KIWI Problem Description

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1 Problem Description

Kiwi.com problem requires the minimisation of the travelling cost by finding the best possible flight route for a given number of areas, where an area is a set of cities (airports). Costs differ according to the direction and day of travel. It is assumed that cost is the same for all hours of any day (i.e. a morning flight has the same price as an evening flight). The trip begins from a given city and everyday exactly one city of each area is visited. Throughout the trip, the arrival city is also the departure city for each area. This means that it is not allowed to arrive to a city and continue the trip by departing from another city of the same area. The trip ends in the area (not necessarily the city) where it began.

Mathematically, let $Area = \{area_1, area_2, \ldots, area_n\}$ be a set of n areas, where each area $r \in Area$ is composed of a set of airports $\{airport_1, airport_2, \ldots\}$; and let c_{ij}^{d} be the flight cost between the departure airport i and the arrival airport j on day d, which has two properties: c_{ij}^{d} is not necessarily equal to c_{ji}^{d} (i.e. the problem is asymmetric); and for $d1 \neq d2$, c_{ij}^{d1} is not necessarily equal c_{ij}^{d2}, (i.e. the problem is time dependent). For some cities, where $d = 0$, flights are available everyday. Moreover, in some instances there are multiple flights between the same cities for the same day with different costs (i.e. different airline companies for the same connection). The objective of the problem is to find the best possible flight route that connects all the given areas and minimises the cost within the time given, subject to the following constraints:

- The trip starts from the starting airport (city) given.
- Exactly one city is visited in each area (but we can choose which one).
- Every day a different area is visited.
- The trip continues from the arrival airport.
- The entire trip ends in any airport of the area where it began.

A simple problem instance consisting of 4 areas and 8 airports is presented in Figure 1. In this example, the 4 areas are; Greece, Italy, Spain, and the UK, where each area contains two cities; Athens and Thessaloniki, Rome and Milan, Madrid and Barcelona, and London and Liverpool, respectively. The trip begins from Athens to Madrid, then continues from Madrid to London, then from London to Rome and ends in Thessaloniki. Notice that in this trip the starting and finishing airports are different, but the trip is acceptable because it ends in the area where it began.

Figure 1: Simple problem instance with a possible solution

Kiwi.com provided small, medium, and large datasets, which are 14 in total, covering a range from 10 to 300 areas and a range from 1 to 6 airports (All 14 datasets can be found at https://code.kiwi.com/travelling-salesman-challenge-2-0-wrap-up-cb4d81e36d5b). Each dataset is structured as follows:

- The first input in the instance is the number of areas the user wants to visit.
- The second input is the starting airport in which the user is currently located.
- Then the areas and the corresponding airports are listed.
- Then follows a list of the travelling costs between each pair of airports for the corresponding day.

The time limits suggested by Kiwi.com for the instances are the following:

- For small test cases, i.e. test cases where the number of areas ≤ 20 and the total number of airports < 50, the time limit is 3 seconds.
- For medium test cases, i.e. test cases where the number of areas ≤ 100 and the total number of airports < 200, the time limit is 5 seconds.
- For large test cases, i.e. test cases where the number of areas > 100, the time limit is 15 seconds.