

Brute Force

Exhaustive Solution Search

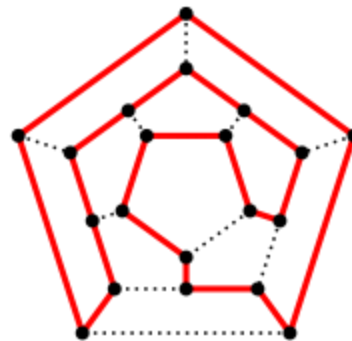
- ▶ A brute force solution to a problem involving search for an element with a special property, usually among combinatorial objects such as permutations, combinations, or subsets of a set.

Method:

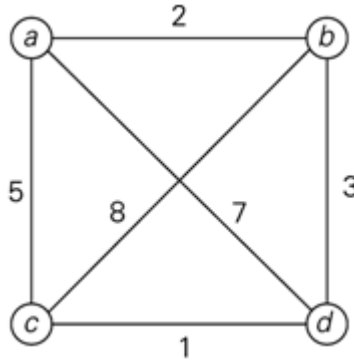
- ▶ Generate a list of all potential solutions to the problem in a systematic manner
- ▶ Evaluate potential solutions one by one, disqualifying infeasible ones and, for an optimization problem, keeping track of the best one found so far
- ▶ When search ends, announce the solution(s) found

Traveling Salesman Problem

- ▶ Informal: Given n cities with known distances between each pair, find the shortest tour that passes through all the cities exactly once before returning to the starting city
- ▶ Formal: Find shortest *Hamiltonian circuit* in a weighted connected graph
- ▶ Hamiltonian Circuit: a cycle that visits each vertex exactly once (except the vertex which is both the start and end, and so is visited twice)



Traveling Salesman Problem



- ▶ Generate a list of all potential circle routes
- ▶ Sum all costs on selected routes. Keep track of the minimum.
- ▶ When search ends, announce the optimal circle found

Knapsack Problem

- ▶ Given n items:
 - ▶ weights: $w_1 \ w_2 \ \dots \ w_n$
 - ▶ values: $v_1 \ v_2 \ \dots \ v_n$
 - ▶ a knapsack of capacity W
 - ▶ Find most valuable subset of the items that fit into the knapsack

Knapsack Problem

- ▶ Given n items:
 - ▶ weights: $w_1 \ w_2 \ \dots \ w_n$
 - ▶ values: $v_1 \ v_2 \ \dots \ v_n$
 - ▶ a knapsack of capacity W
 - ▶ Find most valuable subset of the items that fit into the knapsack
- ▶ Generate a list of all possible combination of items
- ▶ Sum the values of all items in each combination. Keep track of the maximum.
- ▶ When search ends, announce the optimal combination found

Assignment Problem

There are n people who need to be assigned to n jobs, one person per job. The cost of assigning person i to job j is $C[i, j]$. Find an assignment that minimizes the total cost.

	Job 0	Job 1	Job 2	Job 3
Person 0	9	2	7	8
Person 1	6	4	3	7
Person 2	5	8	1	8
Person 3	7	6	9	4

Assignment Problem

There are n people who need to be assigned to n jobs, one person per job. The cost of assigning person i to job j is $C[i, j]$. Find an assignment that minimizes the total cost.

	Job 0	Job 1	Job 2	Job 3
Person 0	9	2	7	8
Person 1	6	4	3	7
Person 2	5	8	1	8
Person 3	7	6	9	4

- ▶ Generate a list of all possible permutation of persons
- ▶ Sum the cost of each job in each assignment. Keep track of the minimum.
- ▶ When search ends, announce the optimal permutation found

Summary

- ▶ Exhaustive-search algorithms run in a realistic amount of time **only on very small instances**
- ▶ In some cases, there are much better alternatives!
 - ▶ Euler circuits
 - ▶ Shortest paths
 - ▶ Minimum spanning tree
 - ▶ Assignment problem
- ▶ In many cases, exhaustive search or its variation is the only known way to get exact solution