

# Traveling Salesman Problem

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# Traveling Salesman Problem

- Wikipedia:

Given a number of cities and the costs of traveling from any city to any other city, what is the cheapest round-trip route that visits each city exactly once and then returns to the starting city?

# Complexity

- So far the problem doesn't have a known polynomial time algorithm that returns the optimal solution.
- Brute force approach:

# cities	time
50	10 sec
70	1 year
80	1000 years

# Our task

- Three minutes.
- Problems up to 1577 cities.
- Find a solution as close as possible to the optimal one.

# Algorithms

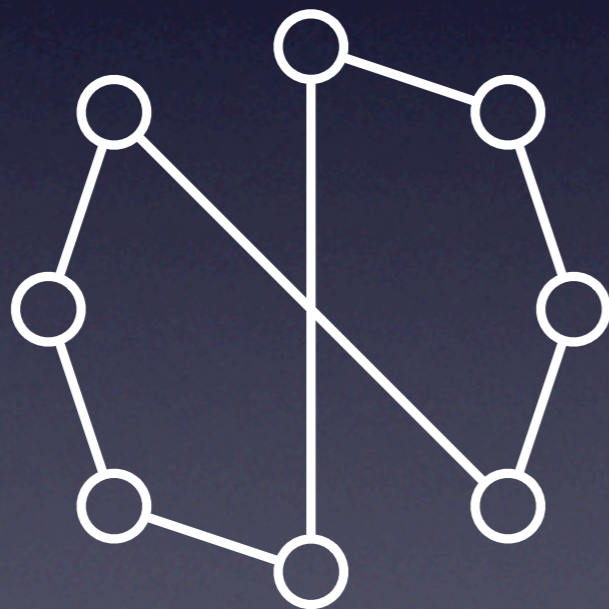
- Greedy constructive (Nearest and Farthest Neighbor)
- Meta-Heuristic (Simulated Annealing and Ant Colony Optimization)
- Local search (2-opt and 3-opt)

# Nearest Neighbor

- Start from a random city
- Select the neighbor of the current city as the closest one not previously visited
- Repeat until every city has been visited
- Add a link from the last city to the first one.
- Error around 20%

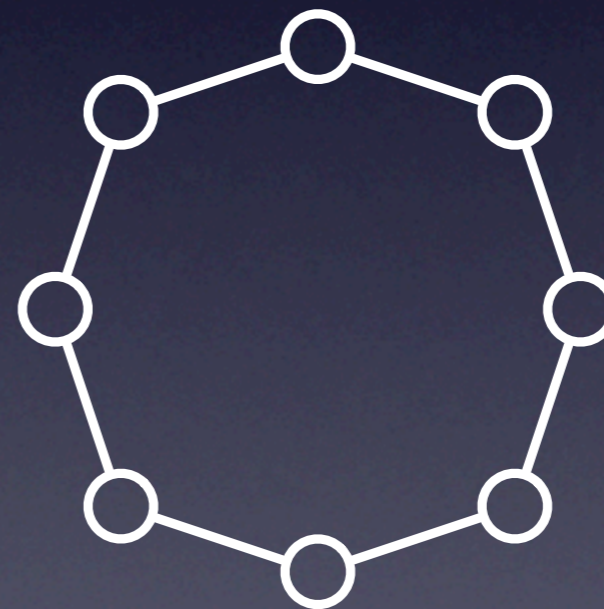
# 2-opt / 3-opt

Before



2-opt

After



3-opt behaves the same, checking 3 edges instead of 2  
Error around 7%

# Simulated Annealing

- Inspired by the annealing of metals
- Involve the controlled cooling of a metal

# Simulated Annealing

- Start with a complete solution
- Replace the solution by a random similar solution
- The probability depends on a temperature that gradually decreases
- Probability admits “bad” moves, this allows the SA to escape from local minima
- Error around 6%

# Ant Colony System

- Inspired by the behavior of the ants
- Ant uses stigmergy to communicate (leaving pheromone on the ground)
- Search in parallel for food, leave pheromone on the path.

# Ant Colony System

- Place  $n$  ants on random cities
- Each ant decides step by step its next city
  - Exploitation: follow the pheromone
  - Exploration: try new paths
- The ant that found the best path can reinforce its path with additional pheromone
- Error around 5%

# Implementations

Name	NN	SA	ACS	x-opt	Error
Jacopo	x			x	1.9 %
Daniele	x		x	x	1.8 %
Yuval	x		x	x	1.6 %
Aleardo	x	x		x	1.4 %