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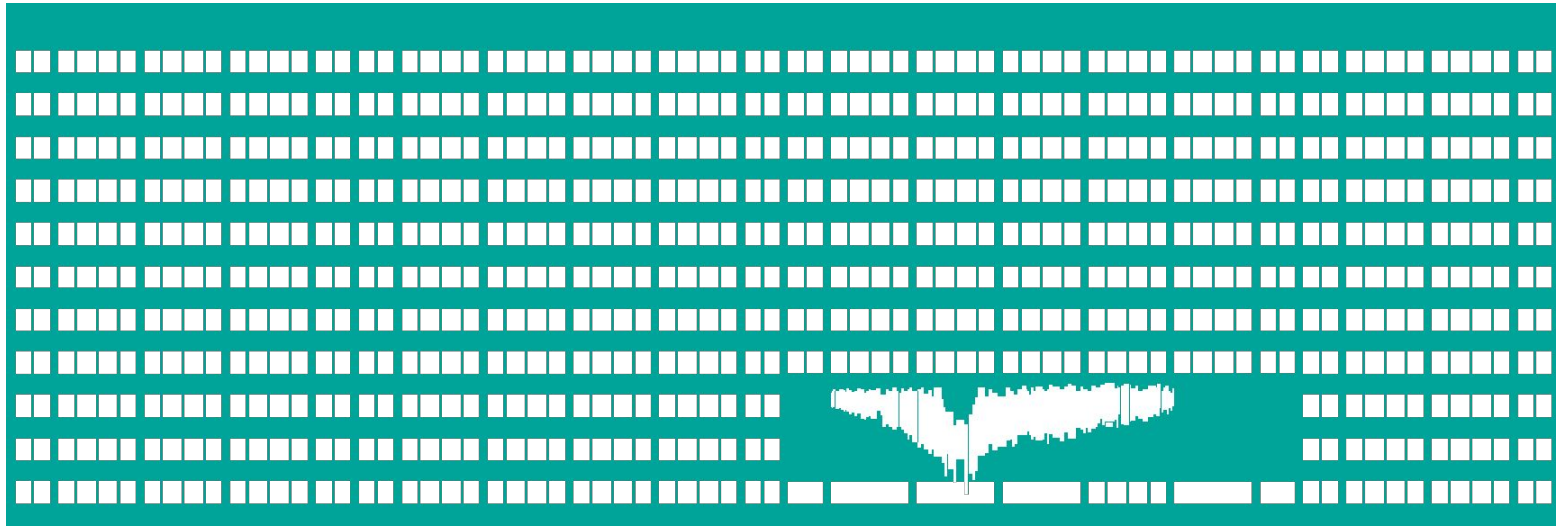

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Biologically inspired algorithms
Exercise 4

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Content

- Genetic algorithm (GA)
- Individual and Population
- Use of GA to solve Travelling Salesman Problem (TSP)

Individual Representation

Binary numbers (originally)

0
1
1
0
1
0

Real numbers

0.5
1.5
3.8
4.2
1.0
5.8

Items from some list

A
B
C
D
E
F

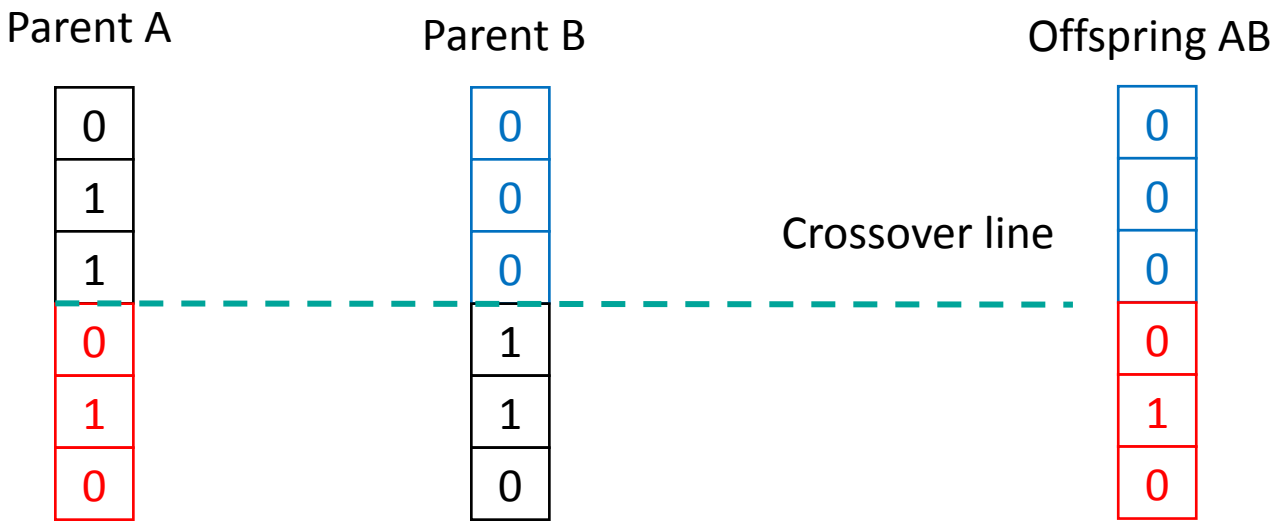
- GA is suitable for discrete optimization problems
- Originally developed for work with binary numbers

Population

- GA works with population of individuals
- Number of individuals (denoted as NP) belongs to control parameters
- GA works with generation (number of generations is denoted as G)
- Communication between individuals:
  - Crossover → Two individuals are crossover to create a new offspring

Crossover

- Selection of parents:
  - Actual individual + randomly selected individual

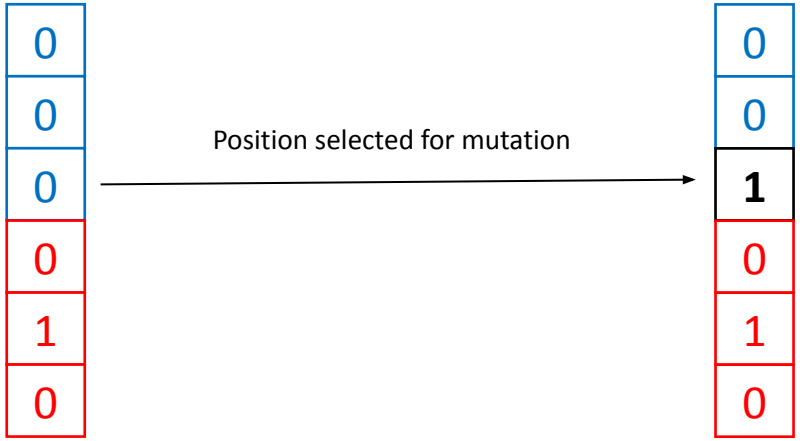


Mutation

- Probability of mutation is one of the control parameters

Offspring AB after crossover

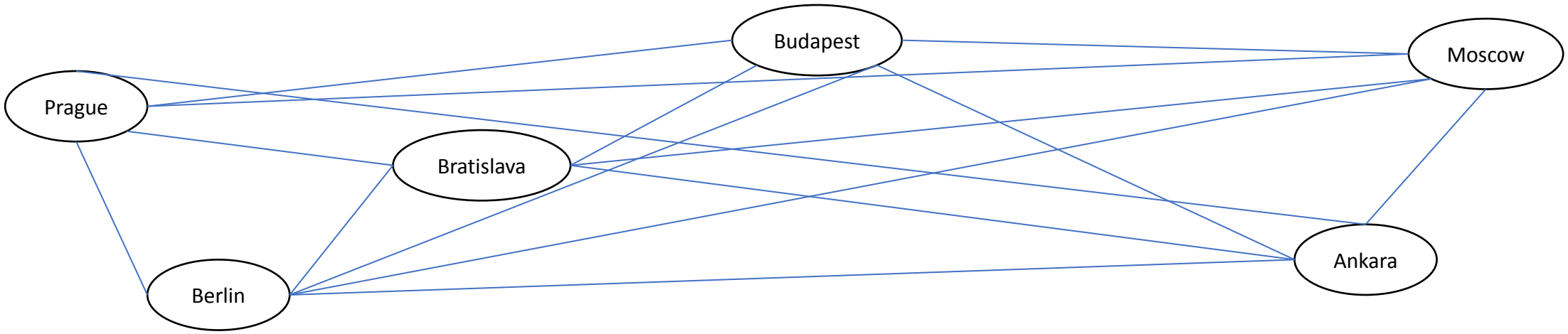
Offspring AB after mutation



- Position of mutation is usually selected randomly
- Value is changed to opposite one
- Offspring replaces actual parent ONLY IF its fitness is better or equal to fitness of the parent

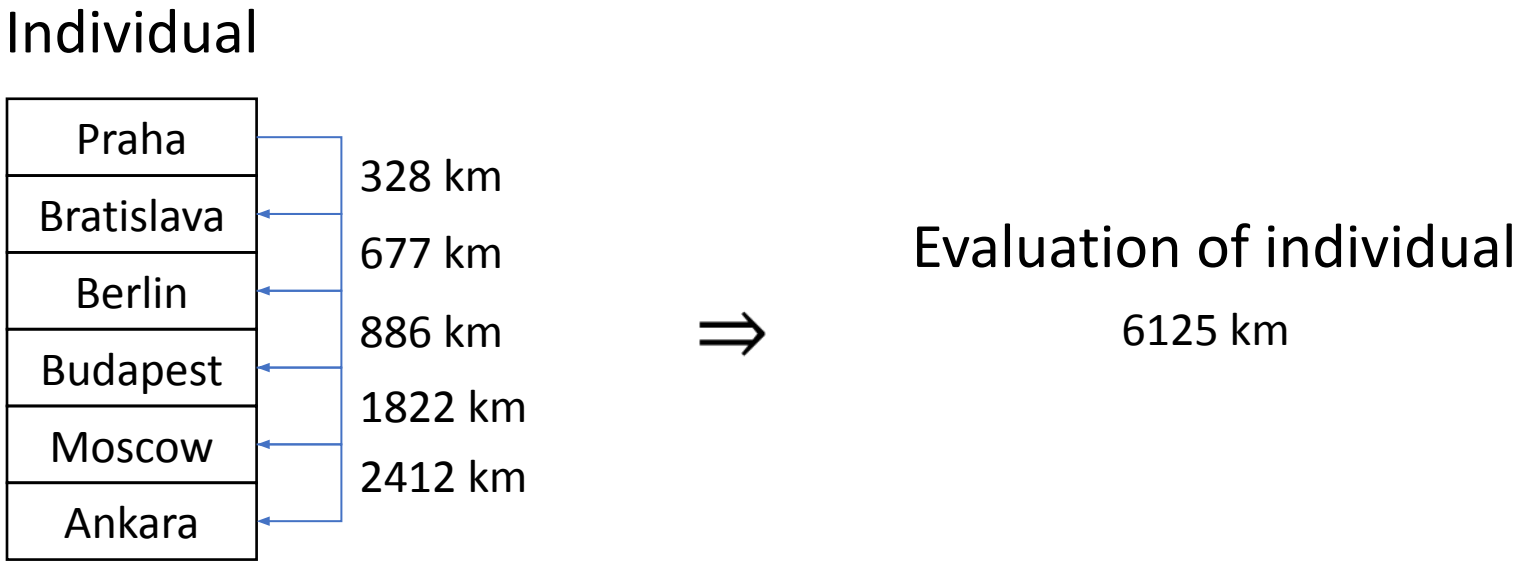
Genetic algorithm and TSP

- Problem:
  - Travelling salesman must find out the shortest possible route that visits each place (city) exactly once and returns to the origin



Genetic algorithm and TSP

- Cities: Prague, Bratislava, Berlin, Budapest, Moscow, Ankara



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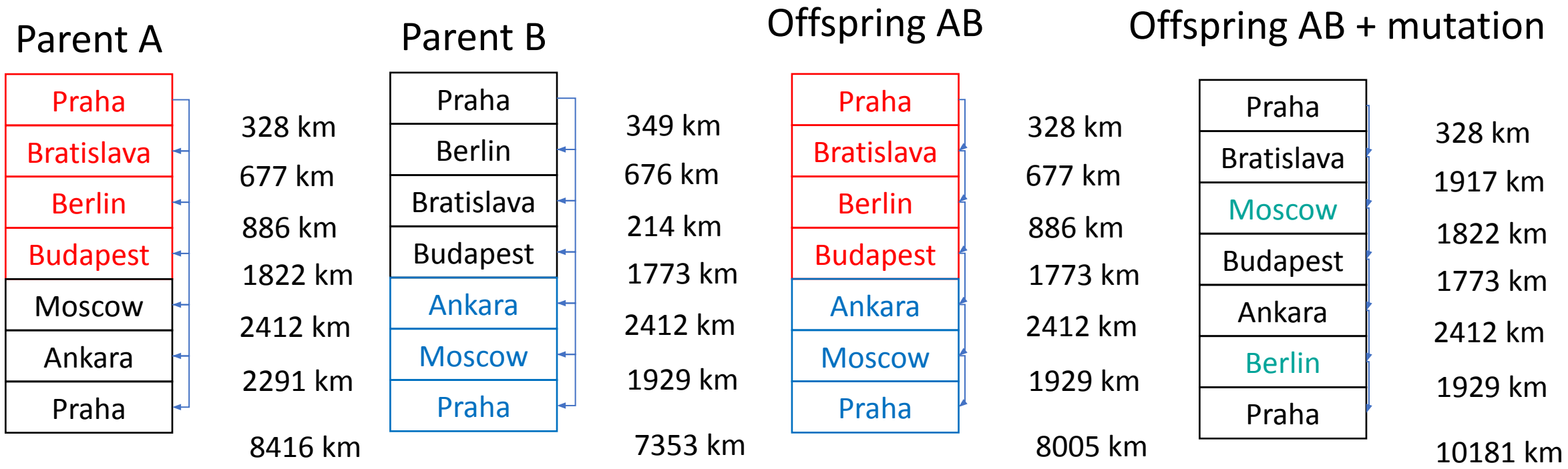
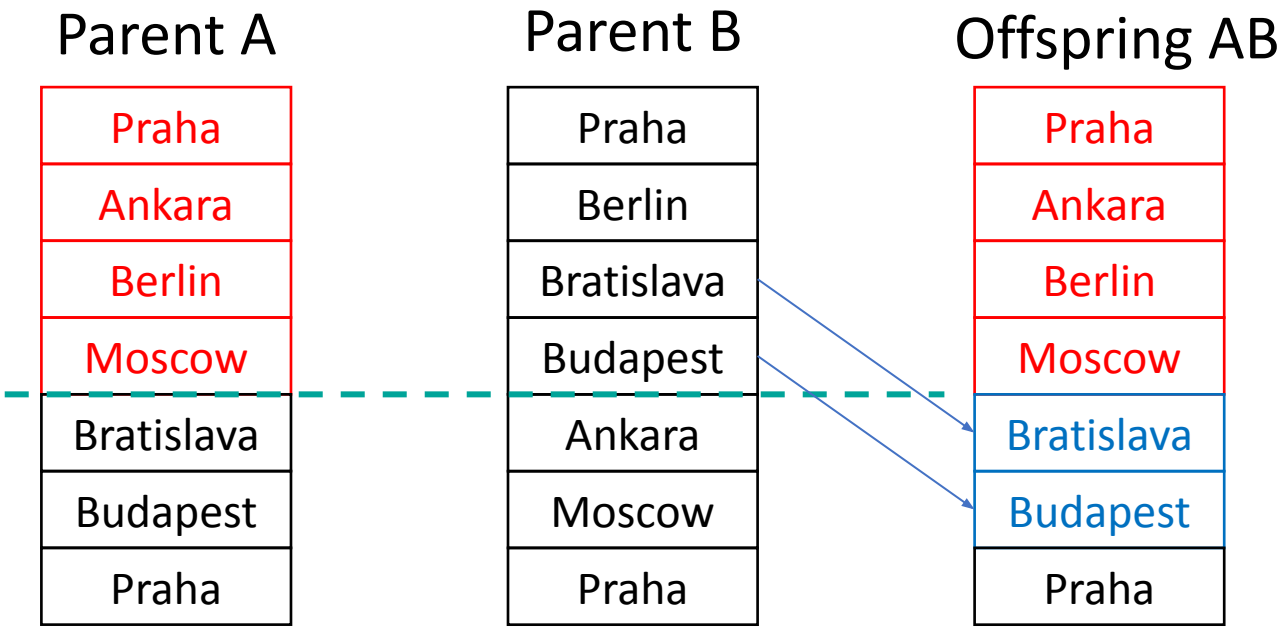


Genetic algorithm and TSP

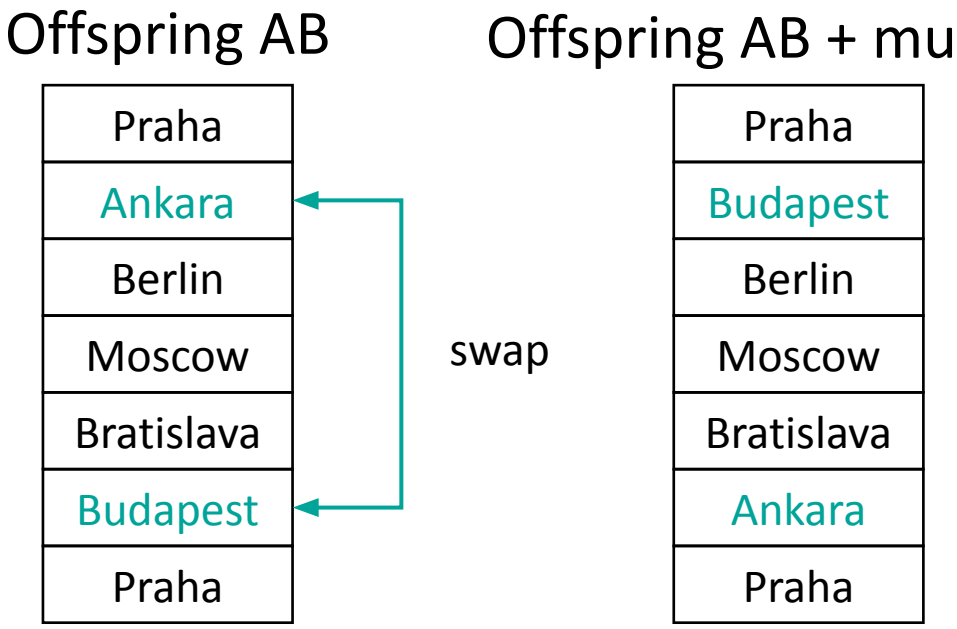
- Cities: Prague, Bratislava, Berlin, Budapest, Moscow, Ankara



- First parameters are taken from the actual parent (Parent A)
- The rest of parameters is taken from the second parent
- No city can be visited twice!

Genetic algorithm and TSP

- Cities: Prague, Bratislava, Berlin, Budapest, Moscow, Ankara



- Two positions are selected randomly
- Values are swapped
- New offspring is finished

Genetic algorithm – Pseudocode

```
NP = 20
G = 200
D = 20  # In TSP, it will be a number of cities

population = Generate NP random individuals
Evaluate individuals within population

for i in range(G):
  new_population = copy(population)  # Offspring is always put to a new population

  for j in range(NP):
     parent_A = population[j]
     parent_B = random individual from population (parent_B != parent_A)
     offspring_AB = crossover(parent_a, parent_B)
     if np.random.uniform() < 0.5:
          offspring_AB = mutate(offspring_AB)
     Evaluate offspring_AB

     If  f(offspring_AB) < f(parent_A)
          new_population[j] = offspring_AB
  population = new_population
```

Task

- Implement genetic algorithm (GA)
- Use GA to find out the optimal rout of Travelling Salesman
  - Number of cities: 20 – 40
  - Positions of cities: Random
- Visualize the process of search (in 2D)
- Inspiration: Figures 1 and 2

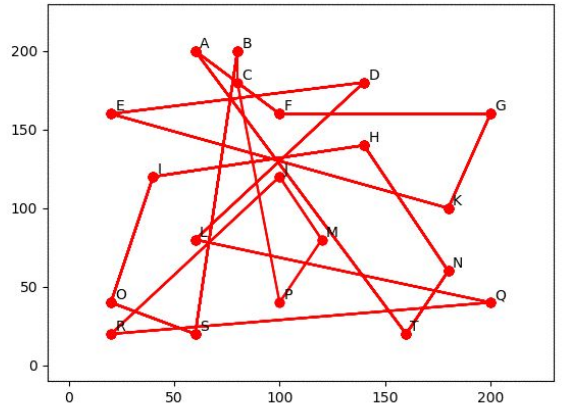
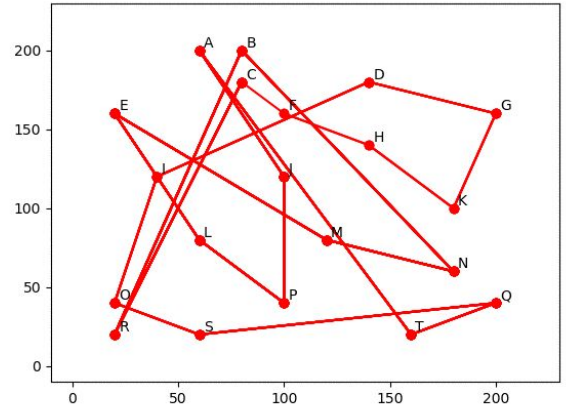


Figure 1

Figure 2



Thank you for your attention

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