Computer Programming: Skills & Concepts (CP1)
Intro to Practical 3:
Travelling Salesman Problem

9th November 2010

Travelling Salesman Problem (TSP)

A well-known theoretical and practical problem:

- a salesman has to visit a number of cities
- what is the shortest route to visit all cities and return home?

Properties of the problem:

- hard to solve for large number of cities
- instance of a *NP-complete* problem

Complexity of problems

We have already encountered problems with different complexity:

- search through unsorted array: linear (ie, $O(n)$)
- binary search through sorted array: log (ie, $O(\lg(n))$)
- BubbleSort: $O(n^2)$
- MergeSort: $O(n \lg(n))$

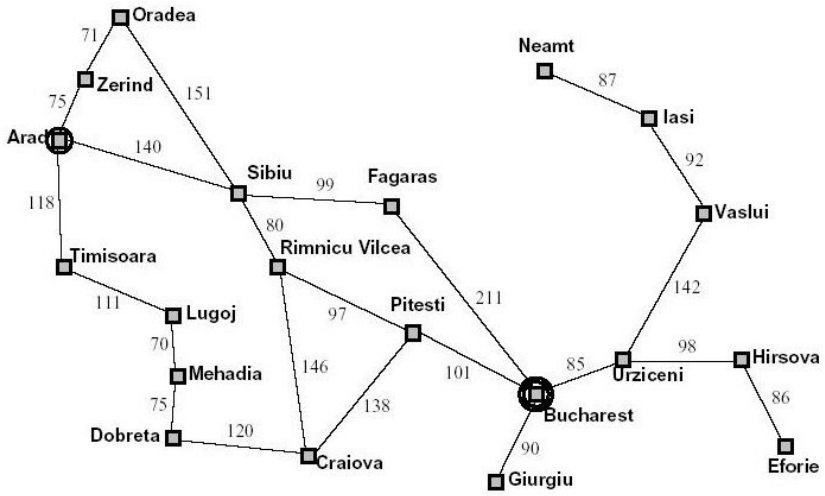
NP-complete?

- For some problems, no polynomial time solution is known — $O(n^c)$ for some constant c. One class of these problems is called NP-complete (NP = non-polynomial).
- There may be polynomial solutions, but nobody found them so far.
- If *efficient* solution of a problem is not possible, we resort to *heuristics* that give us approximate solutions.

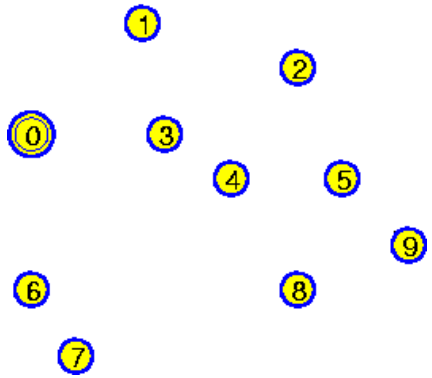
Other NP-hard problems

- Knapsack problem: given a set of whole numbers $a_1, \ldots, a_n$, and an upper bound K find a subset of the numbers whose sum is of *maximum value*, subject to being no more than K.
  eg, for $2, 4, 9, 11, 14$ and $K = 25$, the subset is $\{2, 9, 14\}$
- Minesweeper: is a given configuration "possible"?

Example TSP: Romania



Simplified: Euclidean TSP

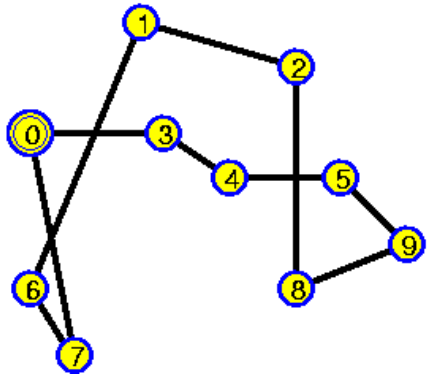


All connections are straight lines. How do we find the shortest path?

Greedy heuristic

- start at some point
- go to closest not visited city

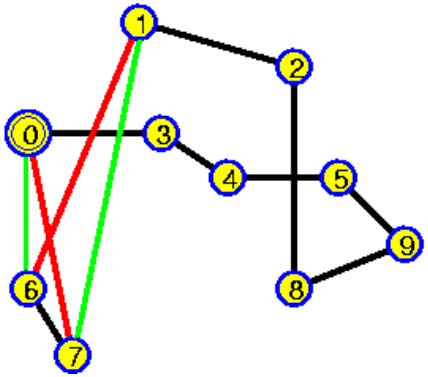
Greedy heuristic: result



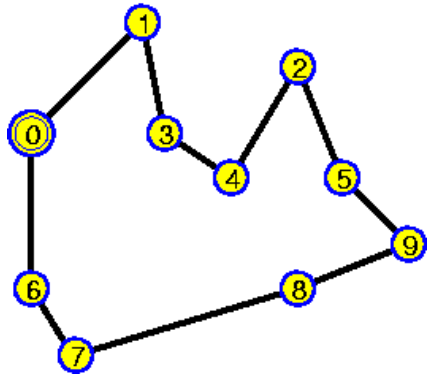
Improving the solution

- Swap neighboring cities, if it shortens path

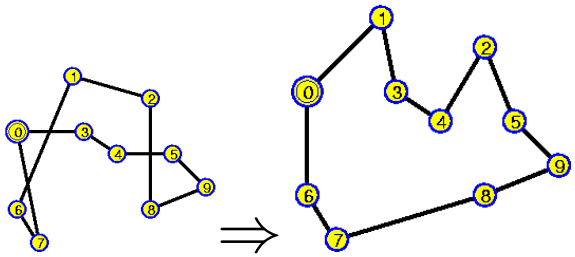
Swap 6,7



Locally Optimal solution



Other improvements?



What other improvements can be made?

Practical 3

- Part A: capture positions of cities (from mouse clicks), and store them all in an array. Write a function to compute the length of a given tour.
- Part B: implement swap heuristic.
- Part C: implement 2-opt heuristic (more powerful).
- Part D: implement greedy heuristic.
- Part E: do better, with almost no extra work?