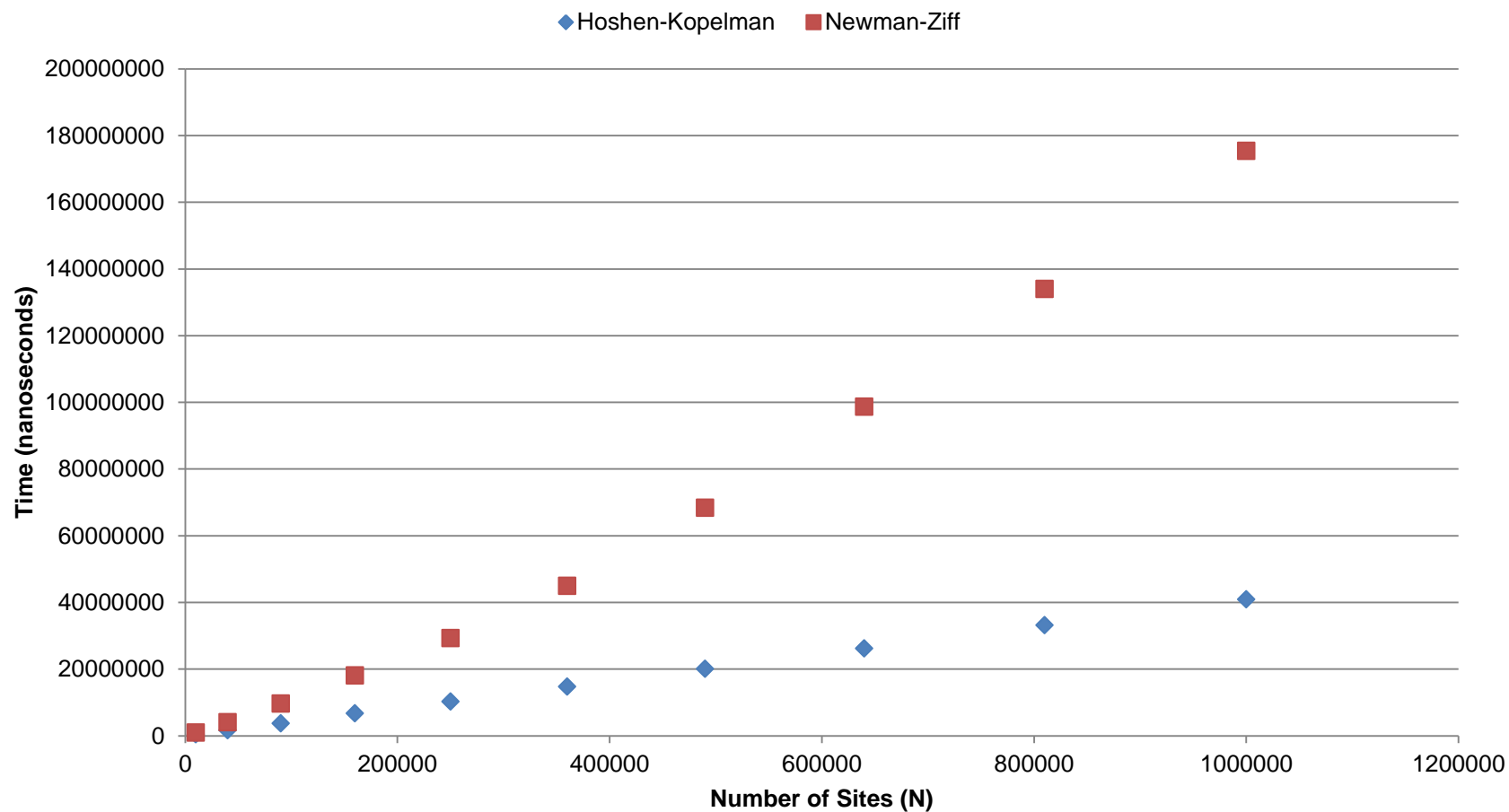
Newman-Ziff Rho vs Size vs Percolation Rate



Small Rho



Large Rho

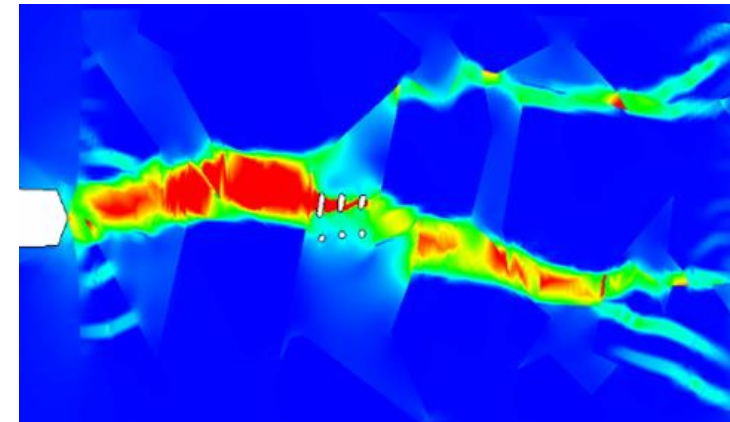
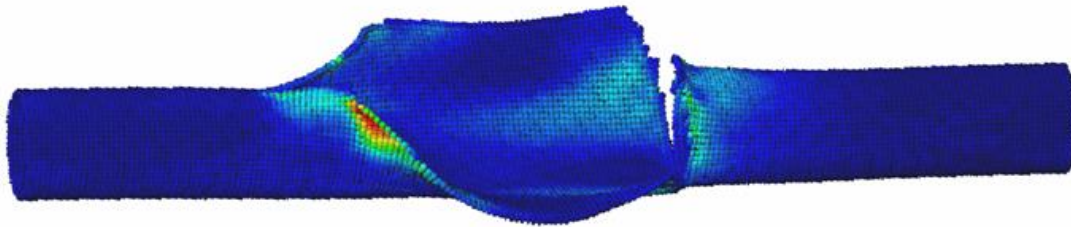


Overall

- Time Complexity
 - HK: $O(N)$
 - NZ: $O(N)$
- Memory Complexity
 - It's complicated
 - HK less than NZ
 - HK better for very large lattices
 - NZ better for smaller lattices (faster)

Findings

- Best material to use?
 - $\rho < 0.55$
 - Probability of percolation small
 - Fault-tolerance
- Applications
 - Fracture Mechanics



Questions?

References

- <http://www.physics.buffalo.edu/phy410-505-2010/>
- <http://www.neurofractal.org/felix/publications/percolation/code.html>
- <http://www.hiskp.uni-bonn.de/uploads/media/percolation.pdf>
- <https://www.tu-chemnitz.de/physik/THUS/lehre/CSM2/NewmanZiff.pdf>
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