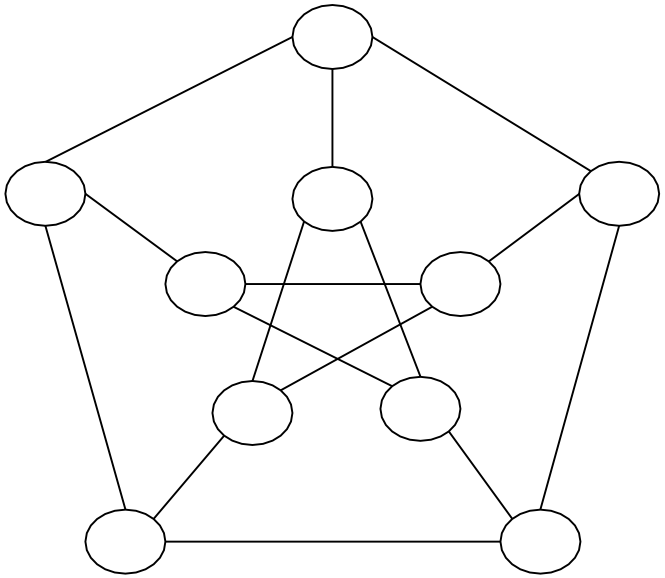
Hill Climbing

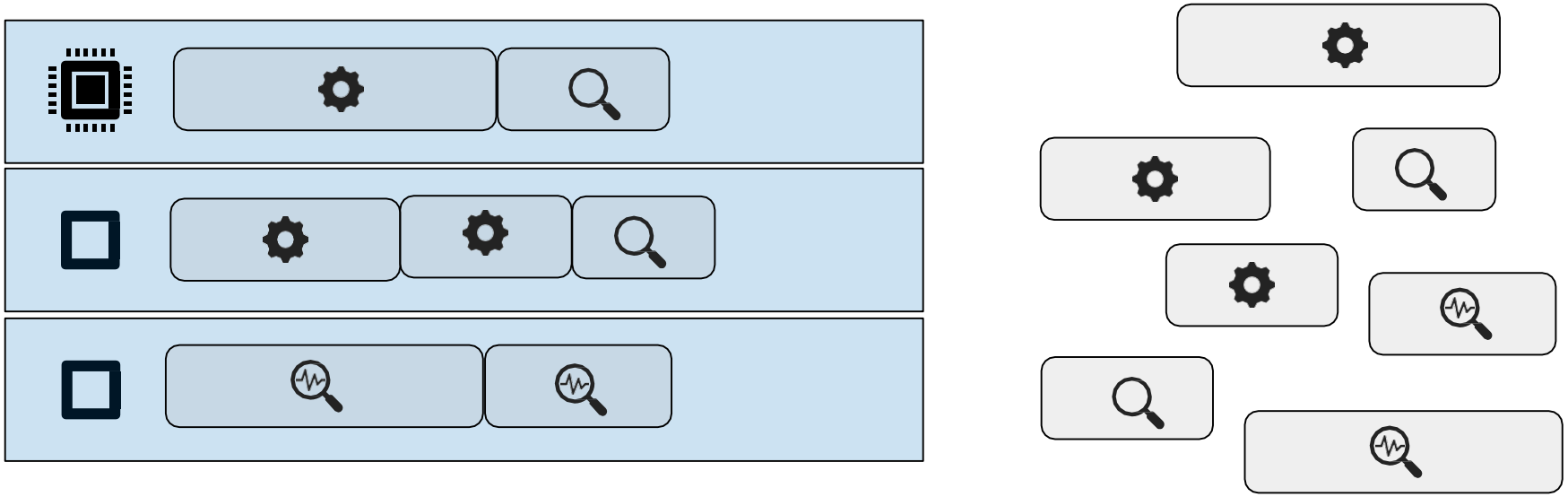
Exercise 1: Graph Coloring



- Problem: assign a color from {1,2,3} to each node such that no two adjacent nodes have the same color
- Define
  - State space
  - Neighborhood
  - Objective function
- Perform Hill-climbing search from an initial state where all nodes have color 1

Minimum Makespan Scheduling

- Given m machines
- and n jobs with processing time $p_1, \ldots, p_n$,
- assign jobs to machines such that overall processing time (makespan) is minimized



Exercise 2: Makespan Problem

Define

- State space
- Neighborhood
- Objective function

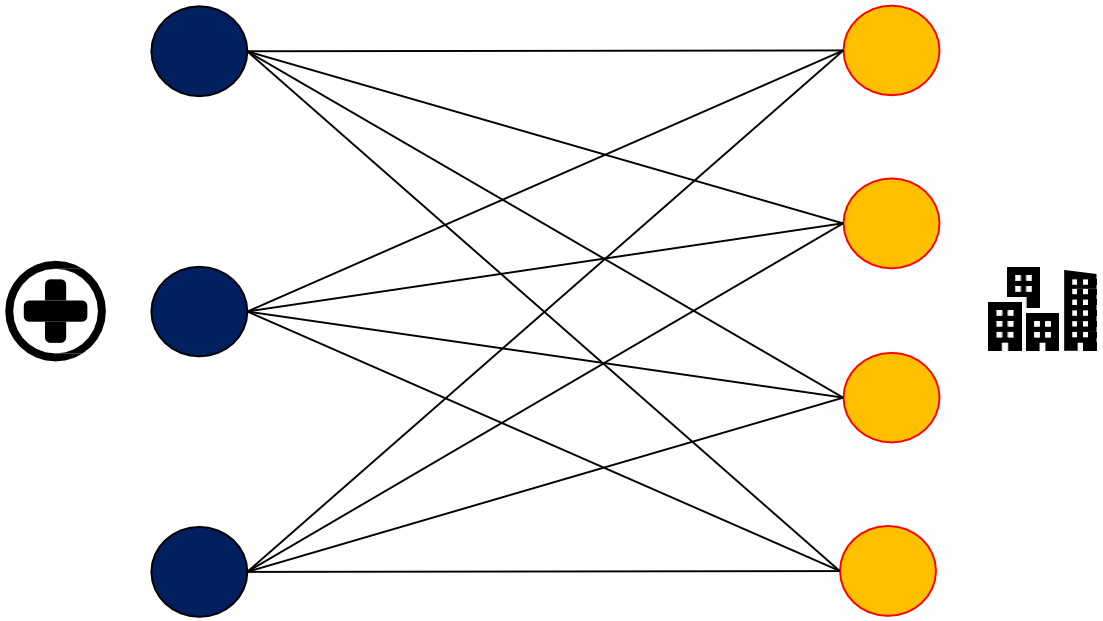
For makespan problem with

- 3 machines
- 10 jobs

Facility Location Problem

- Given m locations l_i where facility can be opened for cost c_i
- and n cities c_j with connection cost c_{ij} to facility location l_i,
- Decide where to open facilities and assign every city to one open facility such that overall cost (opening + connecting) is minimized

Location	Cost
l1	150
l2	600
l3	250



	c1	c2	c3	c4
l1	30	40	70	80
l2	90	80	85	95
l3	99	70	25	20

Exercise 3: Facility Location Problem

Define

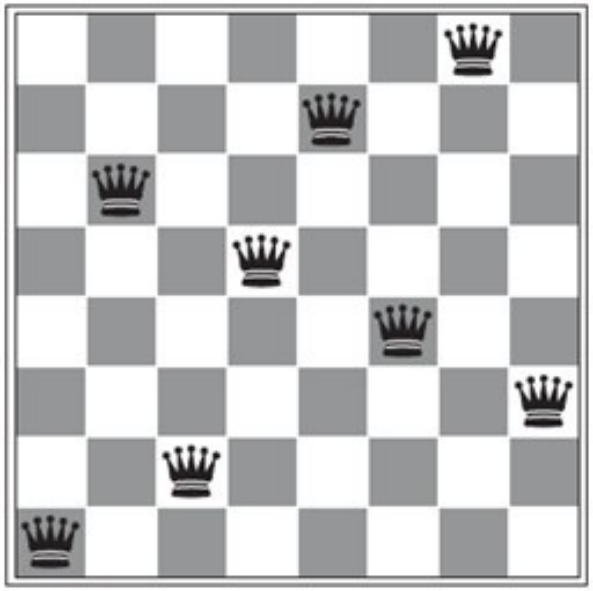
- State space
- Neighborhood
- Objective function

For facility location problem with

- 3 facility locations
- 6 cities

Simulated Annealing

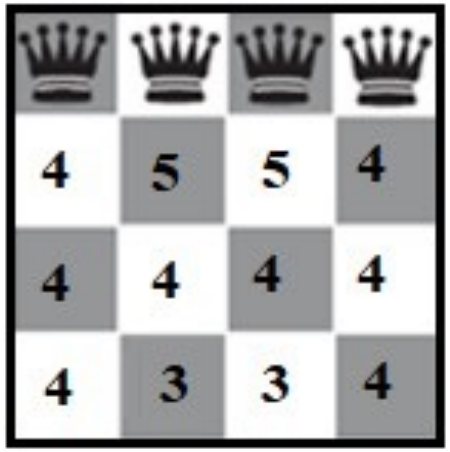
Exercise: Local Optima Revisited



- As we observed before, given state is locally optimal with value -1
- Compute ΔE for the neighbors obtained by
  - moving queen 2 to row 1 (State (8,1,7,4,2,5,1,6))
  - moving queen 4 to row 8 (State (8,3,7,8,2,5,1,6))
- Compute the probability of performing these moves for T=10 and T=1

Local Beam Search

Exercise: 4-Queens Problem

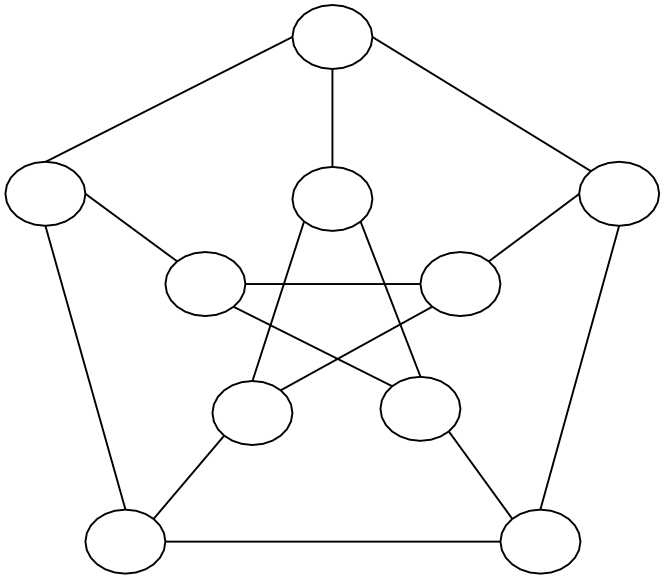


Consider the two states above with the given number of attacks for their neighbors.

- Give two possible next states when performing parallel Hill-climbing (2 runs in parallel).
- Give two possible next states when performing Local Beam Search (k=2).

Genetic Algorithms

Exercise: Graph Coloring



- Problem: assign a color from {1,2,3} to each node such that no two adjacent nodes have the same color
- Define
  - Genes
  - Chromosomes
  - Fitness (value) of individuals
  - Mutation operation
- Illustrate reproduction and mutation by means of a small example

Set Cover Problem

- Set Cover Problem: given set of n elements $U = \{e_1, \ldots, e_n\}$ and subsets $S_1,\ldots,S_m$ of U, find a minimal number of subsets that contain all elements from U (a minimal set cover of U)
- For example, U can be a shopping list and subsets correspond to shops that offer the desired items
  - $U = \{1, 2, 3, 4, 5\}$
  - $S_1 = \{1, 2, 5\}$, $S_2 = \{1,4\}$, $S_3 = \{3, 5\}$, $S_4 = \{1, 2\}$, $S_5 = \{3,4\}$
  - S_2, S_3 and S_4 contain all elements from U (S_2, S_3 and S_4 form a set cover of size 3)
  - S_1 and S_5 do also contain all elements (S_1, and S_5 form a set cover of size 2)
  - Hence, the set cover consisting of S_2, S_3 and S_4 is not minimal

Exercise: Set Cover Problem

- Set Cover Problem: given set of n elements $U = \{e_1, \ldots, e_n\}$ and m subsets $S_1,\ldots,S_m$ of U, find a minimal number of subsets that contain all elements from U

- Define
  - Genes
  - Chromosomes
  - Fitness (value) of individuals
  - Mutation operation
- Illustrate reproduction by means of a small example